HYDRAULIC ANALYSIS & SCOUR ANALYSIS

US 23 OVER OTTAWA RIVER BRIDGE HYDRAULICS REPORT

REVISED

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Prepared for:

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Dated:

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PROJECT DESCRIPTION

The project is located In Lucas County, City of Sylvania on US-23 between interstate 475 and the Ohio/Michigan state line and on SR 51 between Haroun Road and Acres Road. The project involves widening the northbound and southbound bridge of US-23 over Ottawa River. Additionally, the downstream ramp bridge to the east will be removed as a part of the roadways' improvements. The US-23 SB ramp bridge will be separated from the mainline, and new ramp bridge will be added in replacement. Also, another bridge will be added to serve as NB off ramp and to replace the existing ramp bridge, which will be removed as shown in **Fig. 01.**

Fig. 01 Schematic map of the new development.

Ottawa River at this location is in a FEMA Zone AE, Special Flood Hazard Area that is considered a regulatory floodway (See **Fig. 02**). The new bridge system may impact Ottawa River flood upstream the new development.

Therefore, the intent of this hydraulic study is to evaluate such impact and ensure the new bridge system provides a no rise condition with the widening of the bridges.

Fig. 02 FEMA Flood Map.

HYDRAULICS ANALYSIS
The **ODOT Location and Design Manual, Volume 2**, July 15, 2022 version, was used for this study. The hydraulic computations were performed using USACE HEC-RAS program Version 6.3.1.

EXISTING CONDITION
The hydraulic model of the existing condition will include all the bridges within the study limits that could be impacted by the new development. Therefore, the existing scenario model includes pedestrian bridge, SB mainline bridge, NB mainline bridge, NB off ramp bridge, and most downstream golf cart bridge. Type of bridges and geometries are shown in **Table 1.0**

Table 1.0 Bridge types and Geometry

Element	Pedestrian Bridge	SB Mainline Bridge	NB Mainline Bridge	NB off Ramp Bridge	Golf Cart Bridge
Superstructure Type	Single Span Steel Frame Bridge with Concrete Deck	3-Span Concrete Slab Bridge	3-Span Concrete Slab Bridge	3-Span Concrete Slab Bridge	Single Span Steel Beam Bridge with Concrete Deck
Structure Size	98.2-ft f/f abutments	103.6-ft f/f abutments	103.6-ft f/f abutments	103.6-ft f/f abutments	60.8-ft f/f abutments
Out-to Out Width	13.5-ft	73-ft	44-ft	33.7-ft	10.9-ft
Superstructure Depth	30-in	19-in	18-in	18-in	37.2-in
Hydraulic Opening	1266.8-sf	1174.5- sf	1174.5- sf	1128.5-sf	260.64-sf

According to HEC-RAS Hydraulic Reference Manual Version 6.2, 2022, parallel bridges on divided highways may be modeled as single bridge if they were very close to each other, and the flow will not be able to expand between the bridges. Therefore, mainline bridges (SB & NB) will be modeled as a single bridge in this study since they are only 56-ft apart.

PROPOSED CONDITION
The new development involves removing the existing SB ramp portion from the SB mainline bridge as well as removing the NB off ramp Bridge downstream the NB mainline. Then adding two new bridges to carry the proposed SB entrance and NB exit ramps over the Ottawa River. These changes will be reflected in the proposed hydraulic model as shown in **Fig. 03**. The proposed SB and NB ramp bridge types will be 3- span continuous reinforced concrete slab bridges. The SB ramp super structure size is 159.8-ft and 25-ft total width. The NB off ramp bridge size is 130.1-ft in length and 25-ft in width. The existing SB mainline bridge's width was reduced to 41.5-ft as a results of existing SB ramp bridge removal. Detailed bridge site plans of the proposed development can be found in **Appendix 3.**

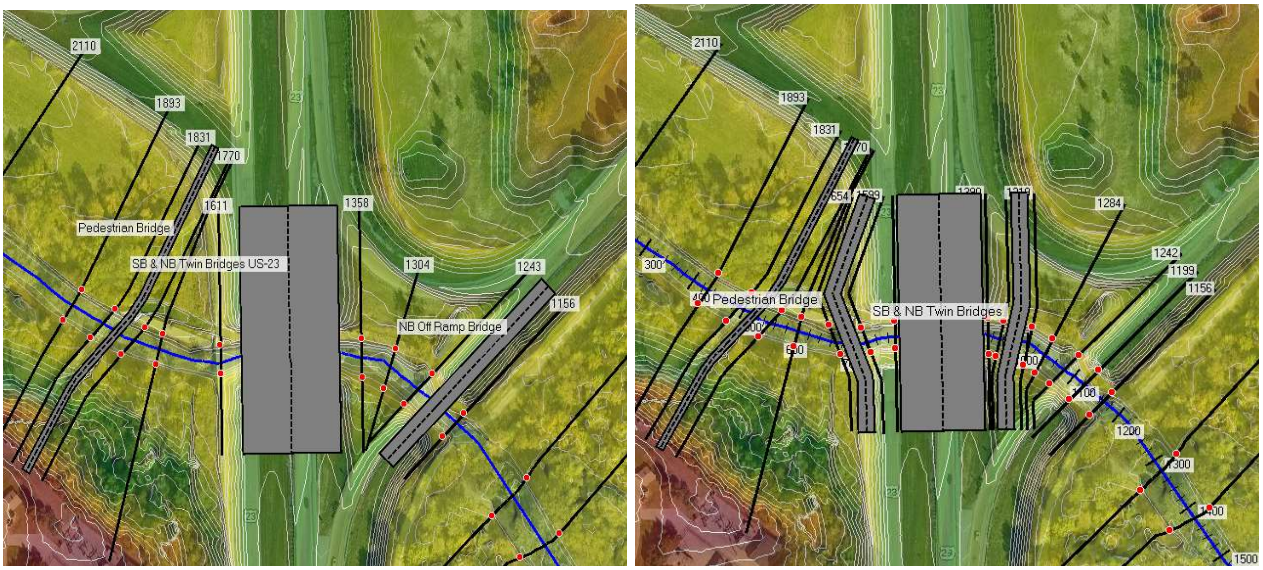


Fig. 03 Proposed(right) and Existing(left) model layout

FLOOD FREQUENCIES & FLOW RATES FOR ANALYSIS

The **USGS Stream Stats** and **ODOT L&D Manual Section 1004.2 and 1005.1** were used to determine the flow rates for the design and check hydraulic frequencies, see **Appendix 1** for Stream Stats data. Since the project location is within NFIP designated floodplain, FIS reports of Ottawa River within city of Sylvania community were checked to compare the 1% AEP discharge against the USGS Stream Stats-generated flow rate. The 1% AEP peak discharge estimated by USGS Stream Stats was higher than the peak discharge in the FIS report. See **Appendix 4** for FIS report.

BRIDGE HEADWATER CONTROL

As per **ODOT Location and Design Manual, Volume 2, Section 1006.3**, evaluate the headwater generated by a bridge in accordance to a flood hazard evaluation. Ensure the headwater meets the following:

A. Match the existing headwater for a bridge replacement for the design storm and the 1% AEP check storm to the maximum extent practicable. If there is an increase in headwater, determine the upstream impacts.

B. The design storm does not contact the low chord for new structures on new alignment.

C. Regulations from the local Conservancy Districts apply if they are more restrictive than the Department's.

D. Controls specific to a FIS. See section 1006.4. Controls Specific to Flood Insurance Studies

The Floodplain Coordinator for Lucas County was sent an LD-52 Letter of Notification and indicated that they follow ODOT's requirements. FEMA was also contacted for existing study information. See

Appendix 5 for correspondence and L-D50, No-Rise Certificate. Once this report is approved, the LD-51 Letter of Compliance will be sent to the Floodplain Coordinator along with the hydraulic report and HEC-RAS files. ODOT will be copied on this correspondence.

MANNING'S "n" VALUES

Manning's "n" values for channel roughness were determined by site visit, photographs and aerial view. Ottawa River within study limits runs through a majority of medium to dense brush upstream and downstream US-23 with small religions of short grass around the mainline and ramps bridges in addition to mature filed crops on the left floodplain downstream the golf cart bridge. Photos of the channel near US-23 are shown in **Fig.04.**

Fig. 04. Upstream US-23 (left), Downstream (right)

The manning's values used are as shown in Error! Reference source not found. **2.0.**

Table 2.0 Manning's Values

Manning's Value		HEC-RAS Ref. Manual, Table 3-1	Location	Description
Main Channel	0.035	A.1.a	Existing and proposed main channel	Clean, Straight, gull no rifts or deep, more stone and weeds
Upstream & Downstream Flood plain	0.040	A.2.a.1	Vicinity of Bridges	Short grass
	0.040	A.2.b.3	Downstream Golf Cart bridge left overbank	Mature Field Crops
	0.070	A.2.c.4	Upstream US-23 and Down Stream NB off ramps	Medium to dense brush

HYDRAULIC OUTPUT

A Summary of the hydraulic output for the proposed and existing models is shown in **Table 3.0**. The design storm of US-23 is 4% AEP for SB and NB off ramps, 2% AEP for the mainline SB interstate US-23 and check storm is 1% AEP based on ADT counts and functional class (**Section 1004.2 ODOT L&D Vol. 2**). The results show a slight increase in the 25- year and 50-year headwaters upstream the pedestrian bridge where HW elevation increased by 7.08-in for 25-year and by 2.5-in for 50-year events from the existing at RS-1831. The increase tends to be lower as you go further towards most upstream river station RS-2307. There was a slight increase in water surface elevations (WSEL) upstream of the proposed SB Ramp Bridge for a 25-year event. The highest increase in WSEL was at the bounding cross sections of the pedestrian bridge (US WSEL@25Y= 7.1" & DS WSEL@25Y= 8.5"). The immediate upstream of the SB Ramp Bridge will experience an increase of about 3.24" for a 25-year event.

For a 100-year event, there was slight increase in WSEL upstream of the SB Ramp Bridge. Most of the increase took place upstream of the pedestrian bridge, the increase was between 0.72"-1.7" for a 100-year storm.

The WSEL inside the proposed bridges were lower than the bridges' low cords for 1% AEP storm. The channel velocities were lower for the proposed scenario in most river stations. The HW elevation was also checked on the downstream side of the proposed development at RS- 1242 and there was no increase in the 4% AEP storm nor in the 1% AEP storm. The channel velocities were lower for the proposed scenario. Detailed HEC-RAS output is provided in **Appendix 2**

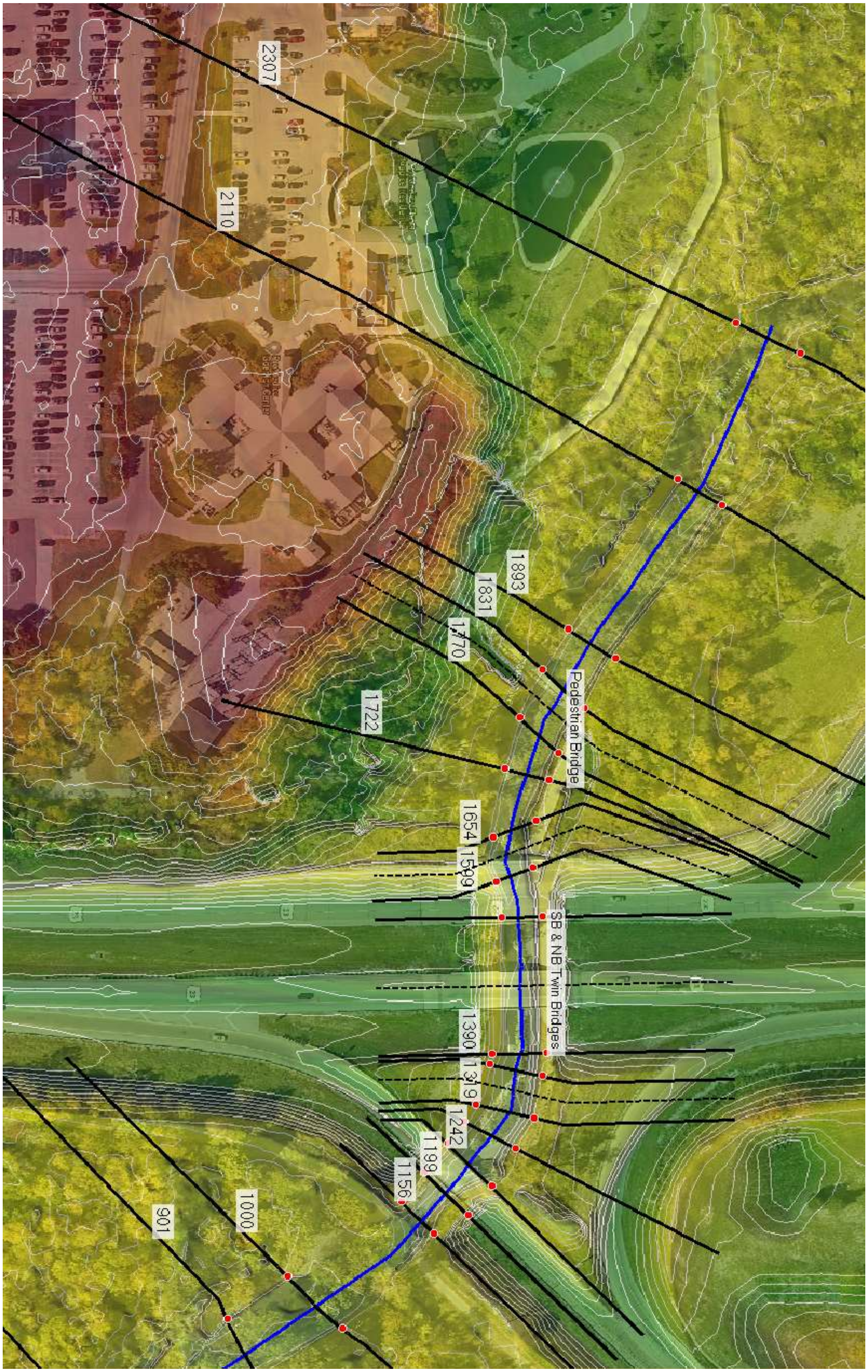


Fig. 05 Cross section Layout upstream SB Ramp Pr. Bridge.

Table 3.0 Existing VS Proposed Hydraulic Output

Scenario		Existing Condition		Proposed Condition		WSEL Diff.	Velocity Diff.
XS Location	Event	WSEL, ft	Velocity, ft/s	WSEL, ft	Velocity, ft/s	ft	ft/s
XS- 2307 Upstream	2-YR	619.24	3.50	619.59	3.17	0.35	-0.33
	5-YR	620.71	3.37	621.15	3.01	0.44	-0.36
	10-YR	621.65	3.22	622.1	2.94	0.45	-0.28
	25-YR	**622.87**	**3.07**	**623.27**	**2.89**	**0.40**	**-0.18**
	50-YR	623.62	3.06	624.04	2.9	0.42	-0.16
	100-YR	**624.67**	**2.93**	**624.81**	**2.92**	**0.14**	**-0.01**
	500-YR	626.59	2.84	626.37	2.99	-0.22	0.15
XS- 2110 Upstream	2-YR	619.08	3.72	619.46	3.41	0.38	-0.31
	5-YR	620.63	3.41	621.06	3.31	0.43	-0.10
	10-YR	621.58	3.30	622.02	3.3	0.44	0.00
	25-YR	**622.81**	**3.18**	**623.20**	**3.30**	**0.39**	**0.12**
	50-YR	623.57	3.19	623.97	3.35	0.40	0.16
	100-YR	**624.63**	**3.07**	**624.74**	**3.39**	**0.11**	**0.32**
	500-YR	626.56	3.03	626.31	3.53	-0.25	0.50
XS- 1893 Upstream	2-YR	618.80	4.45	619.26	3.93	0.46	-0.52
	5-YR	620.36	4.55	620.87	4.08	0.51	-0.47
	10-YR	621.33	4.64	621.82	4.21	0.49	-0.43
	25-YR	**622.57**	**4.69**	**623.02**	**4.23**	**0.45**	**-0.46**
	50-YR	623.51	3.32	623.79	4.35	0.28	1.03
	100-YR	**624.57**	**3.25**	**624.56**	**4.46**	**-0.01**	**1.21**
	500-YR	626.50	3.29	626.12	4.76	-0.38	1.47
XS- 1831 Upstream Pedestrian Bridge	2-YR	618.61	4.92	619.1	4.45	0.49	-0.47
	5-YR	620.14	5.26	620.68	4.82	0.54	-0.44
	10-YR	621.10	5.44	621.63	5.02	0.53	-0.42
	25-YR	**622.33**	**5.55**	**622.92**	**4.63**	**0.59**	**-0.92**
	50-YR	623.49	3.23	623.7	4.74	0.21	1.51
	100-YR	**624.55**	**3.17**	**624.47**	**4.82**	**-0.08**	**1.65**
	500-YR	626.49	3.27	626.02	5.14	-0.47	1.87
XS- 1770 downstream Pedestrian Bridge	2-YR	618.48	5.19	619	4.68	0.52	-0.51
	5-YR	619.99	5.63	620.56	5.15	0.57	-0.48
	10-YR	620.94	5.87	621.5	5.42	0.56	-0.45
	25-YR	**622.18**	**6.05**	**622.89**	**4.20**	**0.71**	**-1.85**
	50-YR	623.37	4.20	623.69	4.31	0.32	0.11
	100-YR	**624.39**	**4.07**	**624.45**	**4.41**	**0.06**	**0.34**
	500-YR	626.40	4.06	626.01	4.71	-0.39	0.65
XS- 1772 Upstream Proposed SB Ramp Bridge	2-YR	618.35	5.67	618.82	5.42	0.47	-0.25
	5-YR	619.97	5.52	620.41	5.79	0.44	0.27
	10-YR	620.94	5.48	621.36	6.02	0.42	0.54
	25-YR	**622.21**	**5.44**	**622.48**	**6.32**	**0.27**	**0.88**
	50-YR	623.21	5.30	623.26	6.5	0.05	1.20
	100-YR	**624.23**	**5.23**	**623.99**	**6.73**	**-0.24**	**1.50**
	500-YR	626.25	5.18	625.5	7.25	-0.75	2.07
XS- 1242 downstream Proposed NB off Ramp Bridge	2-YR	617.39	4.80	617.45	4.77	0.06	-0.03
	5-YR	618.73	5.56	618.68	5.49	-0.05	-0.07
	10-YR	619.55	5.98	619.48	5.72	-0.07	-0.26
	25-YR	**620.80**	**6.24**	**620.47**	**5.85**	**-0.33**	**-0.39**
	50-YR	621.78	6.36	621.19	5.87	-0.59	-0.49
	100-YR	**622.83**	**6.42**	**621.88**	**5.87**	**-0.95**	**-0.55**
	500-YR	624.69	6.82	623.37	5.87	-1.32	-0.95

Since there was an increase design storm headwater elevation, flood inundation for 4% AEP storm was checked to determine if that would negatively impact areas upstream the proposed work. The flood map is shown in **Fig. 06**.

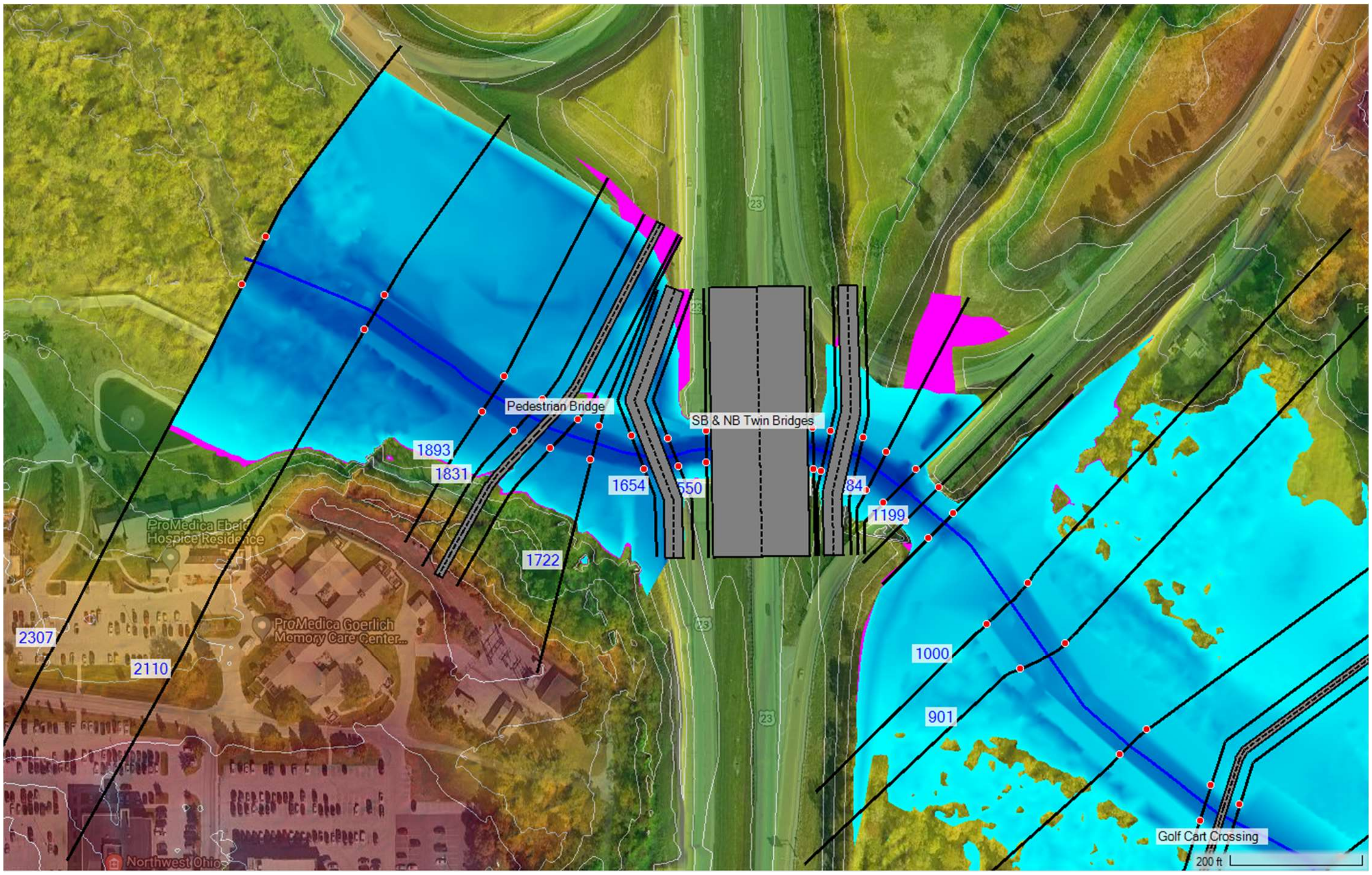


Fig. 06 4% AEP storm flood inundation existing (blue) VS proposed (pink)

The increase in flood area for 4% AEP design storm is minimal and no properties were impacted by the proposed development on the upstream side of US-23. Similarly, the 1% AEP flood map shown in **Fig.07**, shows that the proposed scenario would not result in any significant increase in headwater elevations, and therefore would have no negative impact on surrounding facilities.

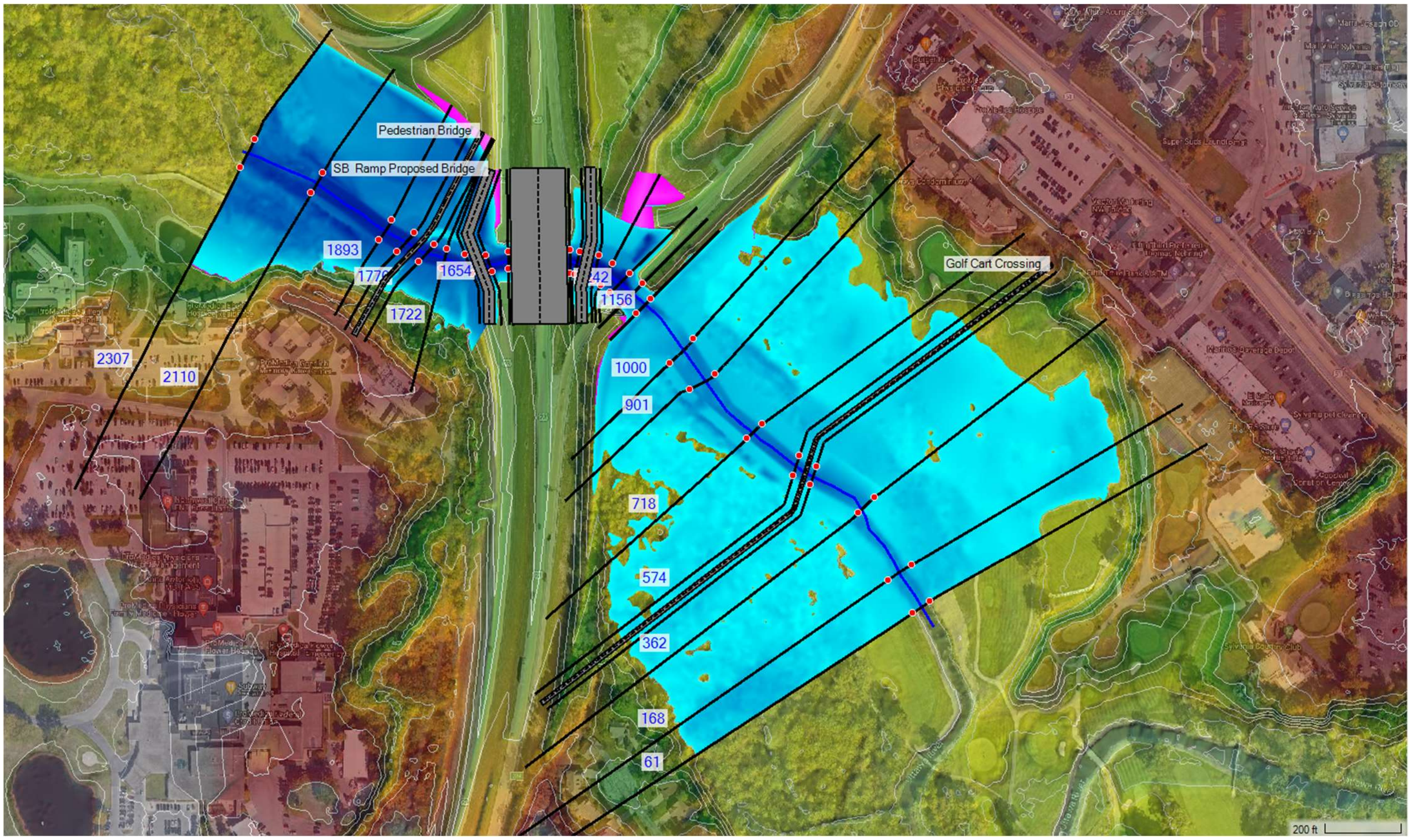


Fig. 07 1% AEP storm flood inundation existing (blue) VS proposed (pink)

FLOODPLAIN COORDINATION

As part of this project and since the work falls within a FEMA Zone AE with a floodway established, coordination with the local floodplain coordinator and documentation through ODOT's self-permitting process is required. The local floodplain coordinator, Kevin Aller, was initially contacted in November of 2021 to discuss the project and to determine if there were more restrictive local requirements than ODOT's. At that time the project included modification to the existing mainline bridges and removal of the northbound off ramp and the flood plain coordinator indicated that we should follow ODOT's requirements. In addition, the modeling approach was discussed since there was only HEC-2 data available for the FEMA model and it was decided to generate an existing and proposed model based on current survey and lidar information. The project evolved to include the construction of two new ramps and removal of a portion of the mainline southbound bridge. The mainline northbound bridge would not be touched and the northbound off ramp would still be removed. Coordination was performed with the floodplain coordinator again, starting over with the LD-52, Notification Letter, on June 22, 2023 (see **Appendix 5)**. At this time the flood plain coordinator was also made aware of the encroachment of the embankments for the new ramps into the floodway. A variance was requested but the local floodplain coordinator indicated that there is no local variance process for the type of work proposed with this project. At this time, less any waterway permitting signatures needed from the local flood plain coordinator, the only other local coordination needed would be to complete and submit a Flood Development Permit at the appropriate time.

The next step will be to provide the local flood plain coordinator a copy of this report along with the HEC-Ras file and to reach out to the Office of Hydraulics to determine the necessary further coordination for the encroachment to the floodway. The LD-51 Compliance Letter is attached in **Appendix 5.**

BRIDGE DECK DRAINAGE

As part of the hydraulic study, the amount of spread anticipated on the bridge decks and the need for deck drainage by way of scuppers was investigated. The 10% AEP was used and since the ramps are part of a freeway system no spread of water was allowed within the travel lanes. Adhering to these design constraints the following bridge deck drainage was determined:

- The SB Entrance Ramp bridge over the Ottawa River does not require any scuppers. The 6-ft shoulder can convey the maximum anticipated spread of 5.9-ft;
- The NB Exit Ramp bridge over the Ottawa River which has a sag or sump location with the field of the deck, will require one scupper at that location to reduce the anticipated spread of 7-ft to fit within the confines of the 6-ft shoulder. During detailed design, the profile and superelevation of this structure will be revisited to determine if the sag point can be moved off of the structure and alleviate the need for any scuppers.
- The modified SB US 23 mainline structure over the Ottawa River does not require any scuppers. The proposed 12-ft shoulders can convey the maximum anticipated spread of 6-ft. The existing scuppers on the east side will remain unless directed by ODOT to plug them.

Refer to **Appendix 6** for bridge deck drainage calculations.

SCOUR

Scour analyses has been performed for the south entrance Ramp D and north exit ramp A. Geotechnical parameters have been provided via the April 17, 2023 Preliminary Scour Design Memo prepared by TTL Associates, Inc., see **Appendix 7**. No evidence of scour was present at the site during the field reconnaissance and bed rock is fairly shallow based on historic boring information.

Review of historical imagery showed that no noticeable meandering of the river has occurred since 2003.

Fig. 08 Evaluation for meandering, 2003 photo on left and 2021 photo on right

The original 1960 construction plans for the southbound and northbound mainline bridges indicated a flowline elevation of 611.5-ft (datum corrected to 610.41-ft). Current project survey information indicates a flowline elevation of approximately 609.06-ft which indicates the bed has degraded 1.35-ft over the past 62-years.

The March 2021 inspection reports indicate a **7-Good** scour condition rating and the probing was conducting in 2019 which found no issues for both the left and right mainline US 23 bridges over the Ottawa River. Photos from the 2LMN site visit agree with the rating.

Fig. 09 Upstream View of Existing NB Exit Ramp (Left), Pier 2 under US 23 SB Bridge (Right)

Fig. 10 Upstream View of US 23 Northbound Bridge

The scour was calculated using outputs from the HECRAS 6.3.1 hydraulic model and inputting necessary values into the FHWA Hydraulic Toolbox. Based on the ODOT L&D Vol. 2, since the bridges on site require a 4% AEP hydraulic design storm, then a 2% AEP design scour and 1% AEP check scour analyses were performed.

Per the preliminary scour design memo, 3 borings were collected for use at the south entrance ramp D, and 2 borings for north exit ramp A. The scour parameter table provided by the Geotechnical Engineer in **Appendix 7** notes which borings were used for each abutment and pier for Ramp A and D bridges. At Ramp D there is a minimal amount of cohesive soil at the top of the test samples, followed by a minimal amount of granular material on top of weathered rock. At Ramp A, the borings indicate a minimal amount of granular material on top of weathered rock. There is also a small presence of cohesive soil at the rear abutment. These calculations assume that all material on top of the test samples has scoured away since no scour parameters are available between top of test sample and top of existing ground. According to the preliminary geotechnical memo, none of the samples found scour resistant rock, in accordance with the ODOT BDM, Section 305.2.1.2.b. Therefore, the weathered rock has been analyzed in the scour calculations.

For both the Ramp A and D bridges, computations were completed for contraction scour in channel and left and right over banks, as well as local scour at abutments and piers. Where cohesive soils were present, the appropriate cohesive soil computations were used. At piers, calculations were performed to determine the critical soil velocity, bed shear stress, and soil erosion rates so that time rate of scour could be determined in the cohesive soils. Where granular soils were present, the Florida DOT method within the hydraulic toolbox was used. Once scour hit the weathered rock elevation, the D50 equivalent for the rock was used, also the Critical Shear Stress (Pa). For abutment scour the NCHRP method was used to compute scour. The following tables include results for the design and check scour at both Ramp A and D bridges.

Table 4.0 Design Scour, Ramp D

50-Year (2% AEP)	Depth (ft)	Existing Ground EL.*	Scour Elevation	Bottom of Footing EL.	Shaft length	Bottom of Shaft Due to Scour / Top of Rock Socket
Contraction Scour (R.A.)	0.85					
Abutment Scour (R.A.)	2.87					
Total Rear Abutment Scour	**3.72**	**615.00**	**611.28**	612.5	11.22	601.28
Contraction Scour (F.A.)	2.14					
Abutment Scour (F.A.)	5.63					
Total Forward Abutment Scour	**7.77**	**612.33**	**604.56**	614	19.44	594.56
Channel Contraction Scour	2.9					
Pier 1 Scour	6.19					
Total Pier 1 Scour	**9.09**	**615.00**	**605.91**	610.79	14.88	595.91
Pier 2 Scour	1.05					
Total Pier 2 Scour	**3.95**	**609.79**	**605.84**	605.14	9.30	595.84

* Existing ground at point of interest, or top of geotech sample, whichever is lower.

Table 5.0 Check Scour, Ramp D

100-Year (1% AEP)	Depth (ft)	Existing Ground EL.*	Scour Elevation	Bottom of Footing EL.	Shaft length	Bottom of Shaft Due to Scour / Top of Rock Socket
Contraction Scour (R.A.)	1.01					
Abutment Scour (R.A.)	3.78					
Total Rear Abutment Scour	**4.79**	**615.00**	**610.21**	612.5	12.29	600.21
Contraction Scour (F.A.)	2.28					
Abutment Scour (F.A.)	5.63					
Total Forward Abutment Scour	**7.91**	**612.33**	**604.42**	614	19.58	594.42
Channel Contraction Scour	3.03					
Pier 1 Scour	6.36					
Total Pier 1 Scour	**9.39**	**615.00**	**605.61**	610.79	15.18	595.61
Pier 2 Scour	1.09					
Total Pier 2 Scour	**4.12**	**609.79**	**605.67**	605.14	9.47	595.67

* Existing ground at point of interest, or top of geotech sample, whichever is lower.

Table 6.0 Design Scour, Ramp A

50-Year (2% AEP)	Depth (ft)	Existing Ground EL.*	Scour Elevation	Bottom of Footing EL.	Shaft length	Bottom of Shaft Due to Scour / Top of Rock Socket
Contraction Scour (R.A.)	7.6					
Abutment Scour (R.A.)	7.6					
Total Rear Abutment Scour**	**7.6**	**613.50**	**605.9**	613.5	17.60	595.90
Contraction Scour (F.A.)	0					
Abutment Scour (F.A.)	0.9					
Total Forward Abutment Scour	**0.9**	**609.50**	**608.6**	615	16.40	598.60
Channel Contraction Scour	2.83					
Pier 1 Scour	7.6					
Total Pier 1 Scour***	**10.43**	**613.50**	**603.07**	610	16.93	593.07
Pier 2 Scour	0.9					
Total Pier 2 Scour	**3.73**	**609.50**	**605.77**	608	12.23	595.77

* Existing ground at point of interest, or top of geotech sample, whichever is lower.
**Contraction and abutment scour stops at rock, therefore these values were not added together.
***Note that for Ramp A Pier 1, the end-bearing elevation associated with the extension of the shaft/socket 10 feet below the scour elevation was just above a highly fractured zone with open fractures at Elev. 592.7. At this elevation, the driller noted loss of water during coring. Due to suspect end-bearing of this material, we recommend the shaft/socket extend deeper. The driller noted 50% water return and we encountered more intact rock at Elev. 591.7. Therefore, use a tip elevation of Elev. 591.7.

Table 6.0 Check Scour, Ramp A

100-Year (1% AEP)	Depth (ft)	Existing Ground EL.*	Scour Elevation	Bottom of Footing EL.	Shaft length	Bottom of Shaft Due to Scour / Top of Rock Socket
Contraction Scour (R.A.)	7.6					
Abutment Scour (R.A.)	7.6					
Total Rear Abutment Scour**	**7.6**	**613.50**	**605.9**	613.5	17.60	595.90
Contraction Scour (F.A.)	0.9					
Abutment Scour (F.A.)	0.9					
Total Forward Abutment Scour	**1.8**	**609.50**	**607.7**	615	17.30	597.70
Channel Contraction Scour	2.88					
Pier 1 Scour	7.6					
Total Pier 1 Scour***	**10.48**	**613.50**	**603.02**	610	16.98	593.02
Pier 2 Scour	0.9					
Total Pier 2 Scour	**3.78**	**609.50**	**605.72**	608	12.28	595.72

* Existing ground at point of interest, or top of geotech sample, whichever is lower.
** Contraction and abutment scour stops at rock, therefore these values were not added together.
***Note that for Ramp A Pier 1, the end-bearing elevation associated with the extension of the shaft/socket 10 feet below the scour elevation was just above a highly fractured zone with open fractures at Elev. 592.7. At this elevation, the driller noted loss of water during coring. Due to suspect end-bearing of this material, we recommend the shaft/socket extend deeper. The driller noted 50% water return and we encountered more intact rock at Elev. 591.7. Therefore, use a tip elevation of Elev. 591.7.

The proposed design at ramps A and D include semi-integral abutments with wall type piers and footings on rock with drilled shafts socketed into rock. At the ramp D bridge, the design and check scours are deeper at pier 1 and the forward abutment. At the ramp A bridge, the rear abutment and pier 1 have the more pronounced scour. The top of rock socket has been placed at 10-ft below the scour elevation for all abutments and piers.

Refer to **Appendix 7** for scour calculations.

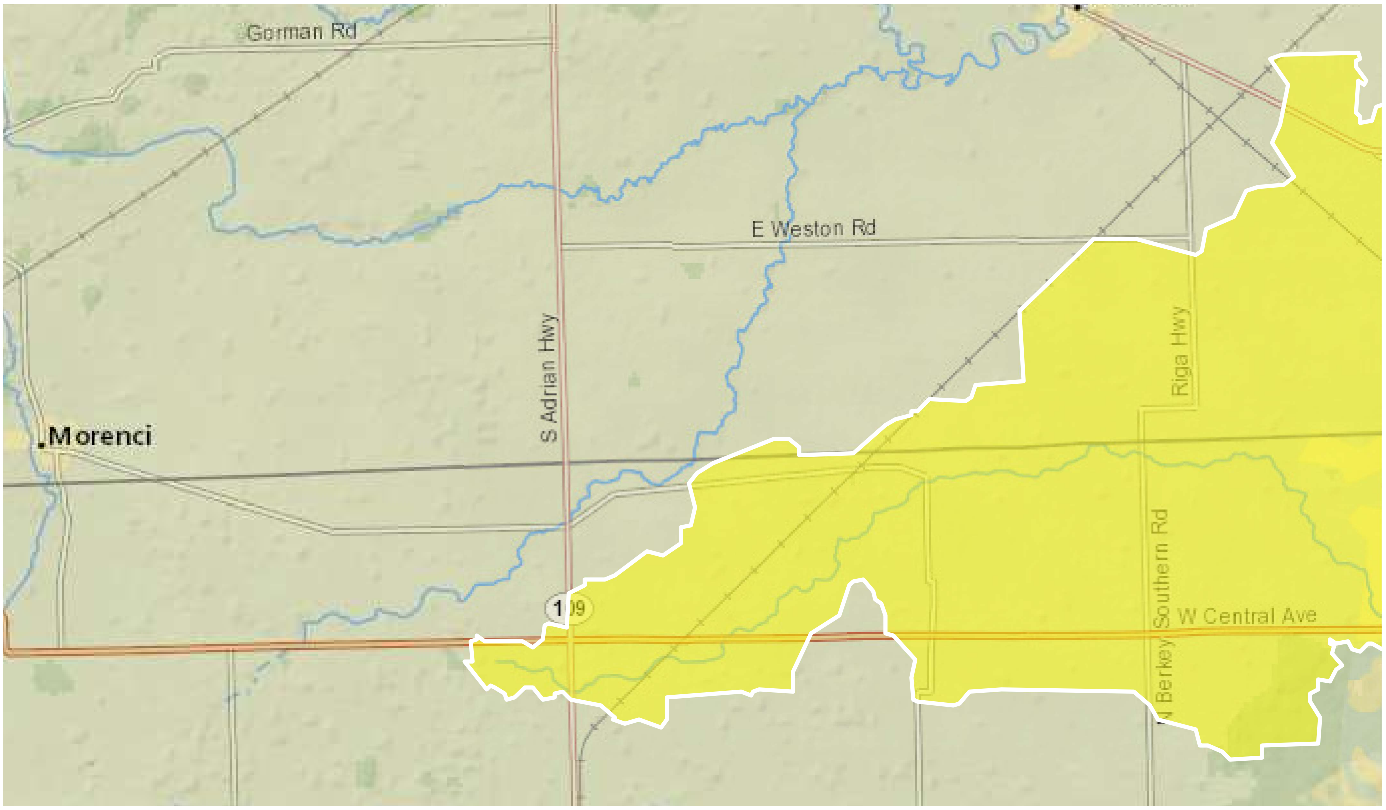
CONCLUSIONS AND RECOMMENDATION

In this report, the proposed development located in Lucas County, City of Sylvania on US-23 Over Ottawa River was evaluated hydraulicly to determine the impact it would have on the surrounding facilities. The results of the hydraulic analysis showed that there will be a slight increase in the HW elevations for 4% AEP design storm for ramps upstream of the proposed improvement. However, the impact this increase would have on the upstream areas is considered minimal and no property or business were impacted by this rise. Since the proposed work is within FEMA regulated zone, 1% AEP was also evaluated. The results showed no increase in the HW elevation of 1% AEP on all river stations upstream the development as well as on the downstream side. With a slight channel bed improvement around the proposed bridge areas and on the upstream side, this 4% AEP HW rise could be mitigated if necessary.

Appendix 1: StreamStats Report Ottawa River Under US 23

StreamStats Report LUC-23-11.75

Region ID: OH
Workspace ID: OH20210707103210363000
Clicked Point (Latitude, Longitude): 41.71172, -83.68721
Time: 2021-07-07 06:32:27 -0400



80,000 Ac.

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	125	square miles
OHREGC	Ohio Region C Indicator	0	dimensionless
OHREGA	Ohio Region A Indicator	0	dimensionless
CSL1085LFP	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 2D grid	4.36	feet per mi

Parameter Code	Parameter Description	Value	Unit
LC92STOR	Percentage of water bodies and wetlands determined from the NLCD	1.44	percent

Peak-Flow Statistics Parameters [100.0 Percent (125 square miles) Peak Flow Full Model Reg B SIR2019 5018]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	125	square miles	0.04	6309
OHREGC	Ohio Region C Indicator 1 if in C else 0	0	dimensionless	0	1
OHREGA	Ohio Region A Indicator 1 if in A else 0	0	dimensionless	0	1
CSL1085LFP	Stream Slope 10 and 85 Longest Flow Path	4.36	feet per mi	1.21	457
LC92STOR	Percent Storage from NLCD1992	1.44	percent	0	7.1

Peak-Flow Statistics Flow Report [100.0 Percent (125 square miles) Peak Flow Full Model Reg B SIR2019 5018]

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

Statistic	Value	Unit	PIl	PIu	SEp
50-percent AEP flood	2290	ft^3/s	1210	4350	40.1
20-percent AEP flood	3280	ft^3/s	1810	5960	37.2
10-percent AEP flood	3960	ft^3/s	2170	7230	37.6
4-percent AEP flood	4840	ft^3/s	2630	8900	38.1
2-percent AEP flood	5510	ft^3/s	2960	10200	37.8
1-percent AEP flood	6190	ft^3/s	3300	11600	39.6
0.2-percent AEP flood	7780	ft^3/s	4110	14700	40.3

Peak-Flow Statistics Citations

Koltun, G.F.,2019, Flood-frequency estimates for Ohio streamgages based on data through water year 2015 and techniques for estimating flood-frequency characteristics of rural, unregulated Ohio streams: U.S. Geological Survey Scientific Investigations Report 2019–5018, xx p. (https://dx.doi.org/10.3133/sir20195018)

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Application Version: 4.5.3
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.2

Appendix 2: HEC-RAS 6.30 Output

HEC-RAS River: Ottawa River Reach: Reach

Reach	River Sta	Profile	Plan	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	2307	2-YR	LUC23_EX	2290.00	612.73	619.24		619.36	0.000815	3.50	1203.62	470.83	0.28
Reach	2307	2-YR	LUC23-PR	2290.00	612.73	619.59		619.69	0.000606	3.17	1374.02	517.95	0.24
Reach	2307	5-YR	LUC23_EX	3280.00	612.73	620.71		620.82	0.000531	3.37	2001.47	569.79	0.23
Reach	2307	5-YR	LUC23-PR	3280.00	612.73	621.15		621.23	0.000389	3.01	2217.55	556.66	0.20
Reach	2307	10-YR	LUC23_EX	3960.00	612.73	621.65		621.74	0.000405	3.22	2549.44	594.54	0.21
Reach	2307	10-YR	LUC23-PR	3960.00	612.73	622.10		622.17	0.000312	2.94	2754.04	576.25	0.19
Reach	2307	25-YR	LUC23_EX	4840.00	612.73	622.87		622.94	0.000300	3.07	3289.09	623.13	0.18
Reach	2307	25-YR	LUC23-PR	4840.00	612.73	623.27		623.33	0.000249	2.89	3444.71	601.43	0.17
Reach	2307	50-YR	LUC23_EX	5510.00	612.73	623.62		623.69	0.000266	3.06	3767.18	640.54	0.18
Reach	2307	50-YR	LUC23-PR	5510.00	612.73	624.04		624.10	0.000226	2.90	3915.99	620.65	0.16
Reach	2307	100-YR	LUC23_EX	6190.00	612.73	624.67		624.73	0.000213	2.93	4449.37	675.46	0.16
Reach	2307	100-YR	LUC23-PR	6190.00	612.73	624.81		624.87	0.000207	2.92	4402.30	647.00	0.16
Reach	2307	500-YR	LUC23_EX	7780.00	612.73	626.59		626.65	0.000159	2.84	5792.18	720.86	0.14
Reach	2307	500-YR	LUC23-PR	7780.00	612.73	626.37		626.44	0.000180	2.99	5443.72	685.05	0.15
Reach	2110	2-YR	LUC23_EX	2290.00	611.99	619.08		619.22	0.000662	3.72	1312.67	517.66	0.26
Reach	2110	2-YR	LUC23-PR	2290.00	612.06	619.46		619.58	0.000515	3.41	1368.71	428.82	0.23
Reach	2110	5-YR	LUC23_EX	3280.00	611.99	620.63		620.72	0.000420	3.41	2128.75	538.97	0.21
Reach	2110	5-YR	LUC23-PR	3280.00	612.06	621.06		621.15	0.000367	3.31	2071.32	449.82	0.20
Reach	2110	10-YR	LUC23_EX	3960.00	611.99	621.58		621.67	0.000338	3.30	2649.36	547.03	0.19
Reach	2110	10-YR	LUC23-PR	3960.00	612.06	622.02		622.11	0.000316	3.30	2505.56	456.62	0.19
Reach	2110	25-YR	LUC23_EX	4840.00	611.99	622.81		622.89	0.000265	3.18	3327.34	556.50	0.17
Reach	2110	25-YR	LUC23-PR	4840.00	612.06	623.20		623.28	0.000270	3.30	3050.72	465.73	0.18
Reach	2110	50-YR	LUC23_EX	5510.00	611.99	623.57		623.65	0.000242	3.19	3753.43	562.79	0.17
Reach	2110	50-YR	LUC23-PR	5510.00	612.06	623.97		624.06	0.000253	3.35	3413.44	471.71	0.17
Reach	2110	100-YR	LUC23_EX	6190.00	611.99	624.63		624.69	0.000199	3.07	4349.57	571.49	0.16
Reach	2110	100-YR	LUC23-PR	6190.00	612.06	624.74		624.83	0.000238	3.39	3779.20	477.64	0.17
Reach	2110	500-YR	LUC23_EX	7780.00	611.99	626.56		626.62	0.000159	3.03	5467.13	585.05	0.14
Reach	2110	500-YR	LUC23-PR	7780.00	612.06	626.31		626.40	0.000220	3.53	4535.05	487.97	0.17
Reach	1893	2-YR	LUC23_EX	2290.00	611.31	618.80	615.85	619.04	0.000920	4.45	846.56	426.31	0.30
Reach	1893	2-YR	LUC23-PR	2290.00	611.30	619.26	615.84	619.44	0.000684	3.93	960.85	263.06	0.26
Reach	1893	5-YR	LUC23_EX	3280.00	611.31	620.36	617.01	620.59	0.000726	4.55	1238.91	439.71	0.28
Reach	1893	5-YR	LUC23-PR	3280.00	611.30	620.87	617.05	621.05	0.000557	4.08	1367.54	275.00	0.25
Reach	1893	10-YR	LUC23_EX	3960.00	611.31	621.33	617.63	621.56	0.000649	4.64	1487.06	447.61	0.27
Reach	1893	10-YR	LUC23-PR	3960.00	611.30	621.82	617.62	622.01	0.000514	4.21	1616.38	282.69	0.24
Reach	1893	25-YR	LUC23_EX	4840.00	611.31	622.57	618.14	622.79	0.000561	4.69	1813.24	457.53	0.26
Reach	1893	25-YR	LUC23-PR	4840.00	611.30	623.02	618.12	623.20	0.000442	4.23	2047.24	302.97	0.23
Reach	1893	50-YR	LUC23_EX	5510.00	611.31	623.51	618.46	623.59	0.000250	3.32	3408.17	465.21	0.17
Reach	1893	50-YR	LUC23-PR	5510.00	611.30	623.79	618.44	623.98	0.000427	4.35	2285.90	316.18	0.23
Reach	1893	100-YR	LUC23_EX	6190.00	611.31	624.57	618.79	624.64	0.000212	3.25	3904.94	473.82	0.16
Reach	1893	100-YR	LUC23-PR	6190.00	611.30	624.56	618.75	624.75	0.000410	4.46	2534.23	329.94	0.23
Reach	1893	500-YR	LUC23_EX	7780.00	611.31	626.50	619.46	626.58	0.000180	3.29	4851.44	499.47	0.15
Reach	1893	500-YR	LUC23-PR	7780.00	611.30	626.12	619.40	626.32	0.000398	4.76	3077.80	368.57	0.23
Reach	1831	2-YR	LUC23_EX	2290.00	611.54	618.61	615.74	618.95	0.001196	4.92	636.16	410.44	0.35
Reach	1831	2-YR	LUC23-PR	2290.00	611.54	619.10	615.75	619.37	0.000884	4.45	719.64	230.45	0.30
Reach	1831	5-YR	LUC23_EX	3280.00	611.54	620.14	616.87	620.50	0.001021	5.26	902.62	425.54	0.33
Reach	1831	5-YR	LUC23-PR	3280.00	611.54	620.68	616.87	620.97	0.000783	4.82	999.28	264.31	0.29
Reach	1831	10-YR	LUC23_EX	3960.00	611.54	621.10	617.48	621.46	0.000937	5.44	1075.73	435.12	0.32
Reach	1831	10-YR	LUC23-PR	3960.00	611.54	621.63	617.49	621.93	0.000737	5.02	1173.19	283.15	0.29
Reach	1831	25-YR	LUC23_EX	4840.00	611.54	622.33	618.10	622.70	0.000818	5.55	1303.62	445.94	0.31
Reach	1831	25-YR	LUC23-PR	4840.00	611.54	622.92	618.09	623.15	0.000527	4.63	1820.51	305.60	0.25
Reach	1831	50-YR	LUC23_EX	5510.00	611.54	623.49	618.48	623.57	0.000240	3.23	3367.96	454.96	0.17
Reach	1831	50-YR	LUC23-PR	5510.00	611.54	623.70	618.49	623.93	0.000502	4.74	2052.93	319.13	0.25
Reach	1831	100-YR	LUC23_EX	6190.00	611.54	624.55	618.86	624.63	0.000204	3.17	3838.48	463.23	0.16
Reach	1831	100-YR	LUC23-PR	6190.00	611.54	624.47	618.85	624.70	0.000476	4.82	2292.42	331.92	0.24
Reach	1831	500-YR	LUC23_EX	7780.00	611.54	626.49	619.62	626.57	0.000178	3.27	4796.58	493.46	0.15
Reach	1831	500-YR	LUC23-PR	7780.00	611.54	626.02	619.63	626.29	0.000461	5.14	2866.71	367.35	0.25
Reach	1802			Bridge									
Reach	1770	2-YR	LUC23_EX	2290.00	611.23	618.48	615.62	618.86	0.001288	5.19	591.82	296.88	0.36
Reach	1770	2-YR	LUC23-PR	2290.00	611.23	619.00	615.61	619.30	0.000947	4.68	671.58	247.13	0.31
Reach	1770	5-YR	LUC23_EX	3280.00	611.23	619.99	616.73	620.41	0.001146	5.63	828.83	355.97	0.35
Reach	1770	5-YR	LUC23-PR	3280.00	611.23	620.56	616.75	620.90	0.000874	5.15	921.86	273.46	0.31
Reach	1770	10-YR	LUC23_EX	3960.00	611.23	620.94	617.37	621.38	0.001074	5.87	984.62	377.59	0.35
Reach	1770	10-YR	LUC23-PR	3960.00	611.23	621.50	617.40	621.87	0.000844	5.42	1080.66	289.81	0.31
Reach	1770	25-YR	LUC23_EX	4840.00	611.23	622.18	618.03	622.63	0.000957	6.05	1199.83	393.53	0.33
Reach	1770	25-YR	LUC23-PR	4840.00	611.23	622.89	618.05	623.06	0.000421	4.20	2164.17	330.96	0.22
Reach	1770	50-YR	LUC23_EX	5510.00	611.23	623.37	618.46	623.53	0.000398	4.20	2665.00	422.24	0.22
Reach	1770	50-YR	LUC23-PR	5510.00	611.23	623.69	618.47	623.86	0.000403	4.31	2425.26	344.74	0.22
Reach	1770	100-YR	LUC23_EX	6190.00	611.23	624.39	618.85	624.54	0.000333	4.07	3087.91	433.80	0.20
Reach	1770	100-YR	LUC23-PR	6190.00	611.23	624.45	618.85	624.63	0.000389	4.41	2680.84	357.11	0.22
Reach	1770	500-YR	LUC23_EX	7780.00	611.23	626.40	619.67	626.53	0.000271	4.06	3999.84	463.38	0.19
Reach	1770	500-YR	LUC23-PR	7780.00	611.23	626.01	619.69	626.21	0.000379	4.71	3278.55	379.81	0.22
Reach	1722	2-YR	LUC23_EX	2290.00	611.09	618.35	616.07	618.77	0.001569	5.67	659.71	327.05	0.39
Reach	1722	2-YR	LUC23-PR	2290.00	611.09	618.82	616.05	619.21	0.001307	5.42	611.88	258.26	0.36
Reach	1722	5-YR	LUC23_EX	3280.00	611.09	619.97	617.26	620.31	0.001102	5.52	1075.06	362.50	0.34
Reach	1722	5-YR	LUC23-PR	3280.00	611.09	620.41	617.19	620.82	0.001131	5.79	873.30	280.44	0.35
Reach	1722	10-YR	LUC23_EX	3960.00	611.09	620.94	618.06	621.26	0.000934	5.48	1334.95	372.75	0.32
Reach	1722	10-YR	LUC23-PR	3960.00	611.09	621.36	617.84	621.79	0.001059	6.02	1035.67	292.63	0.35
Reach	1722	25-YR	LUC23_EX	4840.00	611.09	622.21	618.56	622.50	0.000771	5.44	1692.34	399.47	0.30
Reach	1722	25-YR	LUC23-PR	4840.00	611.09	622.48	618.44	622.94	0.001007	6.32	1245.05	319.61	0.34

HEC-RAS River: Ottawa River Reach: Reach (Continued)

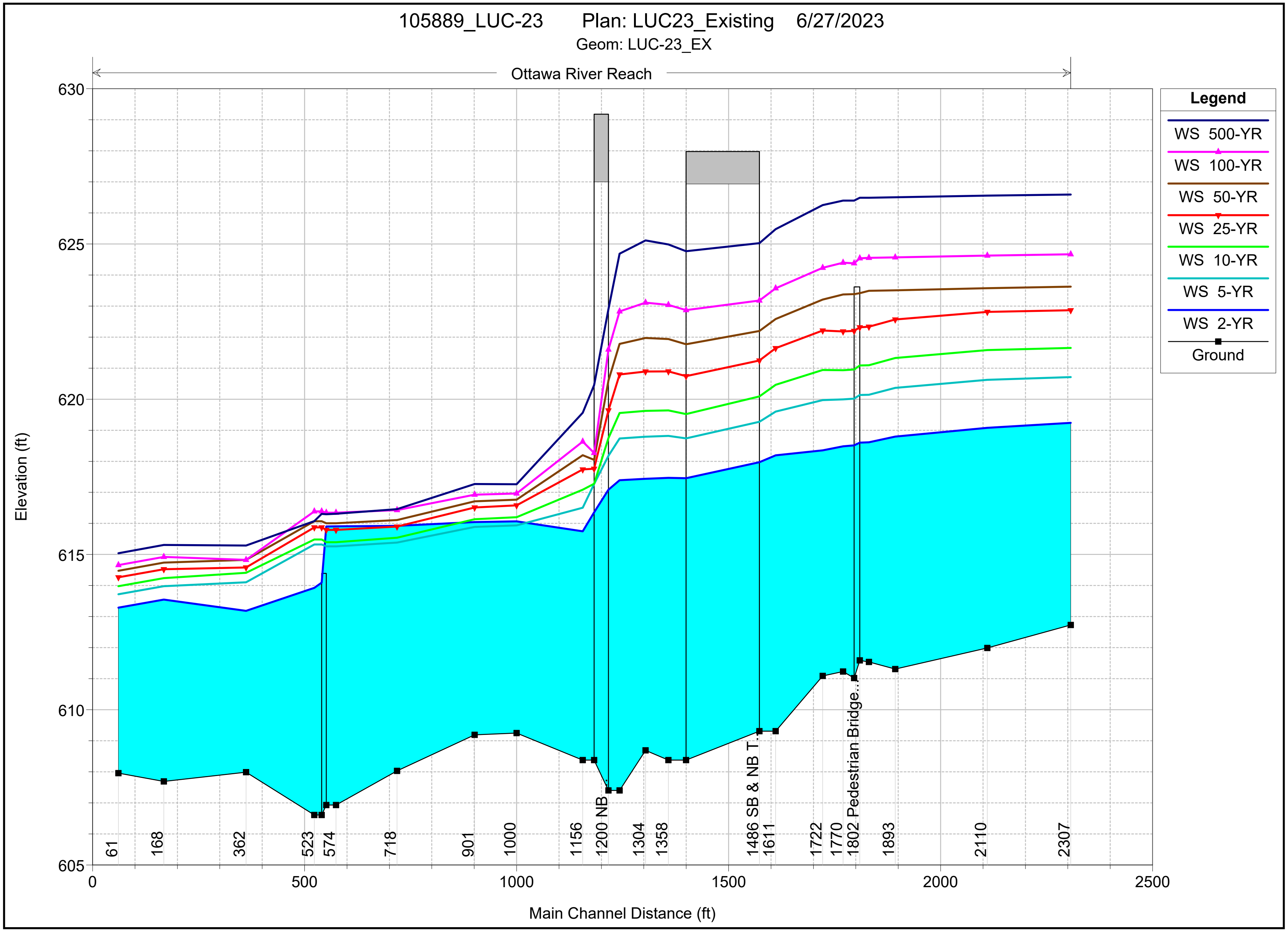
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	1722	50-YR	LUC23_EX	5510.00	611.09	623.21	619.00	623.47	0.000647	5.30	1984.18	406.42	0.28
Reach	1722	50-YR	LUC23-PR	5510.00	611.09	623.26	618.98	623.74	0.000966	6.50	1395.53	327.92	0.34
Reach	1722	100-YR	LUC23_EX	6190.00	611.09	624.23	619.29	624.48	0.000560	5.23	2289.34	422.95	0.26
Reach	1722	100-YR	LUC23-PR	6190.00	611.09	623.99	619.35	624.50	0.000954	6.73	1539.51	341.31	0.34
Reach	1722	500-YR	LUC23_EX	7780.00	611.09	626.25	619.94	626.48	0.000449	5.18	2928.41	470.55	0.24
Reach	1722	500-YR	LUC23-PR	7780.00	611.09	625.50	620.18	626.07	0.000944	7.25	1860.70	368.96	0.35
Reach	1654	2-YR	LUC23-PR	2290.00	609.91	618.83	615.83	619.06	0.000787	4.32	650.69	174.16	0.29
Reach	1654	5-YR	LUC23-PR	3280.00	609.91	620.42	616.74	620.68	0.000700	4.66	863.72	210.20	0.28
Reach	1654	10-YR	LUC23-PR	3960.00	609.91	621.37	617.19	621.66	0.000678	4.91	1006.66	242.50	0.28
Reach	1654	25-YR	LUC23-PR	4840.00	609.91	622.50	617.68	622.81	0.000630	5.10	1180.71	261.83	0.27
Reach	1654	50-YR	LUC23-PR	5510.00	609.91	623.28	618.05	623.61	0.000608	5.25	1301.75	275.20	0.27
Reach	1654	100-YR	LUC23-PR	6190.00	609.91	624.02	618.37	624.36	0.000593	5.40	1416.17	286.39	0.27
Reach	1654	500-YR	LUC23-PR	7780.00	609.91	625.53	619.08	625.93	0.000583	5.79	1651.53	310.86	0.27
Reach	1611	2-YR	LUC23_EX	2290.00	609.31	618.19	614.34	618.62	0.001106	5.51	531.23	385.93	0.34
Reach	1611	5-YR	LUC23_EX	3280.00	609.31	619.60	615.72	620.16	0.001206	6.41	677.61	403.83	0.37
Reach	1611	10-YR	LUC23_EX	3960.00	609.31	620.47	616.34	621.11	0.001252	6.93	767.04	403.98	0.38
Reach	1611	25-YR	LUC23_EX	4840.00	609.31	621.64	617.06	622.35	0.001233	7.39	888.99	404.17	0.39
Reach	1611	50-YR	LUC23_EX	5510.00	609.31	622.58	617.81	623.33	0.001183	7.63	986.38	404.33	0.38
Reach	1611	100-YR	LUC23_EX	6190.00	609.31	623.57	618.39	624.34	0.001116	7.80	1089.03	404.49	0.38
Reach	1611	500-YR	LUC23_EX	7780.00	609.31	625.48	619.42	626.34	0.001070	8.34	1286.51	404.81	0.38
Reach	1599	2-YR	LUC23-PR	2290.00	609.47	618.67	615.01	618.95	0.000776	4.73	624.74	233.54	0.29
Reach	1599	5-YR	LUC23-PR	3280.00	609.47	620.24	615.97	620.56	0.000732	5.16	826.65	260.33	0.29
Reach	1599	10-YR	LUC23-PR	3960.00	609.47	621.18	616.53	621.53	0.000721	5.44	952.12	276.66	0.29
Reach	1599	25-YR	LUC23-PR	4840.00	609.47	622.29	617.16	622.67	0.000696	5.71	1105.06	289.27	0.29
Reach	1599	50-YR	LUC23-PR	5510.00	609.47	623.06	617.35	623.46	0.000686	5.91	1211.47	296.91	0.29
Reach	1599	100-YR	LUC23-PR	6190.00	609.47	623.78	618.40	624.21	0.000681	6.11	1311.92	304.26	0.29
Reach	1599	500-YR	LUC23-PR	7780.00	609.47	625.24	619.27	625.75	0.000709	6.68	1520.53	325.35	0.31
Reach	1550	2-YR	LUC23-PR	2290.00	610.00	618.16	615.11	618.79	0.001919	6.51	381.51	67.94	0.43
Reach	1550	5-YR	LUC23-PR	3280.00	610.00	619.50	616.59	620.34	0.002097	7.64	477.24	74.98	0.46
Reach	1550	10-YR	LUC23-PR	3960.00	610.00	620.29	617.28	621.28	0.002205	8.31	538.70	81.05	0.48
Reach	1550	25-YR	LUC23-PR	4840.00	610.00	621.22	618.04	622.38	0.002293	9.05	617.89	88.37	0.50
Reach	1550	50-YR	LUC23-PR	5510.00	610.00	621.87	618.60	623.14	0.002340	9.53	677.38	93.51	0.51
Reach	1550	100-YR	LUC23-PR	6190.00	610.00	622.50	619.20	623.87	0.002373	9.96	737.25	98.21	0.52
Reach	1550	500-YR	LUC23-PR	7780.00	610.00	623.81	620.42	625.37	0.002404	10.78	869.29	101.80	0.53
Reach	1486			Bridge									
Reach	1390	2-YR	LUC23-PR	2290.00	607.91	617.66	614.39	618.18	0.001708	5.79	409.46	76.75	0.41
Reach	1390	5-YR	LUC23-PR	3280.00	607.91	618.90	615.66	619.60	0.001862	6.82	506.90	81.34	0.44
Reach	1390	10-YR	LUC23-PR	3960.00	607.91	619.64	616.52	620.47	0.001944	7.42	568.73	85.07	0.46
Reach	1390	25-YR	LUC23-PR	4840.00	607.91	620.54	617.27	621.51	0.002003	8.07	647.67	89.77	0.47
Reach	1390	50-YR	LUC23-PR	5510.00	607.91	621.20	617.79	622.27	0.002023	8.49	707.84	93.78	0.48
Reach	1390	100-YR	LUC23-PR	6190.00	607.91	621.84	618.27	622.99	0.002024	8.86	769.16	96.96	0.48
Reach	1390	500-YR	LUC23-PR	7780.00	607.91	623.23	619.30	624.55	0.002011	9.60	906.00	105.89	0.49
Reach	1369	2-YR	LUC23-PR	2290.00	608.28	617.67	614.23	618.11	0.001375	5.42	460.07	105.89	0.37
Reach	1369	5-YR	LUC23-PR	3280.00	608.28	618.94	615.36	619.49	0.001427	6.20	597.24	110.72	0.39
Reach	1369	10-YR	LUC23-PR	3960.00	608.28	619.71	616.14	620.33	0.001442	6.63	683.75	113.90	0.40
Reach	1369	25-YR	LUC23-PR	4840.00	608.28	620.64	617.14	621.34	0.001436	7.09	792.19	137.97	0.40
Reach	1369	50-YR	LUC23-PR	5510.00	608.28	621.32	617.77	622.07	0.001419	7.38	873.32	159.74	0.41
Reach	1369	100-YR	LUC23-PR	6190.00	608.28	621.99	618.23	622.78	0.001401	7.64	953.90	182.79	0.41
Reach	1369	500-YR	LUC23-PR	7780.00	608.28	623.41	619.18	624.30	0.001361	8.17	1132.82	229.83	0.41
Reach	1358	2-YR	LUC23_EX	2290.00	608.38	617.47	614.77	617.98	0.001824	5.83	424.81	111.37	0.42
Reach	1358	5-YR	LUC23_EX	3280.00	608.38	618.82	615.88	619.42	0.001700	6.45	564.72	141.05	0.42
Reach	1358	10-YR	LUC23_EX	3960.00	608.38	619.64	616.73	620.30	0.001637	6.80	650.04	170.11	0.42
Reach	1358	25-YR	LUC23_EX	4840.00	608.38	620.90	617.48	621.57	0.001405	6.93	780.07	243.11	0.40
Reach	1358	50-YR	LUC23_EX	5510.00	608.38	621.94	617.98	622.60	0.001217	6.92	887.97	297.02	0.38
Reach	1358	100-YR	LUC23_EX	6190.00	608.38	623.04	618.40	623.69	0.001050	6.88	1001.95	337.84	0.36
Reach	1358	500-YR	LUC23_EX	7780.00	608.38	624.98	619.28	625.68	0.000923	7.16	1203.84	360.98	0.34
Reach	1319	2-YR	LUC23-PR	2290.00	608.65	617.58	614.17	617.96	0.001200	5.05	490.81	114.42	0.35
Reach	1319	5-YR	LUC23-PR	3280.00	608.65	618.85	615.20	619.34	0.001235	5.77	641.67	120.47	0.36
Reach	1319	10-YR	LUC23-PR	3960.00	608.65	619.64	615.83	620.18	0.001231	6.14	736.96	121.44	0.37
Reach	1319	25-YR	LUC23-PR	4840.00	608.65	620.59	616.60	621.19	0.001216	6.55	853.02	122.67	0.37
Reach	1319	50-YR	LUC23-PR	5510.00	608.65	621.27	617.34	621.91	0.001206	6.82	936.28	138.23	0.38
Reach	1319	100-YR	LUC23-PR	6190.00	608.65	621.93	617.84	622.61	0.001193	7.07	1017.91	159.14	0.38
Reach	1319	500-YR	LUC23-PR	7780.00	608.65	623.34	618.83	624.11	0.001171	7.60	1194.55	178.57	0.38
Reach	1304	2-YR	LUC23_EX	2290.00	608.69	617.44	614.13	617.84	0.001303	5.17	475.85	115.52	0.36
Reach	1304	5-YR	LUC23_EX	3280.00	608.69	618.79	615.17	619.28	0.001270	5.80	640.72	127.46	0.37
Reach	1304	10-YR	LUC23_EX	3960.00	608.69	619.62	615.80	620.16	0.001244	6.15	750.12	139.20	0.37
Reach	1304	25-YR	LUC23_EX	4840.00	608.69	620.89	616.62	621.44	0.001086	6.30	959.56	199.56	0.35
Reach	1304	50-YR	LUC23_EX	5510.00	608.69	621.97	617.34	622.45	0.000873	6.05	1176.11	249.23	0.32
Reach	1304	100-YR	LUC23_EX	6190.00	608.69	623.11	617.86	623.52	0.000682	5.71	1411.17	262.44	0.29
Reach	1304	500-YR	LUC23_EX	7780.00	608.69	625.11	618.81	625.48	0.000520	5.53	1824.73	282.81	0.26
Reach	1284	2-YR	LUC23-PR	2290.00	608.81	617.61	614.42	617.85	0.000877	4.29	680.11	242.88	0.30
Reach	1284	5-YR	LUC23-PR	3280.00	608.81	618.93	615.37	619.18	0.000790	4.60	967.07	302.84	0.29
Reach	1284	10-YR	LUC23-PR	3960.00	608.81	619.75	615.93	620.00	0.000717	4.68	1171.13	327.30	0.28
Reach	1284	25-YR	LUC23-PR	4840.00	608.81	620.73	616.58	620.98	0.000622	4.69	1432.23	349.75	0.27

HEC-RAS River: Ottawa River Reach: Reach (Continued)

