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Vedder River

Hydraulic Profile Update 2018

Final Report
May 2018
KWL Project No. 0607.027

Prepared for:

CITY OF CHILLIWACK

Contents

Executive Summary i

1. Introduction 1

2. River Surveys 1

3. Thalweg Profile 1
3.1 Vedder Canal 1
3.2 Vedder River 2

4. Bed Material Quantity Calculations 9
4.1 Vedder Canal 10
4.2 Vedder River 11

5. Hydraulic Analysis 14
5.1 Flood Profile Analysis 14

6. Recommendations 21

Report Submission

References

Figures

Figure 1: Cross Section Locations – Vedder Canal 3
Figure 2: Cross Section Locations – Vedder River 4
Figure 3: Vedder Canal Thalweg Profile 5
Figure 4: Vedder River Thalweg Profile Lower Reach 6
Figure 5: Vedder River Thalweg Profile Middle Reach 7
Figure 6: Vedder River Thalweg Profile Upper Reach 8
Figure 7: Vedder Canal Flood and Setback Dike Profiles 19
Figure 8: Vedder River Flood and Setback Dike Profiles 20

Tables

Table 1: Channel Gravel Quantities 2016-2018 9
Table 2: Vedder Canal Gravel Quantities 10
Table 3: Vedder River Gravel Quantities 12
Table 4: 2018 Flood Profile and Dike Freeboard for the Vedder Canal 15
Table 5: 2018 Flood Profile and Bank/Dike Freeboard for the Vedder River 16

Appendix

Appendix A: Channel Gravel Quantities
Appendix B: Vedder Canal Historical Water Surface Profile
Appendix C: 2018 HEC-RAS Water Surface Elevations

Executive Summary

Kerr Wood Leidal (KWL) was retained by the City of Chilliwack on behalf of the Vedder River Technical Committee (VRTC) to carry out a hydraulic analysis on the Vedder River and the Vedder Canal to update the 200-year flood profile and to calculate sediment deposition over the past two years (2016-2018). The study area includes the 12 km reach from the Vedder Crossing Bridge to the Highway 1 Bridge. This reach has a long history of gravel removal activities dating back to 1979.

The channel survey was conducted by CRA Canada Surveys Inc. from January 15 to March 5, 2018. The survey includes 23 cross sections in the Vedder Canal and 53 cross sections in the Vedder River. The 200-year design flood of 1,470 m^3/s was routed through the surveyed channel geometry using the HEC-RAS hydraulic model. A starting water level of 7.4 m, was utilized as the boundary condition at the Highway 1 Bridge. The channel Manning roughness coefficients were 0.030 for the Vedder Canal and ranged from 0.034 to 0.036 for the Vedder River. Overbank roughness was 0.03 for the Canal managed overbank and was 0.150 across the brush and treed overbank area. The roughness values remained the same as the 2016 study due to the lack of high flow event for model calibration. The computed 200-year flood profile was compared to the crest elevation of the setback dikes to determine freeboard. In the Vedder Canal, the dike freeboard exceeded the 0.75 m freeboard requirement on both sides. In the Vedder River, the setback dike freeboard exceeded 0.75 m except on the right (north) dike from XS8 to XS13, which remained the same as in 2016. However, the freeboard deficiency is smaller than in 2016 due to a slight drop (0.05m to 0.08m) in the water level. The lowest freeboard was found to be 0.52 m at XS9.

Natural deposition in the Vedder River and the Vedder Canal was calculated as the sum of the surveyed bed surface change (2016-2018) and the known excavation volume in 2016. The average quantity of deposition in the Vedder River and Vedder Canal was calculated to be -1,300 m^3/y (i.e. net degradation) for the past two years (2016-2018). This was based on a calculated deposition rate of 25,900 m^3/y in the Vedder River and degradation rate of 27,200 m^3/y in the Vedder Canal. In comparison, the total annual deposition rate for the Vedder River and Vedder Canal was 41,500 m^3/y for the past 22 years (1996-2018), and 42,200 m^3/y for the past 37 years (1981-2018). Since 2008, the annual deposition rate has fallen below the long term average level.

A review of the discharge record during the study period (February 2016 to March 2018) was conducted for the Vedder Crossing hydrometric station (08MH001). A maximum instantaneous discharge of 442 m^3/s occurred in November 2017, which is associated with a return period of 1 in 2 years. The lack of significant flood events since 2006 is likely the cause of reduced sedimentation in the Vedder River and Vedder Canal in recent years.

1. Introduction

Kerr Wood Leidal (KWL) was engaged by the City of Chilliwack (the City) to undertake a flood profile and gravel management study of the Vedder Canal and Vedder River. This is one of a series of reports that have been prepared every two years as part of the flood control program to reduce the effects of sediment deposition in the Vedder River and Vedder Canal. This project is jointly funded by the City of Chilliwack, BC FLNRORD, and the City of Abbotsford.

The study area includes the 12 km river and canal reach from Vedder Crossing Bridge to the Highway 1 Bridge. The Vedder River and Canal flood profile was last established in 2016 by KWL. The scope of this study was to carry out an updated hydraulic analysis using the 2018 channel survey to update the flood profile and to quantify sediment deposition over the past two years.

The Soowahlie FN plans to remove 50,000 m^3 of sediment upstream of the Vedder Crossing Bridge this year, as an erosion control measure.

2. River Surveys

The 2018 channel geometry survey was conducted by CRA Canada Survey Inc. from January 15 to March 5. The river channel was surveyed from bank to bank with additional points on the top of the setback dikes where applicable. Additional cross sections XSC7, XSC8 and XSC9 were surveyed in the Vedder Canal from the Highway 1 Bridge to the mouth. Overbank areas were not surveyed and were assumed to remain the same as the 2004 overbank survey. Paired distance-elevation survey data were provided in .XLS format oriented looking downstream. Historical cross sections for 2016 and 1991/1996 were also supplied in .DWG plan format for volume calculations. Survey plans of the Vedder Canal and Vedder River are provided in Figure 1 and Figure 2.

3. Thalweg Profile

The thalweg is a line connecting the lowest points along the length of the river bed to define its deepest channel.

3.1 Vedder Canal

The Vedder Canal thalweg profiles for 1991, 2016 and 2018 are provided in Figure 3. Compared with 2016, the 2018 Canal thalweg profile has consistently lowered by an average of 0.3 m from XSC14 to XSC35, which accounts for 80% of the length of the Vedder Canal. Relative to 1991, considerable lowering also occurred in the Canal bed level. The majority of the thalweg dropped by 0.6 m to 1.0 m except for between XSC31 and XSC32 and at XSC37. A greatest thalweg drop, ranging from 1.7 m to 1.9 m, was found at XSC25 and XSC27.

At the downstream end of the Canal (i.e. XSC7, XSC8, XSC9), the thalweg has dropped an average of 0.6 m since 1991. Between 2016 and 2018, the thalweg profile remained at a similar level. The 2016 channel excavation site at the Keith Wilson Bar has partially infilled at the upstream end (XSC26) and not infilled at the middle section (XSC25).

3.2 Vedder River

The Vedder River thalweg profiles for 1996, 2016 and 2018 are shown in Figures 4 to 6. Examination of the profiles shows greatest degradation at XS12, XS33 and XS43, where the channel bed lowered by 1.4 m, 1.1 m and 1.3 m, respectively, since 1996. The greatest thalweg increase was found in the upper reach from XS 41 to XS42, with the increase averaging 2.7 m.

Compared with the 2016 condition, the Vedder River mean thawleg profile elevation increased by 0.5 m, 0.3 m and 0.2 m for the lower, middle and upper reach, respectively. The greatest increase occurred at XS7 and XS11 of 1.5 m and 2.5 m respectively.

The river thalweg switched sides at XS32 due to redistribution of channel material, and at XS24 and XS14 resulting from the 2016 gravel excavation at the Bergman Bar and Yarrow Bar. The 2016 channel excavation sites at XS23 (Bergman Bar) and XS41 (Giesbrecht Bar) have partially infilled. XS19 (Railway Bar) has fully infilled close to pre-excavation levels.

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Vedder River Hydraulic Profile Update 2018

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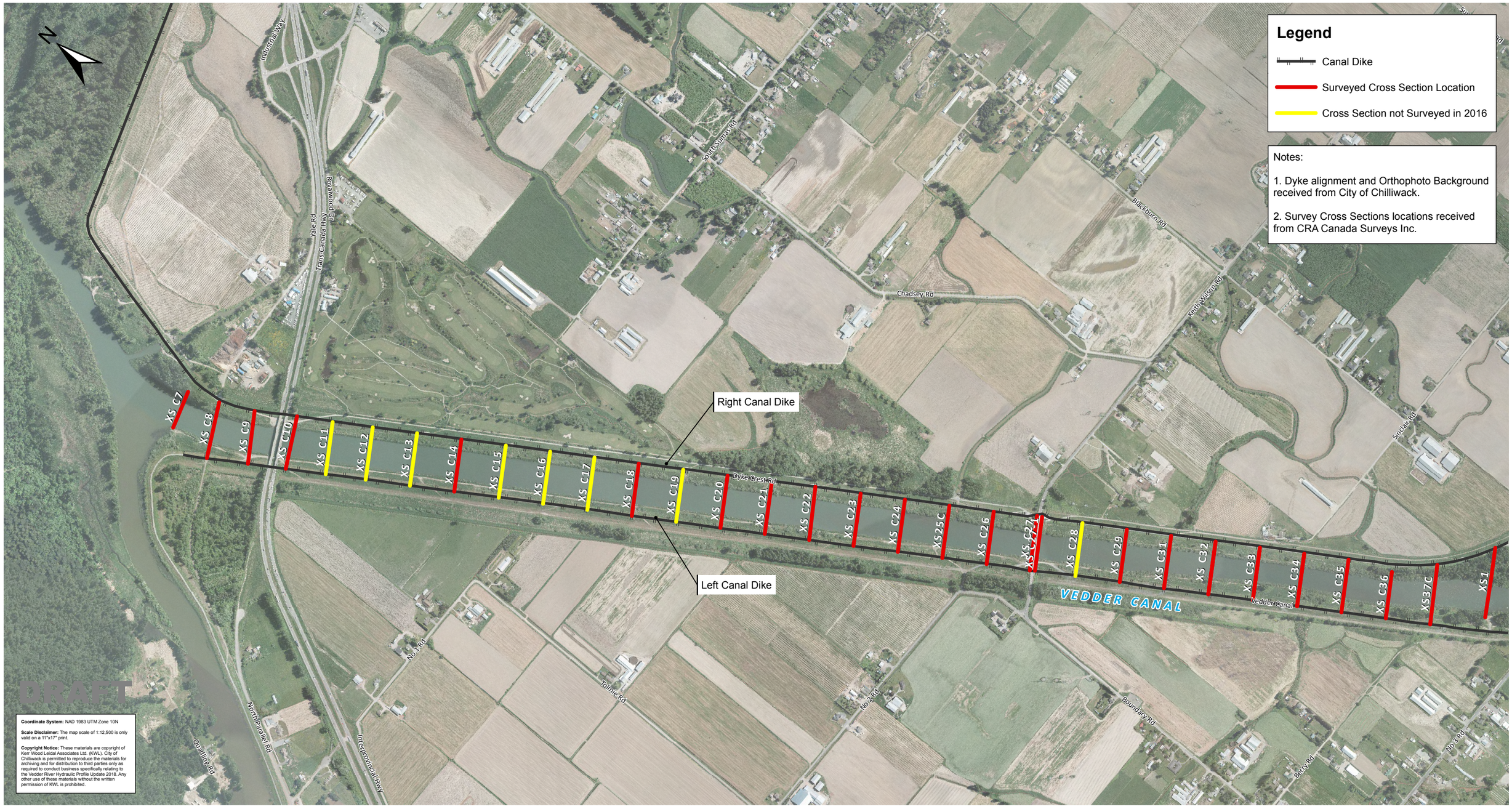

Legend

- Canal Dike
- Surveyed Cross Section Location
- Cross Section not Surveyed in 2016

Notes:

1. Dyke alignment and Orthophoto Background received from City of Chilliwack.

2. Survey Cross Sections locations received from CRA Canada Surveys Inc.

DRAFT

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:12,500 is only valid on a 11"x17" print.

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Date	April 2018
Scale	1:12,500

Vedder River Cross Section Locations - Vedder Canal

Figure 1

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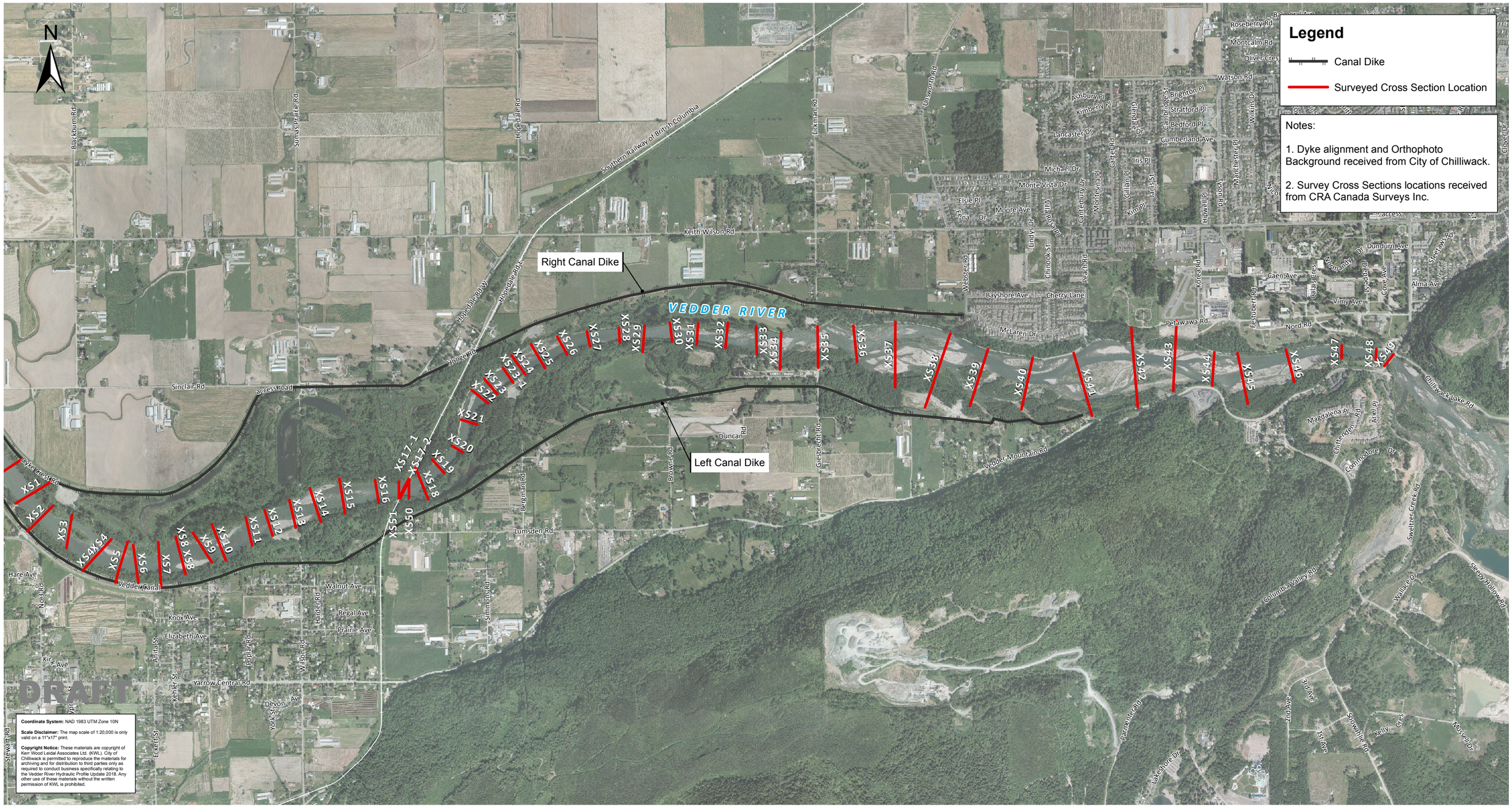

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Vedder River Cross Section Locations - Vedder River

Figure 2

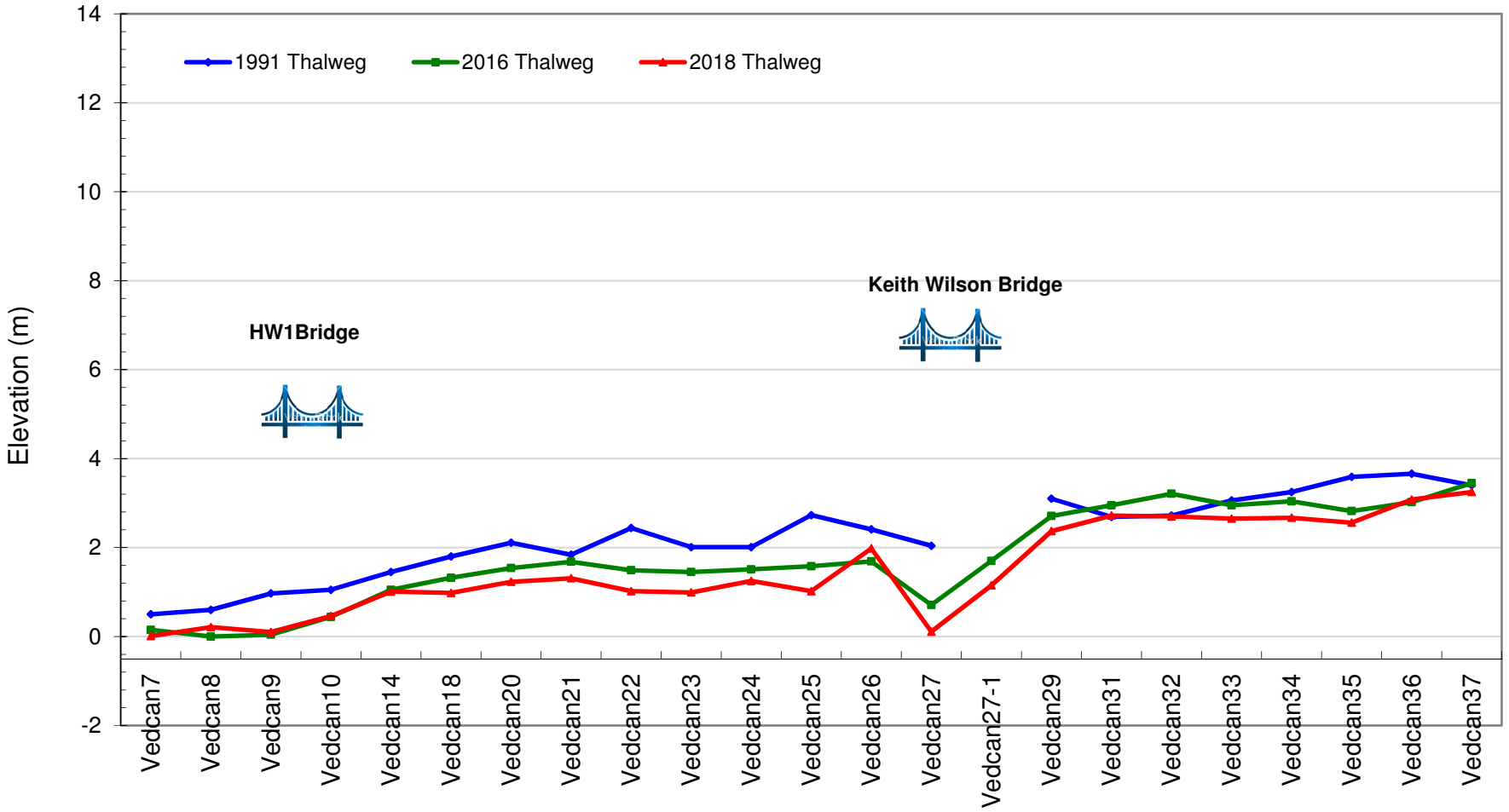

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FIGURE 3

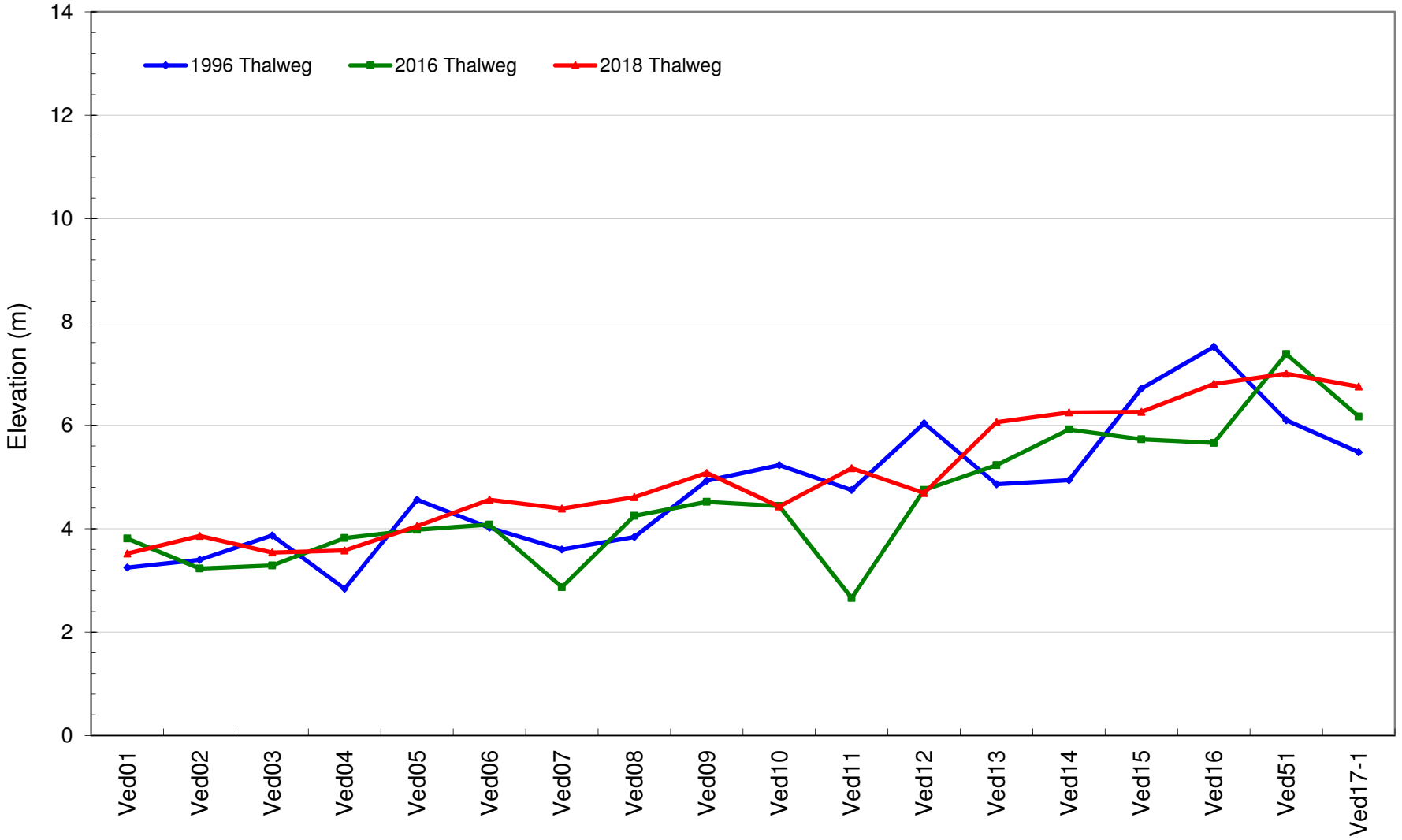

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FIGURE 4

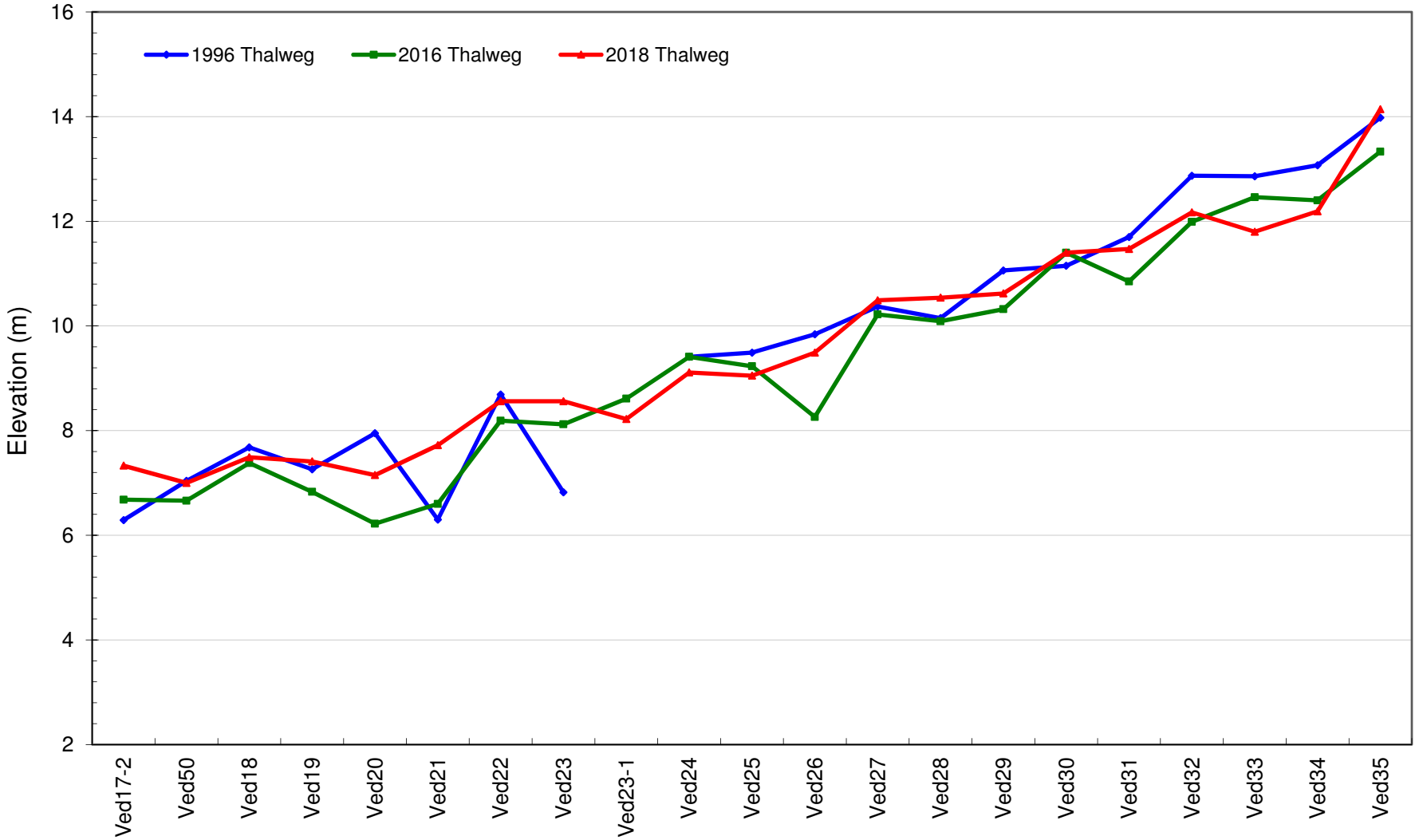

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FIGURE 5

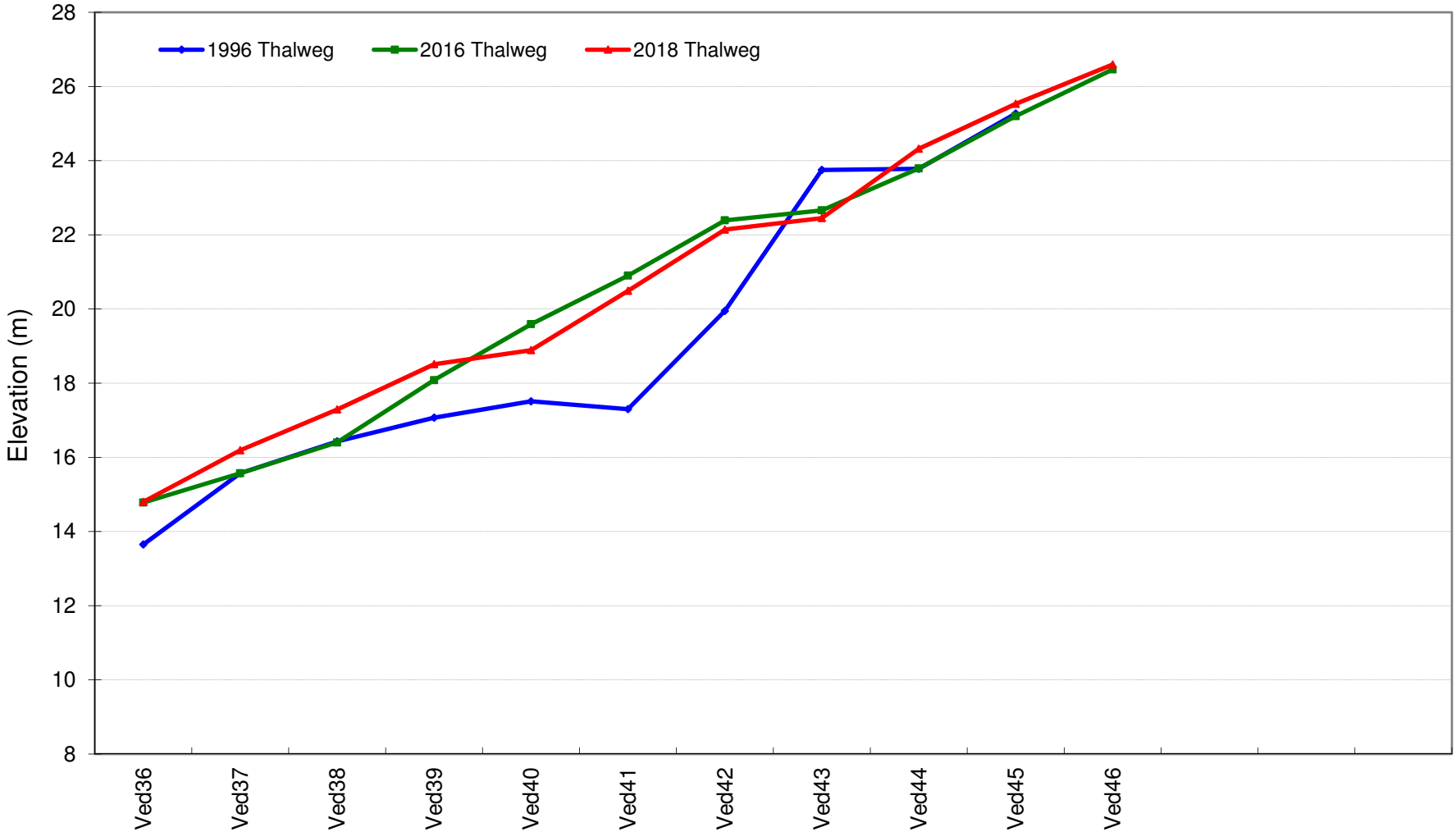

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FIGURE 6

4. Bed Material Quantity Calculations

Gravel aggradation and degradation volumes in the Vedder Canal and Vedder River were calculated using the average end area method. Gravel excavation quantities for 2016 were obtained from the City. Natural bed material deposition was calculated as the difference between surveyed bed material change and bed material excavation. Calculated changes in channel gravel quantities are shown in Table 1 for the past two years (2016-2018). Negative aggradation indicates degradation.

Table 1: Channel Gravel Quantities 2016-2018

Location	Bed Change	Excavation	Total Natural Deposition	
	(m^3)	(m^3)	(m^3)	(m^3/y)
Vedder Canal				
XSC10 – XS1	-71,415	-16,944	-54,471	-27,200
Vedder Canal Sub-total	-71,415	-16,944	-54,471	-27,200
Vedder River				
XS1 – SRBC	30,187	-16,566	46,753	23,400
SRBC – XS35	-9,994	-18,593	8,599	4,300
XS35 – XS45	-44,168	-40,382	-3,786	-1,900
Vedder River Sub-total	-23,975	-75,541	51,566	25,800
Vedder Canal and Vedder River Total Annual Natural Deposition (m^3/y)				**-1,400**
Note: A positive value means river bed aggradation, a negative value means degradation.				

Table 1 shows that Vedder Canal degraded at a rate of 27,200 m^3/y in the last two years. This is contrary to the long term trend (1981-2018) of aggradation at an average rate of 2,600 m^3/y, but is similar to the 2010-2012 and 2014-2016 conditions. The Vedder River lost bed material in the middle reach due to a greater volume of excavation than deposition. It also lost bed material in the upper reach due to natural degradation. Conversely, the Vedder River lower reach aggraded by about 46,800 m^3. Overall, the Vedder River received 25,900 m^3/y of deposition over the period 2016 to 2018. This is 65% of the long term annual deposition rate (39,600 m^3) in the Vedder River.