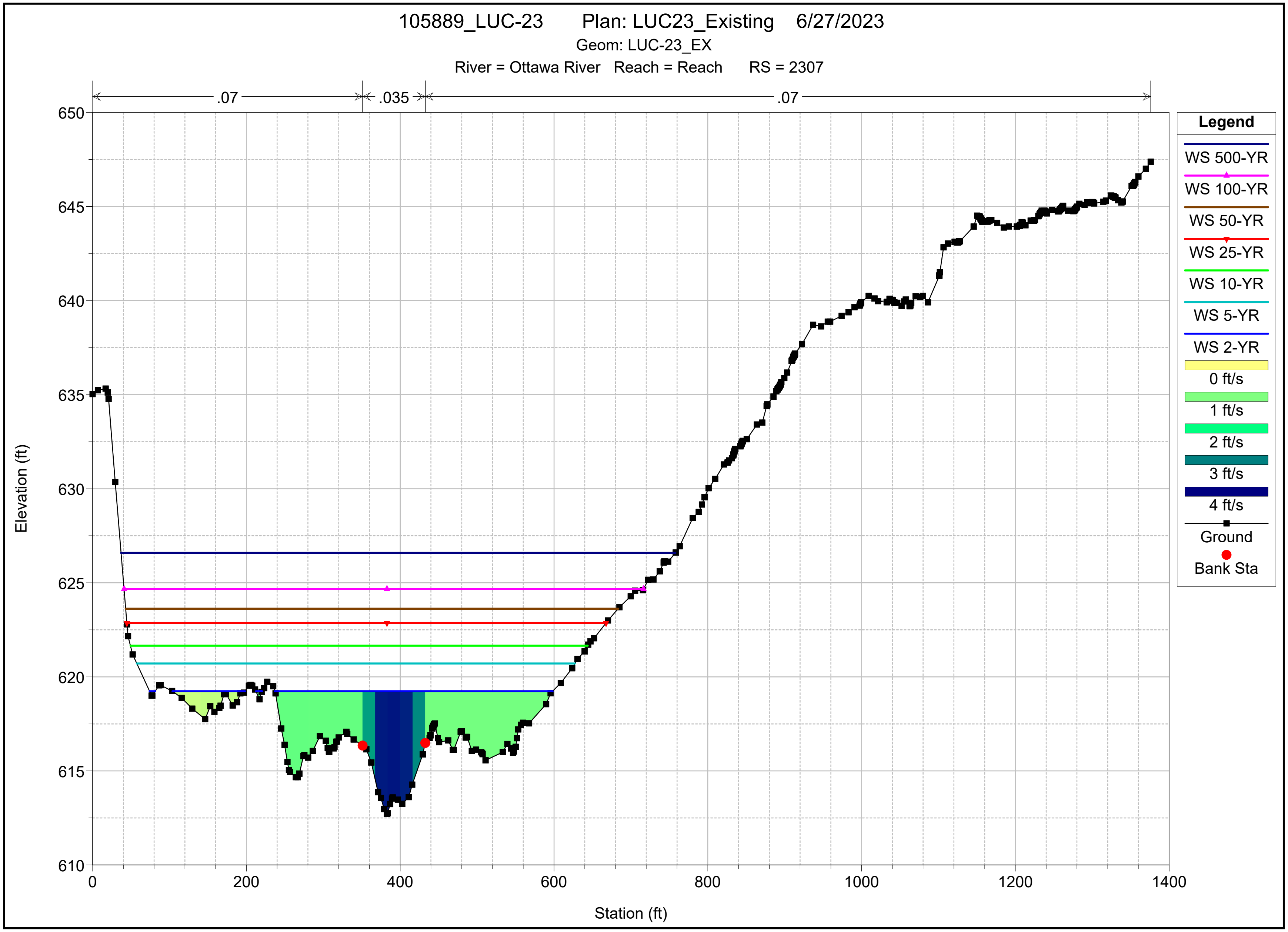
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	1284	50-YR	LUC23-PR	5510.00	608.81	621.44	617.10	621.68	0.000567	4.69	1627.10	367.27	0.26
Reach	1284	100-YR	LUC23-PR	6190.00	608.81	622.12	617.41	622.35	0.000519	4.69	1820.26	386.33	0.25
Reach	1284	500-YR	LUC23-PR	7780.00	608.81	623.58	618.26	623.81	0.000447	4.72	2239.98	394.49	0.24
Reach	1243	2-YR	LUC23_EX	2290.00	607.40	617.39	613.47	617.74	0.001065	4.80	497.95	117.61	0.33
Reach	1243	5-YR	LUC23_EX	3280.00	607.40	618.73	614.57	619.20	0.001121	5.56	632.77	198.58	0.35
Reach	1243	10-YR	LUC23_EX	3960.00	607.40	619.55	615.23	620.08	0.001137	5.98	716.46	222.15	0.35
Reach	1243	25-YR	LUC23_EX	4840.00	607.40	620.80	616.05	621.36	0.001040	6.24	843.11	245.06	0.35
Reach	1243	50-YR	LUC23_EX	5510.00	607.40	621.78	616.67	622.36	0.000954	6.36	943.33	263.81	0.34
Reach	1243	100-YR	LUC23_EX	6190.00	607.40	622.83	617.14	623.42	0.000861	6.42	1050.04	282.76	0.33
Reach	1243	500-YR	LUC23_EX	7780.00	607.40	624.69	618.29	625.35	0.000804	6.82	1239.71	326.76	0.32
Reach	1242	2-YR	LUC23-PR	2290.00	607.44	617.45		617.80	0.001045	4.77	501.33	95.26	0.32
Reach	1242	5-YR	LUC23-PR	3280.00	607.44	618.68		619.12	0.001106	5.49	701.64	194.08	0.34
Reach	1242	10-YR	LUC23-PR	3960.00	607.44	619.48		619.94	0.001054	5.72	866.86	219.38	0.34
Reach	1242	25-YR	LUC23-PR	4840.00	607.44	620.47		620.92	0.000956	5.85	1092.62	237.64	0.33
Reach	1242	50-YR	LUC23-PR	5510.00	607.44	621.19		621.62	0.000878	5.87	1267.99	252.16	0.32
Reach	1242	100-YR	LUC23-PR	6190.00	607.44	621.88		622.30	0.000803	5.87	1447.96	262.24	0.31
Reach	1242	500-YR	LUC23-PR	7780.00	607.44	623.37		623.77	0.000681	5.87	1852.53	280.62	0.29
Reach	1200			Bridge									
Reach	1199	2-YR	LUC23-PR	2290.00	608.56	615.99	615.95	617.57	0.011768	10.11	229.98	72.61	0.97
Reach	1199	5-YR	LUC23-PR	3280.00	608.56	616.83	616.83	618.85	0.011451	11.48	291.93	74.52	0.99
Reach	1199	10-YR	LUC23-PR	3960.00	608.56	617.39	617.39	619.65	0.011039	12.18	333.44	75.69	0.99
Reach	1199	25-YR	LUC23-PR	4840.00	608.56	618.05	618.05	620.61	0.010657	12.98	384.03	77.09	0.99
Reach	1199	50-YR	LUC23-PR	5510.00	608.56	618.53	618.53	621.30	0.010411	13.52	421.04	78.10	0.99
Reach	1199	100-YR	LUC23-PR	6190.00	608.56	618.96	618.96	621.96	0.010344	14.08	455.31	79.02	0.99
Reach	1199	500-YR	LUC23-PR	7780.00	608.56	620.04	620.04	623.40	0.009700	14.94	543.19	84.09	0.98
Reach	1156	2-YR	LUC23_EX	2290.00	608.38	615.75	615.42	617.16	0.007498	9.64	262.78	101.97	0.81
Reach	1156	2-YR	LUC23-PR	2290.00	608.38	615.79	615.54	617.11	0.006989	9.37	270.19	102.74	0.78
Reach	1156	5-YR	LUC23_EX	3280.00	608.38	616.50	616.50	618.45	0.008553	11.45	337.21	155.46	0.89
Reach	1156	5-YR	LUC23-PR	3280.00	608.38	616.71	616.71	618.23	0.006659	10.37	391.16	173.36	0.79
Reach	1156	10-YR	LUC23_EX	3960.00	608.38	617.08	617.08	619.22	0.008320	12.13	396.36	194.07	0.89
Reach	1156	10-YR	LUC23-PR	3960.00	608.38	617.34	617.34	618.77	0.005807	10.43	510.67	208.17	0.75
Reach	1156	25-YR	LUC23_EX	4840.00	608.38	617.74	617.74	620.13	0.008252	12.98	462.91	233.36	0.91
Reach	1156	25-YR	LUC23-PR	4840.00	608.38	617.89	617.89	619.36	0.005580	10.84	636.65	257.26	0.75
Reach	1156	50-YR	LUC23_EX	5510.00	608.38	618.20	618.20	620.78	0.008222	13.57	509.66	293.19	0.91
Reach	1156	50-YR	LUC23-PR	5510.00	608.38	618.04	618.04	619.75	0.006410	11.80	676.65	274.19	0.80
Reach	1156	100-YR	LUC23_EX	6190.00	608.38	618.63	618.63	621.40	0.008203	14.13	554.41	329.16	0.92
Reach	1156	100-YR	LUC23-PR	6190.00	608.38	618.79	618.79	620.06	0.004524	10.64	912.43	330.58	0.69
Reach	1156	500-YR	LUC23_EX	7780.00	608.38	619.56	619.56	622.77	0.008249	15.35	649.15	402.80	0.94
Reach	1156	500-YR	LUC23-PR	7780.00	608.38	619.20	619.20	620.66	0.005099	11.71	1051.06	365.89	0.74
Reach	1000	2-YR	LUC23_EX	2290.00	609.25	616.07	613.70	616.23	0.000884	3.73	1067.84	471.26	0.29
Reach	1000	2-YR	LUC23-PR	2290.00	609.27	616.07	613.72	616.23	0.000889	3.74	1065.99	471.85	0.29
Reach	1000	5-YR	LUC23_EX	3280.00	609.25	615.94	614.64	616.31	0.002027	5.56	1011.40	429.03	0.43
Reach	1000	5-YR	LUC23-PR	3280.00	609.27	615.94	614.69	616.31	0.002037	5.57	1009.71	429.76	0.44
Reach	1000	10-YR	LUC23_EX	3960.00	609.25	616.20	615.00	616.65	0.002366	6.21	1128.76	508.09	0.47
Reach	1000	10-YR	LUC23-PR	3960.00	609.27	616.20	615.00	616.65	0.002375	6.22	1127.40	508.93	0.47
Reach	1000	25-YR	LUC23_EX	4840.00	609.25	616.58	615.36	617.09	0.002563	6.76	1324.71	617.14	0.50
Reach	1000	25-YR	LUC23-PR	4840.00	609.27	616.58	615.39	617.10	0.002575	6.78	1322.56	618.13	0.50
Reach	1000	50-YR	LUC23_EX	5510.00	609.25	616.76	615.66	617.35	0.002855	7.29	1429.78	664.88	0.53
Reach	1000	50-YR	LUC23-PR	5510.00	609.27	616.76	615.64	617.35	0.002867	7.30	1427.80	665.55	0.53
Reach	1000	100-YR	LUC23_EX	6190.00	609.25	616.96	615.78	617.60	0.003048	7.70	1551.78	703.09	0.55
Reach	1000	100-YR	LUC23-PR	6190.00	609.27	616.96	615.83	617.60	0.003061	7.71	1549.60	703.38	0.55
Reach	1000	500-YR	LUC23_EX	7780.00	609.25	617.26	616.57	618.11	0.003910	9.00	1738.69	718.60	0.63
Reach	1000	500-YR	LUC23-PR	7780.00	609.27	617.26	616.58	618.11	0.003920	9.01	1737.10	718.66	0.63
Reach	901	2-YR	LUC23_EX	2290.00	609.19	616.04		616.15	0.000564	3.20	1550.18	790.65	0.23
Reach	901	2-YR	LUC23-PR	2290.00	609.19	616.04		616.15	0.000567	3.20	1545.91	790.81	0.24
Reach	901	5-YR	LUC23_EX	3280.00	609.19	615.89		616.11	0.001260	4.69	1432.03	714.38	0.35
Reach	901	5-YR	LUC23-PR	3280.00	609.19	615.89		616.11	0.001269	4.70	1427.67	713.28	0.35
Reach	901	10-YR	LUC23_EX	3960.00	609.19	616.14		616.42	0.001535	5.33	1626.33	819.14	0.39
Reach	901	10-YR	LUC23-PR	3960.00	609.19	616.14		616.42	0.001547	5.35	1621.97	818.72	0.39
Reach	901	25-YR	LUC23_EX	4840.00	609.19	616.51		616.84	0.001704	5.85	1938.82	839.38	0.41
Reach	901	25-YR	LUC23-PR	4840.00	609.19	616.51		616.84	0.001715	5.87	1934.57	839.83	0.42
Reach	901	50-YR	LUC23_EX	5510.00	609.19	616.71		617.06	0.001816	6.17	2106.42	846.03	0.43
Reach	901	50-YR	LUC23-PR	5510.00	609.19	616.71		617.06	0.001826	6.18	2102.32	846.38	0.43
Reach	901	100-YR	LUC23_EX	6190.00	609.19	616.93		617.29	0.001883	6.42	2289.30	860.08	0.44
Reach	901	100-YR	LUC23-PR	6190.00	609.19	616.93		617.29	0.001894	6.44	2285.12	860.27	0.44
Reach	901	500-YR	LUC23_EX	7780.00	609.19	617.27		617.71	0.002222	7.22	2590.49	891.78	0.48
Reach	901	500-YR	LUC23-PR	7780.00	609.19	617.27		617.71	0.002230	7.23	2586.61	890.33	0.48
Reach	718	2-YR	LUC23_EX	2290.00	608.03	615.92	613.60	616.04	0.000589	3.46	1318.10	751.77	0.24
Reach	718	2-YR	LUC23-PR	2290.00	608.03	615.92	613.60	616.04	0.000589	3.46	1318.10	751.77	0.24
Reach	718	5-YR	LUC23_EX	3280.00	608.03	615.38	614.59	615.79	0.002115	6.19	944.92	626.05	0.44
Reach	718	5-YR	LUC23-PR	3280.00	608.03	615.38	614.59	615.79	0.002115	6.19	944.92	626.05	0.44
Reach	718	10-YR	LUC23_EX	3960.00	608.03	615.54	615.01	616.03	0.002569	6.94	1047.02	664.78	0.49
Reach	718	10-YR	LUC23-PR	3960.00	608.03	615.54	615.01	616.03	0.002569	6.94	1047.02	664.78	0.49
Reach	718	25-YR	LUC23_EX	4840.00	608.03	615.90	615.41	616.42	0.002721	7.41	1298.30	746.62	0.51
Reach	718	25-YR	LUC23-PR	4840.00	608.03	615.90	615.41	616.42	0.002721	7.41	1298.30	746.62	0.51
Reach	718	50-YR	LUC23_EX	5510.00	608.03	616.11	615.56	616.62	0.002726	7.58	1460.78	788.32	0.51
Reach	718	50-YR	LUC23-PR	5510.00	608.03	616.11	615.56	616.62	0.002726	7.58	1460.78	788.32	0.51

HEC-RAS River: Ottawa River Reach: Reach (Continued)

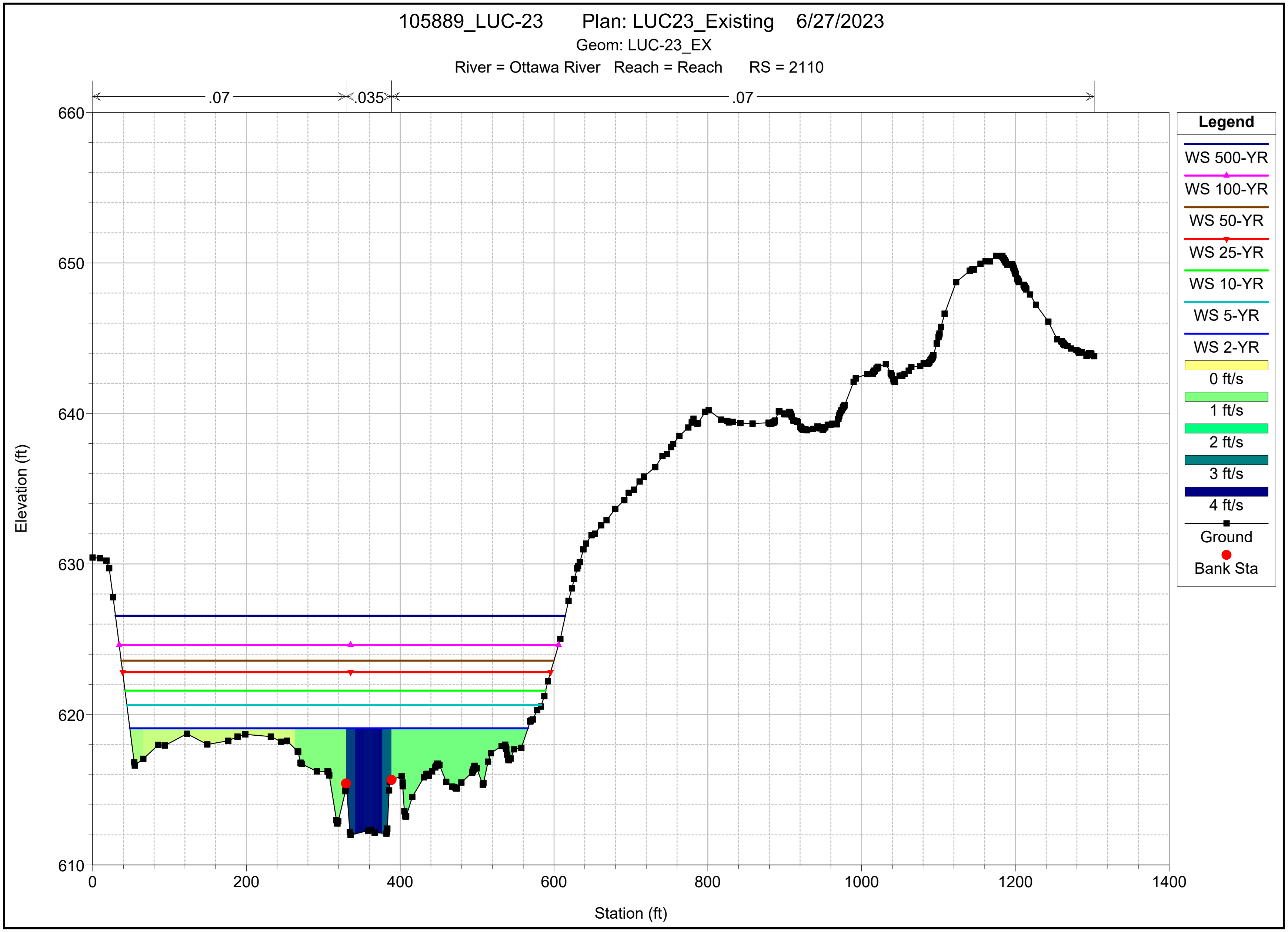
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	718	100-YR	LUC23_EX	6190.00	608.03	616.43	615.56	616.88	0.002388	7.32	1724.65	871.23	0.48
Reach	718	100-YR	LUC23-PR	6190.00	608.03	616.43	615.56	616.88	0.002388	7.32	1724.65	871.23	0.48
Reach	718	500-YR	LUC23_EX	7780.00	608.03	616.46	615.56	617.15	0.003637	9.06	1752.98	876.88	0.60
Reach	718	500-YR	LUC23-PR	7780.00	608.03	616.46	615.56	617.15	0.003637	9.06	1752.98	876.88	0.60
Reach	574	2-YR	LUC23_EX	2290.00	606.93	615.91	612.33	615.96	0.000268	2.54	2154.05	1162.39	0.17
Reach	574	2-YR	LUC23-PR	2290.00	606.93	615.91	612.33	615.96	0.000268	2.54	2154.05	1162.39	0.17
Reach	574	5-YR	LUC23_EX	3280.00	606.93	615.26	613.59	615.51	0.001229	5.10	1444.36	1031.98	0.35
Reach	574	5-YR	LUC23-PR	3280.00	606.93	615.26	613.59	615.51	0.001229	5.10	1444.36	1031.98	0.35
Reach	574	10-YR	LUC23_EX	3960.00	606.93	615.40	614.55	615.69	0.001501	5.71	1583.92	1063.23	0.39
Reach	574	10-YR	LUC23-PR	3960.00	606.93	615.40	614.55	615.69	0.001501	5.71	1583.92	1063.23	0.39
Reach	574	25-YR	LUC23_EX	4840.00	606.93	615.79	614.84	616.06	0.001382	5.70	2022.03	1149.76	0.38
Reach	574	25-YR	LUC23-PR	4840.00	606.93	615.79	614.84	616.06	0.001382	5.70	2022.03	1149.76	0.38
Reach	574	50-YR	LUC23_EX	5510.00	606.93	616.01	615.03	616.27	0.001374	5.79	2270.73	1172.74	0.38
Reach	574	50-YR	LUC23-PR	5510.00	606.93	616.01	615.03	616.27	0.001374	5.79	2270.73	1172.74	0.38
Reach	574	100-YR	LUC23_EX	6190.00	606.93	616.34	615.43	616.56	0.001184	5.54	2673.35	1207.81	0.35
Reach	574	100-YR	LUC23-PR	6190.00	606.93	616.34	615.43	616.56	0.001184	5.54	2673.35	1207.81	0.35
Reach	574	500-YR	LUC23_EX	7780.00	606.93	616.31	615.75	616.67	0.001944	7.08	2630.49	1204.85	0.45
Reach	574	500-YR	LUC23-PR	7780.00	606.93	616.31	615.75	616.67	0.001944	7.08	2630.49	1204.85	0.45
Reach	545			Bridge									
Reach	523	2-YR	LUC23_EX	2290.00	606.61	613.92	612.82	615.42	0.005329	9.84	237.65	580.09	0.72
Reach	523	2-YR	LUC23-PR	2290.00	606.61	613.92	612.82	615.42	0.005329	9.84	237.65	580.09	0.72
Reach	523	5-YR	LUC23_EX	3280.00	606.61	615.32	614.42	615.48	0.000944	4.51	1869.97	1193.26	0.31
Reach	523	5-YR	LUC23-PR	3280.00	606.61	615.32	614.42	615.48	0.000944	4.51	1869.97	1193.26	0.31
Reach	523	10-YR	LUC23_EX	3960.00	606.61	615.48	614.74	615.66	0.001097	4.94	2060.27	1201.42	0.33
Reach	523	10-YR	LUC23-PR	3960.00	606.61	615.48	614.74	615.66	0.001097	4.94	2060.27	1201.42	0.33
Reach	523	25-YR	LUC23_EX	4840.00	606.61	615.87	614.97	616.03	0.000982	4.85	2532.27	1219.92	0.32
Reach	523	25-YR	LUC23-PR	4840.00	606.61	615.87	614.97	616.03	0.000982	4.85	2532.27	1219.92	0.32
Reach	523	50-YR	LUC23_EX	5510.00	606.61	616.07	615.09	616.23	0.001002	4.99	2776.76	1229.33	0.32
Reach	523	50-YR	LUC23-PR	5510.00	606.61	616.07	615.09	616.23	0.001002	4.99	2776.76	1229.33	0.32
Reach	523	100-YR	LUC23_EX	6190.00	606.61	616.39	615.20	616.53	0.000890	4.84	3166.17	1243.75	0.31
Reach	523	100-YR	LUC23-PR	6190.00	606.61	616.39	615.20	616.53	0.000890	4.84	3166.17	1243.75	0.31
Reach	523	500-YR	LUC23_EX	7780.00	606.61	616.08	615.51	616.40	0.001989	7.03	2781.26	1229.50	0.46
Reach	523	500-YR	LUC23-PR	7780.00	606.61	616.08	615.51	616.40	0.001989	7.03	2781.26	1229.50	0.46
Reach	362	2-YR	LUC23_EX	2290.00	607.99	613.19	613.16	614.24	0.006627	8.72	336.86	285.00	0.76
Reach	362	2-YR	LUC23-PR	2290.00	607.99	613.19	613.16	614.24	0.006627	8.72	336.86	285.00	0.76
Reach	362	5-YR	LUC23_EX	3280.00	607.99	614.10	614.10	614.97	0.004836	8.53	629.93	852.56	0.67
Reach	362	5-YR	LUC23-PR	3280.00	607.99	614.10	614.10	614.97	0.004836	8.53	629.93	852.56	0.67
Reach	362	10-YR	LUC23_EX	3960.00	607.99	614.41	614.41	615.17	0.004394	8.46	878.21	1014.15	0.65
Reach	362	10-YR	LUC23-PR	3960.00	607.99	614.41	614.41	615.17	0.004394	8.46	878.21	1014.15	0.65
Reach	362	25-YR	LUC23_EX	4840.00	607.99	614.58	614.58	615.49	0.005272	9.47	996.89	1108.43	0.71
Reach	362	25-YR	LUC23-PR	4840.00	607.99	614.58	614.58	615.49	0.005272	9.47	996.89	1108.43	0.71
Reach	362	50-YR	LUC23_EX	5510.00	607.99	614.82	614.82	615.70	0.005104	9.59	1180.74	1185.53	0.71
Reach	362	50-YR	LUC23-PR	5510.00	607.99	614.82	614.82	615.70	0.005104	9.59	1180.74	1185.53	0.71
Reach	362	100-YR	LUC23_EX	6190.00	607.99	614.82	614.82	615.93	0.006441	10.77	1180.74	1185.53	0.79
Reach	362	100-YR	LUC23-PR	6190.00	607.99	614.82	614.82	615.93	0.006441	10.77	1180.74	1185.53	0.79
Reach	362	500-YR	LUC23_EX	7780.00	607.99	615.29	615.20	615.88	0.004056	9.00	2204.49	1239.78	0.64
Reach	362	500-YR	LUC23-PR	7780.00	607.99	615.29	615.20	615.88	0.004056	9.00	2204.49	1239.78	0.64
Reach	168	2-YR	LUC23_EX	2290.00	607.69	613.55		613.60	0.000799	2.78	1787.28	1178.24	0.26
Reach	168	2-YR	LUC23-PR	2290.00	607.69	613.55		613.60	0.000799	2.78	1787.28	1178.24	0.26
Reach	168	5-YR	LUC23_EX	3280.00	607.69	613.98		614.04	0.000892	3.17	2328.77	1296.32	0.28
Reach	168	5-YR	LUC23-PR	3280.00	607.69	613.98		614.04	0.000892	3.17	2328.77	1296.32	0.28
Reach	168	10-YR	LUC23_EX	3960.00	607.69	614.24		614.30	0.000884	3.29	2670.90	1329.60	0.28
Reach	168	10-YR	LUC23-PR	3960.00	607.69	614.24		614.30	0.000884	3.29	2670.90	1329.60	0.28
Reach	168	25-YR	LUC23_EX	4840.00	607.69	614.53		614.59	0.000888	3.44	3054.62	1343.24	0.28
Reach	168	25-YR	LUC23-PR	4840.00	607.69	614.53		614.59	0.000888	3.44	3054.62	1343.24	0.28
Reach	168	50-YR	LUC23_EX	5510.00	607.69	614.74		614.81	0.000879	3.53	3341.33	1348.06	0.29
Reach	168	50-YR	LUC23-PR	5510.00	607.69	614.74		614.81	0.000879	3.53	3341.33	1348.06	0.29
Reach	168	100-YR	LUC23_EX	6190.00	607.69	614.92		614.99	0.000886	3.63	3585.85	1349.80	0.29
Reach	168	100-YR	LUC23-PR	6190.00	607.69	614.92		614.99	0.000886	3.63	3585.85	1349.80	0.29
Reach	168	500-YR	LUC23_EX	7780.00	607.69	615.31		615.39	0.000906	3.86	4108.92	1355.42	0.29
Reach	168	500-YR	LUC23-PR	7780.00	607.69	615.31		615.39	0.000906	3.86	4108.92	1355.42	0.29
Reach	61	2-YR	LUC23_EX	2290.00	607.96	613.29	612.53	613.45	0.002131	4.71	1187.38	882.40	0.43
Reach	61	2-YR	LUC23-PR	2290.00	607.96	613.29	612.53	613.45	0.002131	4.71	1187.38	882.40	0.43
Reach	61	5-YR	LUC23_EX	3280.00	607.96	613.72	612.86	613.89	0.002133	5.06	1591.44	996.44	0.43
Reach	61	5-YR	LUC23-PR	3280.00	607.96	613.72	612.86	613.89	0.002133	5.06	1591.44	996.44	0.43
Reach	61	10-YR	LUC23_EX	3960.00	607.96	613.98	613.03	614.15	0.002131	5.26	1854.87	1023.33	0.44
Reach	61	10-YR	LUC23-PR	3960.00	607.96	613.98	613.03	614.15	0.002131	5.26	1854.87	1023.33	0.44
Reach	61	25-YR	LUC23_EX	4840.00	607.96	614.27	613.39	614.44	0.002130	5.48	2150.38	1040.27	0.44
Reach	61	25-YR	LUC23-PR	4840.00	607.96	614.27	613.39	614.44	0.002130	5.48	2150.38	1040.27	0.44
Reach	61	50-YR	LUC23_EX	5510.00	607.96	614.48	613.54	614.66	0.002133	5.65	2370.99	1055.51	0.45
Reach	61	50-YR	LUC23-PR	5510.00	607.96	614.48	613.54	614.66	0.002133	5.65	2370.99	1055.51	0.45
Reach	61	100-YR	LUC23_EX	6190.00	607.96	614.66	613.65	614.84	0.002130	5.78	2561.34	1058.83	0.45
Reach	61	100-YR	LUC23-PR	6190.00	607.96	614.66	613.65	614.84	0.002130	5.78	2561.34	1058.83	0.45
Reach	61	500-YR	LUC23_EX	7780.00	607.96	615.04	613.92	615.24	0.002131	6.06	2988.52	1151.60	0.45
Reach	61	500-YR	LUC23-PR	7780.00	607.96	615.04	613.92	615.24	0.002131	6.06	2988.52	1151.60	0.45

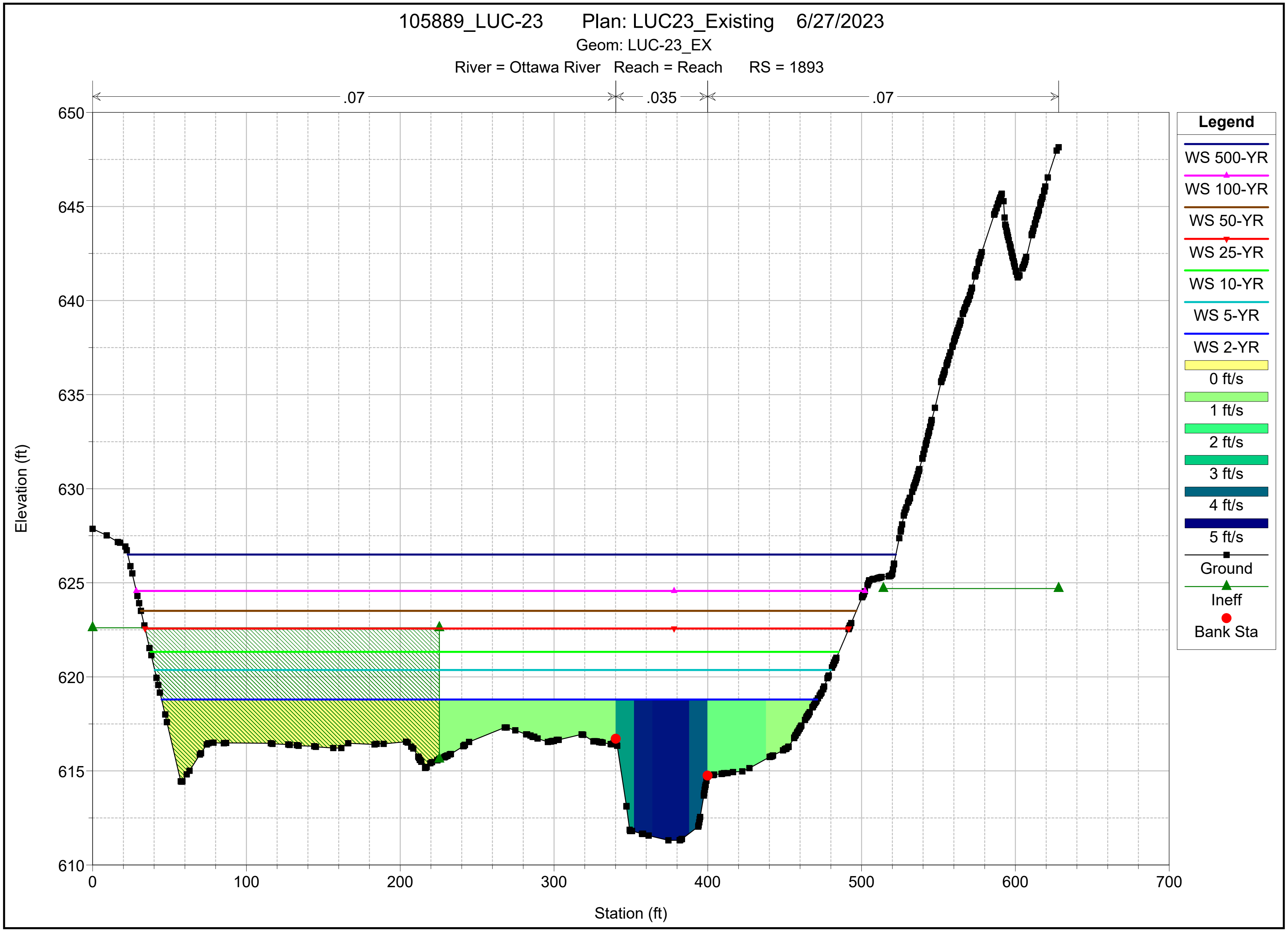


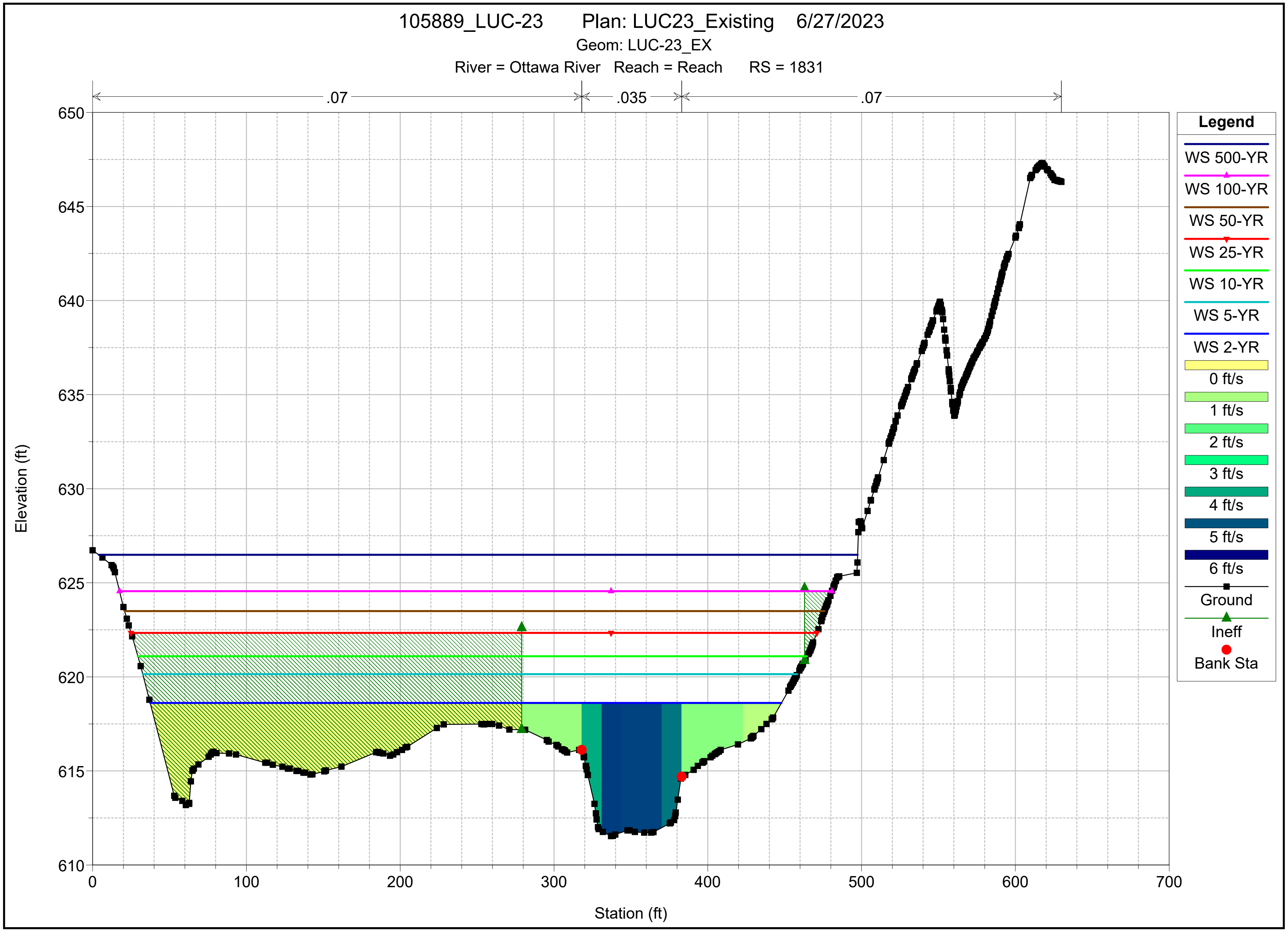
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
Ottawa River Reach
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
Ground
Elevation (ft)
Main Channel Distance (ft)
630
625
620
615
610
605
0
500
1000
1500
2000
2500
61
168
362
523
574
718
901
1000
1156
1200 NB
1304
1358
1486 SB & NB T..
1611
1722
1770
1802 Pedestrian Bridge...
1893
2110
2307

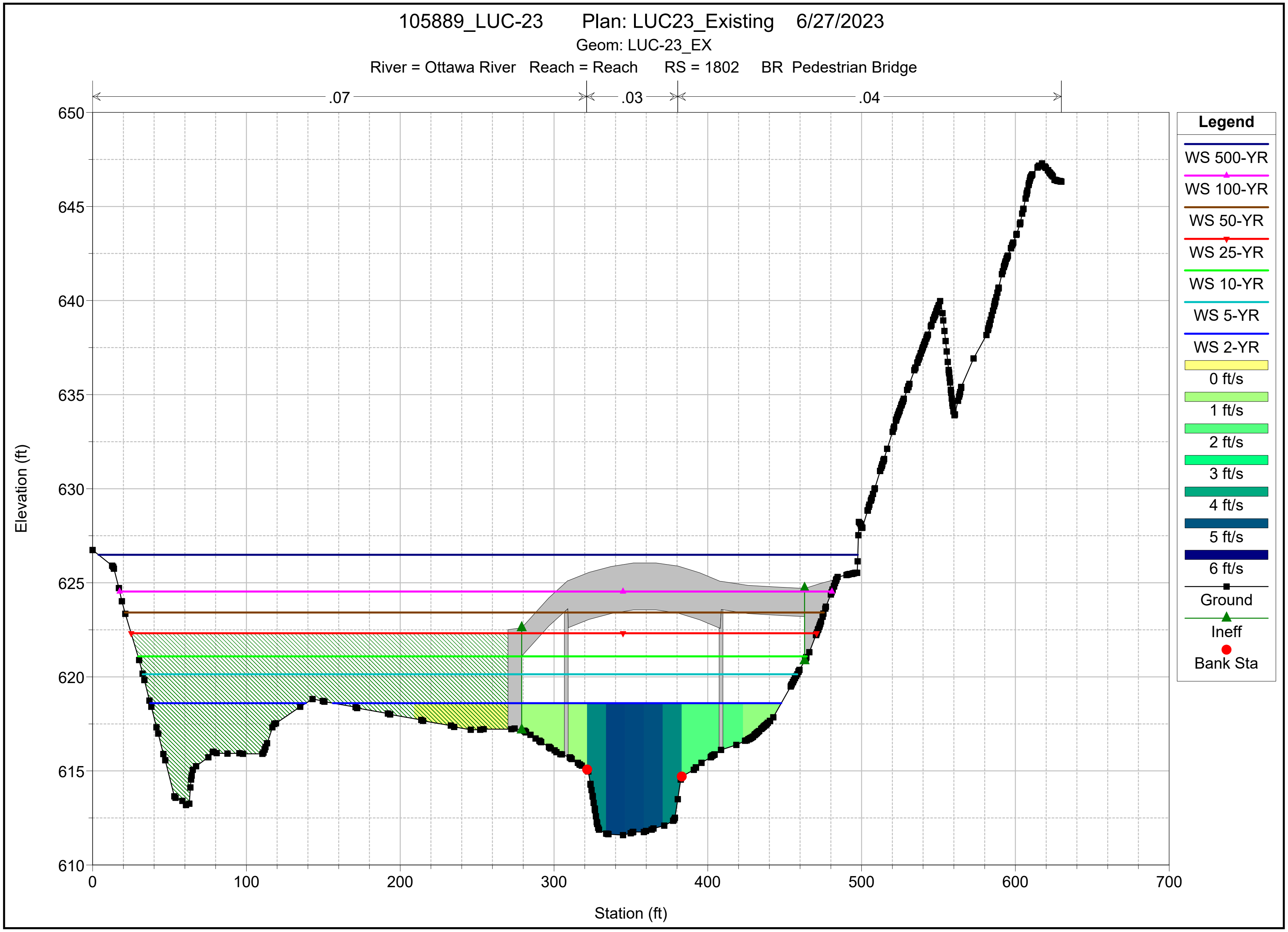


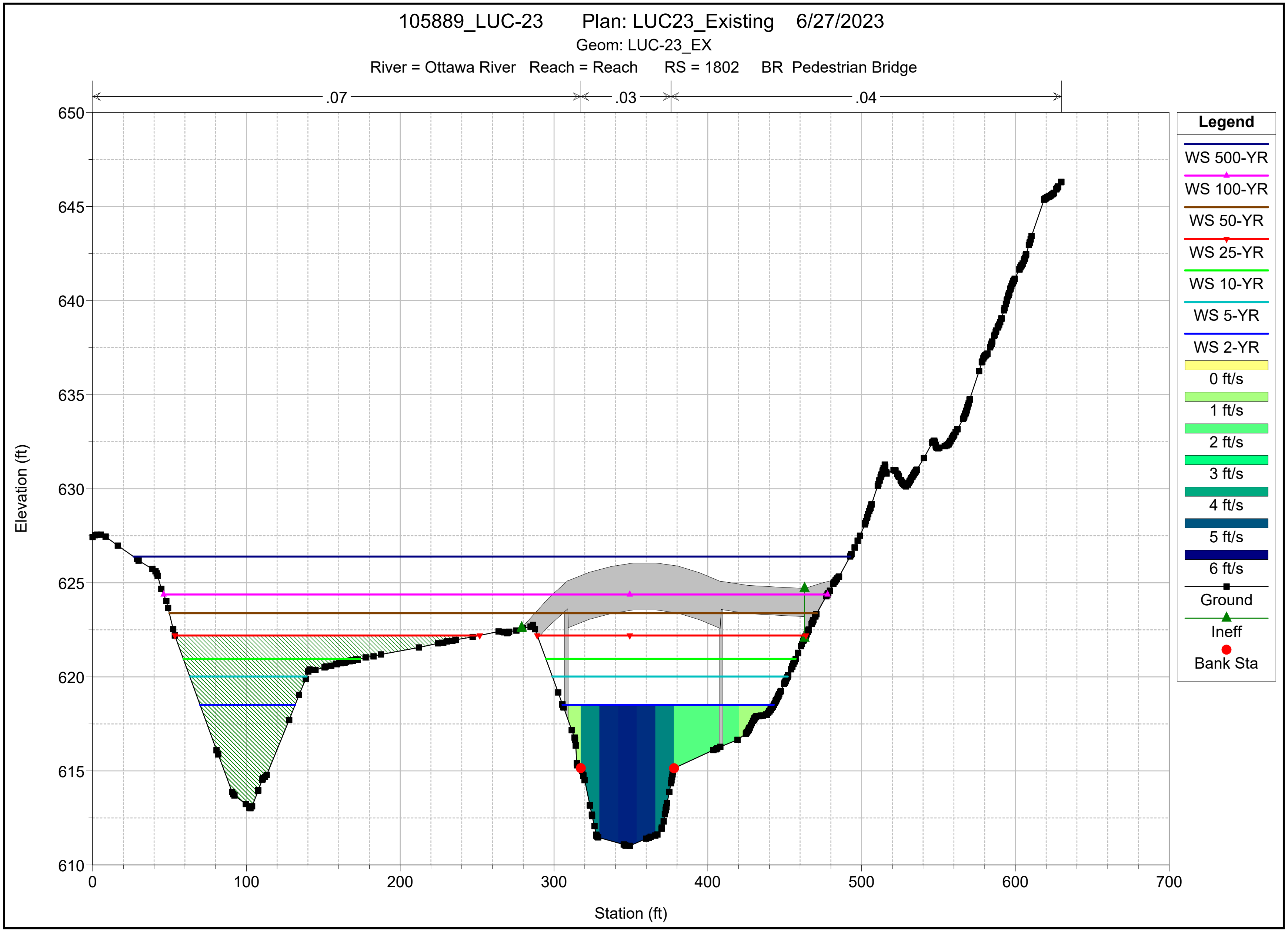
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 2307
.07
.035
.07
Elevation (ft)
Station (ft)
650
645
640
635
630
625
620
615
610
0
200
400
600
800
1000
1200
1400
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Bank Sta

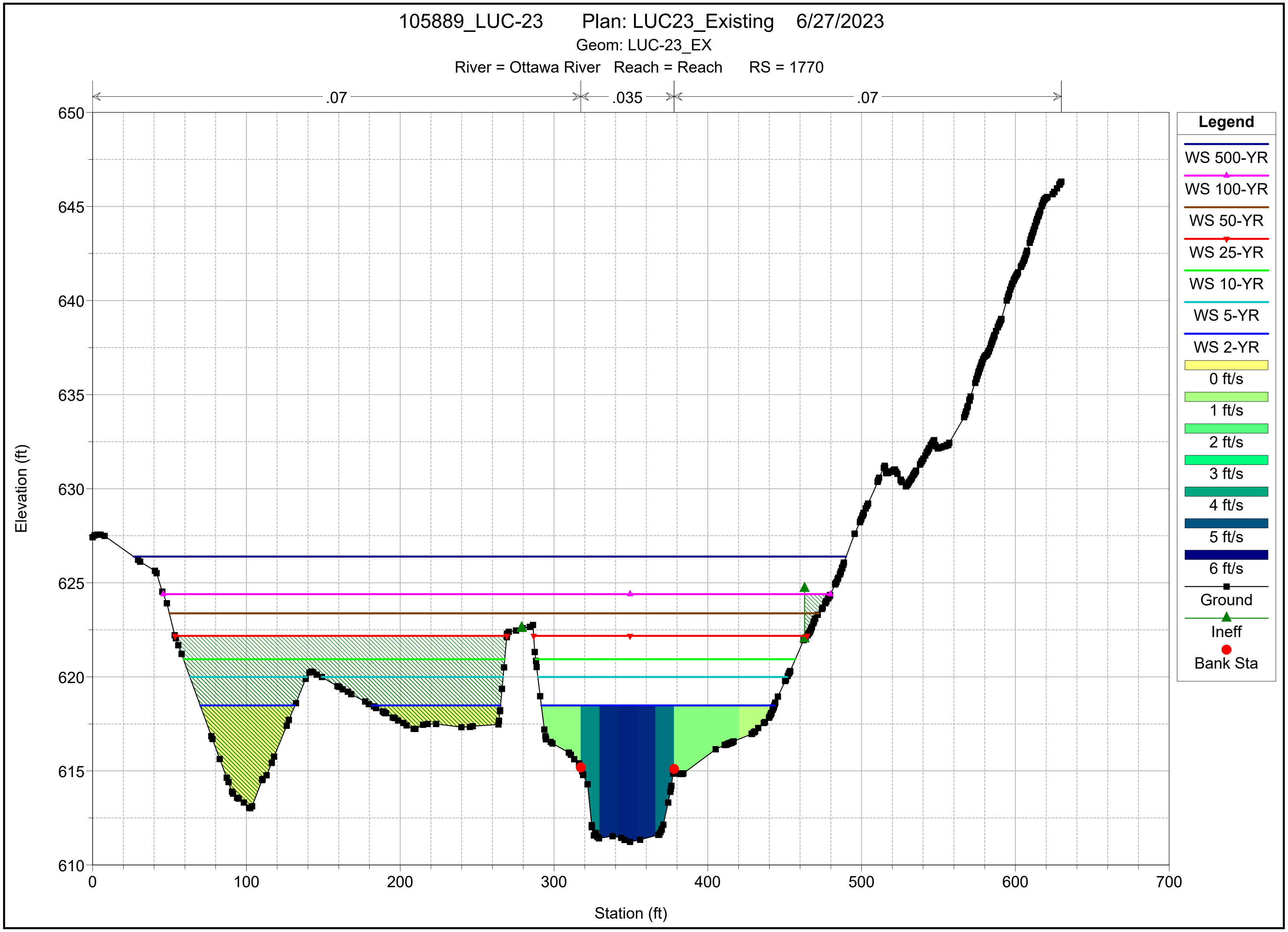

105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 2110
.07
.035
.07
Elevation (ft)
660
650
640
630
620
610
0
200
400
600
800
1000
1200
1400
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Bank Sta


105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1893
.07
.035
.07
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta

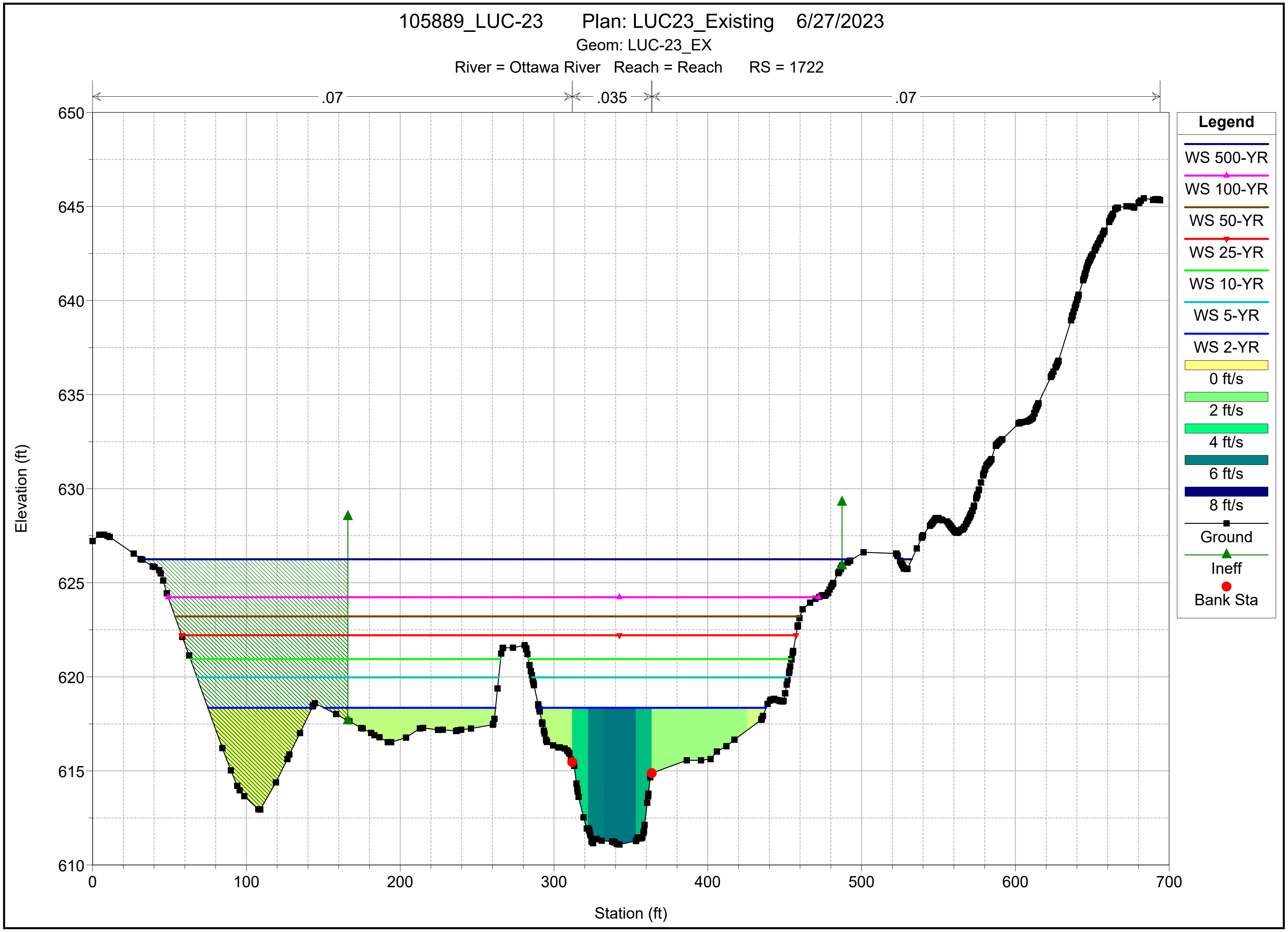

105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1831
.07
.035
.07
Elevation (ft)
Station (ft)
650
645
640
635
630
625
620
615
610
0
100
200
300
400
500
600
700
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta


105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1802 BR Pedestrian Bridge
.07
.03
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
650
645
640
635
630
625
620
615
610
0
100
200
300
400
500
600
700

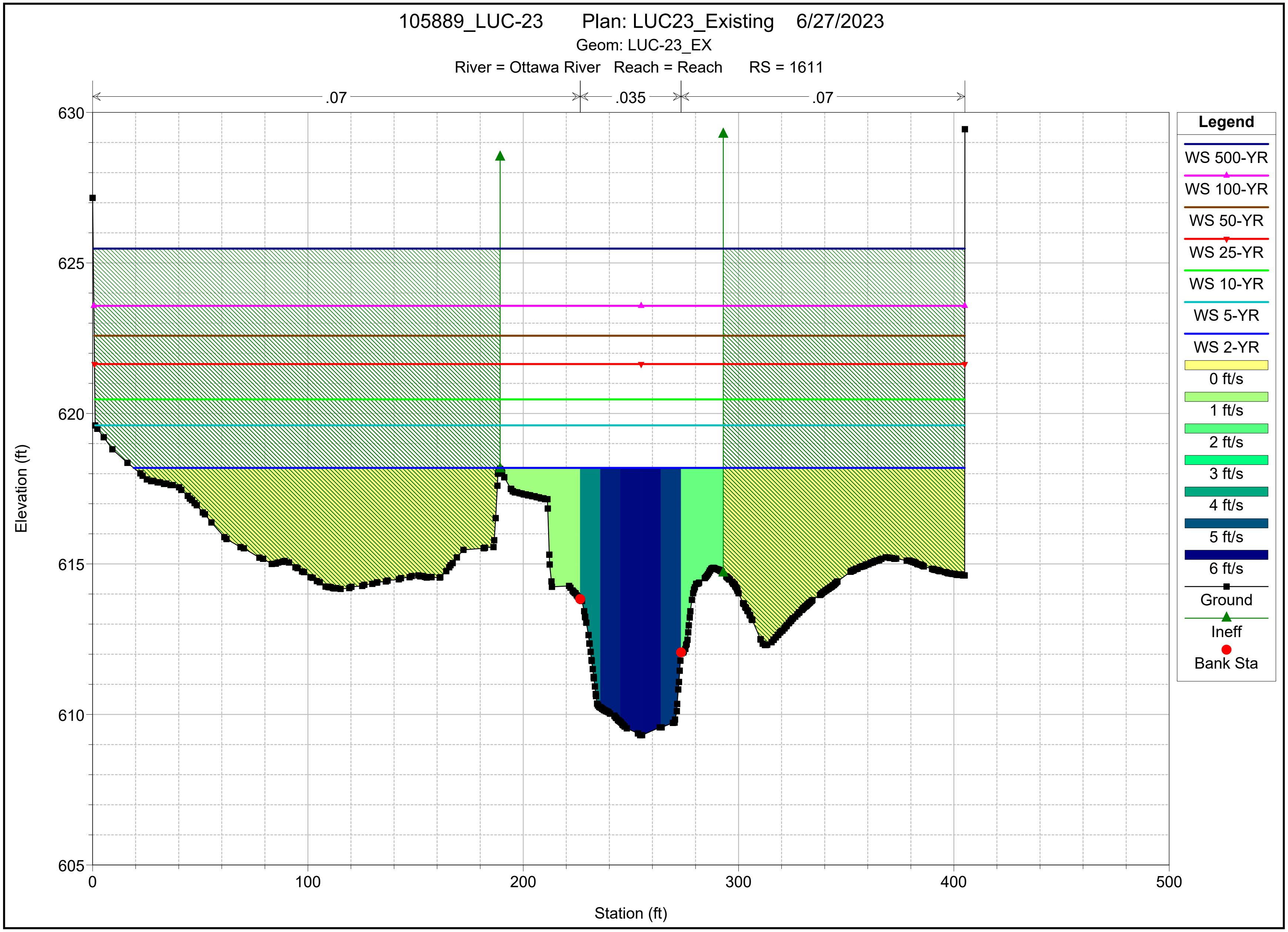

105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1802 BR Pedestrian Bridge
.07
.03
.04
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta

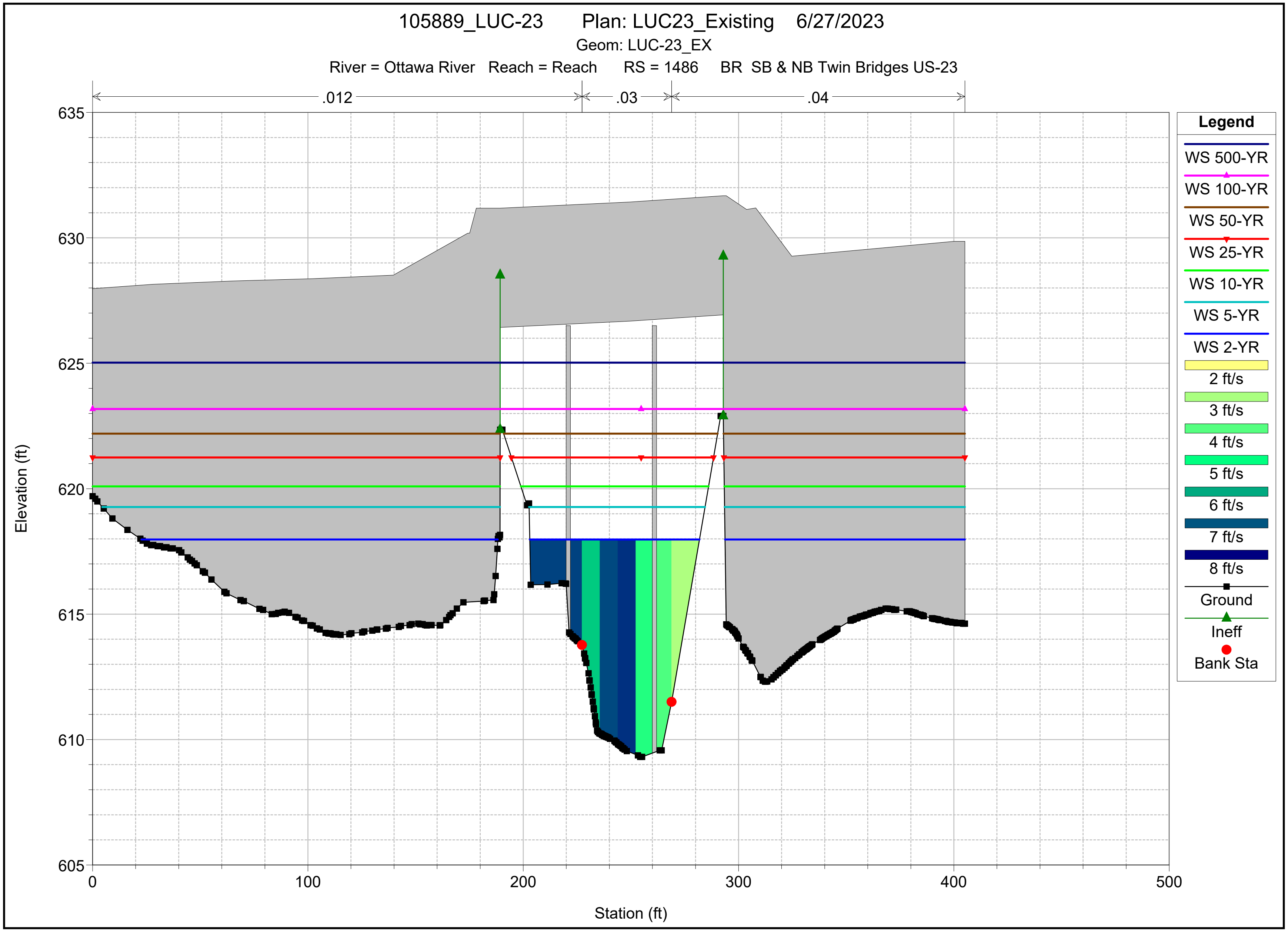


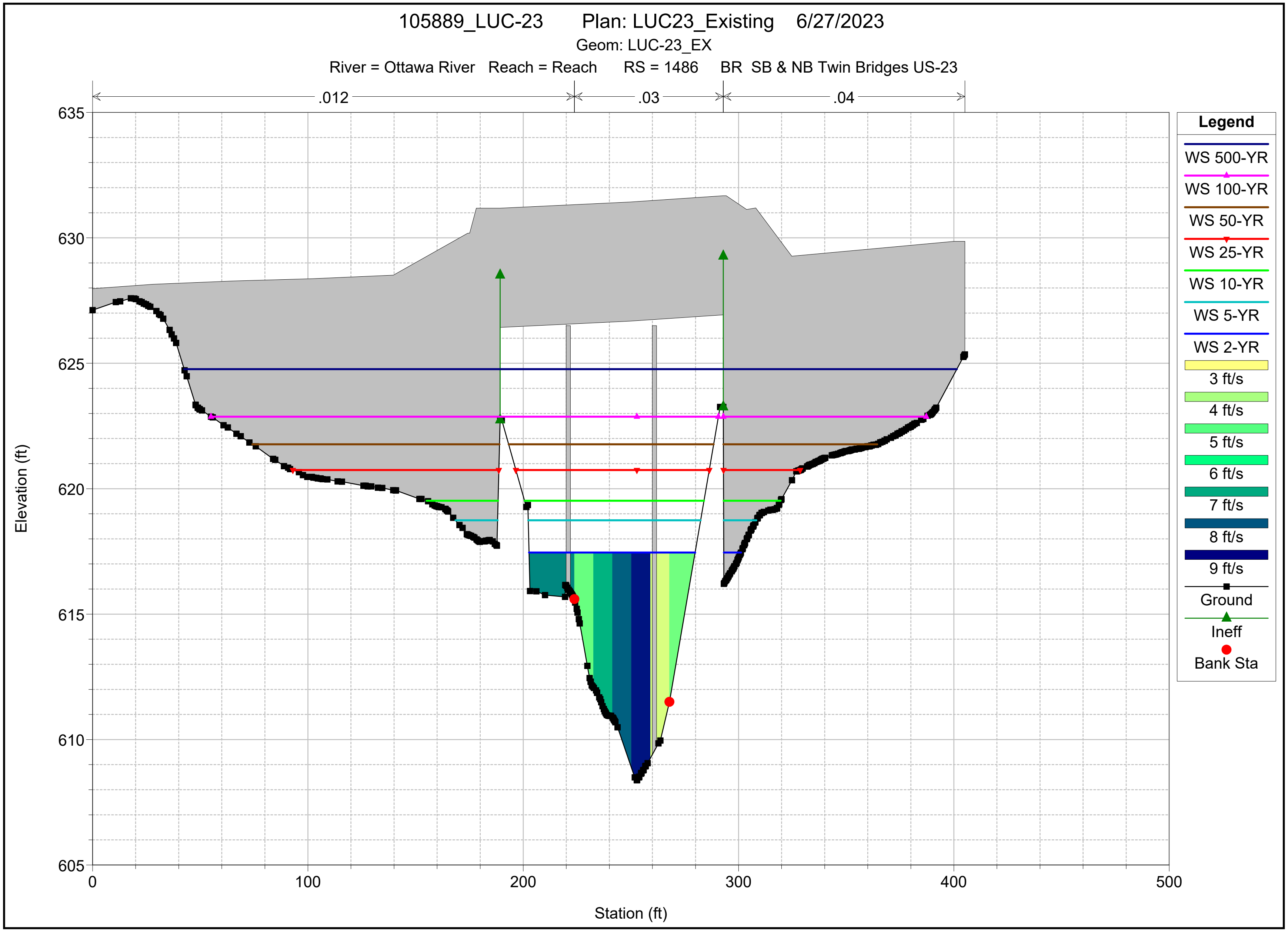
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1770
.07
.035
.07
Elevation (ft)
650
645
640
635
630
625
620
615
610
Station (ft)
0
100
200
300
400
500
600
700
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta

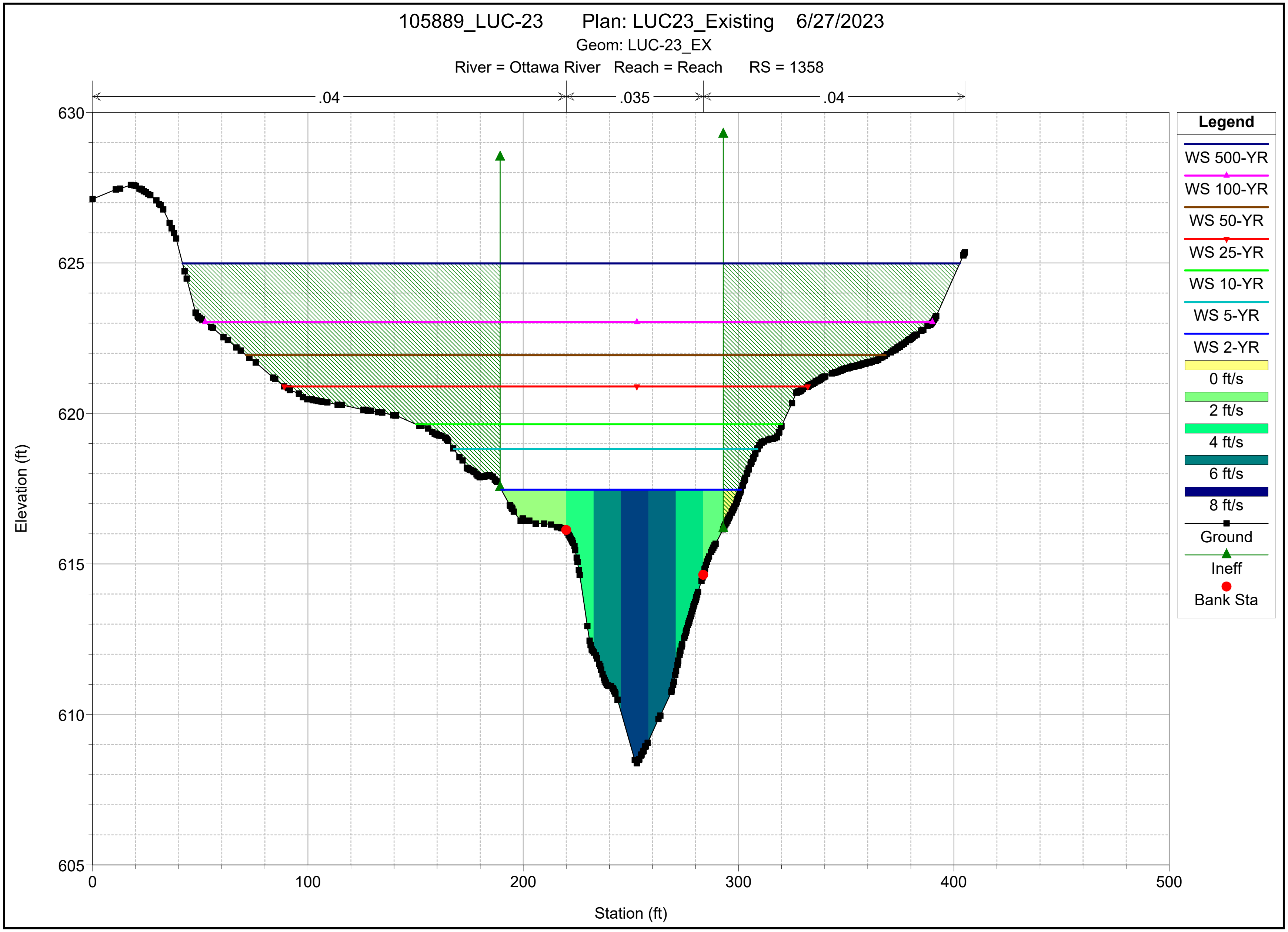


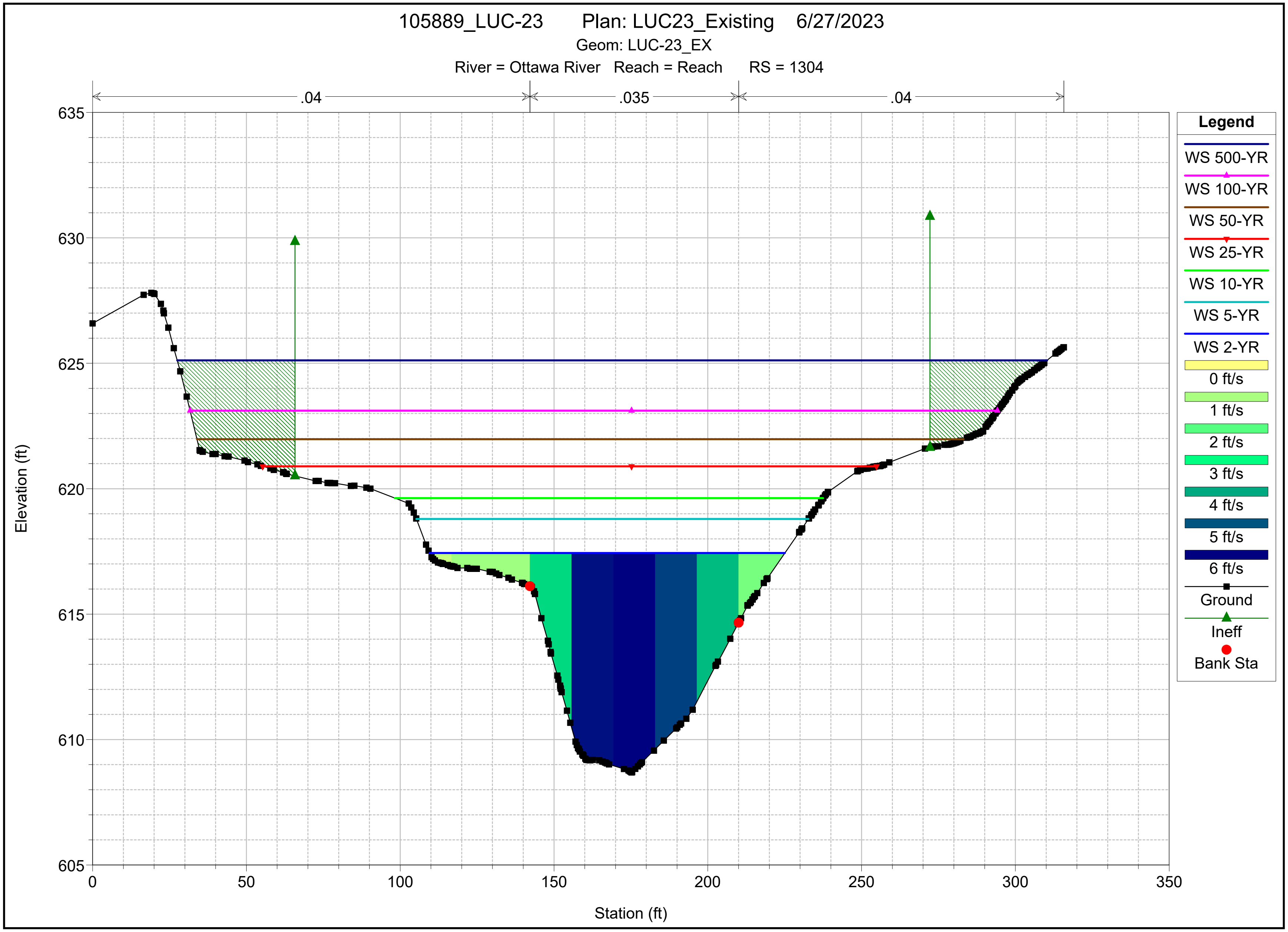
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1722
.07
.035
.07
Elevation (ft)
Station (ft)
650
645
640
635
630
625
620
615
610
0
100
200
300
400
500
600
700
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta

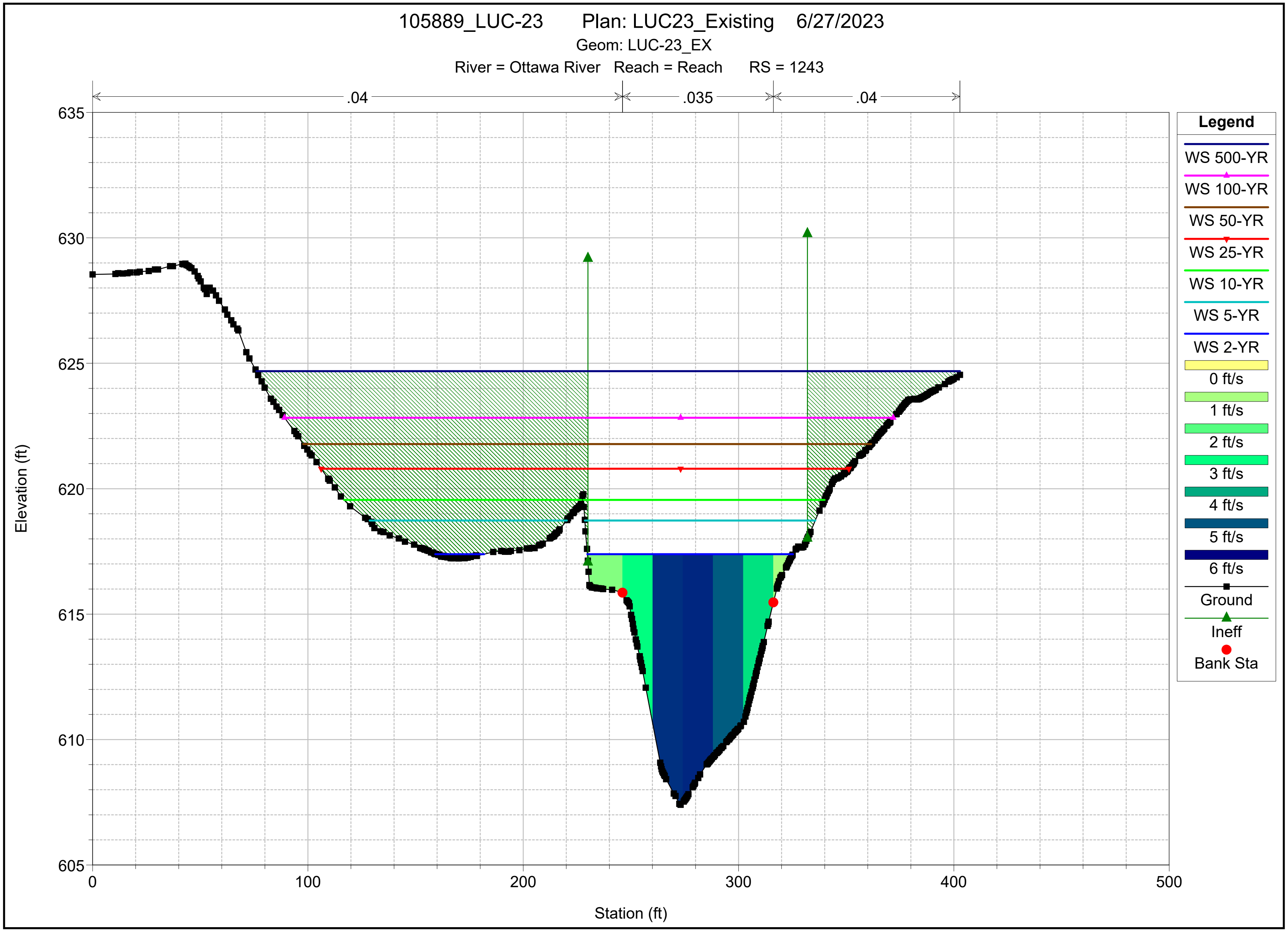

105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1611
.07
.035
.07
Elevation (ft)
Station (ft)
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta

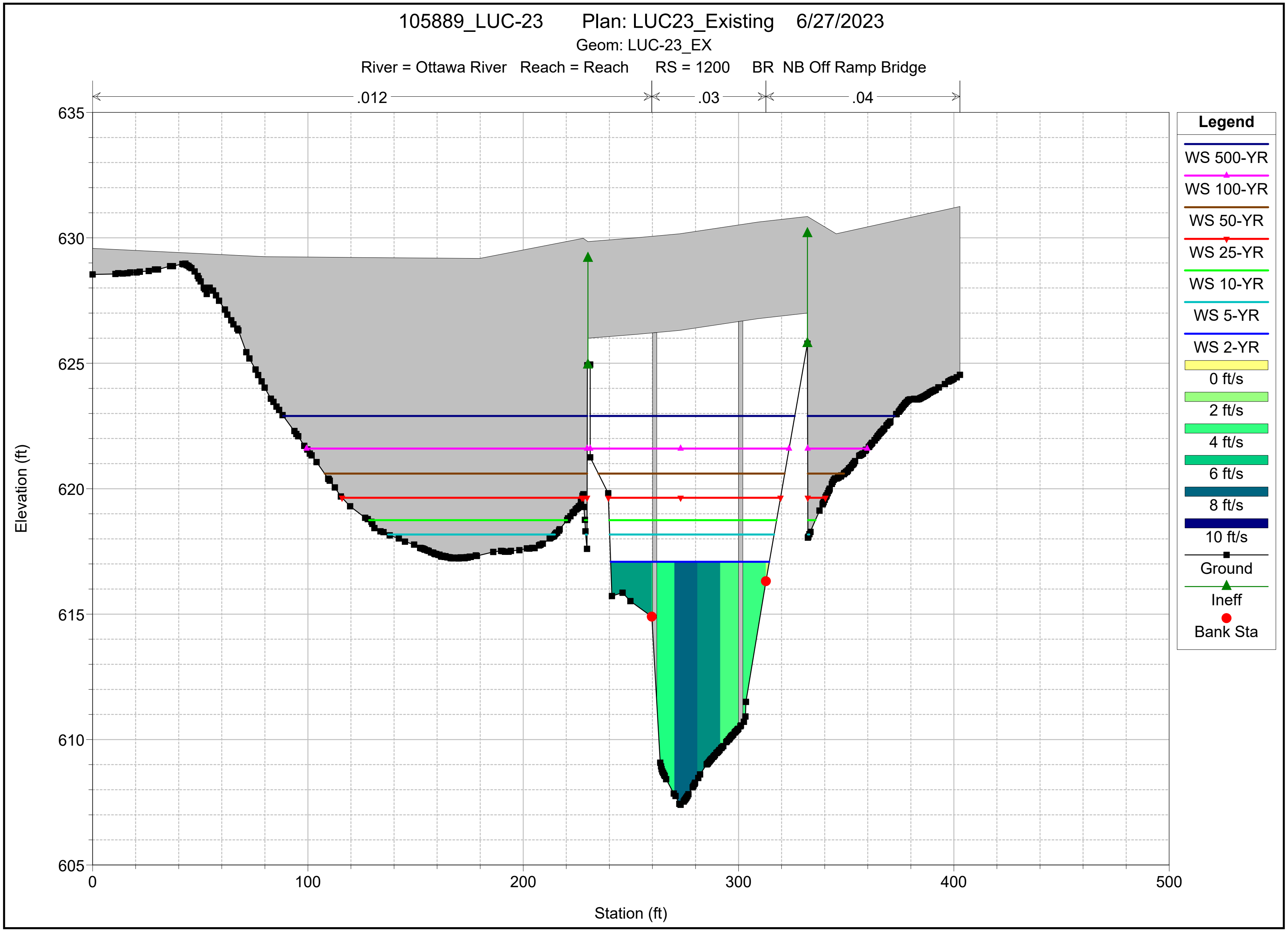

105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1486 BR SB & NB Twin Bridges US-23
.012
.03
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500
Station (ft)

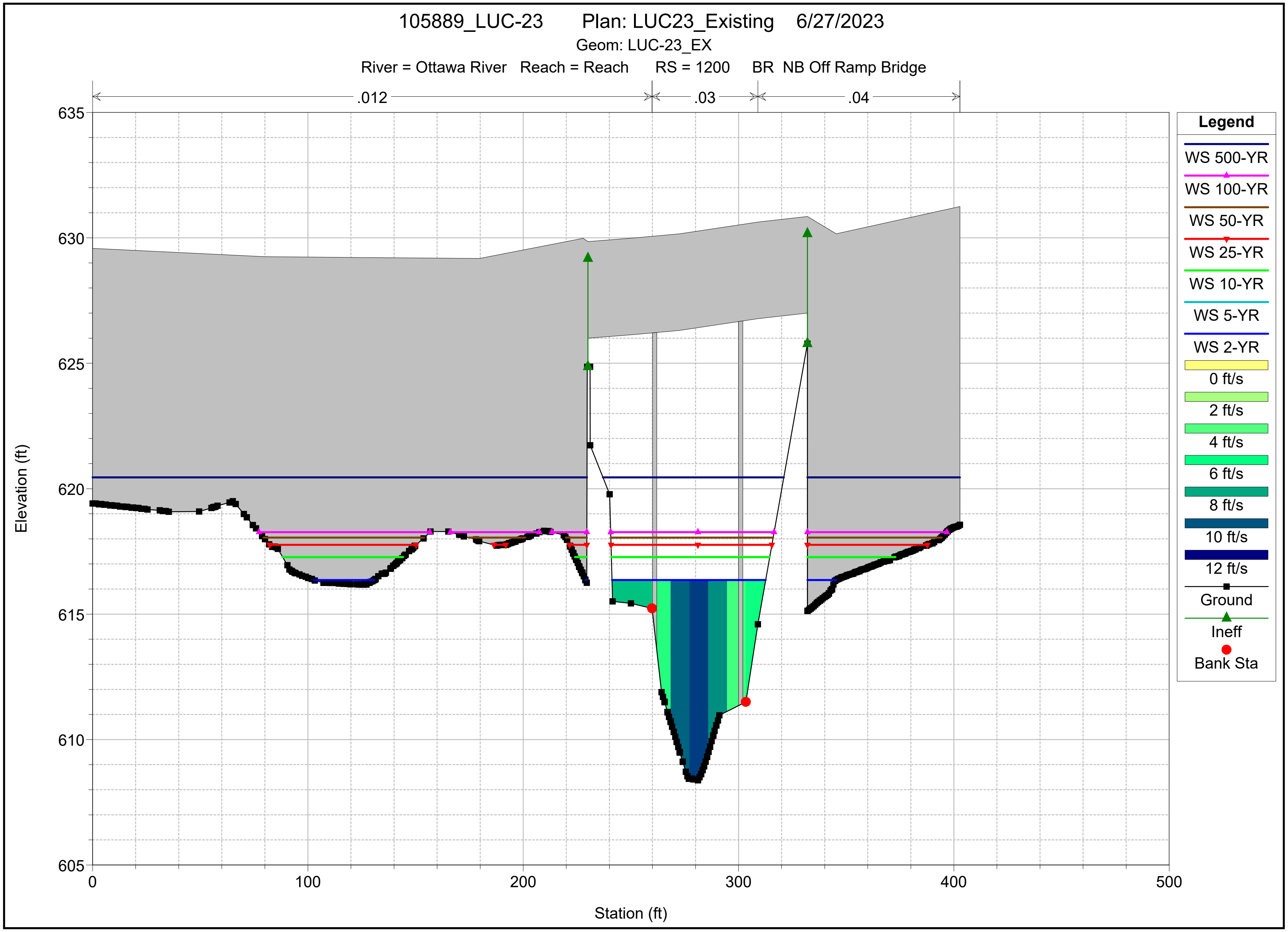

105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1486 BR SB & NB Twin Bridges US-23
.012
.03
.04
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Ineff
Bank Sta


105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1358
.04
.035
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
630
625
620
615
610
605
0
100
200
300
400
500

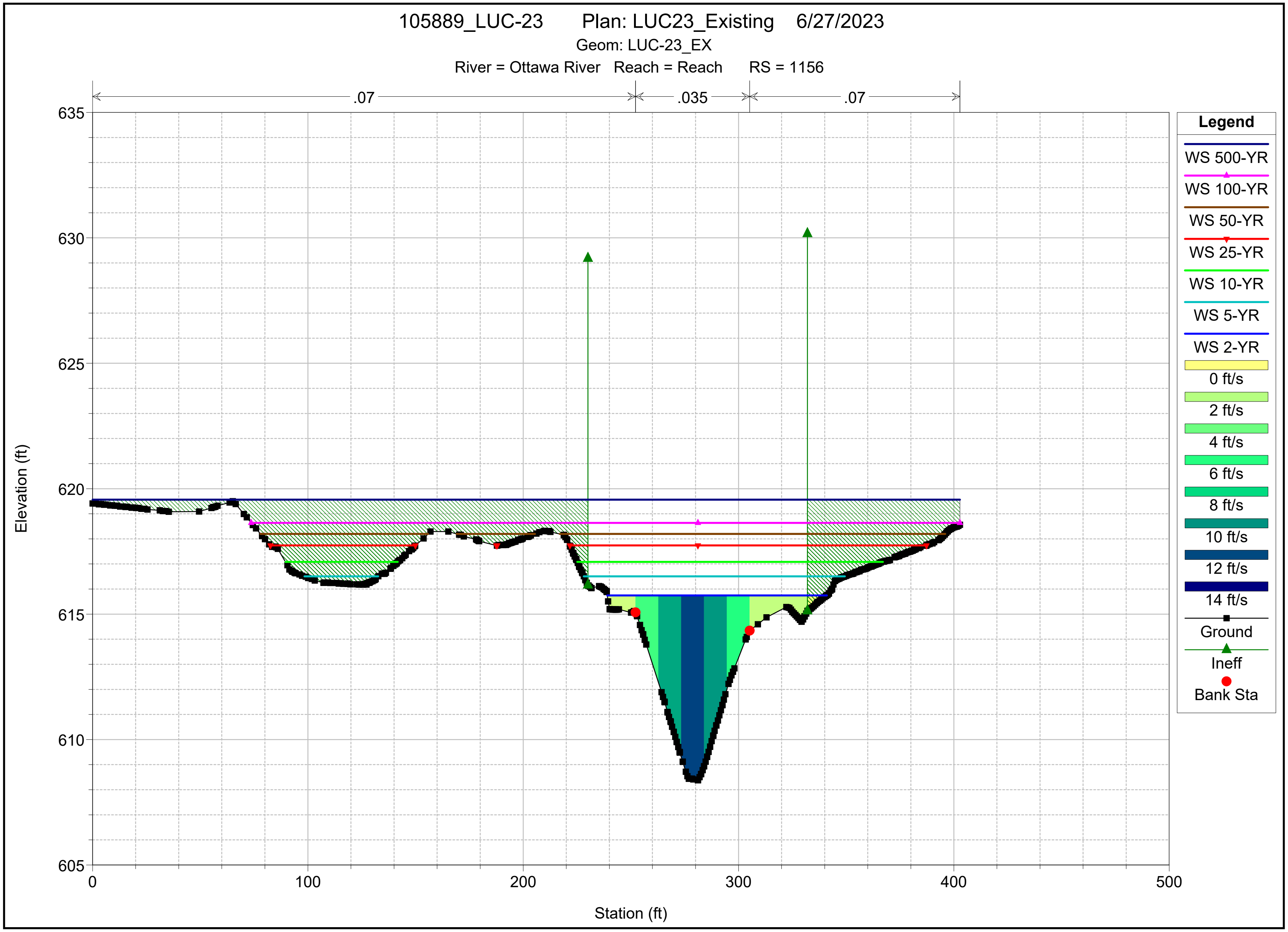

105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1304
.04
.035
.04
Elevation (ft)
Station (ft)
605
610
615
620
625
630
635
0
50
100
150
200
250
300
350
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta

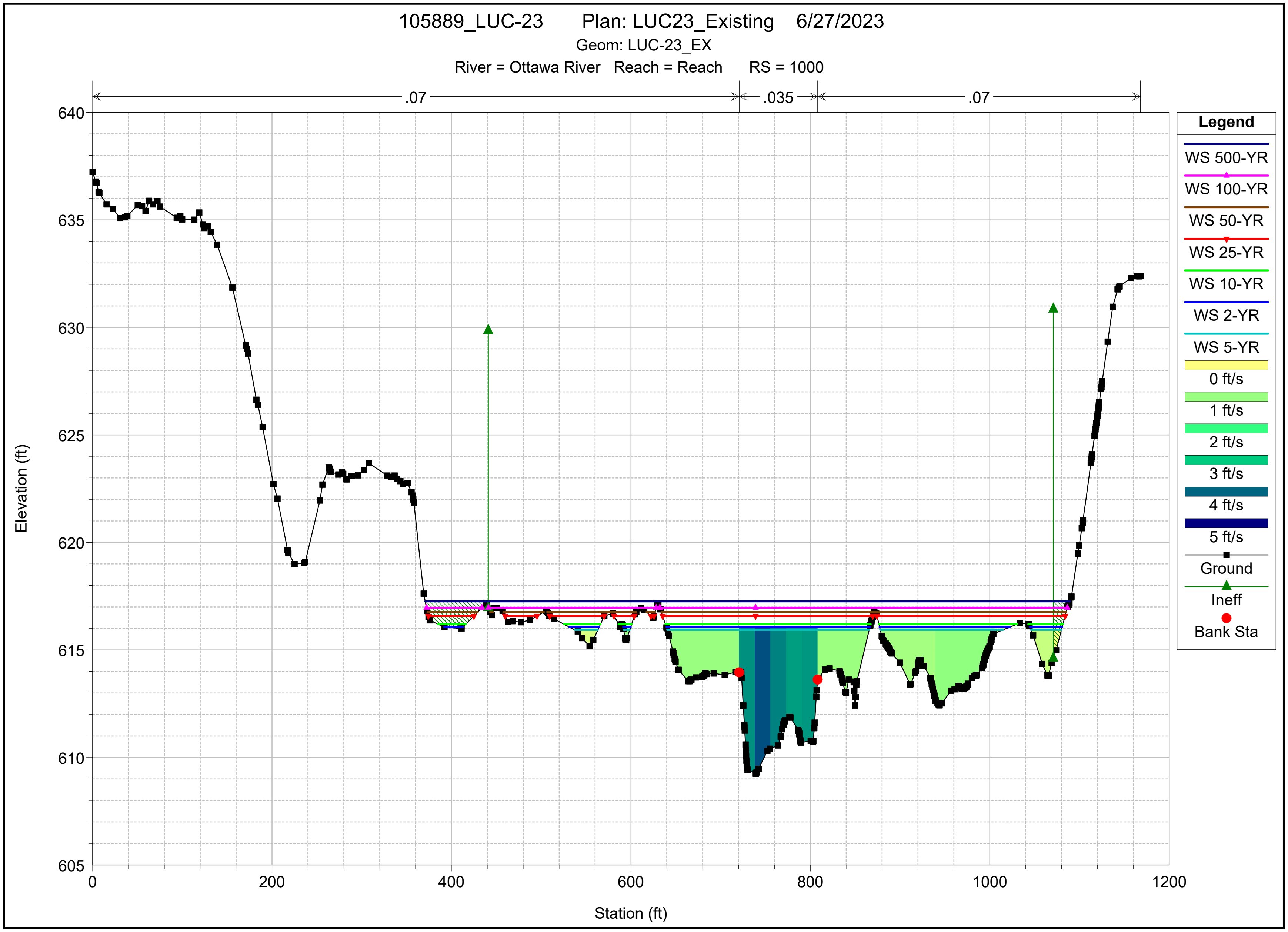

105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1243
.04
.035
.04
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta


105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1200 BR NB Off Ramp Bridge
.012
.03
.04
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Ineff
Bank Sta

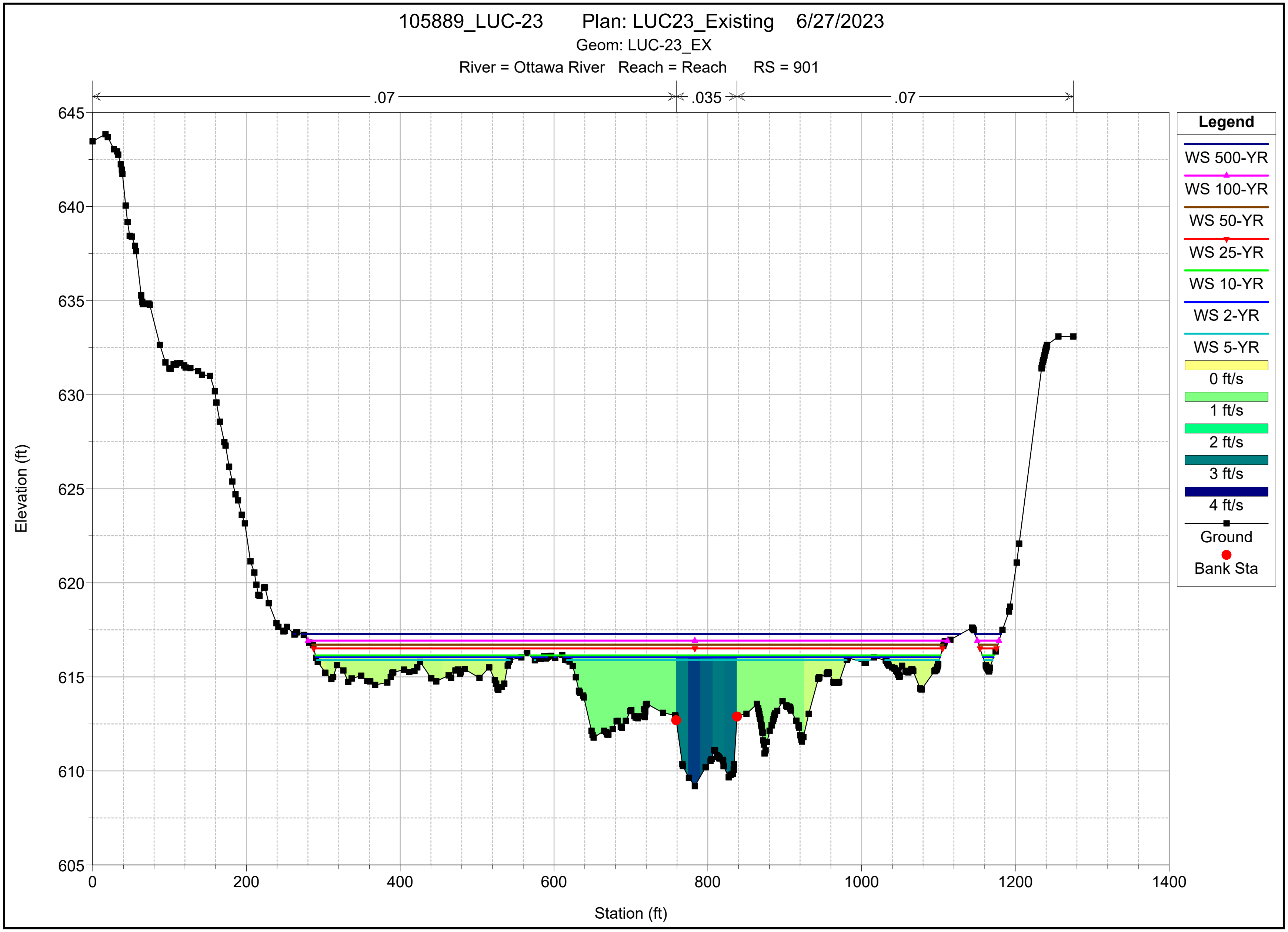


105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1200 BR NB Off Ramp Bridge
.012
.03
.04
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Ineff
Bank Sta

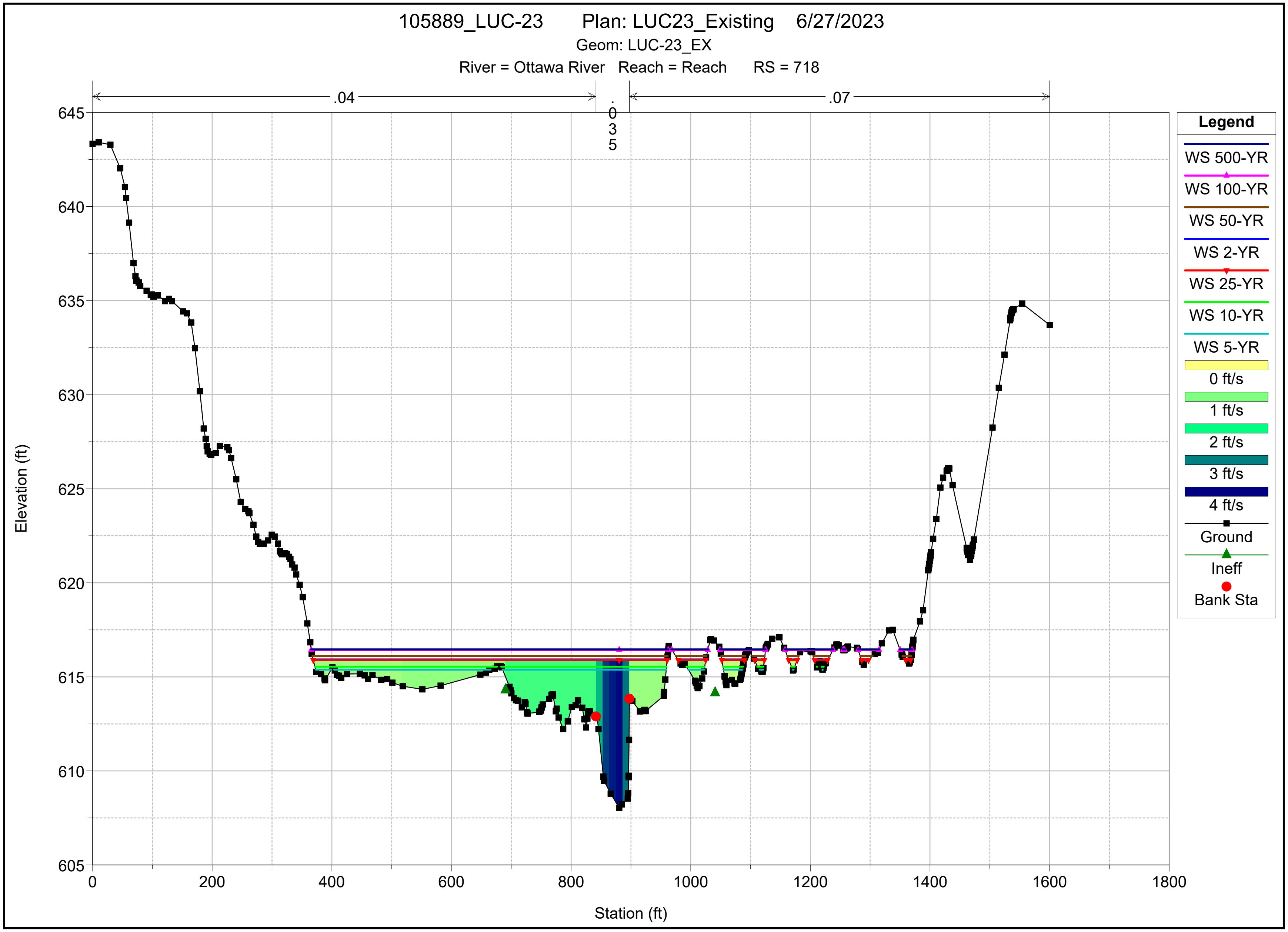

105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1156
.07
.035
.07
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta



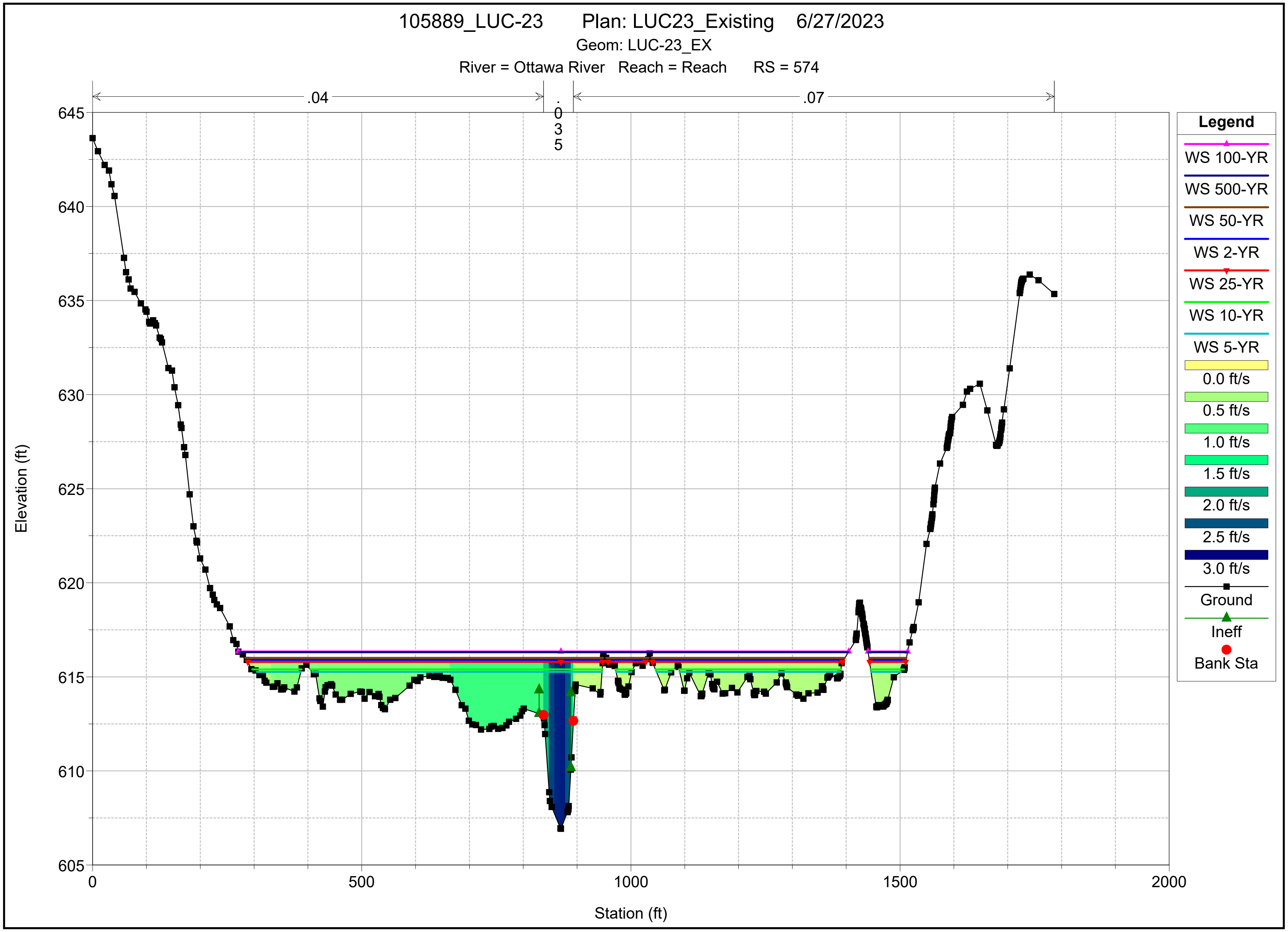
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 1000
.07
.035
.07
Elevation (ft)
640
635
630
625
620
615
610
605
Station (ft)
0
200
400
600
800
1000
1200
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 2-YR
WS 5-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta



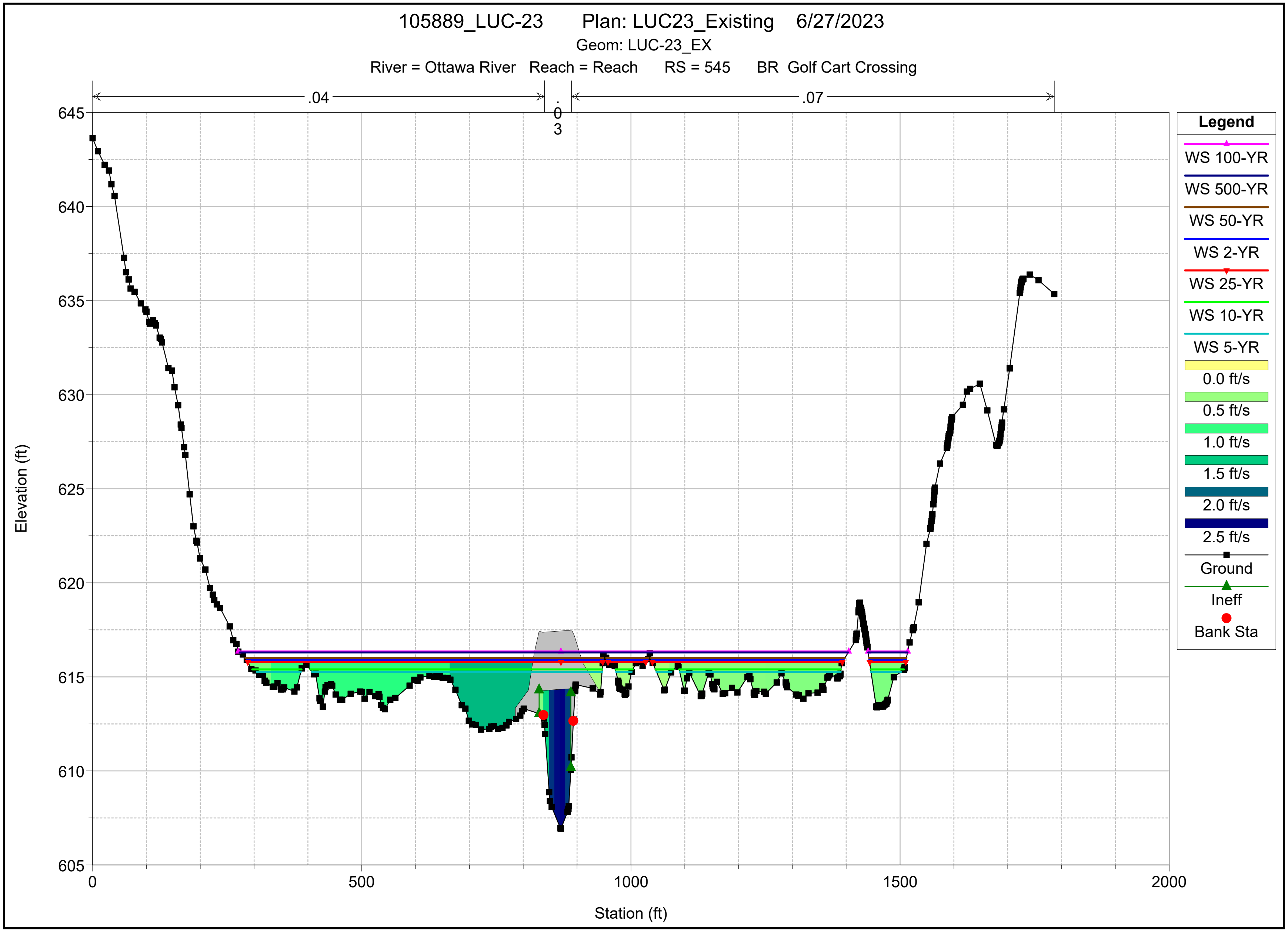
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 901
.07
.035
.07
Elevation (ft)
645
640
635
630
625
620
615
610
605
Station (ft)
0
200
400
600
800
1000
1200
1400
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 2-YR
WS 5-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Bank Sta



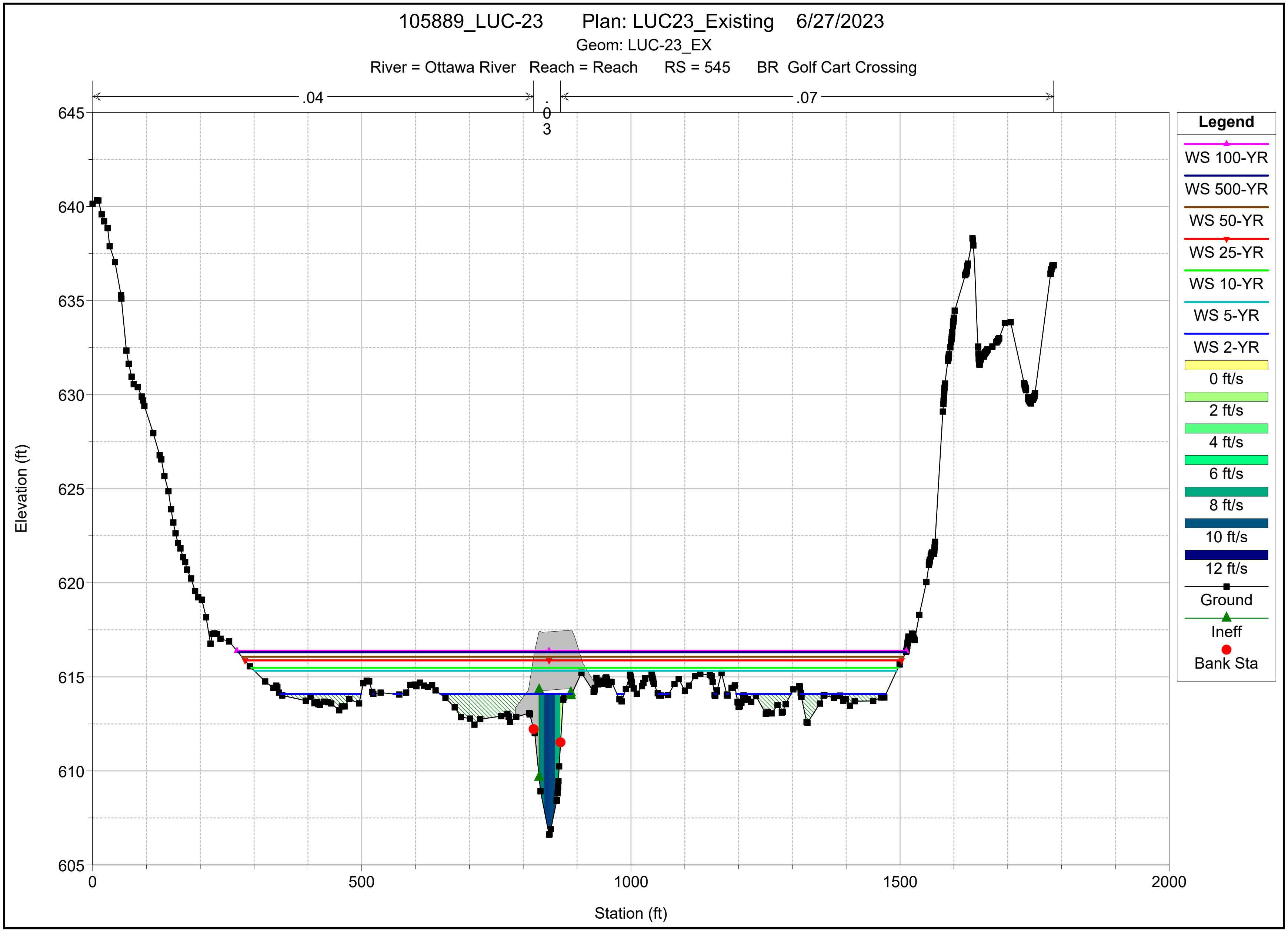
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 718
.04
.035
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
200
400
600
800
1000
1200
1400
1600
1800
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 2-YR
WS 25-YR
WS 10-YR
WS 5-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Ineff
Bank Sta



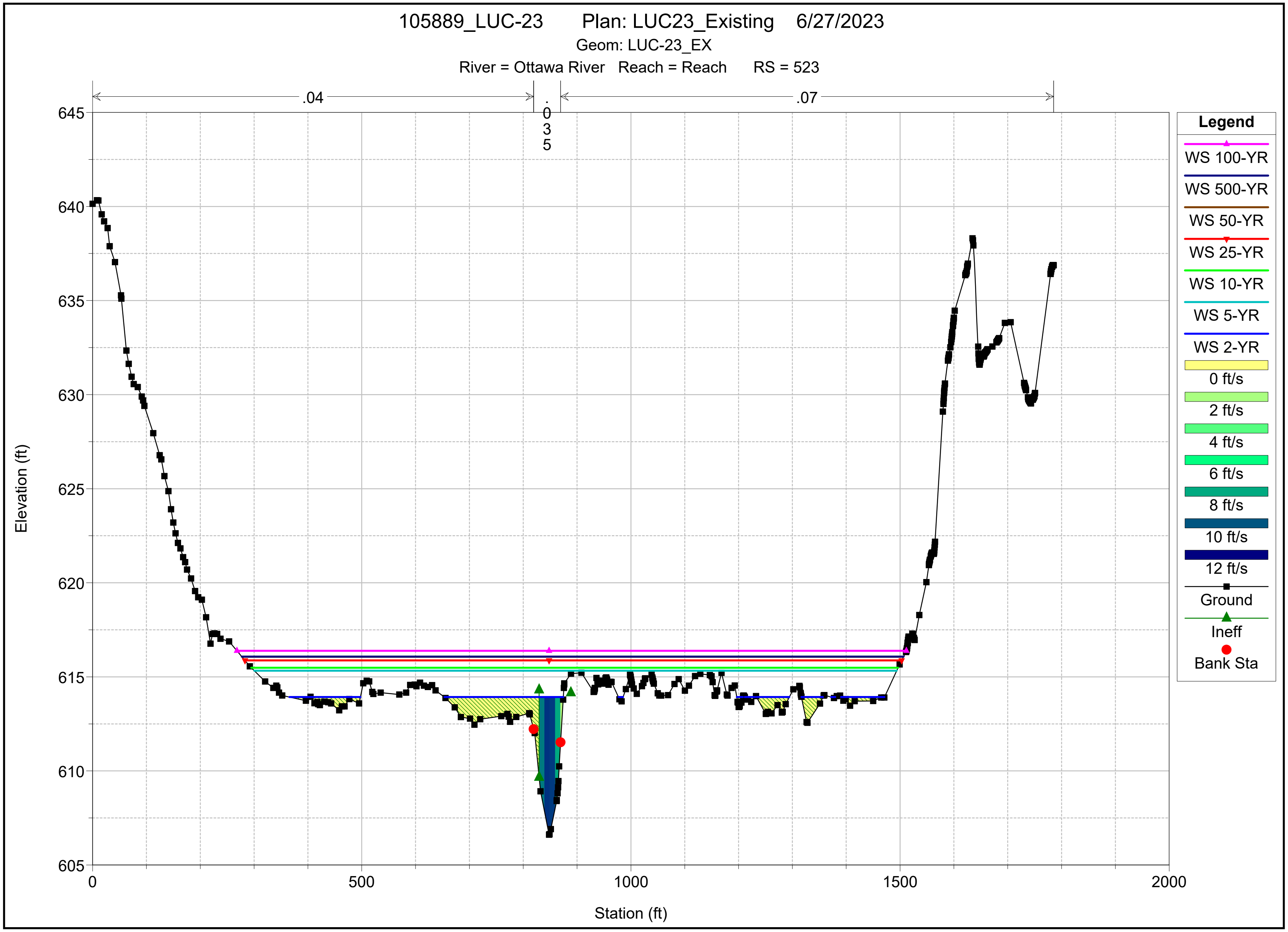
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 574
.04
.035
.07
Legend
WS 100-YR
WS 500-YR
WS 50-YR
WS 2-YR
WS 25-YR
WS 10-YR
WS 5-YR
0.0 ft/s
0.5 ft/s
1.0 ft/s
1.5 ft/s
2.0 ft/s
2.5 ft/s
3.0 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
Station (ft)



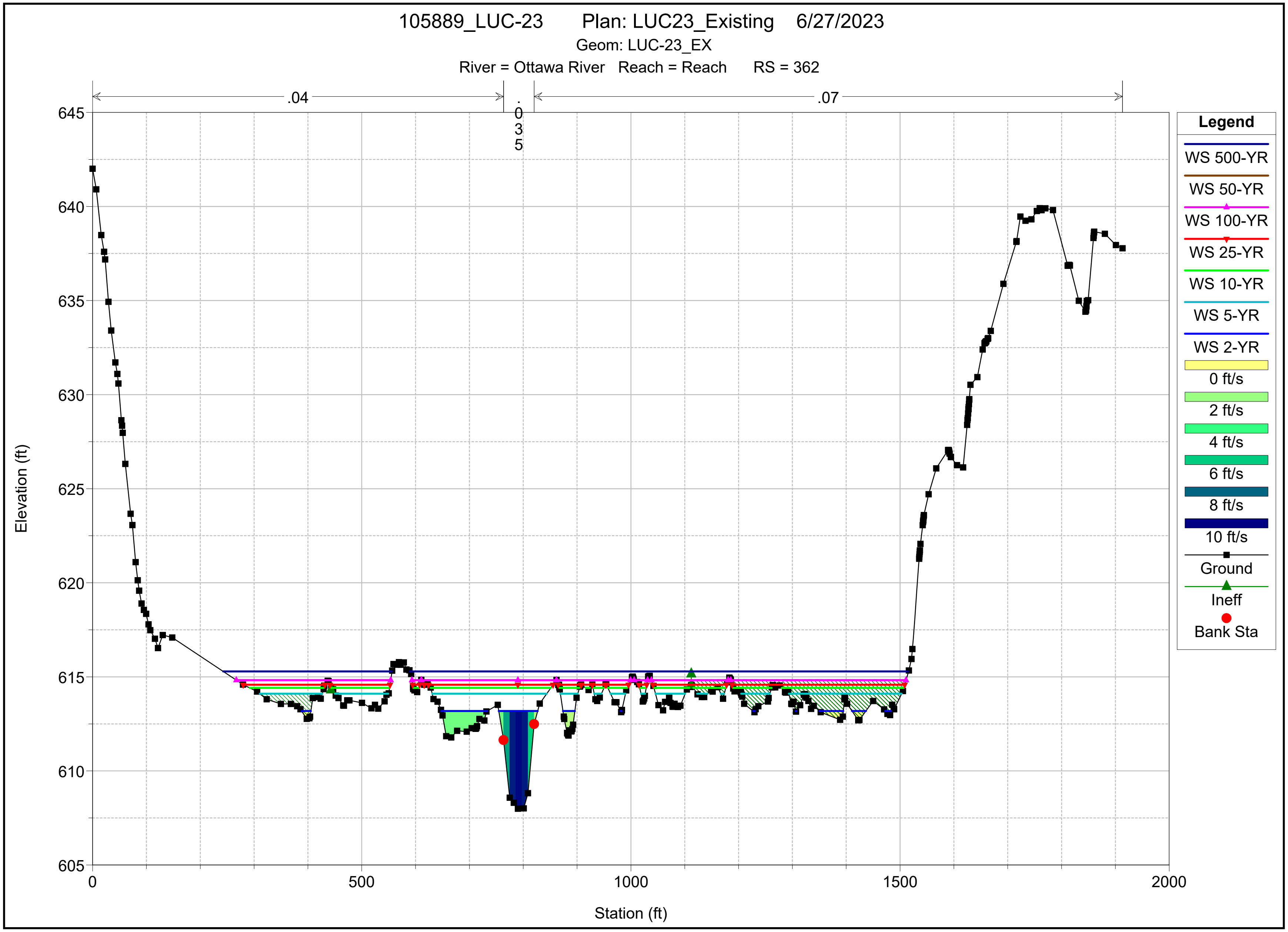
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 545 BR Golf Cart Crossing
.04
.
0
3
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
Legend
WS 100-YR
WS 500-YR
WS 50-YR
WS 2-YR
WS 25-YR
WS 10-YR
WS 5-YR
0.0 ft/s
0.5 ft/s
1.0 ft/s
1.5 ft/s
2.0 ft/s
2.5 ft/s
Ground
Ineff
Bank Sta



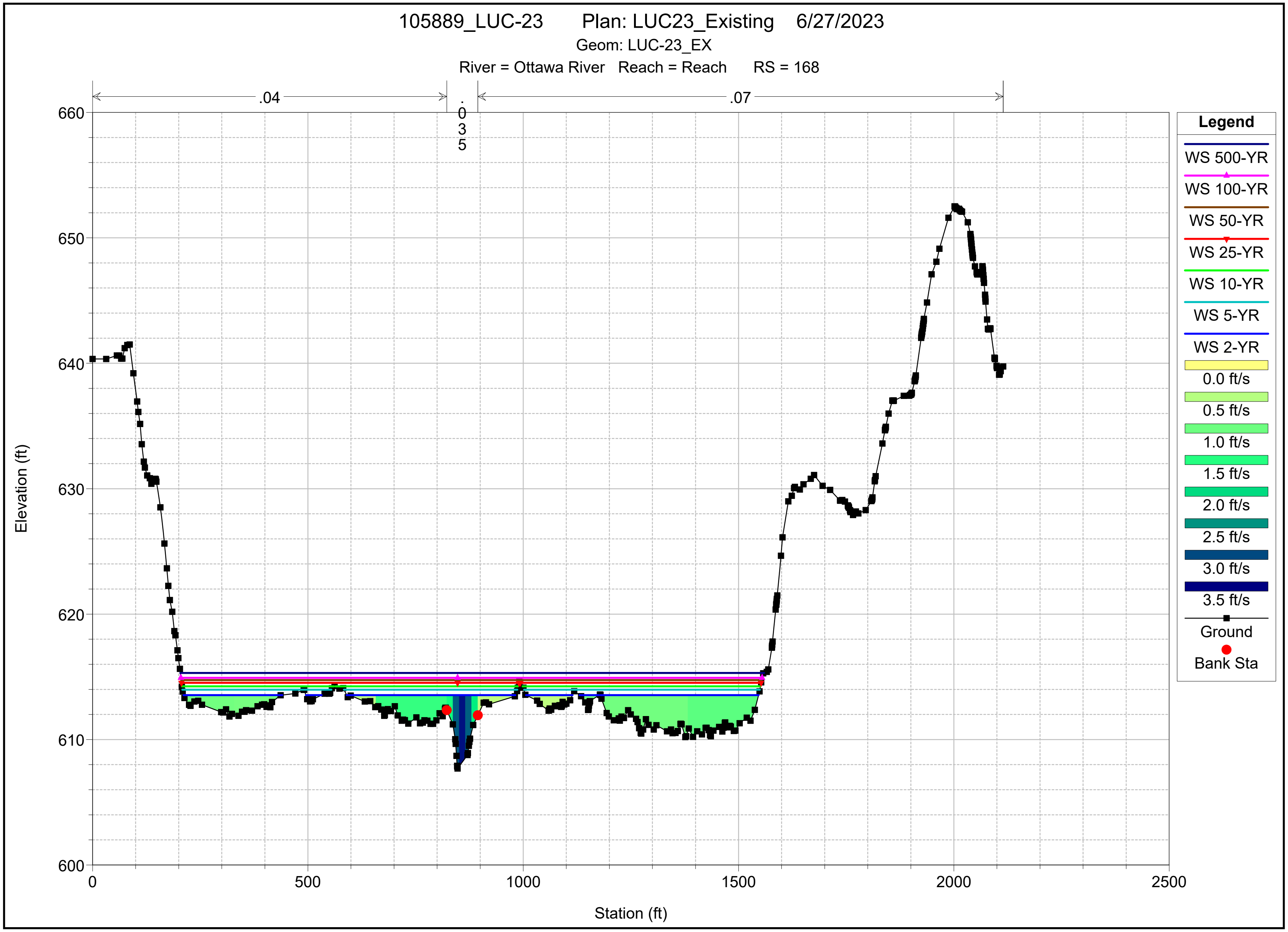
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 545 BR Golf Cart Crossing
.04
.03
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
Legend
WS 100-YR
WS 500-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Ineff
Bank Sta



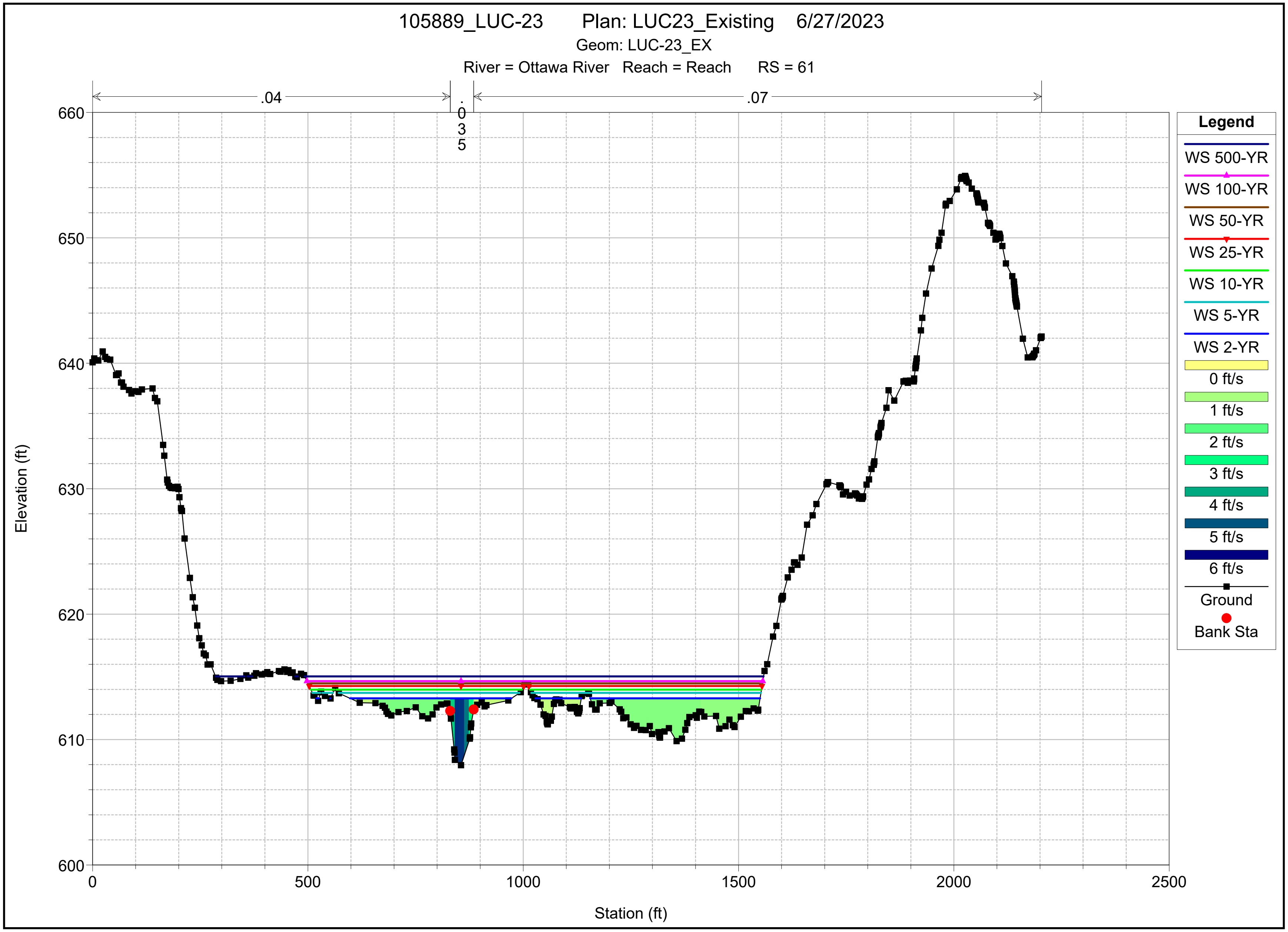
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 523
.04
.035
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
Legend
WS 100-YR
WS 500-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Ineff
Bank Sta



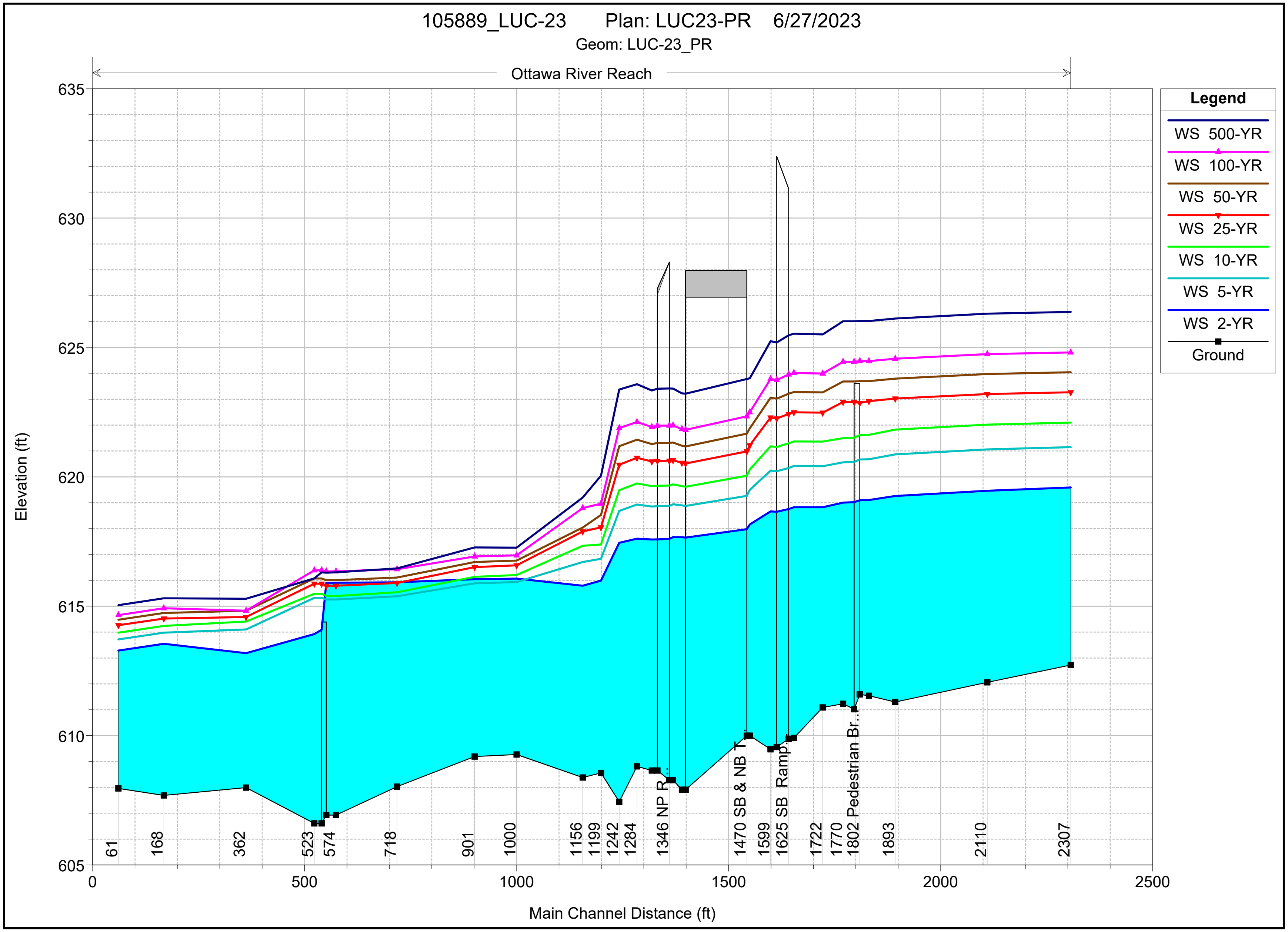
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 362
.04
.035
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
Legend
WS 500-YR
WS 50-YR
WS 100-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Ineff
Bank Sta



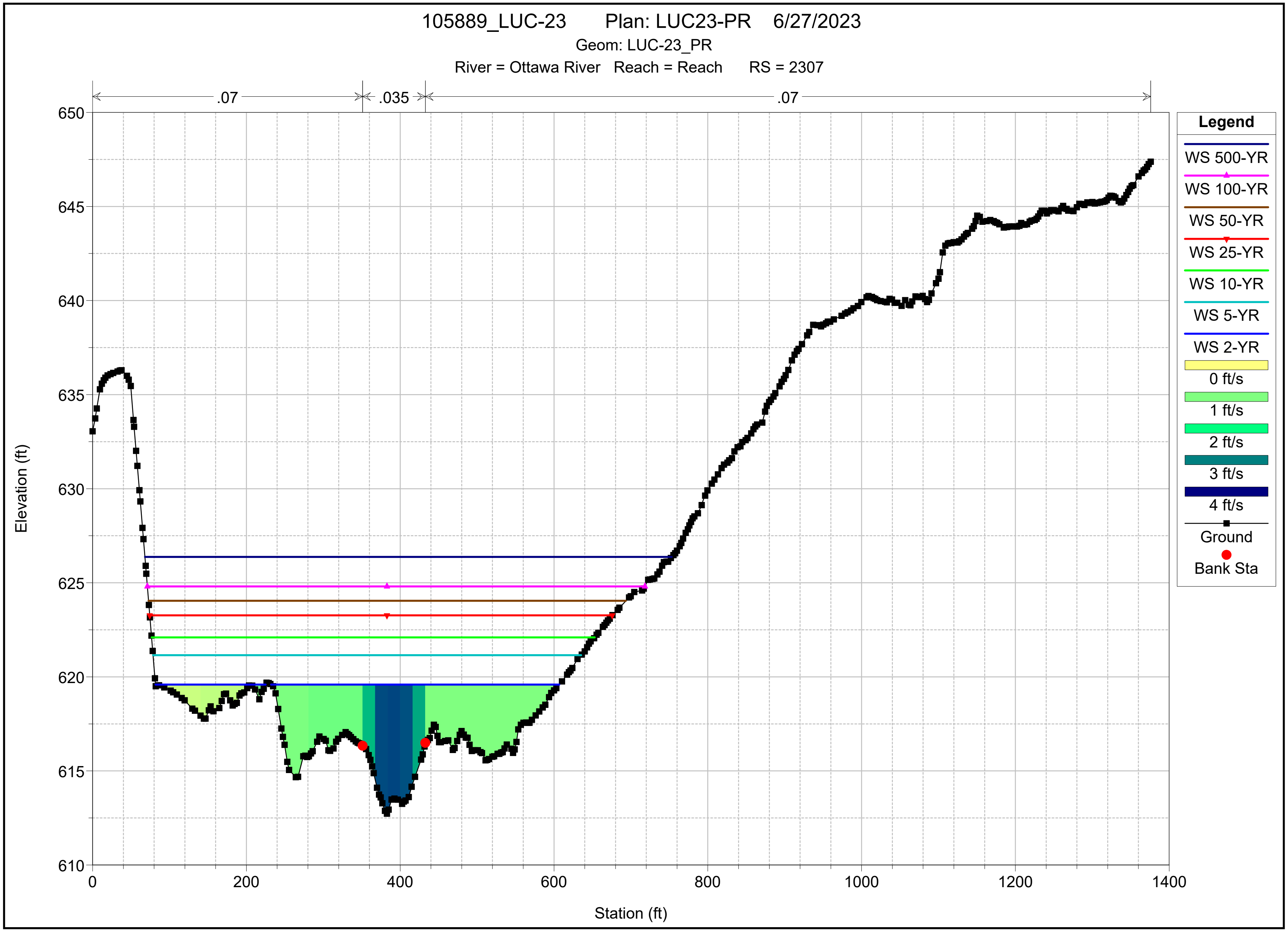
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 168
.04
.035
.07
Elevation (ft)
Station (ft)
600
610
620
630
640
650
660
0
500
1000
1500
2000
2500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0.0 ft/s
0.5 ft/s
1.0 ft/s
1.5 ft/s
2.0 ft/s
2.5 ft/s
3.0 ft/s
3.5 ft/s
Ground
Bank Sta

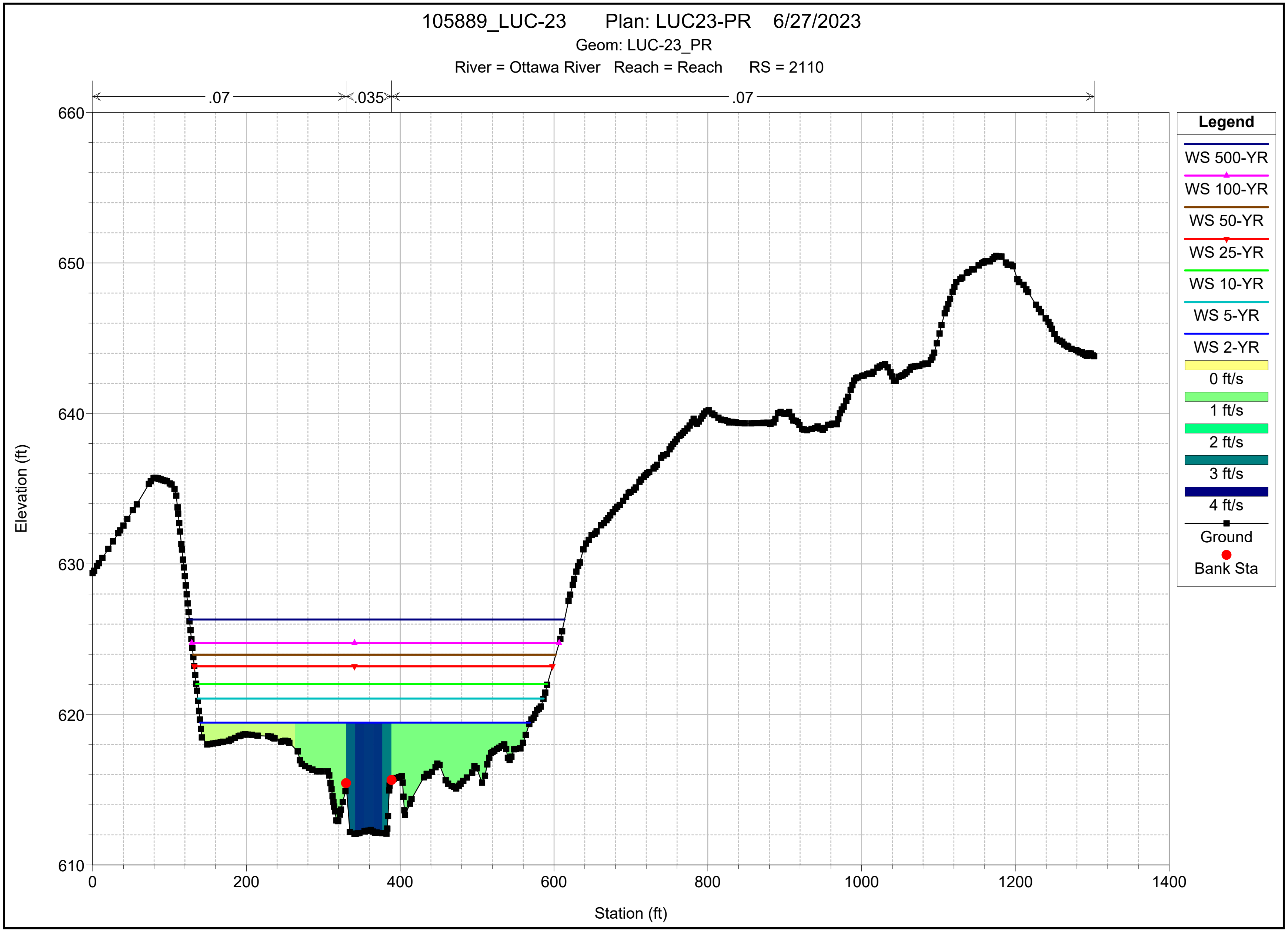


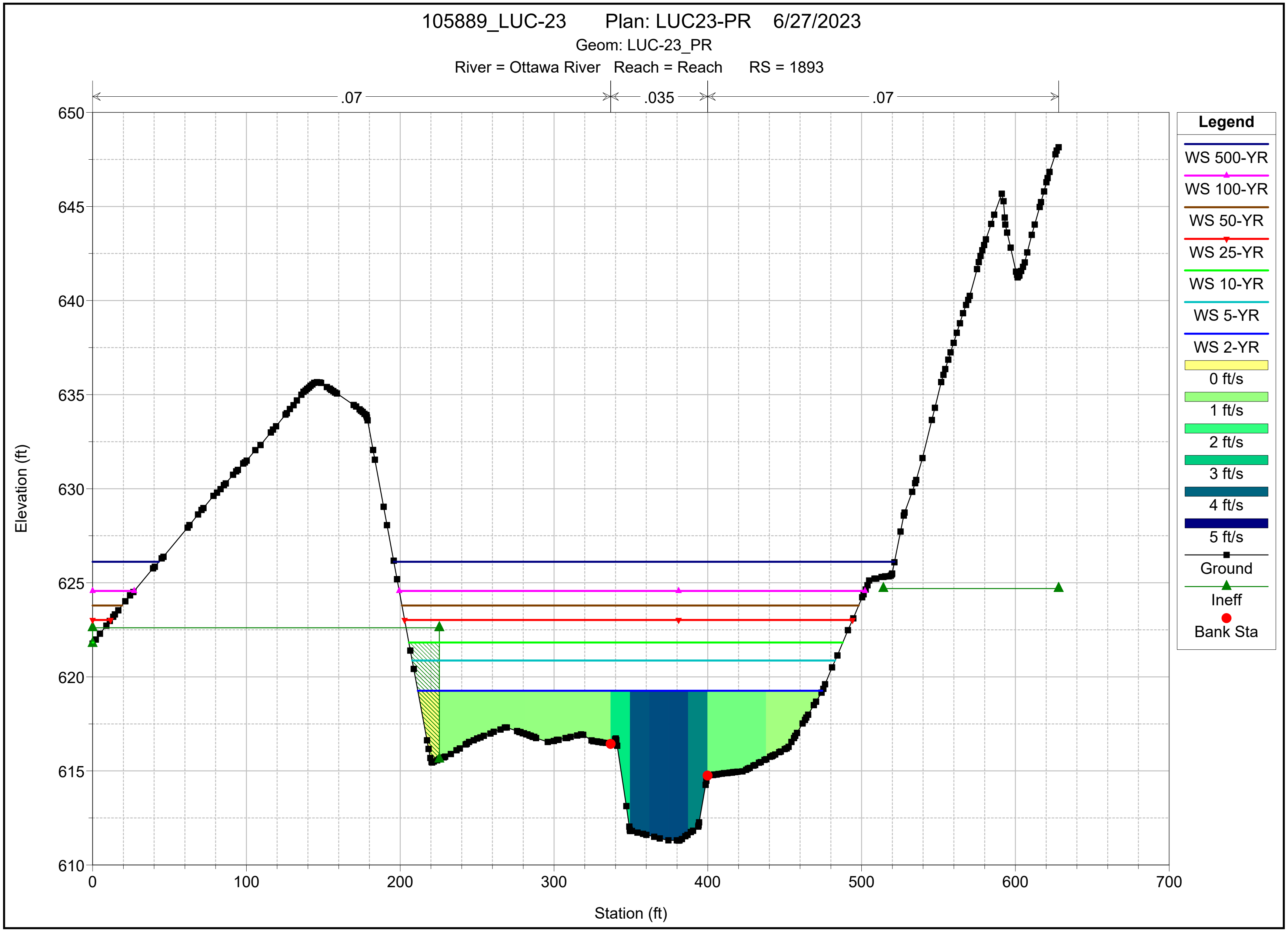
105889_LUC-23 Plan: LUC23_Existing 6/27/2023
Geom: LUC-23_EX
River = Ottawa River Reach = Reach RS = 61
.04
.035
.07
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
660
650
640
630
620
610
600
0
500
1000
1500
2000
2500

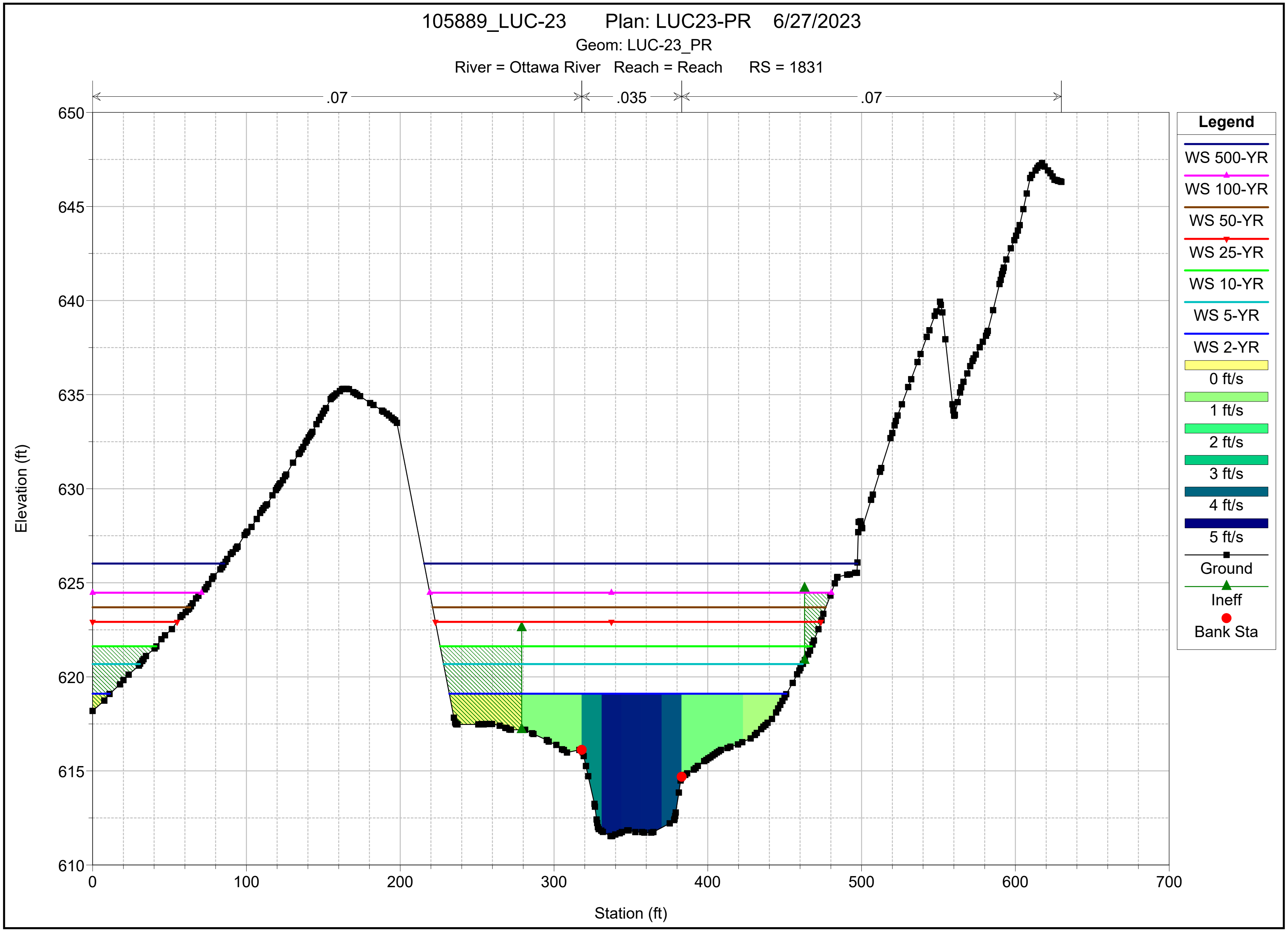


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
Ottawa River Reach
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
Ground
Elevation (ft)
Main Channel Distance (ft)
635
630
625
620
615
610
605
0
500
1000
1500
2000
2500
61
168
362
523
574
718
901
1000
1156
1199
1242
1284
1346 NP R...
1470 SB & NB T
1599
1625 SB Ramp
1722
1770
1802 Pedestrian Br.
1893
2110
2307