The discharge record in the Vedder River was obtained from the real-time gauge at the Vedder Crossing hydrometric station (08MH001). A review of the discharge record available for the study period (February 2016 to March 2018) identified a maximum instantaneous discharge of 440 m^3/s (November 2017). Flood frequency analysis indicates that a peak discharge of 440 m^3/s is close to the mean annual flood, which is associated with a return period of about 2 years. The lack of significant flood events since 2006 is likely the cause of reduced sedimentation in the Vedder River and Vedder Canal in recent years.

4.1 Vedder Canal

Gravel bed aggradation or degradation volumes in the Vedder Canal were calculated using three pairs of survey data:

- April 1991 and February 2016;
- February 2016 and February 2018; and
- April 1991 and February 2018.

Details on volume changes at each cross section are listed in Table 2.

Compared with the 1991 conditions, the 2018 survey shows channel degradation at all Canal cross sections. The total volume of bed material lost from 1991 to 2018 is 185,600 m³ with about 37% of the loss from the lower Canal reach downstream of the Keith Wilson Bridge and the remaining 63% from the upper Canal reach. Compared with the 2016 conditions, the 2018 channel survey shows a degradation of 71,400 m³. This results from 35,000 m³ of bed material loss downstream of the Keith Wilson Bridge and 36,400 m³ loss from upstream.

The Canal gravel quantity changes over the long term, from 1991-2018 and from 1981 to 2018, are summarized in Table A-1 and Table A-2, Appendix A. The 1981-2016 (35 years) gravel quantities were updated by adding the calculated volume changes for the period 2016-2018. Gravel quantities prior to 2010 were obtained from the Tetra Tech EBA (2014) Report.

The gravel quantity changes computed for each Canal cross section are listed in Table 2.

Table 2: Vedder Canal Gravel Quantities

Cross Section	Distance to D/S XS	Volume Change 1991 to 2016	Volume Change 2016 to 2018	Volume Change 1991 to 2018
	(m)	(m^3)	(m^3)	(m^3)
Vedder River XS1 to Keith Wilson Bridge				
XS1	185.93	-2,412	-3,896	-6,308
C37	151.48	-2,889	-4,785	-7,674
C36	152.07	-4,074	-4,538	-8,612
C35	152.34	-4,067	-3,567	-7,634
C34	152.36	-2,589	-3,465	-6,054
C33	152.34	-1,115	-3,724	-4,839
C32	152.30	-536	-3,779	-4,315
C31	152.39	-1,032	-3,260	-4,292
C29	292.16	-14,151	-3,821	-17,972
C27-1	15.98		-121	
C27				
Total		**-32,867**	**-34,955**	**-67,701**

Cross Section	Distance to D/S XS	Volume Change 1991 to 2016	Volume Change 2016 to 2018	Volume Change 1991 to 2018
	(m)	(m^3)	(m^3)	(m^3)
Keith Wilson Bridge to Highway 1 Bridge				
C27	148.98	-7,555	-1,488	-9,043
C26	152.36	-2,570	-7,016	-9,586
C25	152.36	-4,586	-5,888	-10,474
C24	152.38	-5,338	-1,506	-6,844
C23	154.14	-3,252	-2,485	-5,738
C22	150.56	-3,126	-3,202	-6,328
C21	152.35	-4,318	-2,904	-7,221
C20	304.71	-11,909	-1,953	-13,862
C18	609.41	-22,172	-5,011	-27,182
C14	572.00	-16,602	-5,007	-21,609
C10				
Total		**-81,427**	**-36,460**	**-117,887**
Total for Canal		**-114,294**	**-71,415**	**-185,588**

NOTES
1. Quantity calculations are between the section and the next section downstream.
2. Negative numbers represent degradation. Positive numbers represent aggradation.
3. All surveys were prior to the year's excavation.
4. Cross section C27-1 was surveyed in 2016 and 2018, but not in 1991. The volume for C27-1 is included in the 2016 to 2018 total volume calculations, but not included in the 1991-2016 and 1991-2018 total volume calculation.

4.2 Vedder River

Similarly, gravel volume changes for the Vedder River were calculated using three pairs of survey data:

- October 1996 and February 2016;
- February 2016 and February 2018; and
- October 1996 and February 2018.

The Vedder River gravel volumes are summarized in three sub-reaches, namely the lower reach from XS1 to SRBC, the middle reach from SRBC to XS35 and the upper reach from XS35 to XS49. Details of the volume changes at each cross section are listed in Table 3.

Relative to 1996, the Vedder River has degraded through the lower reach and the middle reach. The total losses from 1996 to 2018 amount to 118,300 m^3 and 115,600 m^3, respectively. In the Vedder River upper reach, gravel deposition outweighed gravel loss by 60,200 m^3. Most of the deposition occurred from XS39 to XS42 with the refill and growth of the Giesbrecht Bar near Peach Road. Relative to 2016, the lower reach aggraded by 30,200 m^3. The middle reach and upper reach degraded by 10,000 m^3 and 44,200 m^3. The River channel gravel quantity changes over the longer term, from 1981-2018 and from 1996-2018, are also summarized in Table A-1 and Table A-2 in Appendix A. The gravel quantities were established in the same manner as stated at the beginning of Section 4.

The gravel quantity changes computed for each Vedder River cross section are listed in Table 3.

Table 3: Vedder River Gravel Quantities

Cross Section	Distance to D/S XS	Volume Change 1996 to 2016	Volume Change 2016 to 2018	Volume Change 1996 to 2018
	(m)	(m^3)	(m^3)	(m^3)
SRBC to XS1 (Lower Reach)				
SRBC	27.32	-1,412	370	-1,042
XS51	120.45	-10,777	3,257	-7,520
XS16	190.13	-22,578	7,336	-15,242
XS15	154.57	-10,389	5,639	-4,750
XS14	132.73	-2,650	5,187	2,537
XS13	139.15	-7,879	5,427	-2,452
XS12	116.94	-9,093	1,184	-7,909
XS11	175.51	-13,716	-1,805	-15,521
XS10	94.66	-5,269	-298	-5,567
XS9	126.44	-9,286	311	-8,975
XS8	118.42	-11,442	-604	-12,046
XS7	131.03	-5,332	419	-4,912
XS6	71.08	-653	921	269
XS5	125.46	-4,954	785	-4,168
XS4	201.70	-19,817	260	-19,557
XS3	163.68	-11,149	1,712	-9,437
XS2	136.11	-2,092	86	-2,006
Total		**-148,487**	**30,187**	**-118,299**
XS35 to SRBC (Middle Reach)				
XS35	204.85	-11,699	-11,217	-22,916
XS34		-3,015	-6,870	-9,885
XS33	165.19	-10,924	-1,372	-12,296
XS32	159.56	-8,231	317	-7,914
XS31	143.30	-6,167	108	-6,059
XS30	146.78	-7,879	175	-7,704
XS29	135.43	-4,967	306	-4,661
XS28	169.52	-6,243	1,475	-4,769
XS27	147.59	-6,228	2,139	-4,089
XS26	143.62	-4,556	1,218	-3,338
XS25	-6,227	-2,860	-1,324	-4,184

Cross Section	Distance to D/S XS	Volume Change 1996 to 2016	Volume Change 2016 to 2018	Volume Change 1996 to 2018
	(m)	(m^3)	(m^3)	(m^3)
XS24	-7,340	-2,404	-2,866	-5,271
XS23-1			-1,452	
XS23	-778	-699	-257	-956
XS22	-3,454	-4,647	249	-4,399
XS21	-5,178	-6,458	201	-6,256
XS20	-4,677	-5,940	364	-5,576
XS19	-4,019	-6,849	4,431	-2,418
XS18	-1,828	-4,437	2,561	-1,876
XS50	-727	-1,412	370	-1,042
SRBC				
Total		**-105,615**	**-9,994**	**-115,609**
XS49 to XS35 (Upper Reach)				
XS49	79.05			
XS48	187.60			
XS47	291.29			
XS45	169.62	-26,837	1,097	-25,740
XS44	212.92	-32,880	-3,395	-36,275
XS43	221.05	8,472	-8,380	91
XS42	289.75	89,198	-10,886	78,312
XS41	303.19	63,370	-5,552	57,817
XS40	264.43	27,581	-2,776	24,805
XS39	225.47	22,398	-3,793	18,605
XS38	251.80	827	-4,996	-4,169
XS37	230.76	-22,204	-1,868	-24,071
XS36	204.57	-25,554	-3,618	-29,172
XS35				
TOTAL		**104,371**	**-44,168**	**60,203**

NOTES
1. Quantity calculations are between the section and the next section downstream.
2. Negative numbers represent degradation. Positive numbers represent aggradation.
3. All surveys were prior to the year's excavation.
4. Quantity SRBC-XS51 assumed equal to 50% of quantity XS51-XS50.
5. XS23-1 was not surveyed in 1996 and is not included in totals.
6. XS49 was not surveyed in 2008 or 2010.
7. Volume changes from XS 46 to XS 49 were not included in the total calculation to be consistent with the 2010-2014 EBA studies and the previous Bland Engineering studies.

5. Hydraulic Analysis

The HEC-RAS water surface profile model, Version 5.0.3, developed by the Hydrologic Engineering Center, Davis, California was used for the hydraulic analysis of the River and Canal reach.

5.1 Flood Profile Analysis

In the 2018 hydraulic model, the design flood of 1,470 m^3/s was applied to the surveyed river channel in a steady flow condition. A starting water surface elevation of 7.4 m, was utilized as the boundary condition at the Highway 1 Bridge. This starting water level is a best estimate of the downstream water level, based on regression analysis of peak levels recorded downstream at Barrowtown Pump Station corresponding to the peak flows recorded at the WSC gauge Chilliwack River at Vedder Crossing (BC FLNRO, 2010).

The setback dike was constructed in the early 1980s based on a flood flow of 1,250 m^3 and a dike freeboard of 0.75 m. During 1998-2000, the setback dike was upgraded by raising critical sections about 0.4 m above the 1984 as-built profile to provide 0.6 m freeboard over the 1996 flood profile (1,330 m^3/s). The left setback dike was further raised in 2010 corresponding to the increased design flood of 1,470 m^3/s and to meet the provincial standard for Fraser River flood protection, based on the 2008 NHC Fraser River Hydraulic Model. The raised sections are between Keith Wilson Bridge on the Vedder Canal and XS14 in the Vedder River on the left (south) side.

The upgraded dike crest elevations were obtained from the 2014 report (Tetra Tech EBA, 2014). Bland's assumption on flow split upstream of the railway bridge was adopted in this study. It was assumed that 200 m^3/s leaves the main channel on the right bank between XS21 and XS22 and 150 m^3/s leaves just downstream of XS18 on the left bank under the design flood conditions. Overbank flow travels through the left bank trestle structure and the right bank relief opening through the railway embankment. The split flows were assumed to rejoin the river at XS13.

The 2018 flood profile was calculated and compared to the setback dike crest elevations. Sub-critical flow conditions were assumed in the HEC-RAS model, which provides conservative results for the flood level. The resultant left and right dike freeboards are as listed in Table 4 for the Vedder Canal and in Table 5 for the Vedder River. The freeboard on the right bank (Rotary Trail) from XS40 to XS49 is also included.

Table 4: 2018 Flood Profile and Dike Freeboard for the Vedder Canal

Cross Section	Dike Crest Elevation (m)		Calculated W.L. (m)	Dike Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
C37	*11.28*	10.55	9.49	1.79	1.06
C36	*11.18*	10.21	9.39	1.79	0.82
C35	*11.26*	10.39	9.31	1.95	1.08
C34	*11.19*	10.28	9.18	2.01	1.10
C33	*11.28*	10.36	9.11	2.17	1.25
C32	*11.27*	10.68	9.05	2.22	1.63
C31	*11.34*	10.77	8.93	2.41	1.84
C29	*11.20*	10.77	8.89	2.31	1.88
C27.1	11.51	11.78	8.59	2.92	3.19
KW					
C27	11.41	11.74	8.56	2.85	3.18
C26	*11.27*	10.21	8.47	2.8	1.74
C25	10.93	10.17	8.44	2.49	1.73
C24	10.95	10.18	8.34	2.61	1.84
C23	10.93	10.49	8.29	2.64	2.20
C22	10.99	10.37	8.17	2.82	2.20
C21	10.92	10.25	8.13	2.79	2.12
C20	10.95	10.18	8.04	2.91	2.14
C18	10.83	10.25	7.93	2.9	2.32
C14	10.93	10.25	7.66	3.27	2.59
C10	10.98	10.30	7.40	3.58	2.90

Note: The italic numbers show the dike crest elevation after the raising in 2010.

Table 5: 2018 Flood Profile and Bank/Dike Freeboard for the Vedder River

Cross Section	Bank Elevation (m)		Calculated W.L. (m)	Bank Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
49	37.92	38.26	36.82	--	1.44
48	32.80	33.96	34.99	--	-1.03*
47	31.21	33.22	32.64	--	0.58
46	29.83	31.95	31.01	--	0.94
45	28.48	30.08	29.15	--	0.93
44	29.22	29.89	28.28	--	1.61
43	29.96	29.09	27.08	--	2.01
42	25.26	26.58	25.51	--	1.07
41	23.50	24.67	23.65	--	1.02
40	24.33	23.33	22.36	--	0.97
39	--	21.92	21.40	--	0.52

Cross Section	Dike Crest Elevation (m)		Calculated W.L. (m)	Dike Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
39	22.70	--	21.40	1.30	--
38	21.79	22.20	20.46	1.33	1.74
37	21.00	21.00	19.37	1.63	1.63
36	20.50	20.50	18.50	2.00	2.00
35	19.57	19.40	17.84	1.73	1.56
34	18.67	18.81	17.37	1.30	1.44
33	18.20	18.30	16.80	1.40	1.50
32	17.44	17.80	16.13	1.31	1.67
31	17.12	17.30	15.91	1.21	1.39
30	16.92	16.95	15.59	1.33	1.36
29	16.55	16.60	15.42	1.13	1.18
28	16.24	16.00	15.13	1.11	0.87
27	15.52	15.40	14.44	1.08	0.96
26	15.48	15.05	14.22	1.26	0.83
25	14.88	14.90	13.79	1.09	1.11
24	14.79	14.75	13.58	1.21	1.17
23.1	14.61	14.50	13.24	1.37	1.26
23	14.40	14.18	13.07	1.33	1.11

Cross Section	Dike Crest Elevation (m)		Calculated W.L. (m)	Dike Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
22	14.35	--	12.93	1.42	--
21	14.14	--	12.82	1.32	--
20	13.79	--	12.68	1.11	--
19	13.54	--	12.51	1.03	--
18	13.42	--	11.94	1.48	--
50	13.25	12.98	11.74	1.51	1.24
17.2	--	--	11.57	--	--

Cross Section	Dike Crest Elevation (m)		Calculated W.L. (m)	Bank Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
SRBC	--	--		--	--
17.1	--	--	11.44	--	--
51	13.12	12.80	11.06	2.06	1.74
16	12.00	12.31	10.74	1.26	1.57
15	11.67	11.80	10.61	1.06	1.19
14	*11.51*	11.40	10.48	1.03	0.92
13	*11.28*	11.10	10.44	0.84	**0.66**
12	*11.36*	11.00	10.3	1.06	**0.70**
11	*11.28*	10.90	10.3	0.98	**0.60**
10	*11.30*	10.80	10.23	1.07	**0.57**
9	*11.28*	10.70	10.18	1.10	**0.52**
8	*11.38*	10.80	10.16	1.22	**0.64**
7	*11.31*	11.10	10.10	1.21	1.00
6	*11.32*	11.25	9.97	1.35	1.28
5	*11.31*	11.30	9.95	1.36	1.35
4	*11.28*	11.10	9.93	1.35	1.17
3	*11.30*	10.70	9.84	1.46	0.86
2	*11.30*	10.65	9.67	1.63	0.98
1	*11.27*	10.65	9.57	1.7	1.08

Note: The italic numbers show the elevation of the dike crest after the raising in 2010.

The bold numbers show the dike freeboard that does not meet the required 0.75 m.

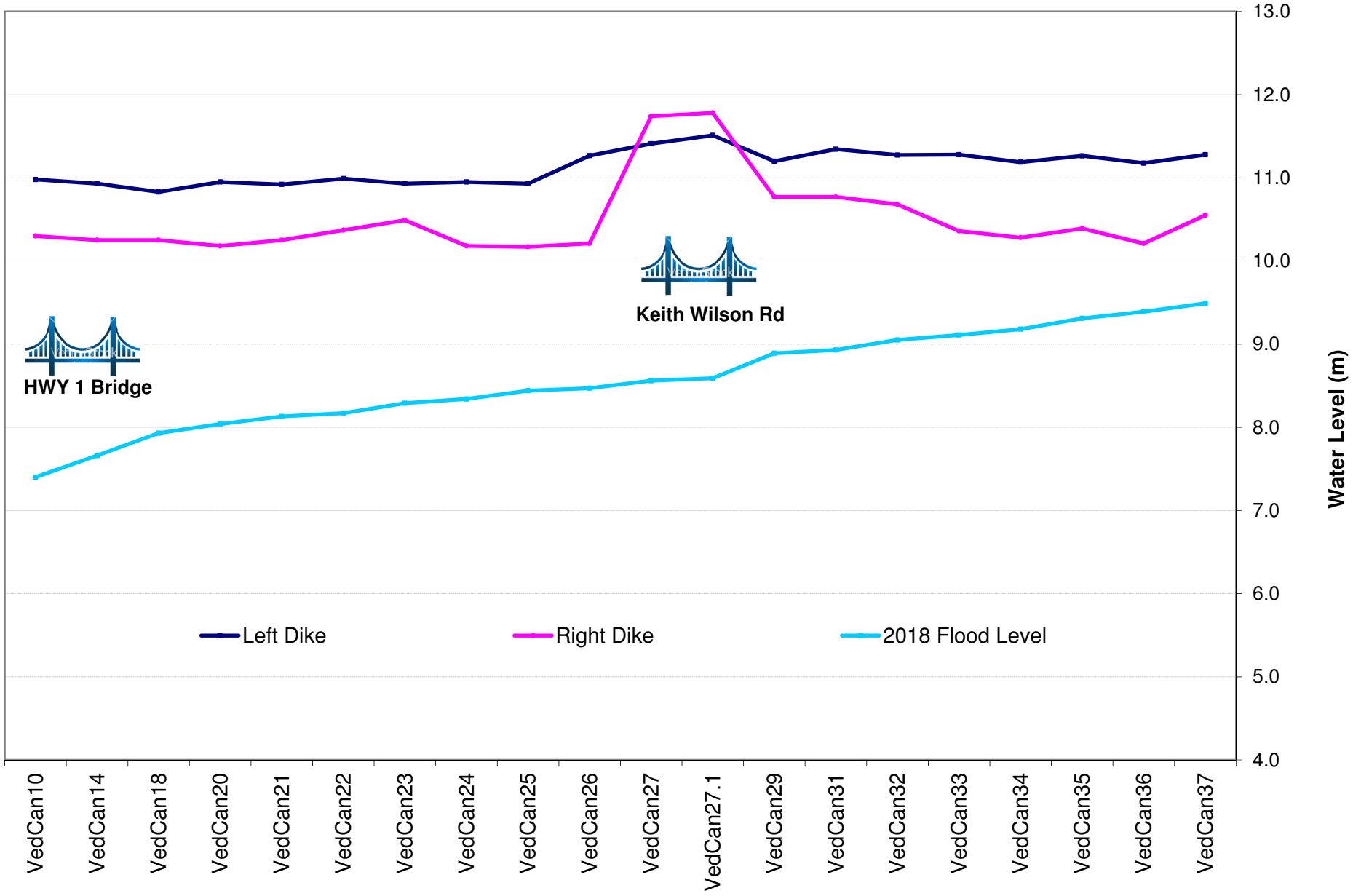
Dike elevations and freeboards were not listed for XS22 to XS18, as the flow on the right bank is obstructed by the railway before reaching the setback dike. The right bank flow leaves the main channel between cross section XS21 and XS22 and forms a side channel through the right bank relief opening. This complex situation at the railway bridge makes freeboard assessment difficult.

*Flow leaving the right bank at XS48 will re-join the river at a lower location upstream of the critical reach.

In the Vedder Canal, the dike freeboard exceeds 0.75 m on both sides. The Canal dike was designed for the Fraser River freshet flood water levels, which exceed the water levels during the Vedder River winter design flood event of 1,470 m^3/s. In the Vedder River the setback dike freeboard exceeds 0.75 m except at Vedder River XS8 to XS13 on the right (north) side. The minimum freeboard is determined to be 0.52 m at XS9. The computed flood profiles, in comparison to the dike crest elevations for the Vedder Canal and Vedder River, are shown in Figures 7 to and 8. Flow leaving the right bank at XS48 will re-join the river at a lower location upstream of the critical reach.

The differences between the 2018 water surface profile and the historical profiles (1996, 2014 and 2016) are listed in Appendix B. Compared with the 2016 water surface profile, the 2018 profile is on average 0.04 m lower in the Vedder Canal and 0.03 m lower in the Vedder River. This is consistent with the surveyed bed change, which identified overall degradation in the Vedder Canal and Vedder River (see Table 1).

The 2018 HEC-RAS cross section plots, showing the updated water surface elevations, are provided in Appendix C.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4.0
Water Level (m)
HWY 1 Bridge
Keith Wilson Rd
Left Dike
Right Dike
2018 Flood Level
VedCan10
VedCan14
VedCan18
VedCan20
VedCan21
VedCan22
VedCan23
VedCan24
VedCan25
VedCan26
VedCan27
VedCan27.1
VedCan29
VedCan31
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VedCan33
VedCan34
VedCan35
VedCan36
VedCan37

FIGURE 7

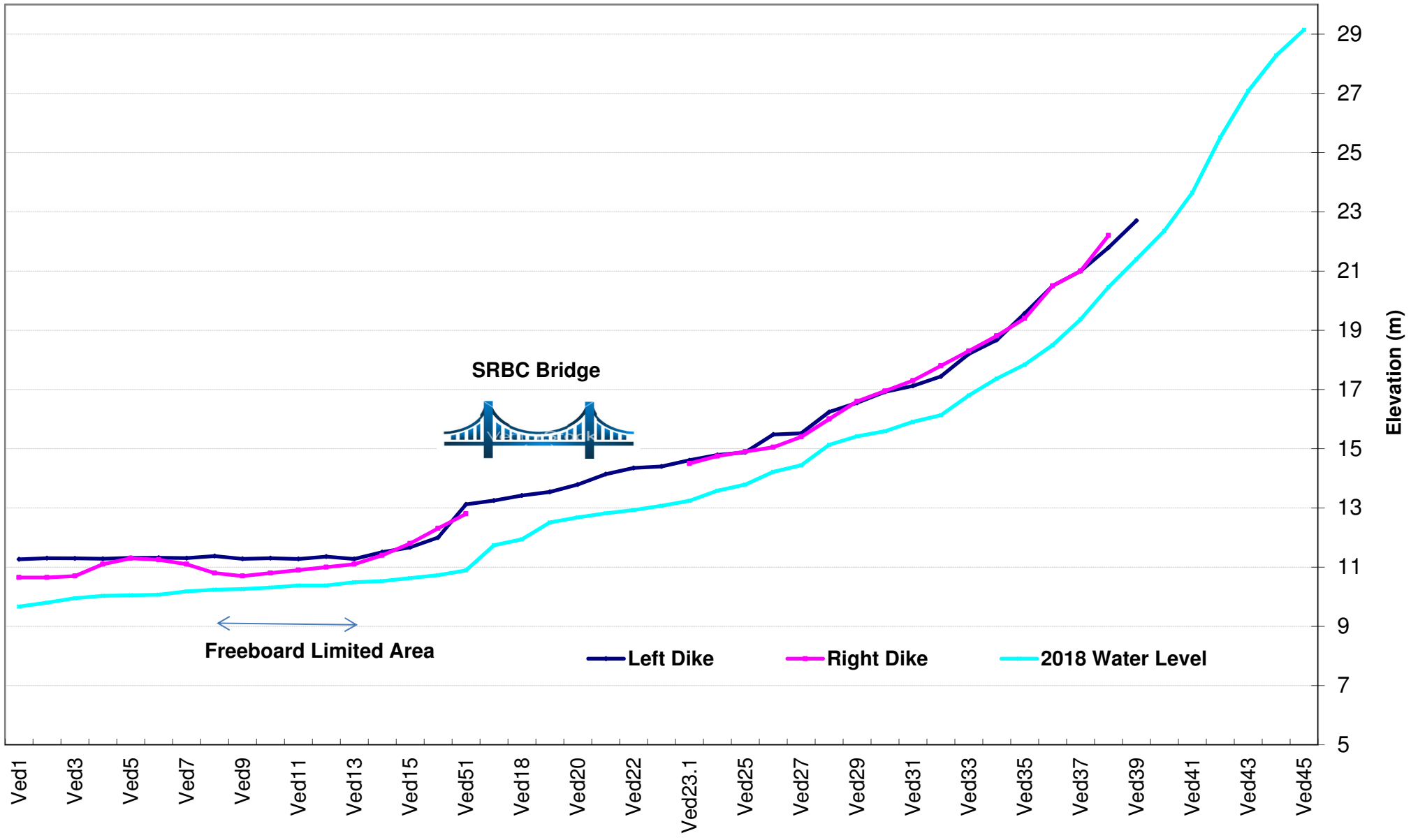

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FIGURE 8

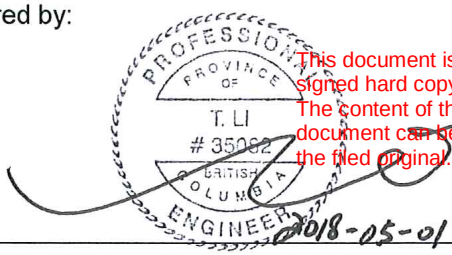
6. Recommendations

- In view of the overall degradation (-1,300 m³/yr) and decreased water surface profile relative to 2016, and the planned removal of gravel upstream of Vedder Crossing, gravel removal is not required this year.

Report Submission

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:



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Reviewed by:

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Senior Technical Specialist

Statement of Limitations

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Revision History

Revision #	Date	Status	Revision	Author
0	May 1, 2018	Final	Issued to client as final	EL
B	April 23, 2018	Draft	Revised to address City's comments	EL
A	April 20, 2018	Draft	Submission to City for review and comment	EL

OQM CERTIFIED

References

KWL, 2016. Vedder River Hydraulic Profile Update 2016.

Tetra Tech EBA, 2014. Vedder River Hydraulic Profile Update 2014.

Tetra Tech, 2015. Vedder River Management Area Plan Update.

Nova Pacific, 2016. 2016 Vedder River Gravel Extraction – Habitat Change and Environmental Impacts. Revised in January, 2018.

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Appendix A

Channel Gravel Quantities

Appendix A

Table A-1: Channel Gravel Quantities 1981-2018

Location	Bed Change	Excavation	Total natural deposition	
	1981-2018 m^3	1981-2018 m^3	m^3	m^3/yr
XSC10 to XS1	-33,900	-127,023	93,123	2,600
XS1 to SRBC	23,397	-601,601	624,998	16,900
SRBC to XS35	-22,230	-897,062	874,832	23,700
XS35 to XS45	-534,997	-495,302	-39,695	-1,000
			Total natural deposition m^3/yr	42,200

Table A-2: Channel Gravel Quantities 1991/6-2018

Location	Bed Change	Excavation	Total natural deposition	
	1991/6-2018 m^3	1991/6-2018 m^3	m^3	m^3/yr
XSC10 to XS1	-185,697	-116,883	-68,814	-2,500
XS1 to SRBC	-118,300	-427,737	309,437	14,100
SRBC to XS35	-115,608	-256,349	140,741	6,400
XS35 to XS45	60,202	-456,318	516,520	23,500
			Total natural deposition m^3/yr	41,500

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Appendix B

Vedder Canal Historical Water Surface Profile

Appendix B

Table B-1 Vedder Canal Historical Water Surface Profile

Cross Section	River Stn	2018 W.L. (7.4m)	2016 W.L. (7.4m)	2014 W.L. (7.4m)	1996 W.L. (5.5m)	2018-2016 W.L. (m)	2016-2014 W.L. (m)	2018-1996 W.L. (m)	2016-1996 W.L. (m)	2014-1996 W.L. (m)
VedCan37	15	9.49	9.58	9.59	9.12	-0.09	-0.01	0.37	0.46	0.47
VedCan36	14	9.39	9.45	9.49	8.97	-0.06	-0.04	0.42	0.48	0.52
VedCan35	13	9.31	9.36	9.41	8.91	-0.05	-0.05	0.40	0.45	0.50
VedCan34	12	9.18	9.23	9.27	8.75	-0.05	-0.04	0.43	0.48	0.52
VedCan33	11	9.11	9.15	9.18	8.63	-0.04	-0.03	0.48	0.52	0.55
VedCan32	10	9.05	9.07	9.11	8.54	-0.02	-0.04	0.51	0.53	0.57
VedCan31	9	8.93	9	9.04	8.44	-0.07	-0.04	0.49	0.56	0.60
VedCan29	8	8.89	8.93	8.94	8.32	-0.04	-0.01	0.57	0.61	0.62
VedCan27.1	7	8.59	8.65	8.68		-0.06	-0.03			
VedCan27	6	8.56	8.62	8.66		-0.06	-0.04			
VedCan26	5	8.47	8.51	8.55	8.02	-0.04	-0.04	0.45	0.49	0.53
VedCan25	4.3	8.44	8.43	8.46		0.01	-0.03			
VedCan24	4.2	8.34	8.36	8.4		-0.02	-0.04			
VedCan23	4.1	8.29	8.3	8.31		-0.01	-0.01			
VedCan22	4	8.17	8.25	8.25	7.59	-0.08	0.00	0.58	0.66	0.66
VedCan21	3.2	8.13	8.14	8.15		-0.01	-0.01			
VedCan20	3.1	8.04	8.06	8.09		-0.02	-0.03			
VedCan18	3	7.93	7.96	7.95	7.19	-0.03	0.01	0.74	0.77	0.76
VedCan14	2	7.66	7.67	7.64	6.55	-0.01	0.03	1.11	1.12	1.09
VedCan10	1	7.40	7.4	7.4	5.5	0.00	0.00	1.90	1.90	1.90

Note:
1. 2010-2018 water surface profiles computed using starting water level at 7.4 m. 1996 water surface profile computed using starting water level at 5.5 m.
2. Design flood of 1330 m^3/s was used to calculate the 1996 water surface profile; Design flood of 1470 m^3/s was used to calculate the 2010-2018 water surface profiles.

Appendix B

Table B-2 Vedder River Historical Water Surface Profile

Cross Section	River Stn	2018 W.L. (7.4m)	2016 W.L. (7.4m)	2014 W.L. (7.4m)	1996 W.L. (5.5m)	2018-2016 W.L. (m)	2016-2014 W.L. (m)	2018-1996 W.L. (m)	2016-1996 W.L. (m)	2014-1996 W.L. (m)
Ved45	71	29.15	29.14	29.17	29.14	0.01	-0.03	0.01	0.00	0.03
Ved44	70	28.28	28.34	28.32	28.22	-0.06	0.02	0.06	0.12	0.10
Ved43	69	27.08	27.25	27.09	26.79	-0.17	0.16	0.29	0.46	0.30
Ved42	68	25.51	25.72	25.5	22.94	-0.21	0.22	2.57	2.78	2.56*
Ved41	67	23.65	23.66	23.7	22.82	-0.01	-0.04	0.83	0.84	0.88
Ved40	66	22.36	22.43	22.22	21.91	-0.07	0.21	0.45	0.52	0.31
Ved39	65	21.4	21.49	21.32	21.18	-0.09	0.17	0.22	0.31	0.14
Ved38	64	20.46	20.46	20.41	20.32	0.00	0.05	0.14	0.14	0.09
Ved37	63	19.37	19.38	19.58	19.98	-0.01	-0.20	-0.61	-0.60	-0.40
Ved36	62	18.5	18.63	19.04	18.89	-0.13	-0.41	-0.39	-0.26	0.15
Ved35	61	17.84	18.05	18.26	17.9	-0.21	-0.21	-0.06	0.15	0.36
Ved34	60	17.37	17.47	17.41	17.47	-0.10	0.06	-0.10	0.00	-0.06
Ved33	59	16.8	16.8	16.73	16.97	0.00	0.07	-0.17	-0.17	-0.24
Ved32	57	16.13	16.13	16.18	16.5	0.00	-0.05	-0.37	-0.37	-0.32
Ved31	55	15.91	15.91	16.01	16.07	0.00	-0.10	-0.16	-0.16	-0.06
Ved30	54	15.59	15.57	15.67	15.77	0.02	-0.10	-0.18	-0.20	-0.10
Ved29	53	15.42	15.4	15.51	15.59	0.02	-0.11	-0.17	-0.19	-0.08
Ved28	52	15.13	15.1	15.31	15.13	0.03	-0.21	0.00	-0.03	0.18
Ved27	51	14.44	14.46	14.52	14.53	-0.02	-0.06	-0.09	-0.07	-0.01
Ved26	50	14.22	14.29	14.31	14.19	-0.07	-0.02	0.03	0.10	0.12
Ved25	48	13.79	13.88	13.92	14	-0.09	-0.04	-0.21	-0.12	-0.08
Ved24	47	13.58	13.66	13.74	13.93	-0.08	-0.08	-0.35	-0.27	-0.19
Ved23.1	46	13.24	13.3	13.5		-0.06	-0.20	13.24		
Ved23	45	13.07	13.07	13.25	13.69	0.00	-0.18	-0.62	-0.62	-0.44
Ved22	44	12.93	12.93	13.12	13.54	0.00	-0.19	-0.61	-0.61	-0.42
Ved21	42	12.82	12.79	12.99	13.3	0.03	-0.20	-0.48	-0.51	-0.31
Ved20	41	12.68	12.51	12.74	12.98	0.17	-0.23	-0.30	-0.47	-0.24
Ved19	40	12.51	12.32	12.58	12.96	0.19	-0.26	-0.45	-0.64	-0.38
Ved18	38	11.94	11.91	12.08	12.8	0.03	-0.17	-0.86	-0.89	-0.72
Ved50	37	11.74	11.53	11.68		0.21	-0.15			
Ved17.2	36	11.57	11.5	11.73	11.55	0.07	-0.23	0.02	-0.05	0.18
SRBC	35.5									
Ved17.1	35	11.44	11.41	11.57		0.03	-0.16			
Ved51	34	11.06	10.89	11.1		0.17	-0.21			
Ved16	33	10.74	10.73	10.93		0.01	-0.20			
Ved15	32	10.61	10.63	10.69	10.71	-0.02	-0.06	-0.10	-0.08	-0.02
Ved14	31	10.48	10.53	10.55	10.66	-0.05	-0.02	-0.18	-0.13	-0.11
Ved13	29	10.44	10.49	10.52	10.47	-0.05	-0.03	-0.03	0.02	0.05
Ved12	27	10.3	10.38	10.4	10.31	-0.08	-0.02	-0.01	0.07	0.09
Ved11	26	10.3	10.38	10.4	10.27	-0.08	-0.02	0.03	0.11	0.13
Ved10	25	10.23	10.31	10.31	10.13	-0.08	0.00	0.10	0.18	0.18
Ved9	24	10.18	10.26	10.27	10.08	-0.08	-0.01	0.10	0.18	0.19
Ved8	23	10.16	10.24	10.25	10.02	-0.08	-0.01	0.14	0.22	0.23
Ved7	22	10.1	10.18	10.19	9.94	-0.08	-0.01	0.16	0.24	0.25
Ved6	21	9.97	10.07	10.07	9.88	-0.10	0.00	0.09	0.19	0.19
Ved5	20	9.95	10.05	10.06	9.85	-0.10	-0.01	0.10	0.20	0.21
Ved4	19	9.93	10.03	10.04	9.79	-0.10	-0.01	0.14	0.24	0.25
Ved3	18	9.84	9.95	9.94	9.63	-0.11	0.01	0.21	0.32	0.31
Ved2	17	9.67	9.8	9.8	9.4	-0.13	0.00	0.27	0.40	0.40
Ved1	16	9.57	9.67	9.66	9.34	-0.10	0.01	0.23	0.33	0.32

Note:
1. 2010-2018 water surface profiles computed using starting water level at 7.4 m. 1996 water surface profile computed using starting water level at 5.5 m.
2. Design flood of 1330 m^3/s was used to calculate the 1996 water surface profile; Design flood of 1470 m^3/s was used to calculate the 2010-2018 water surface profiles.
* Appears inconsistent with other data.

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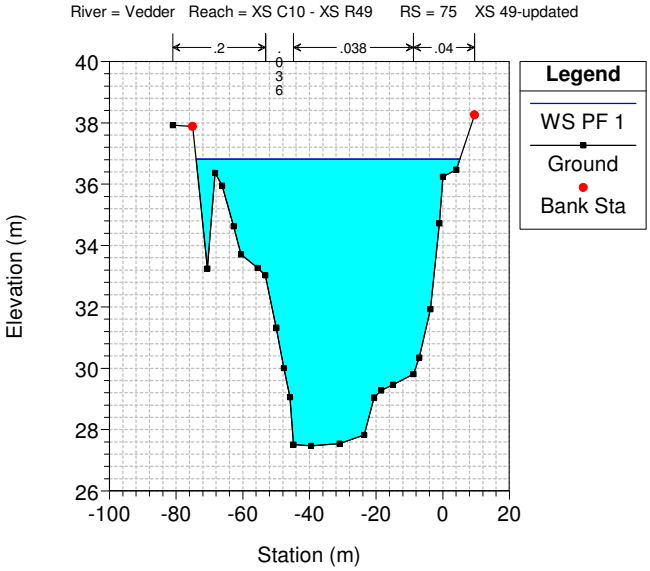
Appendix C

2018 HEC-RAS Water Surface Elevations

Appendix C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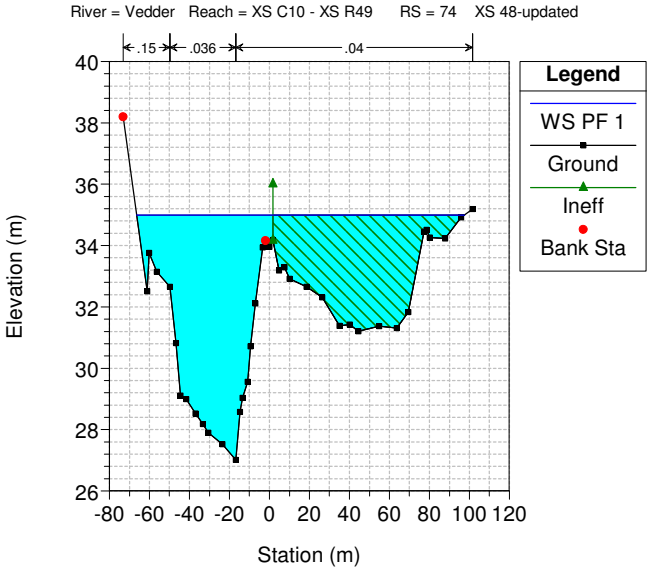
Ground
Bank Sta
Elevation (m)
Station (m)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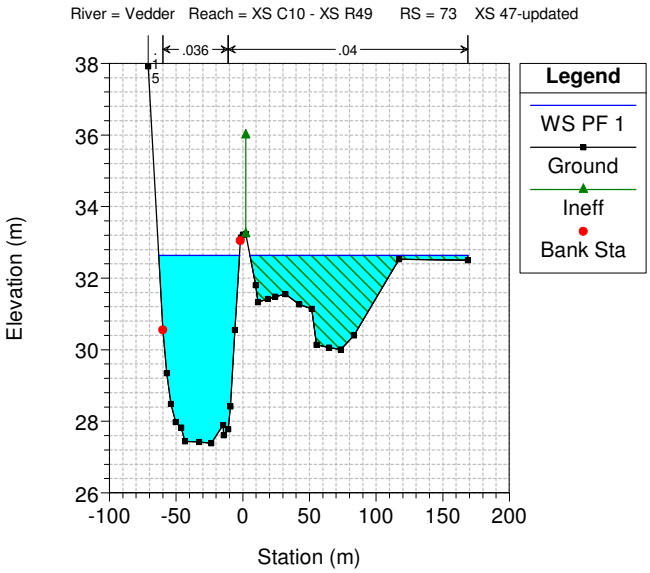
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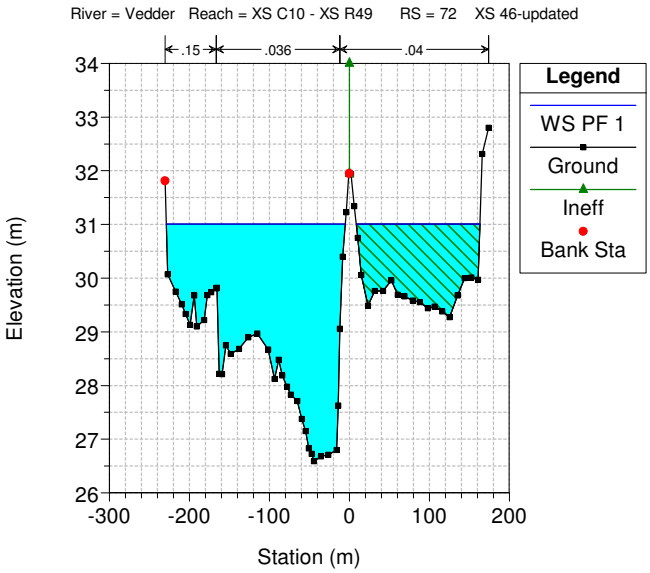
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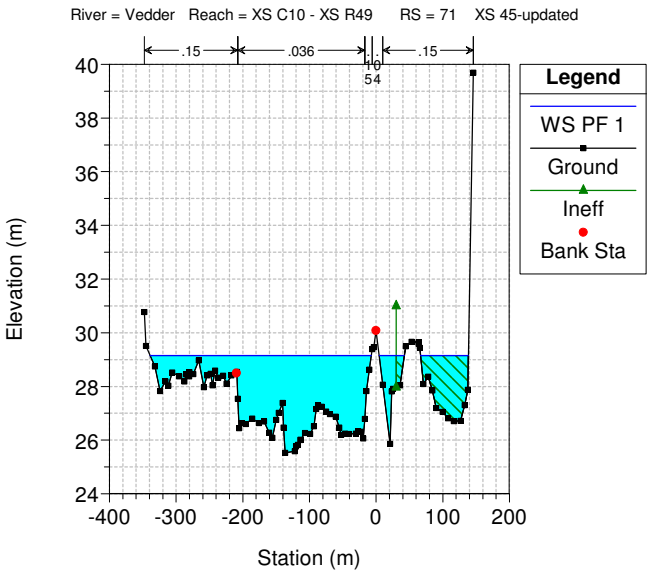
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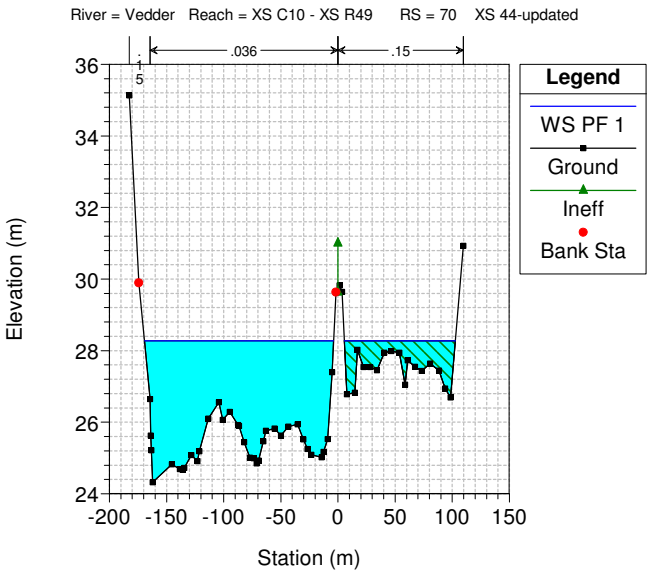
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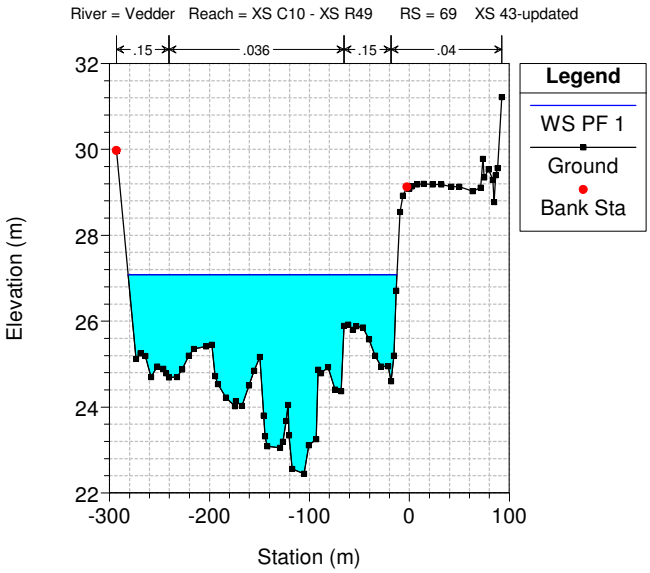
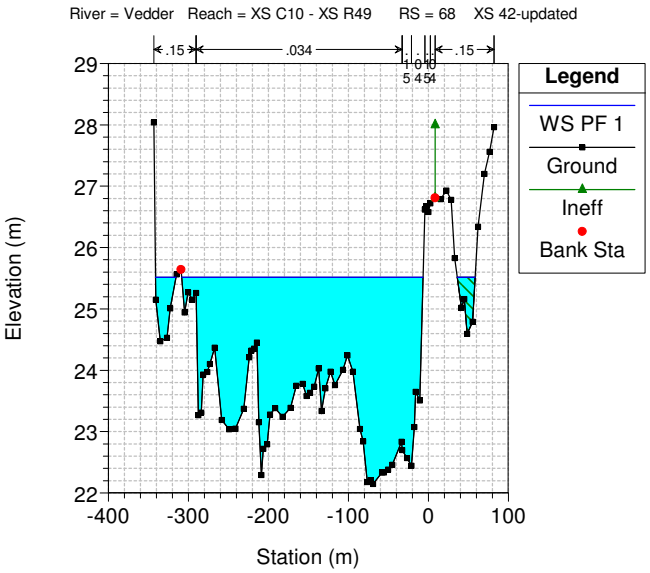
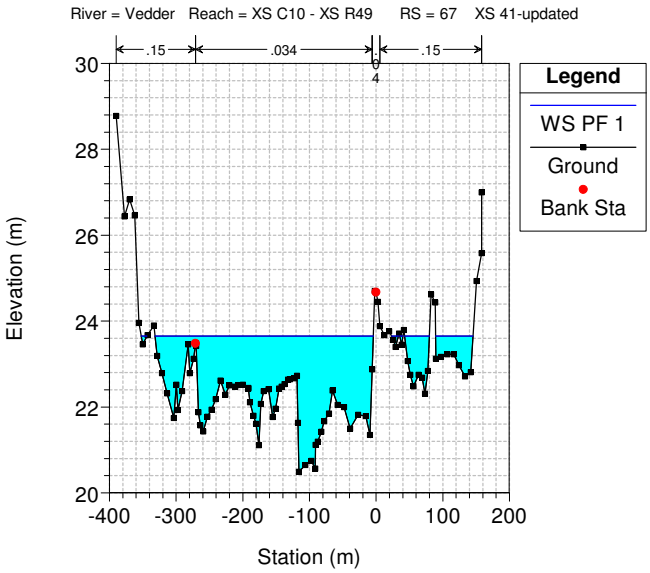
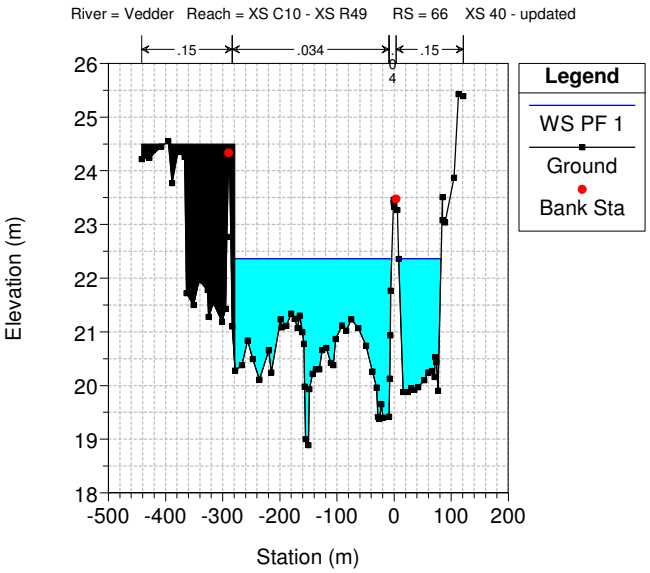
Elevation (m)
Station (m)

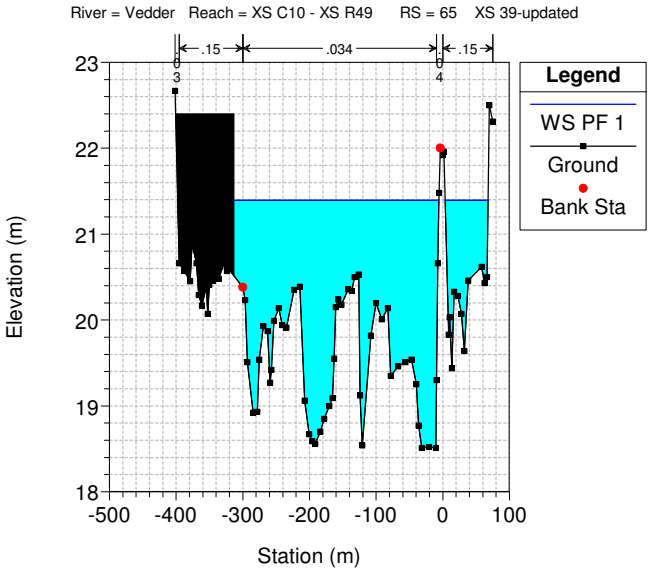
Appendix C

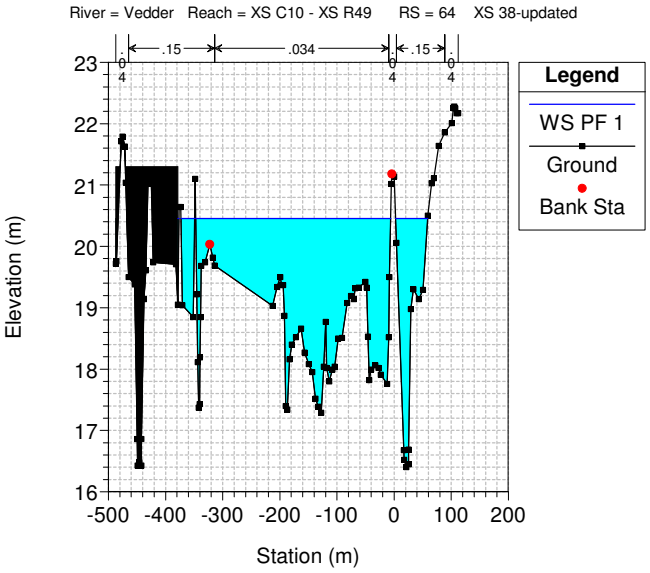

River = Vedder Reach = XS C10 - XS R49 RS = 69 XS 43-updated
.15
.036
.15
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 68 XS 42-updated
.15
.034
.15
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

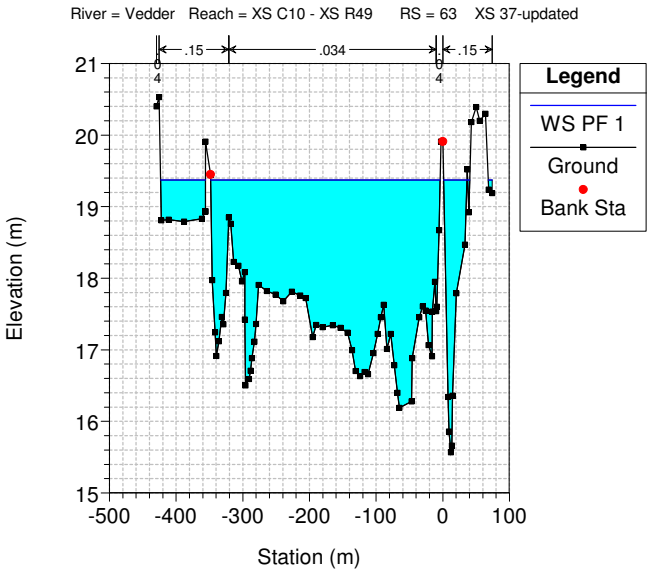

River = Vedder Reach = XS C10 - XS R49 RS = 67 XS 41-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

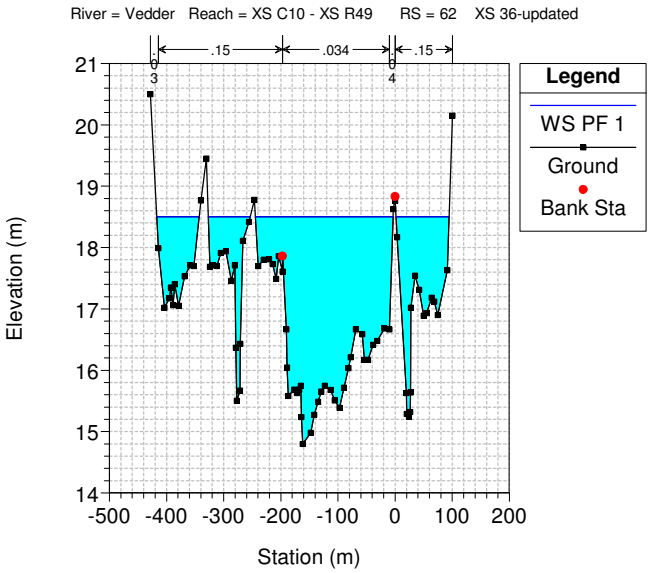

River = Vedder Reach = XS C10 - XS R49 RS = 66 XS 40 - updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

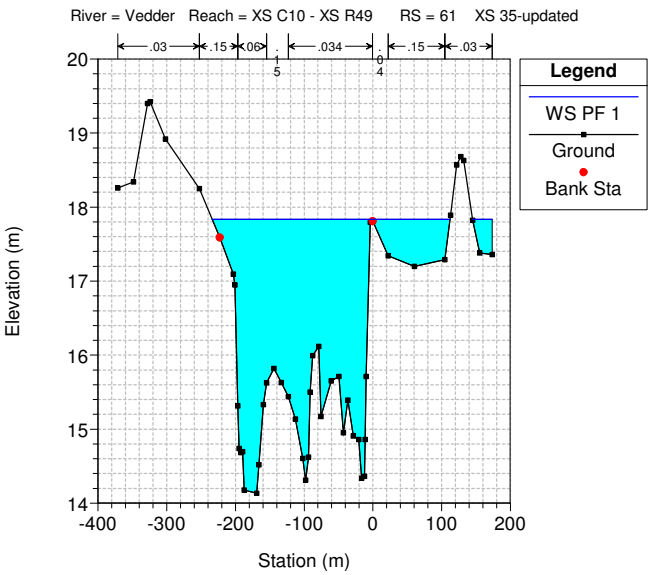

River = Vedder Reach = XS C10 - XS R49 RS = 65 XS 39-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

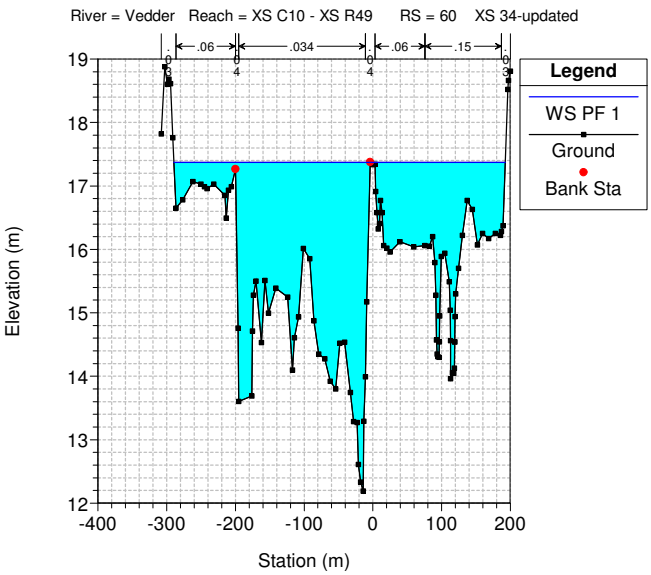

River = Vedder Reach = XS C10 - XS R49 RS = 64 XS 38-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

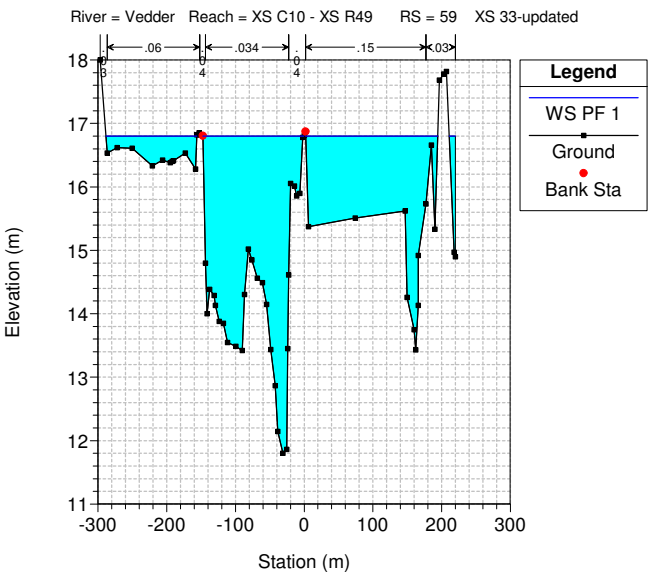
Appendix C

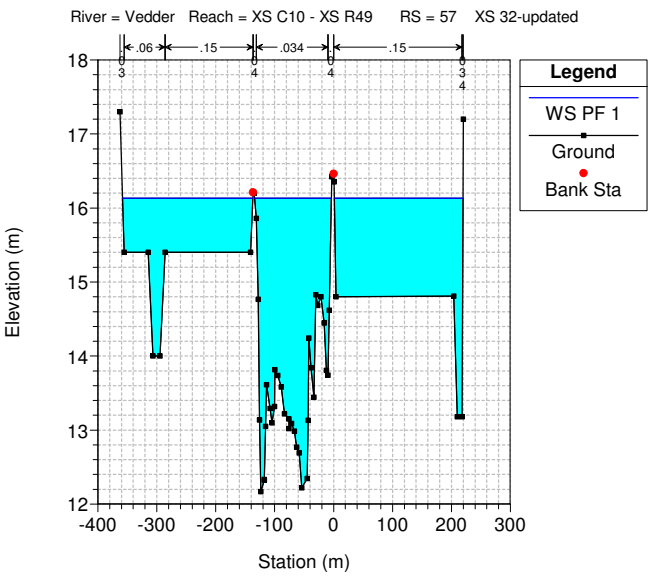

River = Vedder Reach = XS C10 - XS R49 RS = 63 XS 37-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 62 XS 36-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

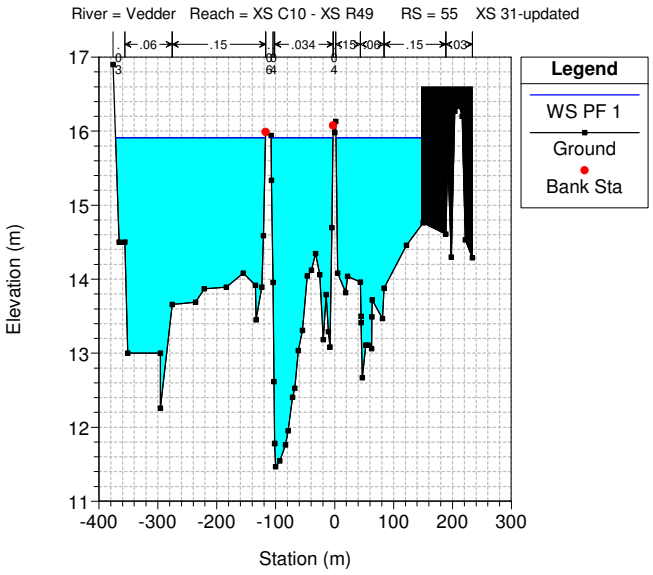

River = Vedder Reach = XS C10 - XS R49 RS = 61 XS 35-updated
.03
.15
.06
.034
.15
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

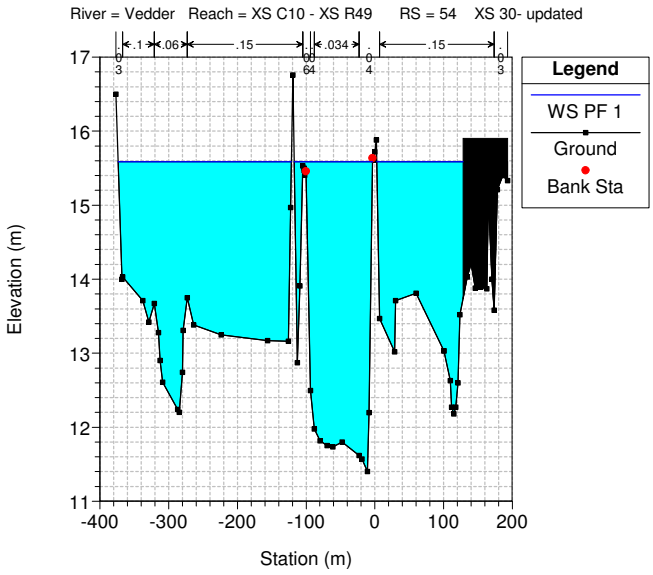

River = Vedder Reach = XS C10 - XS R49 RS = 60 XS 34-updated
.06
.034
.06
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

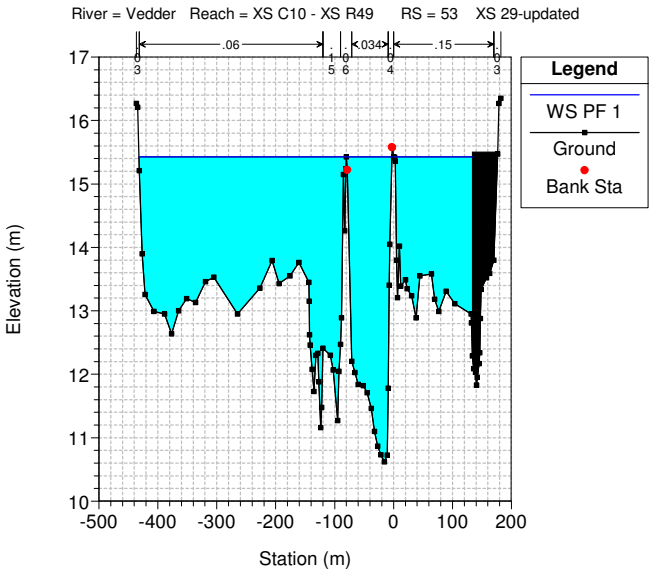

River = Vedder Reach = XS C10 - XS R49 RS = 59 XS 33-updated
.06
.034
.15
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

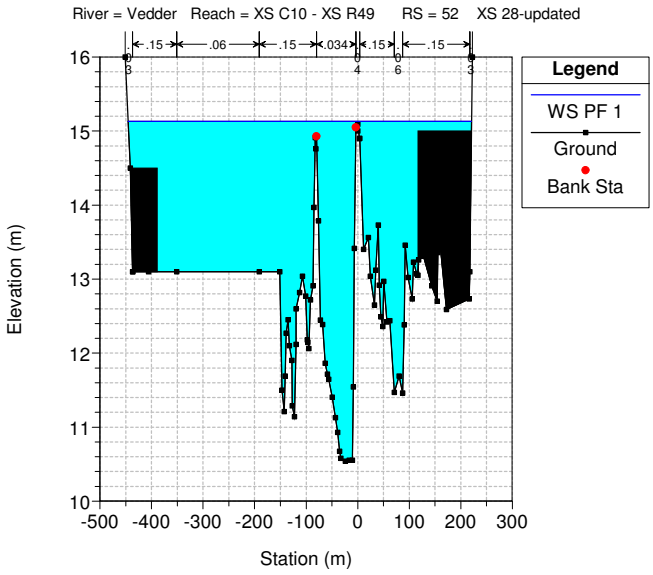

River = Vedder Reach = XS C10 - XS R49 RS = 57 XS 32-updated
.06
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