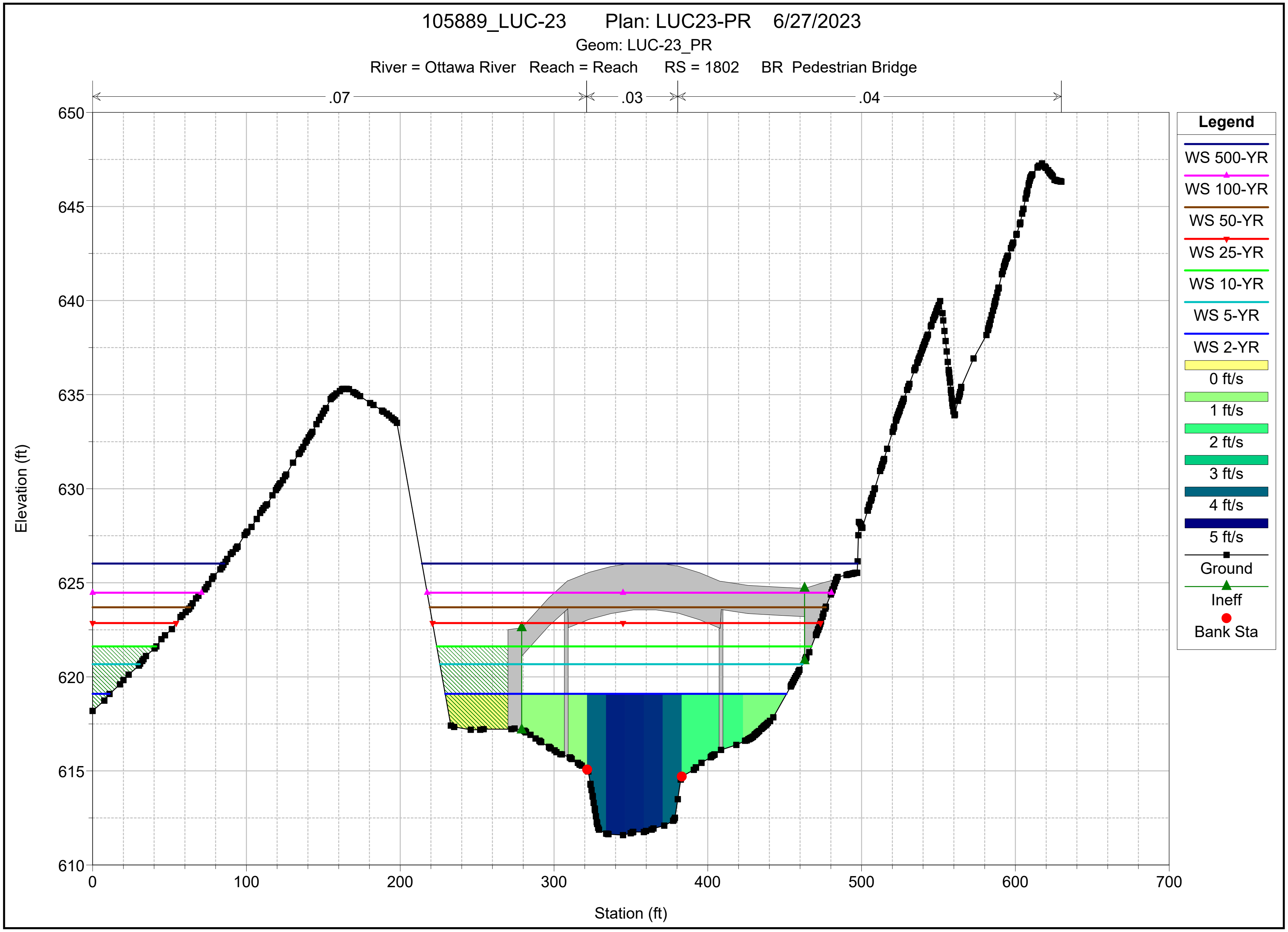

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 2307
.07
.035
.07
Elevation (ft)
Station (ft)
650
645
640
635
630
625
620
615
610
0
200
400
600
800
1000
1200
1400
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Bank Sta


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 2110
.07
.035
.07
Elevation (ft)
Station (ft)
660
650
640
630
620
610
0
200
400
600
800
1000
1200
1400
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Bank Sta

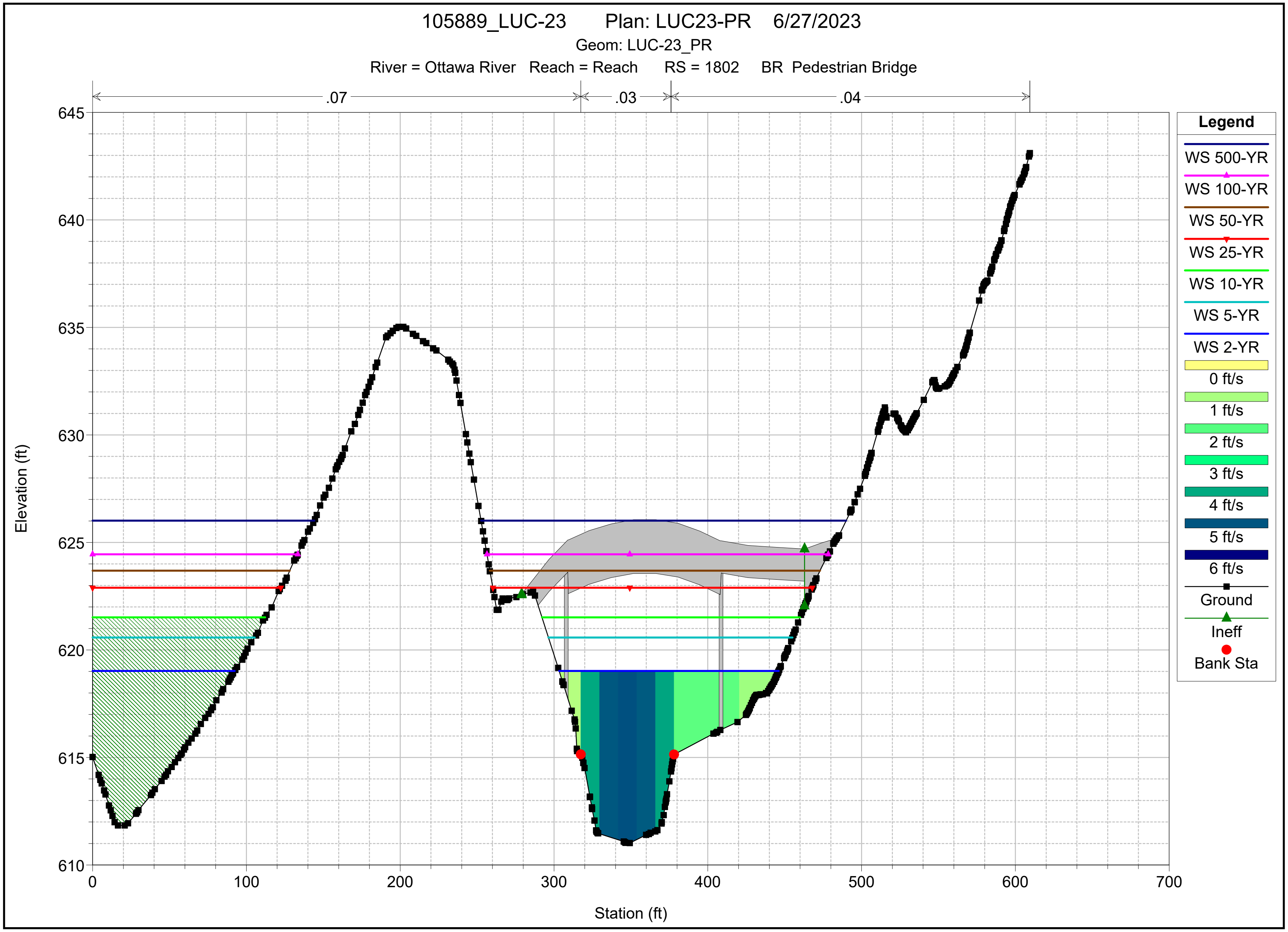

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1893
.07
.035
.07
Elevation (ft)
Station (ft)
650
645
640
635
630
625
620
615
610
0
100
200
300
400
500
600
700
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta

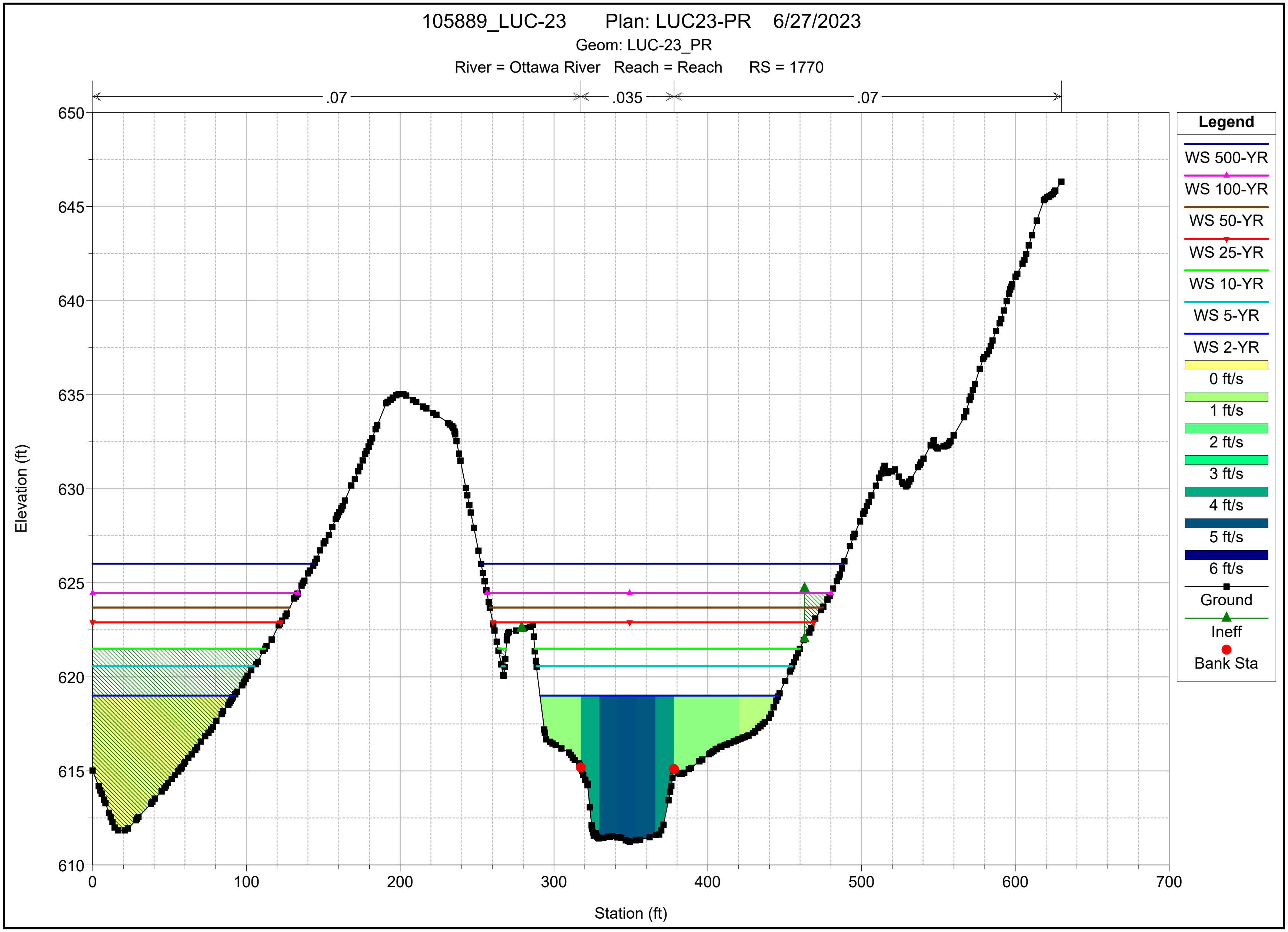


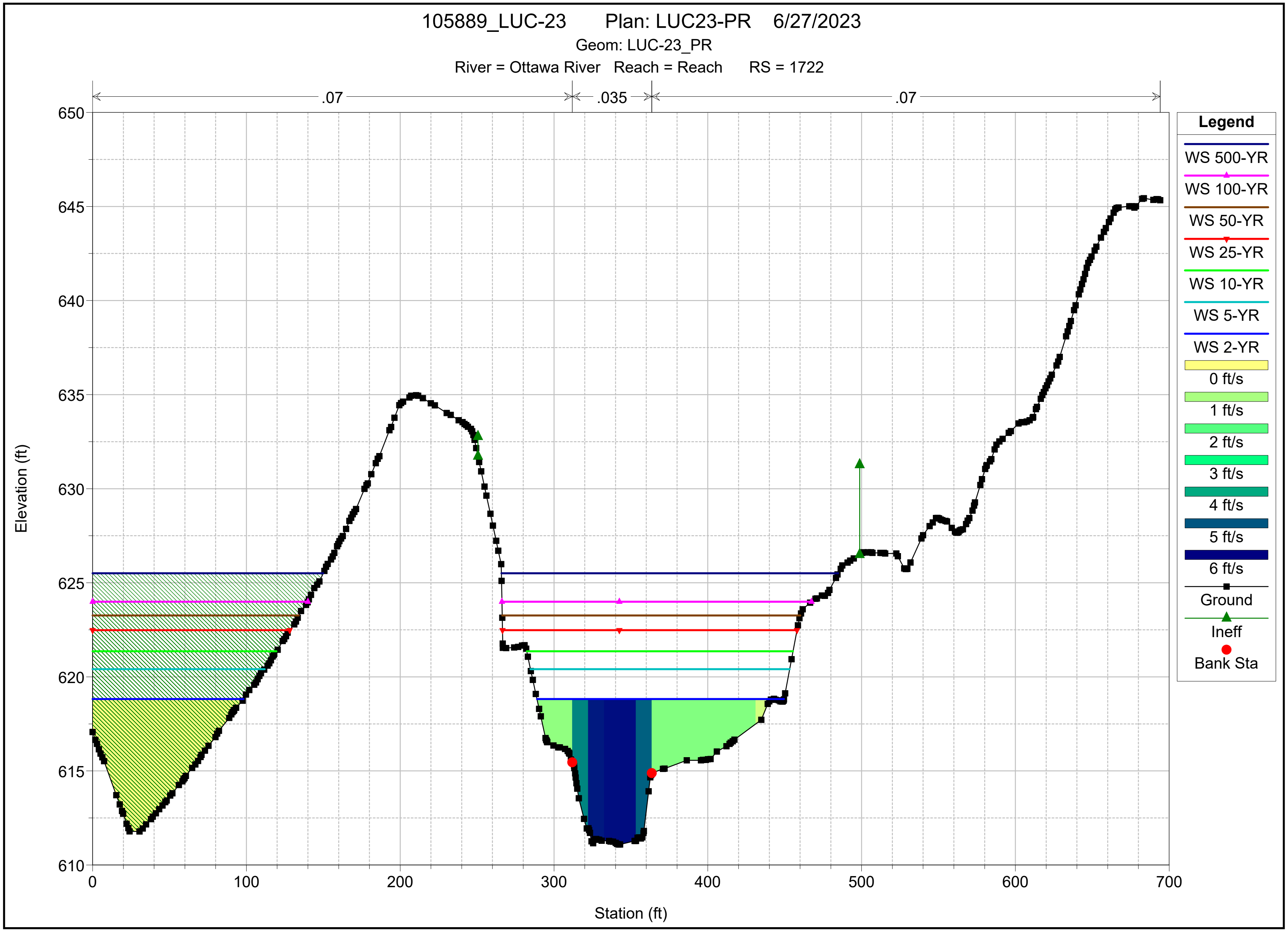
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1831
.07
.035
.07
Elevation (ft)
Station (ft)
650
645
640
635
630
625
620
615
610
0
100
200
300
400
500
600
700
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta



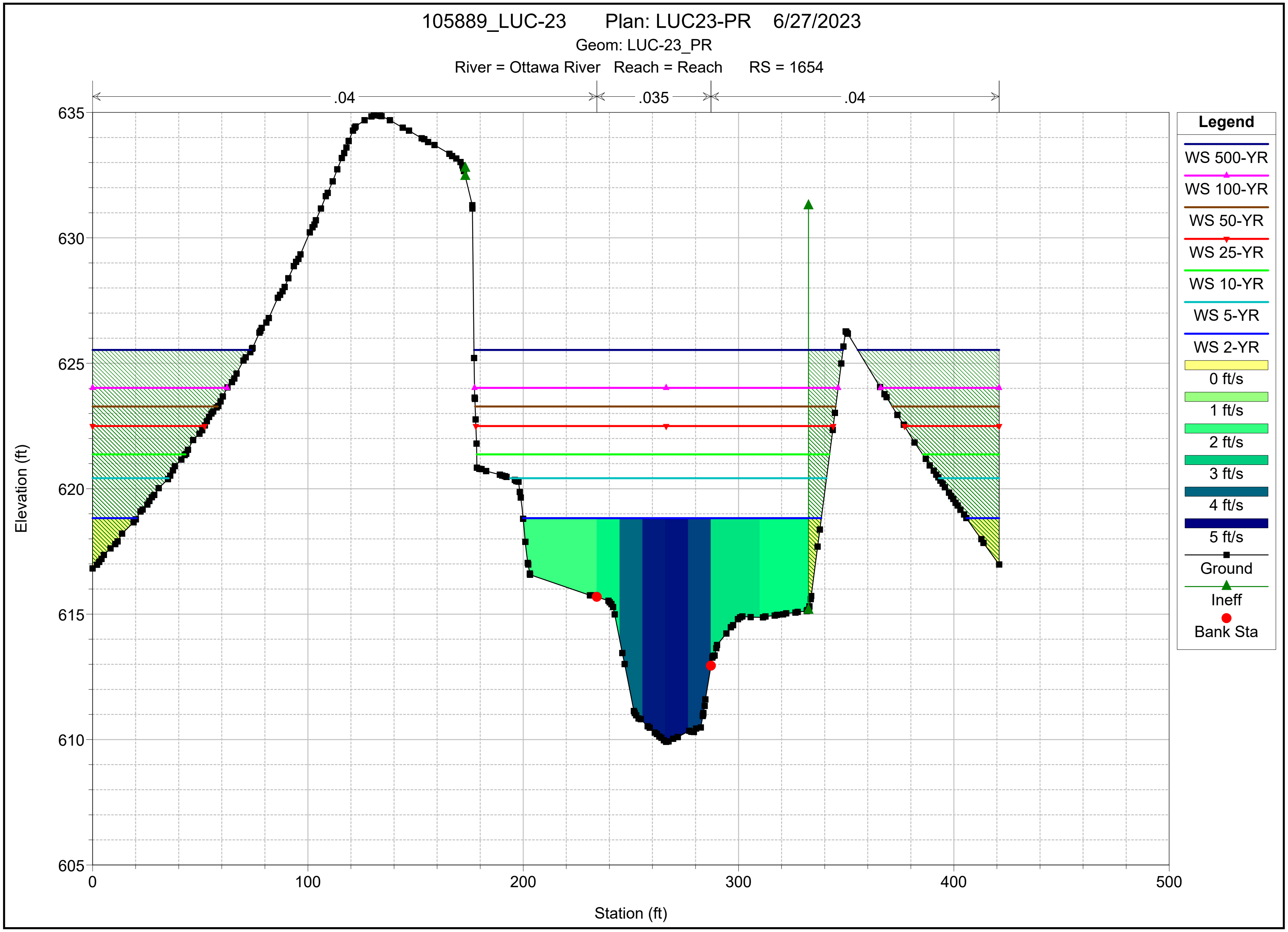
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1802 BR Pedestrian Bridge
.07
.03
.04
Elevation (ft)
650
645
640
635
630
625
620
615
610
0
100
200
300
400
500
600
700
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1802 BR Pedestrian Bridge
.07
.03
.04
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
0
100
200
300
400
500
600
700
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta

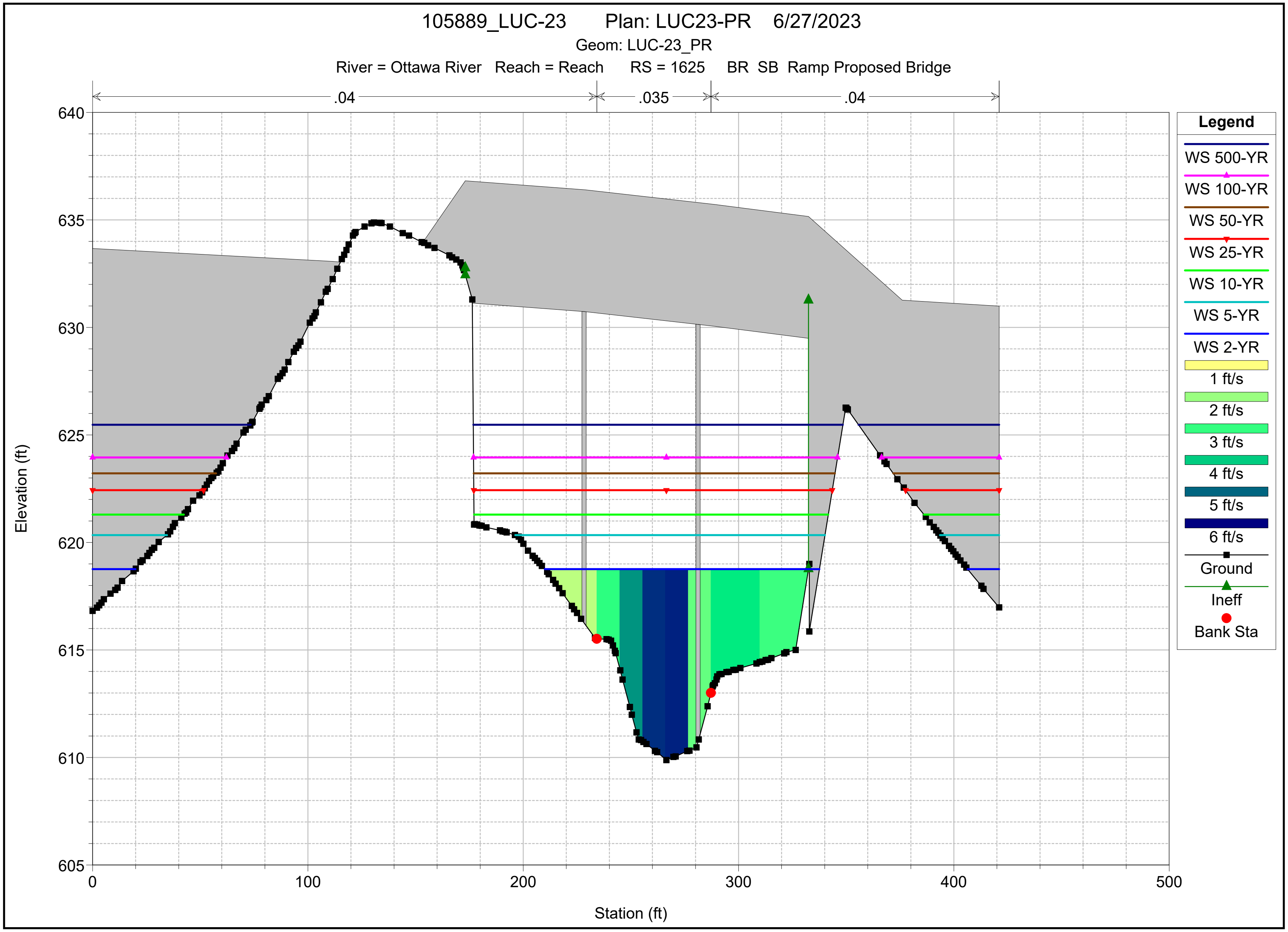

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1770
.07
.035
.07
Elevation (ft)
Station (ft)
650
645
640
635
630
625
620
615
610
0
100
200
300
400
500
600
700
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta

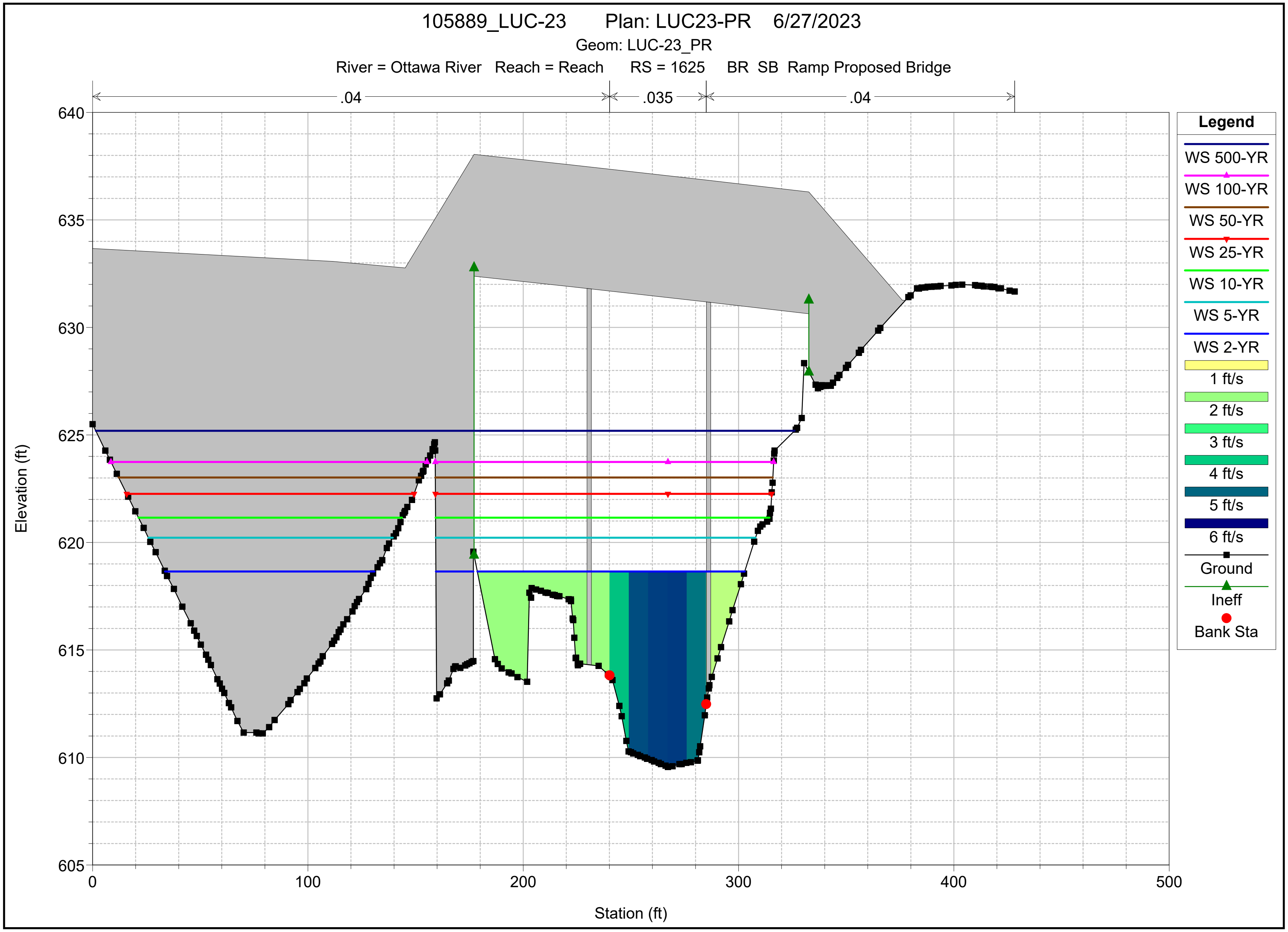


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1722
.07
.035
.07
Elevation (ft)
Station (ft)
650
645
640
635
630
625
620
615
610
0
100
200
300
400
500
600
700
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta

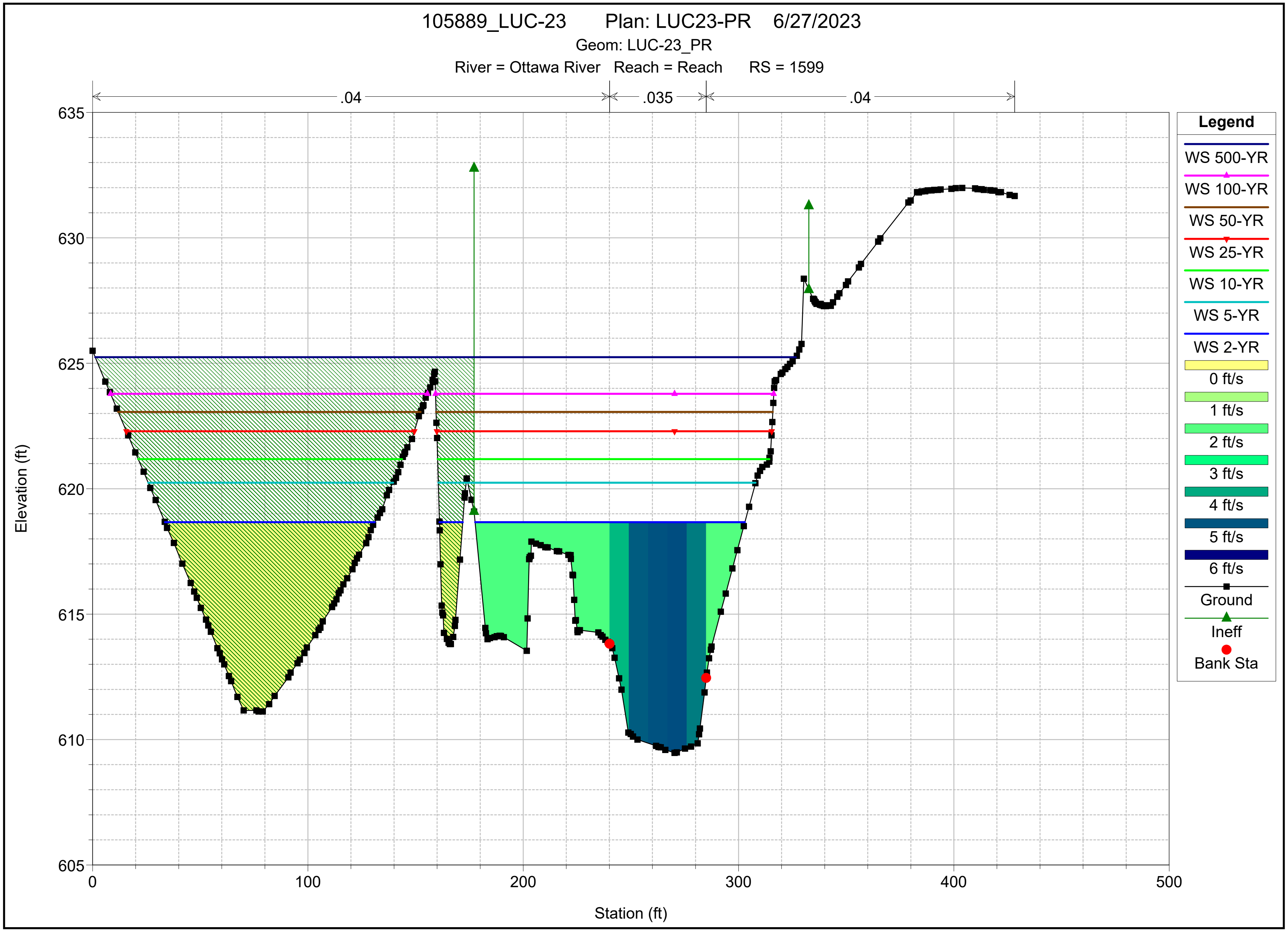


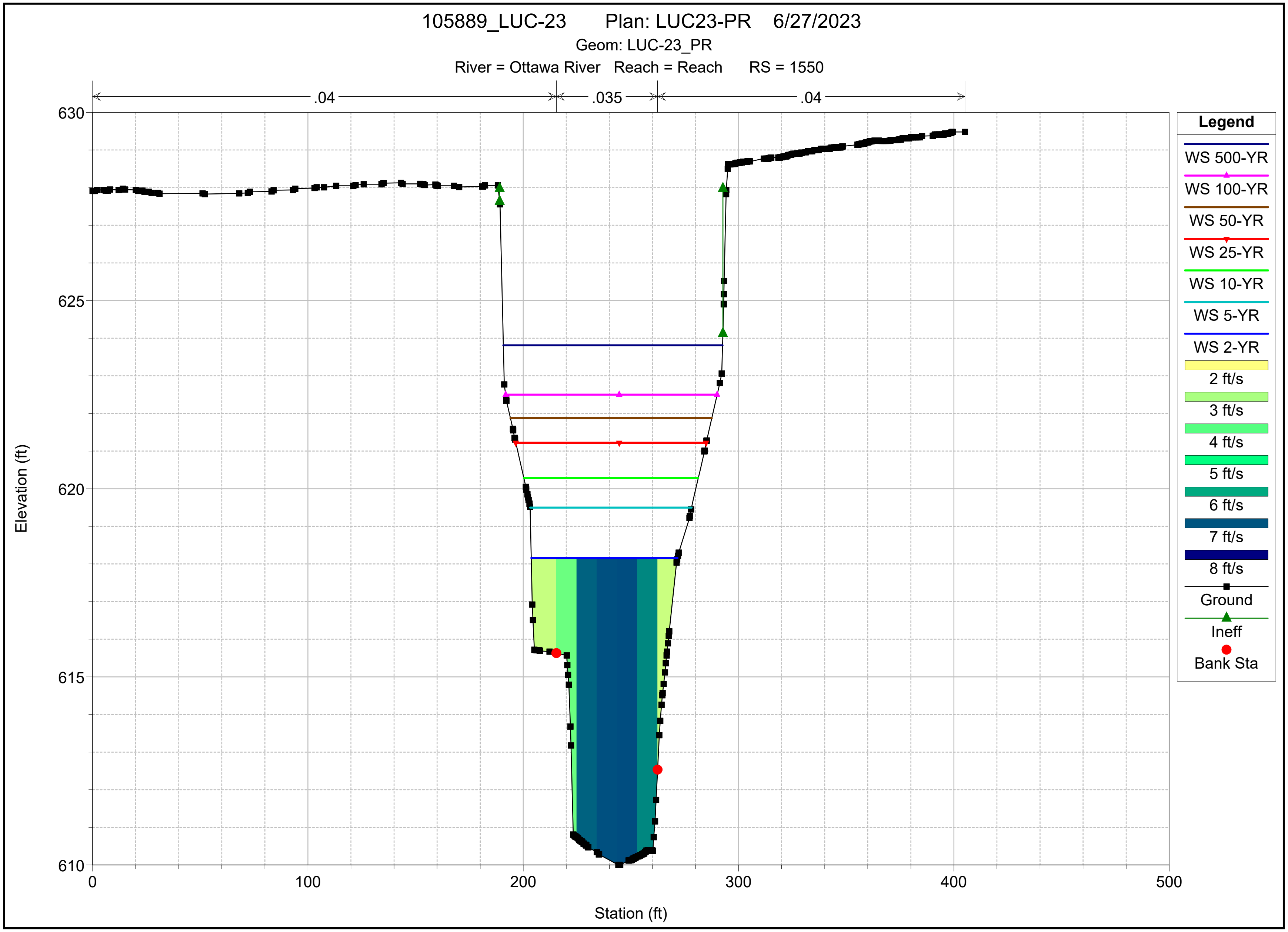
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1654
.04
.035
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
635
630
625
620
615
610
605
Station (ft)
0
100
200
300
400
500

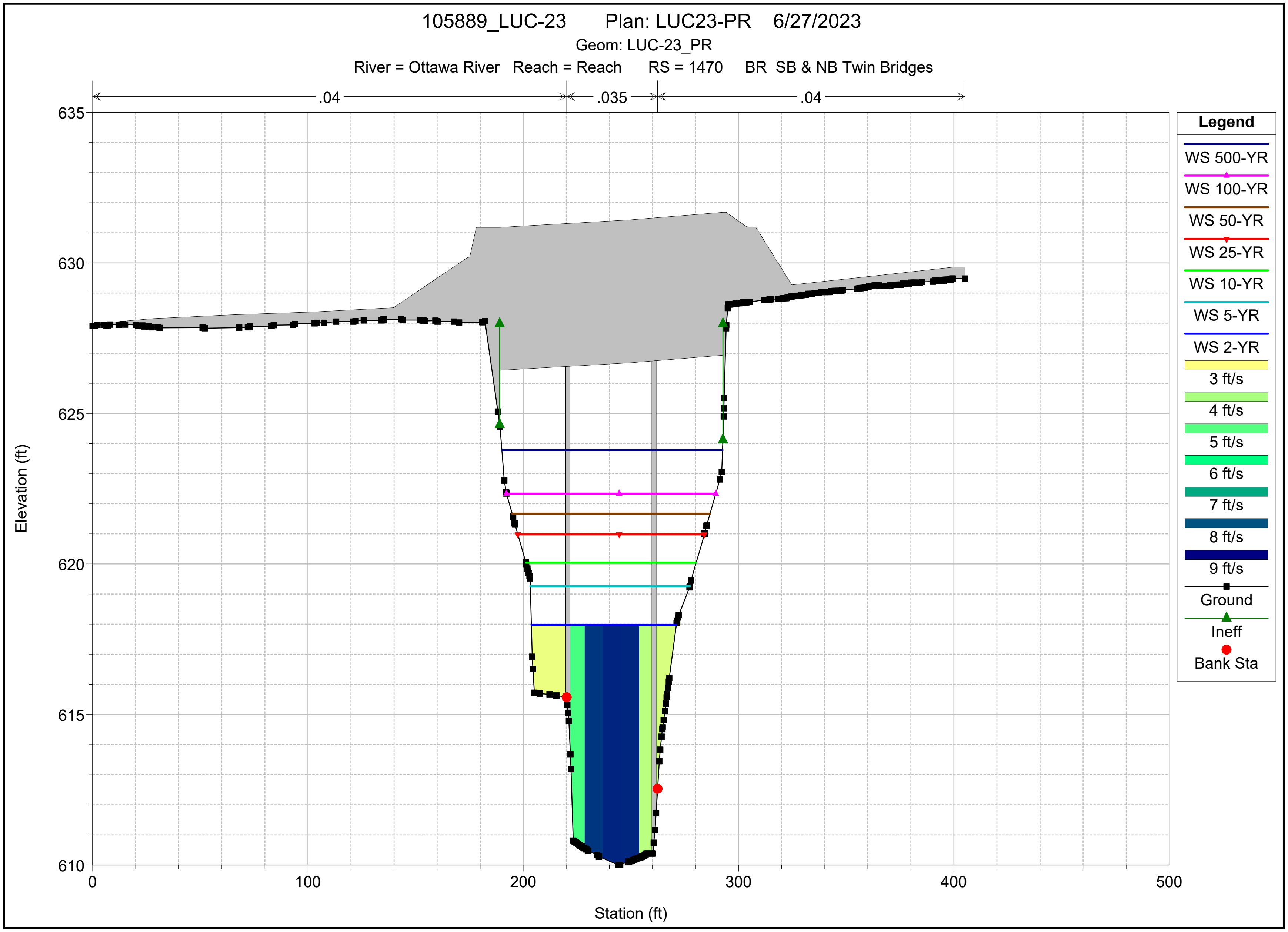

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1625 BR SB Ramp Proposed Bridge
.04
.035
.04
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta



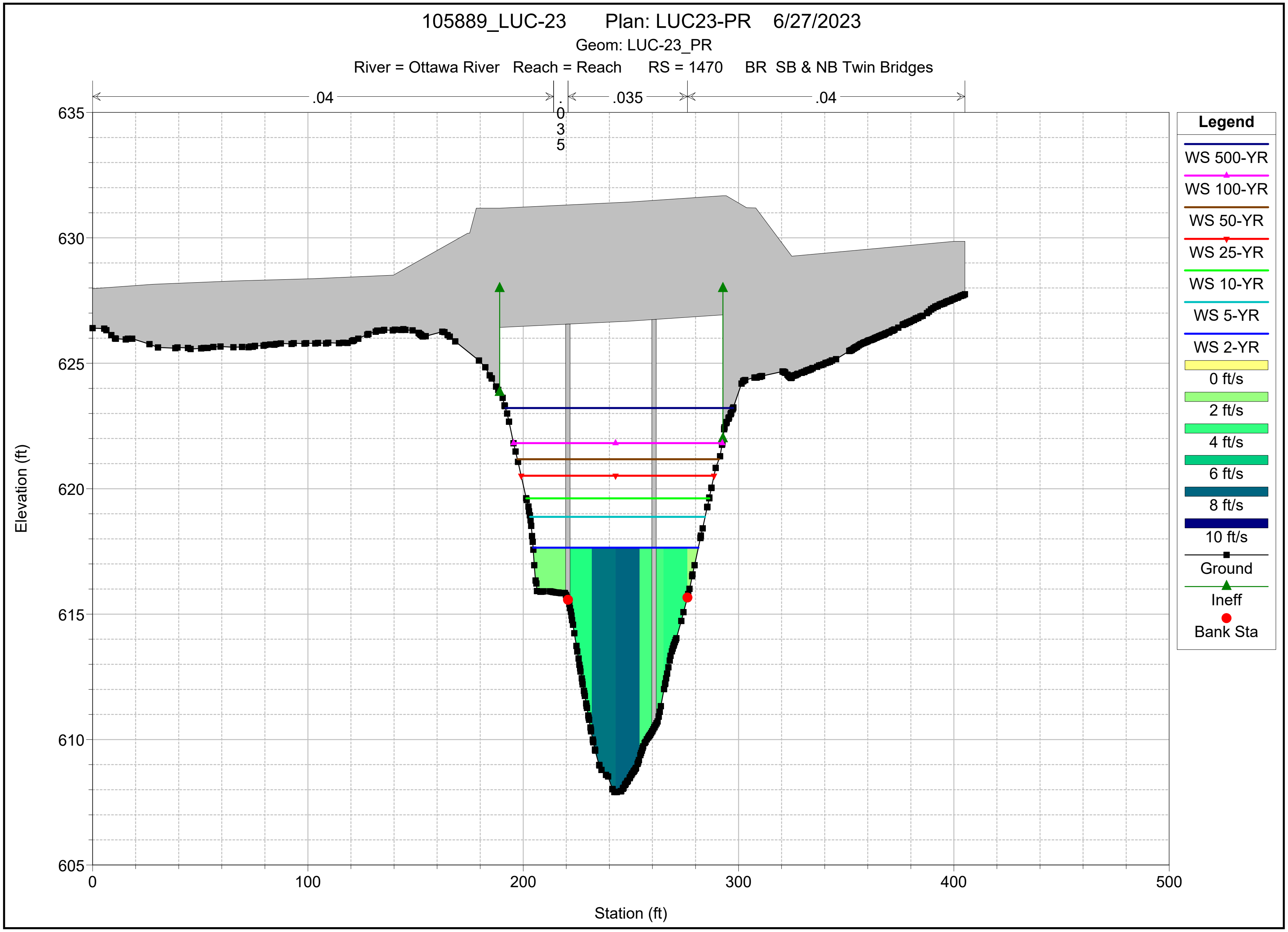
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1625 BR SB Ramp Proposed Bridge
.04
.035
.04
Elevation (ft)
Station (ft)
640
635
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1599
.04
.035
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500

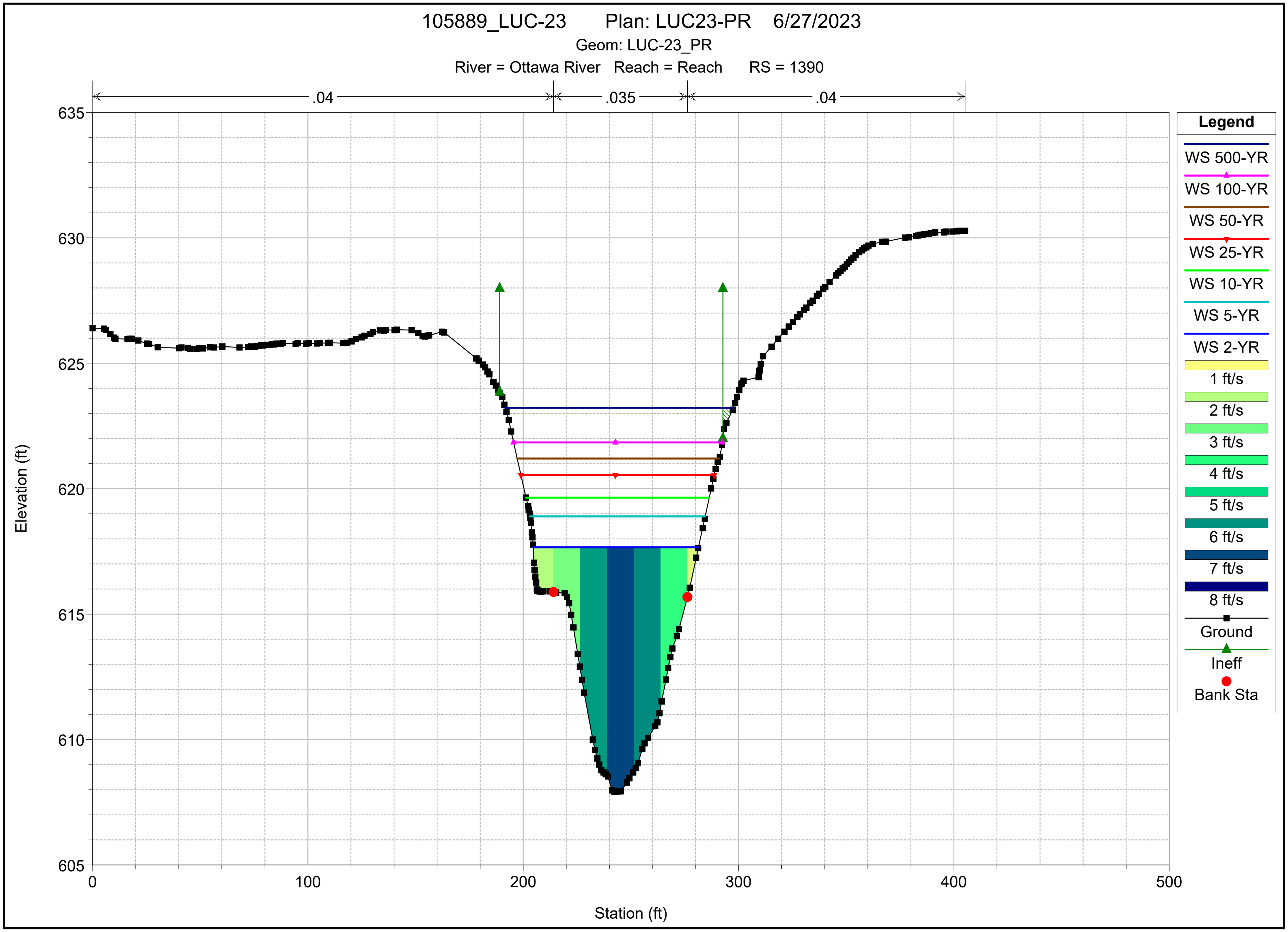

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1550
.04
.035
.04
Elevation (ft)
630
625
620
615
610
Station (ft)
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Ineff
Bank Sta

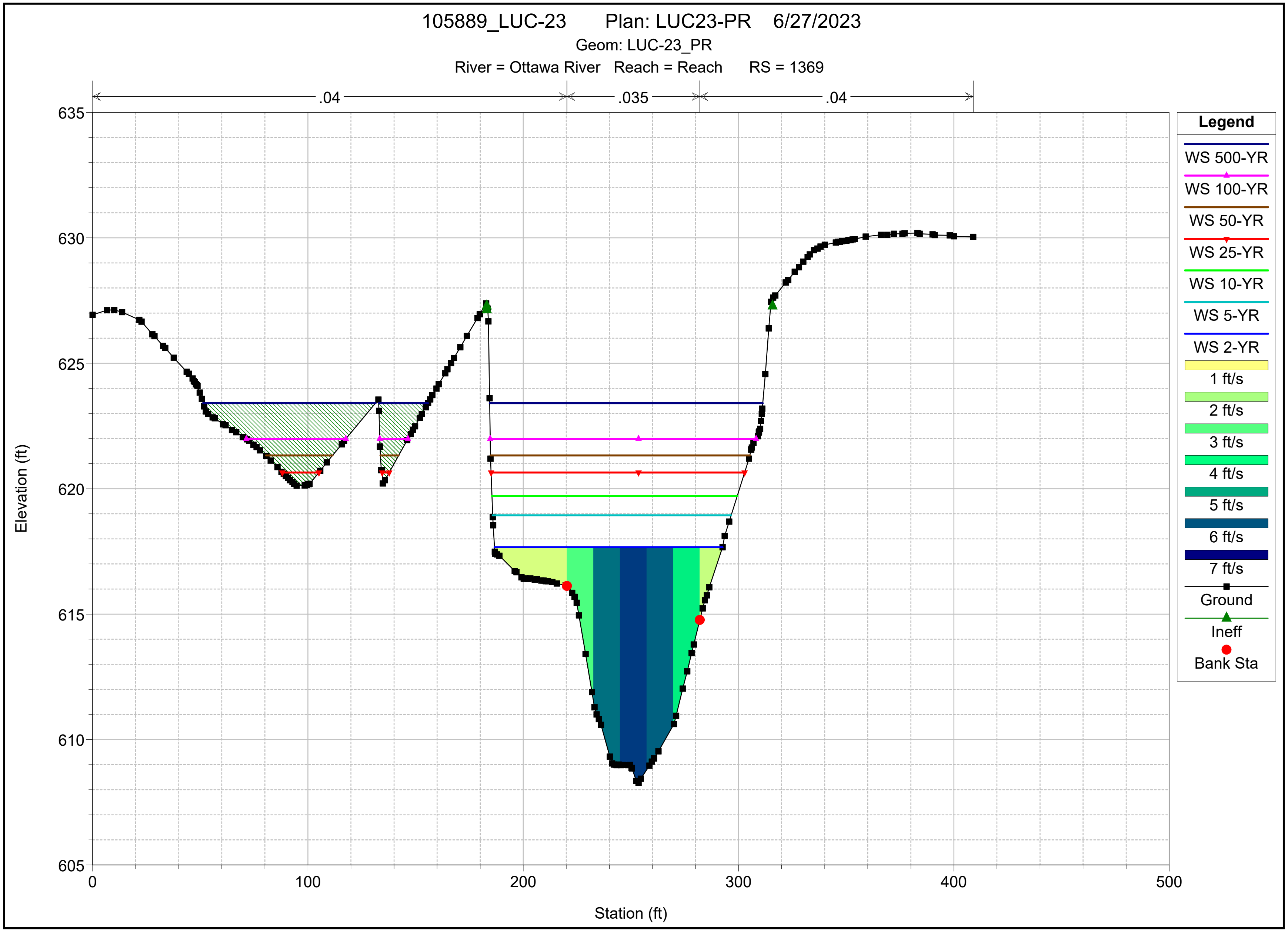


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1470 BR SB & NB Twin Bridges
.04
.035
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
635
630
625
620
615
610
0
100
200
300
400
500

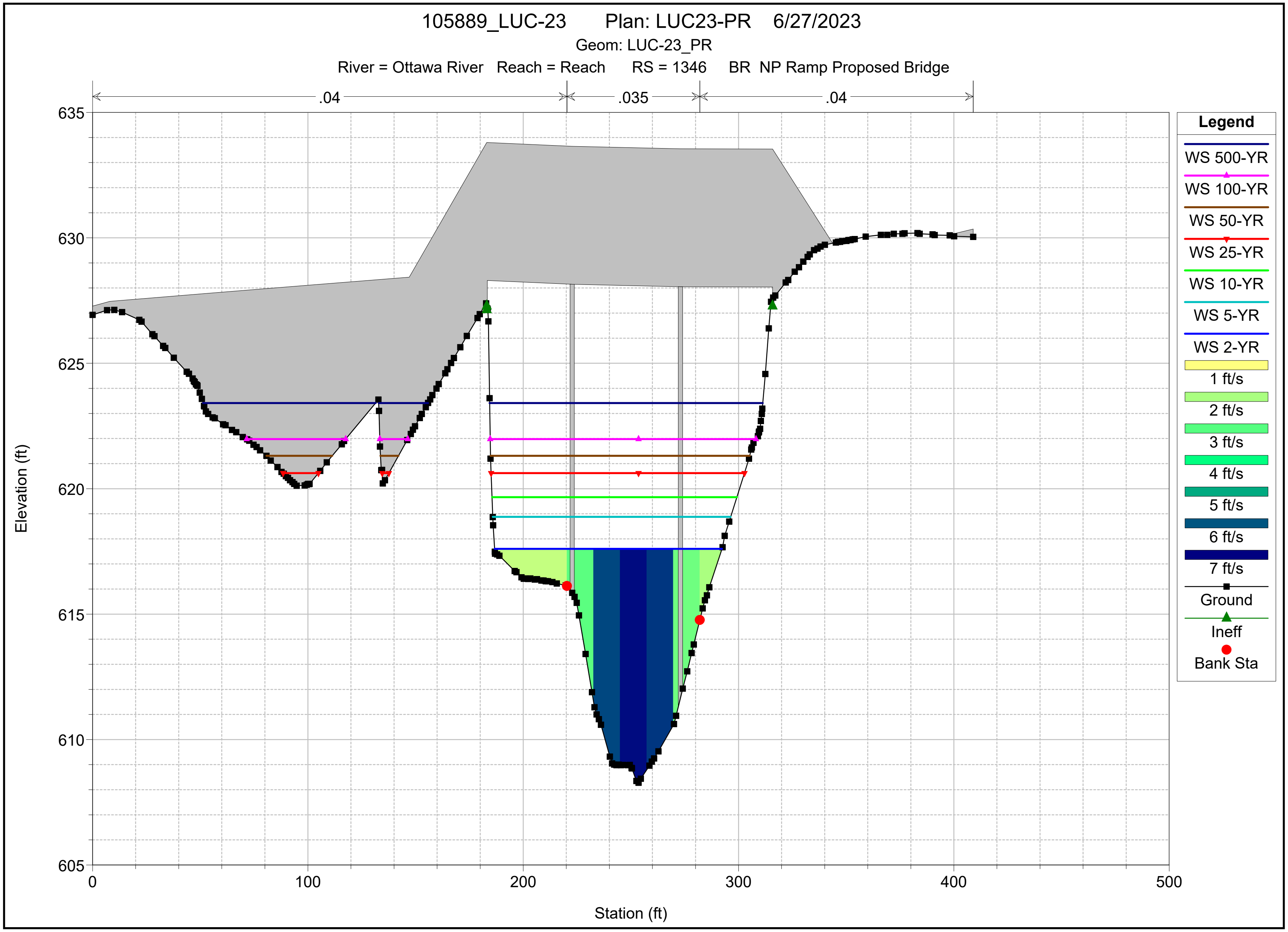


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1470 BR SB & NB Twin Bridges
.04
.035
.035
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500

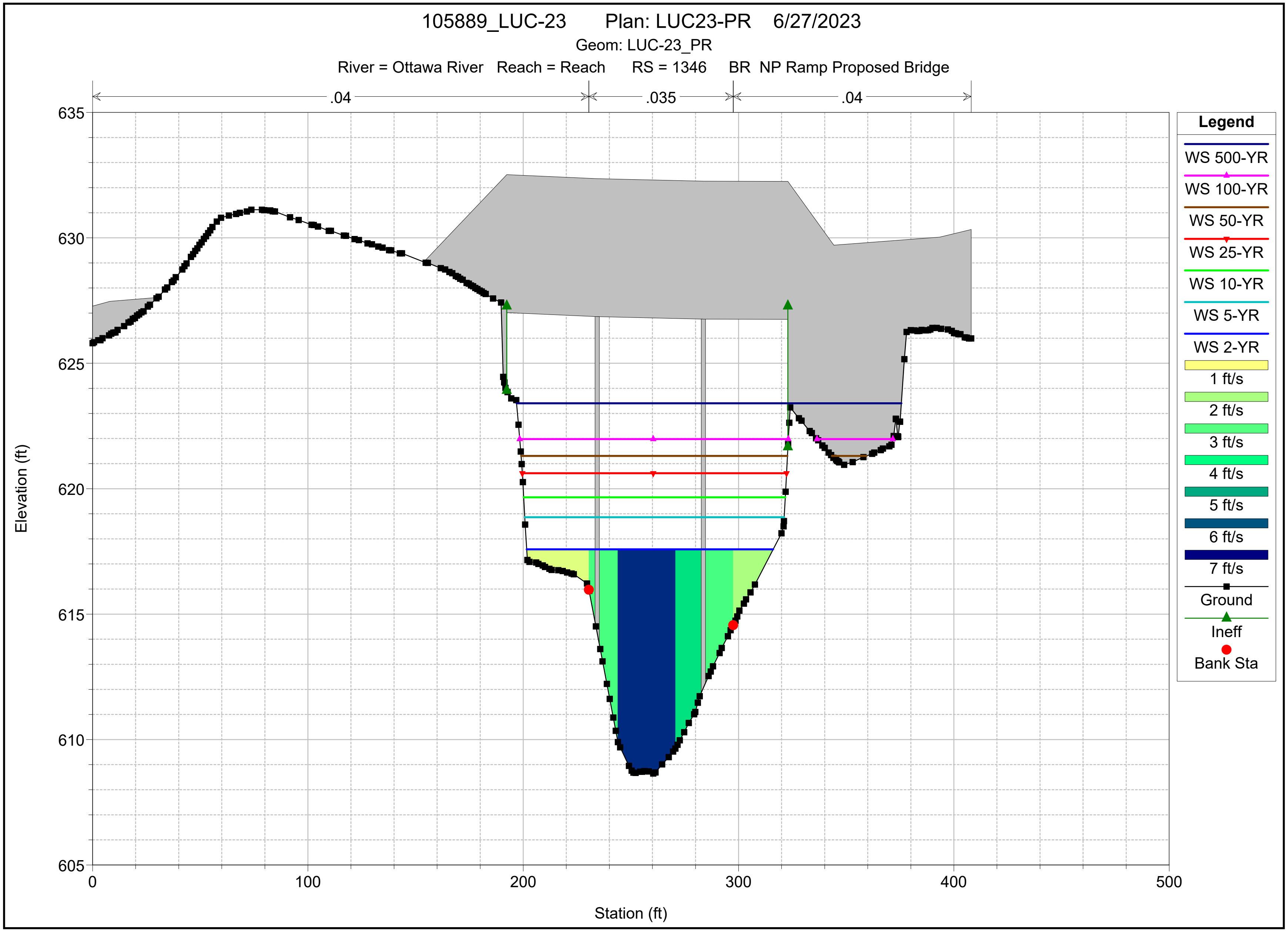

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1390
.04
.035
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500



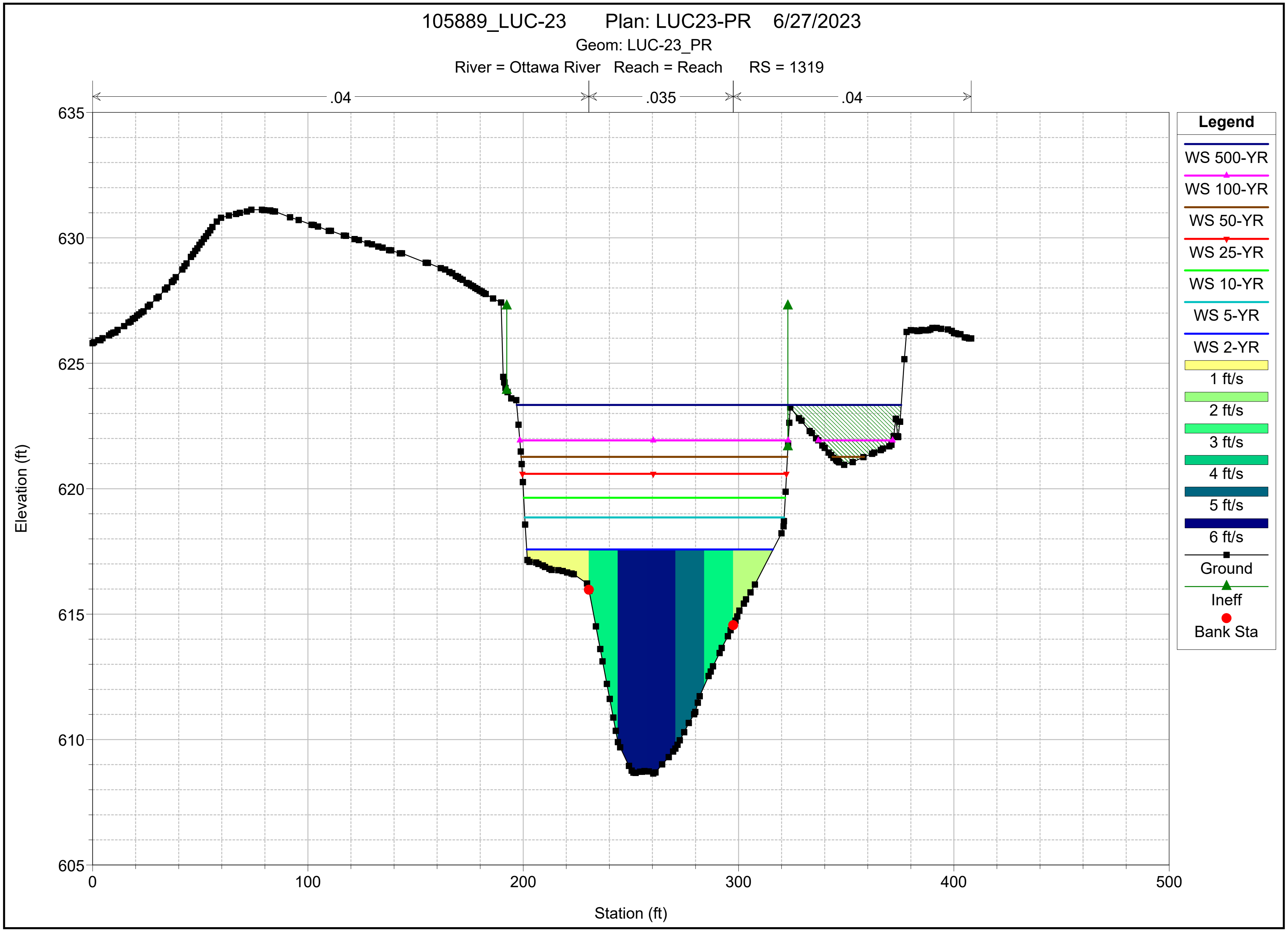
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1369
.04
.035
.04
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Ineff
Bank Sta



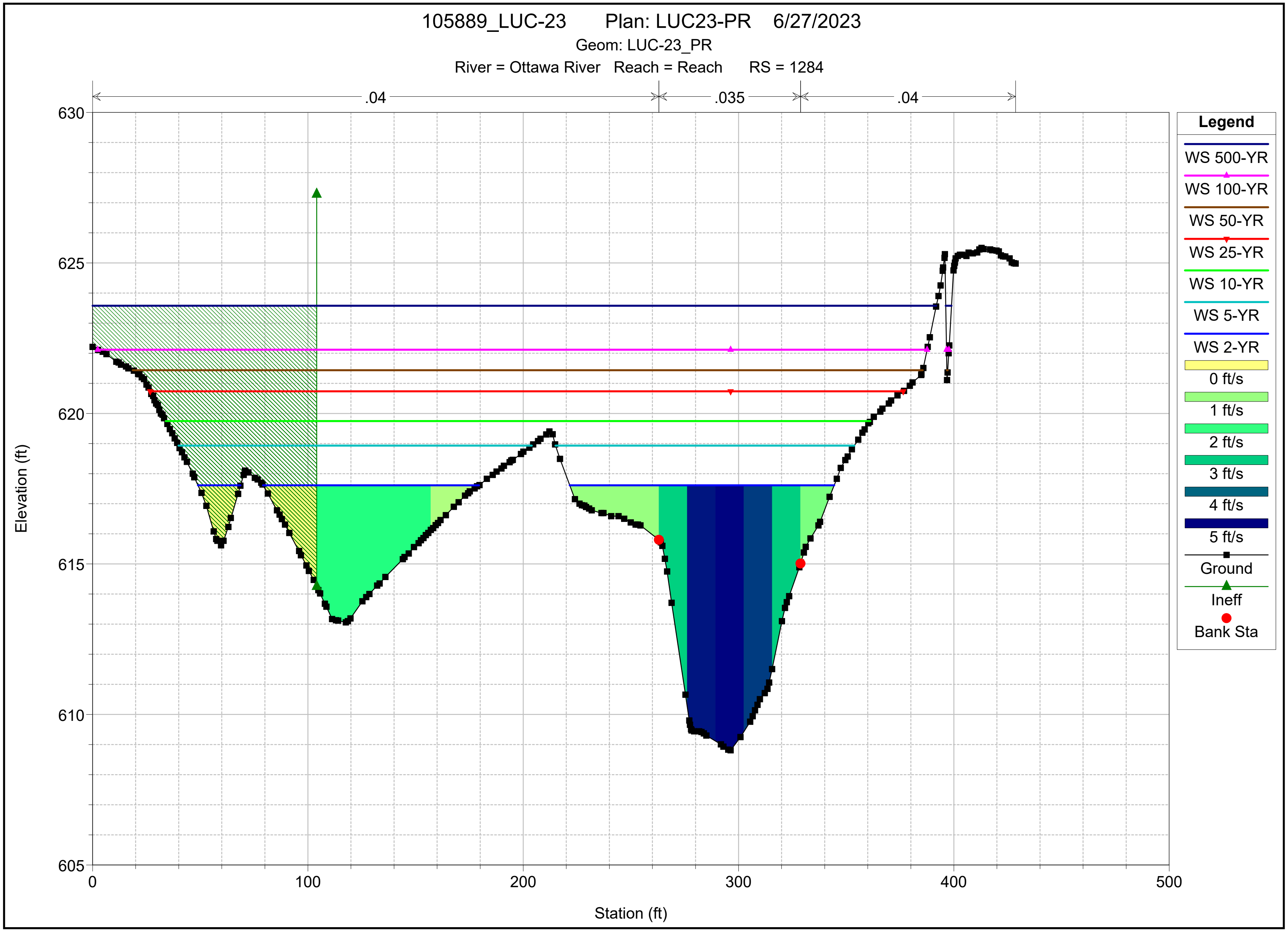
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1346 BR NP Ramp Proposed Bridge
.04
.035
.04
635
630
625
620
615
610
605
Elevation (ft)
0
100
200
300
400
500
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Ineff
Bank Sta

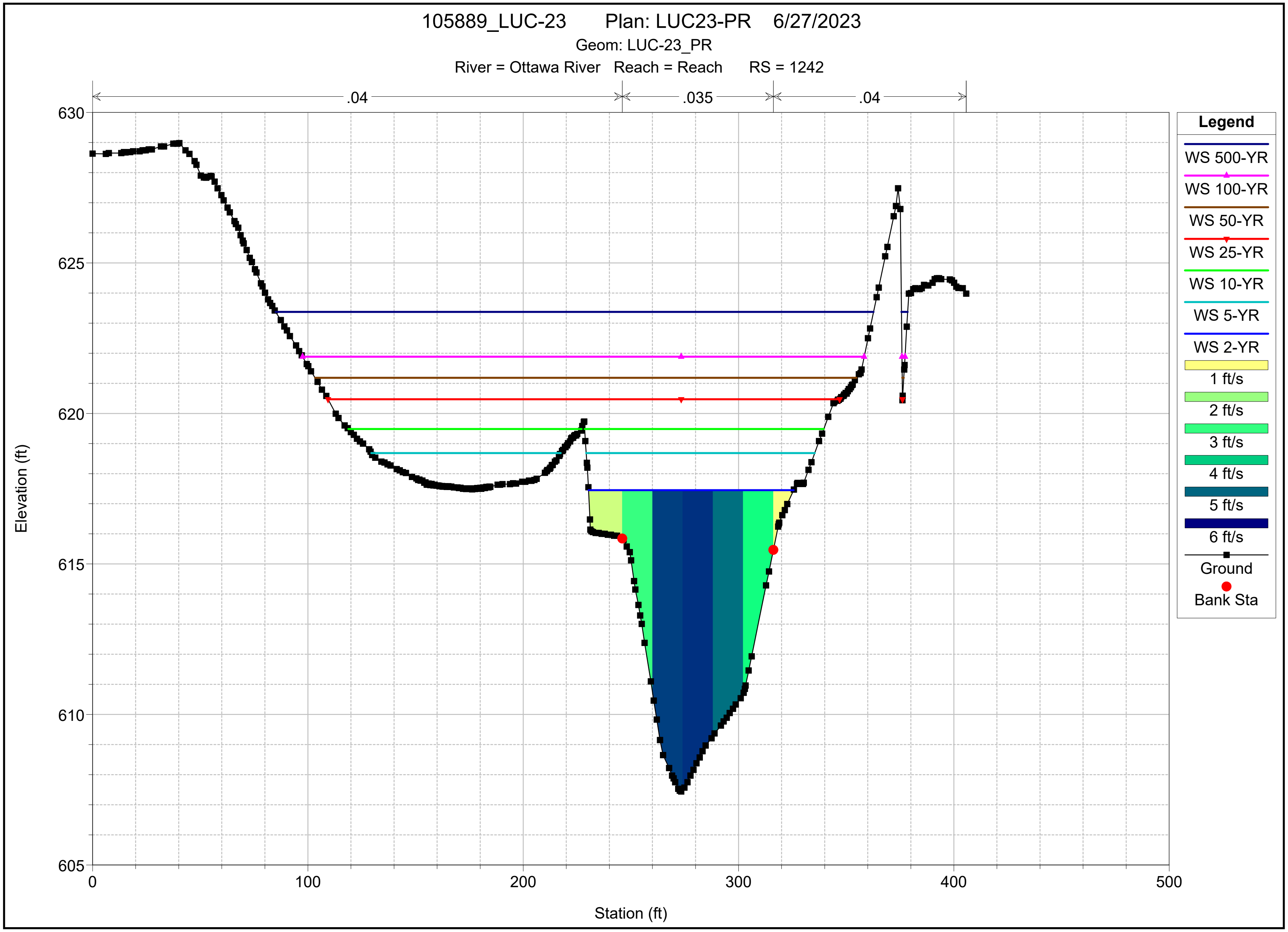


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1346 BR NP Ramp Proposed Bridge
.04
.035
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500

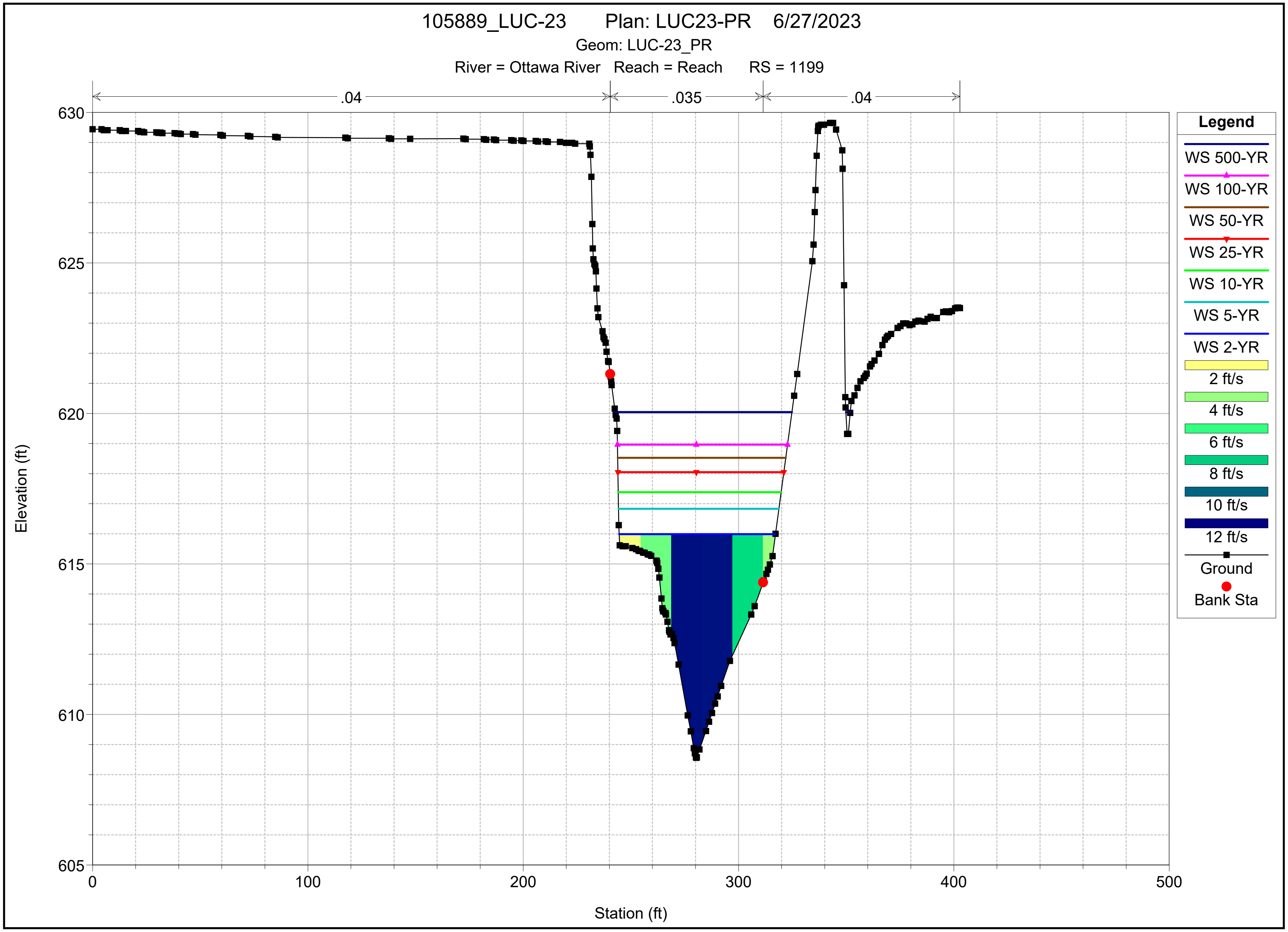


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1319
.04
.035
.04
Elevation (ft)
Station (ft)
635
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta