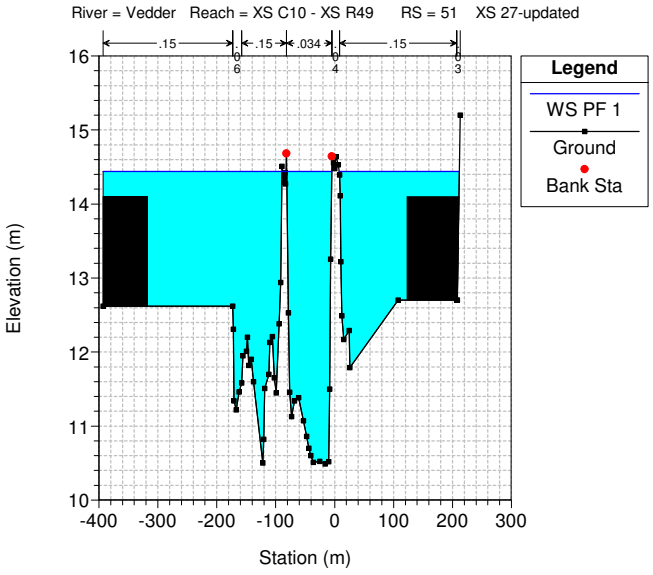
Appendix C

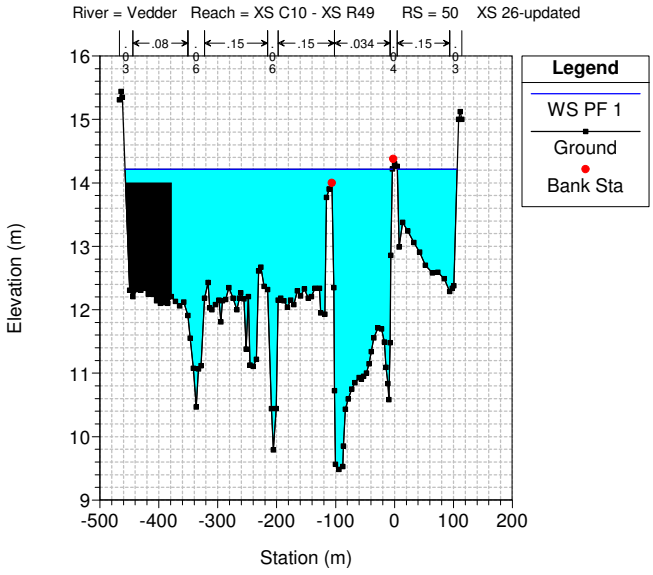

River = Vedder Reach = XS C10 - XS R49 RS = 55 XS 31-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 54 XS 30- updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

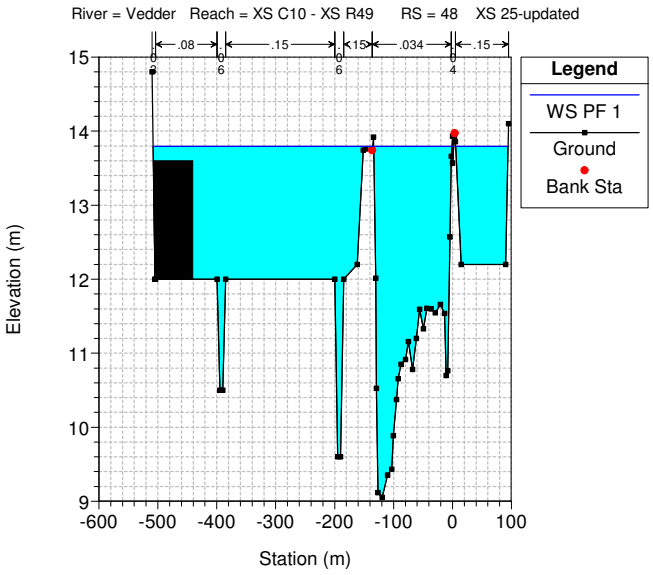

River = Vedder Reach = XS C10 - XS R49 RS = 53 XS 29-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

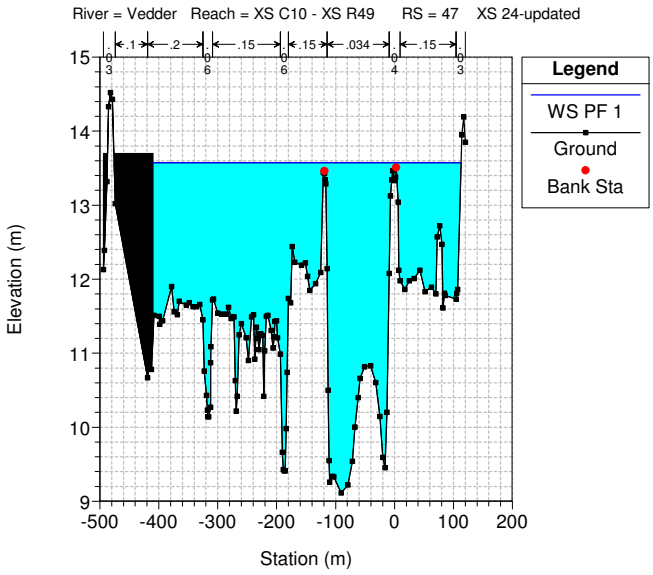

River = Vedder Reach = XS C10 - XS R49 RS = 52 XS 28-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

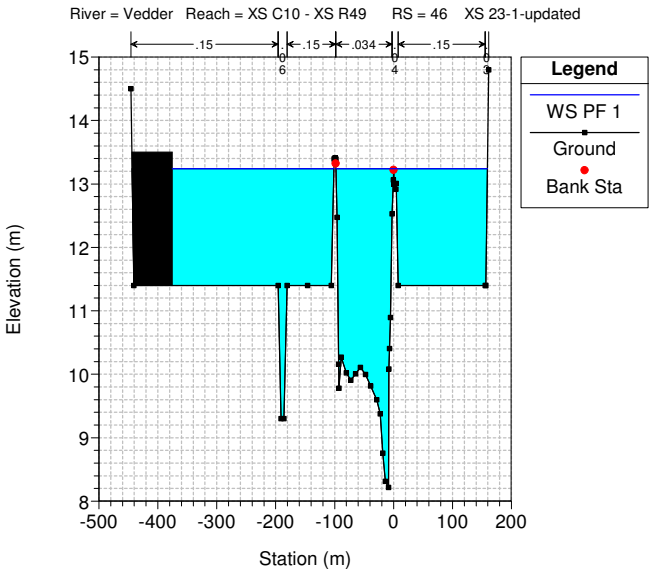

River = Vedder Reach = XS C10 - XS R49 RS = 51 XS 27-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

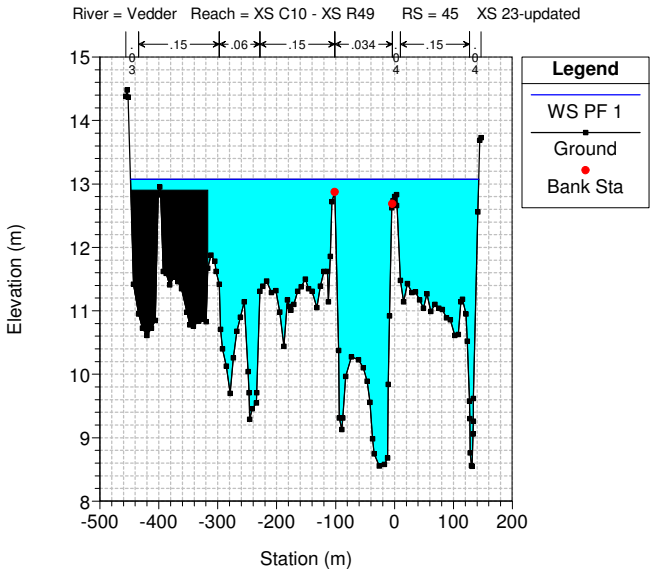

River = Vedder Reach = XS C10 - XS R49 RS = 50 XS 26-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

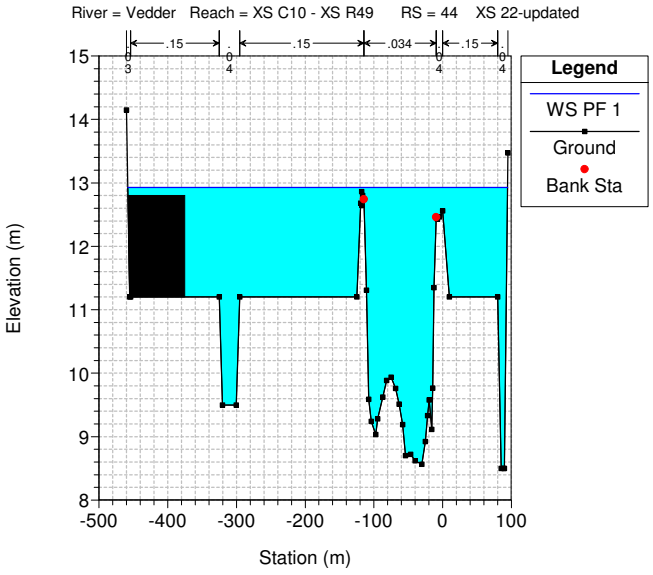
Appendix C

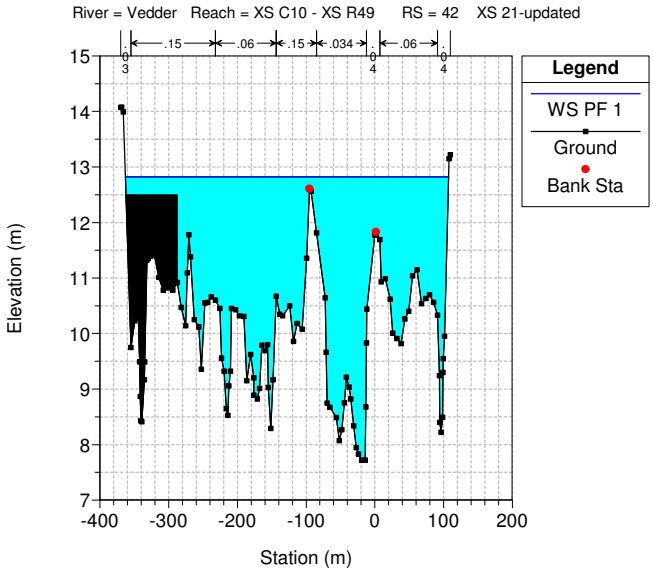

River = Vedder Reach = XS C10 - XS R49 RS = 48 XS 25-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 47 XS 24-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

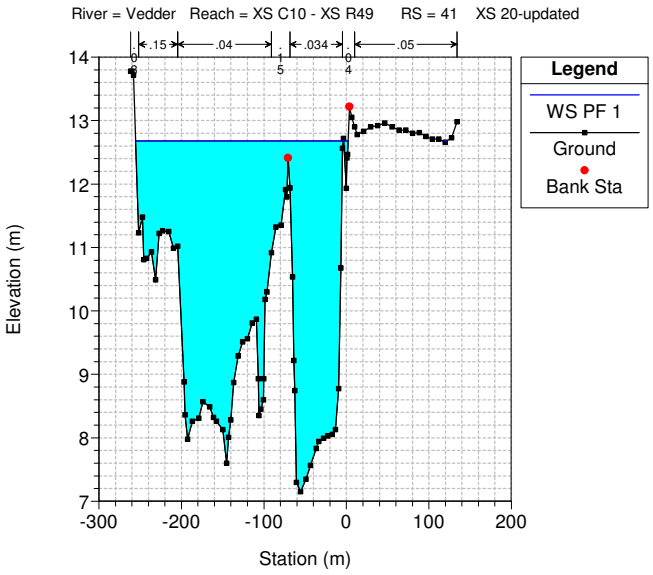

River = Vedder Reach = XS C10 - XS R49 RS = 46 XS 23-1-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

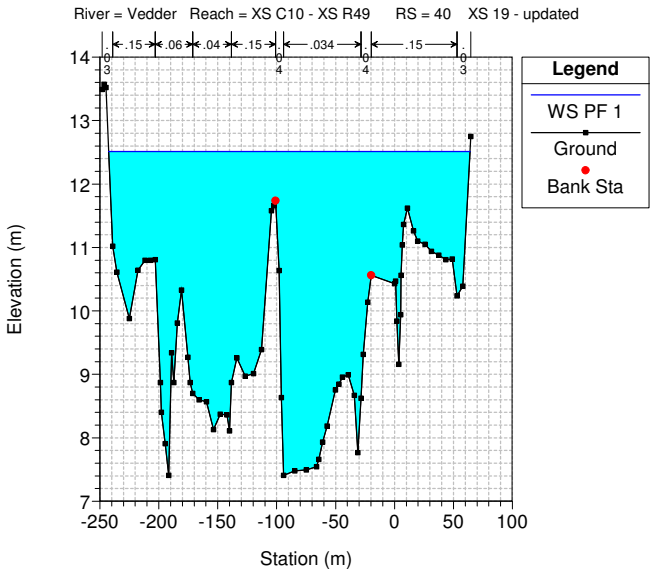

River = Vedder Reach = XS C10 - XS R49 RS = 45 XS 23-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

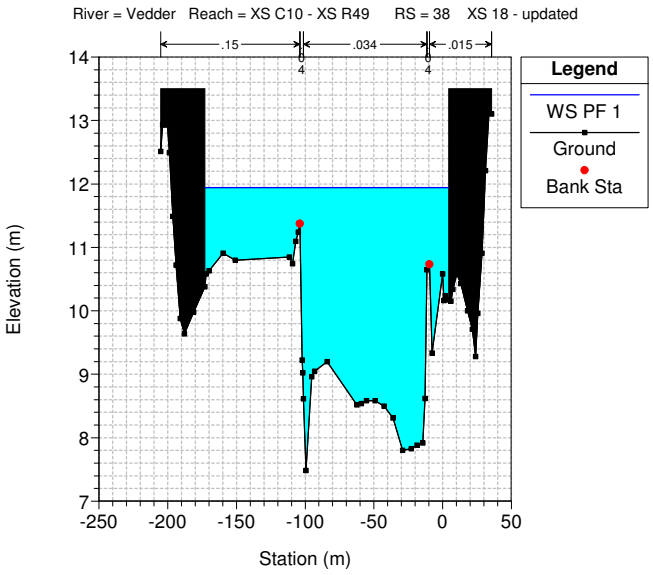

River = Vedder Reach = XS C10 - XS R49 RS = 44 XS 22-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

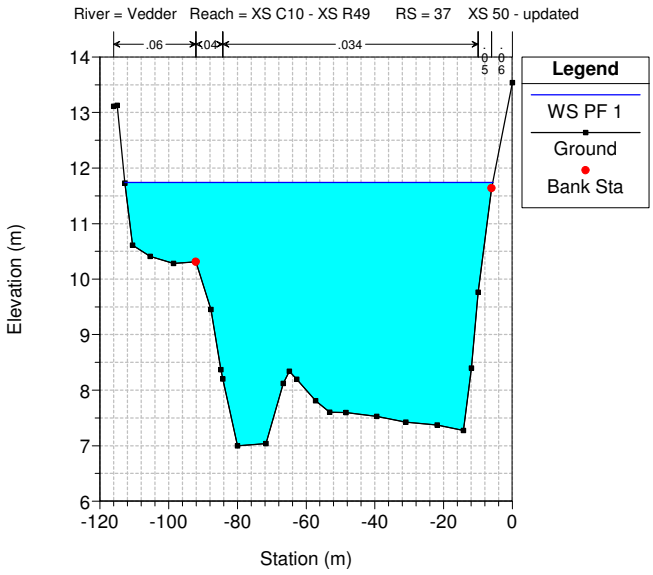

River = Vedder Reach = XS C10 - XS R49 RS = 42 XS 21-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

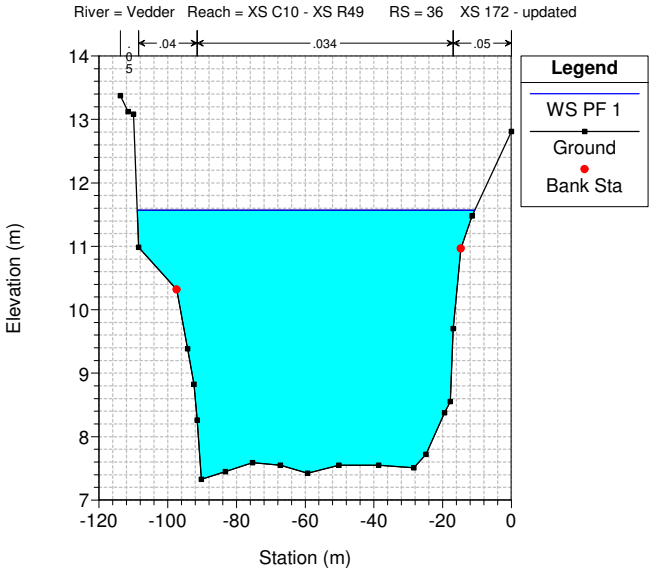
Appendix C

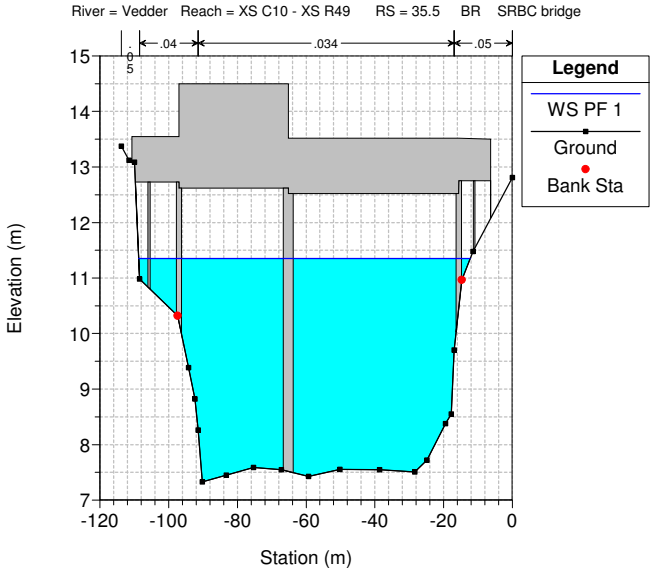

River = Vedder Reach = XS C10 - XS R49 RS = 41 XS 20-updated
.15
.04
.034
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 40 XS 19 - updated
.15
.06
.04
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

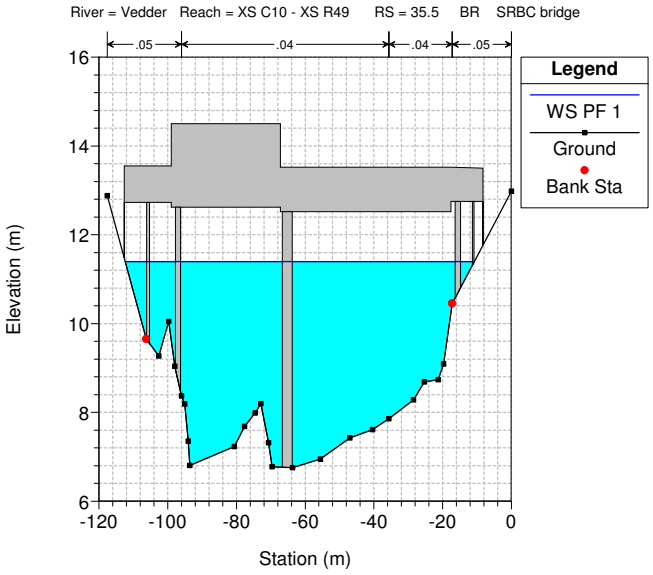

River = Vedder Reach = XS C10 - XS R49 RS = 38 XS 18 - updated
.15
.034
.015
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

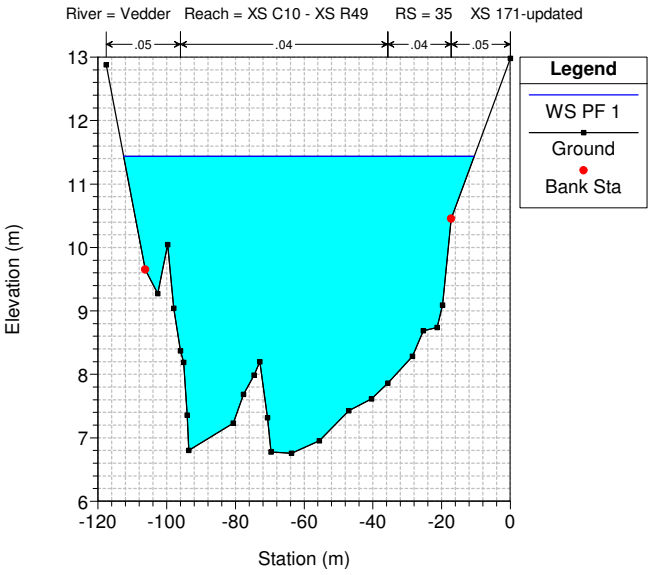

River = Vedder Reach = XS C10 - XS R49 RS = 37 XS 50 - updated
.06
.04
.034
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

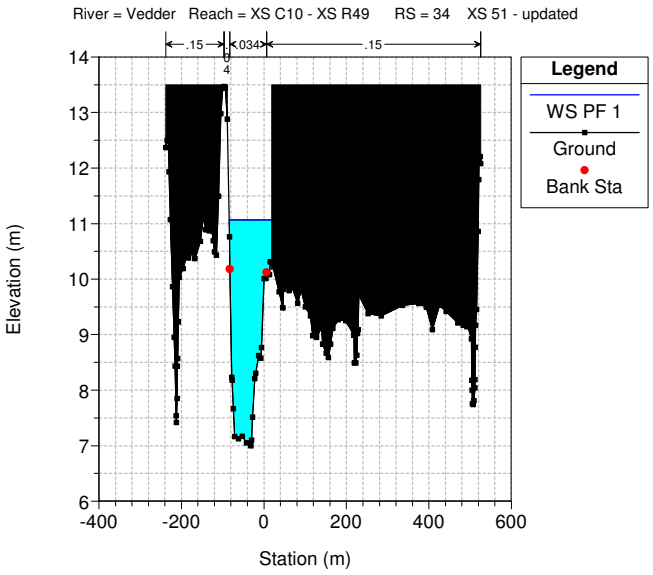

River = Vedder Reach = XS C10 - XS R49 RS = 36 XS 172 - updated
.04
.034
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

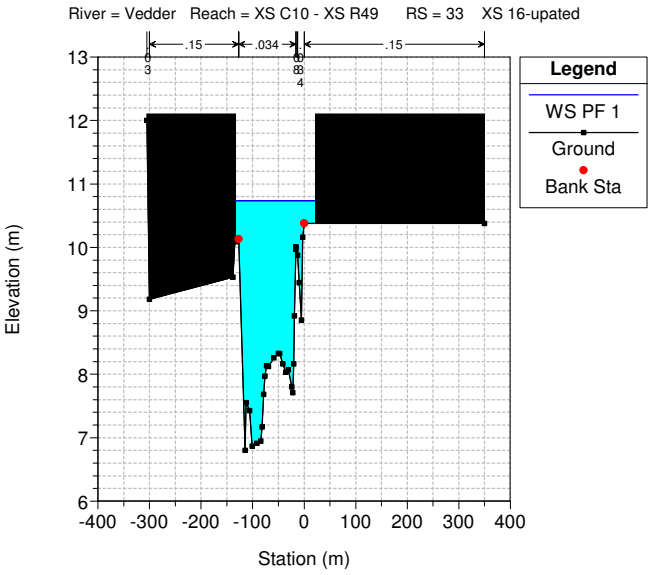

River = Vedder Reach = XS C10 - XS R49 RS = 35.5 BR SRBC bridge
.04
.034
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

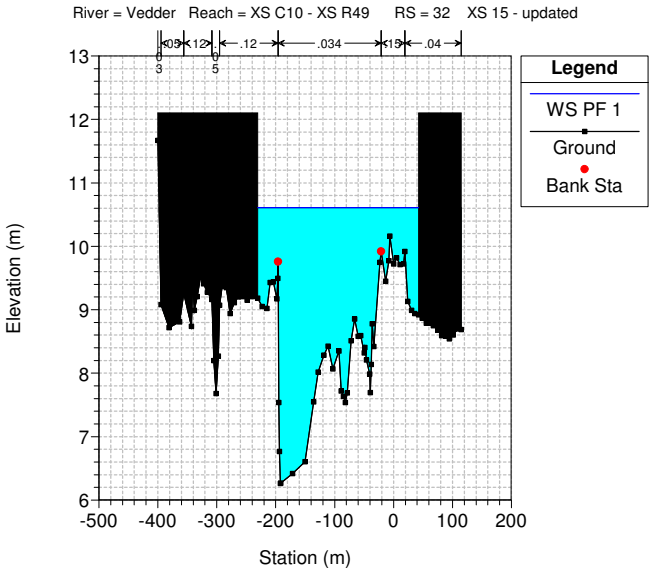
Appendix C

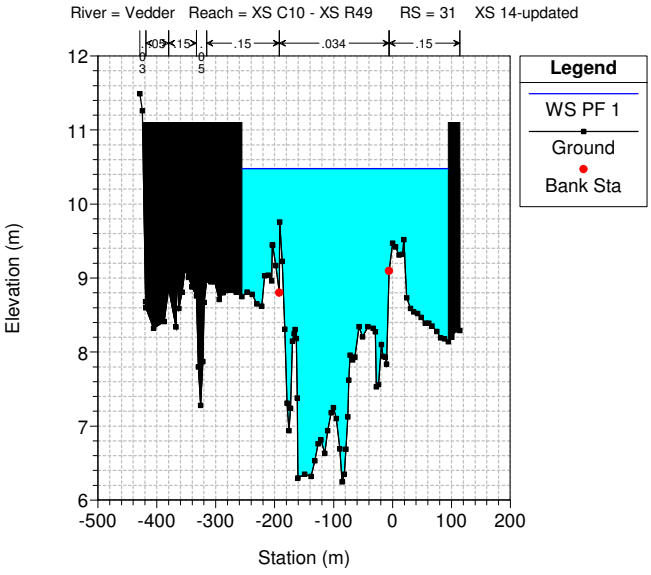

River = Vedder Reach = XS C10 - XS R49 RS = 35.5 BR SRBC bridge
.05
.04
.04
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 35 XS 171-updated
.05
.04
.04
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

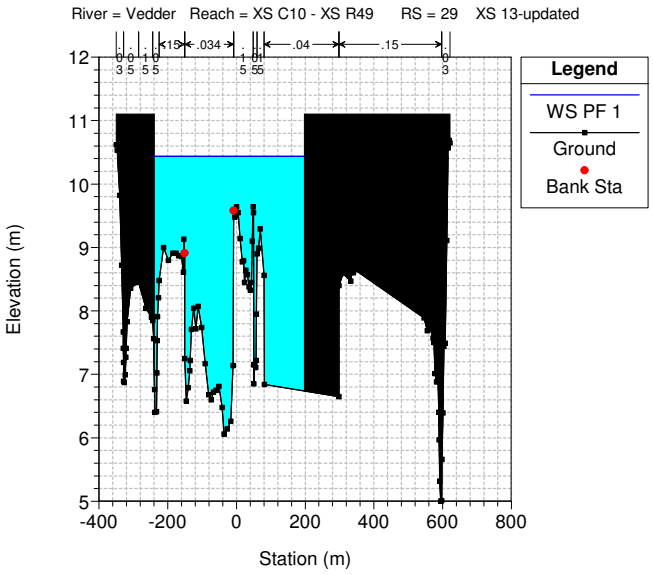

River = Vedder Reach = XS C10 - XS R49 RS = 34 XS 51 - updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

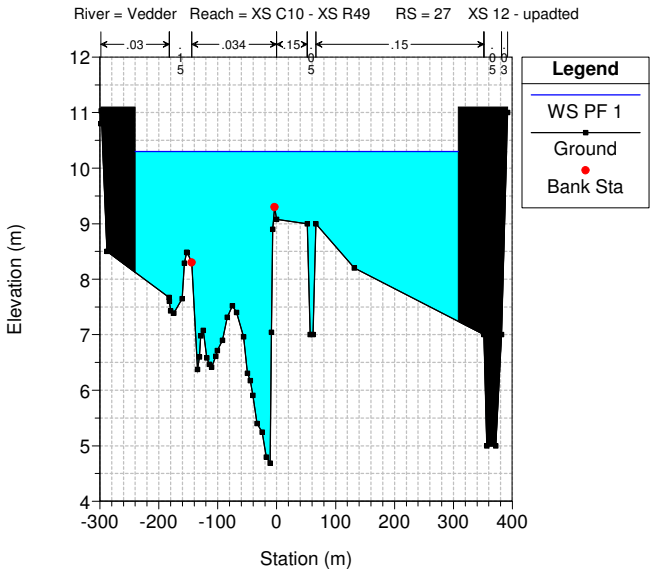

River = Vedder Reach = XS C10 - XS R49 RS = 33 XS 16-upated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

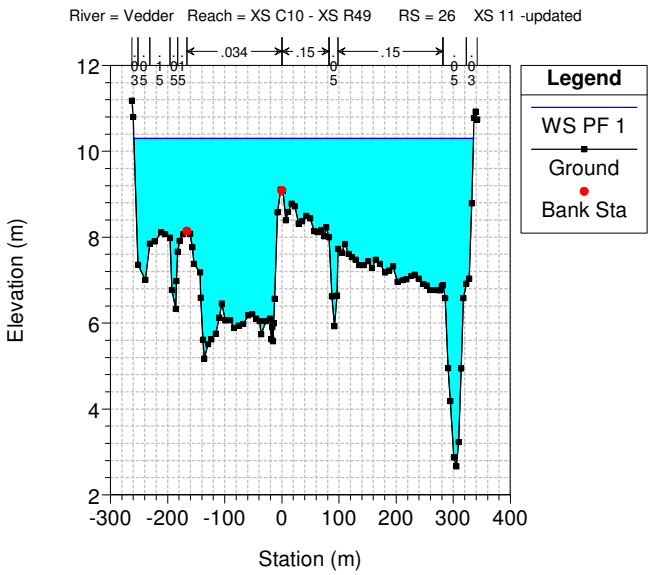

River = Vedder Reach = XS C10 - XS R49 RS = 32 XS 15 - updated
.05
.12
.12
.034
.15
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

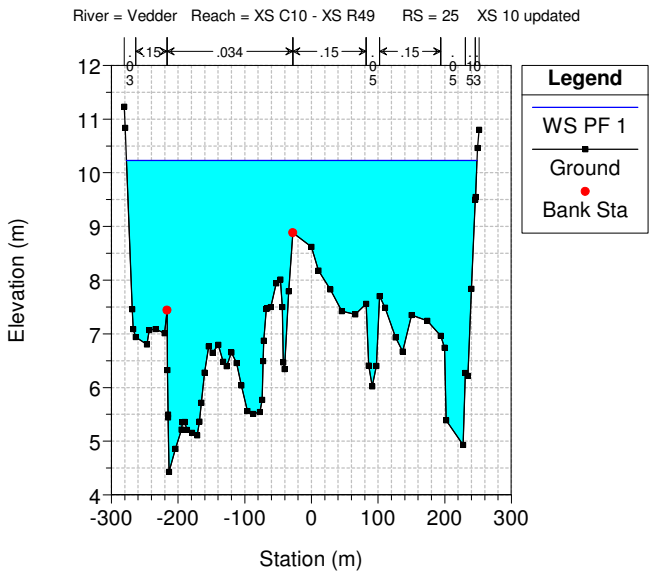

River = Vedder Reach = XS C10 - XS R49 RS = 31 XS 14-updated
.09
.15
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

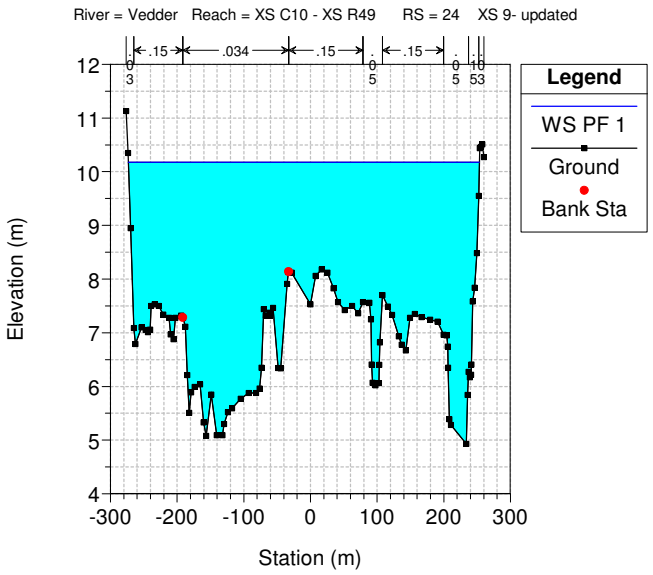
Appendix C

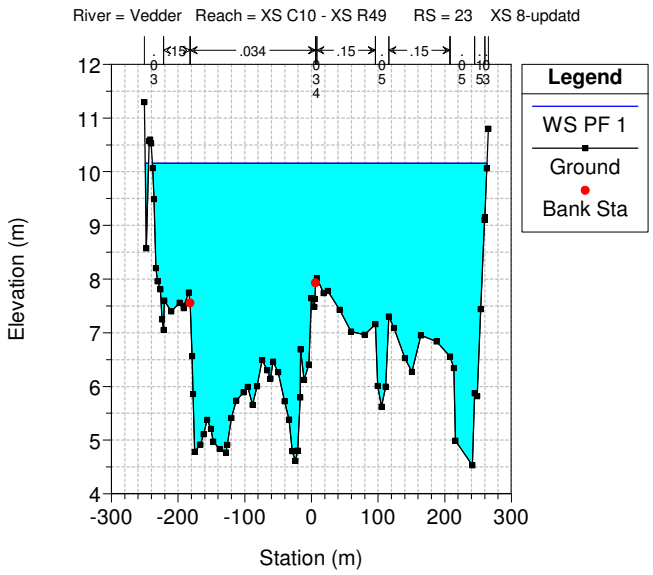

River = Vedder Reach = XS C10 - XS R49 RS = 29 XS 13-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 27 XS 12 - upadted
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

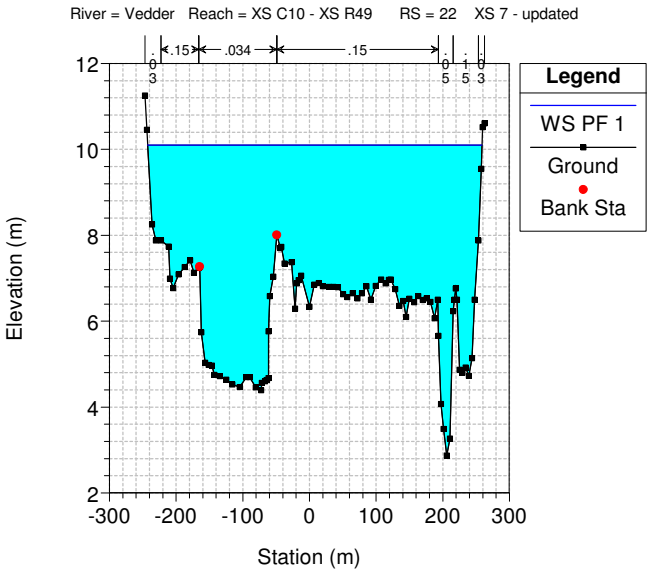

River = Vedder Reach = XS C10 - XS R49 RS = 26 XS 11 -updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

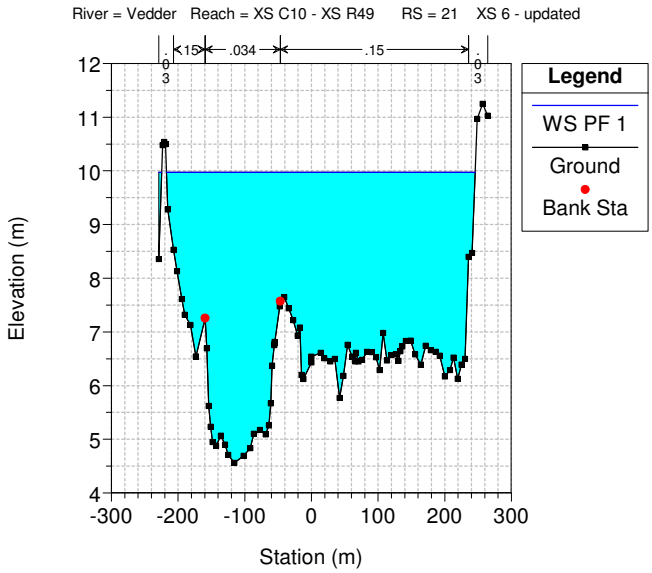

River = Vedder Reach = XS C10 - XS R49 RS = 25 XS 10 updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

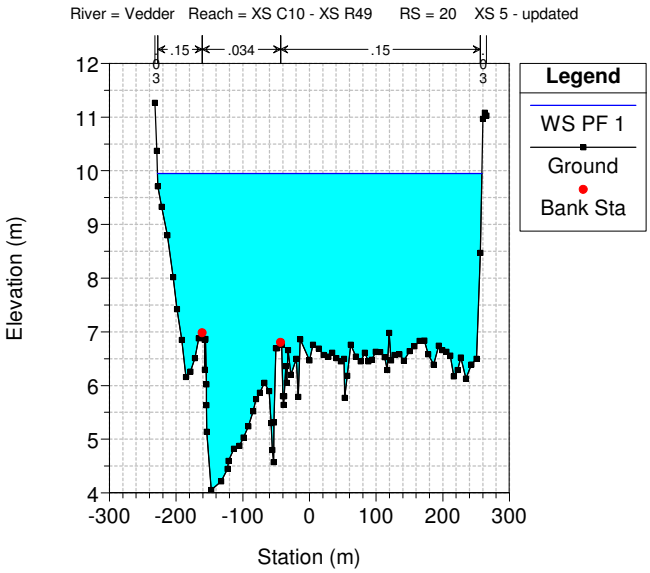

River = Vedder Reach = XS C10 - XS R49 RS = 24 XS 9- updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

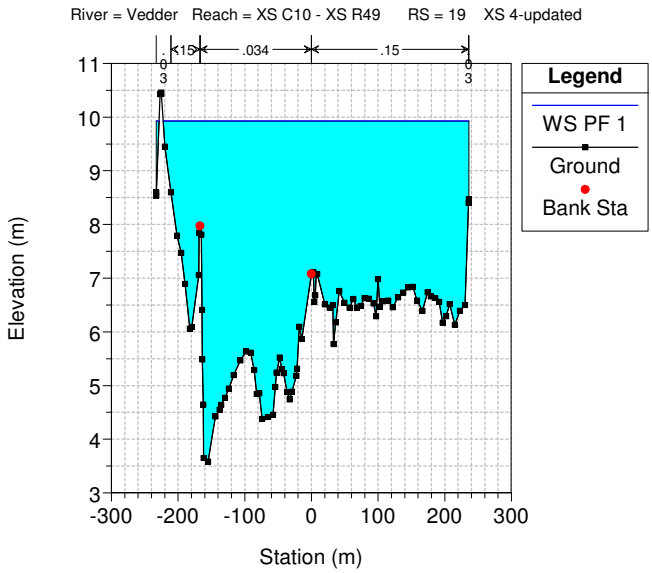

River = Vedder Reach = XS C10 - XS R49 RS = 23 XS 8-updatd
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

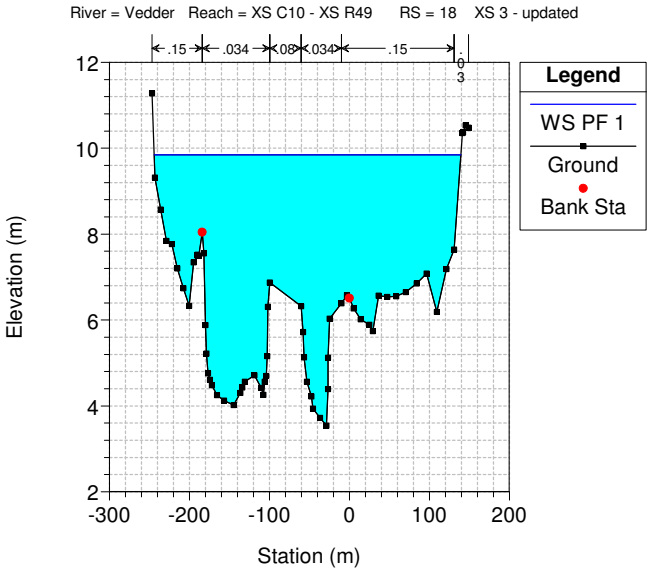
Appendix C

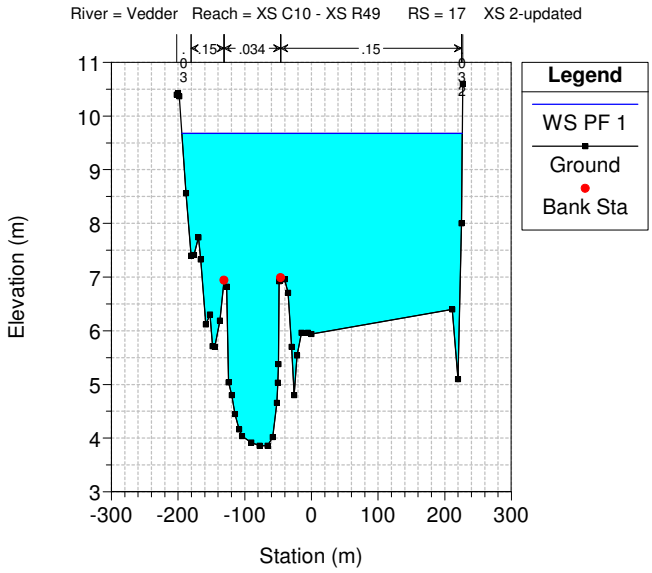

River = Vedder Reach = XS C10 - XS R49 RS = 22 XS 7 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 21 XS 6 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

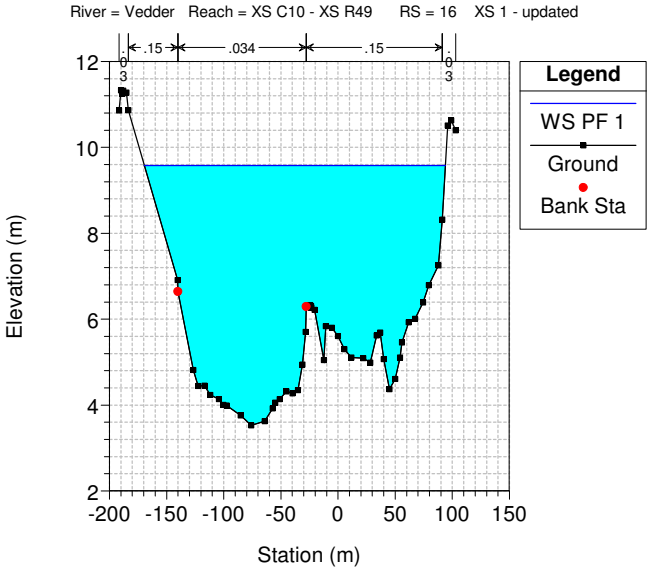

River = Vedder Reach = XS C10 - XS R49 RS = 20 XS 5 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

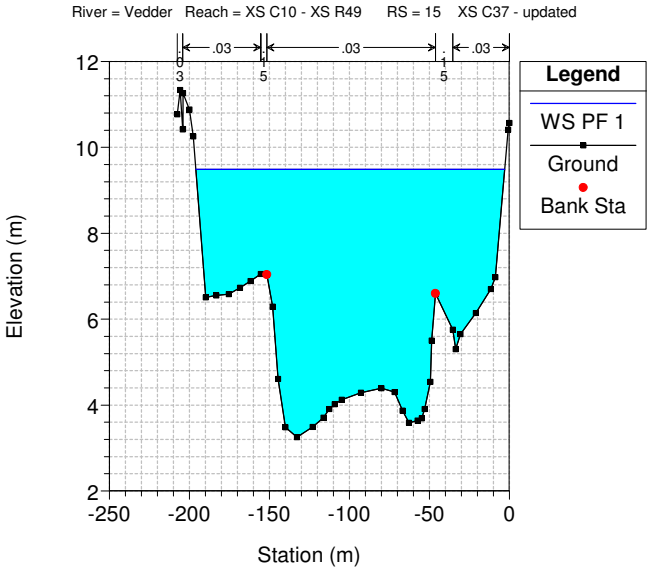

River = Vedder Reach = XS C10 - XS R49 RS = 19 XS 4-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

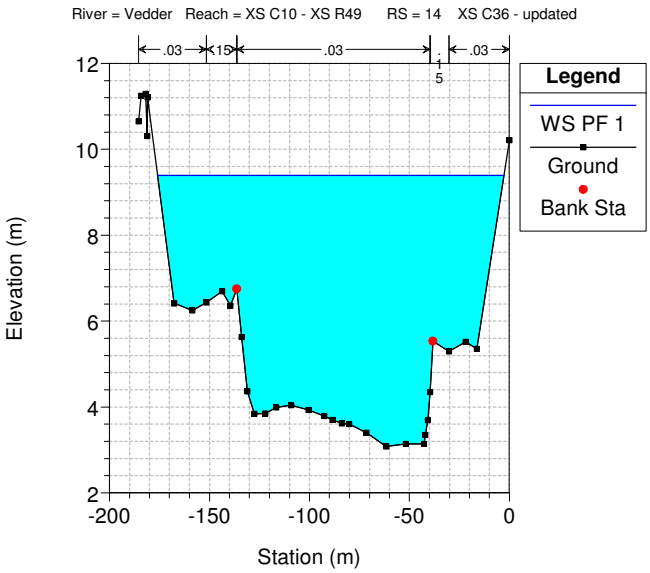

River = Vedder Reach = XS C10 - XS R49 RS = 18 XS 3 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

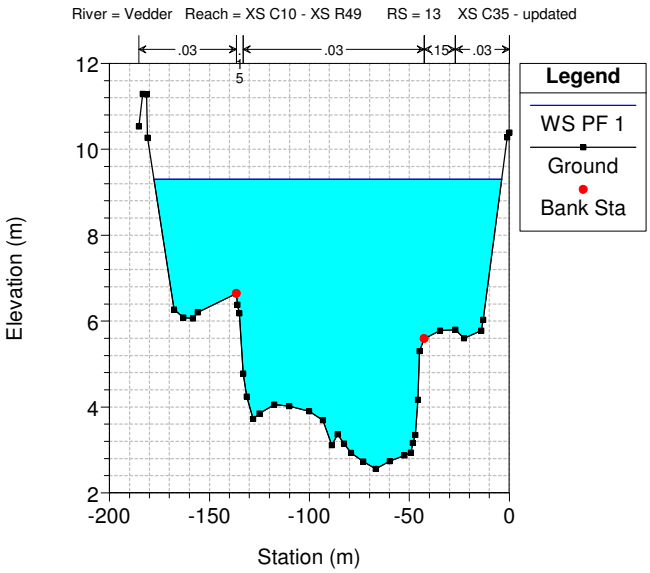

River = Vedder Reach = XS C10 - XS R49 RS = 17 XS 2-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

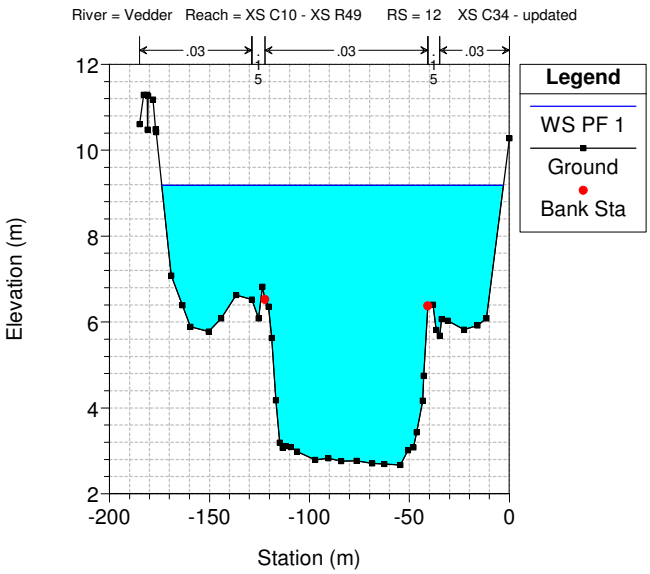
Appendix C

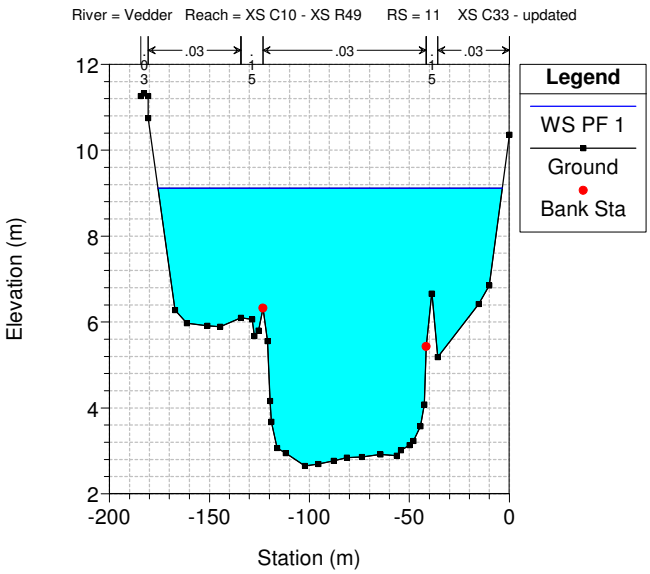

River = Vedder Reach = XS C10 - XS R49 RS = 16 XS 1 - updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 15 XS C37 - updated
.03
.03
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

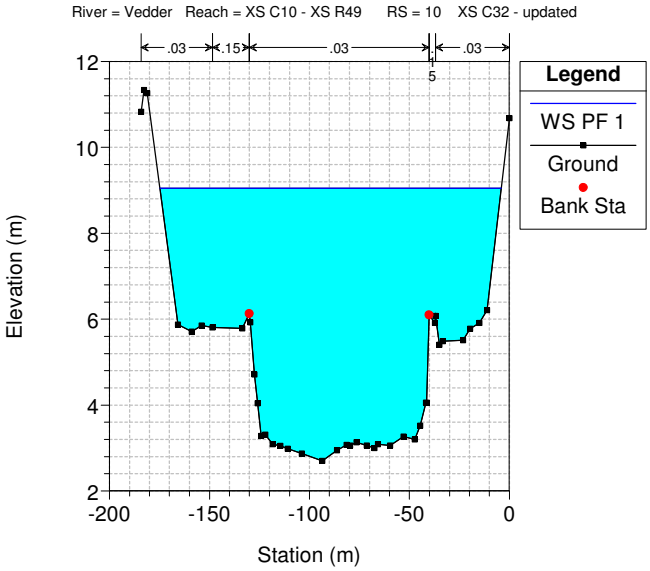

River = Vedder Reach = XS C10 - XS R49 RS = 14 XS C36 - updated
.03
.15
.03
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

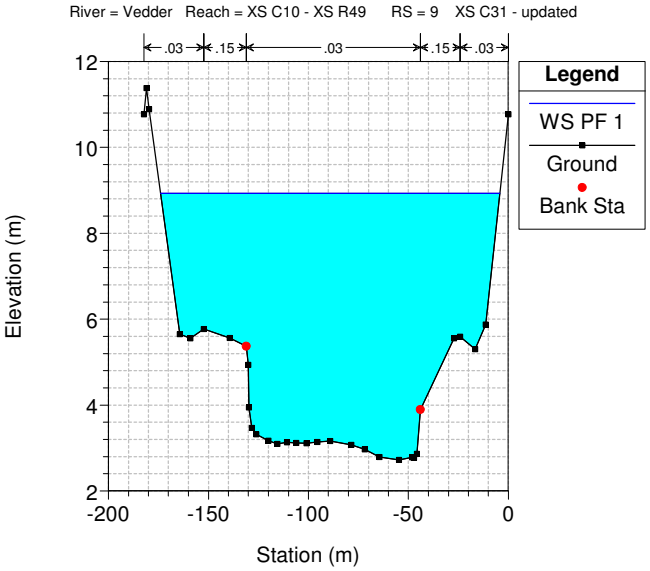

River = Vedder Reach = XS C10 - XS R49 RS = 13 XS C35 - updated
.03
.03
.15
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

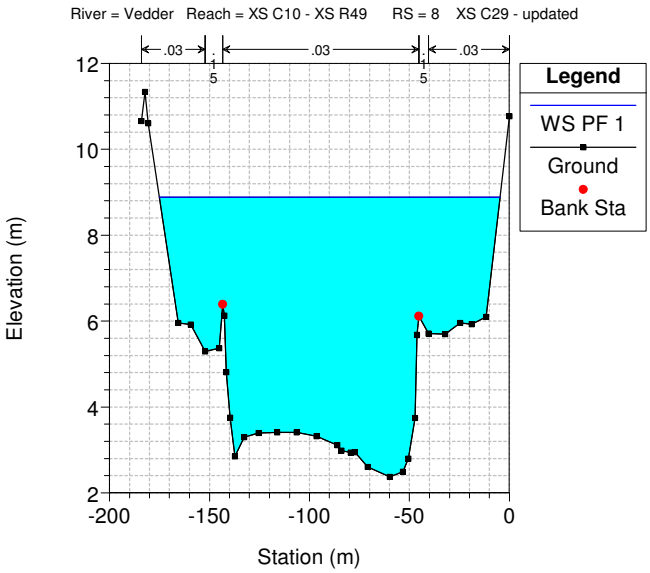

River = Vedder Reach = XS C10 - XS R49 RS = 12 XS C34 - updated
.03
.03
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

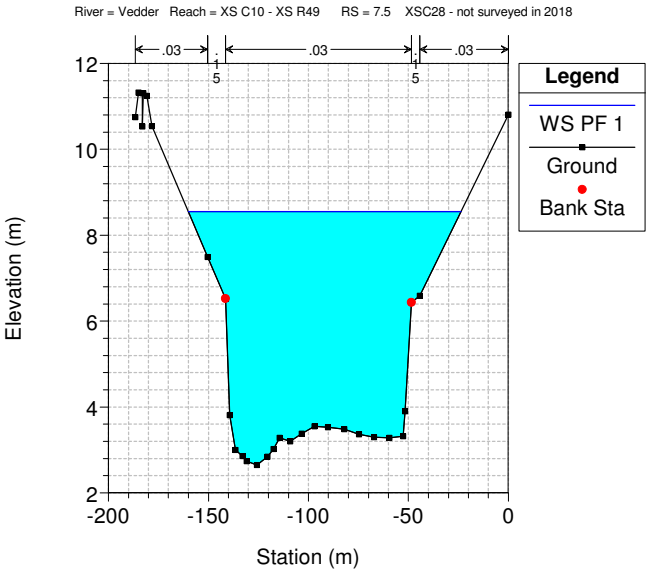

River = Vedder Reach = XS C10 - XS R49 RS = 11 XS C33 - updated
.03
.03
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

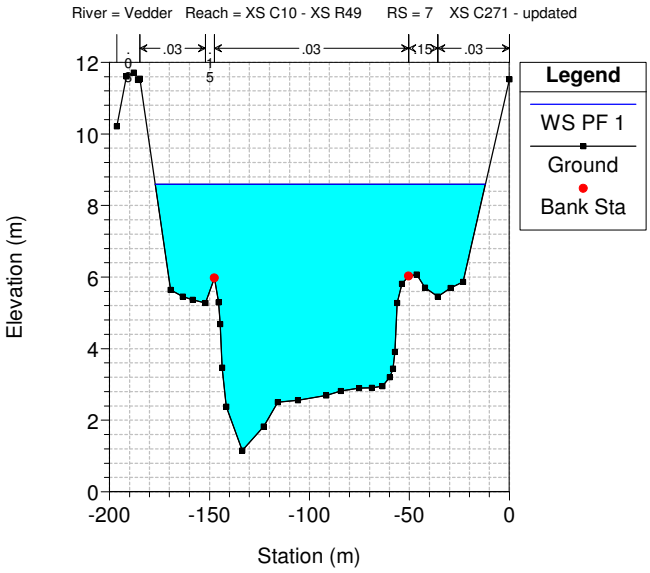
Appendix C

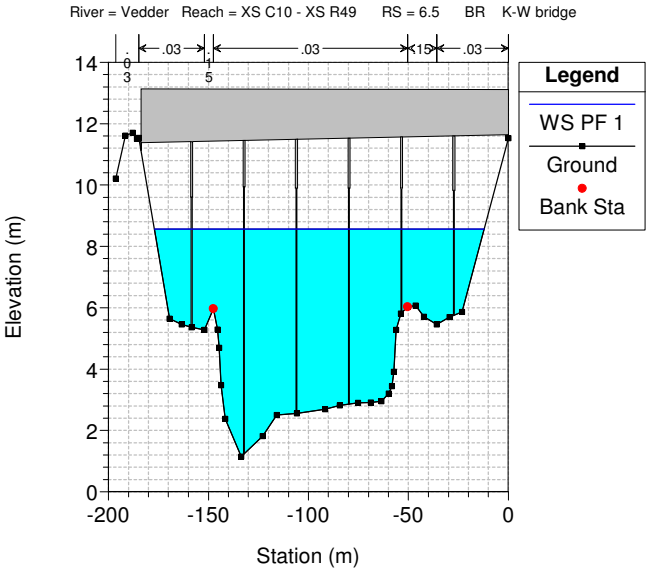

River = Vedder Reach = XS C10 - XS R49 RS = 10 XS C32 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 9 XS C31 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

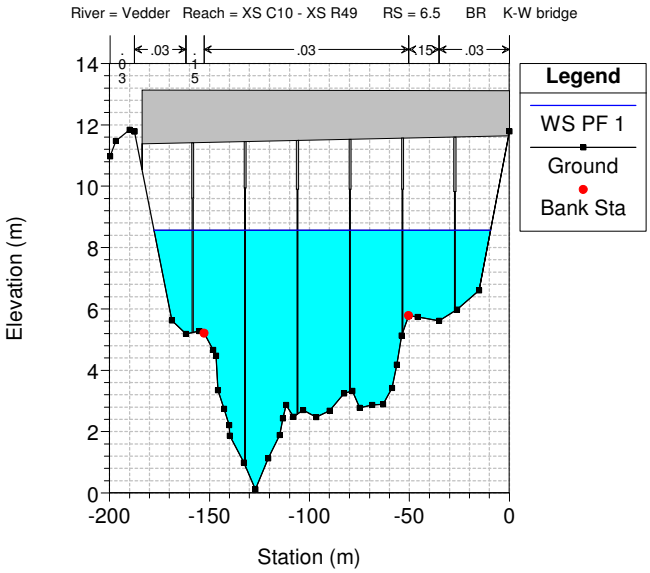

River = Vedder Reach = XS C10 - XS R49 RS = 8 XS C29 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

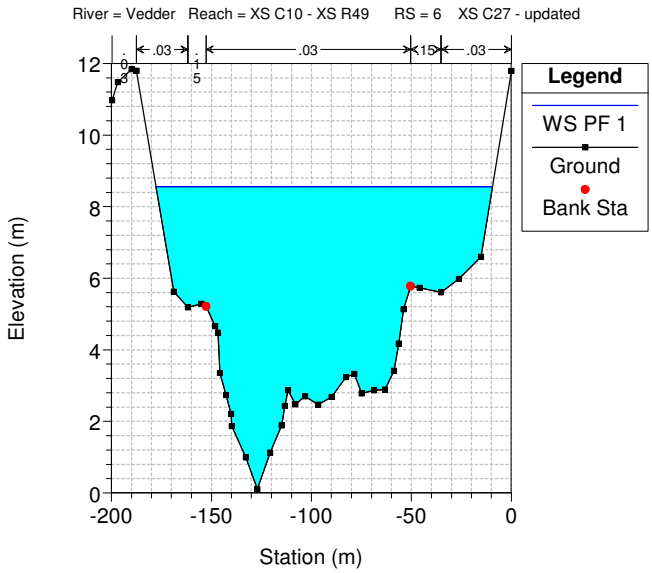

River = Vedder Reach = XS C10 - XS R49 RS = 7.5 XSC28 - not surveyed in 2018
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

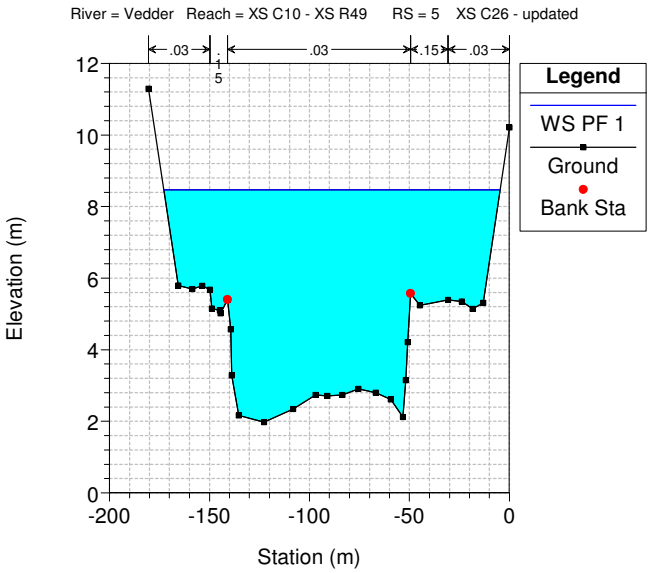

River = Vedder Reach = XS C10 - XS R49 RS = 7 XS C271 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

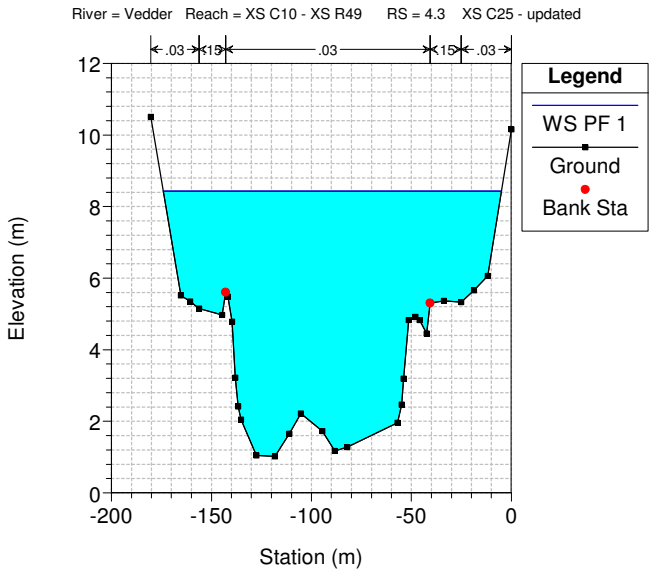

River = Vedder Reach = XS C10 - XS R49 RS = 6.5 BR K-W bridge
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

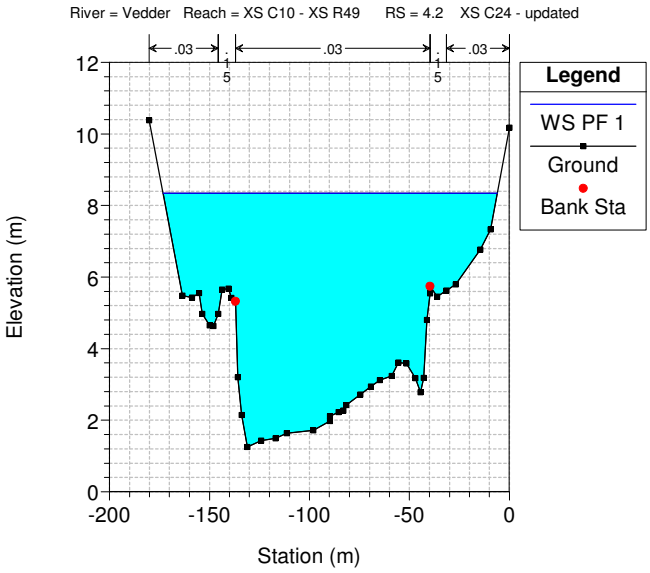
Appendix C

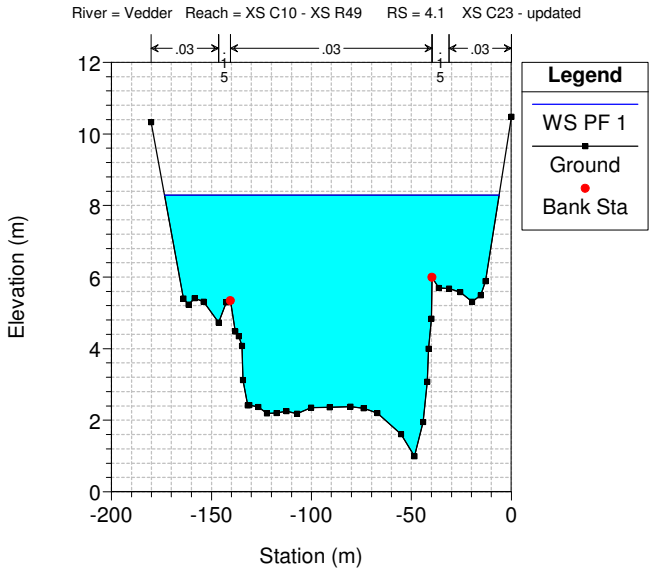

River = Vedder Reach = XS C10 - XS R49 RS = 6.5 BR K-W bridge
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 6 XS C27 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

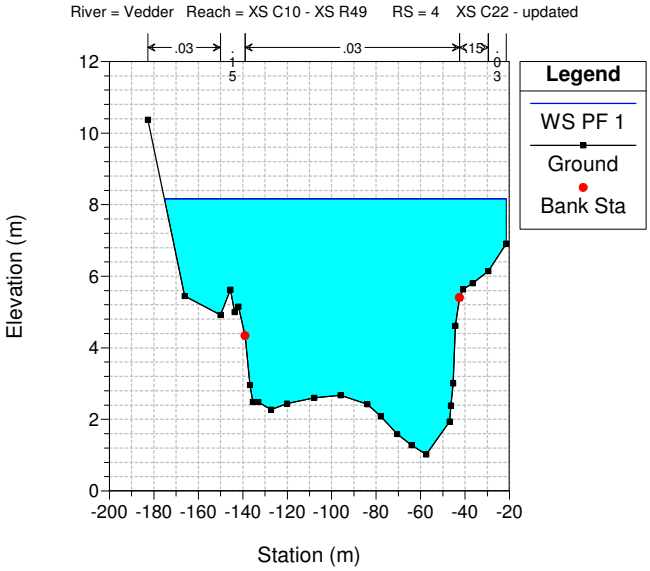

River = Vedder Reach = XS C10 - XS R49 RS = 5 XS C26 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