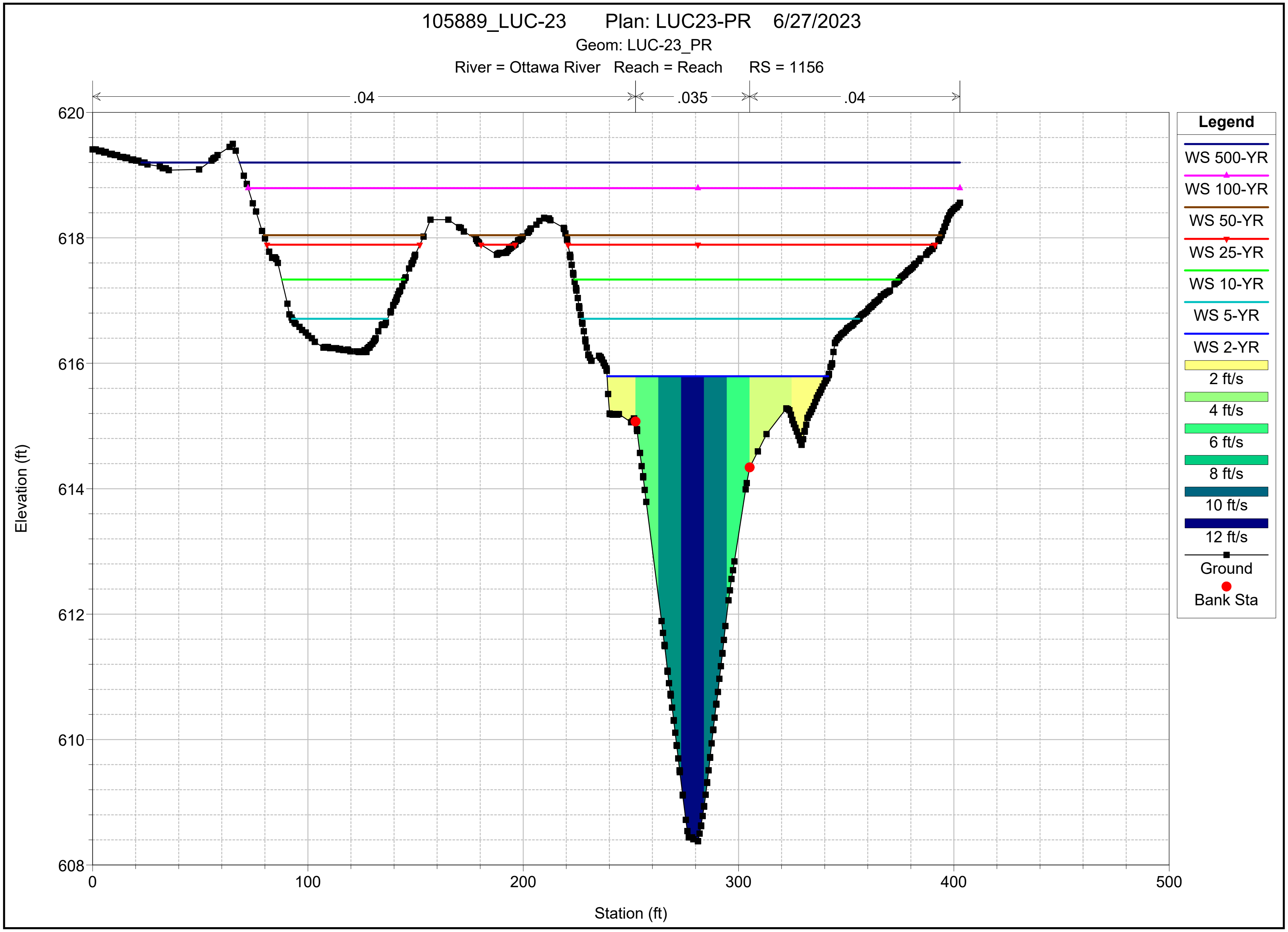

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1284
.04
.035
.04
Elevation (ft)
Station (ft)
630
625
620
615
610
605
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta

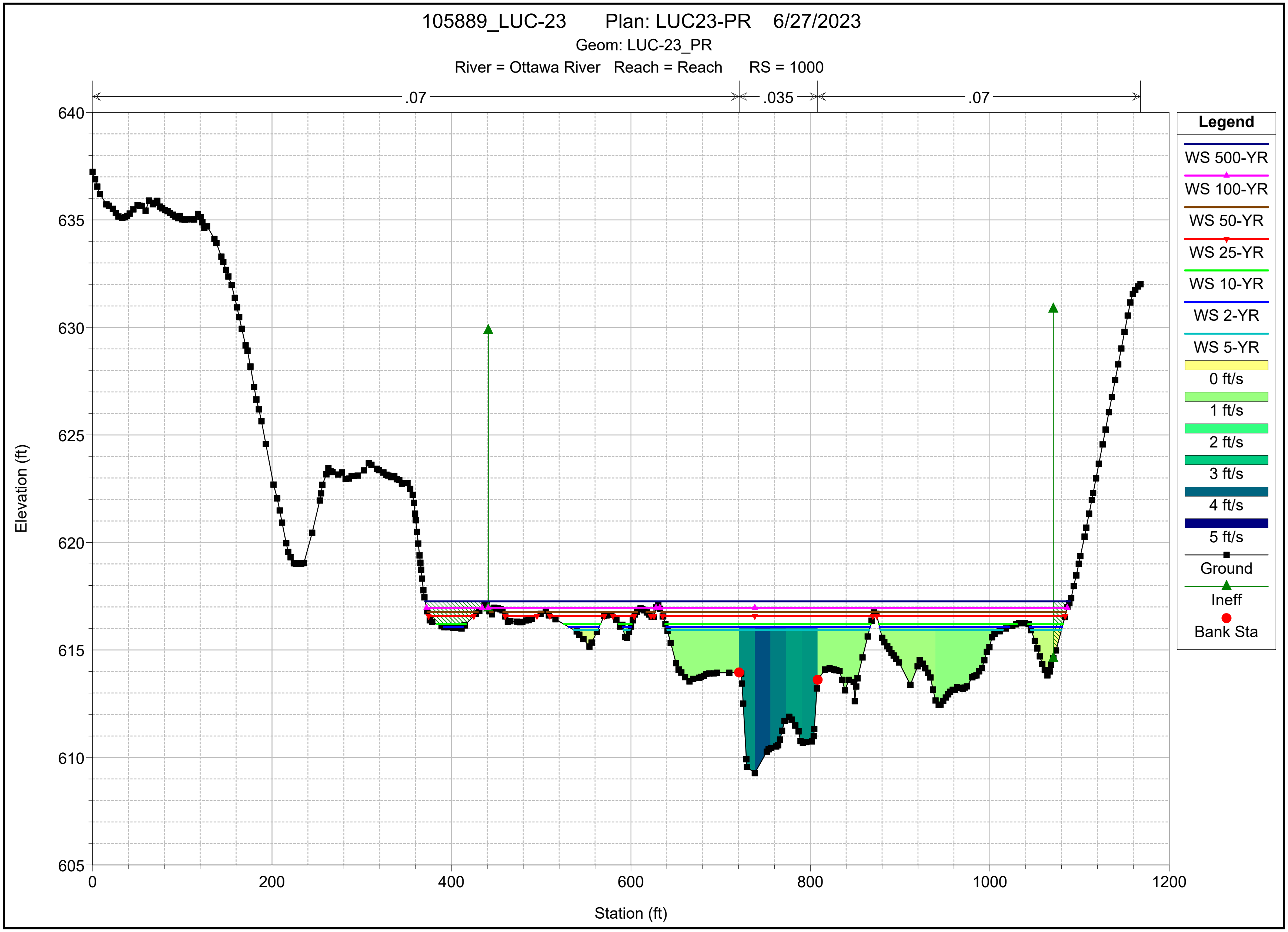


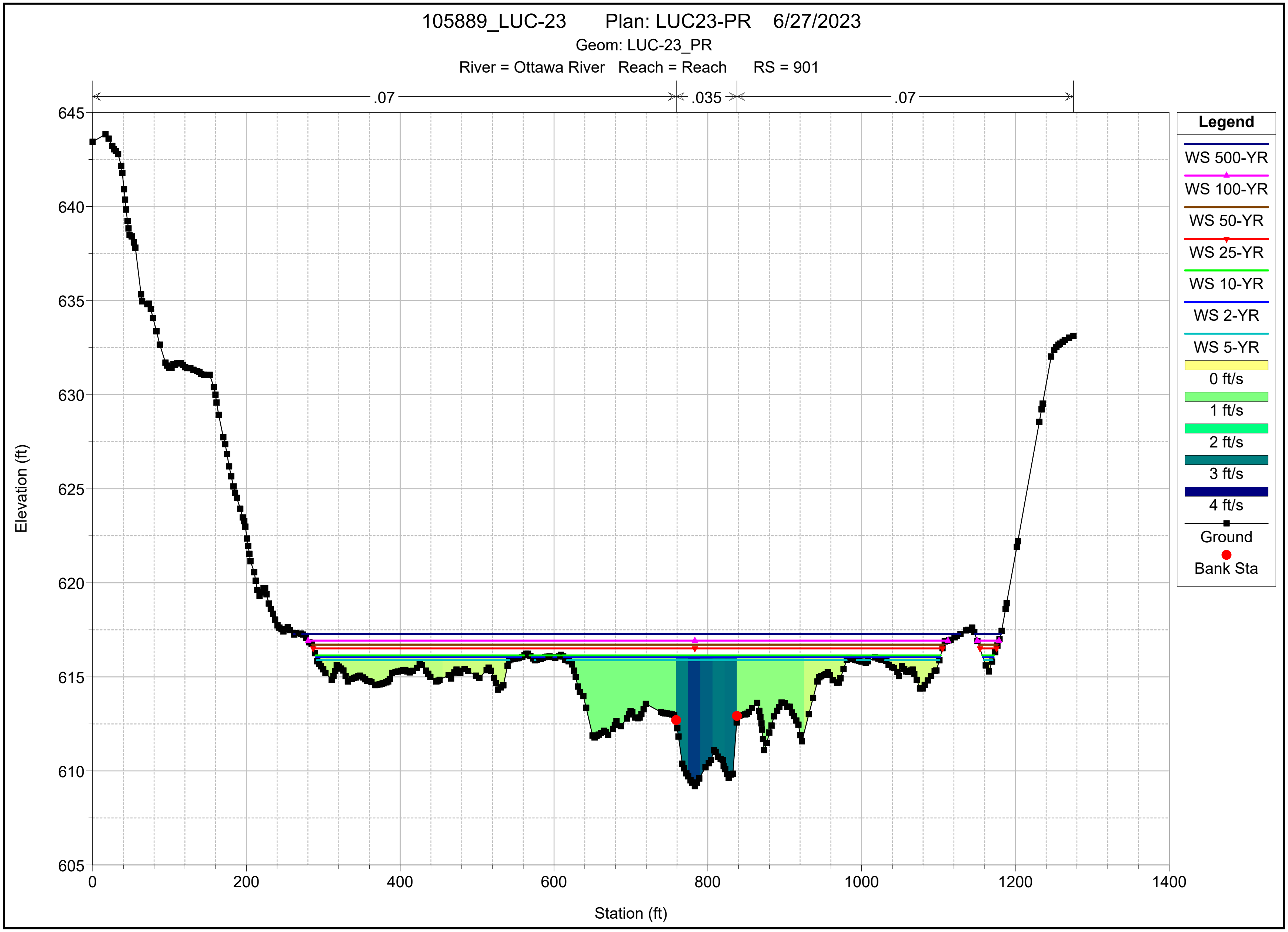
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1242
.04
.035
.04
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
630
625
620
615
610
605
0
100
200
300
400
500



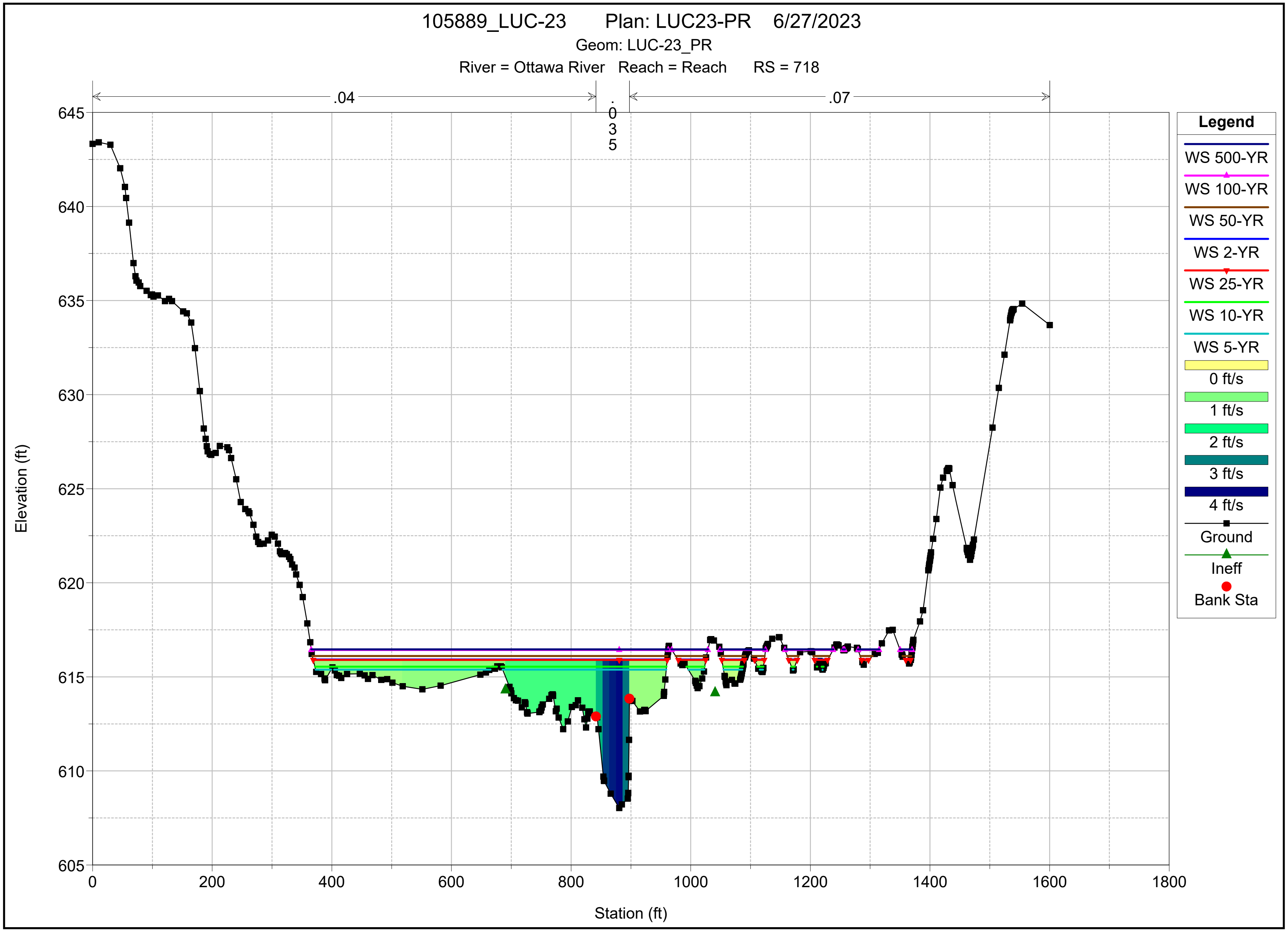
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1199
.04
.035
.04
Elevation (ft)
630
625
620
615
610
605
Station (ft)
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta

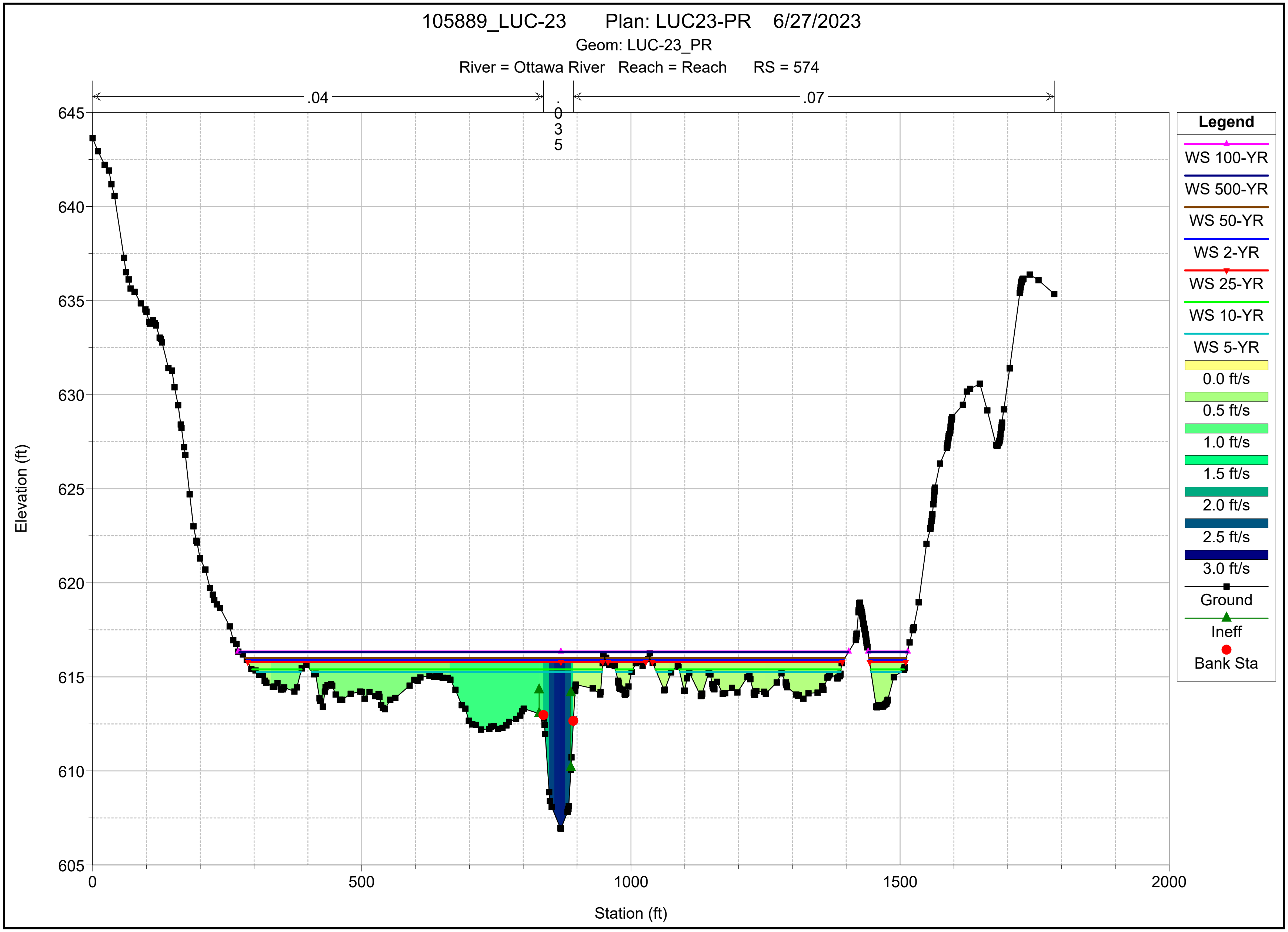

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1156
.04
.035
.04
Elevation (ft)
620
618
616
614
612
610
608
Station (ft)
0
100
200
300
400
500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta

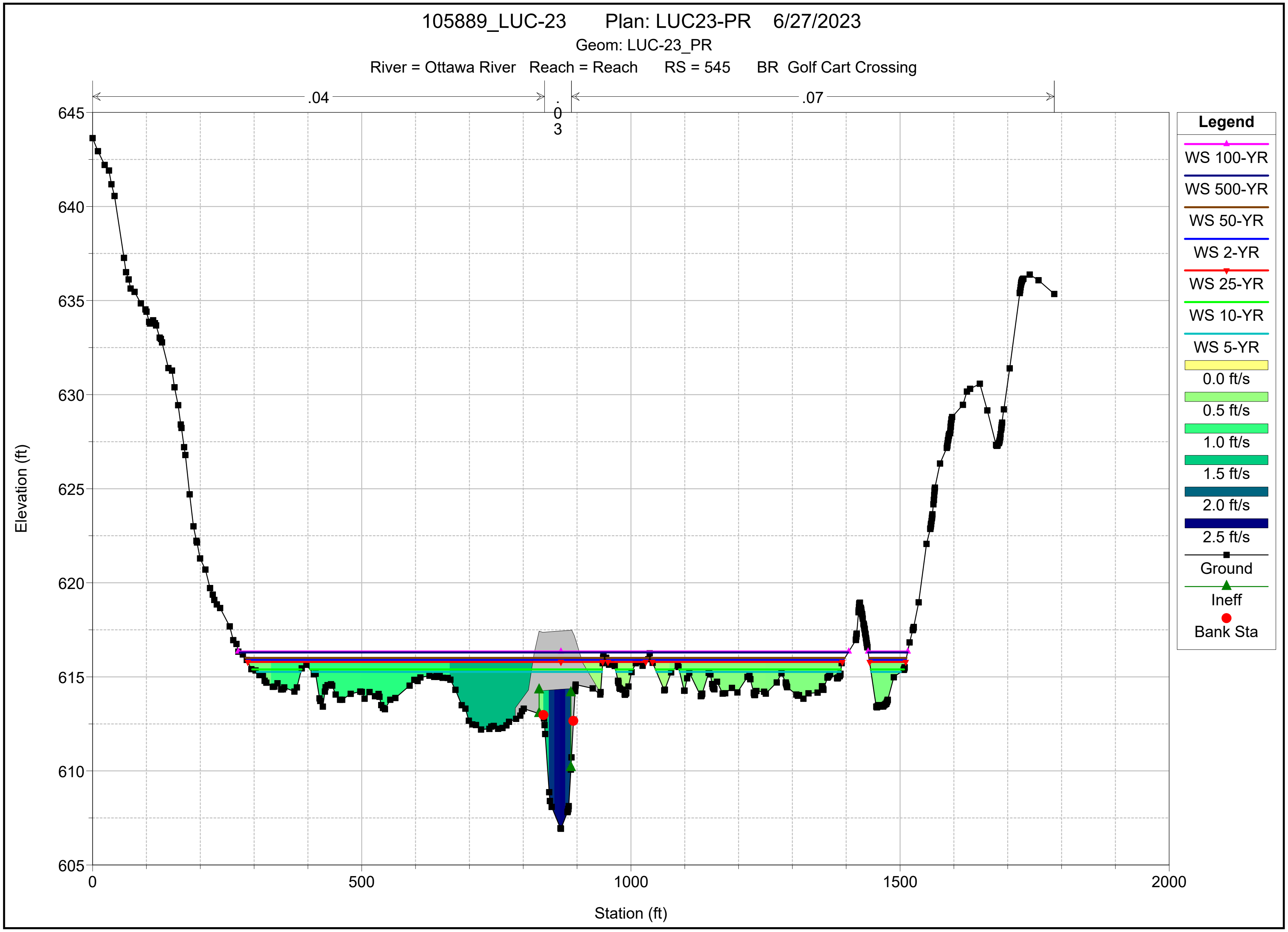

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 1000
.07
.035
.07
Elevation (ft)
Station (ft)
640
635
630
625
620
615
610
605
0
200
400
600
800
1000
1200
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 2-YR
WS 5-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta



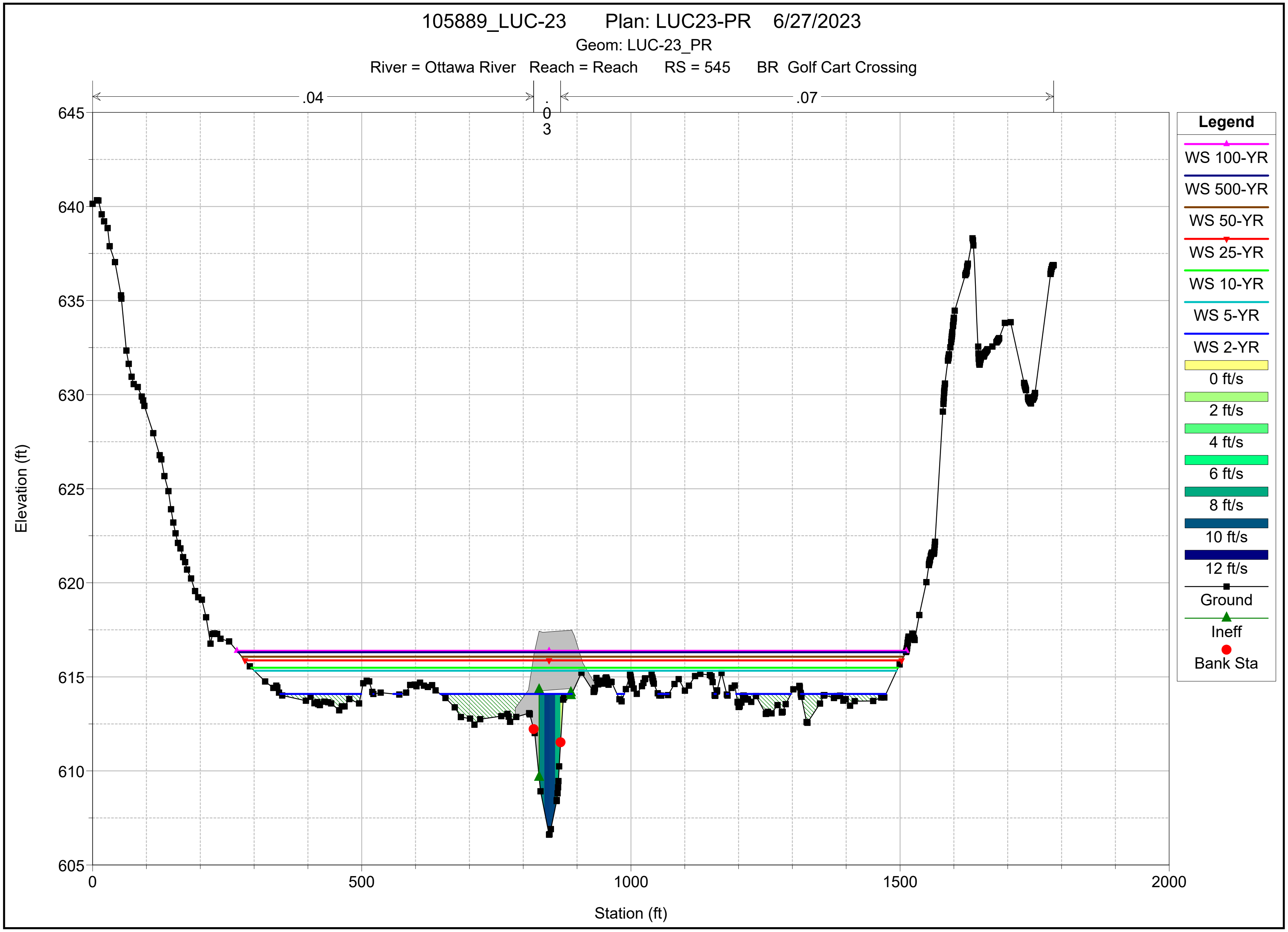
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 901
.07
.035
.07
Elevation (ft)
645
640
635
630
625
620
615
610
605
Station (ft)
0
200
400
600
800
1000
1200
1400
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 2-YR
WS 5-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Bank Sta


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 718
.04
.035
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
200
400
600
800
1000
1200
1400
1600
1800
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 2-YR
WS 25-YR
WS 10-YR
WS 5-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Ineff
Bank Sta

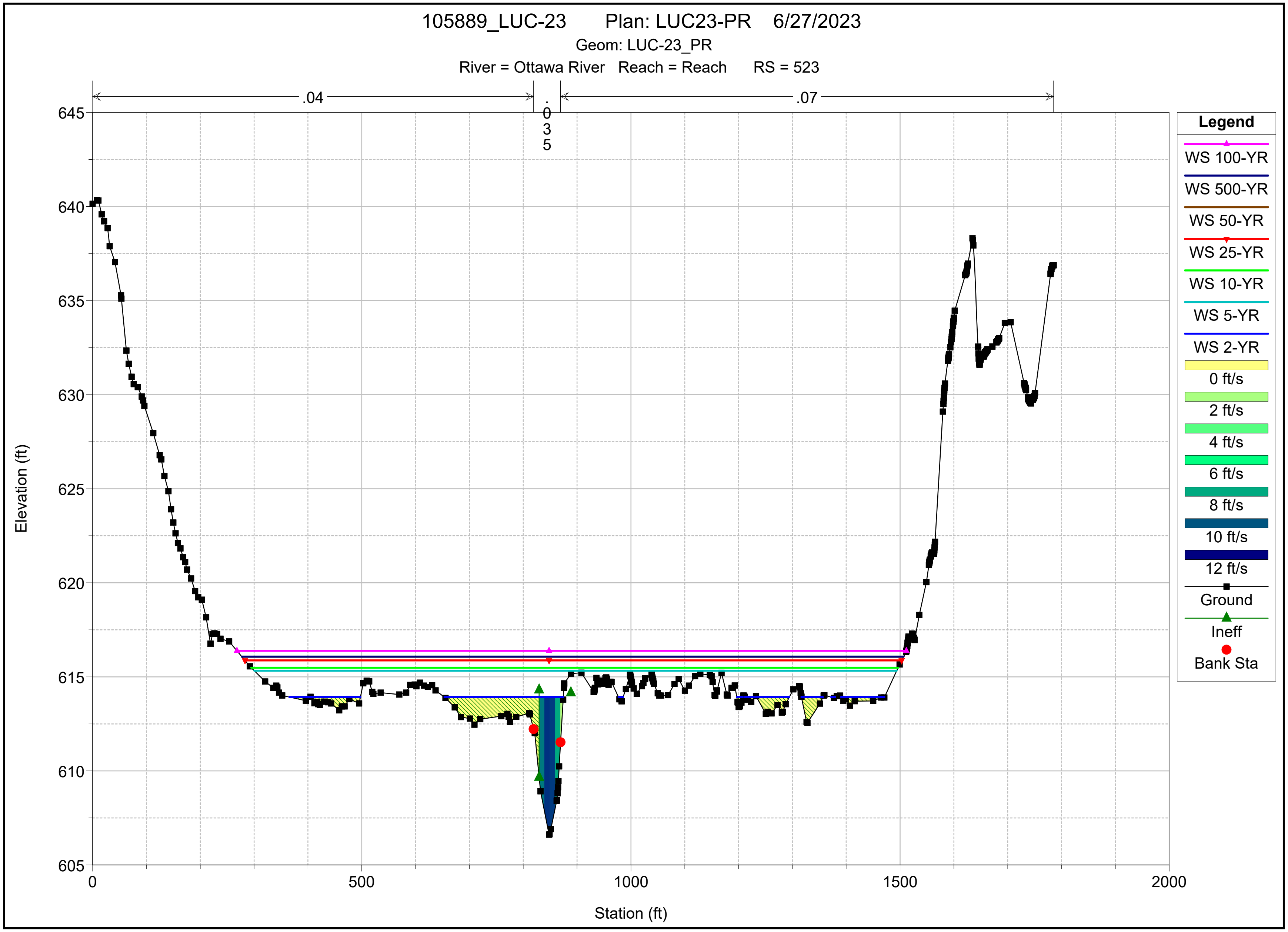

105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 574
.04
.035
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
Legend
WS 100-YR
WS 500-YR
WS 50-YR
WS 2-YR
WS 25-YR
WS 10-YR
WS 5-YR
0.0 ft/s
0.5 ft/s
1.0 ft/s
1.5 ft/s
2.0 ft/s
2.5 ft/s
3.0 ft/s
Ground
Ineff
Bank Sta

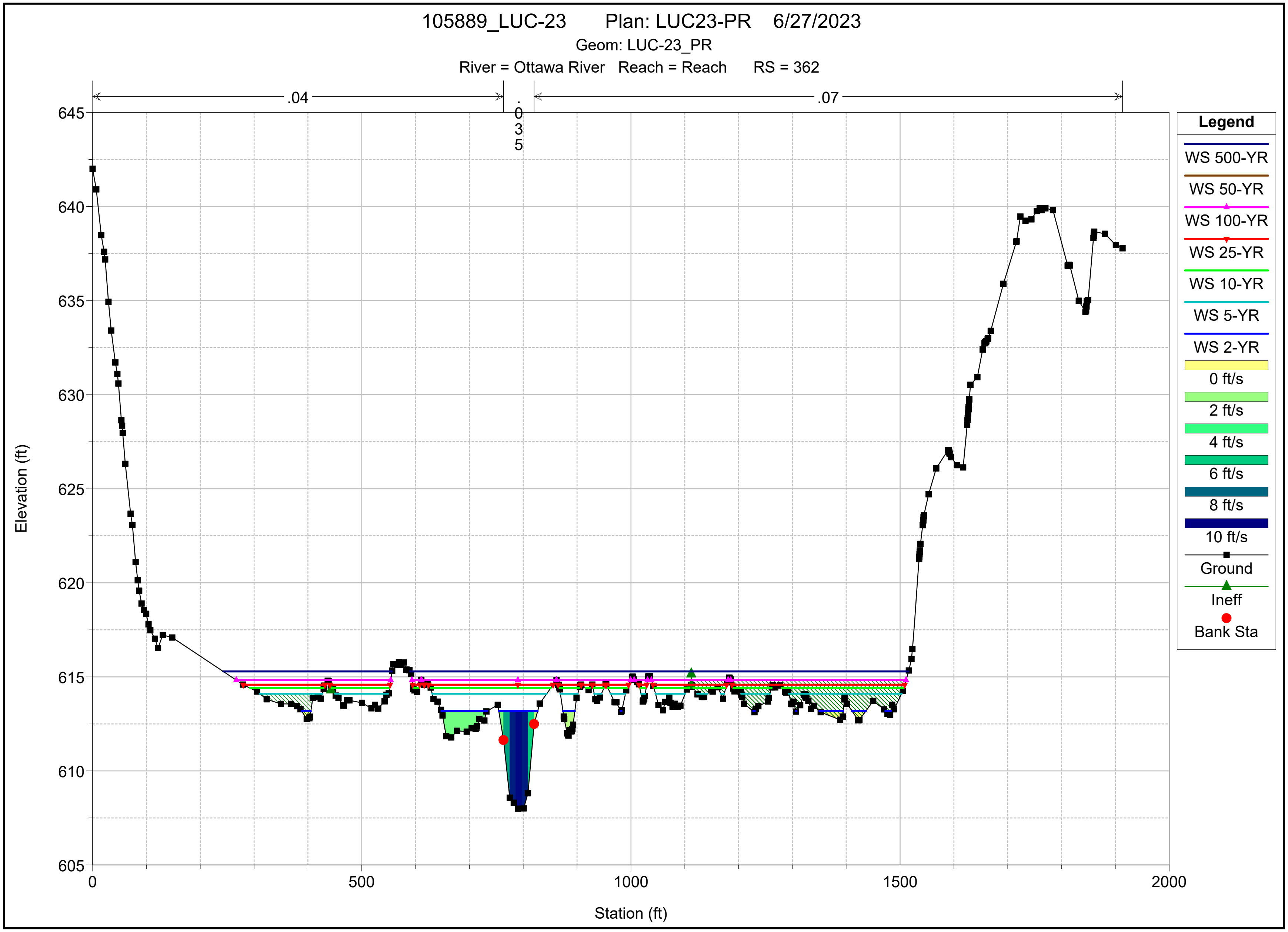


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 545 BR Golf Cart Crossing
.04
.
0
3
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
Legend
WS 100-YR
WS 500-YR
WS 50-YR
WS 2-YR
WS 25-YR
WS 10-YR
WS 5-YR
0.0 ft/s
0.5 ft/s
1.0 ft/s
1.5 ft/s
2.0 ft/s
2.5 ft/s
Ground
Ineff
Bank Sta

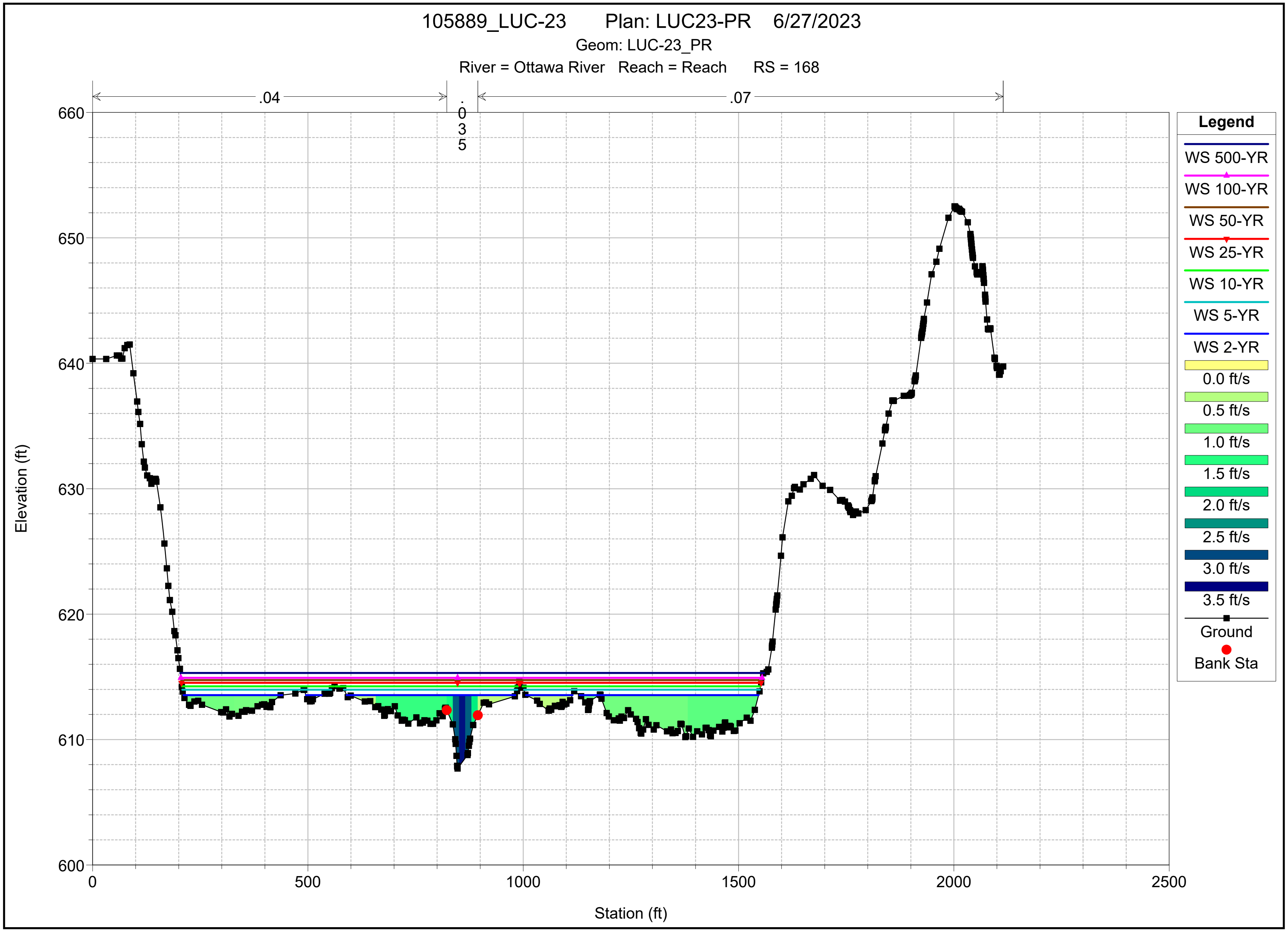


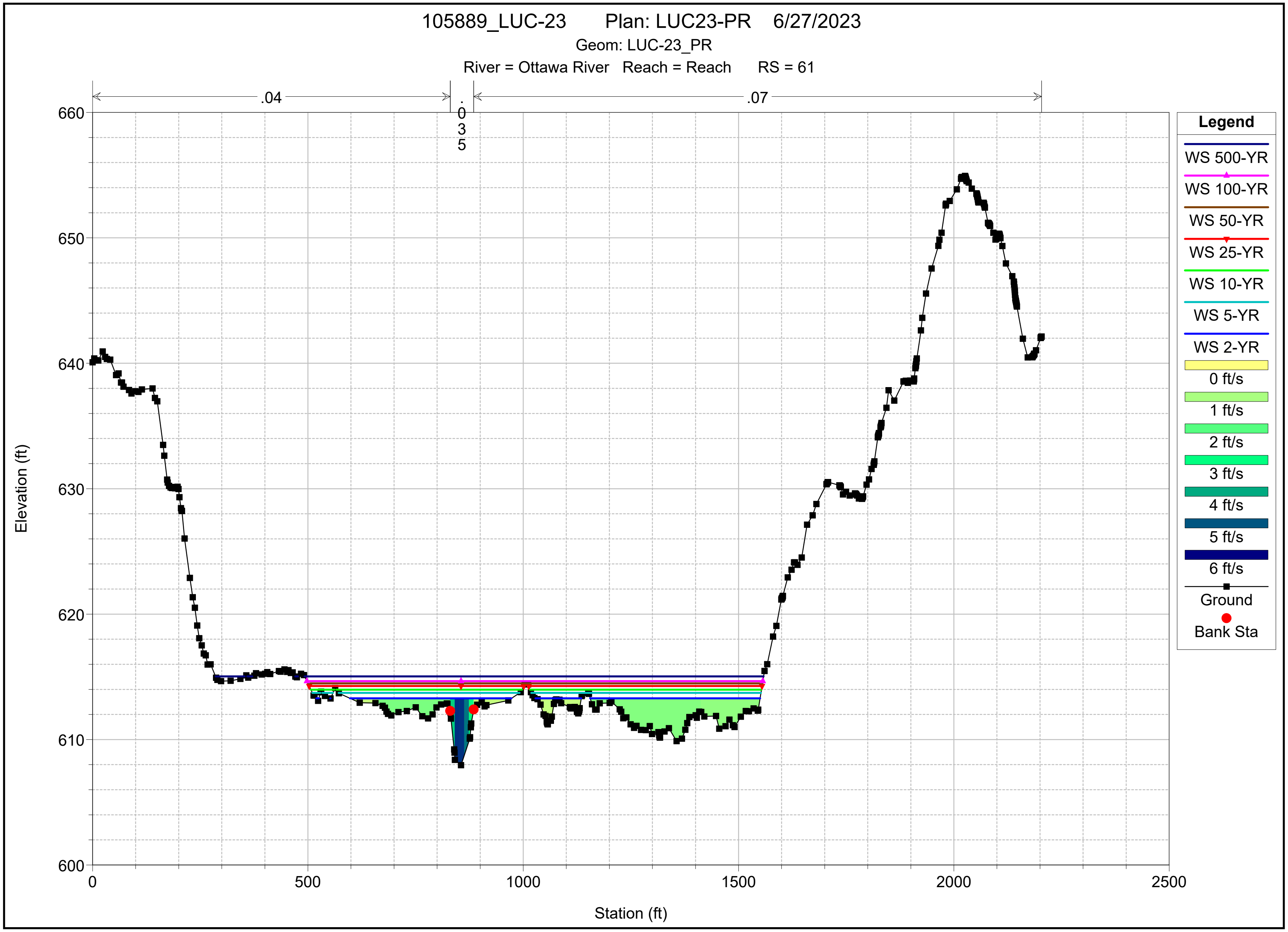
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 545 BR Golf Cart Crossing
.04
.03
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
Legend
WS 100-YR
WS 500-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Ineff
Bank Sta


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 523
.04
.035
.07
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
Legend
WS 100-YR
WS 500-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Ineff
Bank Sta



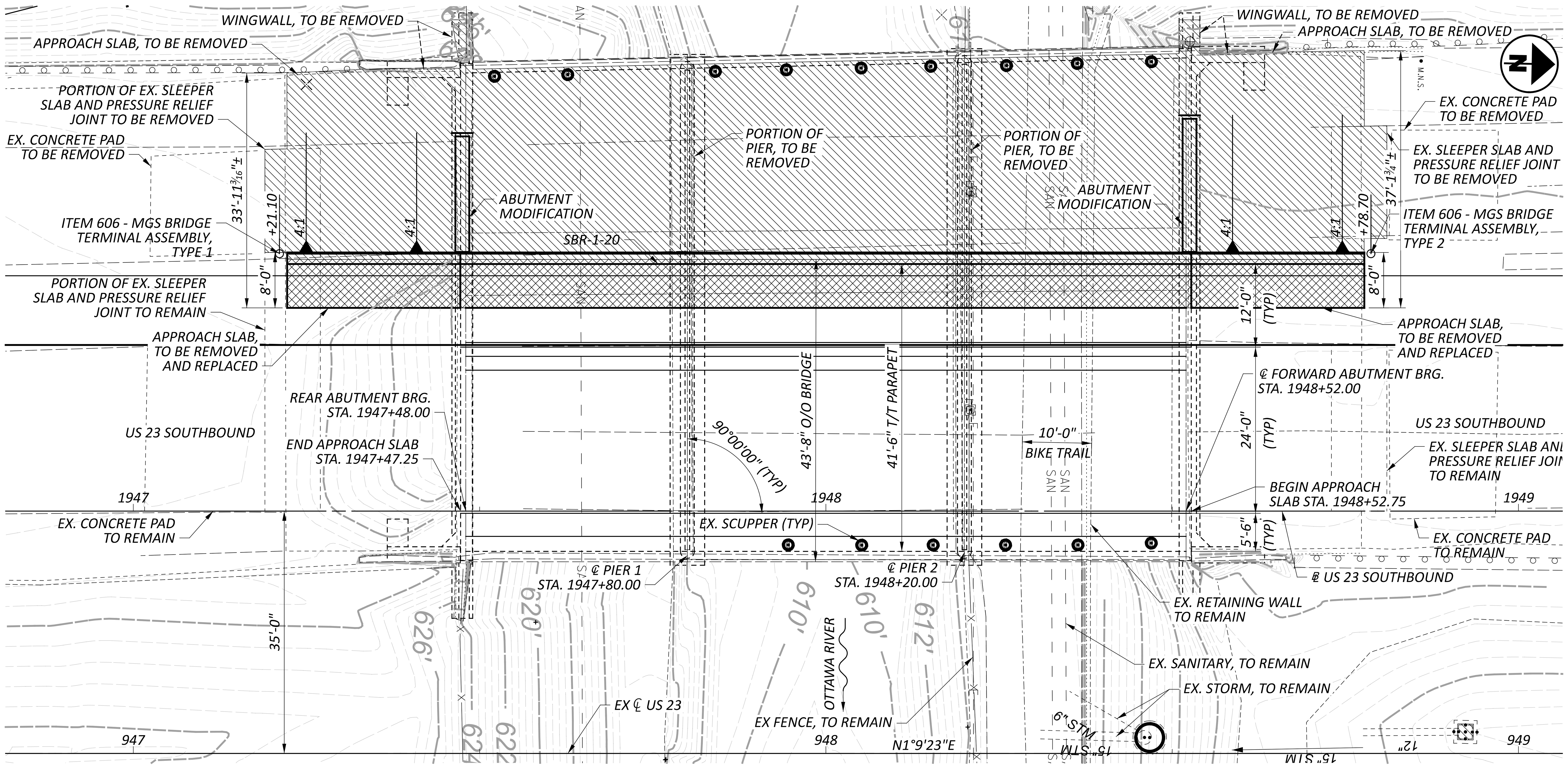
105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 362
.04
.035
.07
Legend
WS 500-YR
WS 50-YR
WS 100-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
645
640
635
630
625
620
615
610
605
0
500
1000
1500
2000


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 168
.04
.035
.07
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0.0 ft/s
0.5 ft/s
1.0 ft/s
1.5 ft/s
2.0 ft/s
2.5 ft/s
3.0 ft/s
3.5 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
600
610
620
630
640
650
660
0
500
1000
1500
2000
2500

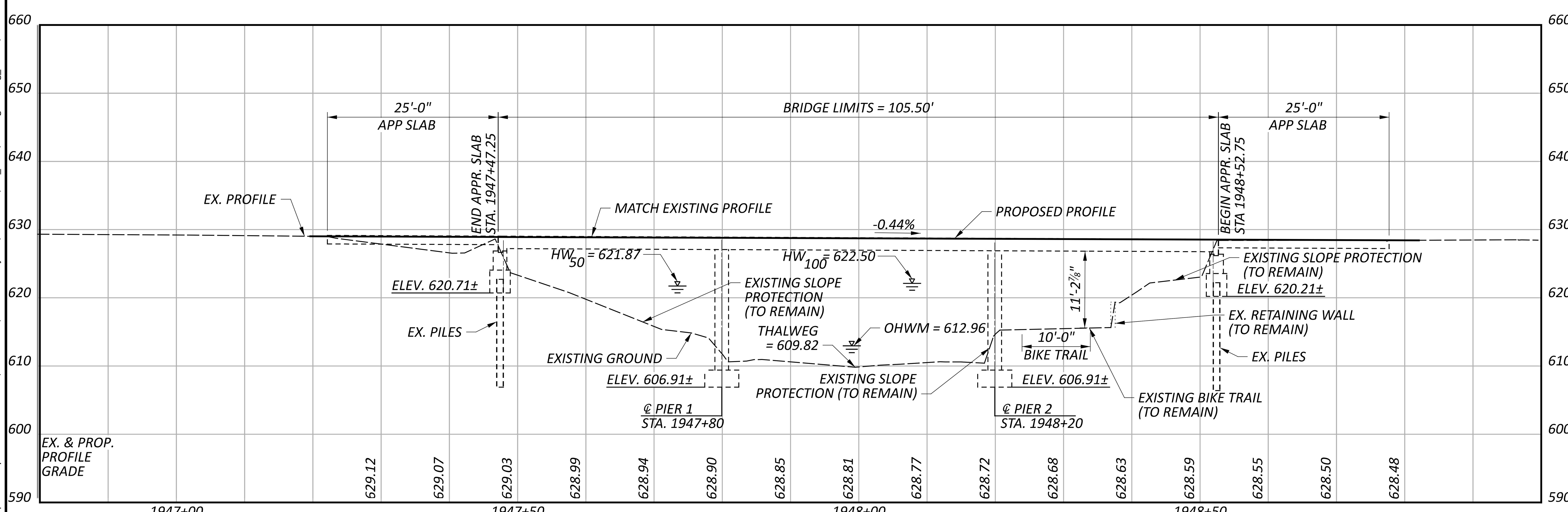


105889_LUC-23 Plan: LUC23-PR 6/27/2023
Geom: LUC-23_PR
River = Ottawa River Reach = Reach RS = 61
.04
.035
.07
Elevation (ft)
Station (ft)
660
650
640
630
620
610
600
0
500
1000
1500
2000
2500
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 25-YR
WS 10-YR
WS 5-YR
WS 2-YR
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Bank Sta

Appendix 3: Proposed Bridges Site plans



PLAN



PROFILE ALONG ℄ US 23 SOUTHBOUND

BENCHMARK DATA

BM #1 STA. 946+49.55,	ELEV. 629.62 ,	OFFSET 203.30,	RT.
BM #2 STA. 948+52.57,	ELEV. 627.76 ,	OFFSET 102.82,	LT.
BM #3 STA. 949+62.69,	ELEV. 620.40 ,	OFFSET 299.97,	RT.

FOR ADDITIONAL BENCHMARK INFORMATION. SEE ROADWAY PLAN SHEET

NOTES

EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

DESIGN TRAFFIC:
2026 ADT = 68,030 2026 ADTT = 13,236
2046 ADT = 72,790 2046 ADTT = 15,286
DIRECTIONAL DISTRIBUTION = 0.50

LEGEND

- TO BE REMOVED
- TO BE REMOVED AND REPLACED

HYDRAULIC DATA

DRAINAGE AREA = 125 SQ. MILES
Q (50) = 5510 CFS V (50) = 8.0 FT/S
Q (100) = 6190 CFS V (100) = 7.8 FT/S
STRUCTURE CLEARS THE 50 YEAR
DESIGN HW BY 5.04 FEET.

PROPOSED WORK

REHABILITATION OF EXISTING STRUCTURE:
1. PARTIAL REMOVAL OF DECK CARRYING EXISTING SOUTHBOUND ENTRANCE RAMP
2. RECONSTRUCTION OF 8'-0" OF CONCRETE DECK SLAB TO PROVIDE 44'-8" O/O
3. MODIFICATION TO ABUTMENTS AND PIERS TO MATCH NEW DECK WIDTH
4. CONSTRUCT NEW WINGWALLS ON EXISTING ABUTMENT FOOTING
5. PARTIAL APPROACH SLAB REMOVAL TO MATCH NEW BRIDGE DECK WIDTH
6. REPLACE EXTERIOR BRIDGE TERMAL ASSEMBLIES
7. REGRADE SLOPES IN AREAS OF ABUTMENT AND PIER REMOVAL

EXISTING STRUCTURE

TYPE: 3-SPAN CONTINUOUS REINFORCED CONCRETE SLAB BRIDGE WITH REINFORCED CONCRETE SUBSTRUCTRURES
SPANS: 32.0' - 40.0' - 32.0' C/C BRGS
ROADWAY: VARIES
LOADING: CF=2000
SKEW: NONE
WEARING SURFACE: 2.25" MICROSILICA MODIFIED CONCRETE
APPROACH SLABS: AS-1-81, 25'-0" LONG
ALIGNMENT: TANGENT
CROWN: 0.016
STRUCTURE FILE NUMBER: 4801261
DATE BUILT: 1960/2010

PROPOSED STRUCTURE

TYPE: 3-SPAN CONTINUOUS REINFORCED CONCRETE SLAB BRIDGE WITH REINFORCED CONCRETE SUBSTRUCTURES
SPANS: 32.0'± - 40.0'± - 32.0'± C/C BRGS
ROADWAY: 41'-6" TOE/TOE PARAPET
LOADING: HL93
SKEW: NONE
WEARING SURFACE: 1" MONOLITHIC CONCRETE ON PROPOSED 2.25" MICROSILICA MODIFIED CONCRETE OVERLAYON EXISTING
APPROACH SLABS: 25'-0" LONG (AS-1-15)
ALIGNMENT: TANGENT
CROWN: 0.016 FT/FT
DECK AREA: 4695 SF
COORDINATES: LATITUDE 41°42'42.67"
LONGITUDE 83°41'18.18"

HORIZONTAL SCALE IN FEET 0 5 10 20

SITE PLAN
BRIDGE NO. LUC-00023-11.650 L OVER OTTAWA RIVER

SFN	4801261
DESIGN AGENCY	2LMN
DESIGNER RFS	CHECKER JAH
REVIEWER	MUR 06-28-23
PROJECT ID	105889
SUBSET 1	TOTAL 17
SHEET P.398	TOTAL 465

LUC-023-11.75

MODEL: Sheet PAPERSIZE: 34x22 (in.) DATE: 6/29/2023 TIME: 8:29:57 PM USER: Julia_Hart
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BENCHMARK DATA

BM #1 STA.	946+49.55,	ELEV.	629.62 ,	OFFSET	203.30,	RT.
BM #2 STA.	948+52.57,	ELEV.	627.76 ,	OFFSET	102.82,	LT.
BM #3 STA.	949+62.69,	ELEV.	620.40 ,	OFFSET	299.97,	RT.

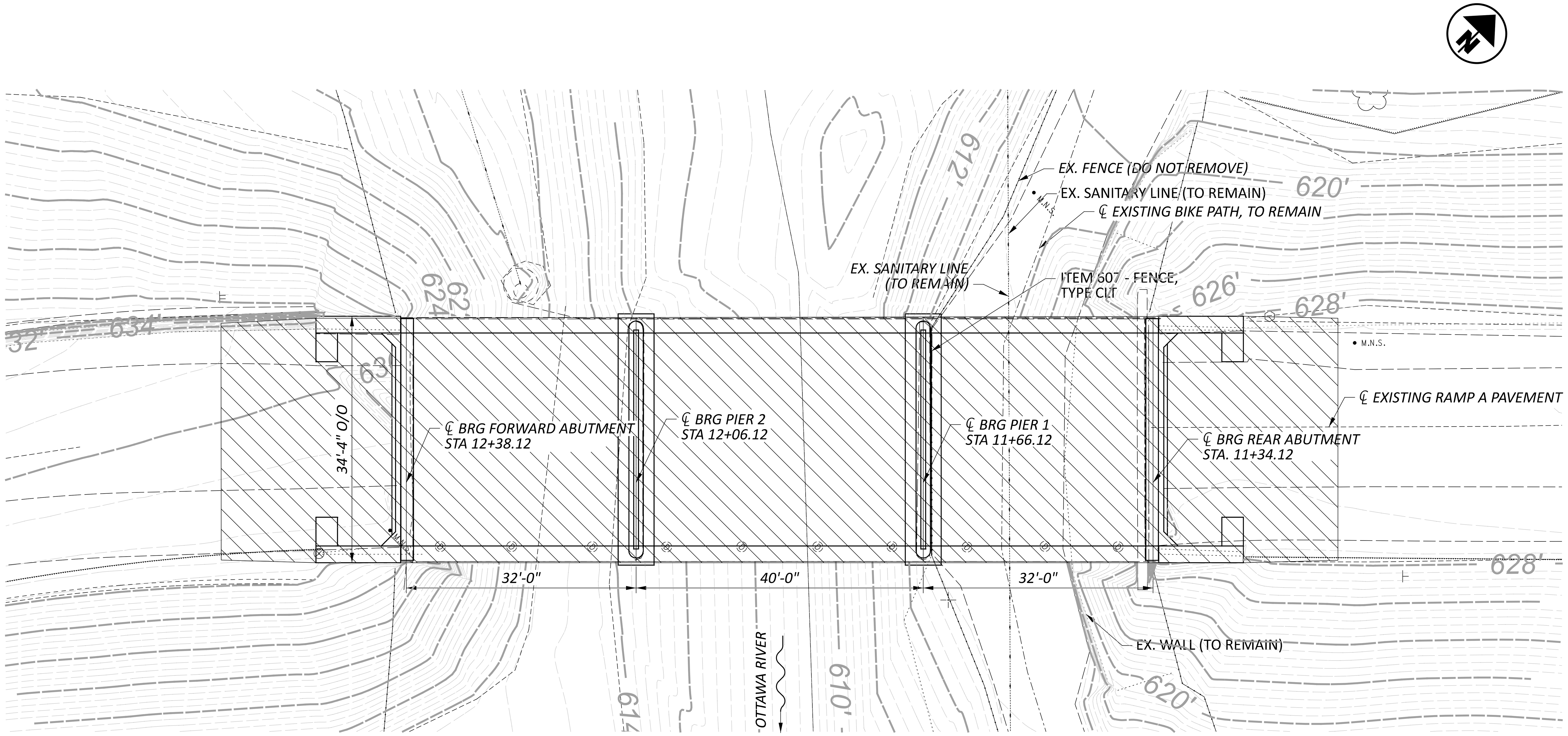
FOR ADDITIONAL BENCHMARK INFORMATION. SEE ROADWAY PLAN SHEET

NOTES

EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

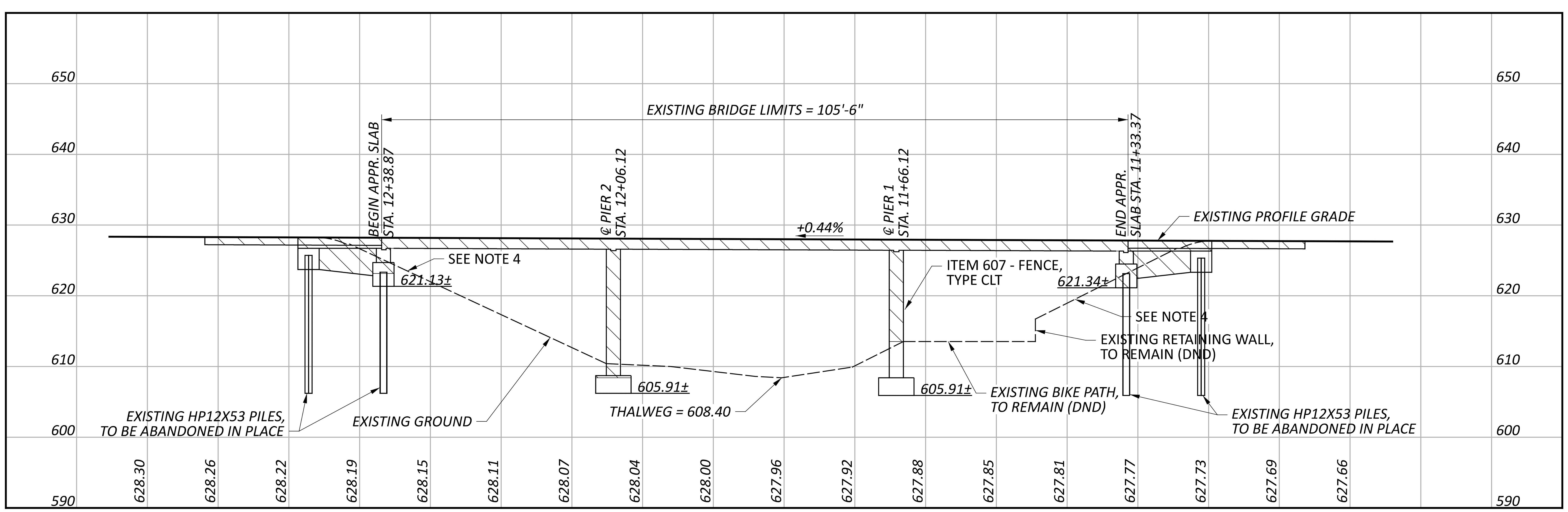
LEGEND

- ITEM 202 - PORTIONS OF STRUCTURE REMOVED, OVER 20 FOOT SPAN, AS PER PLAN



PLAN

NOTES:
1. BRIDGE PARAPETS, DECK, AND APPROACH SLABS SHALL BE REMOVED IN THEIR ENTIRETY.
2. BRIDGE ABUTMENTS, PIERS, AND WINGWALLS SHALL BE REMOVED TO 1'-0" BELOW GRADE.
3. AREAS OF STRUCTURAL REMOVAL SHALL BE REGRADED TO MATCH SURROUNDING TERRAIN.
4. REPLACE AGGREGATE SLOPE PROTECTION AS DIRECTED BY THE ENGINEER IF EXISTING IS DISTURBED DURING REMOVAL OPERATIONS.



PROFILE ALONG BL OF US 23 NORTHBOUND OFF RAMP (RAMP A)

PROPOSED WORK

REMOVE EXISTING STRUCTURE
1. REMOVAL OF EXISTING BRIDGE DECK
2. REMOVAL OF EXISTING ABUTMENTS TO 1'-0" BELOW GRADE
3. REMOVAL OF EXISTING PIERS TO ELEVATION SHOWN IN THESE PLANS
4. REMOVAL OF EXISTING APPROACH SLABS
5. REGRADE EXISTING GROUND
6. INSTALL FENCING ALONG REMAING PORTION OF PIER 2 ADJACENT TO PATH TO CONNECT EXISTING FENCING

EXISTING STRUCTURE

TYPE: 3-SPAN CONTINUOUS REINFORCED CONCRETE SLAB BRIDGE WITH REINFORCED CONCRETE SUBSTRUCTURES

SPANS: 32.0' - 40.0' - 32.0' C/C BRGS

ROADWAY: 29'-8" F/F SAFETY CURB

LOADING: CF-2000 (57)

SKEW: NONE

WEARING SURFACE: LATEX CONCRETE OVERLAY

APPROACH SLABS: AS-1-54 (25'-0" LONG)

ALIGNMENT: TANGENT

CROWN: 0.016 FT/FT

STRUCTURE FILE NUMBER: 4805135

DATE BUILT: 1960

DISPOSITION: REMOVED

HORIZONTAL SCALE IN FEET 0 5 10 20

SITE PLAN
BRIDGE NO. LUC-00184-00.030R NORTHBOUND RAMP
OVER OTTAWA RIVER

SFN	4805135
DESIGN AGENCY	2LMN
DESIGNER RFS	CHECKER JAH
REVIEWER	MUR 06-28-23
PROJECT ID	105889
SUBSET 1	TOTAL 7
SHEET P.415	TOTAL 465

LUC-023-11.75

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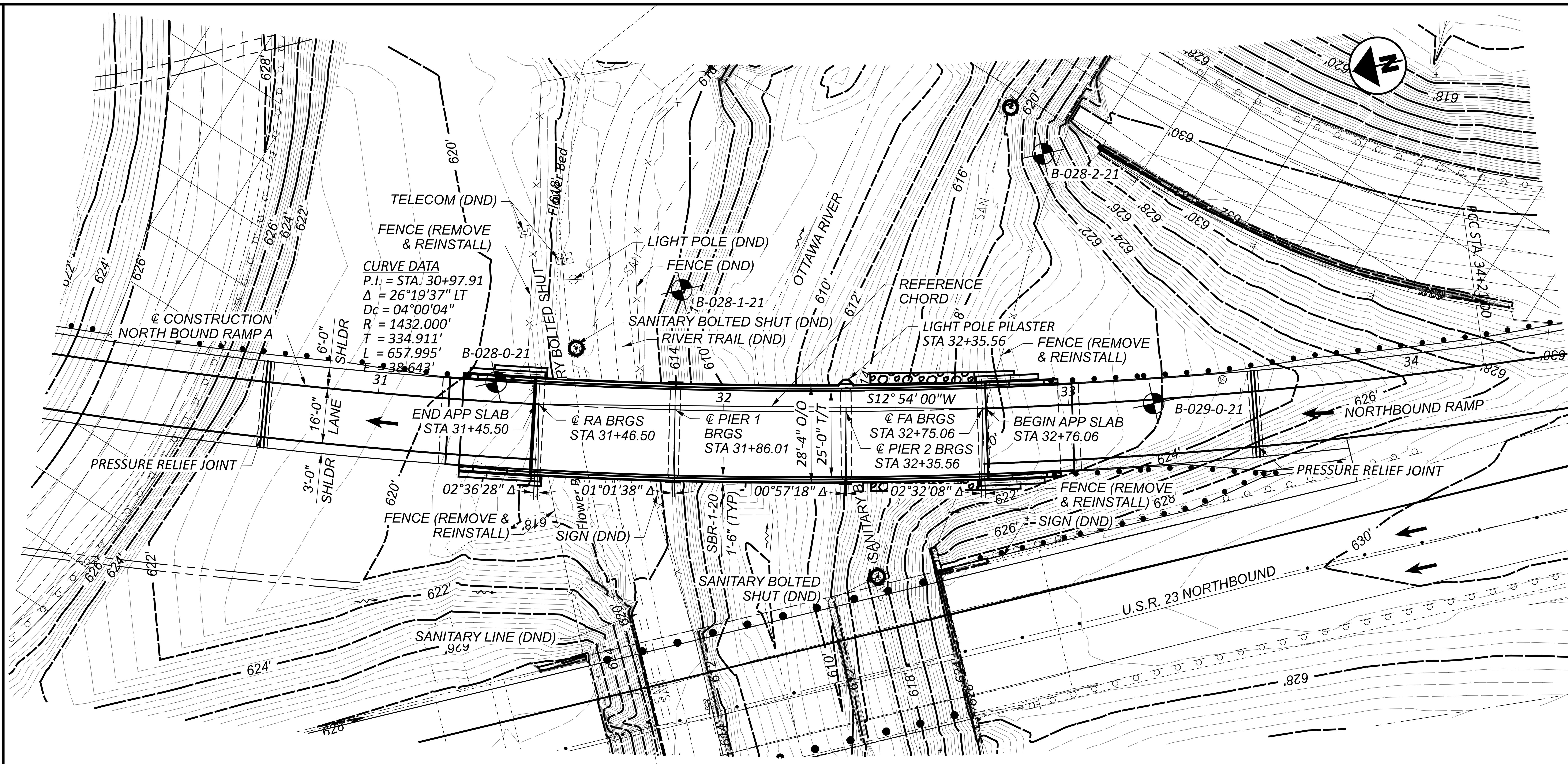
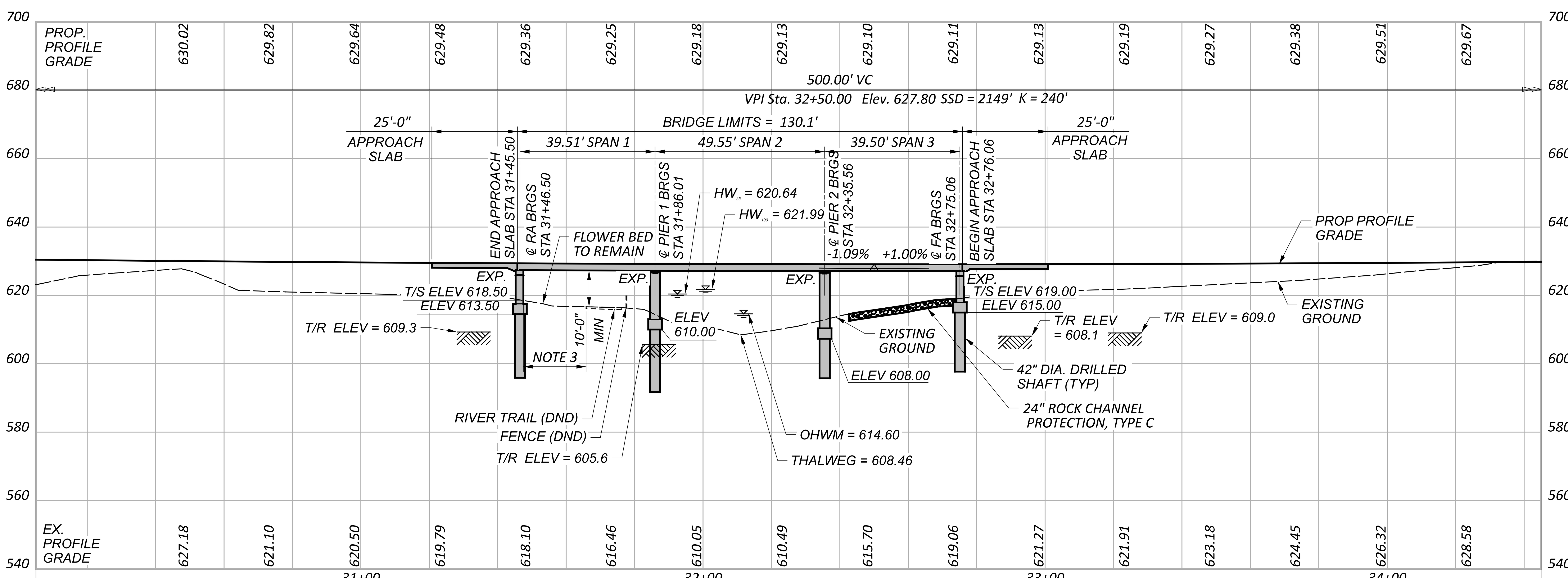


PLAN



PROFILE ALONG ℄ CONSTRUCTION NORTHBOUND RAMP A

BENCHMARK DATA

BM #1 STA. 29+80.84,	ELEV. 620.40,	OFFSET 106.60',	LT
BM #2 STA. 33+34.87,	ELEV. 629.62,	OFFSET 100.39',	LT
BM #3 STA. 38+09.55,	ELEV. 631.27,	OFFSET 25.02',	LT

FOR ADDITIONAL BENCHMARK INFORMATION. SEE ROADWAY PLAN SHEET

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.
2. GEOTECHNICAL INFORMATION WAS NOT AVAILABLE YET.
3. LATERAL CLEARANCE RANGES FROM 8'-6" MIN TO 14'-2.

LEGEND

- ● 10'-0" REQUIRED MINIMUM VERTICAL CLEARANCE AT RIVER TRAIL
- Δ TO REFERENCE CHORD
- EXISTING RAMPS TO BE REMOVED
- PROJECT BORING LOCATION

HYDRAULIC DATA

DRAINAGE AREA = 125 SQ. MILES
Q (25) = 4840 CFS V (25) = 6.23 FT/S
Q (100) = 6190 CFS V (100) = 6.60 FT/S
STRUCTURE CLEARS THE 25 YEAR DESIGN HW BY 6.65 FEET.

PROPOSED STRUCTURE

TYPE: 3-SPAN CONTINUOUS REINFORCED CONCRETE SLAB WITH SEMI-INTEGRAL ABUTMENTS AND SOLID WALL PIERS ON DRILLED SHAFTS.