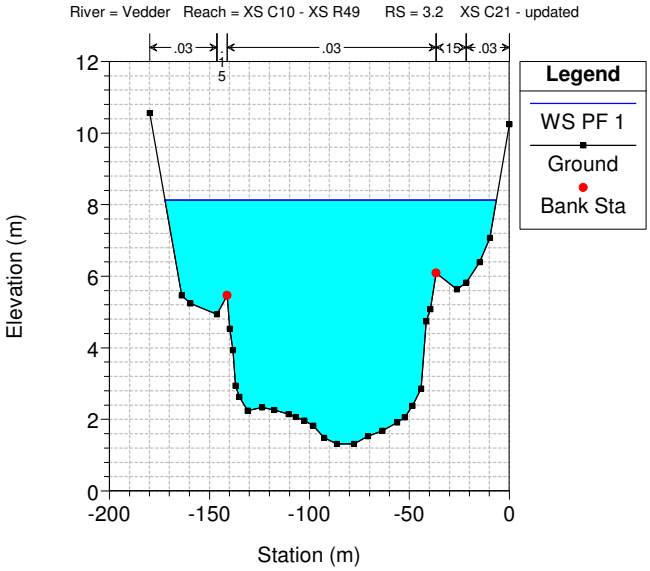

River = Vedder Reach = XS C10 - XS R49 RS = 4.3 XS C25 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

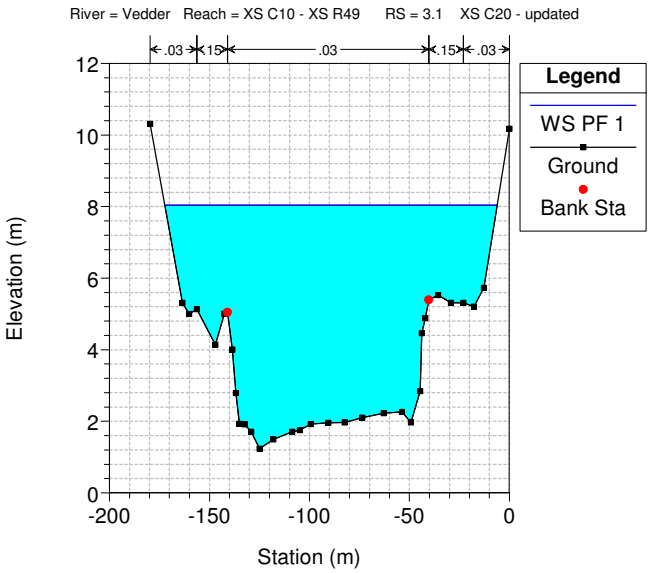

River = Vedder Reach = XS C10 - XS R49 RS = 4.2 XS C24 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

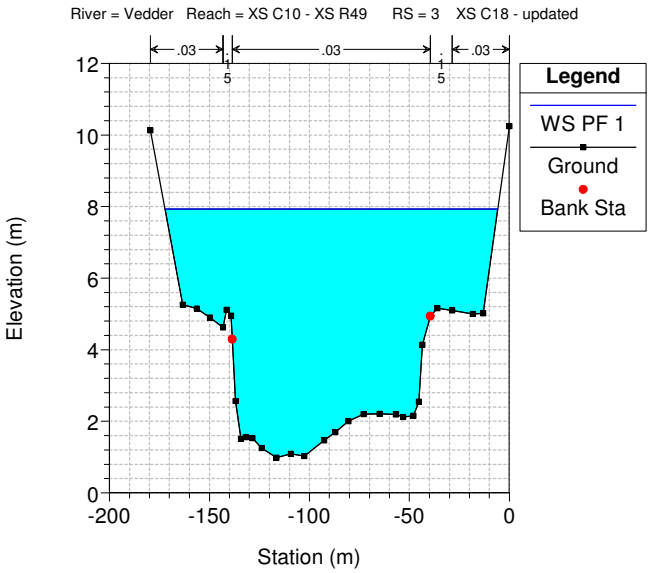

River = Vedder Reach = XS C10 - XS R49 RS = 4.1 XS C23 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

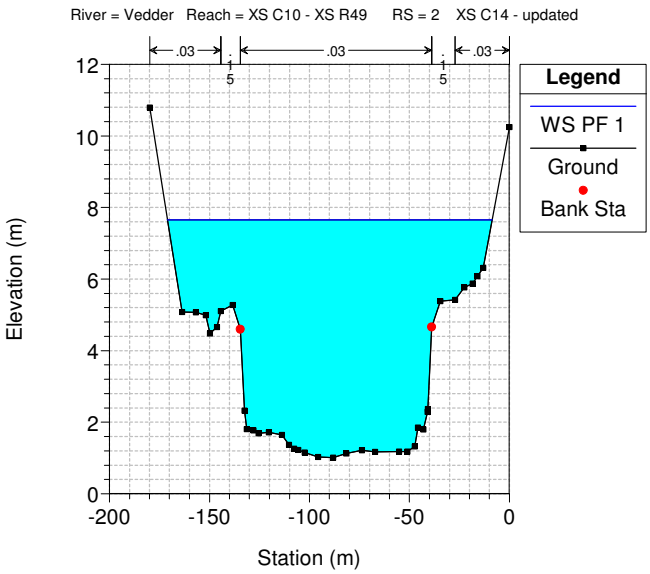
Appendix C

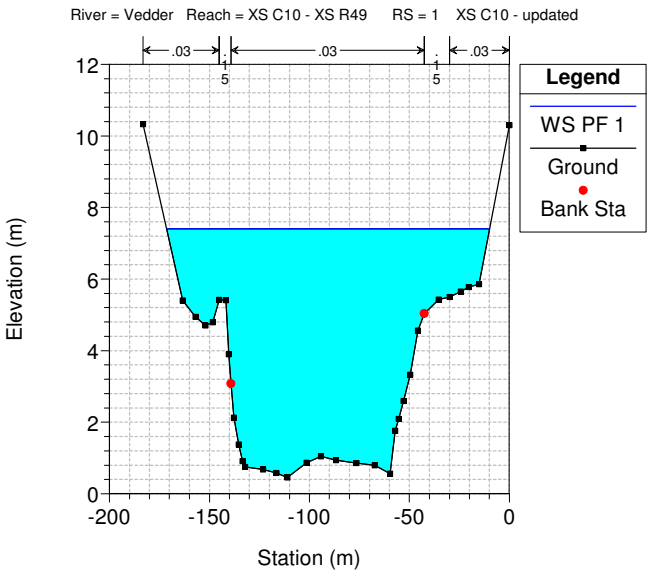

River = Vedder Reach = XS C10 - XS R49 RS = 4 XS C22 - updated
.03
.03
.15
.03
1
5
1
5
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -180 -160 -140 -120 -100 -80 -60 -40 -20


River = Vedder Reach = XS C10 - XS R49 RS = 3.2 XS C21 - updated
.03
.03
.15
.03
1
5
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -150 -100 -50 0

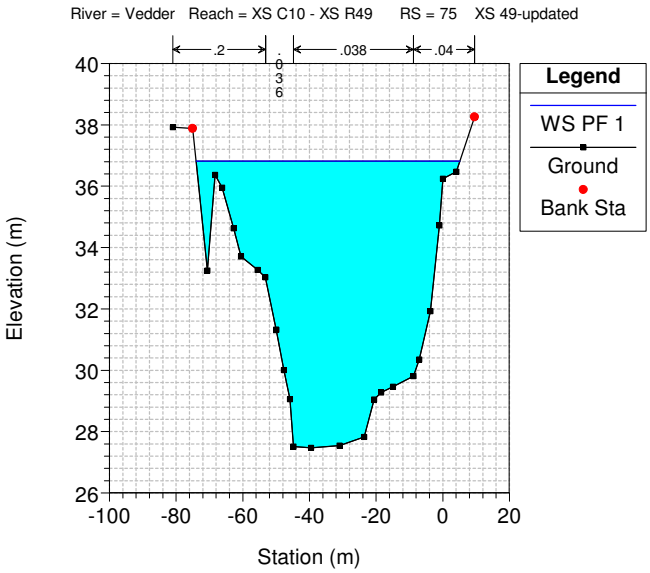

River = Vedder Reach = XS C10 - XS R49 RS = 3.1 XS C20 - updated
.03
.15
.03
.15
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -150 -100 -50 0

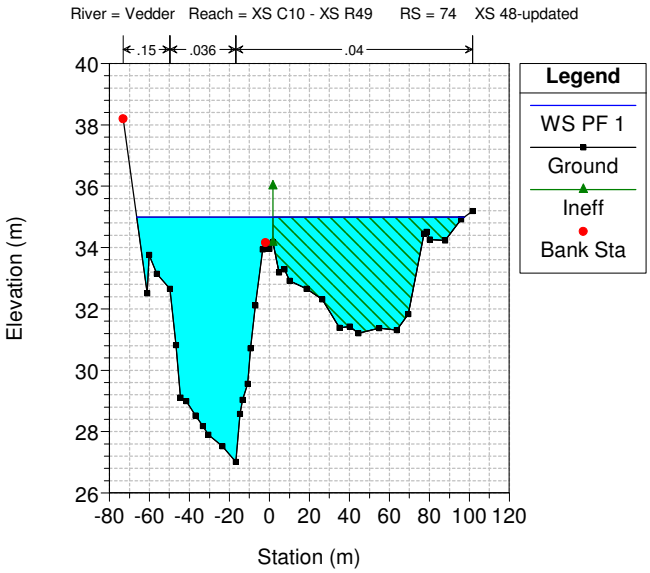

River = Vedder Reach = XS C10 - XS R49 RS = 3 XS C18 - updated
.03
.03
.03
1
5
1
5
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -150 -100 -50 0

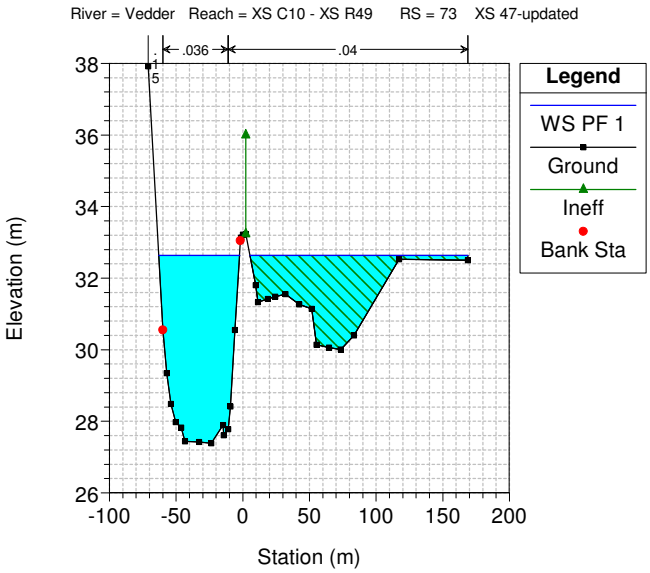

River = Vedder Reach = XS C10 - XS R49 RS = 2 XS C14 - updated
.03
.03
.03
1
5
1
5
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -150 -100 -50 0

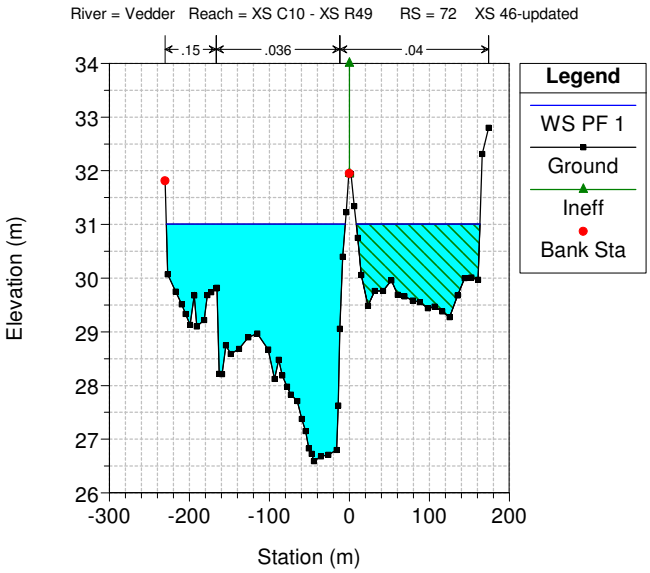

River = Vedder Reach = XS C10 - XS R49 RS = 1 XS C10 - updated
.03
.03
.03
1
5
1
5
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -150 -100 -50 0

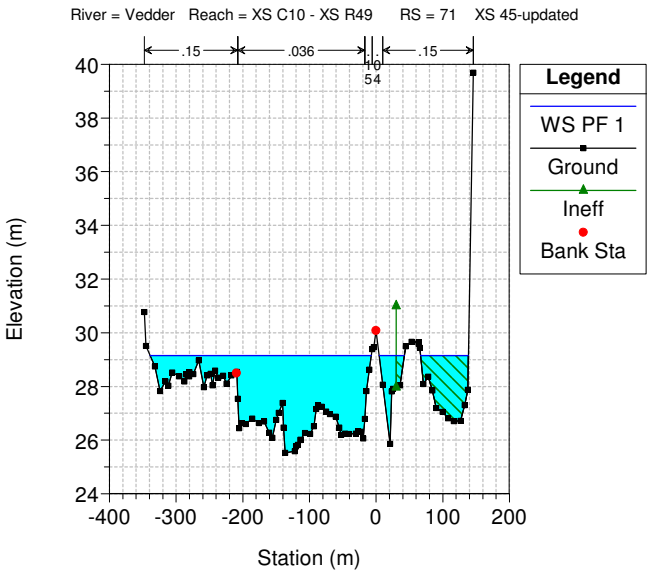
Appendix C

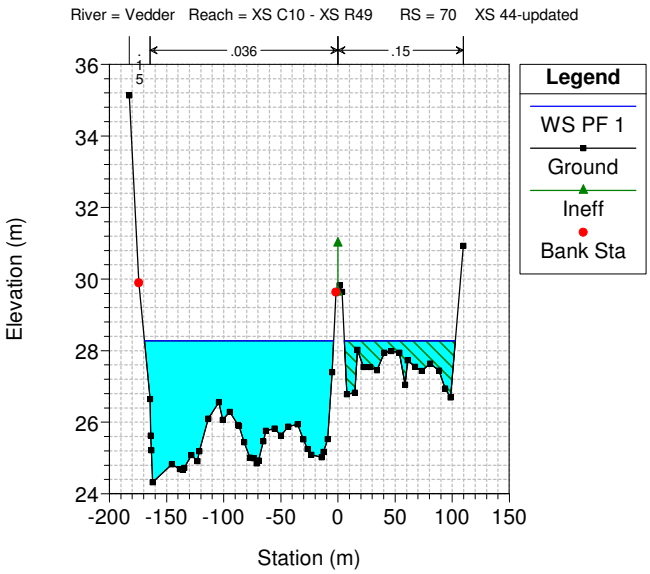

River = Vedder Reach = XS C10 - XS R49 RS = 75 XS 49-updated
.2
.038
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 74 XS 48-updated
.15
.036
.04
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

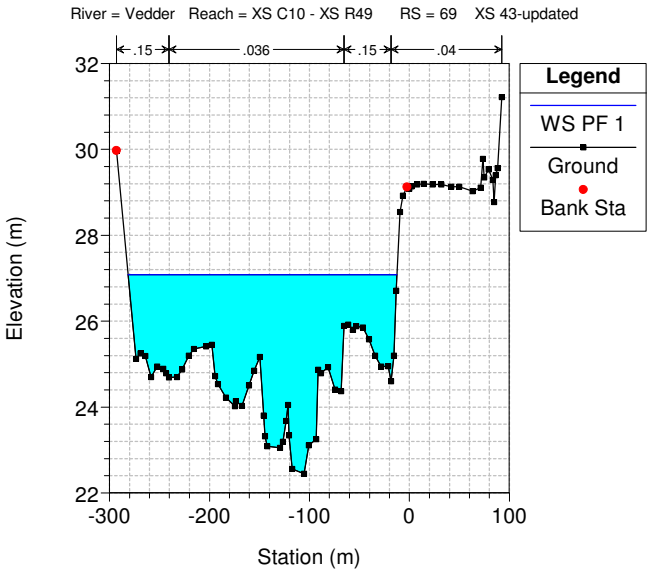

River = Vedder Reach = XS C10 - XS R49 RS = 73 XS 47-updated
.036
.04
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

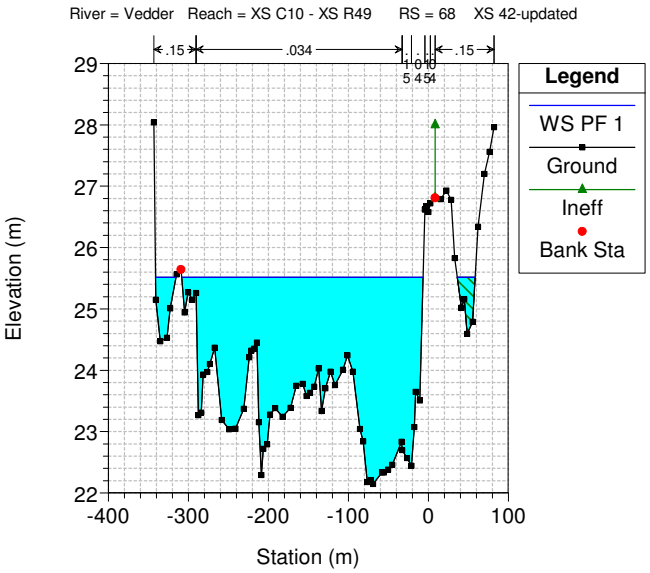

River = Vedder Reach = XS C10 - XS R49 RS = 72 XS 46-updated
.15
.036
.04
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

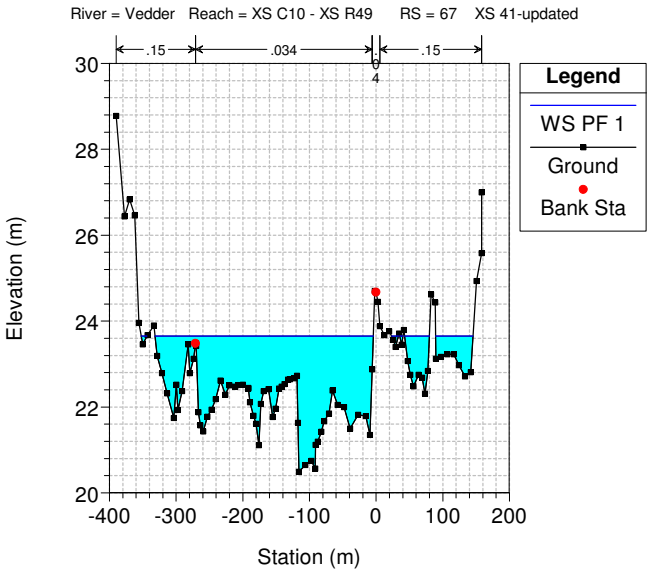

River = Vedder Reach = XS C10 - XS R49 RS = 71 XS 45-updated
.15
.036
.15
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

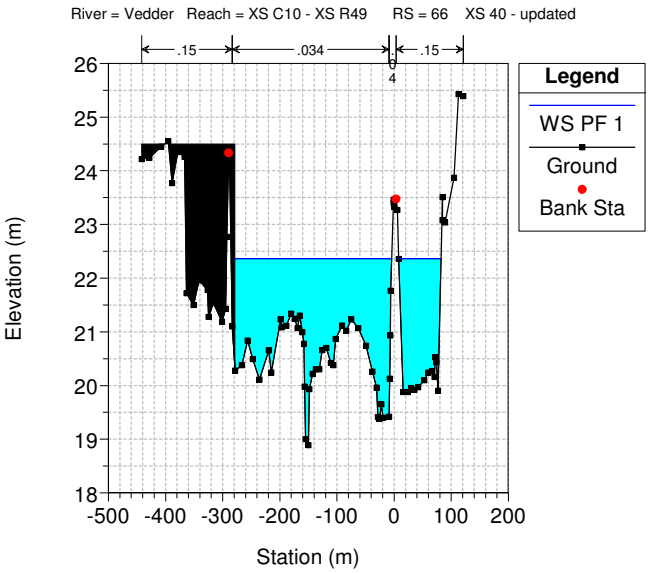

River = Vedder Reach = XS C10 - XS R49 RS = 70 XS 44-updated
.036
.15
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

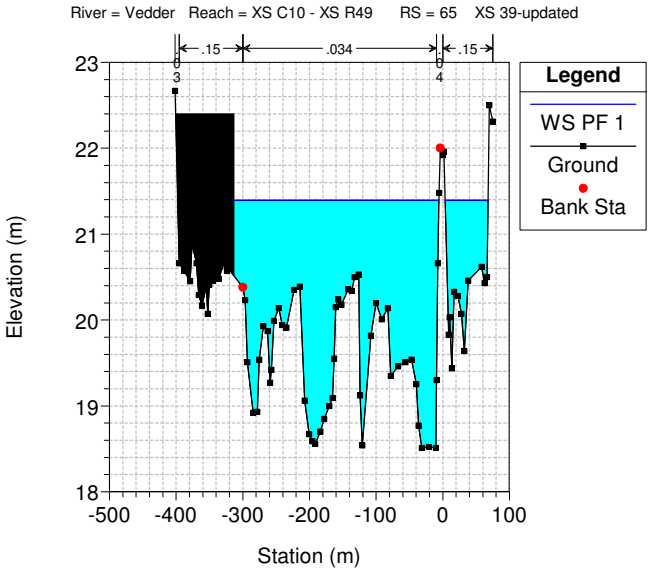
Appendix C

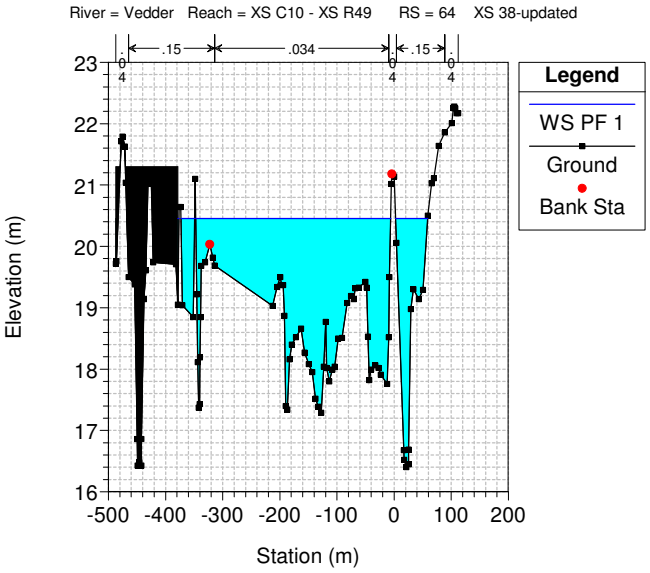

River = Vedder Reach = XS C10 - XS R49 RS = 69 XS 43-updated
.15
.036
.15
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 68 XS 42-updated
.15
.034
.15
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

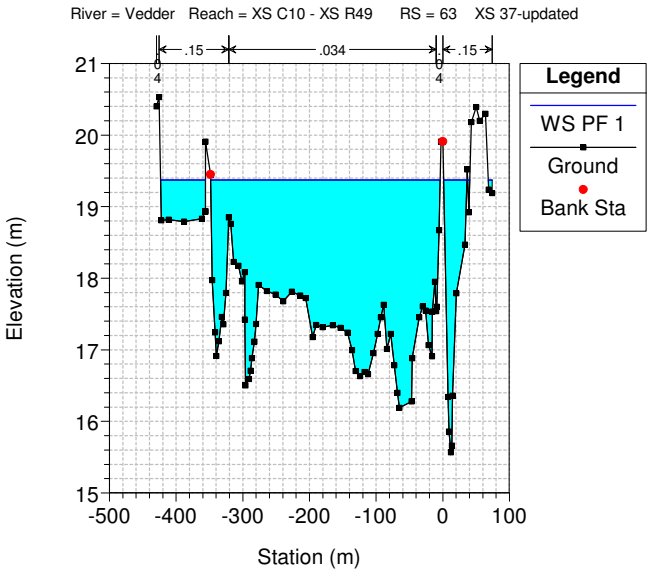

River = Vedder Reach = XS C10 - XS R49 RS = 67 XS 41-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

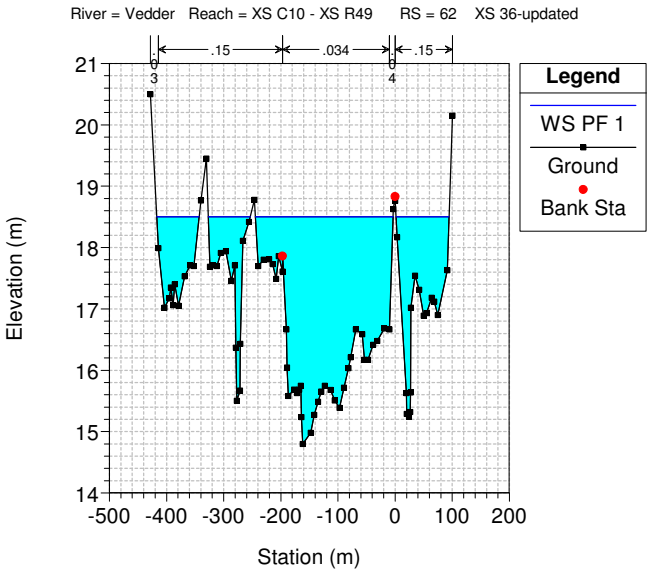

River = Vedder Reach = XS C10 - XS R49 RS = 66 XS 40 - updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

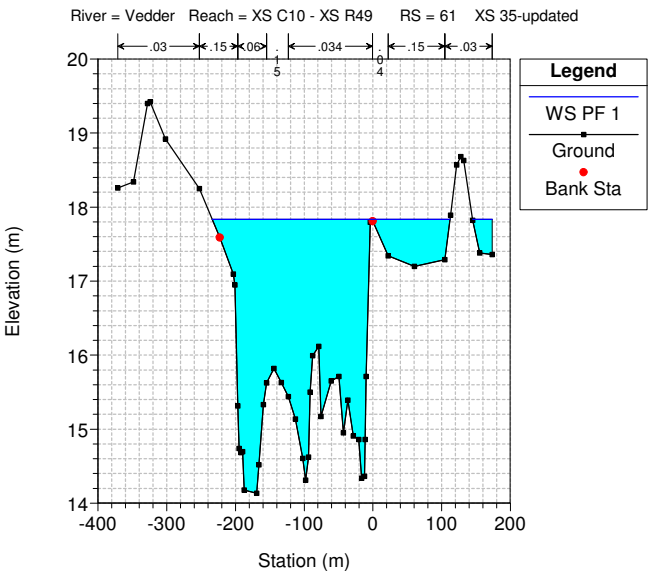

River = Vedder Reach = XS C10 - XS R49 RS = 65 XS 39-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

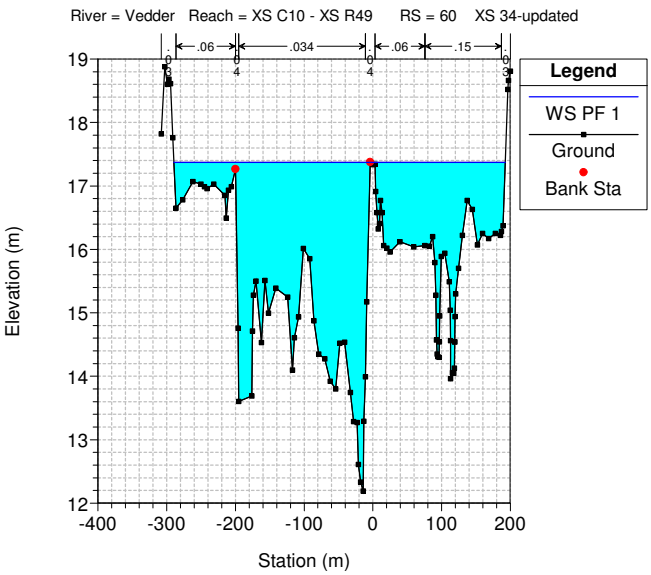

River = Vedder Reach = XS C10 - XS R49 RS = 64 XS 38-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

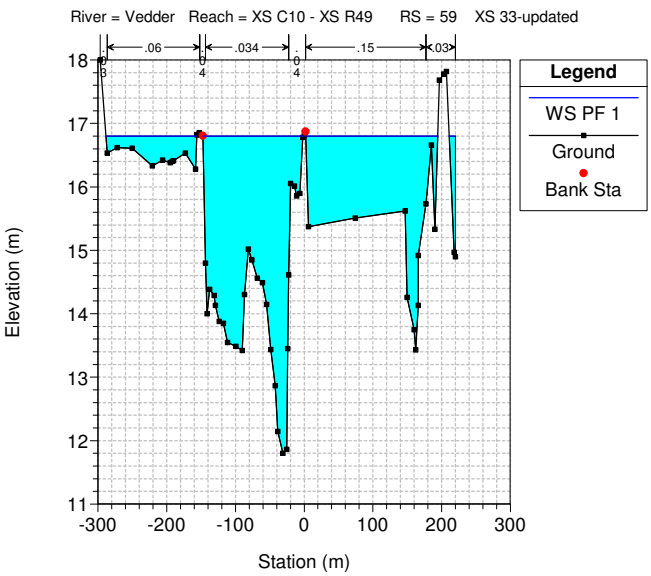
Appendix C

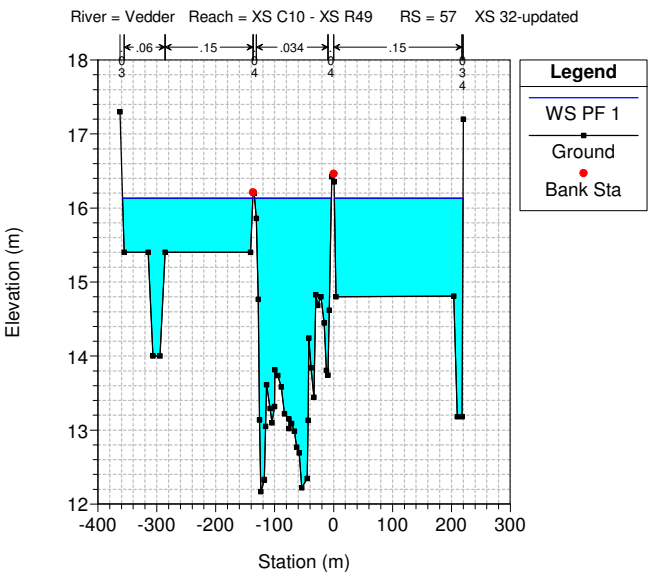

River = Vedder Reach = XS C10 - XS R49 RS = 63 XS 37-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 62 XS 36-updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

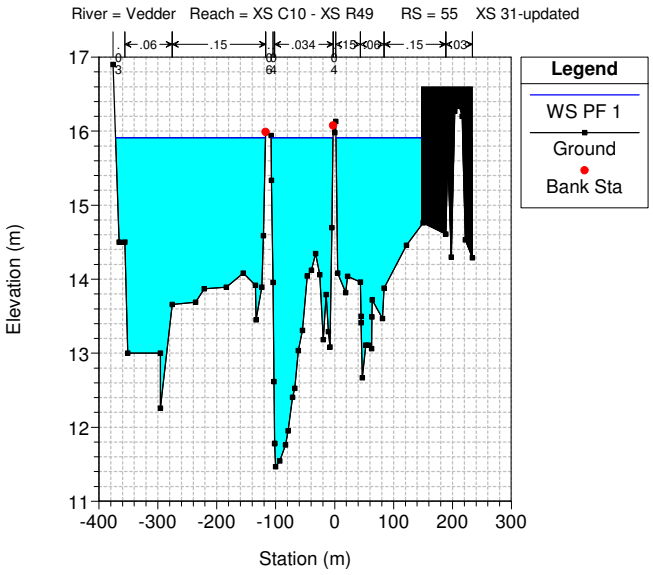

River = Vedder Reach = XS C10 - XS R49 RS = 61 XS 35-updated
.03
.15
.06
.034
.15
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

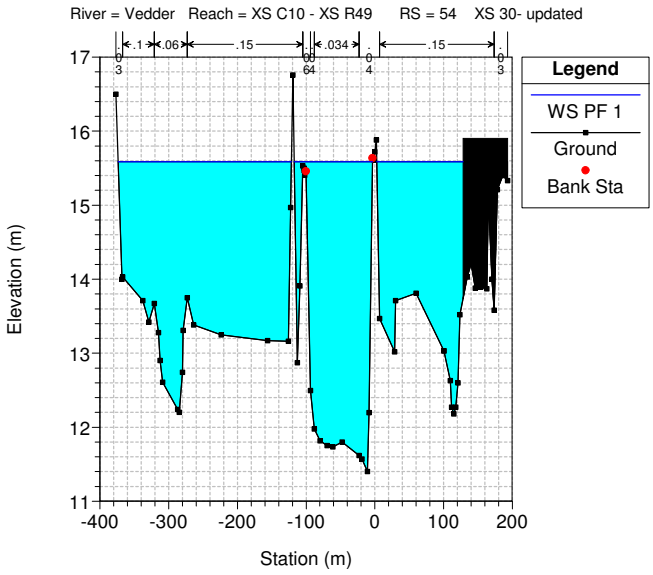

River = Vedder Reach = XS C10 - XS R49 RS = 60 XS 34-updated
.06
.034
.06
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

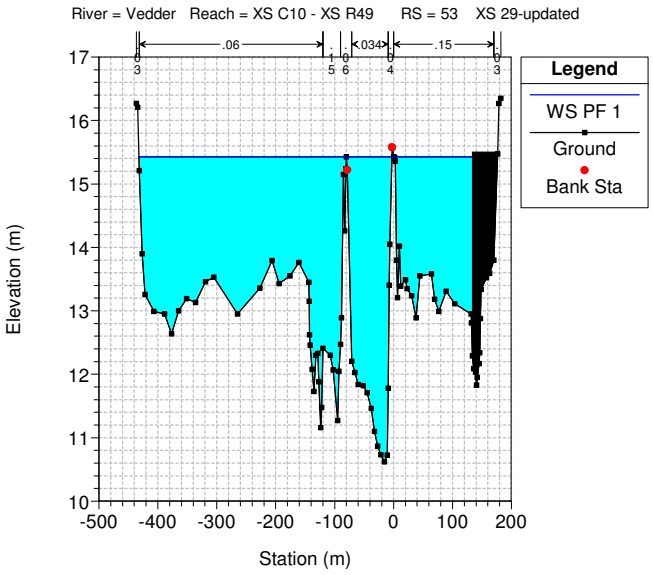

River = Vedder Reach = XS C10 - XS R49 RS = 59 XS 33-updated
.06
.034
.15
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

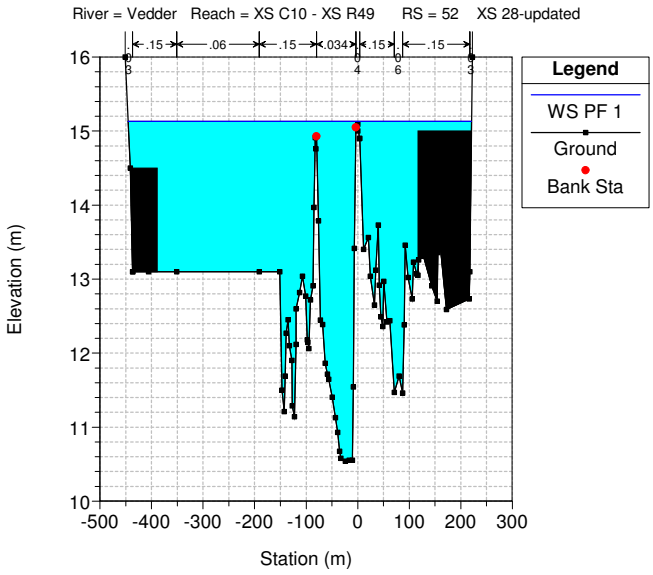

River = Vedder Reach = XS C10 - XS R49 RS = 57 XS 32-updated
.06
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

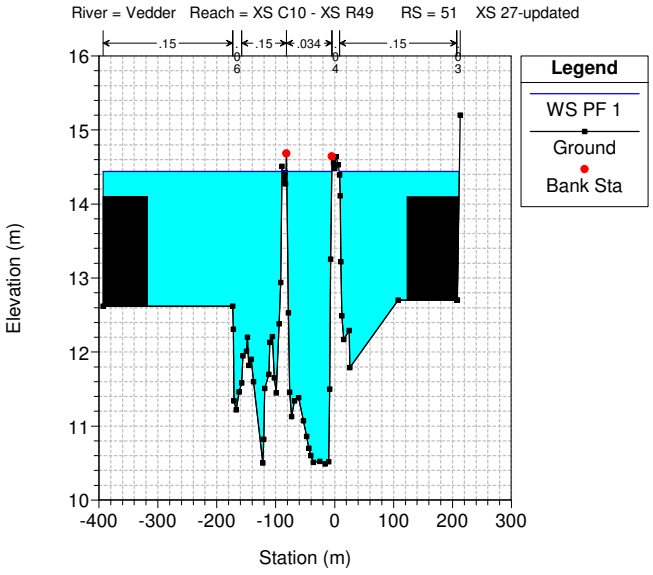
Appendix C

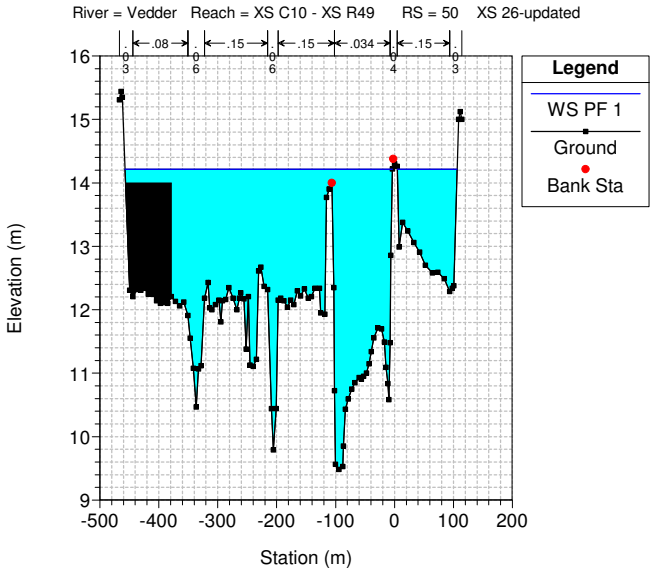

River = Vedder Reach = XS C10 - XS R49 RS = 55 XS 31-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 54 XS 30- updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

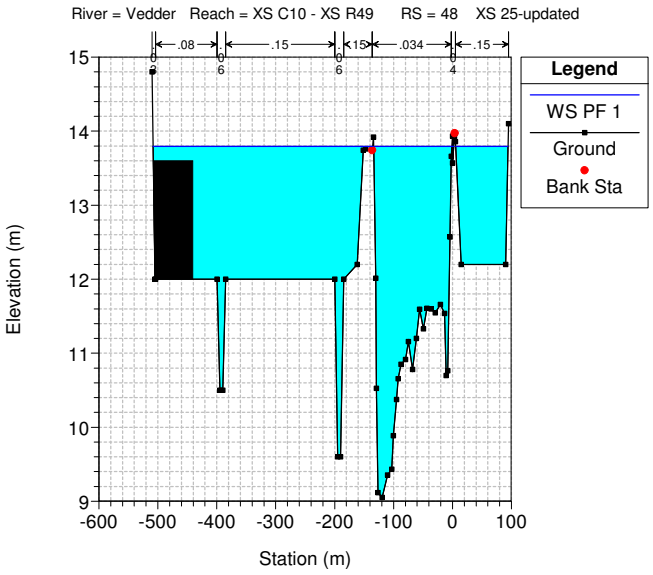

River = Vedder Reach = XS C10 - XS R49 RS = 53 XS 29-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

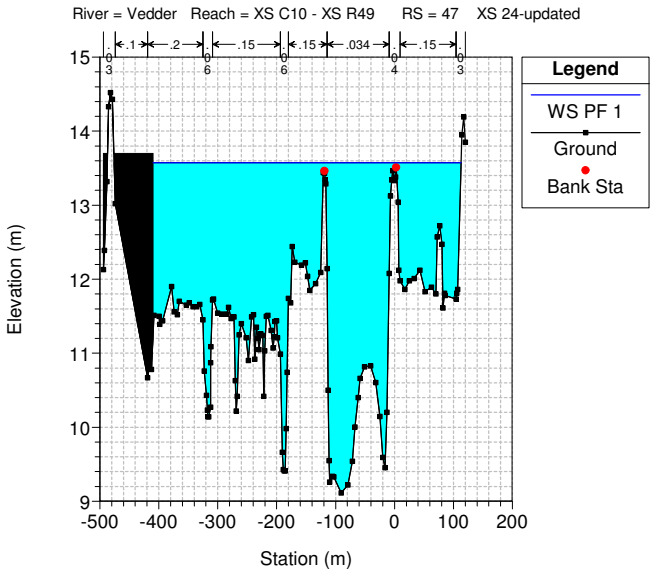

River = Vedder Reach = XS C10 - XS R49 RS = 52 XS 28-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

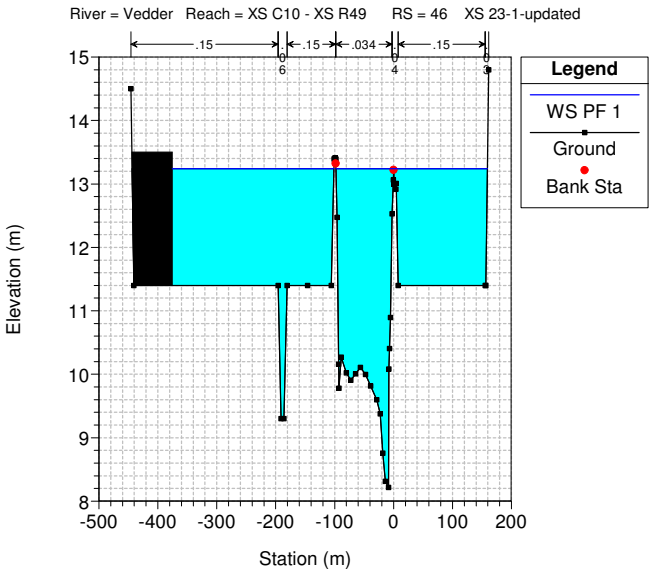

River = Vedder Reach = XS C10 - XS R49 RS = 51 XS 27-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

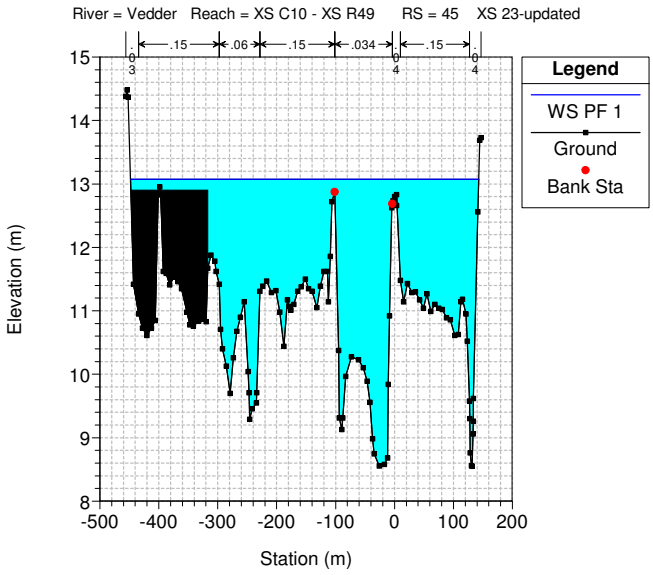

River = Vedder Reach = XS C10 - XS R49 RS = 50 XS 26-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

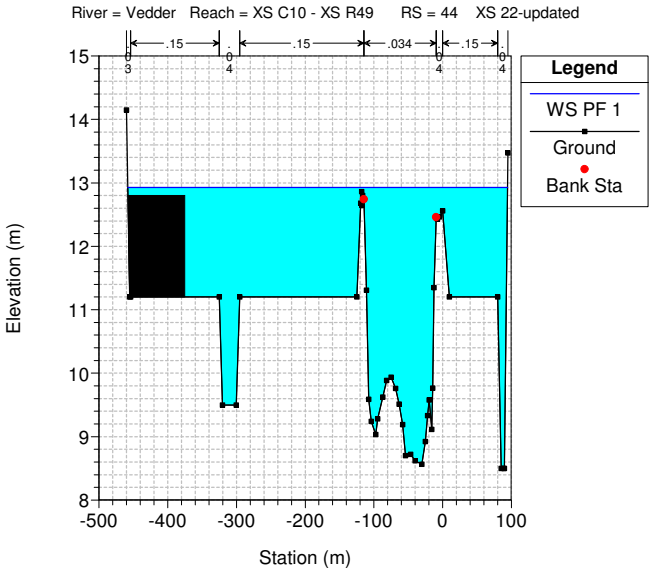
Appendix C

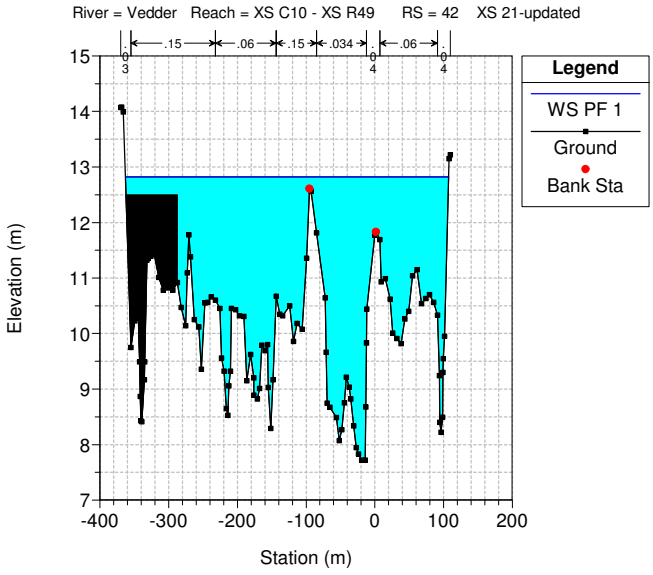

River = Vedder Reach = XS C10 - XS R49 RS = 48 XS 25-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 47 XS 24-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

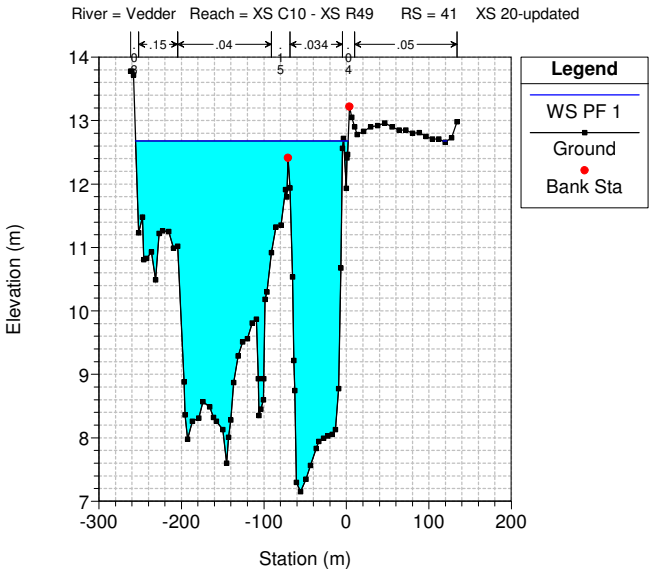

River = Vedder Reach = XS C10 - XS R49 RS = 46 XS 23-1-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

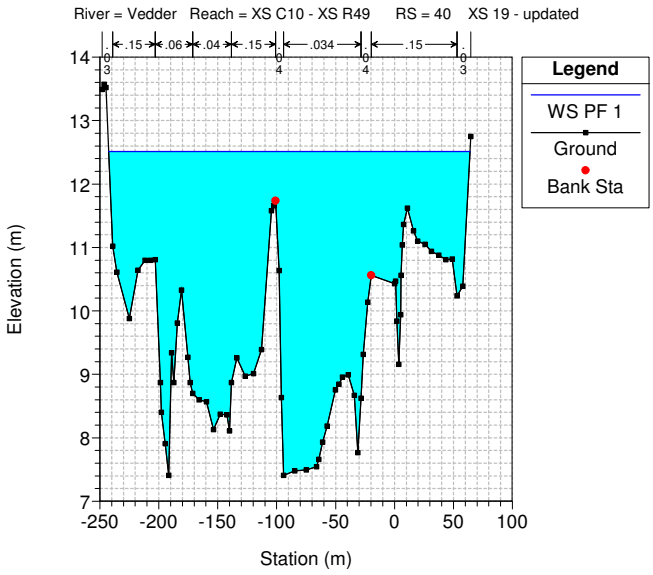

River = Vedder Reach = XS C10 - XS R49 RS = 45 XS 23-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

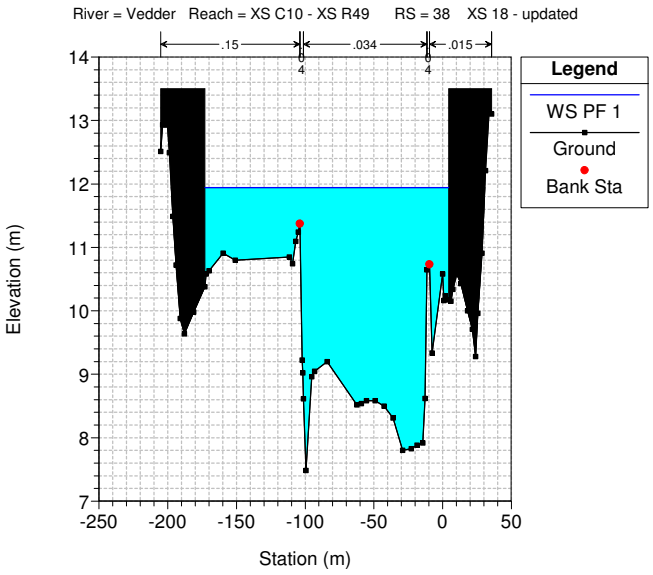

River = Vedder Reach = XS C10 - XS R49 RS = 44 XS 22-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

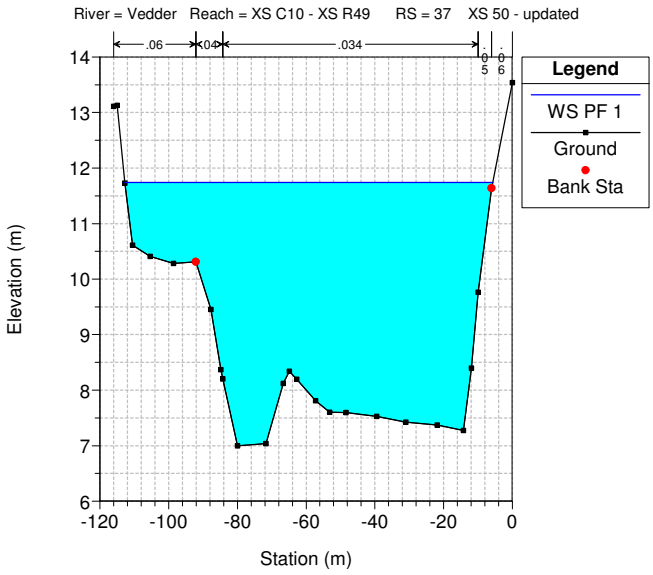

River = Vedder Reach = XS C10 - XS R49 RS = 42 XS 21-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

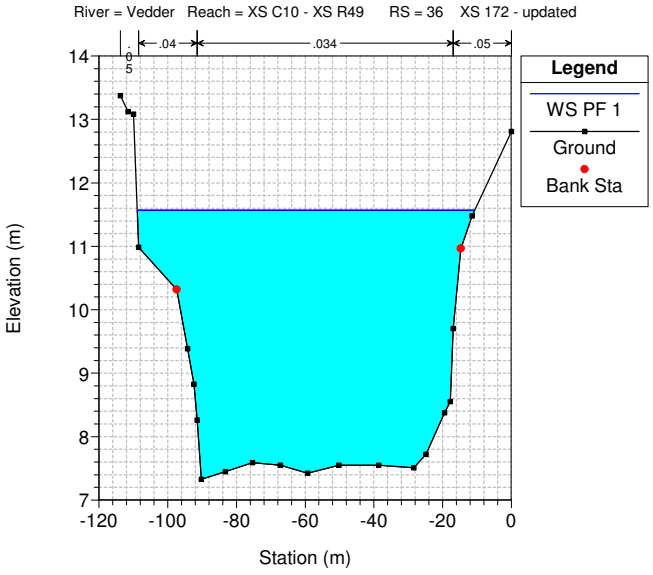
Appendix C

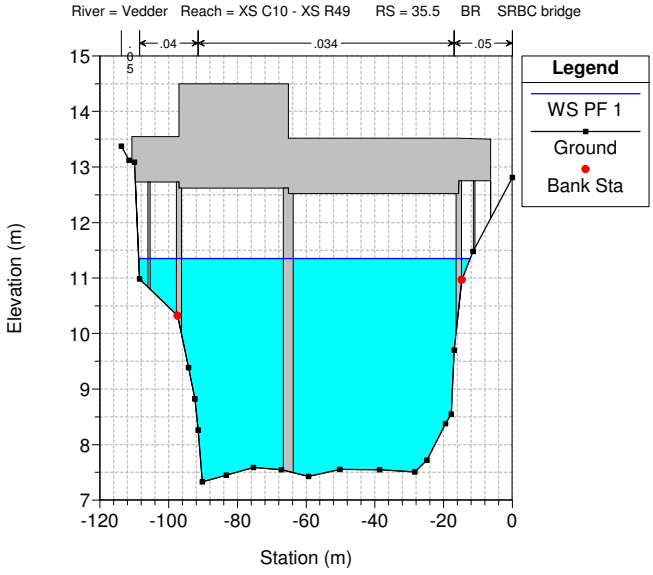

River = Vedder Reach = XS C10 - XS R49 RS = 41 XS 20-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 40 XS 19 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

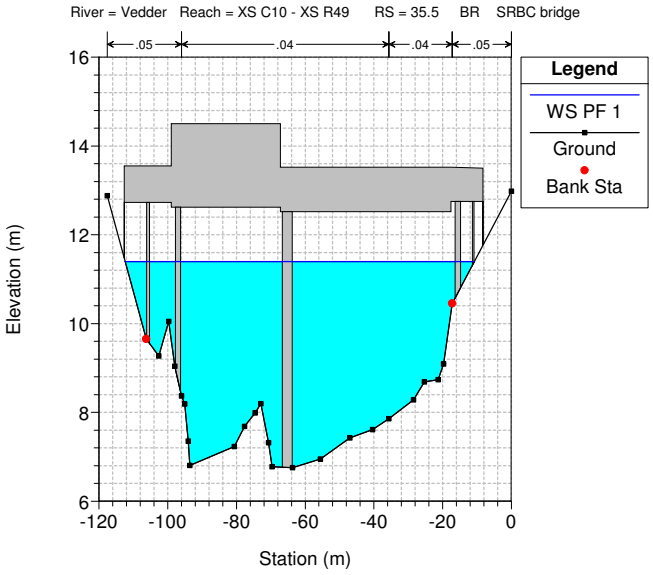

River = Vedder Reach = XS C10 - XS R49 RS = 38 XS 18 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

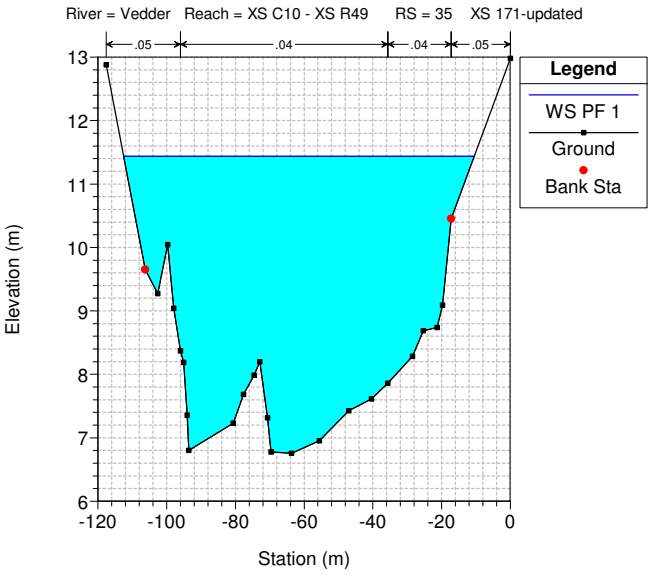

River = Vedder Reach = XS C10 - XS R49 RS = 37 XS 50 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

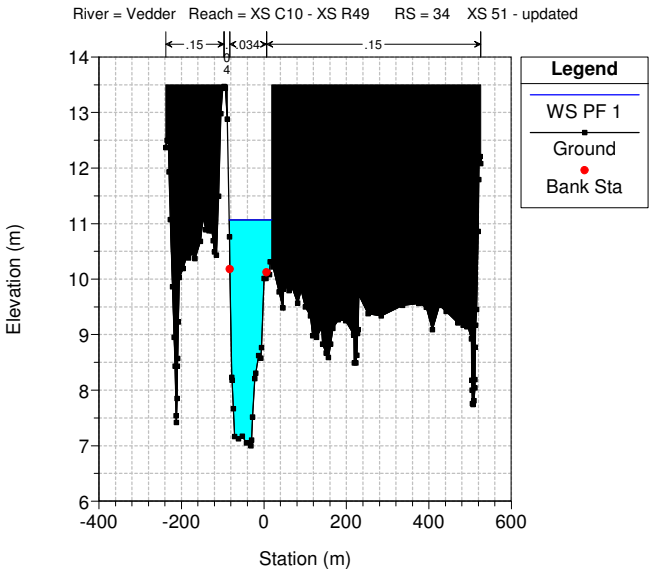

River = Vedder Reach = XS C10 - XS R49 RS = 36 XS 172 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

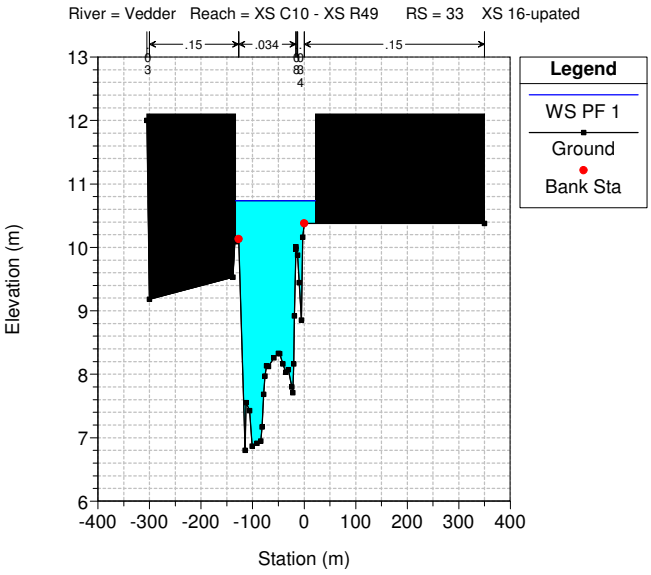

River = Vedder Reach = XS C10 - XS R49 RS = 35.5 BR SRBC bridge
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

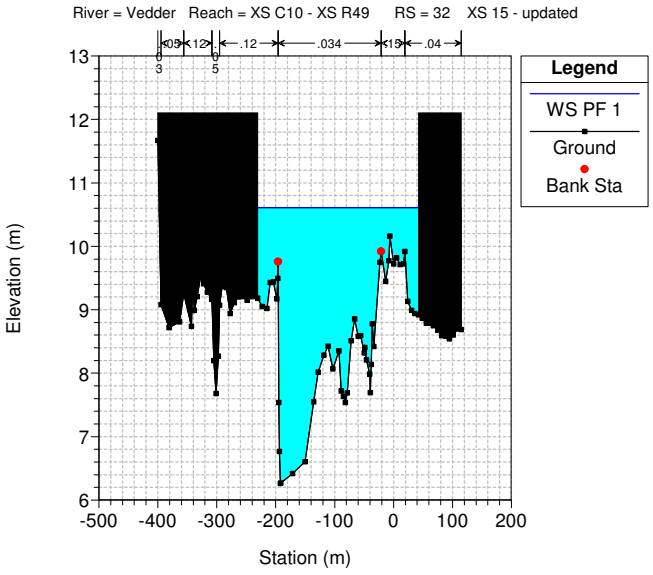
Appendix C

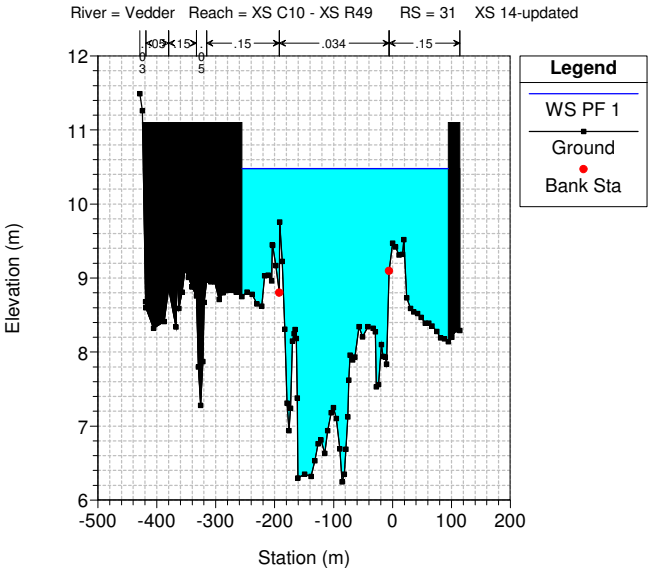

River = Vedder Reach = XS C10 - XS R49 RS = 35.5 BR SRBC bridge
.05
.04
.04
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 35 XS 171-updated
.05
.04
.04
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

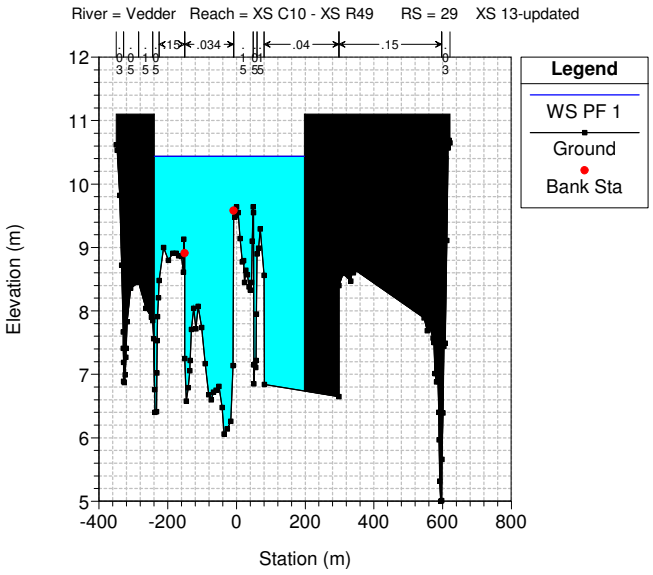

River = Vedder Reach = XS C10 - XS R49 RS = 34 XS 51 - updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

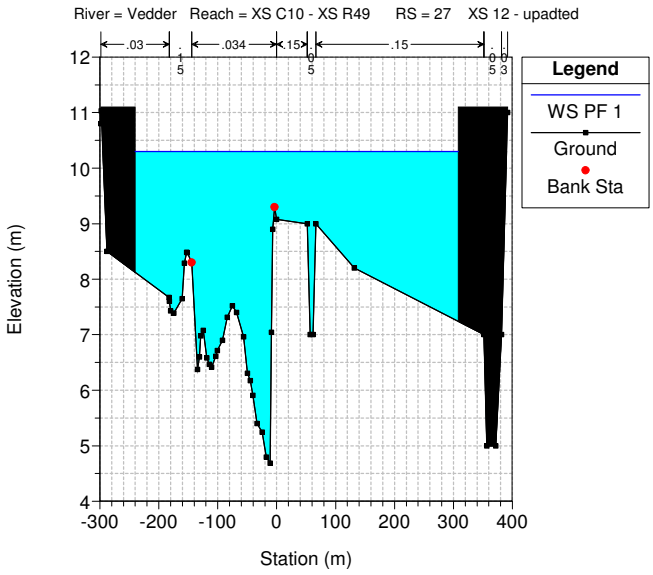

River = Vedder Reach = XS C10 - XS R49 RS = 33 XS 16-upated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

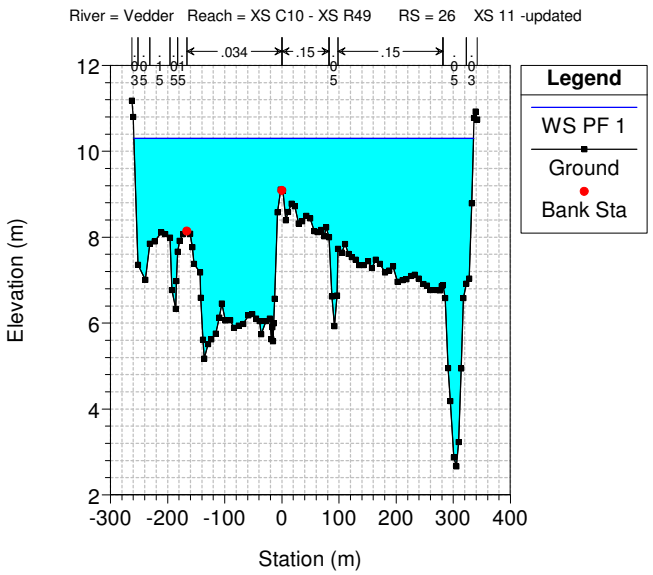

River = Vedder Reach = XS C10 - XS R49 RS = 32 XS 15 - updated
.05
.12
.12
.034
.15
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