SPANS: 49'-6", 49'-6", 49'-6" C/C BEARINGS ALONG REFERENCE CHORD

ROADWAY: 25'-0" TOE/TOE PARAPET

LOADING: HL93 AND 60PSF FUTURE WEARING SURFACE

SKEW: VARIES

WEARING SURFACE: 1" MONOLITHIC CONCRETE

APPROACH SLABS: 25'-0" LONG (AS-1-15, AS-2-15)

ALIGNMENT: 4°-00'-04" CURVE LT

CROWN: VARIES FT/FT

DECK AREA: 3702 SF

COORDINATES: LATITUDE 41° 42' 43.90" N
LONGITUDE 83° 41' 15.10" W

HORIZONTAL SCALE IN FEET 0 10 20 40

SITE PLAN
BRIDGE NO. LUC-00184-00.200R NORTHBOUND RAMP OVER OTTAWA RIVER

SFN 4805136

DESIGN AGENCY 2LMN

DESIGNER	CHECKER
HHH	JAH

REVIEWER MUR 06-28-23

PROJECT ID 105889

SUBSET	TOTAL
1	22

SHEET	TOTAL
P.422	465

LUC-023-11.75

MODEL: 105889_SFN_0000002_SP301 PAPERSIZE: 34x22 (in.) DATE: 6/30/2023 TIME: 12:28:27 PM USER: Julia_Hart
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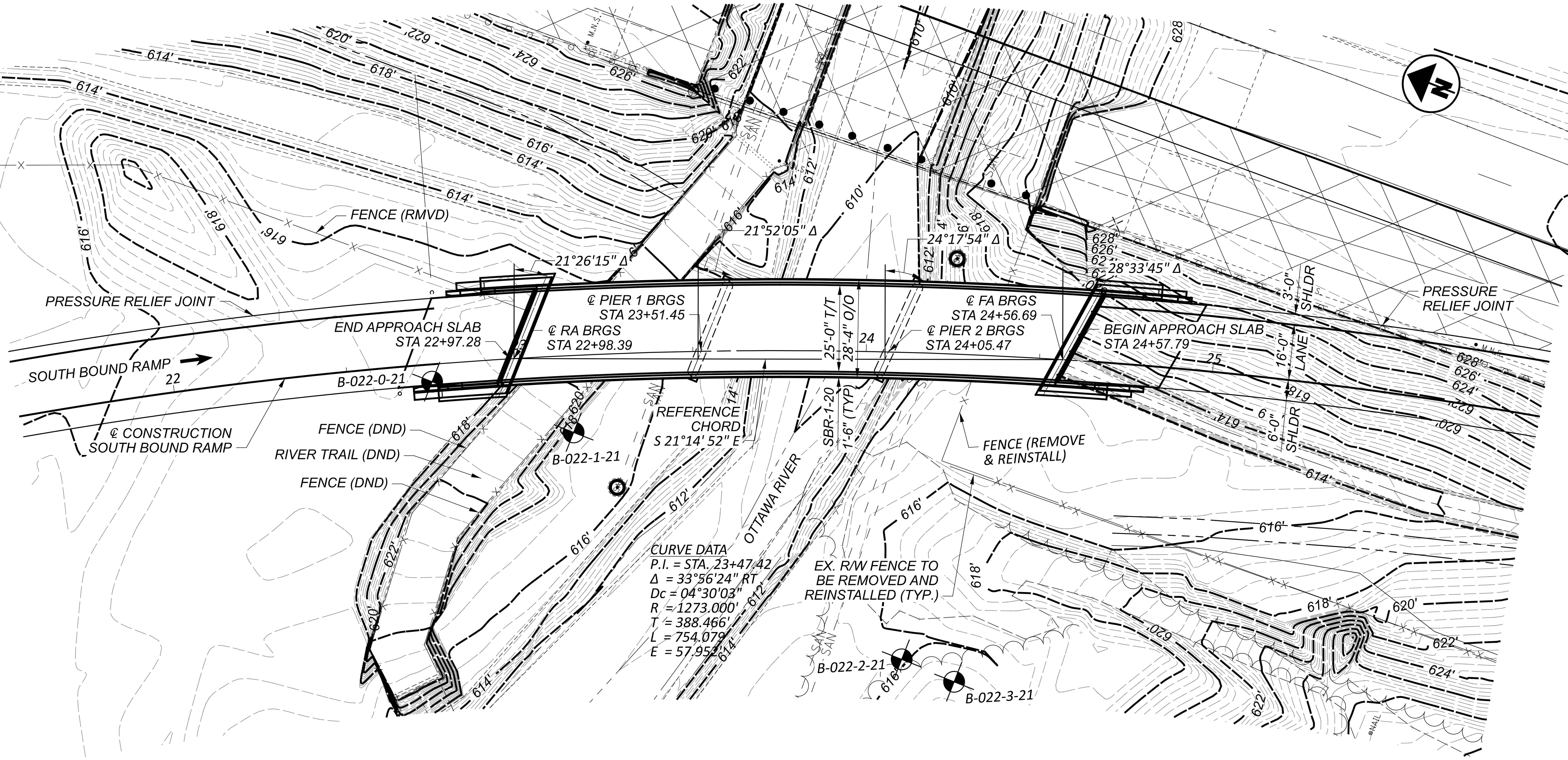
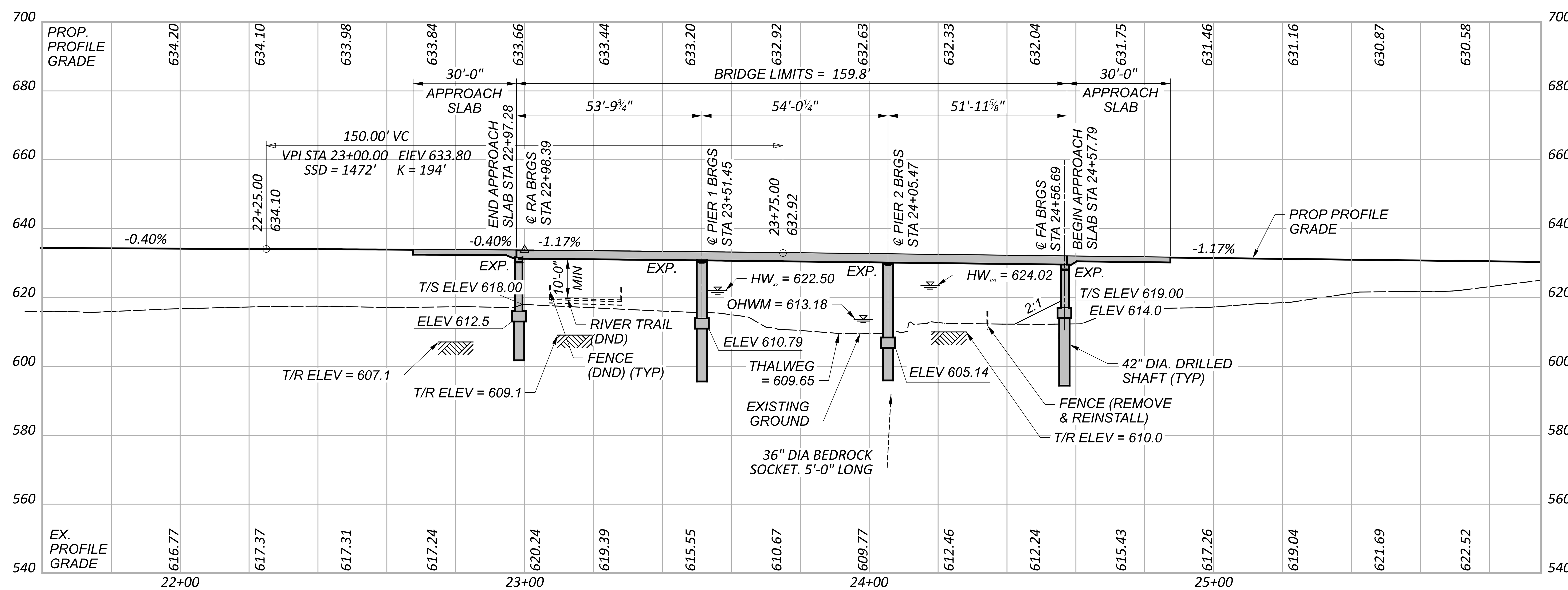


PLAN



PROFILE ALONG ℄ CONSTRUCTION SOUTHBOUND RAMP

BENCHMARK DATA

BM #1 STA.	17+75.39,	ELEV.	618.44,	OFFSET	203.45',	LT
BM #2 STA.	23+51.47,	ELEV.	627.76,	OFFSET	75.01',	LT
BM #3 STA.	25+93.55,	ELEV.	629.62,	OFFSET	315.29',	LT

FOR ADDITIONAL BENCHMARK INFORMATION. SEE ROADWAY PLAN SHEET

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.
2. GEOTECHNICAL INFORMATION WAS NOT AVAILABLE YET.

LEGEND

- ● 10'-0" REQUIRED MINIMUM VERTICAL CLEARANCE AT RIVER TRAIL
- Δ TO REFERENCE CHORD
- EXISTING RAMP STRUCTURE TO BE REMOVED
- PROJECT BORING LOCATION

HYDRAULIC DATA

DRAINAGE AREA = 125 SQ. MILES

Q (25) = 4840 CFS V (25) = 4.11 FT/S

Q (100) = 6190 CFS V (100) = 4.37 FT/S

STRUCTURE CLEARS THE 25 YEAR DESIGN HW BY 7.20 FEET.

PROPOSED STRUCTURE

TYPE: 3-SPAN CONTINUOUS REINFORCED CONCRETE SLAB WITH SEMI-INTEGRAL ABUTMENTS AND SOLID WALL PIERS ON DRILLED SHAFTS.

SPANS: 47'-8 ⅞", 60'-9 ⅛", 49'-8 ⅜" C/C BEARINGS ALONG REFERENCE CHORD

ROADWAY: 25'-0" TOE/TOE PARAPET

LOADING: HL93 AND 60PSF FUTURE WEARING SURFACE

SKEW: VARIES

WEARING SURFACE: 1" MONOLITHIC CONCRETE

APPROACH SLABS: 30'-0" LONG (AS-1-15, AS-2-15)

ALIGNMENT: 4°-30'-03" CURVE RT

CROWN: VARIES FT/FT

DECK AREA: 4555 SF

COORDINATES: LATITUDE 41° 42' 44.04" N

LONGITUDE 83° 41' 19.58" W

HORIZONTAL SCALE IN FEET 0 10 20 40

SITE PLAN
BRIDGE NO. LUC-00184-00.180 SOUTHBOUND RAMP OVER OTTAWA RIVER

SFN 4805137

DESIGN AGENCY 2LMN

DESIGNER	CHECKER
HHH	JAH

REVIEWER MUR 06-28-23

PROJECT ID 105889

SUBSET	TOTAL
1	22

SHEET	TOTAL
P.444	465

LUC-023-11.75

MODEL: 105889_SFN_0000001_SP301 PAPERSIZE: 34x22 (in.) DATE: 6/30/2023 TIME: 12:23:29 PM USER: Julia_Hart
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Appendix 4: FIS Study Report – 1% AEP Peak discharge

FLOOD INSURANCE STUDY

VOLUME 1 OF 4

LUCAS COUNTY, OHIO

AND INCORPORATED AREAS

Community Name	Community Number
Berkey, Village of	390901
Harbor View, Village of	390702
Holland, Village of	390659
Lucas County (Unincorporated Areas)	390359
Maumee, City of	390360
Oregon, City of	390361
Ottawa Hills, Village of	390362
Swanton, Village of (Fulton & Lucas Counties)	390632
Sylvania, City of	390364
Toledo, City of	395373
Waterville, Village of	390637
Whitehouse, Village of	390639

REVISED:
March 16, 2016

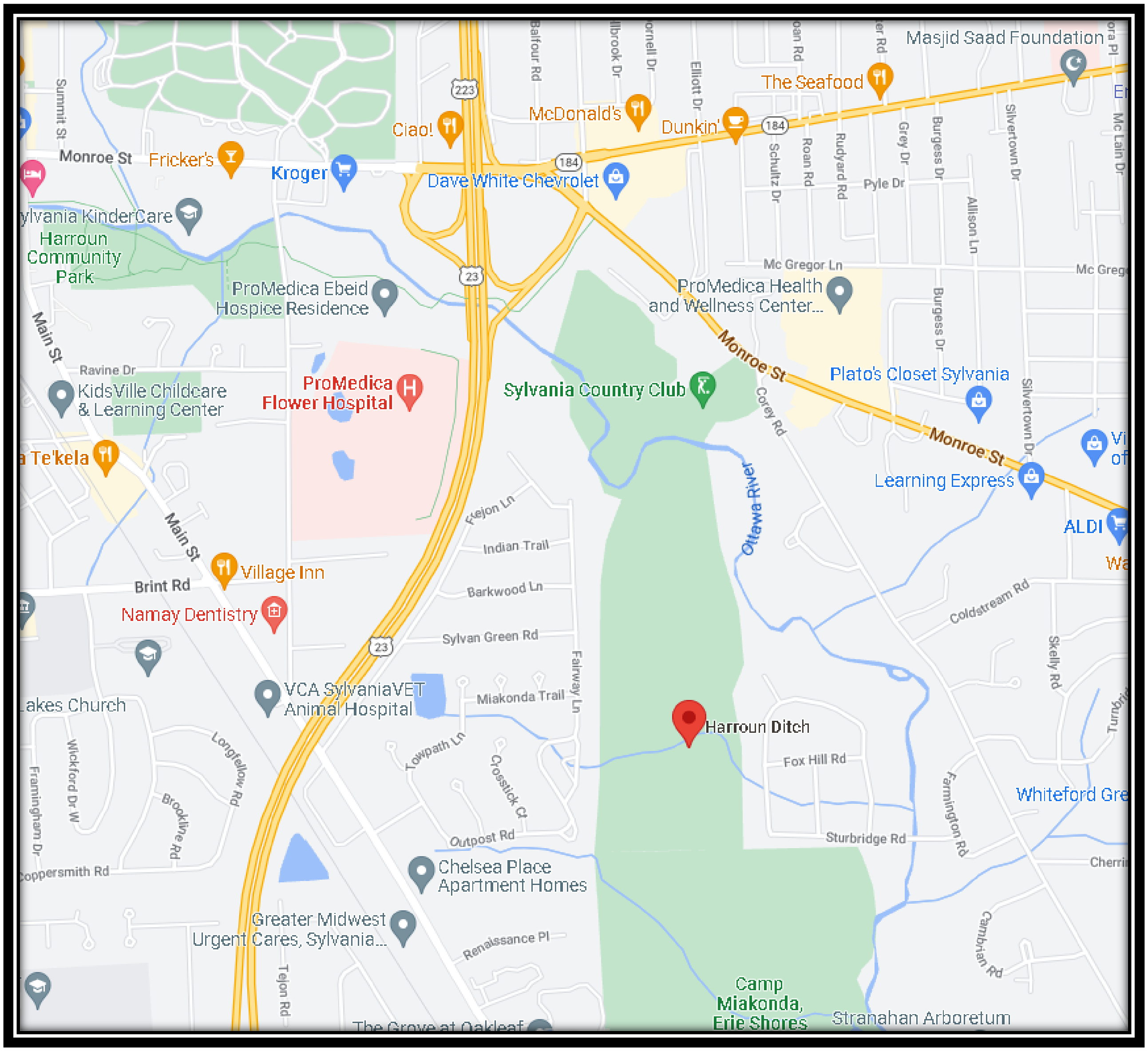
Federal Emergency Management Agency

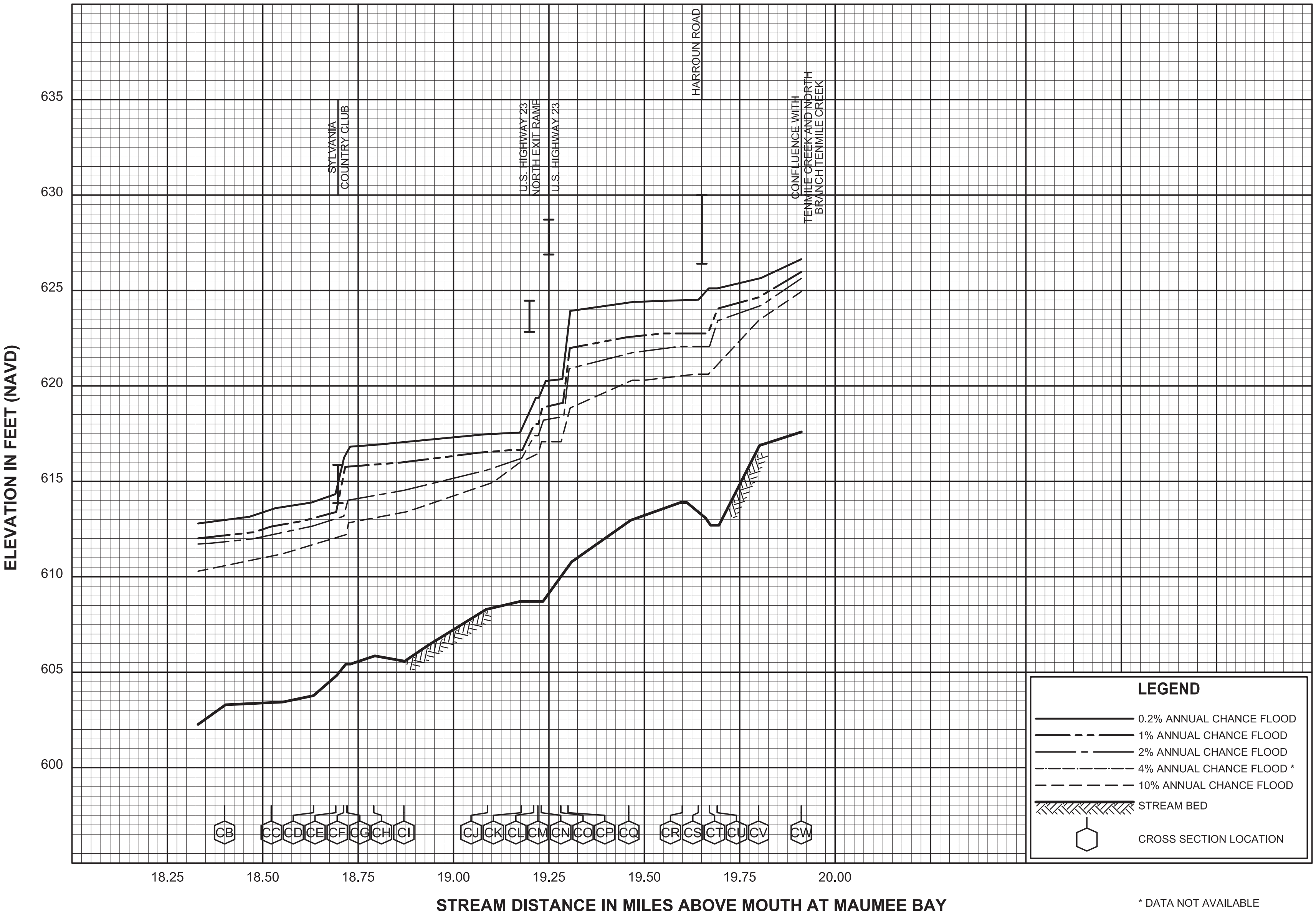
FLOOD INSURANCE STUDY NUMBER
39095CV001B

TABLE 8 – Summary of Peak Discharges *(continued)*

Flooding Source and Location	Drainage Area (Sq. Miles)	Peak Discharges (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Maumee River *(continued)*					
Just upstream of confluence with Tontogany Creek	6,266	80,900	109,000	121,800	152,300
Just upstream of confluence with Beaver Creek	6,058	78,800	105,700	117,800	146,700
Mayer Ditch					
At inlet to Rochelle Enclosure	0.29	62	99	116	160
At Nebraska Avenue	0.21	55	84	98	135
Downstream of Saturn Drive	0.19	50	80	94	130
At Interstate 475	0.10	*	*	17	*
At culvert at apartments	0.03	*	*	9	*
McPeak Ditch					
Upstream of confluence with Tenmile Creek	3.10	*	*	780	*
(not published)	3.05	470	650	765	935
(not published)	2.90	450	620	720	900
(not published)	2.70	370	555	615	795
North Branch Ketcham Ditch					
At mouth	0.46	*	*	150	*
North Branch Tenmile Creek					
(not published)	39.0	1,540	2,450	2,925	3,700
Ottawa River					
At North Maumee Bay	172.0	5,200	7,500	8,500	11,000
At confluence with Sibley Creek	162.0	4,800	6,800	7,700	9,700
Upstream of confluence with Woodlaum Cemetery Tributary	155.0	4,700	6,500	7,400	9,400
At Monroe Street	149.0	4,518	6,250	7,110	9,036
At Talmadge Road	129.0	3,915	5,415	6,160	7,830
At Interstate 475	125.4	3,790	5,300	6,000	7,600
Upstream of confluence with Harroun Ditch	122.4	3,500	5,000	5,750	7,300
(not published)	120.0	3,600	5,100	5,800	7,300
Otter Creek					
At Corduroy Road	7.67	572	850	970	1,248
At Brown Road	3.85	335	501	572	738
Peter May Ditch					
At Interstate 475	1.11	160	237	270	340
At McCord Road	0.99	140	208	235	290

* Data not available


Masjid Saad Foundation
The Seafood
McDonald's
Dunkin'
Ciao!
Fricker's
Kroger
Monroe St
Dave White Chevrolet
Summit St
Balfour Rd
Elliott Dr
Schultz Dr
Roan Rd
Rudyard Rd
Pyle Dr
Grey Dr
Burgess Dr
Silvertown Dr
Mc Lain Dr
Allison Ln
Harroun Community Park
ProMedica Ebeid Hospice Residence
Mc Gregor Ln
ProMedica Health and Wellness Center...
Main St
Ravine Dr
KidsVille Childcare & Learning Center
ProMedica Flower Hospital
Sylvania Country Club
Monroe St
Corey Rd
Plato's Closet Sylvania
Monroe St
Learning Express
ALDI
Ottawa River
Main St
Tejon Ln
Indian Trail
Barkwood Ln
Village Inn
Brint Rd
Namay Dentistry
Sylvan Green Rd
Coldstream Rd
Skelly Rd
Fairway Ln
Miakonda Trail
VCA SylvaniaVET Animal Hospital
Lakes Church
Harroun Ditch
Fox Hill Rd
Towpath Ln
Crosstick Ct
Longfellow Rd
Wickford Dr W
Framingham Dr
Brookline Rd
Farmington Rd
Whiteford
Sturbridge Rd
Outpost Rd
Coppersmith Rd
Chelsea Place Apartment Homes
Greater Midwest Urgent Cares, Sylvania...
Renaissance Pl
Tejon Rd
Cambrian Rd
Camp Miakonda, Erie Shores
Stranahan Arboretum
The Grove at Oakleaf
223
184
23



FLOOD PROFILES

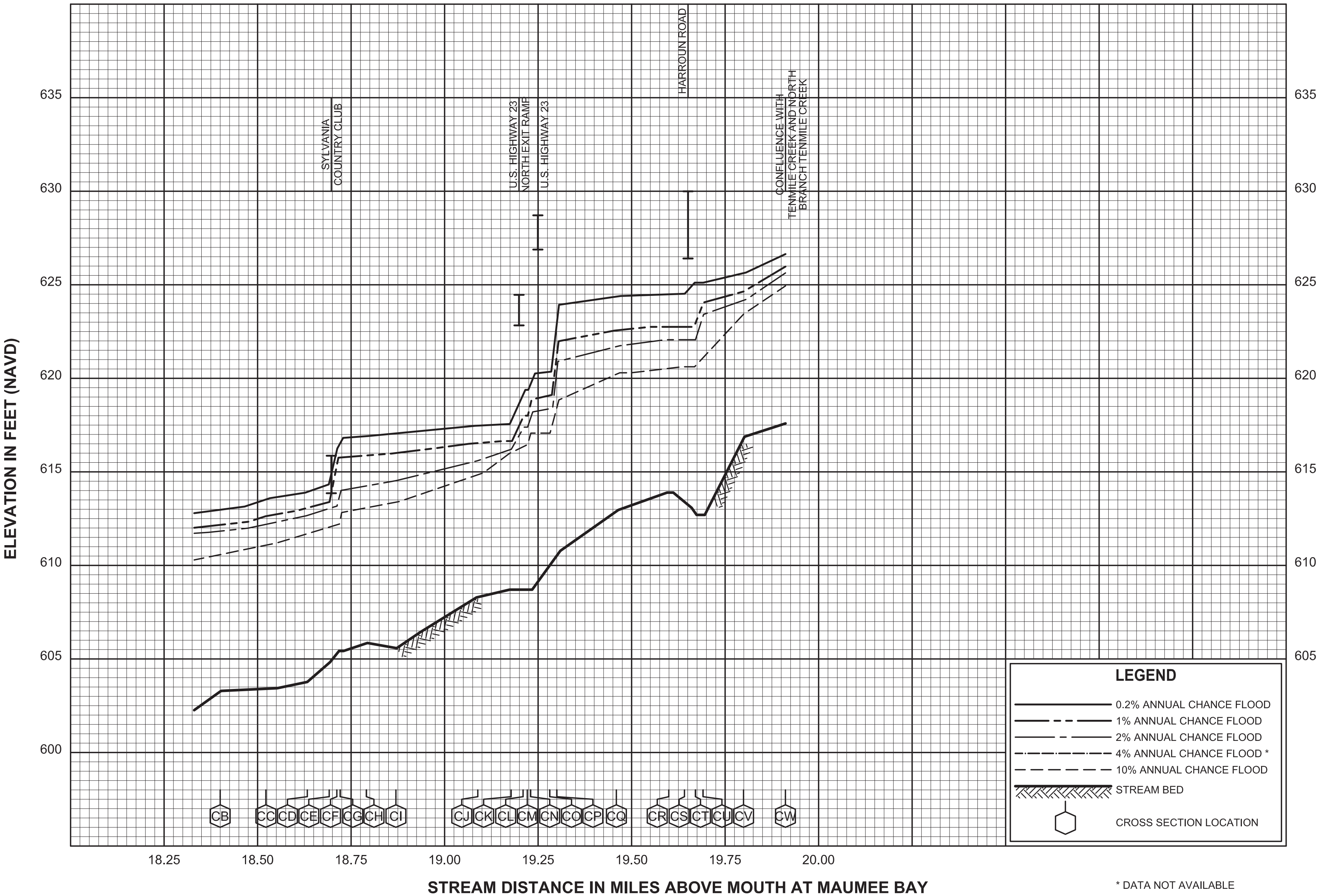
OTTAWA RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

LUCAS COUNTY, OH

AND INCORPORATED AREAS

107P



FLOOD PROFILES

OTTAWA RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

LUCAS COUNTY, OH

AND INCORPORATED AREAS

107P

Appendix 5: LD-52 & LD-51 Letters and Other Documentation of Flood Plain Coordination

2475 Sugar Grove Road, SE ~ Lancaster, Ohio 43130
(740) 687-5542 Phone ~ www.2LMN.com

November 18, 2021

Mr. Kevin Aller, Service Director
Department of Public Service
6730 Monroe St.
City of Sylvania
Lucas County, OH, 43560

Re: LUC-23-11.75 PID 105889
Letter of Notification

Dear Mr. Aller:

The Ohio Department of Transportation project LUC-23-11.75 encroaches upon a Special Flood Hazard Area Zone AE within your community.

The proposed project plans to widen the existing structure that carries US 23 Northbound over the Ottawa River as part of the interchange modifications to the US 23 and Monroe St/Alexis Rd interchange. There is a slight possibility that the existing structure that carries US 23 Southbound over the Ottawa River will also be widened, but this it trying to be avoided to minimize bridge work at this location. In addition, the existing bridge carries the off-ramp from US 23 to Monroe Street will be removed.

Please provide your community's flood zone regulations if they differ from FEMA requirements and forward any questions you may have about the project. Future correspondence will include hydraulic calculations and required documentation for compliance. We will move forward with this project if no concerns are brought to our attention.

If you need additional information, please contact Julia Hart, Project Manager, at 740-687-5542 or julia.hart@2lmn.com.

Respectfully,

Julia A. Hart

Julia A. Hart, P.E.
Project Manager

Cc: Julia Fahey, ODOT D2 Project Manager
Phoenix Neal, ODOT D2 Environmental
Craig Hebebrand, Arcadis Project Manager
Chantil Milam, Lawhon & Associates
Joe Shaw, City of Sylvania, Deputy Director - Engineering

Form LD-52
Revised January 2017

2LMN
2475 Sugar Grove Road, SE ~ Lancaster, Ohio 43130
(740) 687-5542 Phone ~ www.2LMN.com

June 22, 2023

Mr. Kevin Aller, Service Director
Department of Public Service
6730 Monroe St.
City of Sylvania
Lucas County, OH, 43560

Re: LUC-23-11.75 PID 105889
Letter of Notification

Dear Mr. Aller:

The Ohio Department of Transportation project LUC-23-11.75 encroaches upon a Special Flood Hazard Area Zone AE within your community.

The proposed project as part of the interchange modifications to the US 23 and Monroe Street / Alexis Road interchange, plans to reduce the width of the existing structure that carries US 23 southbound over the Ottawa River, construct a new US 23 on ramp to southbound US 23, construct a new off ramp from US 23 northbound to Monroe Street. In addition, the existing bridge that carries the off-ramp from US 23 northbound to Monroe Street will be removed.

Please provide your community's flood zone regulations if they differ from FEMA requirements and forward any questions you may have about the project. Future correspondence will include hydraulic calculations and required documentation for compliance. We will move forward with this project if no concerns are brought to our attention.

If you need additional information, please contact Julia Hart, Project Manager, at 740-687-5542 or julia.hart@2lmn.com.

Respectfully,

Julia A. Hart

Julia A. Hart, P.E.
Project Manager

Cc: Julia Fahey, ODOT D2 Project Manager
Phoenix Neal, ODOT D2 Environmental
Craig Hebebrand, Arcadis Project Manager
Chantil Milam, Lawhon & Associates
Joe Shaw, City of Sylvania, Deputy Director - Engineering

Form LD-52
Revised January 2017

2LMN
2475 Sugar Grove Road, SE ~ Lancaster, Ohio 43130
(740) 687-5542 Phone ~ www.2LMN.com

June 30, 2023

Mr. Kevin Aller, Service Director
Department of Public Service
6730 Monroe St.
City of Sylvania
Lucas County, OH, 43560

Re: LUC-23-11.75 PID 105889
Letter of Compliance

Dear Mr. Aller:

Enclosed please find the floodplain analysis for Ohio Department of Transportation project LUC-23-11.75. The subject roadway project encroaches upon a Special Flood Hazard Area Zone AE within your community at the location identified in the attached report. The hydraulic calculations show a minor rise above the base flood elevation (BFE) and we are working on providing the necessary documentation of compliance to all federal, state, and local floodplain standards as required.

If you need additional information, please contact Julia Hart, Project Manager, at 740-687-5542 or julia.hart@2lmn.com.

Respectfully,

Julia A. Hart, P.E.
Project Manager

Cc: Julia Fahey, ODOT D2 Project Manager
Phoenix Neal, ODOT D2 Environmental
Craig Hebebrand, Arcadis Project Manager
Chantil Milam, Lawhon & Associates
Joe Shaw, City of Sylvania, Deputy Director - Engineering

Form LD-51
Revised January 2017

APPLICATION FOR PERMIT TO DEVELOP IN A FLOOD HAZARD AREA

The undersigned hereby makes application for a permit to develop in a designated flood hazard area. The work to be performed is described below and in attachments hereto. The undersigned agrees that all such work shall be done in accordance with the requirements of Chapter 1149, Flood Plain Districts, Codified Ordinances of the City of Sylvania, and with all other applicable local, state, and federal laws.

Owner: ______________________________ Builder: ______________________________

Address: ______________________________ Address: ______________________________

______________________________ ______________________________

Telephone: ______________________________ Telephone: ______________________________

A. DESCRIPTION OF WORK - (Attach required drawings)

Check appropriate boxes. All references to elevations are in mean sea level.

1. Kind of development proposed: New Building ☐ Addition ☐ Alteration ☐ Filling ☐ Mining ☐ Dredging ☐ Mobile Home ☐

2. Location of development site: ____

____

____

3. Is proposed development located in an identified floodway. Yes ☐ No ☐
If Yes, a technical evaluation is required with the application.

STRUCTURES

4. Type of construction: New residential ☐ New nonresidential ☐
Addition or improvement to existing structure ☐ Accessory structure ☐

5. If the proposed construction is an alteration, addition, or improvement to an existing structure, please indicate the cost of the proposed construction $ ______. What is the estimated market value of the existing structure? $ _______.
Note: An existing structure must comply with the flood protection standards if it is substantially (i.e., equal to or greater than 50% of the market value of the structure) improved.

6. Structure will be flood protected by:
Adding fill to the construction site. Top of fill to be at elevation _____ feet above mean sea level (m.s.l.), and is to extend a minimum of 15 feet beyond the structure.
Floodproofing (Nonresidential) ☐ Tie downs (Mobile Home) ☐
Other (Describe) ____

____

7. New structures and substantially improved existing structures: Elevation of lowest floor (including basement) is _____ feet m.s.l. Note: All structures must be built with the lowest floor (including basement) at least 2 feet above the 100-year elevation, unless a variance has been granted. If a variance is granted, the applicant is hereby notified the reduced floor elevation will increase the risk of flooding and the cost of flood insurance will be commensurate with the increase risk.

ADMINISTRATIVE

1. Proposed development: Must comply with all applicable flood damage prevention standards □
Is exempt from flood damage prevention standards □

2. Elevation of 100-year base flood at site _____ feet m.s.l. Data source _____________.

3. Filing fee $ ________. Paid on ________________, 20 ___.

4. Permit issued on ________________, 20 ___.

5. Work inspected by ____________________________ Date ________________

6. As-built construction:

Finished elevation of lowest floor ____ feet m.s.l.
Source: Community □ Applicant □

If furnished by applicant, it must be accompanied with certification by registered surveyor, engineer, or architect.

7. Certificate of compliance of as-built construction issued on __________, 20 ___.

8. Permit denied on ________________, 20 ___.

Reasons:

____

____

____

Applicant:	Kevin G. Aller, Administrator
Date	Date

CERTIFICATION FORM

This form should be completed by a professional surveyor and returned to the local flood plain administrator. The form can be used to serve two purposes. First, it can be used by the property owner to certify that the completed construction meets the flood elevation standards of the community. Secondly, this form can be used by insurance agents to complete the Elevation Certificate which they need to complete for insuring new construction in the flood plain. The community should keep the completed original on file and provide the property owner with a copy that he or she can furnish to the insurance agent. In this manner, the agent will not have to call upon community officials for assistance in determining the elevation data they require.

I, the undersigned, do hereby certify that during _____________________ the property described below was surveyed, and that the elevation shown below is in compliance with the permit requirements of "Flood Plain Districts" as described in Chapter 1149 of the Codified Ordinances of the City of Sylvania, Ohio.

Location of property ____

Owner of property ____

Lowest floor elevation, ____ feet above
including basement (mean sea level)

____
Signature of Surveyor

Professional Seal Date __________________________

Julia Hart

From: Shaw, Joseph <jshaw@cityofsylvania.com>
Sent: Friday, June 23, 2023 8:42 AM
To: Julia Hart
Cc: craig.hebebrand@arcadis.com; Lindsay Walker; Jim Barna; Chantil Milam (cmilam@lawhon-assoc.com); Aller, Kevin
Subject: RE: LUC-23-11.75 Floodplain / Floodway impacts
Attachments: FLOOD Permit.doc

Follow Up Flag: Flag for follow up
Flag Status: Flagged

Julia:
Less any waterway permitting signatures you would need from us, the only other local coordination you should need would be to complete and submit a Flood Development Permit when appropriate. I have attached a copy for your use.

There isn't a local variance process for the type of work proposed with this project.

Please contact me with further questions.

Thanks,

Joseph E. Shaw, P.E., P.S. | Deputy Director
City of Sylvania | Department of Public Service
6730 Monroe Street, Sylvania, OH 43560 | P: 419-885-8967 | F: 419-885-0486

From: Julia Hart <Julia.Hart@2LMN.com>
Sent: Thursday, June 22, 2023 10:36 AM
To: Shaw, Joseph <jshaw@cityofsylvania.com>; Aller, Kevin <kaller@cityofsylvania.com>
Cc: craig.hebebrand@arcadis.com; Lindsay Walker <Lindsay.Walker@2LMN.com>; Jim Barna <Jim.Barna@2LMN.com>; Chantil Milam (cmilam@lawhon-assoc.com) <cmilam@lawhon-assoc.com>
Subject: LUC-23-11.75 Floodplain / Floodway impacts
Importance: High

This message has originated from an **External Source**. Please use proper judgment and caution when opening attachments, clicking links, or responding to this email.

Kevin & Joe,
As we are progressing on our design for the new ramp bridges over the Ottawa River we are revisiting the Hydraulic Model and floodplain coordination. The current proposed layout of the Southbound on ramp to US 23 encroaches into the Floodplain and Floodway. The previous hydraulic model made assumptions about the ramp grading but didn't incorporate all that is necessary to capture what the current grading plan intends to fill so we are making sure that all of that is captured in the model to accurately reflect the proposed condition.

Please find attached a sketch that shows the encroachments to the floodplain (red) and the floodway (blue). Our understanding is that floodplain encroachments are allowable as long as the increase in not above 1 foot in elevation. Floodway encroachments should be avoided if possible since they can lead to the need to revise the flood maps (CLOMR and LOMR). However, to make the improvements to the ramp alignment we will need to encroach on the Floodplain and Floodway.

The southbound ramp has approximately (A) 21,052 sf encroachment into the floodway and the grading of the northbound off ramp has approximately (B) 859 sf of encroachment into the floodway.

Areas C through H, as labelled on the attachment, are all floodplain encroachments.

Our initial coordination with you determined that we are to follow ODOT's policies since there are no local requirements that are more restrictive, we would like confirmation that this remains the same. As part of ODOT self-permitting process. **I am attaching a new LD-52 Notification form** since the scope of work has changed substantially since the previous coordination.

Our revised, **preliminary hydraulic model is currently showing a slight increase in relation to the BFE**, this is based off of our model created from survey data and lidar (see the attached for more information). The HECRas output attached provided the water surface elevations for both the existing (LUC23_EX) and proposed models (LUC23_PR), respectively under the Plan column. **The increase varies from 0.06-ft to 0.16-ft.** *(When we requested the FEMA model, we were provided with a HEC2 modeling PDF from 1977. It was discussed previously with you, that we should just create our own model from survey and lidar to avoid the time consuming process of recreating the HEC-2 model from the PDF information provided, which is the process we followed to obtain these results.)*

Our understanding for the next step is that **we need to request a variance from local standards** since we have this increase above the BFE (refer to ODOT Location & Design Volume 2, Section 1005.1.2).

This email serves as our request for the variance. Can you please let us know what else you may need to process our variance request?

The project is approaching its Stage 2 review submission and we will be submitting our revised Hydraulic Analysis and Scour Analysis report with that submission. At that time, we will also provide you with the HEC-Ras information and report. It would make sense to include the variance request documentation and approval if available, at that time.

Please let us know if you have any question.

Thanks!
Julia

Julia A. Hart, P.E.
Director of Structures
2LMN
DBE • MBE • SBE Certified
Lancaster | Cleveland | Columbus | Charleston
(740) 785-6474 Direct
(330) 312-8522 Cell

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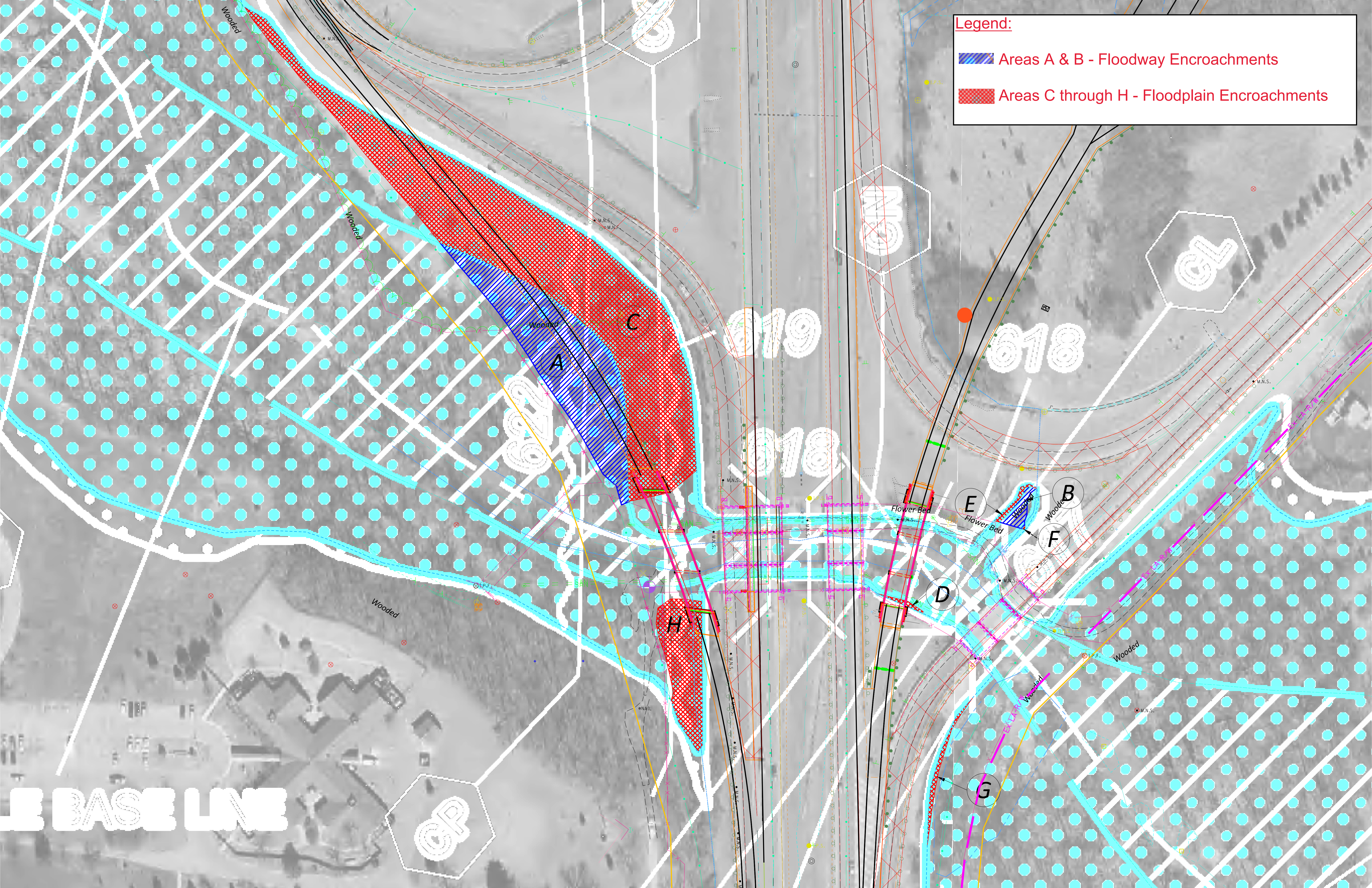
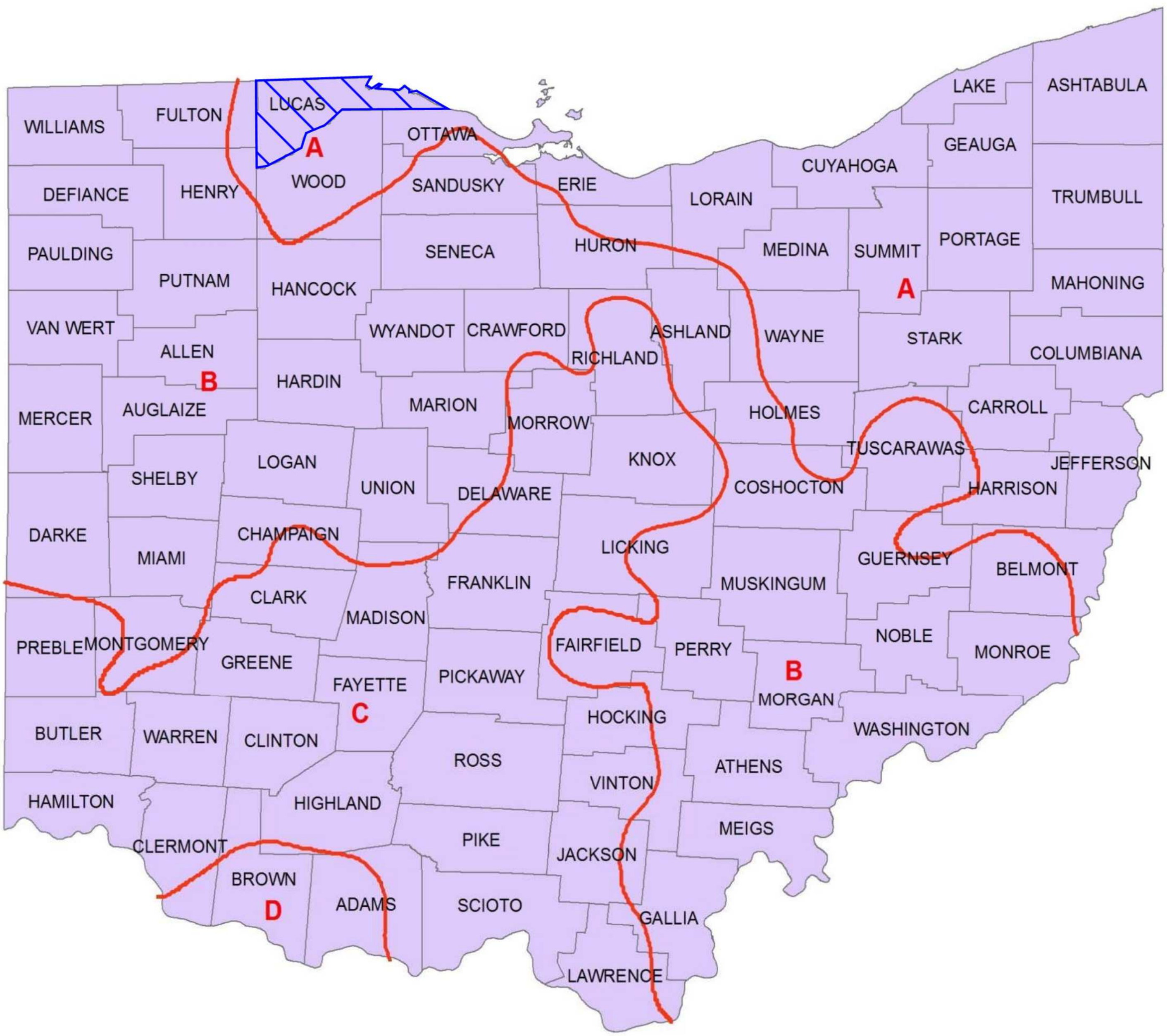

Legend:
Areas A & B - Floodway Encroachments
Areas C through H - Floodplain Encroachments
A
B
C
D
E
F
G
H
Wooded
Flower Bed
819
818
618
GL
GP
BASE LINE
EX LA R/W

Appendix 6: Bridge Deck Drainage Calculations

July 2022

Rainfall Intensity-Frequency-Duration Curves	1101-2
	REFERENCE SECTION 1101.2.3



Rainfall Intensity Zone Map

1103.2 Design AEP Storm

Locate pavement inlets or catch basins to limit the spread of flow on the traveled lane to those shown in Table 1103-1. Base the design on the following recurrence interval:

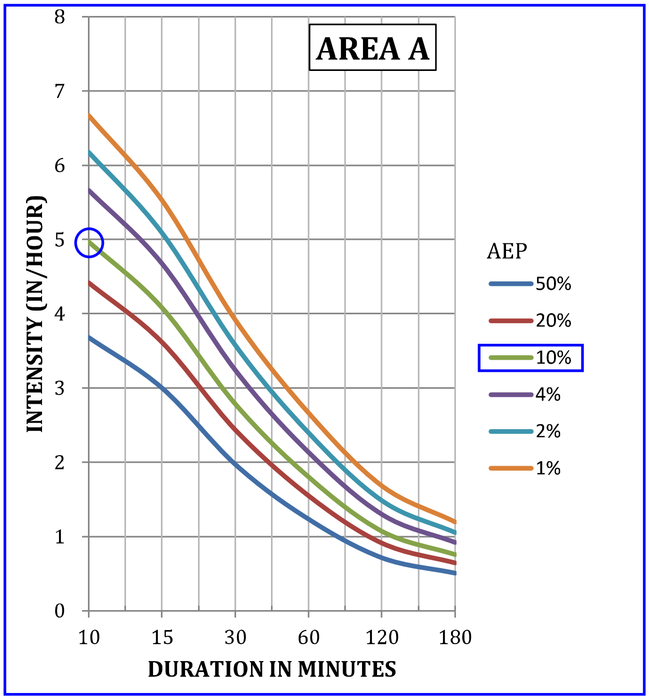
Facility	Design (AEP)
Freeways	10%
High Volume Highways (Over 6000 ADT)	20%
All other Highways	50%

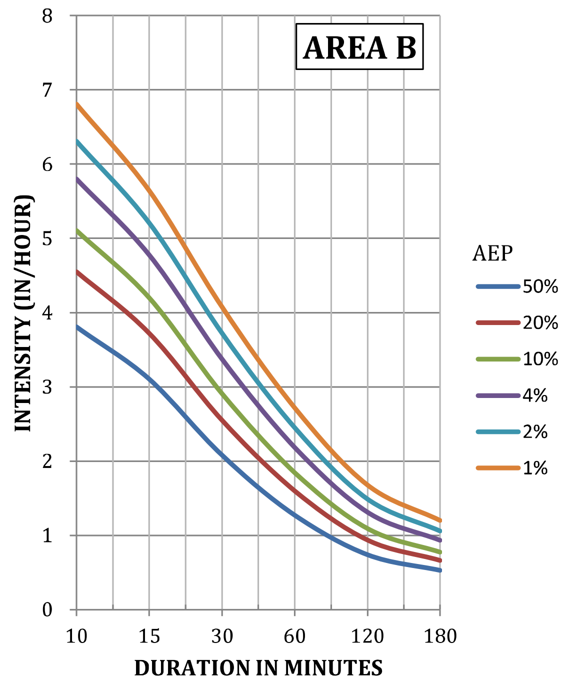
For underpasses or other depressed roadways where ponded water can be removed only through the storm sewer system, check the spread for a 2% AEP storm on Freeways and other high volume highways as defined above. Use a 4% AEP storm on other multiple lane highways. Ponding is permitted to cover all but one through lane of a multiple lane roadway.

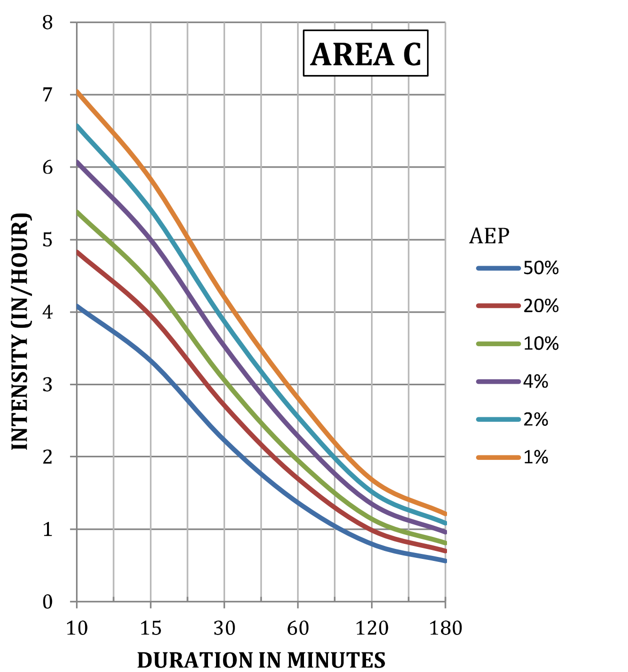
The depth of flow or ponding at the curb cannot exceed 1 inch below the top of the curb for the design storm discharge regardless of the type of highway. A maximum depth of 6 inches is permitted where a barrier is provided.

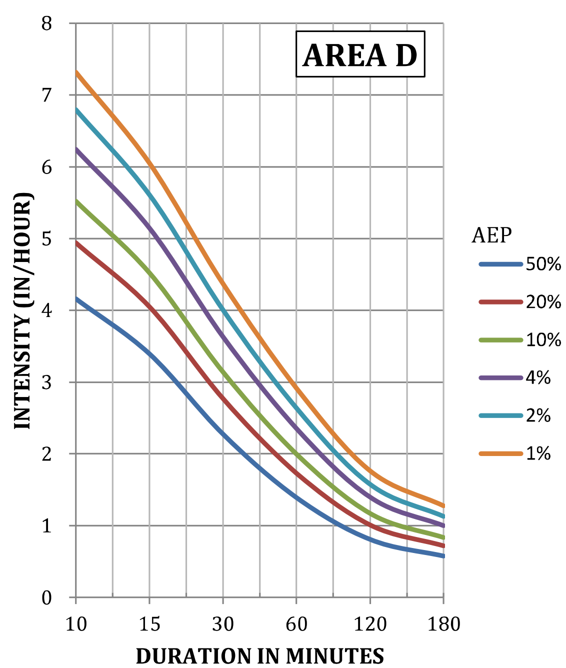
July 2022

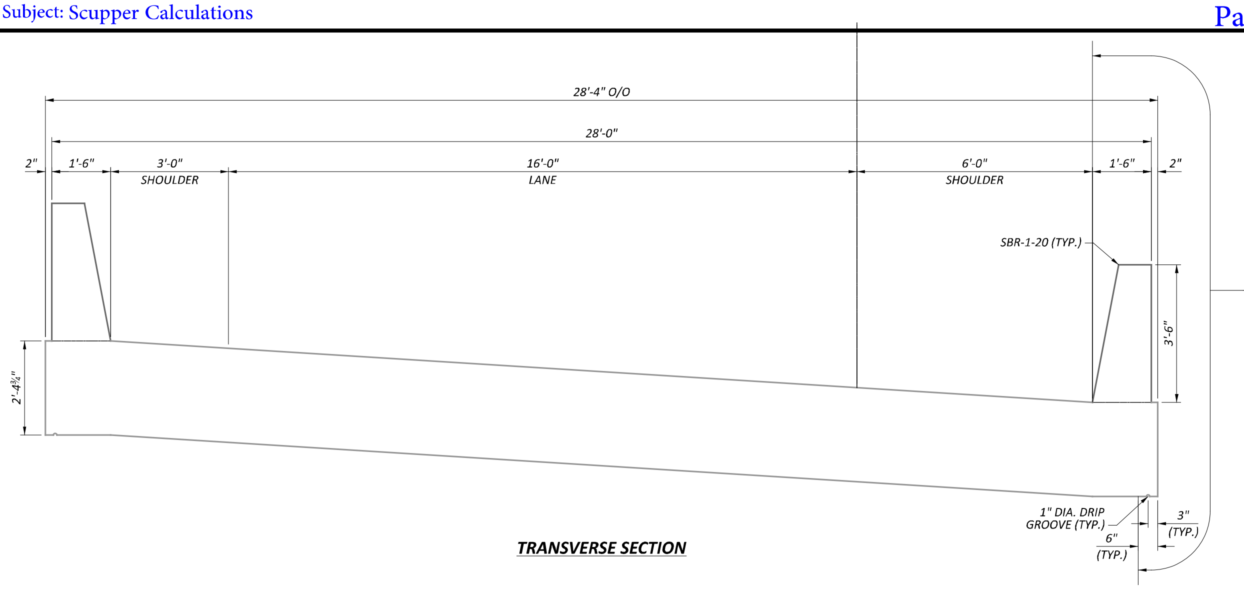
Rainfall Intensity-Frequency-Duration Curves	1101-2
	REFERENCE SECTION 1101.2.3





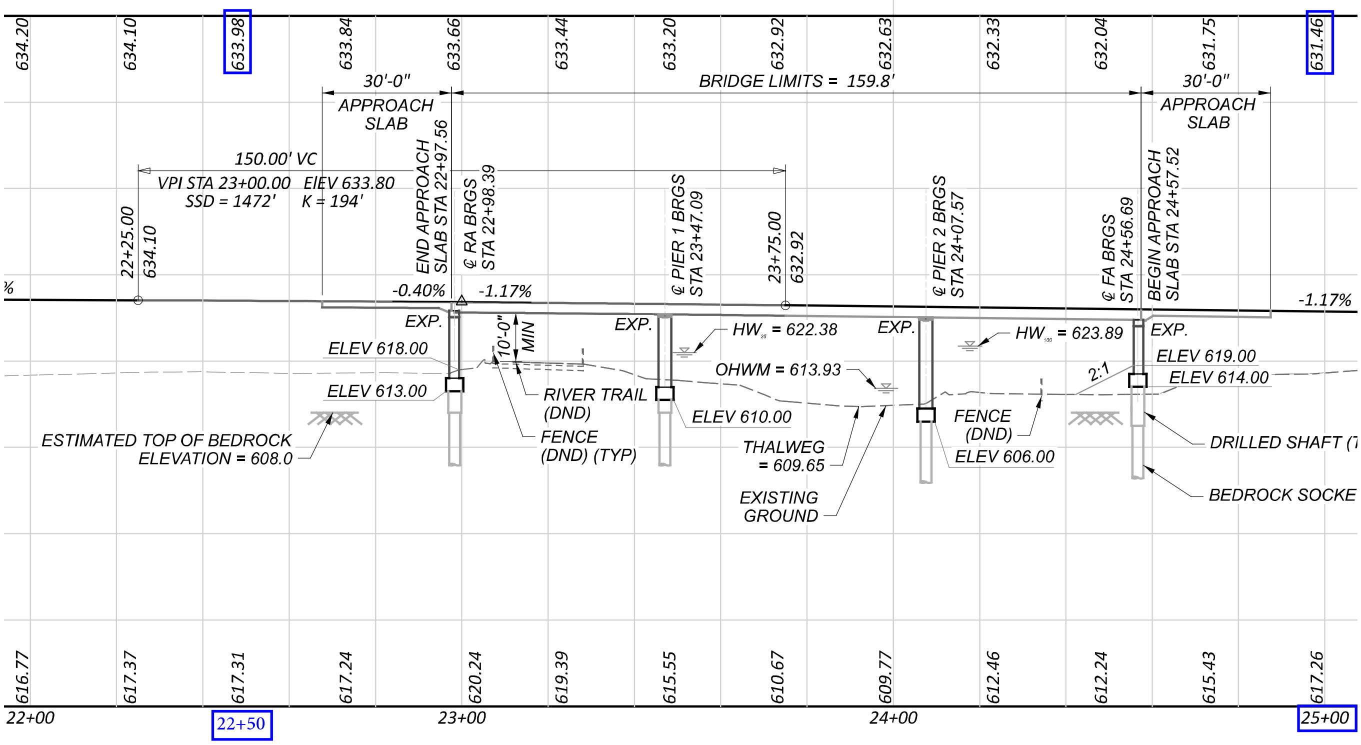






Cross Slope Slope not listed. Since bridge is curved, assume at a minimum, 2% super applied.

Width of bridge side = 16'+3'+6'=25' between barriers



Spread and Scupper Bypass

	Station* (ft)	Elevation (ft)		Longitudinal Slope S (ft/ft)	Contributing Drainage Width (ft)	Area A (acres)	intensity** i (in/hr)	Gutter Flow Q (cfs)	Cross Slope S_x (ft/ft)	Spread T (ft)	Grate Width W (ft)	Efficiency E	Bypass Flow Q_b (cfs)
Begin	2250	633.98											
At Scupper	2500	631.46		0.01008	25	0.143	4.9	0.63	0.0200	5.9	0	0.00	0.63

Notes:

[yellow] = input required
* i.e.; enter 22+50 as 2250
** see L&D Vol. 2 Fig. 1101-2 & 1101-3

Equations:

$$Q = ciA$$

where c=0.9

$$T = \left(\frac{Qn}{0.56\, S_x^{1.67} S^{0.5}}\right)^{0.375}$$

where n=0.015

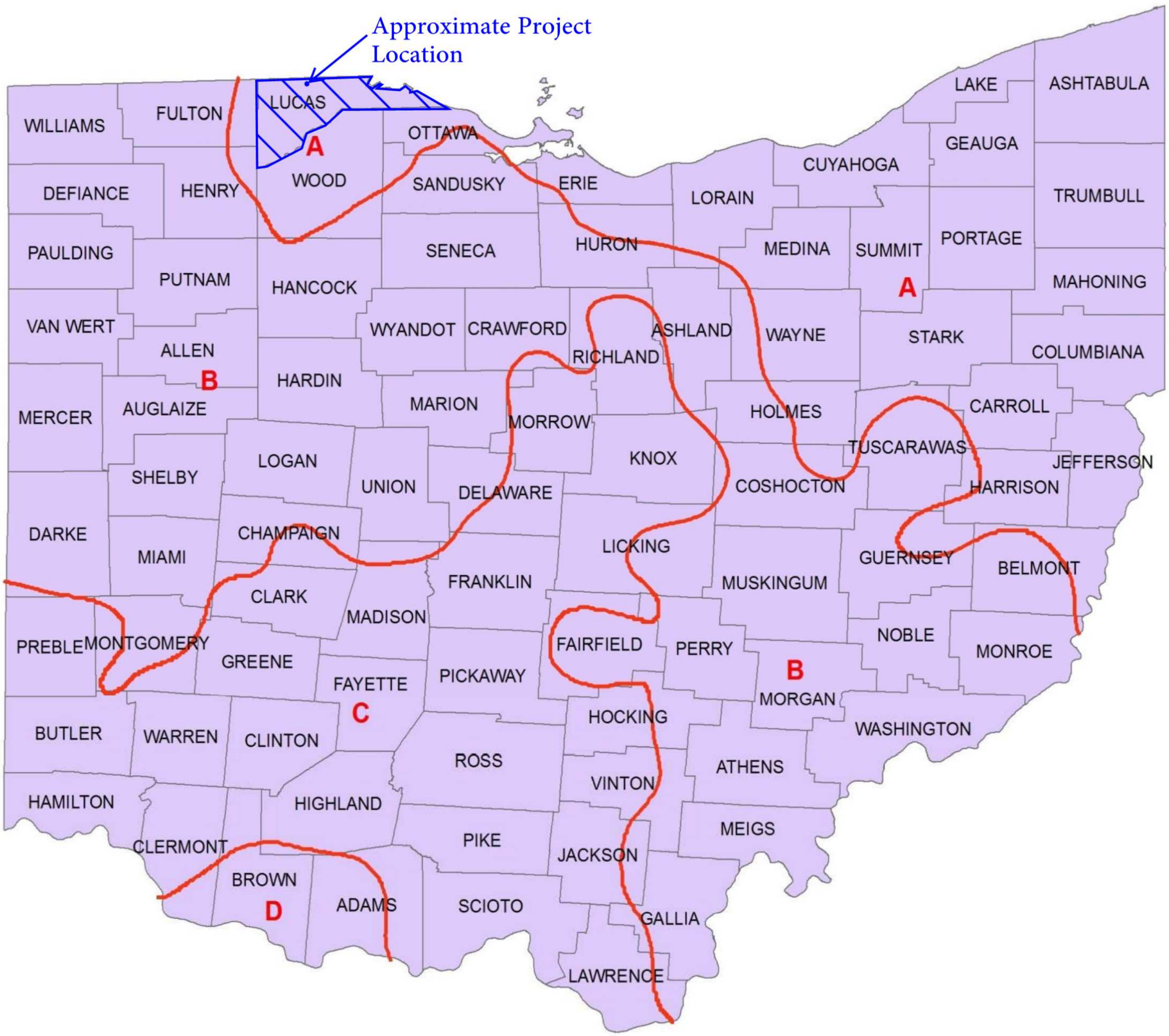
$$E = 1 - \left(1 - \frac{W}{T}\right)^{2.67}$$

$$Q_b = Q(1 - E)$$

Shoulder width = 6 ft
Need for Scuppers None Since shoulder width is greater than spread width

July 2022

Rainfall Intensity-Frequency-Duration Curves	1101-2
	REFERENCE SECTION 1101.2.3



Rainfall Intensity Zone Map

1103.2 Design AEP Storm

Locate pavement inlets or catch basins to limit the spread of flow on the traveled lane to those shown in Table 1103-1. Base the design on the following recurrence interval:

Facility	Design (AEP)
Freeways	10%
High Volume Highways (Over 6000 ADT)	20%
All other Highways	50%

For underpasses or other depressed roadways where ponded water can be removed only through the storm sewer system, check the spread for a 2% AEP storm on Freeways and other high volume highways as defined above. Use a 4% AEP storm on other multiple lane highways. Ponding is permitted to cover all but one through lane of a multiple lane roadway.

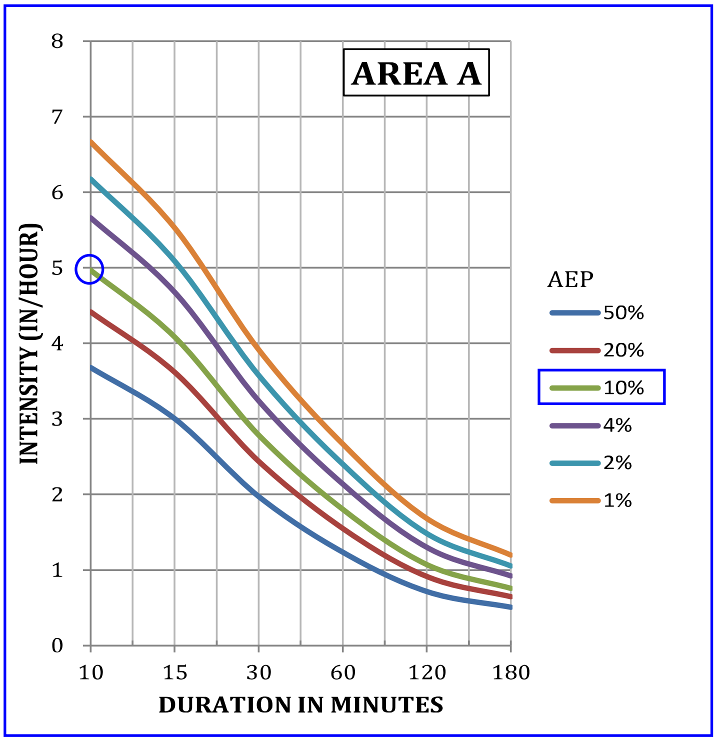
The depth of flow or ponding at the curb cannot exceed 1 inch below the top of the curb for the design storm discharge regardless of the type of highway. A maximum depth of 6 inches is permitted where a barrier is provided.

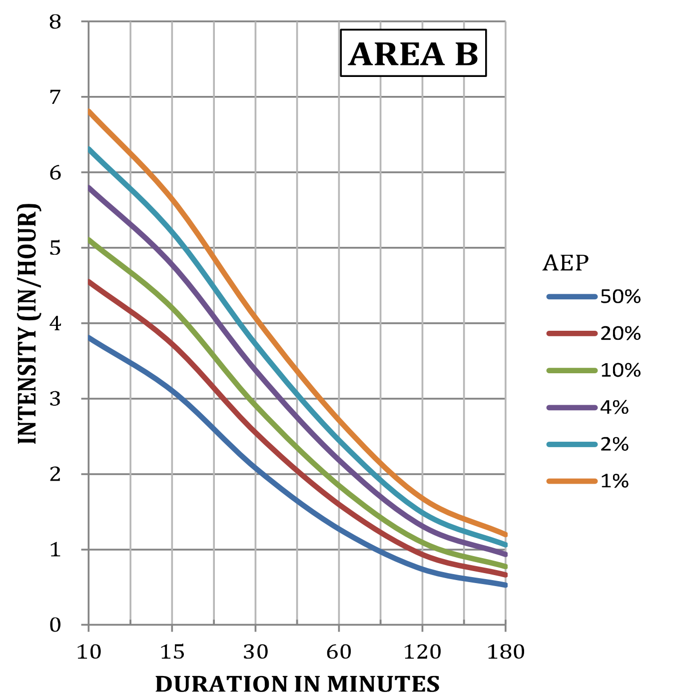
July 2022

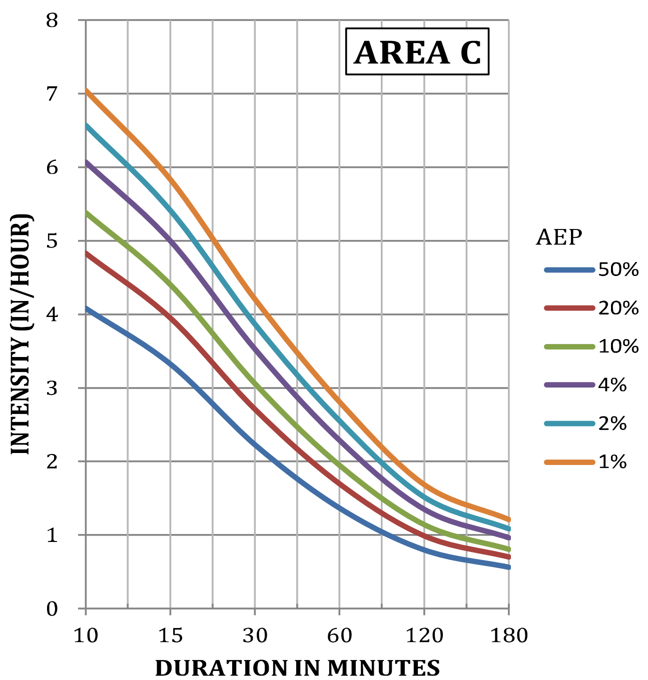
Rainfall Intensity-Frequency-Duration Curves

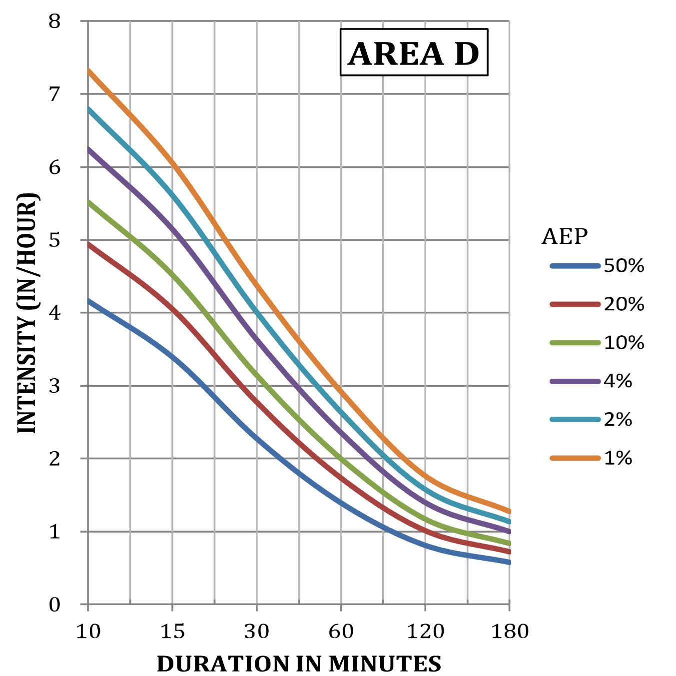
1101-2

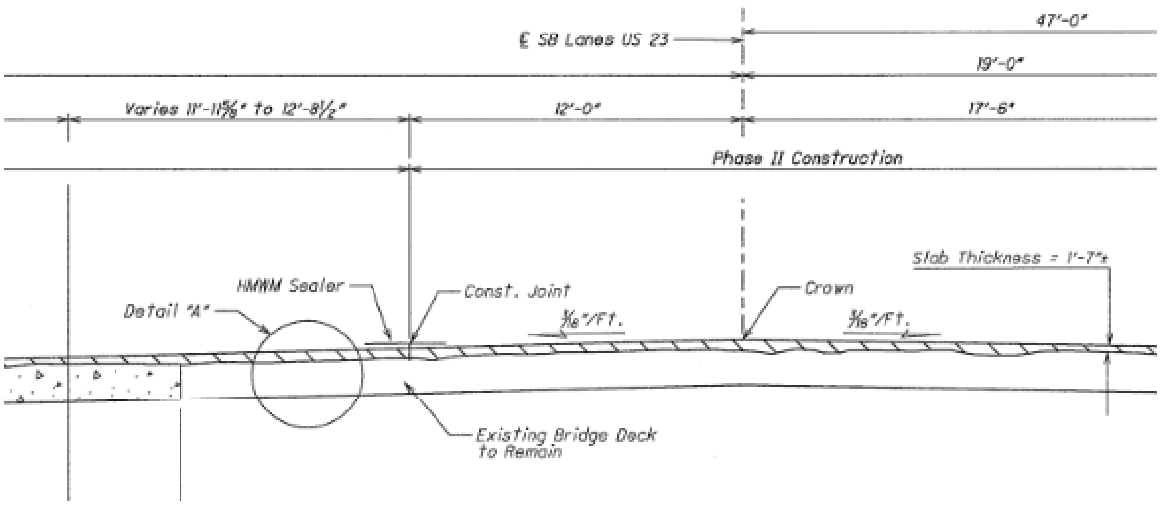
REFERENCE SECTION 1101.2.3



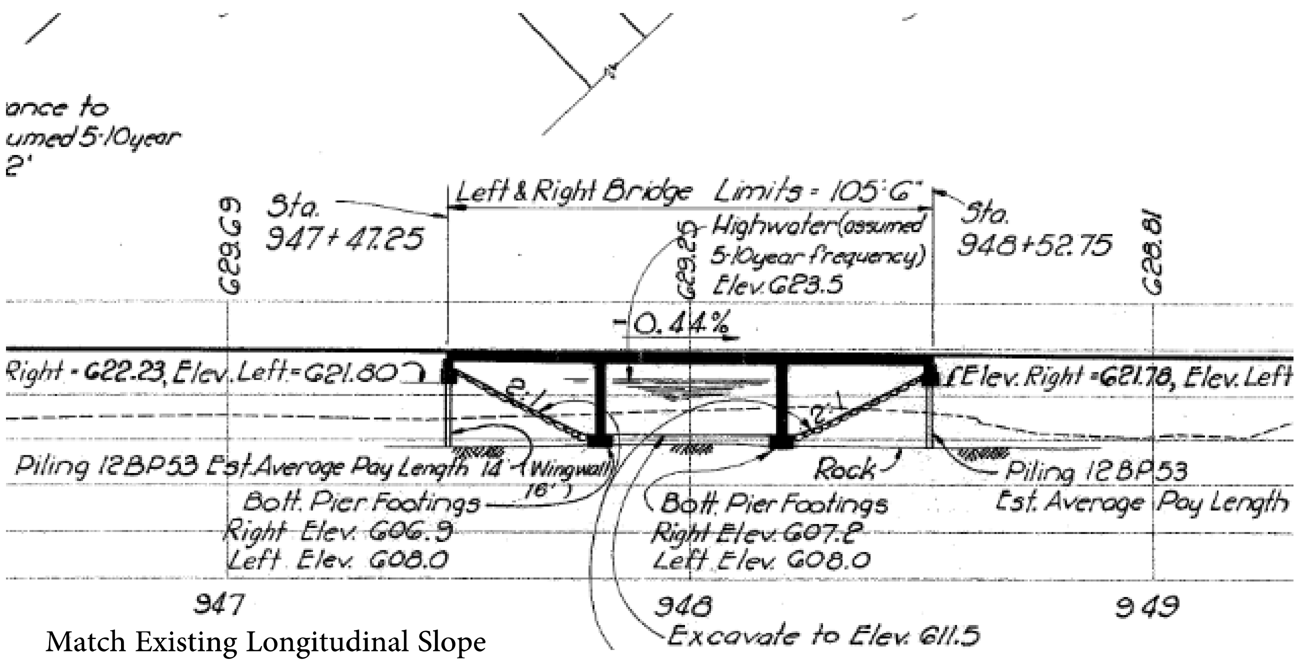




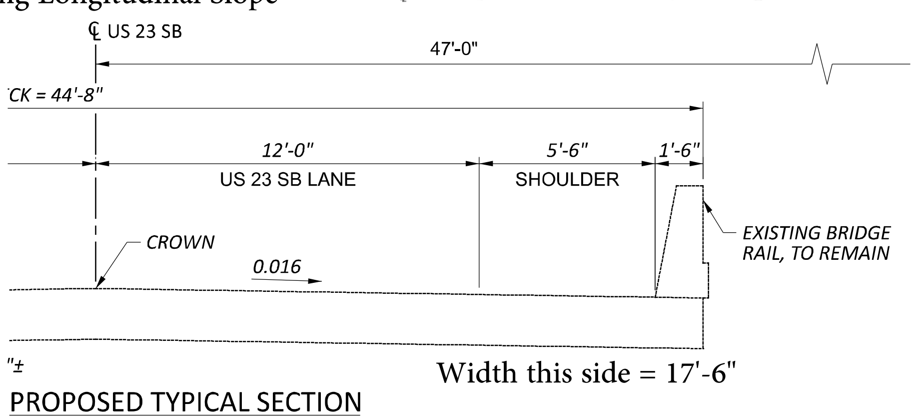




Match Existing Cross Slope



Match Existing Longitudinal Slope



Width this side = 17'-6"

Spread and Scupper Bypass

	Station* (ft)	Elevation (ft)		Longitudinal Slope S (ft/ft)	Contributing Drainage Width (ft)	Area A (acres)	intensity** i (in/hr)	Gutter Flow Q (cfs)	Cross Slope S_x (ft/ft)	Spread T (ft)	Grate Width W (ft)	Efficiency E	Bypass Flow Q_b (cfs)
Begin	5360	629.07											
At Scupper	5480	628.55		0.00433	18	0.048	4.9	0.21	0.0160	5.3		0.00	0.21

Notes:

(yellow) = input required
* i.e.; enter 22+50 as 2250
** see L&D Vol. 2 Fig. 1101-2 & 1101-3

Equations:

$$Q = ciA$$

where c=0.9

$$T = \left(\frac{Qn}{0.56\, S_x^{1.67} S^{0.5}}\right)^{0.375}$$

where n=0.015

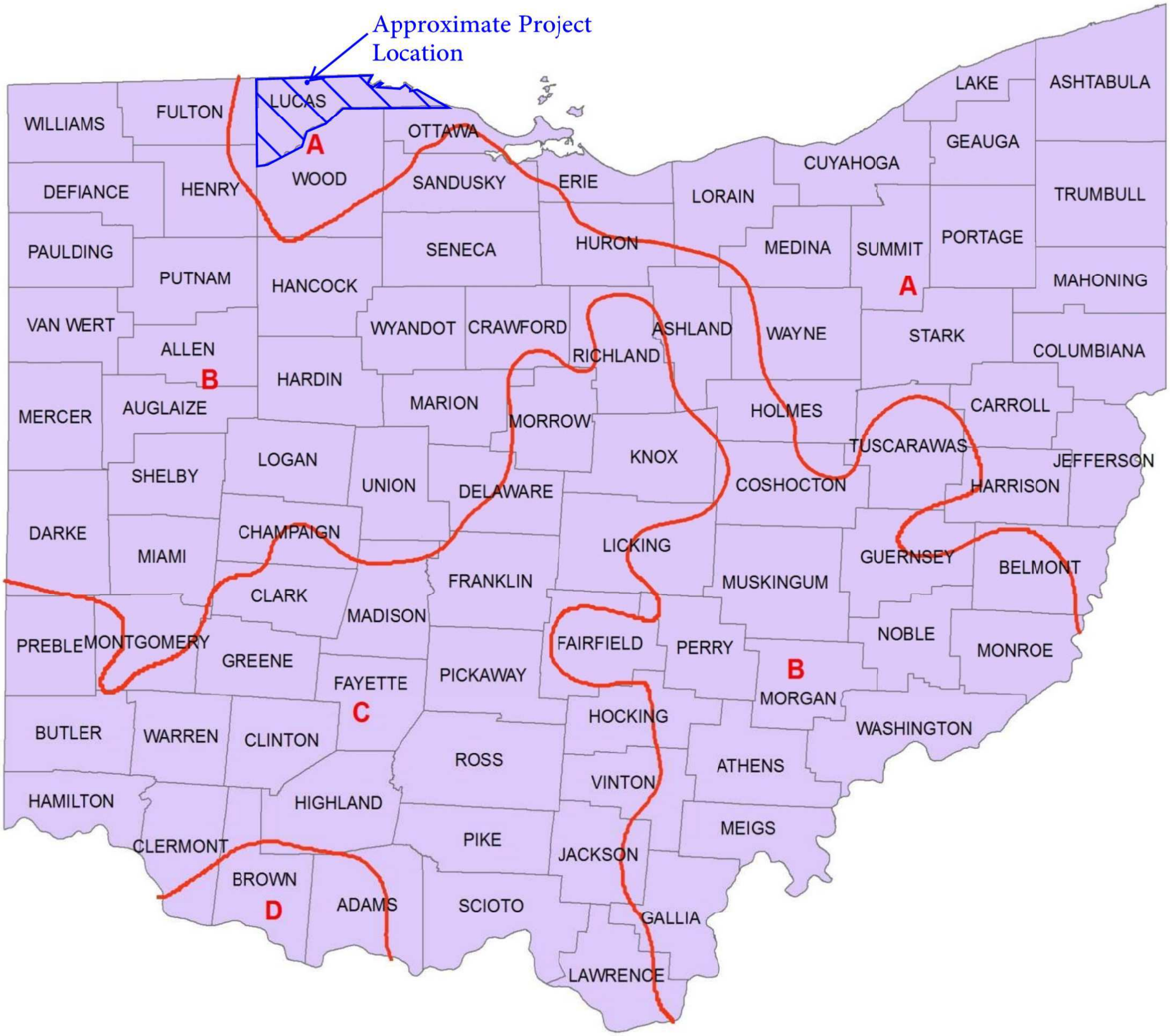
$$E = 1 - \left(1 - \frac{W}{T}\right)^{2.67}$$

$$Q_b = Q(1 - E)$$

Shoulder width = 5.5 ft
Need for Scuppers None Since shoulder width is greater than spread width

July 2022

Rainfall Intensity-Frequency-Duration Curves	1101-2
	REFERENCE SECTION 1101.2.3



Rainfall Intensity Zone Map

1103.2 Design AEP Storm

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All other Highways	50%

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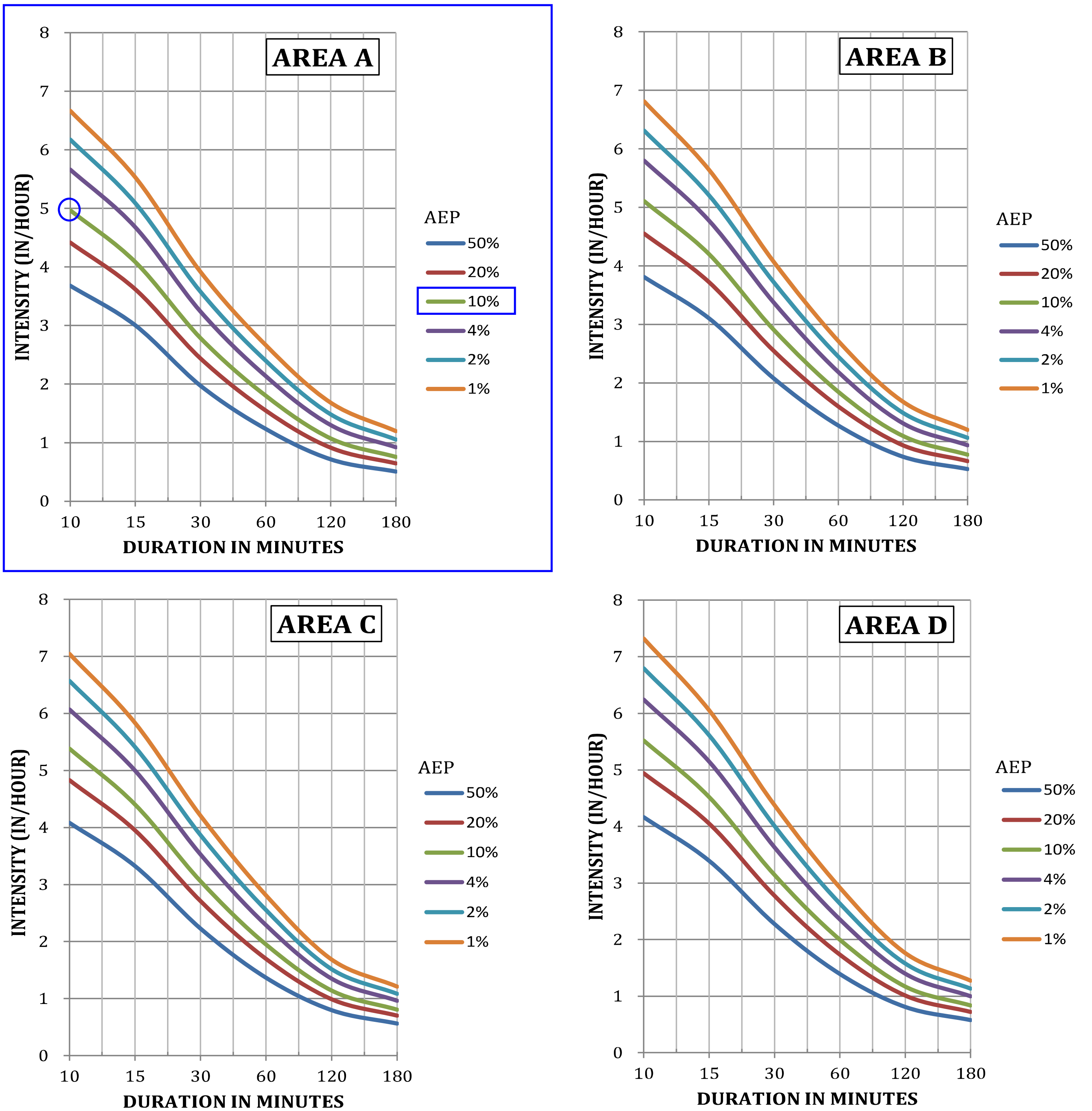
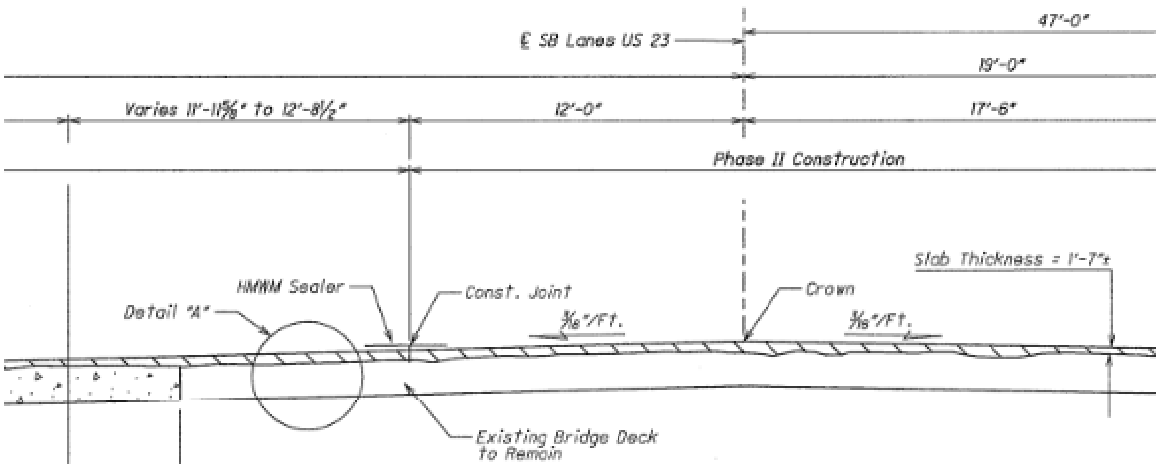
The depth of flow or ponding at the curb cannot exceed 1 inch below the top of the curb for the design storm discharge regardless of the type of highway. A maximum depth of 6 inches is permitted where a barrier is provided.

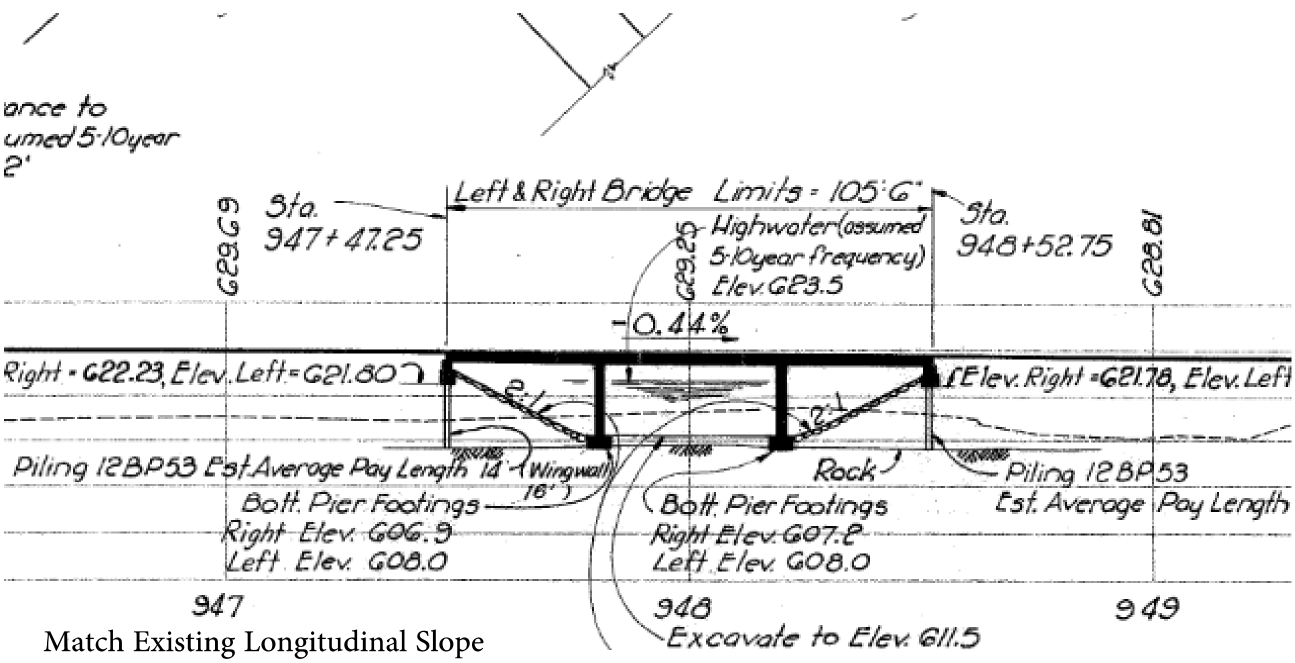
July 2022

Rainfall Intensity-Frequency-Duration Curves	1101-2
	REFERENCE SECTION 1101.2.3

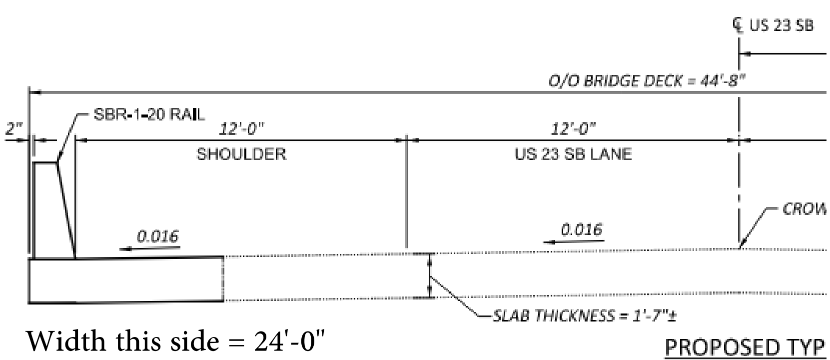




Match Existing Cross Slope



Match Existing Longitudinal Slope



Width this side = 24'-0"

Calculated: RFS Date: 10/27/2022
Checked: JAH Date: 10/27/2022
Concurred: Date:
Back Checked: Date:
Released: JAH Date: 10/27/2022
Project: ARCA-105889_LUC-23-11.75
Subject: Scupper Calculations

Stage Review Submission: Stage 1
PID/Job No.: 105889
Bridge No.: LUC-00023-11.650 L
SFN: 4801261

Spread and Scupper Bypass

	Station* (ft)	Elevation (ft)		Longitudinal Slope S (ft/ft)	Contributing Drainage Width (ft)	Area A (acres)	intensity** i (in/hr)	Gutter Flow Q (cfs)	Cross Slope S_x (ft/ft)	Spread T (ft)	Grate Width W (ft)	Efficiency E	Bypass Flow Q_b (cfs)
Begin	5360	629.07											
At Scupper	5480	628.55		0.00433	24	0.066	4.9	0.29	0.0160	6.0		0.00	0.29

Notes:

(yellow) = input required
* i.e.; enter 22+50 as 2250
** see L&D Vol. 2 Fig. 1101-2 & 1101-3

Equations:

$$Q = ciA$$

where c=0.9

$$T = \left(\frac{Qn}{0.56\, S_x^{1.67} S^{0.5}}\right)^{0.375}$$

where n=0.015

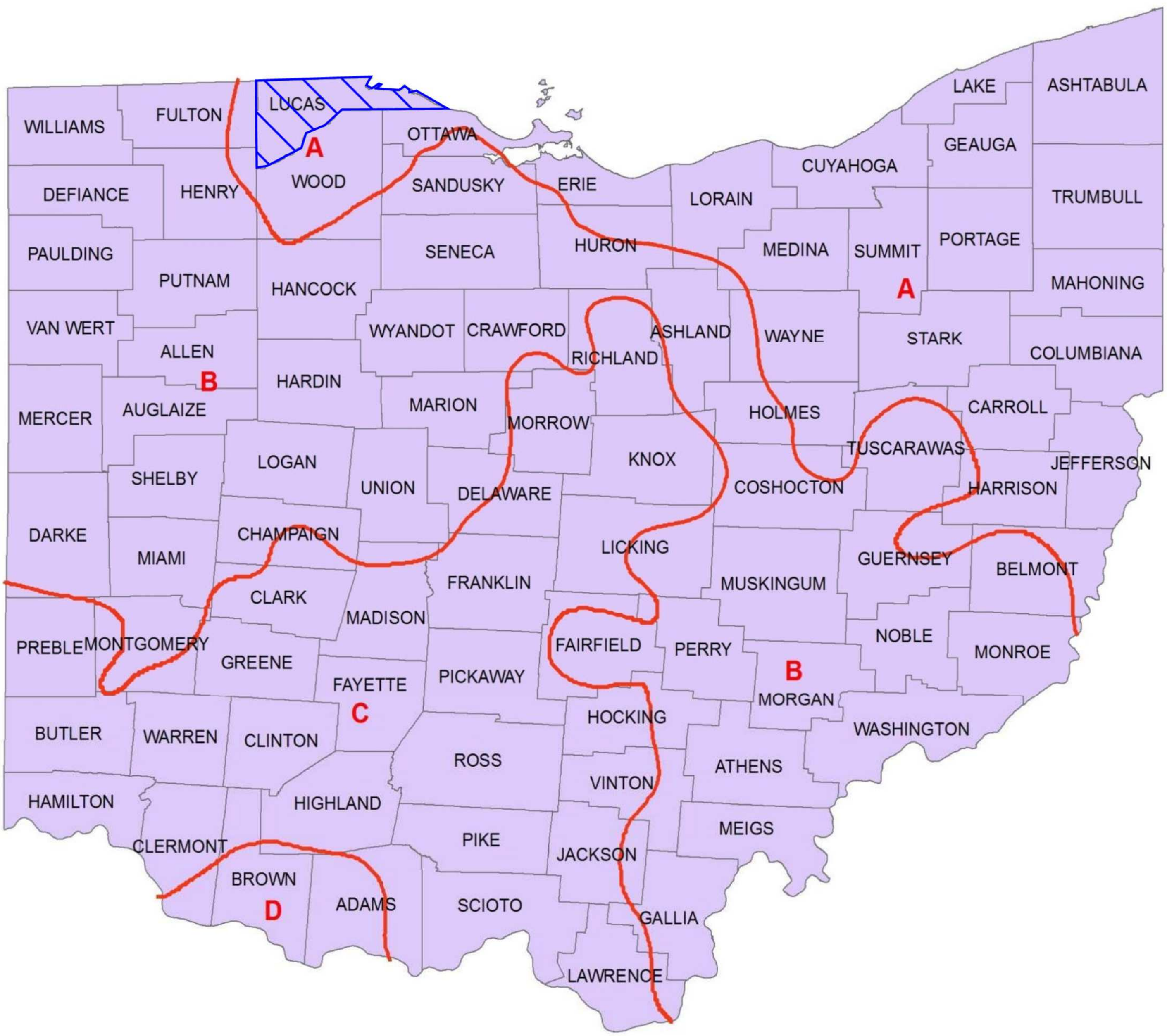
$$E = 1 - \left(1 - \frac{W}{T}\right)^{2.67}$$

$$Q_b = Q(1 - E)$$

Shoulder width = 12 ft
Need for Scuppers None Since shoulder width is greater than spread width

July 2022

Rainfall Intensity-Frequency-Duration Curves	1101-2
	REFERENCE SECTION 1101.2.3



Rainfall Intensity Zone Map

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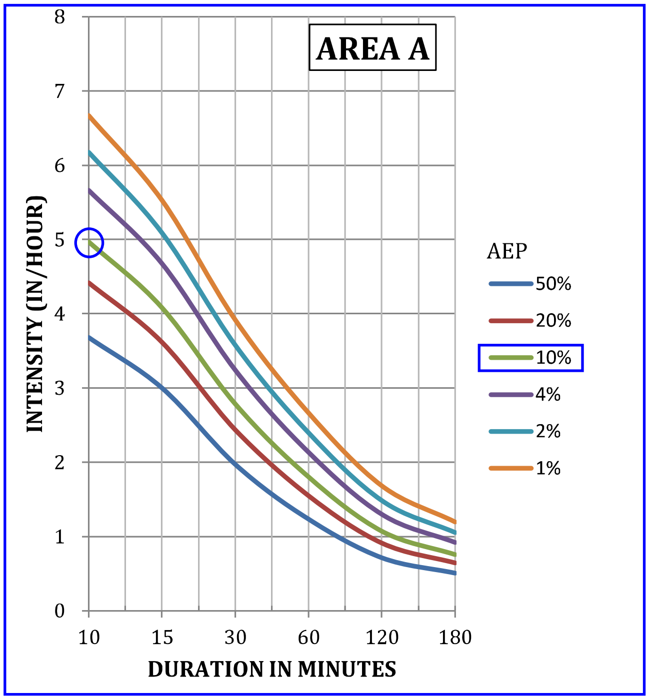
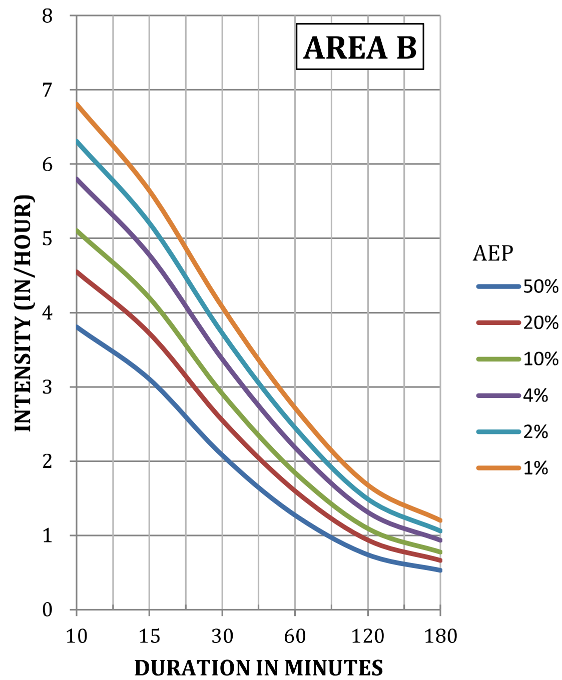
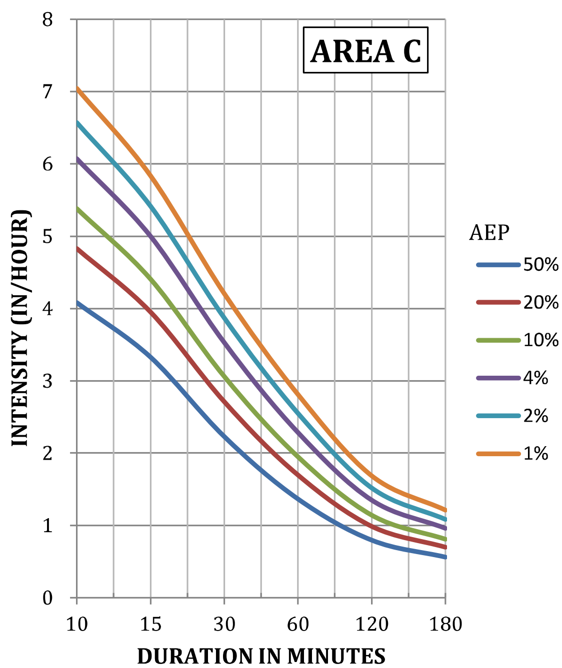
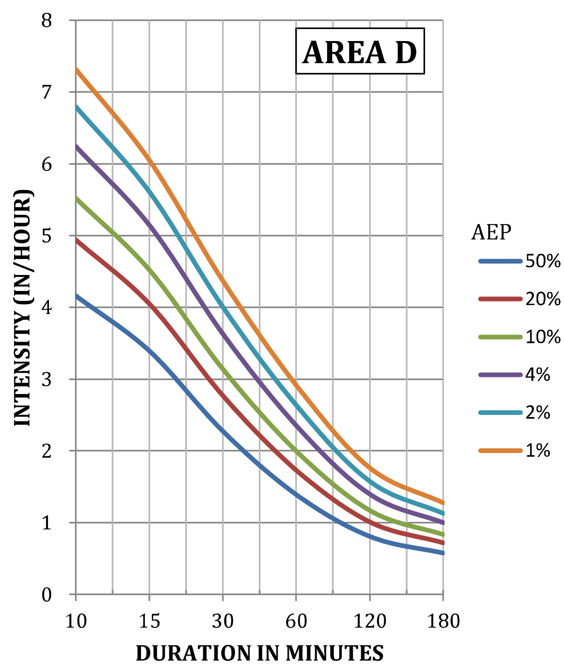
July 2022

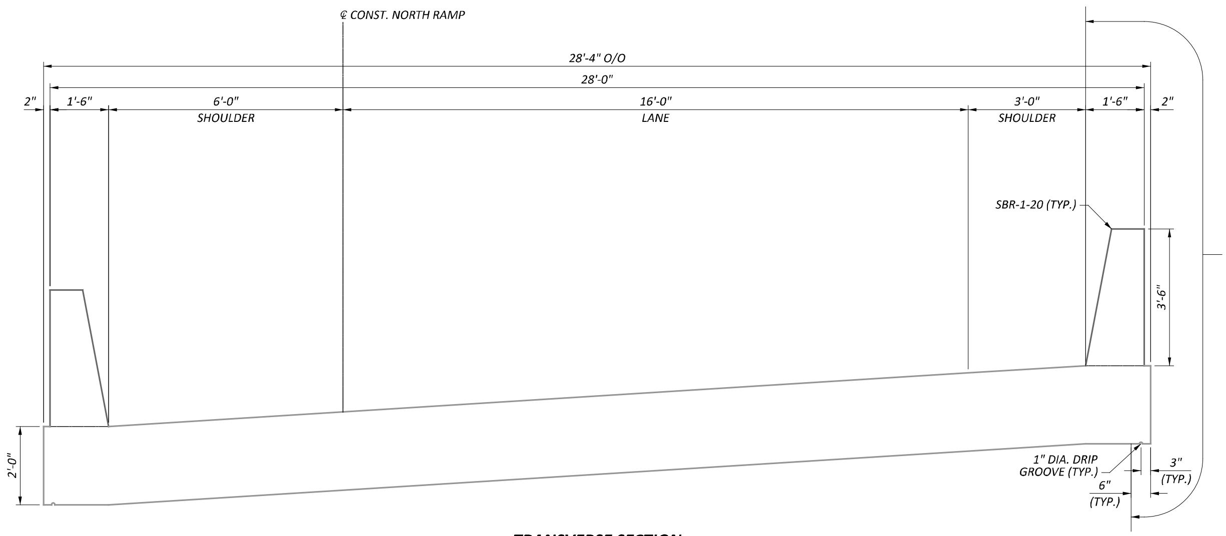
Rainfall Intensity-Frequency-Duration Curves	1101-2
	REFERENCE SECTION 1101.2.3







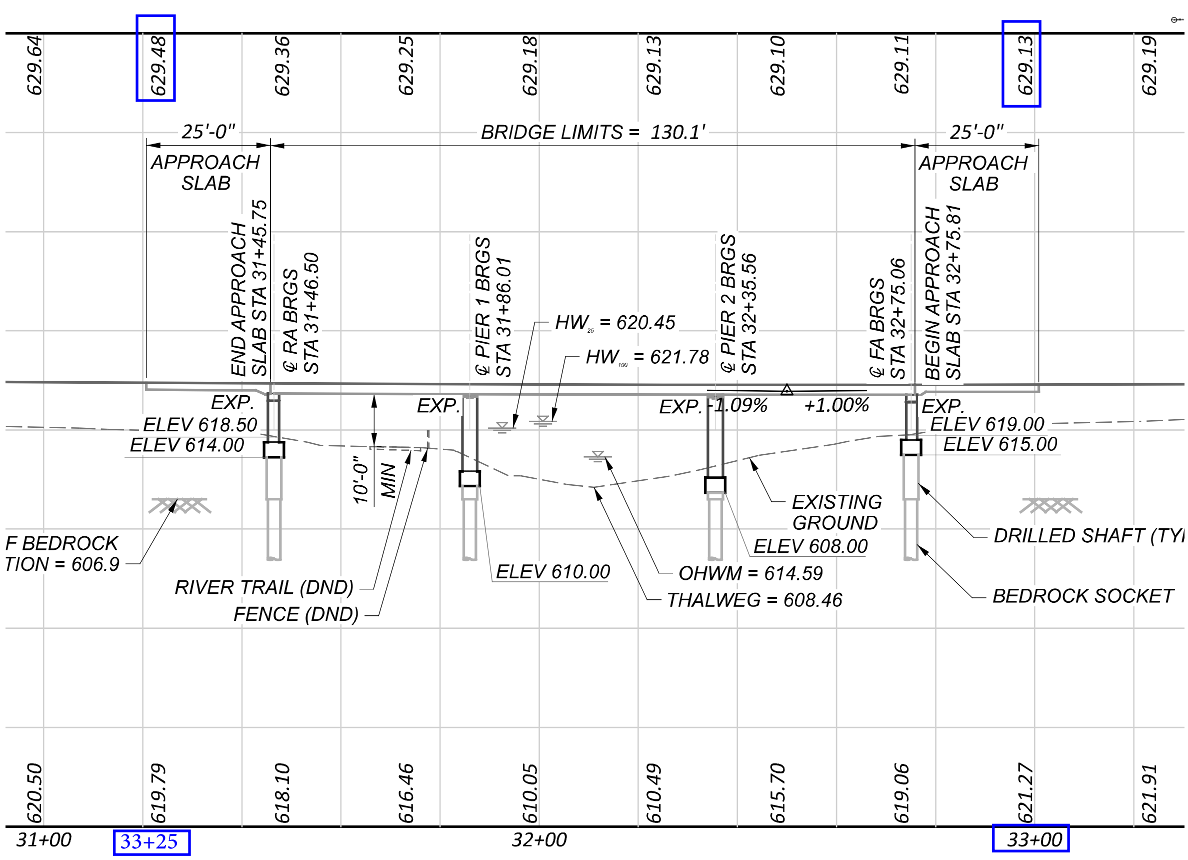




TRANSVERSE SECTION

Cross Slope Slope not listed. Since bridge is curved, assume at a minimum, 2% super applied.

Width of bridge side = 16'+3'+6'=25' between barriers



Calculated: RFS Date: 10/27/2022
Checked: JAH Date: 10/28/2022
Concurred: Date:
Back Checked: Date:
Released: JAH Date: 10/28/2022
Project: ARCA-105889_LUC-23-11.75
Subject: Scupper Calculations

Stage Review Submission: Stage 1
PID/Job No.: 105889
Bridge No.: LUC-00023-11.750 NB-R
SFN: 4805136

Spread and Scupper Bypass

	Station* (ft)	Elevation (ft)		Longitudinal Slope S (ft/ft)	Contributing Drainage Width (ft)	Area A (acres)	intensity** i (in/hr)	Gutter Flow Q (cfs)	Cross Slope S_x (ft/ft)	Spread T (ft)	Grate Width W (ft)	Efficiency E	Bypass Flow Q_b (cfs)
Begin	3125	629.48											
At Scupper	3300	629.13		0.00200	25	0.100	4.9	0.44	0.0200	7.0	4.5	0.94	0.03

Notes:
(yellow) = input required
* i.e.; enter 22+50 as 2250
** see L&D Vol. 2 Fig. 1101-2 & 1101-3

Equations:

$$Q = ciA$$

where c=0.9

$$T = \left(\frac{Qn}{0.56\, S_x^{1.67} S^{0.5}}\right)^{0.375}$$

where n=0.015

$$E = 1 - \left(1 - \frac{W}{T}\right)^{2.67}$$

$$Q_b = Q(1 - E)$$

Shoulder width = 6 ft
Need for Scuppers Required
Place one scupper at load point in ramp

Roadway geometry to be further reviewed in next stage to see if sag can be moved off of bridge and adjust longitudinal/cross slope to possibly eliminate scupper.

Appendix 7: Scour Calculations

Existing Ground Elevation

R.A.	618.00
Pier 1	615.58
Pier 2	609.79
F.A.	612.33

Project Name: LUC-023-11.75, PID 105889
Project Numbe 2065201
Calculated by: KCH 04/11/2023
Reviewed By: CPI 04/17/2023

= D50 equivalent (mm)

Scour Determination - Ramp D

Upper Elevation Limit for Analysis = 623.88 feet, based on 100-year floodplain
Lower Elevation Limit for Analysis = 602.46 feet, based on 6 feet below bottom of river

Table 1. Scour Parameters for Soils - Ramp D

	Boring Number	Sample Number	Sample Depth (feet)	Sample Approximate Elevation (feet)	ODOT Soil Class	Fines (<75 µm) (percent)	PI (percent)	w (percent)	q_u[1] (psf)	D_{50} (mm)	D_{95} (mm)	Critical Shear Stress, τ_c (psf)	Critical Shear Stress, τ_c (Pa)
R.A & Pier 1	B-022-1-21	SS-1	1.0 - 2.5	615.0 - 613.5	A-4a (2)	44	8	17	3,500	0.0940	0.9801	0.066	3.09
	B-022-1-21	SS-2	3.5 - 5.0	612.5 - 611.0	A-4a (3)	49	9	19	2,000	0.0791	9.7229	0.061	2.86
	B-022-1-21	SS-3	6.0 - 7.3	610.0 - 608.7	A-3 (0)	24	0	68	-	0.2838	17.0339	0.006	0.28
Pier 2 & F.A.	B-022-2-21	SS-2	3.5 - 5.0	612.5 - 611.0	A-4a (3)	50	9	19	4,250	0.0707	1.4922	0.086	4.02
	B-022-2-21	SS-3	6.0 - 6.2	610.0 - 609.8	A-1-a (0)	0	0	7	-	9.1626	17.9364	0.191	9.16
	B-022-3-21	SS-1	6.0 - 7.3	610.0 - 608.7	A-2-4 (0)	0	0	9	-	1.0398	22.3951	0.022	1.04

[1] For cohesive samples which were not intact for an unconfined compressive strength test or a hand penetrometer value, q_u was estimated by N_{60}x250.

Table 2. Scour Parameters for Rock - Ramp D

Boring Number	Sample Number	Sample Depth (feet)	Sample Approximate Elevation (feet)	Unconfined Compressive Strength, Q_u (psi)	Slake Durability Index, S_{DI} (percent)	Rock Quality Designation, RQD (percent)	Unit Weight (pcf)	Rock Mass Rating, RMR (Superseded by GSI)	Geologic Strength Index, GSI	Erodibility Index, K	Critical Shear Stress, τ_c (psf)	Critical Shear Stress, τ_c (Pa)
B-022-1-21	NQ-1	8.6 - 13.6	607.4 - 602.4	15,630	99.2	22	163.5	47	35 to 55	142	63.05	3,018.8
B-022-3-21	NQ-1	9.3 - 14.3	606.7 - 601.7	17,840	99.7	45	159.5	57	45 to 65	332	96.34	4,612.6

Existing Ground Elevation

R.A.	618.56
Pier 1	613.69
Pier 2	612.52
F.A.	618.94

Project Name: LUC-023-11.75, PID 105889
Project Numbe 2065201
Calculated by: KCH 04/11/2023
Reviewed By: CPI 04/17/2023

Scour Determination - Ramp A

Upper Elevation Limit for Analysis = 621.79 feet, based on 100-year floodplain
Lower Elevation Limit for Analysis = 602.40 feet, based on 6 feet below bottom of river

Table 3. Scour Parameters for Soils - Ramp A

	Boring Number	Sample Number	Sample Depth (feet)	Sample Approximate Elevation (feet)	ODOT Soil Class	Fines (<75 µm) (percent)	PI (percent)	w (percent)	q_u [1] (psf)	D_{50} (mm)	D_{95} (mm)	Critical Shear Stress, τ_c (psf)	Critical Shear Stress, τ_c (Pa)
R.A. & Pier 1	B-028-1-21	SS-2	3.5 - 5.0	613.5 - 612.0	A-4a (4)	54	5	22	2,000	0.0452	1.3659	0.026	1.21
	B-028-1-21	SS-3	6.0 - 7.5	611.0 - 609.5	A-2-4 (0)	25	6	11	-	0.3939	23.785	0.008	0.39
	B-028-1-21	SS-4	8.5 - 10	608.5 - 607.0	A-2-4 (0)	31	4	12	-	1.0692	23.894	0.022	1.07
	B-028-1-21	SS-5	11 - 11.1	606.0 - 605.9	A-2-4 (0)	31	0	-	-	0.3334	9.9839	0.007	0.33
Pier 2 & F.A.	B-028-2-21	SS-1	0.0 - 0.9	609.5 - 608.6	A-1-b (0)	20	0	-	-	6.3707	23.5121	0.133	6.37

[1] For cohesive samples which were not intact for an unconfined compressive strength test or a hand penetrometer value, q_u was estimated by N_{60}x250.

Table 4. Scour Parameters for Rock - Ramp A

	Boring Number	Sample Number	Sample Depth (feet)	Sample Approximate Elevation (feet)	Unconfined Compressive Strength, Q_u (psi)	Slake Durability Index, S_{DI} (percent)	Rock Quality Designation, RQD (percent)	Unit Weight (pcf)	Rock Mass Rating, RMR (Superseded by GSI)	Geologic Strength Index, GSI	Erodibility Index, K	Critical Shear Stress, τ_c (psf)	Critical Shear Stress, τ_c (Pa)
R.A. & Pier 1	B-028-1-21	NQ-1	11.2 - 16.2	606.0 - 601.0	12,510	99.6	77	160.5	38	30 to 45	266	86.16	4,125.5
Pier 2 & F.A.	B-028-2-21	NQ-1	1.5 - 5.0	608.0 - 604.5	10,750	99.6	67	164.6	57	45 to 65	298	91.25	4,369.0
	B-028-2-21	NQ-2	5.0 - 10.0	604.5 - 599.5	19,230	-	37	164.2	57	45 to 65	294	90.69	4,342.5

2LMN

North Exit Ramp Summary For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.: 105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.: LUC-00184-00.200R
Project:	LUC-23-11.75			SFN: TBD

50-Year (2% AEP)	Depth (ft)	Existing Ground EL.*	**Scour Elevation**	Bottom of Footing EL.	Shaft length	**Bottom of Shaft Due to Scour / Top of Rock Socket**
Contraction Scour (R.A.)	7.6					
Abutment Scour (R.A.)	7.6					
Total Rear Abutment Scour**	**7.6**	**613.50**	**605.9**	613.5	17.60	595.90
Contraction Scour (F.A.)	0					
Abutment Scour (F.A.)	0.9					
Total Forward Abutment Scour	**0.9**	**609.50**	**608.6**	615	16.40	598.60
Channel Contraction Scour	2.83					
Pier 1 Scour	7.6					
Total Pier 1 Scour***	**10.43**	**613.50**	**603.07**	610	16.93	593.07
Pier 2 Scour	0.9					
Total Pier 2 Scour	**3.73**	**609.50**	**605.77**	608	12.23	595.77

* Existing ground at point of interest, or top of geotech sample, whichever is lower.

**Contraction and abutment scour stops at rock, therefore these values were not added together.

***Note that for Ramp A Pier 1, the end-bearing elevation associated with the extension of the shaft/socket 10 feet below the scour elevation was just above a highly fractured zone with open fractures at Elev. 592.7. At this elevation, the driller noted loss of water during coring. Due to suspect end-bearing of this material, we recommend the shaft/socket extend deeper. The driller noted 50% water return and we encountered more intact rock at Elev. 591.7. Therefore, use a tip elevation of Elev. 591.7.

2LMN

Contraction Channel Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

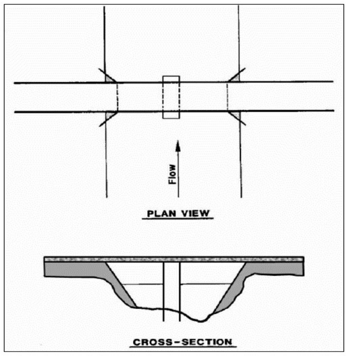
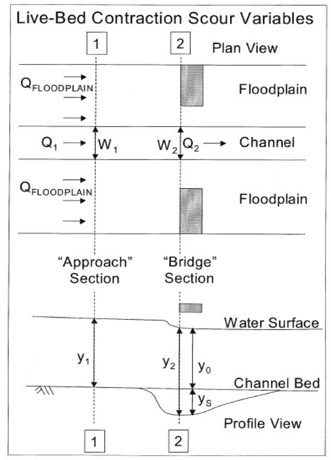


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
10.27	ft	Average Depth Upstream
6.69	ft/s	Average Velocity in Contracted Section
10.28	ft	Depth Prior to Scour in Contracted Section

Boring B-028-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	1.5000	ft	Depth of Bed Material Ground EL. 613.5-612
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0452	mm	
	F_1 =	54	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	5		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	22		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.5000	ft	Depth of Bed Material EL. 612-609.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.3939	mm	
	F_2 =	25	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =	6		Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	11		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =	1.5000	ft	Depth of Bed Material 608.5 -607
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0692	mm	
	F_3 =	31	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =	4		Plasticity Index (from geotechnical information)
	qu3 =	0	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =	12		Water Content (from geotechnical information)

2LMN

Contraction Channel Scour For 50-Yr Frequency

Calculated By:	LAW	Date: 6/27/2023		Job No.:	105889
Checked By:	JAH	Date: 6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	10.27	ft	
Average Velocity in Contracted Section	6.69	ft/s	
Critical Shear Stress	0.03	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	10.28	ft	
Results			
Scour Depth	5.77	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	4.31	ft	

Scour extends into second layer 4.31 > 1.50

Bed Material 2 Contraction Scour

11.772 Average Depth Upstream

Contraction Scour

Computation Method: Clear-Water or Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	11.77	ft	
D50	0.393900	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	6.69	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	1.84	ft/s	
Contraction Scour Condition	Live Bed		
Live Bed Input Parameters			
Temperature of Water	60.00	ºF	
Slope of Energy Grade Line at Approach Section	0.001401	ft/ft	
Discharge in Contracted Section	4433.49	cfs	
Discharge Upstream that is Transporting Sediment	4674.97	cfs	
Width in Contracted Section	57.70	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	61.70	ft	
Depth Prior to Scour in Contracted Section	10.45	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results			
k1	0.690000		
Shear Velocity	0.73	ft/s	
Fall Velocity	0.17	ft/s	
Average Depth in Contracted Section after Scour	11.78	ft	
Scour Depth	1.33	ft	Negative values imply 'zero' ...
Scour may be limited by armoring. Compute all m...			

Zero Scour in Layer 2.

Scour may be limited by armoring. Compute all methods to check.

Contraction Scour

2LMN

Contraction Channel Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	11.77	ft	
D50	0.393900	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	6.69	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	1.84	ft/s	
Contraction Scour Condition	Live Bed		
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	ºF	
Slope of Energy Grade Line at Approach Section	0.001401	ft/ft	
Discharge in Contracted Section	4433.49	cfs	
Discharge Upstream that is Transporting Sediment	4674.97	cfs	
Width in Contracted Section	57.70	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	61.70	ft	
Depth Prior to Scour in Contracted Section	10.45	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	0.492375	mm	
Average Depth in Contracted Section after Scour	32.21	ft	
Scour Depth	21.76	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.690000		
Shear Velocity	0.73	ft/s	
Fall Velocity	0.17	ft/s	
Average Depth in Contracted Section after Scour	11.78	ft	
Scour Depth	1.33	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.3445	lb/ft^2	
Shear Required for Movement of D50 Particle	0.0052	lb/ft^2	
Recommendations			
Recommended Scour Depth	1.33	ft	Negative values imply 'zero' ...

Scour = 1.33 < 2.5

No pressure flow for this bridge.

Scour stops in Bed 2 Soil.

Total Contraction Scour

Total Scour Depth = 2.83 ft

2LMN

Contraction Scour Rear Abutment For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

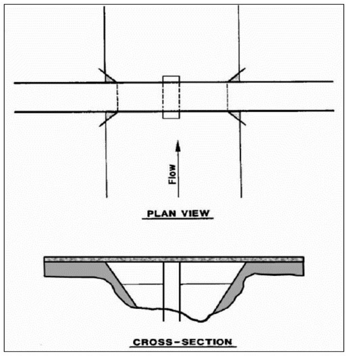
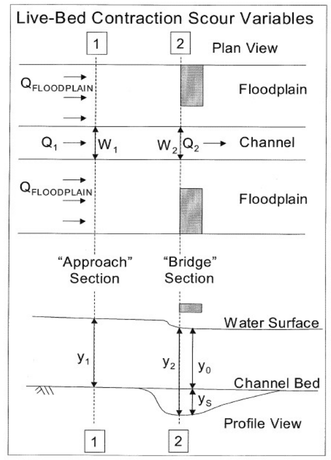


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
4.62	ft	Average Depth Upstream
4.80	ft/s	Average Velocity in Contracted Section
4.61	ft	Depth Prior to Scour in Contracted Section

Boring B-028-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	1.5000	ft	Depth of Bed Material Ground EL. 613.5 - 612
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0452	mm	
	F_1 =	54	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	5		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	22		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.5000	ft	Depth of Bed Material EL. 612 - 609.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.3939	mm	
	F_2 =	25	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =	6		Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	11		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =	3.6000	ft	Depth of Bed Material EL. 609.5 - 605.9
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0692	mm	
	F_3 =	31	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =	4		Plasticity Index (from geotechnical information)
	qu3 =	0	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =	12		Water Content (from geotechnical information)

2LMN

Contraction Scour Rear Abutment For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour RA

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	4.62	ft	
Average Velocity in Contracted Section	4.80	ft/s	
Critical Shear Stress	0.03	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	4.61	ft	
Results			
Scour Depth	2.70	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	2.19	ft	

Scour = 2.19 > 1.5000

Scour extends to Bed 2.

Bed Material 2 Contraction Scour RA

6.12 Average Depth Upstream

Contraction Scour

Computation Method: Clear-Water or Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	6.12	ft	
D50	0.393900	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	4.80	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	1.65	ft/s	
Contraction Scour Condition	Live Bed		
Live Bed Input Parameters			
Temperature of Water	60.00	°F	
Slope of Energy Grade Line at Approach Section	0.001419	ft/ft	
Discharge in Contracted Section	785.48	cfs	
Discharge Upstream that is Transporting Sediment	609.08	cfs	
Width in Contracted Section	35.50	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	74.82	ft	
Depth Prior to Scour in Contracted Section	4.61	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results			
k1	0.690000		
Shear Velocity	0.53	ft/s	
Fall Velocity	0.17	ft/s	
Average Depth in Contracted Section after Scour	12.73	ft	
Scour Depth	8.12	ft	Negative values imply 'zero' ...
Scour may be limited by armoring. Compute all m...			

Scour = 8.12 > 2.5000

Scour may be limited by armoring. Compute all methods to check.

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes

2LMN

Contraction Scour Rear Abutment For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Input Parameters			
Average Depth Upstream of Contraction	6.12	ft	
D50	0.393900	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	4.80	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	1.65	ft/s	
Contraction Scour Condition	Live Bed		
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	ºF	
Slope of Energy Grade Line at Approach Section	0.001419	ft/ft	
Discharge in Contracted Section	785.48	cfs	
Discharge Upstream that is Transporting Sediment	609.08	cfs	
Width in Contracted Section	35.50	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	74.82	ft	
Depth Prior to Scour in Contracted Section	4.61	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	0.492375	mm	
Average Depth in Contracted Section after Scour	11.08	ft	
Scour Depth	6.47	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.690000		
Shear Velocity	0.53	ft/s	
Fall Velocity	0.17	ft/s	
Average Depth in Contracted Section after Scour	12.73	ft	
Scour Depth	8.12	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.0251	lb/ft^2	
Shear Required for Movement of D50 Particle	0.0052	lb/ft^2	
Recommendations			
Recommended Scour Depth	6.47	ft	Negative values imply 'zero' ...

Scour extends through Bed 2.

Bed Material 3 Contraction Scour RA

8.62 Average Depth Upstream

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	8.62	ft	
D50	1.069200	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	4.80	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	2.43	ft/s	
Contraction Scour Condition	Live Bed		
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	ºF	
Slope of Energy Grade Line at Approach Section	0.001419	ft/ft	
Discharge in Contracted Section	785.48	cfs	
Discharge Upstream that is Transporting Sediment	609.08	cfs	
Width in Contracted Section	35.50	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	74.82	ft	
Depth Prior to Scour in Contracted Section	4.61	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	1.336500	mm	
Average Depth in Contracted Section after Scour	8.33	ft	
Scour Depth	3.72	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.640000		
Shear Velocity	0.63	ft/s	

Contraction Scour Rear Abutment For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75				SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Fall Velocity	0.42	ft/s	
Average Depth in Contracted Section after Scour	17.27	ft	
Scour Depth	12.66	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.0210	lb/ft^2	
Shear Required for Movement of D50 Particle	0.0140	lb/ft^2	
Recommendations			
Recommended Scour Depth	3.72	ft	Negative values imply 'zero' ...

Scour = 3.72 > 3.6000

Scours through Bed 3.

Bed Material 4 Contraction Scour RA

12.22 Average Depth Upstream

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
D50	4125.500000	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	4.80	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	40.40	ft/s	
Contraction Scour Condition	Clear Water		
Clear Water Input Parameters			
Discharge in Contracted Section	785.48	cfs	
Bottom Width in Contracted Section	35.50	ft	Width should exclude pier wi...
Depth Prior to Scour in Contracted Section	4.61	ft	
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	°F	
Slope of Energy Grade Line at Approach Section	0.001419	ft/ft	
Discharge in Contracted Section	785.48	cfs	
Discharge Upstream that is Transporting Sediment	609.08	cfs	
Width in Contracted Section	35.50	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	74.82	ft	
Depth Prior to Scour in Contracted Section	4.61	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	5156.875000	mm	
Average Depth in Contracted Section after Scour	0.79	ft	
Scour Depth	-3.82	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.590000		
Shear Velocity	0.75	ft/s	
Fall Velocity	1.64	ft/s	
Average Depth in Contracted Section after Scour	23.59	ft	
Scour Depth	18.98	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.1964	lb/ft^2	
Shear Required for Movement of D50 Particle	54.1594	lb/ft^2	
Recommendations			
Recommended Scour Depth	-3.82	ft	Negative values imply 'zero' ...

Bed 4 does not scour.

Total Contraction Scour RA

Total Scour Depth = 7.60 ft

2LMN

Contraction Scour Fwd Abutment For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

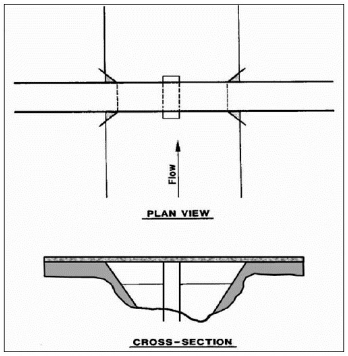
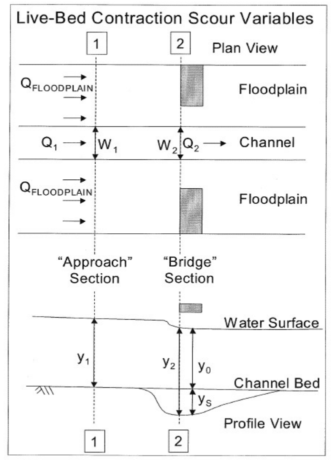


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
3.25	ft	Average Depth Upstream
3.87	ft/s	Average Velocity in Contracted Section
3.24	ft	Depth Prior to Scour in Contracted Section

Boring B-028-2-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	0.9000	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	6.3707	mm	
	F_1 =	20	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	9.1000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4369	mm	
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Contraction Scour Fwd Abutment For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour FA

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	3.25	ft	
D50	6.370700	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	3.24	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	3.74	ft/s	
Contraction Scour Condition	Clear Water		
Clear Water Input Parameters			
Discharge in Contracted Section	291.04	cfs	
Bottom Width in Contracted Section	23.18	ft	Width should exclude pier wi...
Depth Prior to Scour in Contracted Section	3.24	ft	
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	°F	
Slope of Energy Grade Line at Approach Section	0.001419	ft/ft	
Discharge in Contracted Section	291.04	cfs	
Discharge Upstream that is Transporting Sediment	225.95	cfs	
Width in Contracted Section	23.18	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	23.22	ft	
Depth Prior to Scour in Contracted Section	3.24	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	7.963375	mm	
Average Depth in Contracted Section after Scour	3.08	ft	
Scour Depth	-0.16	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.590000		
Shear Velocity	0.39	ft/s	
Fall Velocity	1.21	ft/s	
Average Depth in Contracted Section after Scour	4.04	ft	
Scour Depth	0.80	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.1383	lb/ft^2	
Shear Required for Movement of D50 Particle	0.0836	lb/ft^2	
Recommendations			
Recommended Scour Depth	-0.16	ft	Negative values imply 'zero' ...

No scour

Total Contraction Scour FA

Total Scour Depth = **0.00** **ft**

2LMN

Rear Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

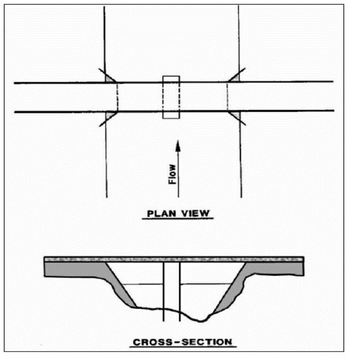
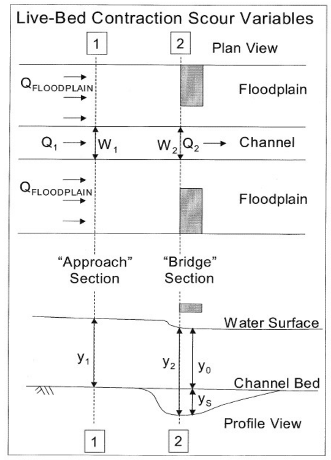


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		(Entries pulled from HEC-Ras Info Tab, unless otherwise noted)
33.75	ft	Centerline Length of Embankment (measured along abutment wall)
120.42	ft	Width of Floodplain
8.14	cfs/ft	Unit Discharge, Upstream Approach Section
22.13	cfs/ft	Unit Discharge in Constricted Area
4.62000	ft	Upstream Flow Depth
4.61000	ft	Flow Depth prior to Scour

Boring B-028-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	1.5000	ft	Depth of Bed Material Ground EL. 613.5 to 612
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.21	mm	D50 Equivalent
	F_1 =	54	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	5		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	22		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.5000	ft	Depth of Bed Material EL. 612 - 609.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.3939	mm	D50 Equivalent
	F_2 =	25	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =	6		Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	11		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =	3.6000	ft	Depth of Bed Material EL. 609.5 - 605.9
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0692	mm	
	F_3 =	31	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =	4		Plasticity Index (from geotechnical information)
	qu3 =	0	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =	12		Water Content (from geotechnical information)

2LMN

Rear Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Rear Abutment Scour

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	120.42	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	8.14	cfs/ft	
Unit Discharge in Constricted Area (q2)	22.13	cfs/ft	
D50	1.210000	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	4.62	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0260	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	4.61	ft	Depth at Abutment Toe
Results			
q2 / q1	2.72		
Average Velocity Upstream	1.76	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm...	2.28	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.64		
Flow Depth including Contraction Scour	16.07	ft	
Maximum Flow Depth including Abutment Scour	26.38	ft	
Scour Hole Depth	21.77	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	22.55	ft	

Scour enters Bed 2

Bed Material 2 Local Rear Abutment Scour

6.12000 Upstream Flow Depth

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	120.42	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	8.14	cfs/ft	
Unit Discharge in Constricted Area (q2)	22.13	cfs/ft	
D50	0.393900	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	6.12	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0080	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	4.61	ft	Depth at Abutment Toe

2LMN

Rear Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Results			
q2 / q1	2.72		
Average Velocity Upstream	1.33	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm...	1.65	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.64		
Flow Depth including Contraction Scour	26.64	ft	
Maximum Flow Depth including Abutment Scour	43.72	ft	
Scour Hole Depth	39.11	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	40.50	ft	

Scour enters Bed 3

Bed Material 3 Local Rear Abutment Scour

8.62000 Upstream Flow Depth

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	120.42	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	8.14	cfs/ft	
Unit Discharge in Constricted Area (q2)	22.13	cfs/ft	
D50	1.069200	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	8.62	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0220	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	4.61	ft	Depth at Abutment Toe
Results			
q2 / q1	2.72		
Average Velocity Upstream	0.94	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm...	2.43	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.64		
Flow Depth including Contraction Scour	17.27	ft	
Maximum Flow Depth including Abutment Scour	28.34	ft	
Scour Hole Depth	23.73	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	24.58	ft	

Scour enters Bed 4

Bed Material 4 Local Rear Abutment Scour

12.22000 Upstream Flow Depth

2LMN

Rear Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

4125.5 D50 equivalent

86.16 Critical Shear Stress

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	120.42	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	8.14	cfs/ft	
Unit Discharge in Constricted Area (q2)	22.13	cfs/ft	
D50	4125.500000	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	12.22	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	86.1600	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	4.61	ft	Depth at Abutment Toe
Results			
q2 / q1	2.72		
Average Velocity Upstream	0.67	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm...	40.40	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.64		
Flow Depth including Contraction Scour	0.50	ft	
Maximum Flow Depth including Abutment Scour	0.82	ft	
Scour Hole Depth	-3.79	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...

Scour Stops before Bed 4.

Total Local Rear Abutment Scour

Total Scour Depth = **7.60** **ft**

2LMN

Forward Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

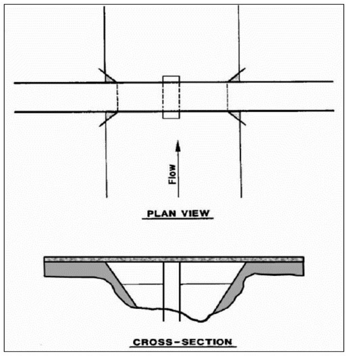
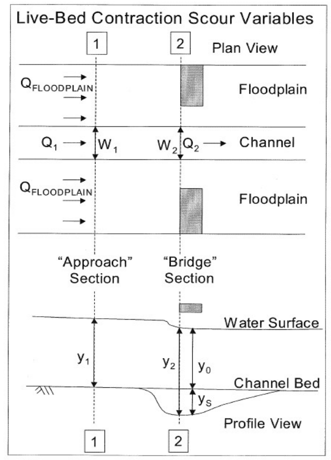


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		*(Entries pulled from HEC-Ras Info Tab, unless otherwise noted)*
33.75	ft	Centerline Length of Embankment (measured along abutment wall)
120.42	ft	Width of Floodplain
9.73	cfs/ft	Unit Discharge, Upstream Approach Section
12.56	cfs/ft	Unit Discharge in Constricted Area
3.25000	ft	Upstream Flow Depth
3.24000	ft	Flow Depth prior to Scour

Boring B-028-1-21

Layer	Variable	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	0.9000	ft	Depth of Bed Material Ground EL. 609.5 - 608.6
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	6.3707	mm	D50 Equivalent
	F_1 =	20	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	9.1000	ft	Depth of Bed Material EL. 608.6 - 599.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4369	mm	D50 Equivalent
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Forward Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Forward Abutment Scour

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	120.42	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	9.73	cfs/ft	
Unit Discharge in Constricted Area (q2)	12.56	cfs/ft	
D50	6.370700	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	3.25	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.1330	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	3.24	ft	Depth at Abutment Toe
Results			
q2 / q1	1.29		
Average Velocity Upstream	2.99	ft/s	
Critical Velocity above which Bed Material of Size D and Sm...	3.74	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	2.11		
Flow Depth including Contraction Scour	4.91	ft	
Maximum Flow Depth including Abutment Scour	10.38	ft	
Scour Hole Depth	7.14	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	7.40	ft	

Scour = 7.14 > 0.9000

Bed Material 2 Local Forward Abutment Scour

4.15000 Upstream Flow Depth

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	120.42	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	9.73	cfs/ft	
Unit Discharge in Constricted Area (q2)	12.56	cfs/ft	
D50	4369.000000	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	4.15	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	91.2500	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		

2LMN

Forward Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Flow Depth prior to Scour	3.24	ft	Depth at Abutment Toe
Results			
q2 / q1	1.29		
Average Velocity Upstream	2.34	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm...	34.40	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	2.11		
Flow Depth including Contraction Scour	0.30	ft	
Maximum Flow Depth including Abutment Scour	0.63	ft	
Scour Hole Depth	-2.61	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...

Scour stops before Bed 2.

Total Local Forward Abutment Scour

Total Scour Depth = **0.90 ft**

Time-Rate of Scour - Pier 1 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

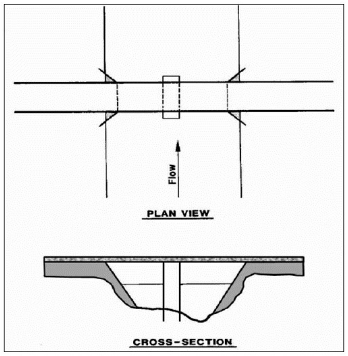
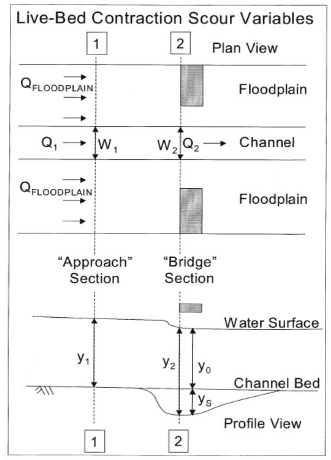


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

	50-yr		*(Entries pulled from HEC-Ras Info Tab)*
V2 =	4.80	ft/s	Average Velocity in Contracted Section (HEC-RAS)
y_0 =	10.28	ft	Flow Depth at Structure

Boring B-028-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	1.5000	ft	Depth of Bed Material Ground EL. 613.5 - 612
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0452	mm	
	F_1 =	54	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	5		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	22		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.5000	ft	Depth of Bed Material 612 - 609.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.3939	mm	
	F_2 =	25	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =	6		Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	11		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =	3.6000	ft	Depth of Bed Material 609.5 - 605.9
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0692	mm	
	F_3 =	31	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =	4		Plasticity Index (from geotechnical information)
	qu3 =	0	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =	12		Water Content (from geotechnical information)

2LMN

Time-Rate of Scour - Pier 1 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Pier 1 Scour

Time rate of scour for cohesive soils

D_{50} = 0.0452 mm	0.0018	in	Bed Material Size
	0.0001	ft	

Determine Critical Soil Velocity

Reference: ODOT L&D Vol. 2, Fig. 1008-18

τc =	0.0260	psf	Soil Scour Critical Shear Stress (from TTL Preliminary Scour Design Memo)
$Vc = (1.486/n) x ((\tau_c\, y^{1/3})/y_w)^{1/2}$			Critical Soil Velocity
n =	0.0350		Manning's number
y =	10.2780	ft	Depth prior to contracted section
yw =	62.4000	pcf	unit weight of water
Vc =	**1.2779**	fps	Critical Soil Velocity
V2 =	4.8000	fps	Average velocity in contracted section
	V2	> Vc	SCOUR WILL OCCUR, DETERMINE BED SHEAR STRESS

Determine Bed Shear Stress from Hydraulic Flow for Soil Erosion Rate

$\tau = (nKV/Ku)^2 \times (y_w/y^{1/3})$

n =	0.0350		Manning's number
K =	1.5000		for circular piers
V =	4.8000	fps	flow velocity at point of consideration
Ku =	1.4860		U.S. customary units
yw =	62.4000	pcf	unit weight of water
y =	10.2780	ft	Depth prior to contracted section
τ =	**1.8226**	psf	Bed Shear Stress

$z = 10^{(\alpha \log(\tau+47.88)+\beta)}/304.8$	**24.57**	ft/hr	Estimate of erosion rate versus shear stress of a cohesive soil
$\alpha = [13/(EC^{0.309})]-7.1363$	2.83		dimensionless, for 1 ≤ EC ≤ 6
$\beta = 7.377777-[(1-(EC-4.5)^2/3.57^2)*10.377777^2]^{0.5}$	-0.93		
$EC = 4.5-(3/1.07^{PI})$	2.36		Erosion category, dimensionless, for 1.5 ≤ EC ≤ 4.5

Layer 1 scours in	0.06	hours	
	23.94	time remaining	
Duration =	24	hours	CHECK LAYER 2

Bed Material 2 Local Pier 1 Scour

D_{50} =	0.3939	mm	Bed Material Size
y =	11.7780	ft	Depth prior to contracted section
V =	4.8000	fps	flow velocity at point of consideration

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	11.78	ft	
Velocity Upstream of Pier	4.80	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	0.393900	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.95		
f2	-1.00		
f3	0.55		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	1.32	ft/s	
Velocity of the live-bed peak scour	11.69	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	3.93	ft	
Scour Hole			

2LMN

Time-Rate of Scour - Pier 1 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	8.01	ft	

Scour = 3.93 > 2.5000 Bed Depth, Look at Layer 3

Bed Material 3 Local Pier 1 Scour

D_{50} =	1.0692 mm	Bed Material Size
y =	14.2780 ft	Depth prior to contracted section
V =	4.8000 fps	flow velocity at point of consideration

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	14.28	ft	
Velocity Upstream of Pier	4.80	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	1.069200	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.96		
f2	0.17		
f3	0.67		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	2.09	ft/s	
Velocity of the live-bed peak scour	12.87	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	4.35	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	8.86	ft	

Scour = 4.35 > 3.6000 Bed Depth, Look at Layer 4

Bed Material 4 Local Pier 1 Scour

D_{50} =	4612.6 mm (D50 equivalent)	Bed Material Size
y =	17.8780 ft	Depth prior to contracted section
V =	4.8000 fps	flow velocity at point of consideration

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	17.88	ft	
Velocity Upstream of Pier	4.80	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	59.000000	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.98		
f2	0.00		

D50 with 0 scour is less than available D50

2LMN

Time-Rate of Scour - Pier 1 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

f3	0.80		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	11.96	ft/s	
Velocity of the live-bed peak scour	59.78	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	0.00	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	2.50	ft	

Scour in Bed 4= 0.00 < 5.0000 SCOUR ENDS IN BED 4

Total Local Pier 1 Scour

Total Scour Depth = 7.60 ft

2LMN

Local Scour Pier 2 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023
Checked By:	JAH	Date:	6/30/2023
Project:	LUC-23-11.75		

Job No.:	105889
Bridge No.	LUC-00184-00.200R
SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

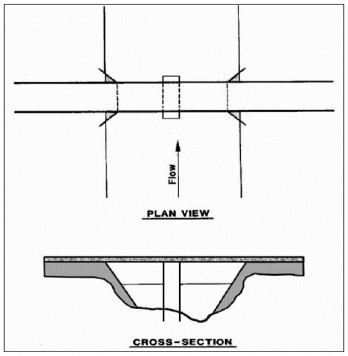
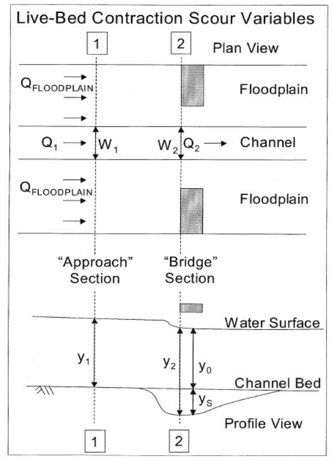


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
3.25	ft	Depth of Upstream Pier
2.99	ft/s	Velocity of Upstream Pier
2.50	ft	Width of Pier
28.33	ft	Length of Pier (measured in plan)

Boring B-028-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	0.9000	ft	Depth of Bed Material Ground EL. 609.5 - 608.6
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	6.3707	mm	
	F_1 =	20	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts 2 x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	9.1000	ft	Depth of Bed Material EL. 608.6 - 599.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4369	mm	D50 equivalent
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts 2 x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts 2 x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Local Scour Pier 2 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Pier 2 Scour

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	3.25	ft	
Velocity Upstream of Pier	2.99	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	6.370700	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.80		
f2	0.86		
f3	0.92		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	4.20	ft/s	
Velocity of the live-bed peak scour	21.01	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	3.97	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	8.09	ft	

Scour extends into second layer.

Bed Material 1 Local Pier 2 Scour

4.15 Depth of Upstream Pier

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	4.15	ft	
Velocity Upstream of Pier	2.99	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	30.000000	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.84		
f2	0.00		
f3	0.96		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	7.45	ft/s	
Velocity of the live-bed peak scour	37.24	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	0.00	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	2.50	ft	

D50 with 0 scour is less than available D50

Equivalent D50 for rock = 4369 mm, per Table 2: Scour Parameters for Rock, Ramp D in the Preliminary Scour Design Memo

Local Scour Pier 2 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Scour does not exceed past rock layer.

Total Local Pier 2 Scour

Total Scour Depth = **0.90** **ft**

2LMN

North Exit Ramp Summary For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.:	LUC-00184-00.180
Project:	LUC-23-11.75			SFN:	TBD

100-Year (1% AEP)	Depth (ft)	Existing Ground EL.*	**Scour Elevation**	Bottom of Footing EL.	Shaft length	**Bottom of Shaft Due to Scour / Top of Rock Socket**
Contraction Scour (R.A.)	7.6					
Abutment Scour (R.A.)	7.6					
Total Rear Abutment Scour**	**7.6**	**613.50**	**605.9**	613.5	17.60	595.90
Contraction Scour (F.A.)	0.9					
Abutment Scour (F.A.)	0.9					
Total Forward Abutment Scour	**1.8**	**609.50**	**607.7**	615	17.30	597.70
Channel Contraction Scour	2.88					
Pier 1 Scour	7.6					
Total Pier 1 Scour***	**10.48**	**613.50**	**603.02**	610	16.98	593.02
Pier 2 Scour	0.9					
Total Pier 2 Scour	**3.78**	**609.50**	**605.72**	608	12.28	595.72

* Existing ground at point of interest, or top of geotech sample, whichever is lower.

** Contraction and abutment scour stops at rock, therefore these values were not added together.

***Note that for Ramp A Pier 1, the end-bearing elevation associated with the extension of the shaft/socket 10 feet below the scour elevation was just above a highly fractured zone with open fractures at Elev. 592.7. At this elevation, the driller noted loss of water during coring. Due to suspect end-bearing of this material, we recommend the shaft/socket extend deeper. The driller noted 50% water return and we encountered more intact rock at Elev. 591.7. Therefore, use a tip elevation of Elev. 591.7.

2LMN

Contraction Channel Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

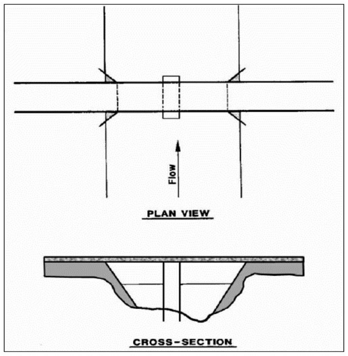
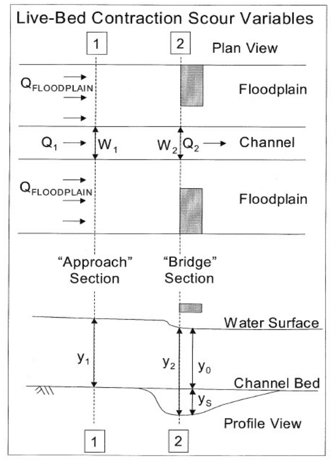


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
10.93	ft	Average Depth Upstream
6.88	ft/s	Average Velocity in Contracted Section
10.95	ft	Depth Prior to Scour in Contracted Section

Water

Boring B-028-1-21

Layer	Parameter	Value	Unit	Description
Bed Material 1	y_{bed1} =	1.5000	ft	Depth of Bed Material Ground EL. 613.5-612
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0452	mm	
	F_1 =	54	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	5		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	22		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.5000	ft	Depth of Bed Material EL. 612-609.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.3939	mm	
	F_2 =	25	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =	6		Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	11		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =	1.5000	ft	Depth of Bed Material 608.5 -607
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0692	mm	
	F_3 =	31	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =	4		Plasticity Index (from geotechnical information)
	qu3 =	0	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =	12		Water Content (from geotechnical information)

2LMN

Contraction Channel Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	10.93	ft	
Average Velocity in Contracted Section	6.88	ft/s	
Critical Shear Stress	0.03	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	10.95	ft	
Results			
Scour Depth	6.14	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	4.56	ft	

Scour extends into second layer 4.56 > 1.50

Bed Material 2 Contraction Scour

12.434 Average Depth Upstream

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	12.43	ft	
D50	0.393802	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	6.88	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	1.85	ft/s	
Contraction Scour Condition	Live Bed		
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	ºF	
Slope of Energy Grade Line at Approach Section	0.001401	ft/ft	
Discharge in Contracted Section	4838.82	cfs	
Discharge Upstream that is Transporting Sediment	5155.22	cfs	
Width in Contracted Section	57.70	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	61.70	ft	
Depth Prior to Scour in Contracted Section	10.95	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	0.492252	mm	
Average Depth in Contracted Section after Scour	34.73	ft	
Scour Depth	23.78	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.690000		
Shear Velocity	0.75	ft/s	
Fall Velocity	0.17	ft/s	
Average Depth in Contracted Section after Scour	12.33	ft	
Scour Depth	1.38	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.3802	lb/ft^2	
Shear Required for Movement of D50 Particle	0.0052	lb/ft^2	
Recommendations			
Recommended Scour Depth	1.38	ft	Negative values imply 'zero' ...

2LMN

Contraction Channel Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

1.38 < 2.5000 scour remains in bed 2

Total Contraction Scour

Total Scour Depth = 2.88 ft

2LMN

Contraction Scour Rear Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

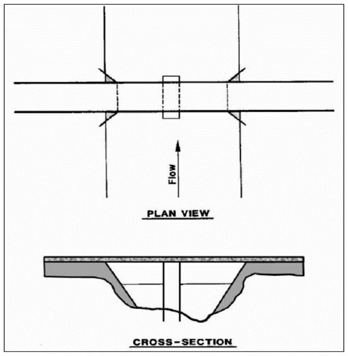
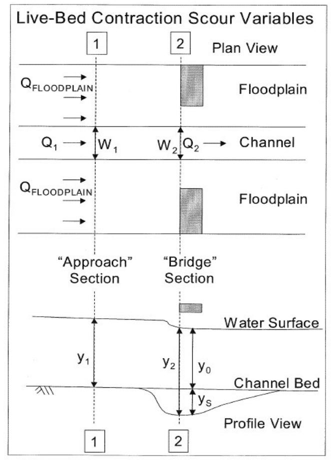


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)
5.26	ft	Average Depth Upstream
5.22	ft/s	Average Velocity in Contracted Section
5.26	ft	Depth Prior to Scour in Contracted Section

Boring B-028-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	1.5000	ft	Depth of Bed Material Ground EL. 613.5 - 612
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0452	mm	
	F_1 =	54	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	5		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	22		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.5000	ft	Depth of Bed Material EL. 612 - 609.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.3939	mm	
	F_2 =	25	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =	6		Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	11		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =	3.6000	ft	Depth of Bed Material EL. 609.5 - 605.9
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0692	mm	
	F_3 =	31	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =	4		Plasticity Index (from geotechnical information)
	qu3 =	0	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =	12		Water Content (from geotechnical information)

2LMN

Contraction Scour Rear Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour RA

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	5.26	ft	
Average Velocity in Contracted Section	5.22	ft/s	
Critical Shear Stress	0.03	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	5.26	ft	
Results			
Scour Depth	3.16	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	2.54	ft	

2.54 > 1.5000 Scours through bed 1

Bed Material 2 Contraction Scour RA

6.76 Average Depth Upstream

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	6.76	ft	
D50	0.393900	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	5.22	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	1.67	ft/s	
Contraction Scour Condition	Live Bed		
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	ºF	
Slope of Energy Grade Line at Approach Section	0.002400	ft/ft	
Discharge in Contracted Section	976.83	cfs	
Discharge Upstream that is Transporting Sediment	748.13	cfs	
Width in Contracted Section	35.63	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	94.93	ft	
Depth Prior to Scour in Contracted Section	5.26	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	0.492375	mm	
Average Depth in Contracted Section after Scour	13.32	ft	
Scour Depth	8.06	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.690000		
Shear Velocity	0.72	ft/s	
Fall Velocity	0.17	ft/s	
Average Depth in Contracted Section after Scour	16.71	ft	
Scour Depth	11.45	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.0245	lb/ft^2	
Shear Required for Movement of D50 Particle	0.0052	lb/ft^2	
Recommendations			
Recommended Scour Depth	8.06	ft	Negative values imply 'zero' ...

2LMN

Contraction Scour Rear Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

8.06 > 2.5000 Scours through bed 2

Bed Material 3 Contraction Scour RA

9.26 Average Depth Upstream

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	9.26	ft	
D50	1.069200	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	5.22	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	2.46	ft/s	
Contraction Scour Condition	Live Bed		
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	°F	
Slope of Energy Grade Line at Approach Section	0.002400	ft/ft	
Discharge in Contracted Section	976.83	cfs	
Discharge Upstream that is Transporting Sediment	748.13	cfs	
Width in Contracted Section	35.63	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	94.93	ft	
Depth Prior to Scour in Contracted Section	5.26	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	1.336500	mm	
Average Depth in Contracted Section after Scour	10.01	ft	
Scour Depth	4.75	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.690000		
Shear Velocity	0.85	ft/s	
Fall Velocity	0.42	ft/s	
Average Depth in Contracted Section after Scour	22.89	ft	
Scour Depth	17.63	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.0202	lb/ft^2	
Shear Required for Movement of D50 Particle	0.0140	lb/ft^2	
Recommendations			
Recommended Scour Depth	4.75	ft	Negative values imply 'zero' ...

4.75 > 3.6000 Scours through bed 3

Bed Material 4 Contraction Scour RA

12.86 Average Depth Upstream

4125.5 D50 (Equivalent)

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	12.86	ft	
D50	4125.500000	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	5.22	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	40.75	ft/s	
Contraction Scour Condition	Clear Water		
Clear Water Input Parameters			
Discharge in Contracted Section	976.83	cfs	
Bottom Width in Contracted Section	35.63	ft	Width should exclude pier wi...
Depth Prior to Scour in Contracted Section	5.26	ft	
Live Bed & Clear Water Input Parameters			

2LMN

Contraction Scour Rear Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Temperature of Water	60.00	°F	
Slope of Energy Grade Line at Approach Section	0.002400	ft/ft	
Discharge in Contracted Section	976.83	cfs	
Discharge Upstream that is Transporting Sediment	748.13	cfs	
Width in Contracted Section	35.63	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	94.93	ft	
Depth Prior to Scour in Contracted Section	5.26	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	5156.875000	mm	
Average Depth in Contracted Section after Scour	0.95	ft	
Scour Depth	-4.31	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.640000		
Shear Velocity	1.00	ft/s	
Fall Velocity	1.64	ft/s	
Average Depth in Contracted Section after Scour	30.26	ft	
Scour Depth	25.00	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.1991	lb/ft^2	
Shear Required for Movement of D50 Particle	54.1594	lb/ft^2	
Recommendations			
Recommended Scour Depth	-4.31	ft	Negative values imply 'zero' ...

No scour in Bed 4

Total Contraction Scour RA

Total Scour Depth = 7.60 ft

2LMN

Contraction Scour Fwd Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75				SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

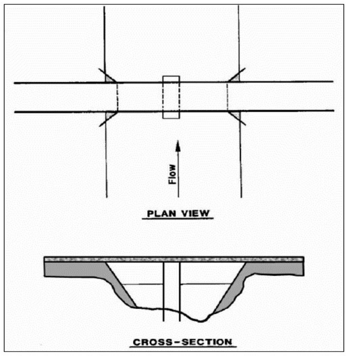
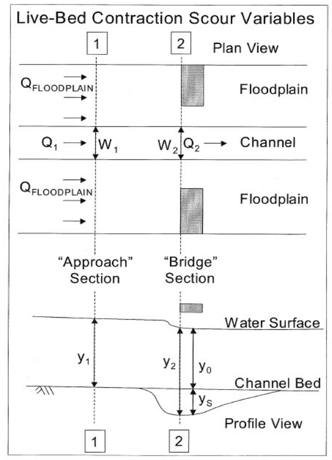


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)
3.50	ft	Average Depth Upstream
4.09	ft/s	Average Velocity in Contracted Section
3.50	ft	Depth Prior to Scour in Contracted Section

Boring B-028-2-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	0.9000	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	6.3707	mm	
	F_1 =	20	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	9.1000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4369	mm	
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Contraction Scour Fwd Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour FA

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	3.50	ft	
D50	0.900000	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	4.09	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	1.97	ft/s	
Contraction Scour Condition	Live Bed		
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	ºF	
Slope of Energy Grade Line at Approach Section	0.002400	ft/ft	
Discharge in Contracted Section	374.35	cfs	
Discharge Upstream that is Transporting Sediment	286.66	cfs	
Width in Contracted Section	26.10	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	26.16	ft	
Depth Prior to Scour in Contracted Section	3.50	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	1.125000	mm	
Average Depth in Contracted Section after Scour	6.04	ft	
Scour Depth	2.54	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.640000		
Shear Velocity	0.52	ft/s	
Fall Velocity	0.37	ft/s	
Average Depth in Contracted Section after Scour	4.41	ft	
Scour Depth	0.91	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.0814	lb/ft^2	
Shear Required for Movement of D50 Particle	0.0118	lb/ft^2	
Recommendations			
Recommended Scour Depth	0.91	ft	Negative values imply 'zero' ...

Scour remains in first layer. 0.91 > 0.9000 scours through bed 1

Bed Material 2 Contraction Scour FA

4.400 Average Depth Upstream

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	4.40	ft	
D50	4369.000000	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	4.09	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	34.73	ft/s	
Contraction Scour Condition	Clear Water		
Clear Water Input Parameters			
Discharge in Contracted Section	374.35	cfs	
Bottom Width in Contracted Section	26.10	ft	Width should exclude pier wi...
Depth Prior to Scour in Contracted Section	3.50	ft	
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	ºF	
Slope of Energy Grade Line at Approach Section	0.002400	ft/ft	
Discharge in Contracted Section	374.35	cfs	

2LMN

Contraction Scour Fwd Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Discharge Upstream that is Transporting Sediment	286.66	cfs	
Width in Contracted Section	26.10	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	26.16	ft	
Depth Prior to Scour in Contracted Section	3.50	ft	
Unit Weight of Water	62.40	lb/ft^3	
Unit Weight of Sediment	165.00	lb/ft^3	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	5461.250000	mm	
Average Depth in Contracted Section after Scour	0.53	ft	
Scour Depth	-2.97	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.590000		
Shear Velocity	0.58	ft/s	
Fall Velocity	1.64	ft/s	
Average Depth in Contracted Section after Scour	5.54	ft	
Scour Depth	2.04	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	0.9416	lb/ft^2	
Shear Required for Movement of D50 Particle	57.3560	lb/ft^2	
Recommendations			
Recommended Scour Depth	-2.97	ft	Negative values imply 'zero' ...

0 < 9.1000 scour stops before bed 2.

Total Contraction Scour FA

Total Scour Depth = 0.90 ft

2LMN

Rear Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

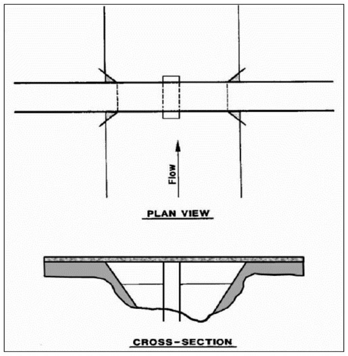
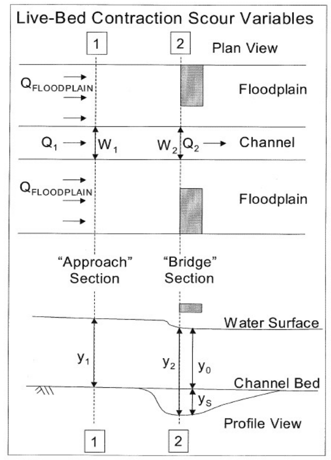


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		(Entries pulled from HEC-Ras Info Tab, unless otherwise noted)
33.75	ft	Centerline Length of Embankment (measured along abutment wall)
123.49	ft	Width of Floodplain
7.88	cfs/ft	Unit Discharge, Upstream Approach Section
27.42	cfs/ft	Unit Discharge in Constricted Area
5.26000	ft	Upstream Flow Depth
5.26000	ft	Flow Depth prior to Scour

Boring B-028-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	1.5000	ft	Depth of Bed Material Ground EL. 613.5 to 612
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.21	mm	D50 Equivalent
	F_1 =	54	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	5		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	22		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.5000	ft	Depth of Bed Material EL. 612 - 609.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.3939	mm	D50 Equivalent
	F_2 =	25	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =	6		Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	11		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =	3.6000	ft	Depth of Bed Material EL. 609.5 - 605.9
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0692	mm	
	F_3 =	31	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =	4		Plasticity Index (from geotechnical information)
	qu3 =	0	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =	12		Water Content (from geotechnical information)

2LMN

Rear Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Rear Abutment Scour

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	123.49	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	7.88	cfs/ft	
Unit Discharge in Constricted Area (q2)	27.42	cfs/ft	
D50	1.210000	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	5.26	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0260	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	5.26	ft	Depth at Abutment Toe
Results			
q2 / q1	3.48		
Average Velocity Upstream	1.50	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm...	2.33	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.35		
Flow Depth including Contraction Scour	19.32	ft	
Maximum Flow Depth including Abutment Scour	25.99	ft	
Scour Hole Depth	20.73	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	21.47	ft	

Scour enters Bed 2

Bed Material 2 Local Rear Abutment Scour

6.76000 Upstream Flow Depth

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	123.49	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	7.88	cfs/ft	
Unit Discharge in Constricted Area (q2)	27.42	cfs/ft	
D50	0.393900	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	6.76	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0080	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	5.26	ft	Depth at Abutment Toe

2LMN

Rear Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Results			
q2 / q1	3.48		
Average Velocity Upstream	1.17	ft/s	
Critical Velocity above which Bed Material of Size D and Sm...	1.67	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.35		
Flow Depth including Contraction Scour	32.01	ft	
Maximum Flow Depth including Abutment Scour	43.08	ft	
Scour Hole Depth	37.82	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	39.16	ft	

Scour enters Bed 3

Bed Material 3 Local Rear Abutment Scour

9.26000 Upstream Flow Depth

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	123.49	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	7.88	cfs/ft	
Unit Discharge in Constricted Area (q2)	27.42	cfs/ft	
D50	1.069200	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	9.26	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0220	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	5.26	ft	Depth at Abutment Toe
Results			
q2 / q1	3.48		
Average Velocity Upstream	0.85	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm...	2.46	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.35		
Flow Depth including Contraction Scour	20.75	ft	
Maximum Flow Depth including Abutment Scour	27.92	ft	
Scour Hole Depth	22.66	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	23.47	ft	

Scour enters Bed 4

Bed Material 4 Local Rear Abutment Scour

12.86000 Upstream Flow Depth

2LMN

Rear Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

4125.5 D50 equivalent

86.16 Critical Shear Stress

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen…
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	123.49	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A…	7.88	cfs/ft	
Unit Discharge in Constricted Area (q2)	27.42	cfs/ft	
D50	4125.500000	mm	0.2 mm is the lower limit for coh…
Upstream Flow Depth	12.86	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	86.1600	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	5.26	ft	Depth at Abutment Toe
Results			
q2 / q1	3.48		
Average Velocity Upstream	0.61	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm…	40.75	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.35		
Flow Depth including Contraction Scour	0.60	ft	
Maximum Flow Depth including Abutment Scour	0.81	ft	
Scour Hole Depth	-4.45	ft	Negative values imply 'zero' sco…
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will …

Scour Stops before Bed 4.

Total Local Rear Abutment Scour

Total Scour Depth = **7.60** **ft**

Forward Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

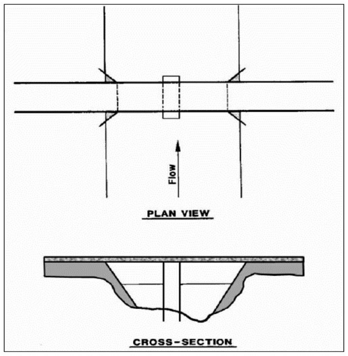
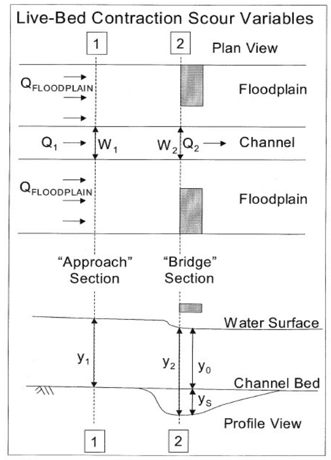


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		(Entries pulled from HEC-Ras Info Tab, unless otherwise noted)
33.75	ft	Centerline Length of Embankment (measured along abutment wall)
123.49	ft	Width of Floodplain
10.96	cfs/ft	Unit Discharge, Upstream Approach Section
14.34	cfs/ft	Unit Discharge in Constricted Area
3.50000	ft	Upstream Flow Depth
3.50000	ft	Flow Depth prior to Scour

Water

Boring B-028-1-21

Layer	Parameter	Value	Unit	Description
Bed Material 1	y_{bed1} =	0.9000	ft	Depth of Bed Material Ground EL. 609.5 - 608.6
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	6.3707	mm	D50 Equivalent
	F_1 =	20	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	9.1000	ft	Depth of Bed Material EL. 608.6 - 599.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4369	mm	D50 Equivalent
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Forward Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Forward Abutment Scour

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0º is downstream, 90º is perpen…
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	123.49	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A…	10.96	cfs/ft	
Unit Discharge in Constricted Area (q2)	14.34	cfs/ft	
D50	6.370700	mm	0.2 mm is the lower limit for coh…
Upstream Flow Depth	3.50	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.1330	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	3.50	ft	Depth at Abutment Toe
Results			
q2 / q1	1.31		
Average Velocity Upstream	3.13	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm…	3.79	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	2.13		
Flow Depth including Contraction Scour	5.51	ft	
Maximum Flow Depth including Abutment Scour	11.71	ft	
Scour Hole Depth	8.21	ft	Negative values imply 'zero' sco…
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will …
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	8.51	ft	

8.51 > 0.9000 scour extends thru bed 1

Bed Material 2 Local Forward Abutment Scour

4.4000

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0º is downstream, 90º is perpen…
Centerline Length of Embankment	33.75	ft	
Width of Flood Plain	123.49	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A…	10.96	cfs/ft	
Unit Discharge in Constricted Area (q2)	14.34	cfs/ft	
D50	4369.000000	mm	0.2 mm is the lower limit for coh…
Upstream Flow Depth	4.40	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	91.2500	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	3.50	ft	Depth at Abutment Toe

2LMN

Forward Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Results			
q2 / q1	1.31		
Average Velocity Upstream	2.49	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm…	34.73	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	2.13		
Flow Depth including Contraction Scour	0.34	ft	
Maximum Flow Depth including Abutment Scour	0.71	ft	
Scour Hole Depth	-2.79	ft	Negative values imply 'zero' sco…
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will …

scour does not extend into bed 2.

Total Local Forward Abutment Scour

Total Scour Depth = 0.90 ft

2LMN

Time-Rate of Scour - Pier 1 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

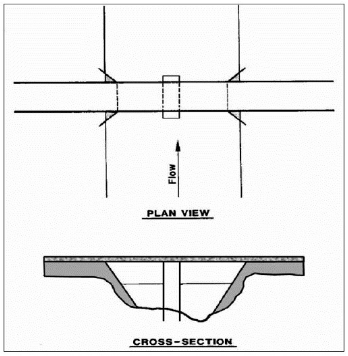
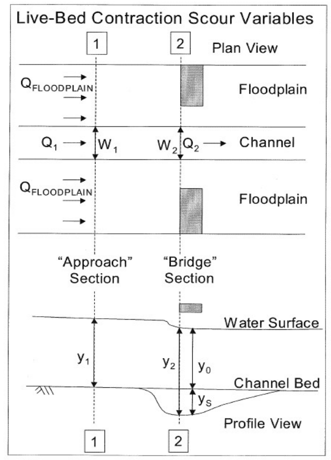


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

	100-yr		***(Entries pulled from HEC-Ras Info Tab)***
V2 =	5.22	ft/s	Average Velocity in Contracted Section (HEC-RAS)
y_0 =	10.95	ft	Flow Depth at Structure

Water	**Boring B-028-1-21**			
Bed Material 1	y_{bed1} =	1.5000	ft	Depth of Bed Material Ground EL. 613.5 - 612
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0452	mm	
	F_1 =	54	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	5		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	22		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.5000	ft	Depth of Bed Material 612 - 609.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.3939	mm	
	F_2 =	25	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =	6		Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	11		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =	3.6000	ft	Depth of Bed Material 609.5 - 605.9
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0692	mm	
	F_3 =	31	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =	4		Plasticity Index (from geotechnical information)
	qu3 =	0	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =	12		Water Content (from geotechnical information)

2LMN

Time-Rate of Scour - Pier 1 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Pier 1 Scour

Time rate of scour for cohesive soils

D_{50} =	0.0452 mm	0.0018	in	Bed Material Size
		0.0001	ft	

Determine Critical Soil Velocity

Reference: ODOT L&D Vol. 2, Fig. 1008-18

τc =	0.0260	psf	Soil Scour Critical Shear Stress (from TTL Preliminary Scour Design Memo)
$Vc = (1.486/n)x\ ((\tau_c\ y^{1/3})/y_w)^{1/2}$			Critical Soil Velocity
n =	0.0350		Manning's number
y =	10.9460	ft	Depth prior to contracted section
yw =	62.4000	pcf	unit weight of water
Vc =	**1.2914**	fps	Critical Soil Velocity
V2 =	5.2200	fps	Average velocity in contracted section
	V2	> Vc	SCOUR WILL OCCUR, DETERMINE BED SHEAR STRESS

Determine Bed Shear Stress from Hydraulic Flow for Soil Erosion Rate

$\tau = (nKV/Ku)^2\ x\ (y_w/y^{1/3})$

n =	0.0350		Manning's number
K =	1.5000		for circular piers
V =	5.2200	fps	flow velocity at point of consideration
Ku =	1.4860		U.S. customary units
yw =	62.4000	pcf	unit weight of water
y =	10.9460	ft	Depth prior to contracted section
τ =	**2.1107**	psf	Bed Shear Stress

$z = 10^{(\alpha \log(\tau+47.88)+\beta)}/304.8$	**24.97**	ft/hr	Estimate of erosion rate versus shear stress of a cohesive soil
$\alpha = [13/(EC^{0.309})]-7.1363$	2.83		dimensionless, for 1 ≤ EC ≤ 6
$\beta = 7.377777-[(1-(EC-4.5)^2/3.57^2)*10.377777^2]^{0.5}$	-0.93		
$EC = 4.5-(3/1.07^{PI})$	2.36		Erosion category, dimensionless, for 1.5 ≤ EC ≤ 4.5

Layer 1 scours in	0.06	hours	
	23.94	time remaining	
Duration =	24	hours	CHECK LAYER 2

Bed Material 2 Local Pier 1 Scour

D_{50} =	0.3939	mm	Bed Material Size
y =	12.4460	ft	Depth prior to contracted section
V =	5.2200	fps	flow velocity at point of consideration

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	12.45	ft	
Velocity Upstream of Pier	5.22	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	0.393900	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.96		
f2	-1.25		
f3	0.55		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	1.33	ft/s	
Velocity of the live-bed peak scour	12.01	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	4.00	ft	
Scour Hole			
Angle of Repose	44.00	degrees	

2LMN

Time-Rate of Scour - Pier 1 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	8.15	ft	

Scour = 8.15 > 2.5000 Bed Depth, Look at Layer 3

Bed Material 3 Local Pier 1 Scour

D_{50} = 1.0692 mm Bed Material Size
y = 14.9460 ft Depth prior to contracted section
V = 5.2200 fps flow velocity at point of consideration

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	14.95	ft	
Velocity Upstream of Pier	5.22	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	1.069200	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.97		
f2	0.00		
f3	0.67		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	2.10	ft/s	
Velocity of the live-bed peak scour	13.16	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	4.40	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	8.96	ft	

Scour = 8.96 > 3.6000 Bed Depth, Look at Layer 4

Bed Material 4 Local Pier 1 Scour

D_{50} = 4612.6 mm (D50 equivalent) Bed Material Size
y = 18.5460 ft Depth prior to contracted section
V = 5.2200 fps flow velocity at point of consideration

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	18.55	ft	
Velocity Upstream of Pier	5.22	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	75.000000	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.98		
f2	-0.01		

D50 with 0 scour is less than available D50

2LMN

Time-Rate of Scour - Pier 1 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

f3	0.71		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	13.04	ft/s	
Velocity of the live-bed peak scour	65.21	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	-0.03	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	2.50	ft	

Scour in Bed 4= 0.00 SCOUR DOES NOT EXTEND INTO BED 4

Total Local Pier 1 Scour

Total Scour Depth = 7.60 ft

2LMN

Local Scour Pier 2 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75				SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

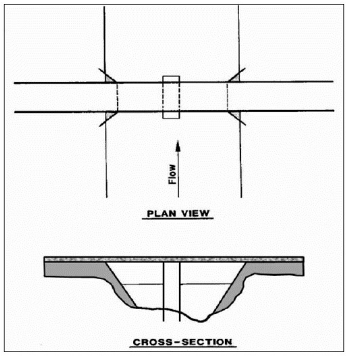
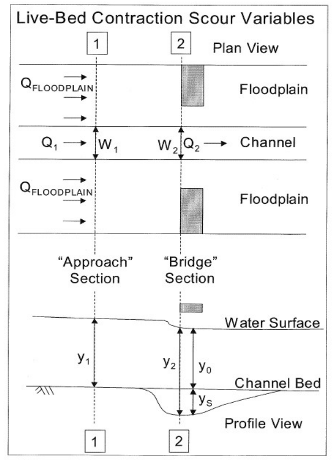


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
3.50	ft	Depth of Upstream Pier
3.13	ft/s	Velocity of Upstream Pier
2.50	ft	Width of Pier
28.33	ft	Length of Pier (measured in plan)

Water

Boring B-028-2-21

Layer	Parameter	Value	Unit	Description
Bed Material 1	y_{bed1} =	0.9000	ft	Depth of Bed Material Ground EL. 609.5 - 608.6
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	6.3707	mm	
	F_1 =	20	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts 2 x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	9.1000	ft	Depth of Bed Material EL. 608.6 - 599.5
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4369	mm	D50 equivalent
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts 2 x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts 2 x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Local Scour Pier 2 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.200R
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Pier 2 Scour

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	3.50	ft	
Velocity Upstream of Pier	3.13	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	6.370700	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.82		
f2	0.89		
f3	0.92		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	4.25	ft/s	
Velocity of the live-bed peak scour	21.24	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	4.16	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	8.46	ft	

Scour extends into second layer.

Bed Material 1 Local Pier 2 Scour

4.40 Depth of Upstream Pier

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	4.40	ft	
Velocity Upstream of Pier	3.13	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	34.000000	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.85		
f2	-0.01		
f3	0.94		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	7.83	ft/s	
Velocity of the live-bed peak scour	39.16	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	0.06	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	2.50	ft	

Equivalent D50 for rock = 4369 mm, per Table 2: Scour Parameters for Rock, Ramp D in the Preliminary Scour Design Memo

2LMN

Local Scour Pier 2 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.200R
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Florida DOT option does not produce a result beyond D50 = 99mm, therefore, this was used in calculations.

Scour does not exceed past rock layer.

Total Local Pier 2 Scour

Total Scour Depth = **0.90** **ft**

South Entrance Ramp Summary For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.:	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

50-Year (2% AEP)	Depth (ft)	Existing Ground EL.*	**Scour Elevation**	Bottom of Footing EL.	Shaft length	**Bottom of Shaft Due to Scour / Top of Rock Socket**
Contraction Scour (R.A.)	0.85					
Abutment Scour (R.A.)	2.87					
Total Rear Abutment Scour	**3.72**	**615.00**	**611.28**	612.5	11.22	601.28
Contraction Scour (F.A.)	2.14					
Abutment Scour (F.A.)	5.63					
Total Forward Abutment Scour	**7.77**	**612.33**	**604.56**	614	19.44	594.56
Channel Contraction Scour	2.9					
Pier 1 Scour	6.19					
Total Pier 1 Scour	**9.09**	**615.00**	**605.91**	610.79	14.88	595.91
Pier 2 Scour	1.05					
Total Pier 2 Scour	**3.95**	**609.79**	**605.84**	605.14	9.30	595.84

* Existing ground at point of interest, or top of geotech sample, whichever is lower.

2LMN

Contraction Scour Channel For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

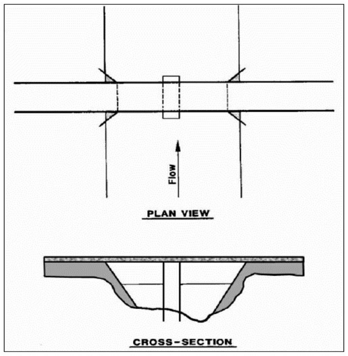
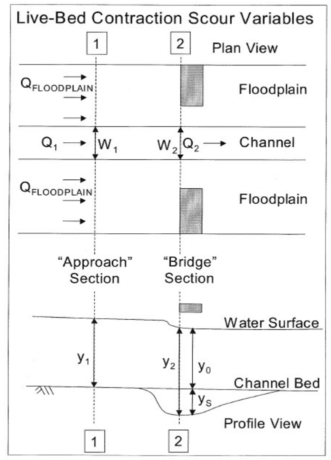


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)
11.37	ft	Average Depth Upstream
5.12	ft/s	Average Velocity in Contracted Section
11.32	ft	Depth Prior to Scour in Contracted Section

Boring B-022-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	4.5800	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0791	mm	
	F_1 =	49	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	9		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	19		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.3000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.2838	mm	
	F_2 =	24	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	68		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Contraction Scour Channel For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour Channel

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	11.37	ft	
Average Velocity in Contracted Section	5.12	ft/s	
Critical Shear Stress	0.06	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	11.32	ft	
Results			
Scour Depth	4.13	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	2.90	ft	

Scour remains in first layer.

Total Contraction Scour Channel

Total Scour Depth = **2.90** **ft**

2LMN

Contraction Scour Rear Abutment For 50-Yr Frequency

Calculated By:	LAW	Date: 6/27/2023		Job No.:	105889
Checked By:	JAH	Date: 6/30/2023		Bridge No.	LUC-00184-00.180
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

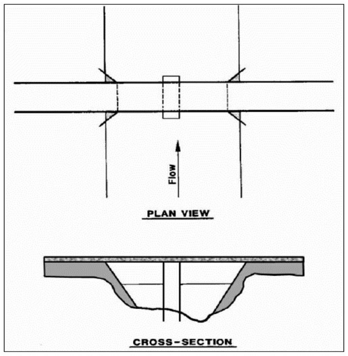
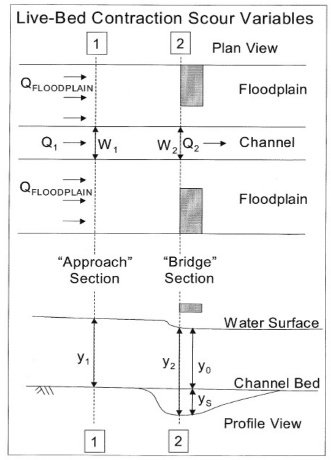


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
4.41	ft	Average Depth Upstream
2.67	ft/s	Average Velocity in Contracted Section
4.24	ft	Depth Prior to Scour in Contracted Section

Boring B-022-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	4.5800	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0791	mm	
	F_1 =	49	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	9		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	19		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.3000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.2838	mm	
	F_2 =	24	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	68		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Contraction Scour Rear Abutment For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour RA

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	4.41	ft	
Average Velocity in Contracted Section	2.67	ft/s	
Critical Shear Stress	0.06	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	4.24	ft	
Results			
Scour Depth	1.11	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	0.85	ft	

Scour remains in first layer.

Total Contraction Scour RA

Total Scour Depth = **0.85** **ft**

2LMN

Contraction Scour Fwd Abutment For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

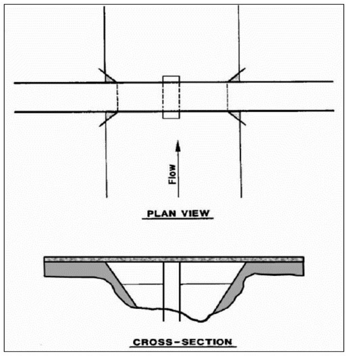
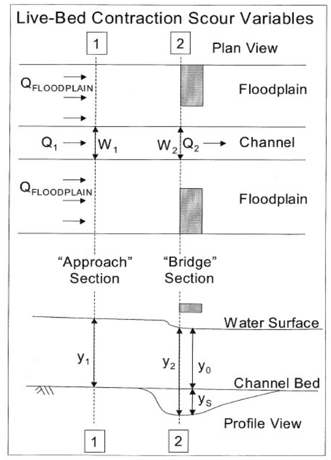


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
6.31	ft	Average Depth Upstream
4.68	ft/s	Average Velocity in Contracted Section
8.55	ft	Depth Prior to Scour in Contracted Section

Boring B-022-1-21 (used worst case for ROB for contraction)

Layer	Parameter	Value	Unit	Note
Water				
Bed Material 1	y_{bed1} =	4.5800	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0791	mm	
	F_1 =	49	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	9		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	19		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.3000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.2838	mm	
	F_2 =	24	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	68		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Contraction Scour Fwd Abutment For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour FA

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	6.31	ft	
Average Velocity in Contracted Section	4.68	ft/s	
Critical Shear Stress	0.06	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	8.55	ft	
Results			
Scour Depth	2.82	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	2.14	ft	

Scour remains in first layer.

Total Contraction Scour FA

Total Scour Depth = **2.14** **ft**

2LMN

Rear Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

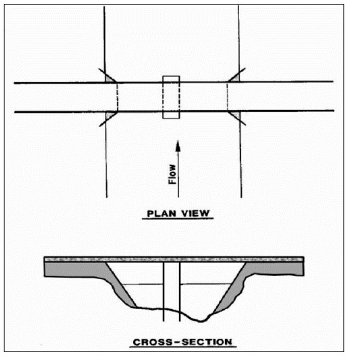
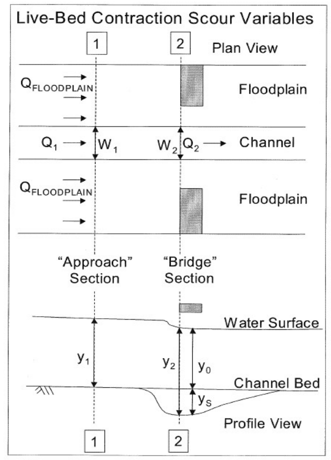


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		***(Entries pulled from HEC-Ras Info Tab, unless otherwise noted)***
36.50	ft	Centerline Length of Embankment (measured along abutment wall)
177.24	ft	Width of Floodplain
1.92	cfs/ft	Unit Discharge, Upstream Approach Section
11.30	cfs/ft	Unit Discharge in Constricted Area
4.41000	ft	Upstream Flow Depth
4.24000	ft	Flow Depth prior to Scour

Boring B-022-1-21

Layer	Variable	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	4.0000	ft	Depth of Bed Material Ground EL. 615 to 611
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	2.86	mm	D50 Equivalent
	F_1 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =		ft	Depth of Bed Material
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	D50 Equivalent
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Rear Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Rear Abutment Scour

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen…
Centerline Length of Embankment	36.50	ft	
Width of Flood Plain	200.35	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A…	1.92	cfs/ft	
Unit Discharge in Constricted Area (q2)	11.30	cfs/ft	
D50	2.859938	mm	0.2 mm is the lower limit for coh…
Upstream Flow Depth	4.41	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0610	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	4.24	ft	Depth at Abutment Toe
Results			
q2 / q1	5.89		
Average Velocity Upstream	0.44	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm…	3.02	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.13		
Flow Depth including Contraction Scour	6.27	ft	
Maximum Flow Depth including Abutment Scour	7.11	ft	
Scour Hole Depth	2.87	ft	Negative values imply 'zero' sco…
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will …
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	2.97	ft	

Scour stays within Bed 1.

Total Local Rear Abutment Scour

Total Scour Depth = **2.87** **ft**

2LMN

Forward Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

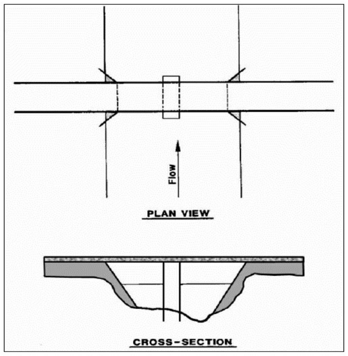
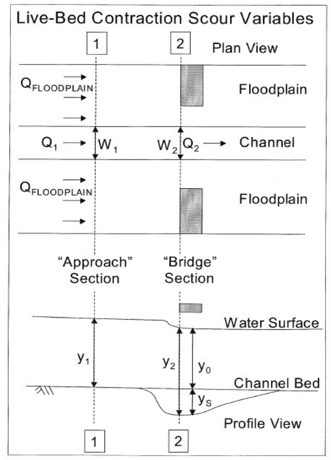


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		*(Entries pulled from HEC-Ras Info Tab, unless otherwise noted)*
36.50	ft	Centerline Length of Embankment (measured along abutment wall)
177.24	ft	Width of Floodplain
14.12	cfs/ft	Unit Discharge, Upstream Approach Section
40.03	cfs/ft	Unit Discharge in Constricted Area
6.31000	ft	Upstream Flow Depth
8.55000	ft	Flow Depth prior to Scour

Boring B-022-2-21 & B-022-3-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	5.6300	ft	Depth of Bed Material Ground EL. 612.33 to 606.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4.02	mm	D50 Equivalent
	F_1 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	5.0000	ft	Depth of Bed Material
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4612.6	mm	D50 Equivalent
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Forward Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Forward Abutment Scour

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen…
Centerline Length of Embankment	36.50	ft	
Width of Flood Plain	200.35	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A…	14.12	cfs/ft	
Unit Discharge in Constricted Area (q2)	40.03	cfs/ft	
D50	4.020000	mm	0.2 mm is the lower limit for coh…
Upstream Flow Depth	6.31	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0860	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	8.55	ft	Depth at Abutment Toe
Results			
q2 / q1	2.83		
Average Velocity Upstream	2.24	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm…	3.59	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.59		
Flow Depth including Contraction Scour	16.00	ft	
Maximum Flow Depth including Abutment Scour	25.38	ft	
Scour Hole Depth	16.83	ft	Negative values imply 'zero' sco…
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will …
Scour Hole Bottom Width	0.00	ft	
Scour Hole Top Width	17.43	ft	

Soil above rock scours. Check scourable rock layer.

2LMN

Forward Abutment Scour For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen...
Centerline Length of Embankment	36.50	ft	
Width of Flood Plain	200.35	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A...	14.12	cfs/ft	
Unit Discharge in Constricted Area (q2)	40.03	cfs/ft	
D50	4612.600000	mm	0.2 mm is the lower limit for coh...
Upstream Flow Depth	6.31	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	96.3400	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	8.55	ft	Depth at Abutment Toe
Results			
q2 / q1	2.83		
Average Velocity Upstream	2.24	ft/s	
Critical Velocity above which Bed Material of Size D and Sm...	37.56	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.59		
Flow Depth including Contraction Scour	0.79	ft	
Maximum Flow Depth including Abutment Scour	1.25	ft	
Scour Hole Depth	-7.30	ft	Negative values imply 'zero' sco...
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	0.00		1.0 means the bottom width will ...

Scour is negative, indicating no scour in rock layer.

Total Local Forward Abutment Scour

Existing ground elevation	612.33
Top of Rock elevation	606.7

Total Scour Depth = 5.63 ft

2LMN

Time-Rate of Scour - Pier 1 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

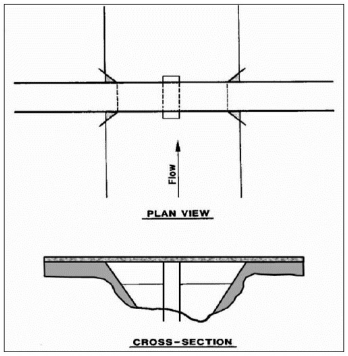
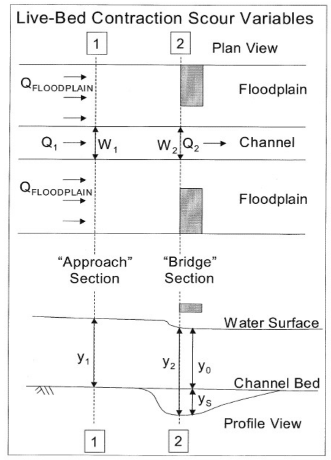


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

	50-yr		(Entries pulled from HEC-Ras Info Tab)
V2 =	2.70	ft/s	Average Velocity in Contracted Section (HEC-RAS)
y_0 =	11.37	ft	Flow Depth at Structure

Boring B-022-1-21

Time rate of scour must be analyzed for each soil layer.

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	4.5800	ft	Depth of Bed Material Ground EL. 615.58
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0791	mm	
	F_1 =	49	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	9		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	19		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.3000	ft	Depth of Bed Material
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.2838	mm	
	F_2 =	24	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	68		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Time-Rate of Scour - Pier 1 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Pier 1 Scour

Time rate of scour for cohesive soils

D_{50} = 0.0791 mm	0.0031	in	Bed Material Size
	0.0003	ft	

Determine Critical Soil Velocity

Reference: ODOT L&D Vol. 2, Fig. 1008-18

τc =	0.0610	psf	Soil Scour Critical Shear Stress (from TTL Preliminary Scour Design Memo)
$Vc = (1.486/n) x ((\tau_c\, y^{1/3})/y_w)^{1/2}$			Critical Soil Velocity
n =	0.0350		Manning's number
y =	11.3720	ft	Depth prior to contracted section
yw =	62.4000	pcf	unit weight of water
Vc =	**1.9907**	fps	Critical Soil Velocity
V2 =	2.7000	fps	Average velocity in contracted section
	V2	> Vc	SCOUR WILL OCCUR, DETERMINE BED SHEAR STRESS

Determine Bed Shear Stress from Hydraulic Flow for Soil Erosion Rate

$\tau = (nKV/Ku)^2 \times (y_w/y^{1/3})$

n =	0.0350		Manning's number
K =	1.5000		for circular piers
V =	2.6700	fps	flow velocity at point of consideration
Ku =	1.4860		U.S. customary units
yw =	62.4000	pcf	unit weight of water
y =	11.3720	ft	Depth prior to contracted section
τ =	**0.5452**	psf	Bed Shear Stress

$z = 10^{(\alpha \log(\tau+47.88)+\beta)}/304.8$	**0.29**	ft/hr	Estimate of erosion rate versus shear stress of a cohesive soil
$\alpha = [13/(EC^{0.309})]-7.1363$	2.25		dimensionless, for 1 ≤ EC ≤ 6
$\beta = 7.377777-[(1-(EC-4.5)^2/3.57^2)*10.377777^2]^{0.5}$	-1.85		
$EC = 4.5-(3/1.07^{PI})$	2.87		Erosion category, dimensionless, for 1.5 ≤ EC ≤ 4.5
Layer 1 scours in	13.98	hours	
Duration =	24	hours	CHECK LAYER 2

Bed Material 2 Local Pier 1 Scour

D_{50} = 0.2838 mm	0.0031	in	Bed Material Size
	0.0003	ft	

Determine Critical Soil Velocity

Reference: ODOT L&D Vol. 2, Fig. 1008-18

τc =	0.0060	psf	Soil Scour Critical Shear Stress (from TTL Preliminary Scour Design Memo)
$Vc = (1.486/n) x ((\tau_c\, y^{1/3})/y_w)^{1/2}$			Critical Soil Velocity
n =	0.0350		Manning's number
y =	15.9520	ft	Depth prior to contracted section
yw =	62.4000	pcf	unit weight of water
Vc =	**0.6605**	fps	Critical Soil Velocity
V2 =	0.0031	fps	Average velocity in contracted section
	V2	< Vc	NO SIGNIFICANT SCOUR

Determine Bed Shear Stress from Hydraulic Flow for Soil Erosion Rate

$\tau = (nKV/Ku)^2 \times (y_w/y^{1/3})$

n =	0.0350		Manning's number
K =	1.5000		for circular piers
V =	2.6700	fps	flow velocity at point of consideration
Ku =	1.4860		U.S. customary units
yw =	62.4000	pcf	unit weight of water
y =	15.9520	ft	Depth prior to contracted section
τ =	**0.4871**	psf	Bed Shear Stress

$z = 10^{(\alpha \log(\tau+47.88)+\beta)}/304.8$	**0.29**	ft/hr	Estimate of erosion rate versus shear stress of a cohesive soil
$\alpha = [13/(EC^{0.309})]-7.1363$	2.25		dimensionless, for 1 ≤ EC ≤ 6
$\beta = 7.377777-[(1-(EC-4.5)^2/3.57^2)*10.377777^2]^{0.5}$	-1.85		

2LMN

Time-Rate of Scour - Pier 1 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

EC = $4.5-(3/1.07^{PI})$ 2.87 Erosion category, dimensionless, for 1.5 ≤ EC ≤ 4.5

Remaining hours 10.02

Duration = 24 hours

Run Hydraulic Toolbox

Pier Scour

Computation Method: Cohesive Materials

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Angle of Attack	0.00	Degrees	
Average Velocity Upstream	2.67	ft/s	
Pier Width	2.50	ft	
Pier Length	28.33	ft	
Critical Velocity for Soil	1.99	ft/s	
Time Rate of Scour			
Flow Duration	10.02	hr	
Initial Erosion Rate	0.29	ft/hr	
Results			
Scour Depth	3.63	ft	
Results for Time Rate of Scour			
Depth of Scour After Flow Event	1.61	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	7.39	ft	

Scour in Bed 2 = 1.61 < 2.3000 SCOUR ENDS IN BED 2

Total Local Pier 1 Scour

Total Scour Depth = 6.19 ft

2LMN

Local Scour Pier 2 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

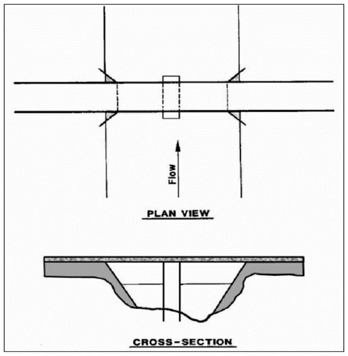
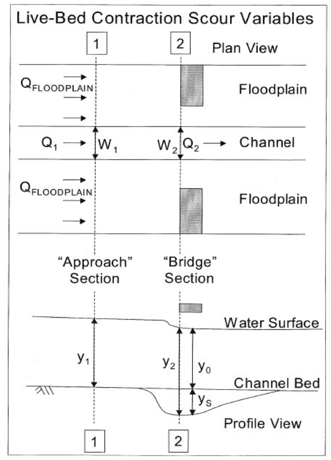


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

50-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
10.76	ft	Depth of Upstream Pier
6.01	ft/s	Velocity of Upstream Pier
2.50	ft	Width of Pier
28.33	ft	Length of Pier (measured in plan)

Water

Boring B-022-2-21 & B-022-3-21

Layer	Parameter	Value	Unit	Description
Bed Material 1	y_{bed1} =	1.0900	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0398	mm	
	F_1 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	7.0000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Local Scour Pier 2 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Pier 2 Scour

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	10.76	ft	
Velocity Upstream of Pier	6.01	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	1.039800	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.95		
f2	-0.47		
f3	0.67		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	1.99	ft/s	
Velocity of the live-bed peak scour	11.17	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	4.49	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	9.14	ft	

Scour extends into second layer.

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	10.76	ft	
Velocity Upstream of Pier	6.01	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	99.000000	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.95		
f2	0.29		
f3	0.60		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	12.94	ft/s	
Velocity of the live-bed peak scour	64.72	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	1.05	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	2.50	ft	

Equivalent D50 for rock = 4612.6 mm, per Table 2: Scour Parameters for Rock, Ramp D in the Preliminary Scour Design Memo

Florida DOT option does not produce a result beyond D50 = 99mm, therefore, this was used in calculations.

Scour does not exceed past rock layer.

2LMN

Local Scour Pier 2 For 50-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Total Local Pier 2 Scour

Total Scour Depth =	**1.05**	**ft**
Scour Elevation =	**608.74**	

2LMN

South Entrance Ramp Summary For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.:	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

100-Year (1% AEP)	Depth (ft)	Existing Ground EL.*	**Scour Elevation**	Bottom of Footing EL.	Shaft length	**Bottom of Shaft Due to Scour / Top of Rock Socket**
Contraction Scour (R.A.)	1.01					
Abutment Scour (R.A.)	3.78					
Total Rear Abutment Scour	**4.79**	**615.00**	**610.21**	612.5	12.29	600.21
Contraction Scour (F.A.)	2.28					
Abutment Scour (F.A.)	5.63					
Total Forward Abutment Scour	**7.91**	**612.33**	**604.42**	614	19.58	594.42
Channel Contraction Scour	3.03					
Pier 1 Scour	6.36					
Total Pier 1 Scour	**9.39**	**615.00**	**605.61**	610.79	15.18	595.61
Pier 2 Scour	1.09					
Total Pier 2 Scour	**4.12**	**609.79**	**605.67**	605.14	9.47	595.67

* Existing ground at point of interest, or top of geotech sample, whichever is lower.

2LMN

Contraction Channel Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

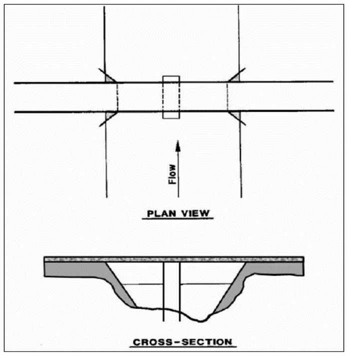
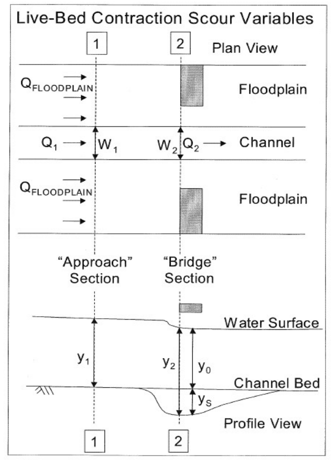


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)
12.05	ft	Average Depth Upstream
5.24	ft/s	Average Velocity in Contracted Section
12.11	ft	Depth Prior to Scour in Contracted Section

Water

Boring B-022-1-21

Layer	Parameter	Value	Unit	Description
Bed Material 1	y_{bed1} =	4.5800	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0791	mm	
	F_1 =	49	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	9		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	19		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.3000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.2838	mm	
	F_2 =	24	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	68		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Contraction Channel Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	12.05	ft	
Average Velocity in Contracted Section	5.24	ft/s	
Critical Shear Stress	0.06	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	12.11	ft	
Results			
Scour Depth	4.37	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	3.03	ft	

Scour remains in first layer.

Total Contraction Scour

Total Scour Depth = 3.03 ft

2LMN

Contraction Scour Rear Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:	LUC-23-11.75				SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

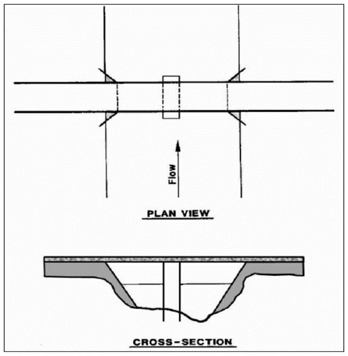
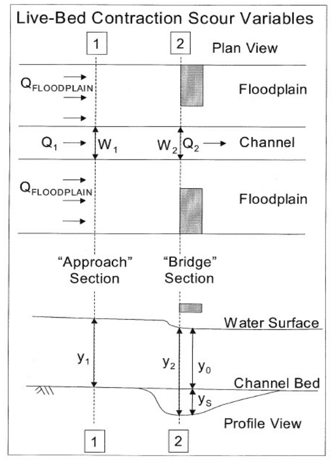


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
5.12	ft	Average Depth Upstream
2.90	ft/s	Average Velocity in Contracted Section
4.97	ft	Depth Prior to Scour in Contracted Section

Boring B-022-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	4.5800	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0791	mm	
	F_1 =	49	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	9		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	19		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.3000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.2838	mm	
	F_2 =	24	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	68		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Contraction Scour Rear Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour RA

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	5.12	ft	
Average Velocity in Contracted Section	2.90	ft/s	
Critical Shear Stress	0.06	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	4.97	ft	
Results			
Scour Depth	1.34	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	1.01	ft	

Scour remains in first layer.

Total Contraction Scour RA

Total Scour Depth = **1.01** **ft**

2LMN

Contraction Scour Fwd Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

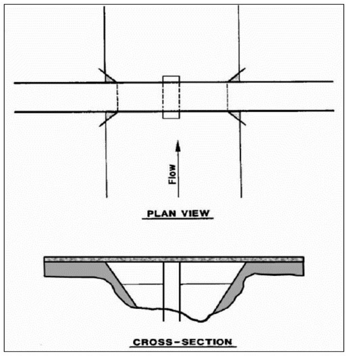
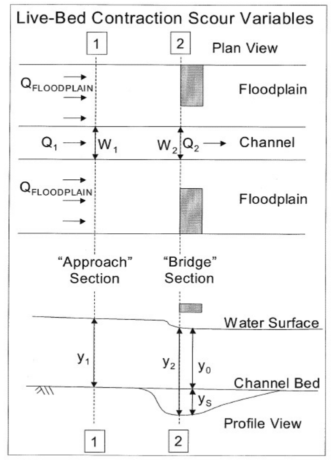


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)
6.57	ft	Average Depth Upstream
4.87	ft/s	Average Velocity in Contracted Section
9.29	ft	Depth Prior to Scour in Contracted Section

Boring B-022-1-21 (used worst case for ROB for contraction)

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	4.5800	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0791	mm	
	F_1 =	49	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	9		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	19		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.3000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.2838	mm	
	F_2 =	24	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	68		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Contraction Scour Fwd Abutment For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Contraction Scour FA

Contraction Scour

Computation Method: Cohesive Soil

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream	6.57	ft	
Average Velocity in Contracted Section	4.87	ft/s	
Critical Shear Stress	0.06	lb/ft^2	
Density of Water	1.94	slug/ft^3	
Manning's n	0.0350		
Depth Prior to Scour in Contracted Section	9.29	ft	
Results			
Scour Depth	3.02	ft	Negative values imply 'zero' scour depth
Time Rate of Scour			
Unit Weight of Water	62.400	lb/ft^3	
Duration of Flow	24.000	hr	
Results			
Scour Depth from Flow Event	2.28	ft	

Scour remains in first layer.

Total Contraction Scour FA

Total Scour Depth = 2.28 ft

2LMN

Rear Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

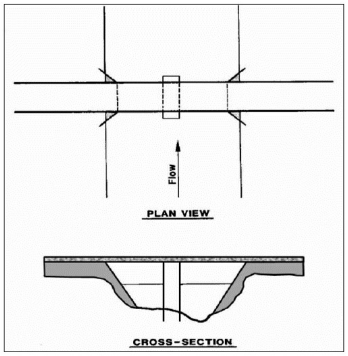
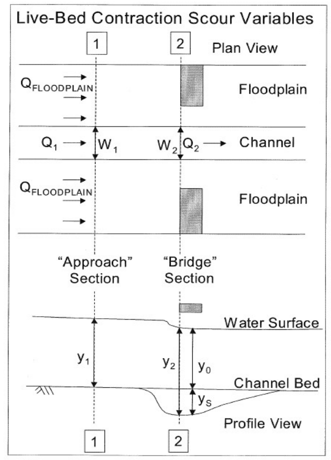


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		*(Entries pulled from HEC-Ras Info Tab, unless otherwise noted)*
36.50	ft	Centerline Length of Embankment (measured along abutment wall)
200.35	ft	Width of Floodplain
2.36	cfs/ft	Unit Discharge, Upstream Approach Section
14.39	cfs/ft	Unit Discharge in Constricted Area
5.12000	ft	Upstream Flow Depth
4.97000	ft	Flow Depth prior to Scour

Boring B-022-1-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	4.0000	ft	Depth of Bed Material Ground EL. 615 to 611
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	2.86	mm	D50 Equivalent
	F_1 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =		ft	Depth of Bed Material
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	D50 Equivalent
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Rear Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Rear Abutment Scour

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen…
Centerline Length of Embankment	36.50	ft	
Width of Flood Plain	200.35	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A…	2.36	cfs/ft	
Unit Discharge in Constricted Area (q2)	14.39	cfs/ft	
D50	2.860000	mm	0.2 mm is the lower limit for coh…
Upstream Flow Depth	5.12	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0610	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	4.97	ft	Depth at Abutment Toe
Results			
q2 / q1	6.10		
Average Velocity Upstream	0.46	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm…	3.09	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.13		
Flow Depth including Contraction Scour	7.71	ft	
Maximum Flow Depth including Abutment Scour	8.75	ft	
Scour Hole Depth	3.78	ft	Negative values imply 'zero' sco…
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	1.00		1.0 means the bottom width will …
Scour Hole Bottom Width	3.78	ft	
Scour Hole Top Width	7.69	ft	

Scour stays within Bed 1.

Total Local Rear Abutment Scour

Total Scour Depth = **3.78** **ft**

2LMN

Forward Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

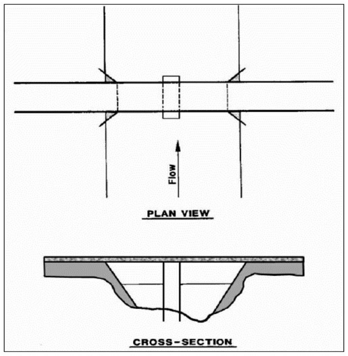
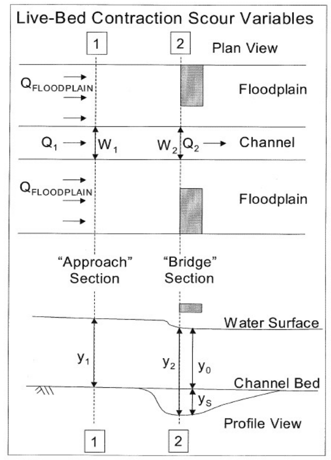


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		*(Entries pulled from HEC-Ras Info Tab, unless otherwise noted)*
36.50	ft	Centerline Length of Embankment (measured along abutment wall)
200.35	ft	Width of Floodplain
15.00	cfs/ft	Unit Discharge, Upstream Approach Section
45.21	cfs/ft	Unit Discharge in Constricted Area
6.57000	ft	Upstream Flow Depth
9.29000	ft	Flow Depth prior to Scour

Boring B-022-2-21 & B-022-3-21

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	5.6300	ft	Depth of Bed Material Ground EL. 612.33 to 606.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4.02	mm	D50 Equivalent
	F_1 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	5.0000	ft	Depth of Bed Material
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	4612.6	mm	D50 Equivalent
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Forward Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Forward Abutment Scour

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen…
Centerline Length of Embankment	36.50	ft	
Width of Flood Plain	200.35	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A…	15.00	cfs/ft	
Unit Discharge in Constricted Area (q2)	45.21	cfs/ft	
D50	4.020000	mm	0.2 mm is the lower limit for coh…
Upstream Flow Depth	6.57	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	0.0860	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	9.29	ft	Depth at Abutment Toe
Results			
q2 / q1	3.01		
Average Velocity Upstream	2.28	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm…	3.61	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.50		
Flow Depth including Contraction Scour	17.76	ft	
Maximum Flow Depth including Abutment Scour	26.70	ft	
Scour Hole Depth	17.41	ft	Negative values imply 'zero' sco…
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	1.00		1.0 means the bottom width will …
Scour Hole Bottom Width	17.41	ft	
Scour Hole Top Width	35.44	ft	

Soil above rock scours. Check scourable rock layer.

2LMN

Forward Abutment Scour For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Abutment Scour

Computation Method: NCHRP

Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Compute		
Abutment Type	Spill-through abutment		
Angle of Embankment to Flow	0.00	degrees	0° is downstream, 90° is perpen…
Centerline Length of Embankment	36.50	ft	
Width of Flood Plain	200.35	ft	projected normal to flow
Unit Discharge, Upstream in Active, Approach Overbank A…	15.00	cfs/ft	
Unit Discharge in Constricted Area (q2)	45.21	cfs/ft	
D50	4612.600000	mm	0.2 mm is the lower limit for coh…
Upstream Flow Depth	6.57	ft	
Define Shear Stress of Floodplain	☑		
Critical Shear Stress of Floodplain Material	96.3400	lb/ft^2	
Unit Weight of Water	62.40	lb/ft^3	
Manning's n	0.035		
Flow Depth prior to Scour	9.29	ft	Depth at Abutment Toe
Results			
q2 / q1	3.01		
Average Velocity Upstream	2.28	ft/s	
Critical Velocity above which Bed Material of Size D and Sm…	37.81	ft/s	
Scour Condition	Clear Water		
Embankment Length/Floodplain Width Ratio	0.00		
Scour Condition	b (Overbank)		
Amplification Factor	1.50		
Flow Depth including Contraction Scour	0.88	ft	
Maximum Flow Depth including Abutment Scour	1.32	ft	
Scour Hole Depth	-7.97	ft	Negative values imply 'zero' sco…
Scour Hole			
Angle of Repose	44.00	degrees	
Ratio of Bottom Width of Scour Hole to Scour Hole Depth	1.00		1.0 means the bottom width will …

Scour is negative, indicating no scour in rock layer.

Total Local Forward Abutment Scour

Existing ground elevation	612.33
Top of Rock elevation	606.7

Total Scour Depth = 5.63 ft

Time-Rate of Scour - Pier 1 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

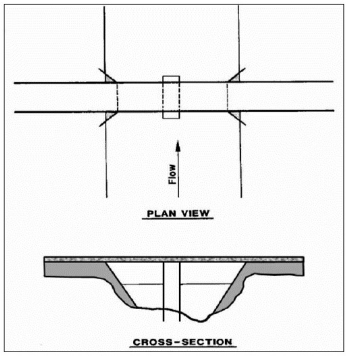
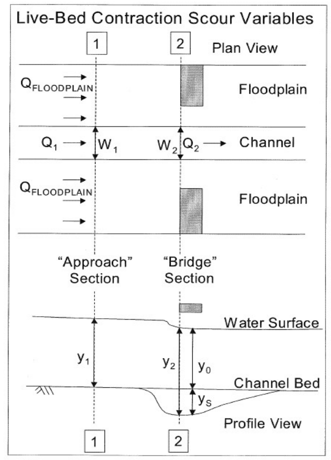


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

	100-yr		(Entries pulled from HEC-Ras Info Tab)
V2 =	2.90	ft/s	Average Velocity in Contracted Section (HEC-RAS)
y_0 =	12.11	ft	Flow Depth at Structure

Boring B-022-1-21

Time rate of scour must be analyzed for each soil layer.

Layer	Parameter	Value	Unit	Description
Water				
Bed Material 1	y_{bed1} =	4.5800	ft	Depth of Bed Material Ground EL. 615.58
	Type =	Cohesive		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.0791	mm	
	F_1 =	49	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =	9		Plasticity Index (from geotechnical information)
	qu1 =	2000	psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =	19		Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	2.3000	ft	Depth of Bed Material
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	0.2838	mm	
	F_2 =	24	%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =	68		Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Time-Rate of Scour - Pier 1 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Pier 1 Scour

Time rate of scour for cohesive soils

D_{50} = 0.0791 mm	0.0031	in	Bed Material Size
	0.0003	ft	

Determine Critical Soil Velocity

Reference: ODOT L&D Vol. 2, Fig. 1008-18

τc =	0.0610	psf	Soil Scour Critical Shear Stress (from TTL Preliminary Scour Design Memo)
$Vc = (1.486/n)x((\tau_c\, y^{1/3})/y_w)^{1/2}$			Critical Soil Velocity
n =	0.0350		Manning's number
y =	12.1120	ft	Depth prior to contracted section
yw =	62.4000	pcf	unit weight of water
Vc =	**2.0117**	fps	Critical Soil Velocity
V2 =	2.9000	fps	Average velocity in contracted section
	V2 > Vc		SCOUR WILL OCCUR, DETERMINE BED SHEAR STRESS

Determine Bed Shear Stress from Hydraulic Flow for Soil Erosion Rate

$\tau = (nKV/Ku)^2 \times (y_w/y^{1/3})$

n =	0.0350		Manning's number
K =	1.5000		for circular piers
V =	2.9000	fps	flow velocity at point of consideration
Ku =	1.4860		U.S. customary units
yw =	62.4000	pcf	unit weight of water
y =	12.1120	ft	Depth prior to contracted section
τ =	**0.6298**	psf	Bed Shear Stress

$z = 10^{(\alpha \log(\tau+47.88)+\beta)}/304.8$	**0.29**	ft/hr	Estimate of erosion rate versus shear stress of a cohesive soil
$\alpha = [13/(EC^{0.309})]-7.1363$	2.25		dimensionless, for 1 ≤ EC ≤ 6
$\beta = 7.377777-[(1-(EC-4.5)^2/3.57^2)*10.377777^2]^{0.5}$	-1.85		
$EC = 4.5-(3/1.07^{PI})$	2.87		Erosion category, dimensionless, for 1.5 ≤ EC ≤ 4.5
Layer 1 scours in	13.92	hours	
Duration =	24	hours	CHECK LAYER 2

Bed Material 2 Local Pier 1 Scour

D_{50} = 0.2838 mm	0.0031	in	Bed Material Size
	0.0003	ft	

Determine Critical Soil Velocity

Reference: ODOT L&D Vol. 2, Fig. 1008-18

τc =	0.0060	psf	Soil Scour Critical Shear Stress (from TTL Preliminary Scour Design Memo)
$Vc = (1.486/n)x((\tau_c\, y^{1/3})/y_w)^{1/2}$			Critical Soil Velocity
n =	0.0350		Manning's number
y =	16.6920	ft	Depth prior to contracted section
yw =	62.4000	pcf	unit weight of water
Vc =	**0.6656**	fps	Critical Soil Velocity
V2 =	0.0031	fps	Average velocity in contracted section
	V2 < Vc		NO SIGNIFICANT SCOUR

Determine Bed Shear Stress from Hydraulic Flow for Soil Erosion Rate

$\tau = (nKV/Ku)^2 \times (y_w/y^{1/3})$

n =	0.0350		Manning's number
K =	1.5000		for circular piers
V =	2.9000	fps	flow velocity at point of consideration
Ku =	1.4860		U.S. customary units
yw =	62.4000	pcf	unit weight of water
y =	16.6920	ft	Depth prior to contracted section
τ =	**0.5660**	psf	Bed Shear Stress

$z = 10^{(\alpha \log(\tau+47.88)+\beta)}/304.8$	**0.29**	ft/hr	Estimate of erosion rate versus shear stress of a cohesive soil
$\alpha = [13/(EC^{0.309})]-7.1363$	2.25		dimensionless, for 1 ≤ EC ≤ 6
$\beta = 7.377777-[(1-(EC-4.5)^2/3.57^2)*10.377777^2]^{0.5}$	-1.85		

2LMN

Time-Rate of Scour - Pier 1 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:	LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

$EC = 4.5-(3/1.07^{PI})$ 2.87 Erosion category, dimensionless, for $1.5 \le EC \le 4.5$

Remaining hours 10.08

Duration = 24 hours

Run Hydraulic Toolbox

Pier Scour

Computation Method: Cohesive Materials

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Angle of Attack	0.00	Degrees	
Average Velocity Upstream	2.90	ft/s	
Pier Width	2.50	ft	
Pier Length	28.33	ft	
Critical Velocity for Soil	0.67	ft/s	
Time Rate of Scour			
Flow Duration	10.08	hr	
Initial Erosion Rate	0.29	ft/hr	
Results			
Scour Depth	4.56	ft	
Results for Time Rate of Scour			
Depth of Scour After Flow Event	1.78	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	9.29	ft	

Scour in Bed 2 = 1.78 < 2.3000 SCOUR ENDS IN BED 2

Total Local Pier 1 Scour

Total Scour Depth = 6.36 ft

2LMN

Local Scour Pier 2 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Schematics

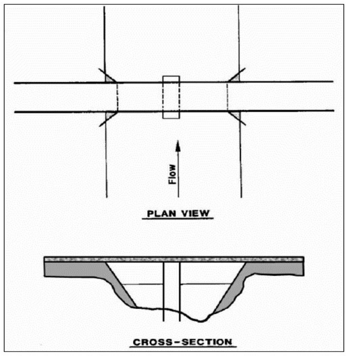
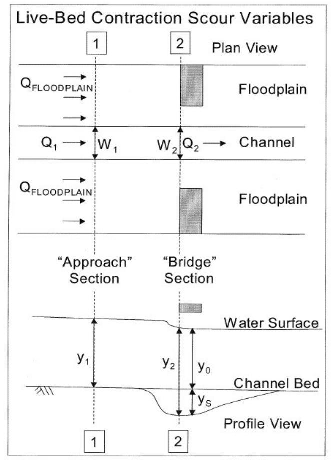


Figure 6.5. Case 2b: Bridge abutments and/or piers constrict flow.



Input

100-yr		*(Entries pulled from HEC-Ras Info Tab, unless noted otherwise)*
11.50	ft	Depth of Upstream Pier
6.25	ft/s	Velocity of Upstream Pier
2.50	ft	Width of Pier
28.33	ft	Length of Pier (measured in plan)

Water

Boring B-022-2-21 & B-022-3-21

Layer	Parameter	Value	Unit	Description
Bed Material 1	y_{bed1} =	1.0900	ft	Depth of Bed Material Ground EL. 609.79 - 608.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =	1.0398	mm	
	F_1 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_1 =			Plasticity Index (from geotechnical information)
	qu1 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_1 =			Water Content (from geotechnical information)
Bed Material 2	y_{bed2} =	7.0000	ft	Depth of Bed Material EL. 608.7 - 601.7
	Type =	Sediment		If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_2 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_2 =			Plasticity Index (from geotechnical information)
	qu2 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_2 =			Water Content (from geotechnical information)
Bed Material 3	y_{bed3} =		ft	Depth of Bed Material
	Type =			If D50 < or = 0.20 mm calculate scour for cohesive
	D_{50} =		mm	
	F_3 =		%	Fraction of fine particles (from geotechnical information, add silt and clay)
	PI_3 =			Plasticity Index (from geotechnical information)
	qu3 =		psf	Unconfined compressive strength, Blow counts x 125 if n < 50
	w_3 =			Water Content (from geotechnical information)

2LMN

Local Scour Pier 2 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023		Job No.:	105889
Checked By:	JAH	Date:	6/30/2023		Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75			SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Bed Material 1 Local Pier 2 Scour

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	11.50	ft	
Velocity Upstream of Pier	6.25	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	1.039800	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.95		
f2	-0.56		
f3	0.67		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	2.00	ft/s	
Velocity of the live-bed peak scour	11.55	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	4.52	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	9.21	ft	

Scour extends into second layer.

Pier Scour

Computation Method: Florida DOT

Parameter	Value	Units	Notes
Input Parameters			
Pier Shape	Round Nose		
Depth Upstream of Pier	11.50	ft	
Velocity Upstream of Pier	6.25	ft/s	
Width of Pier	2.50	ft	
Length of Pier	28.33	ft	
Angle of Attack	0.00	Degrees	
D50	99.000000	mm	0.00mm < D50 < 0.33mm
Results			
f1	0.95		
f2	0.34		
f3	0.60		
Shape Factor (Ksf)	1.00		
Critical Velocity for Movement of D50	13.11	ft/s	
Velocity of the live-bed peak scour	65.54	ft/s	
Projected Pier Width in Direction of Flow	2.50	ft	
Effective Pier Width	2.50	ft	
Scour Depth	1.22	ft	
Scour Hole			
Angle of Repose	44.00	degrees	
Use the Pier Width as the Bottom Width of Scour Hole	☑		
Scour Hole Bottom Width	2.50	ft	
Scour Hole Top Width	2.50	ft	

Equivalent D50 for rock = 4612.6 mm, per Table 2: Scour Parameters for Rock, Ramp D in the Preliminary Scour Design Memo

Florida DOT option does not produce a result beyond D50 = 99mm, therefore, this was used in calculations.

Scour does not exceed past rock layer.

2LMN

Local Scour Pier 2 For 100-Yr Frequency

Calculated By:	LAW	Date:	6/27/2023	Job No.:	105889
Checked By:	JAH	Date:	6/30/2023	Bridge No.	LUC-00184-00.180
Project:		LUC-23-11.75		SFN:	TBD

Code Used: *HEC-18: Evaluating Scour at Bridges, Fifth Edition, April 2013 (FHWA-HIF-12-003)*

Total Local Pier 2 Scour

Total Scour Depth =	**1.09**	**ft**
Scour Elevation =	**608.70**	