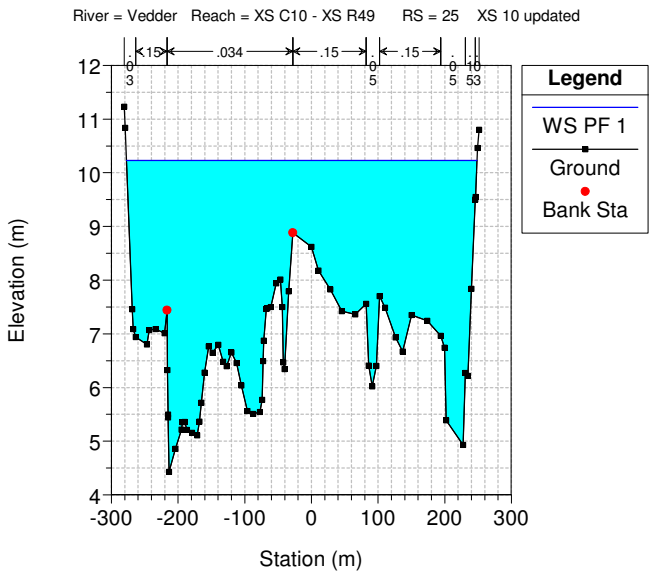

River = Vedder Reach = XS C10 - XS R49 RS = 31 XS 14-updated
.09
.15
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

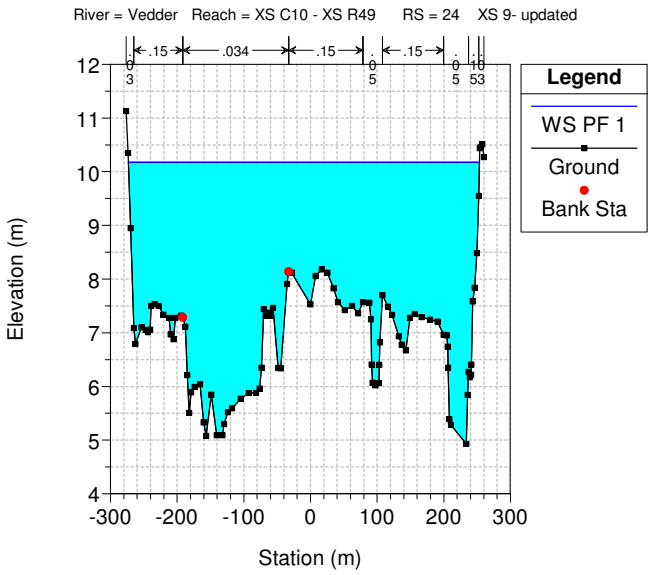
Appendix C

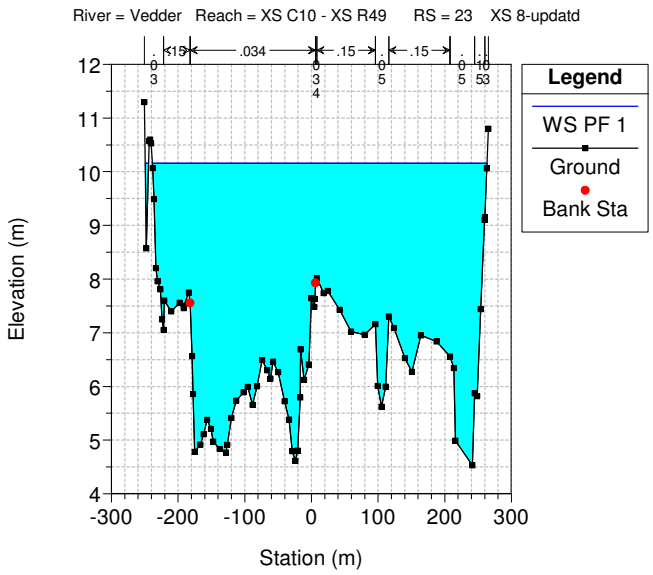

River = Vedder Reach = XS C10 - XS R49 RS = 29 XS 13-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 27 XS 12 - upadted
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

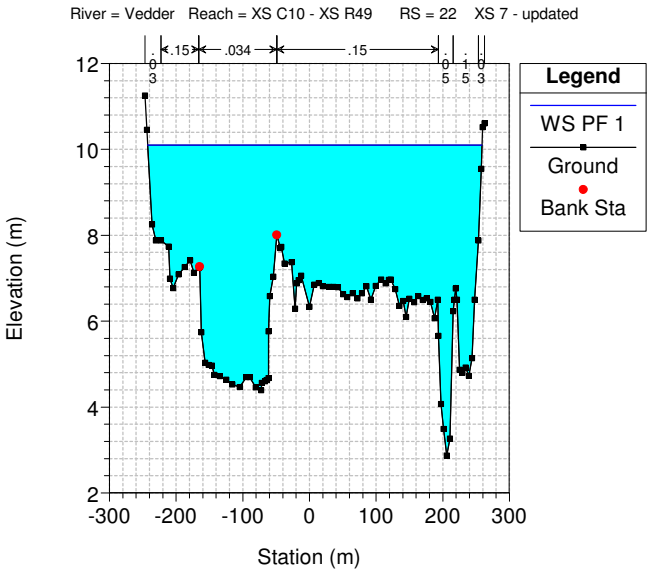

River = Vedder Reach = XS C10 - XS R49 RS = 26 XS 11 -updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

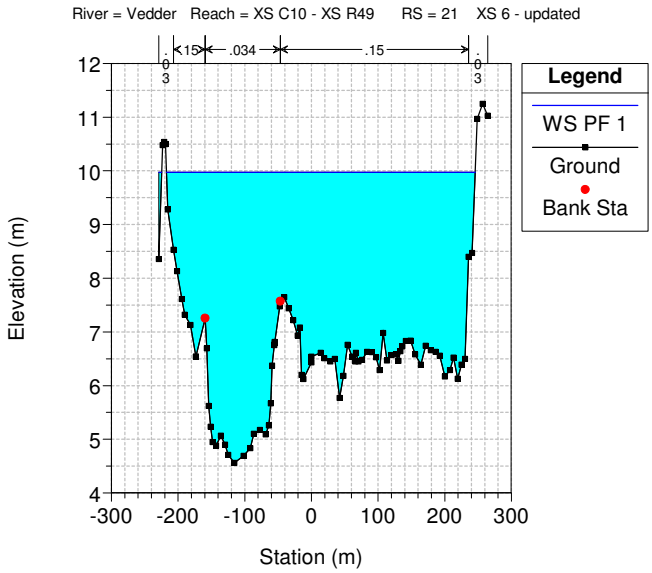

River = Vedder Reach = XS C10 - XS R49 RS = 25 XS 10 updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

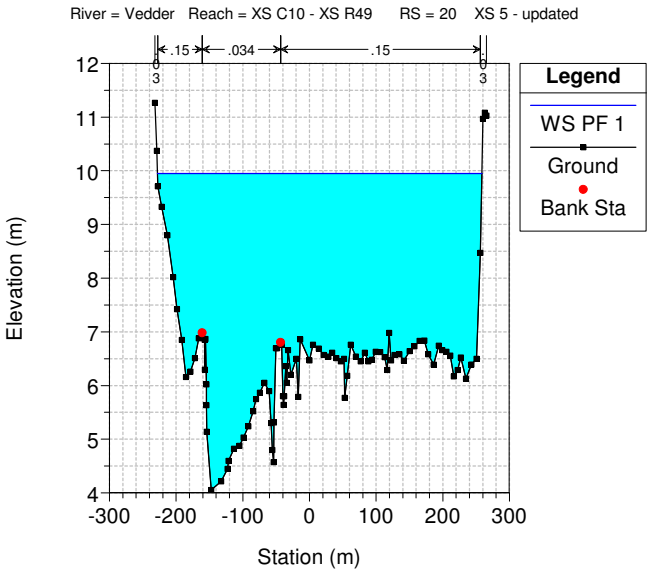

River = Vedder Reach = XS C10 - XS R49 RS = 24 XS 9- updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

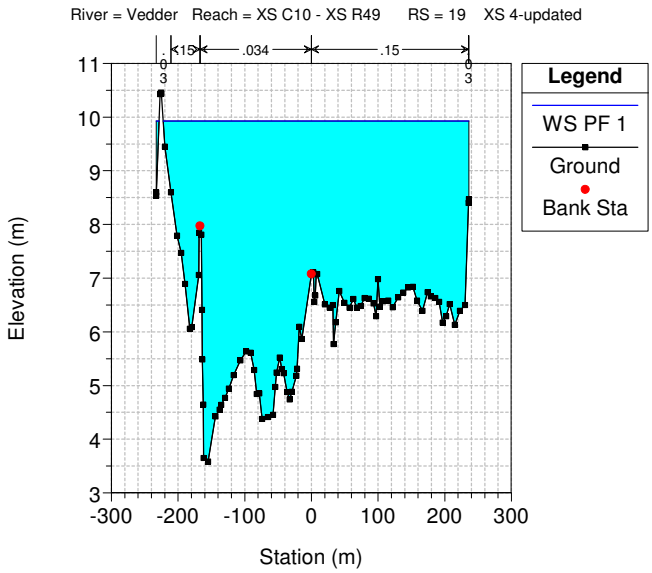

River = Vedder Reach = XS C10 - XS R49 RS = 23 XS 8-updatd
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

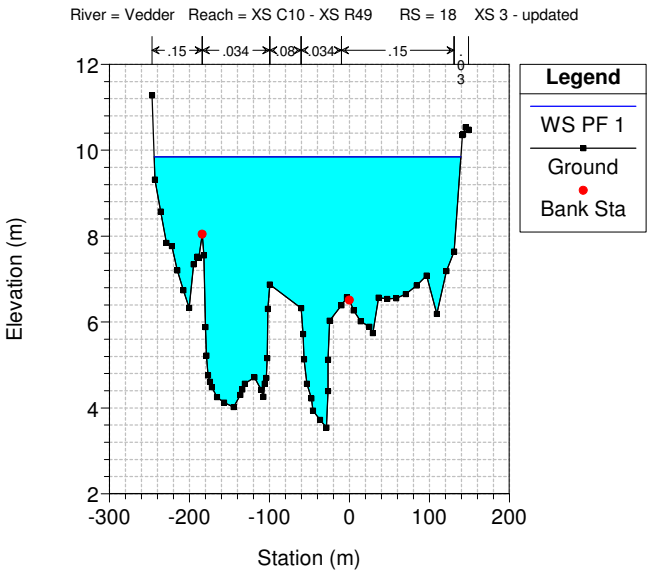
Appendix C

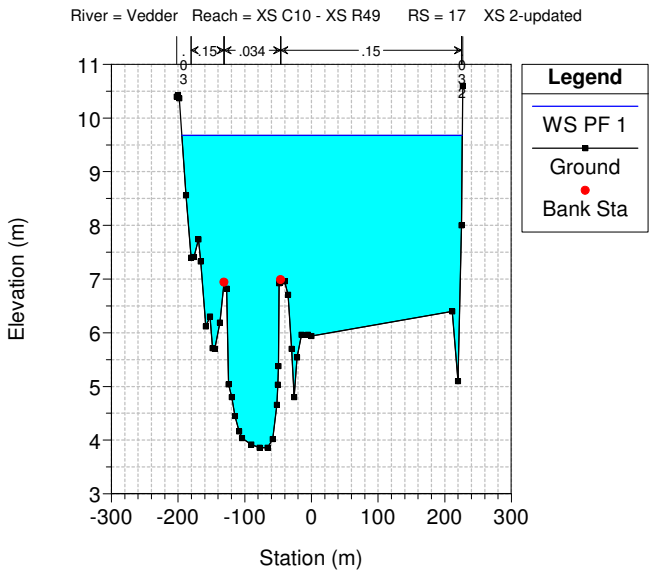

River = Vedder Reach = XS C10 - XS R49 RS = 22 XS 7 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 21 XS 6 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

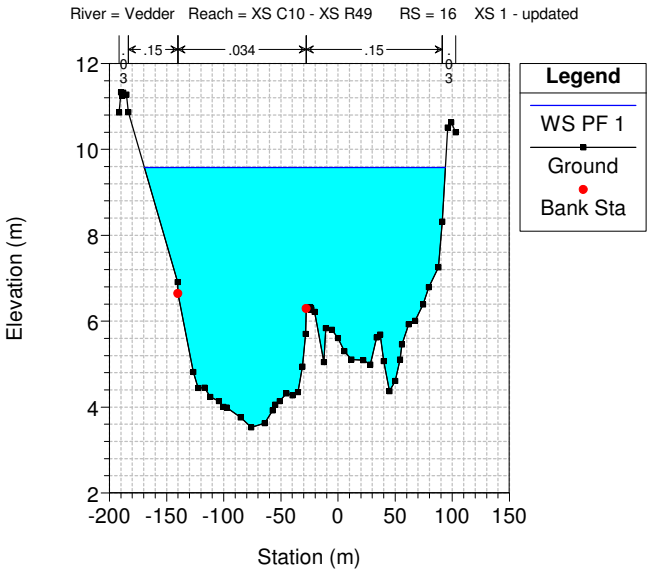

River = Vedder Reach = XS C10 - XS R49 RS = 20 XS 5 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

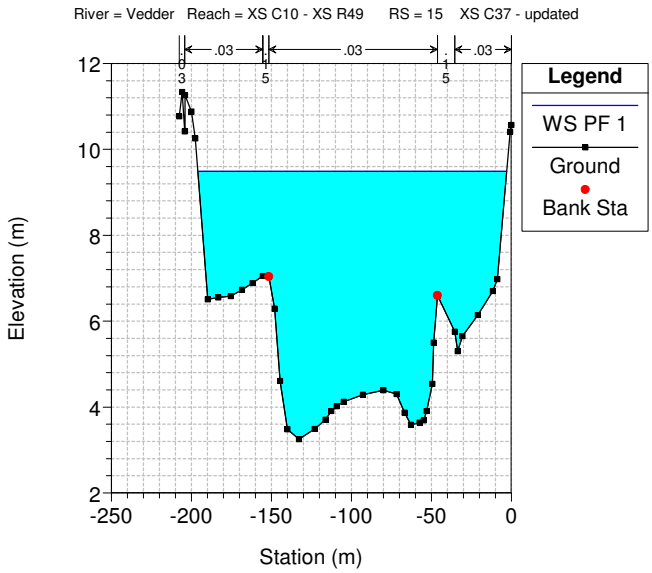

River = Vedder Reach = XS C10 - XS R49 RS = 19 XS 4-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

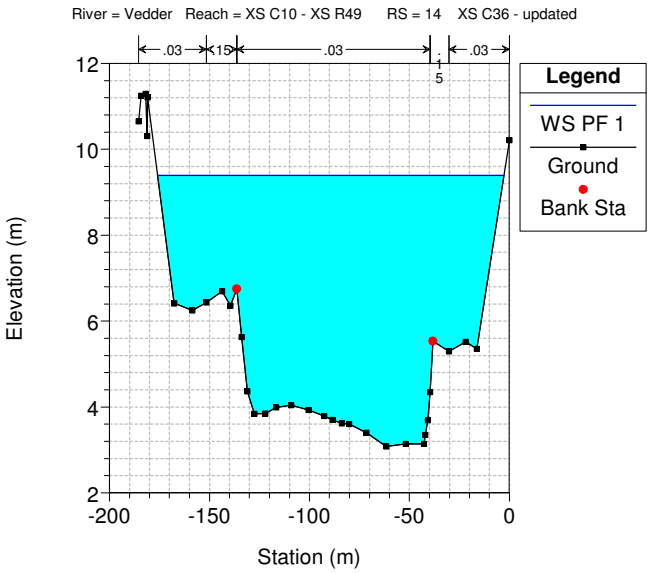

River = Vedder Reach = XS C10 - XS R49 RS = 18 XS 3 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

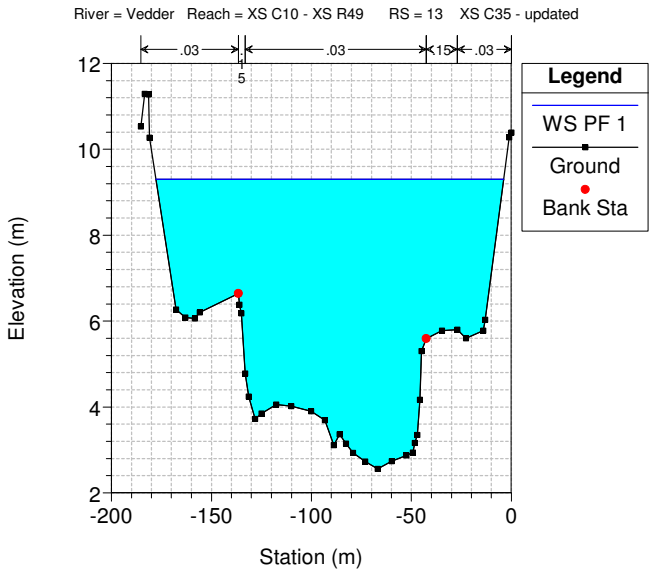

River = Vedder Reach = XS C10 - XS R49 RS = 17 XS 2-updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

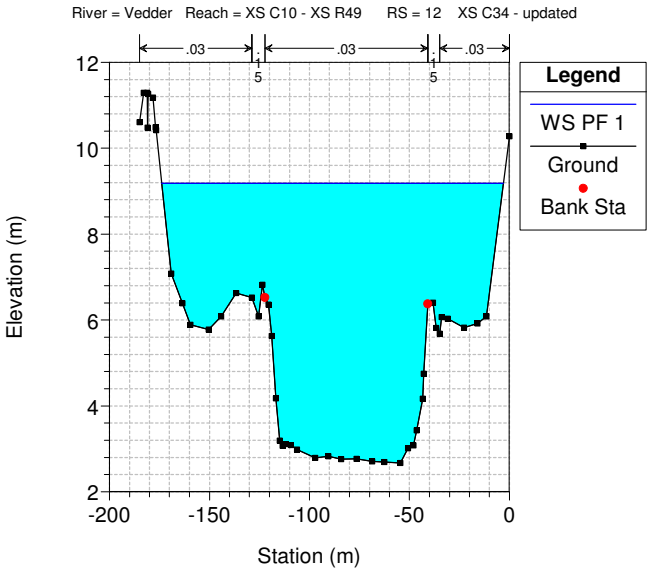
Appendix C

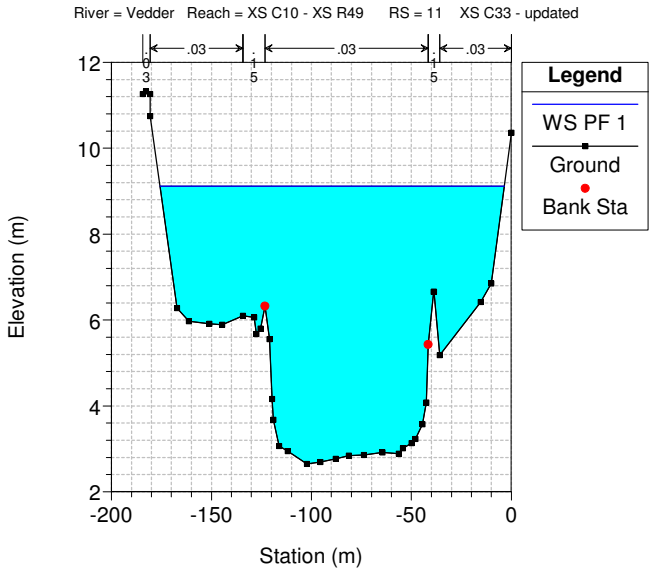

River = Vedder Reach = XS C10 - XS R49 RS = 16 XS 1 - updated
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 15 XS C37 - updated
.03
.03
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

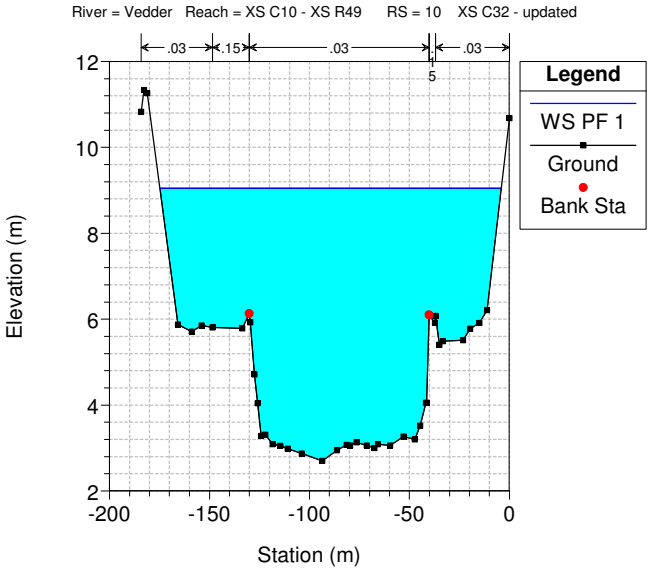

River = Vedder Reach = XS C10 - XS R49 RS = 14 XS C36 - updated
.03
.15
.03
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

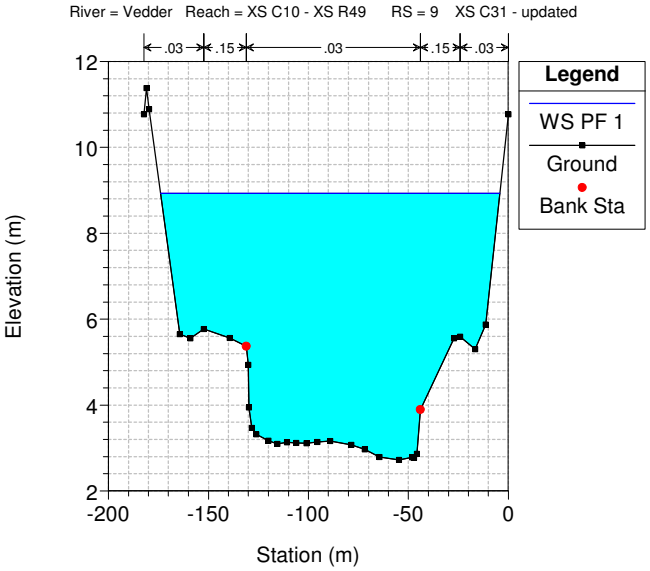

River = Vedder Reach = XS C10 - XS R49 RS = 13 XS C35 - updated
.03
.03
.15
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

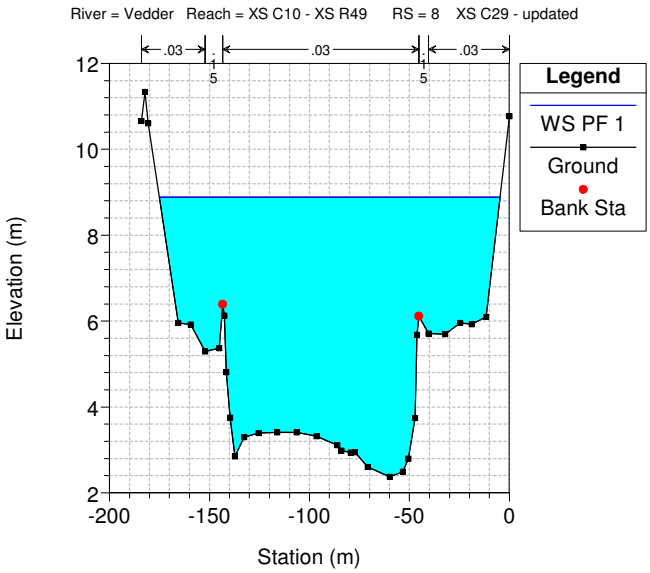

River = Vedder Reach = XS C10 - XS R49 RS = 12 XS C34 - updated
.03
.03
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

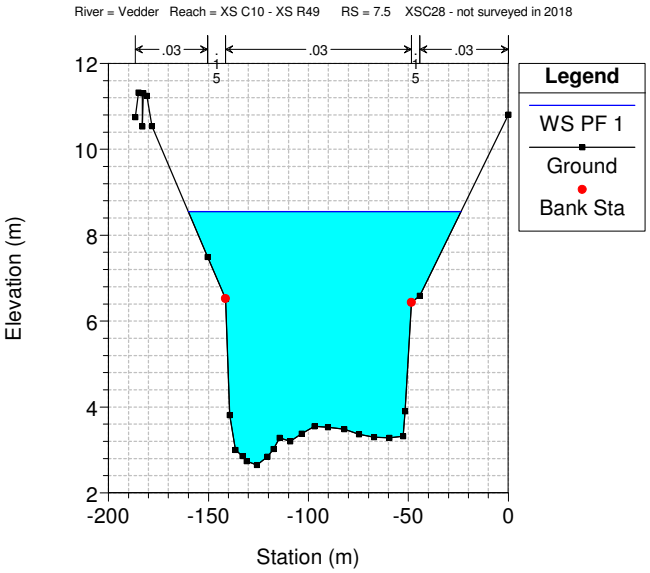

River = Vedder Reach = XS C10 - XS R49 RS = 11 XS C33 - updated
.03
.03
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

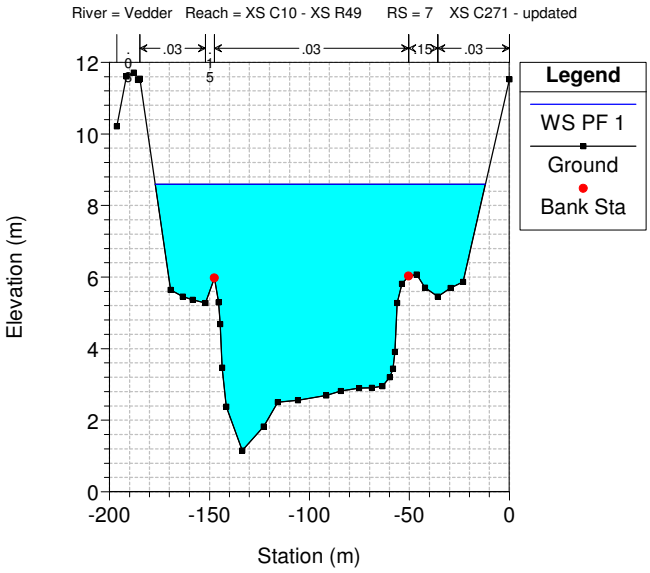
Appendix C

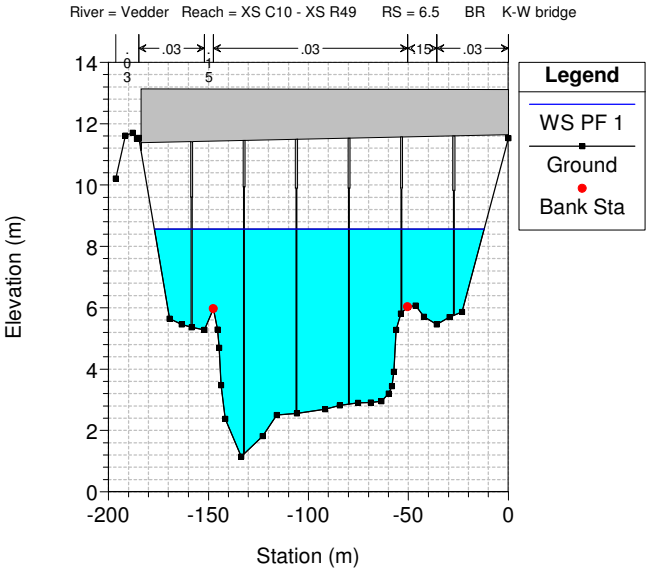

River = Vedder Reach = XS C10 - XS R49 RS = 10 XS C32 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 9 XS C31 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

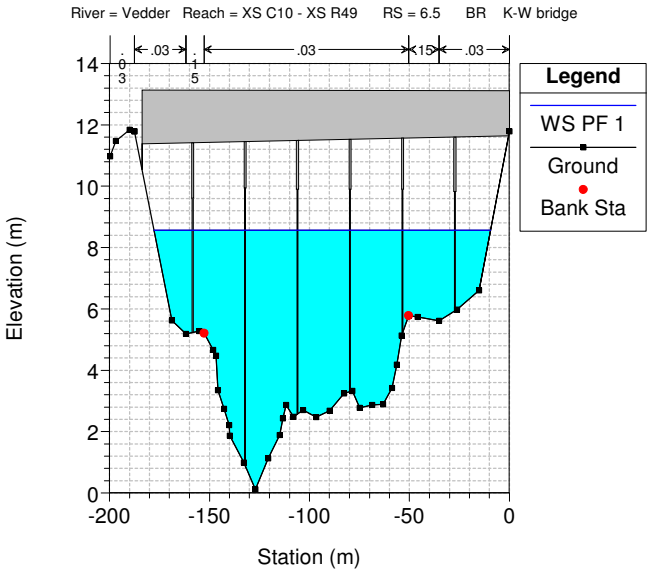

River = Vedder Reach = XS C10 - XS R49 RS = 8 XS C29 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

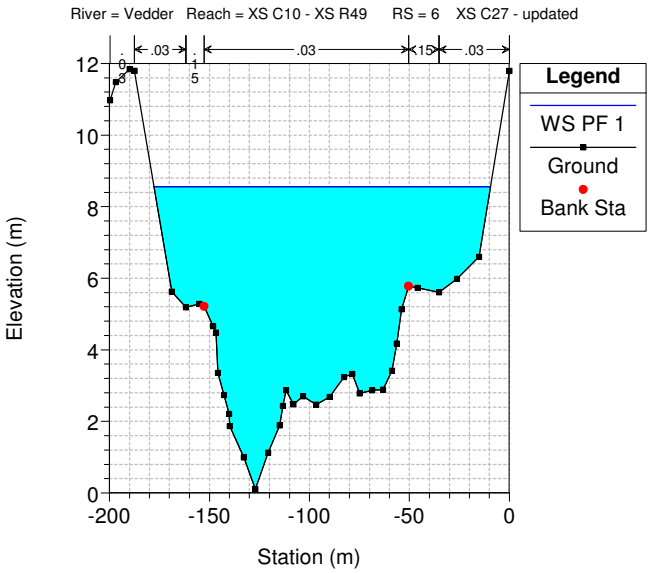

River = Vedder Reach = XS C10 - XS R49 RS = 7.5 XSC28 - not surveyed in 2018
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

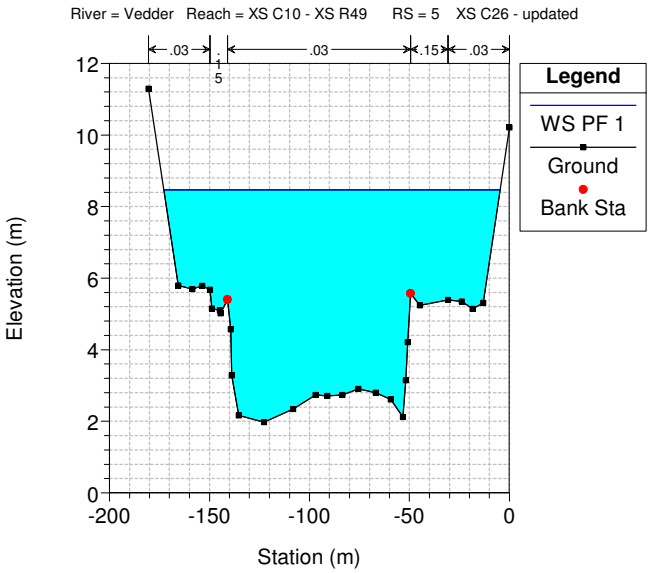

River = Vedder Reach = XS C10 - XS R49 RS = 7 XS C271 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

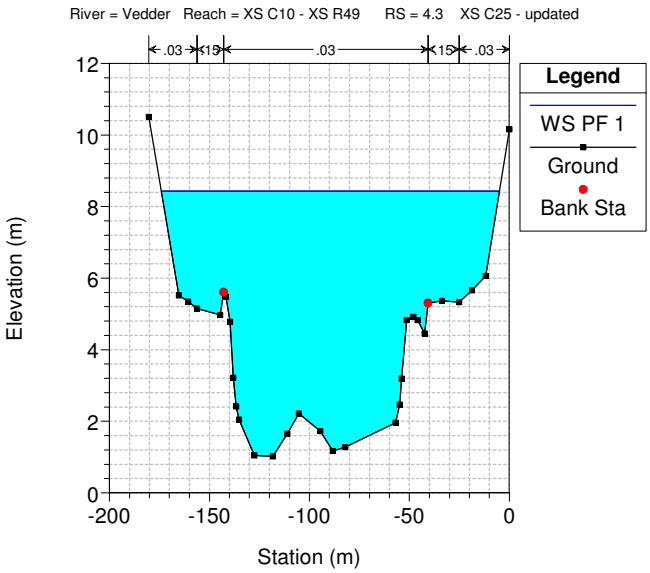

River = Vedder Reach = XS C10 - XS R49 RS = 6.5 BR K-W bridge
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

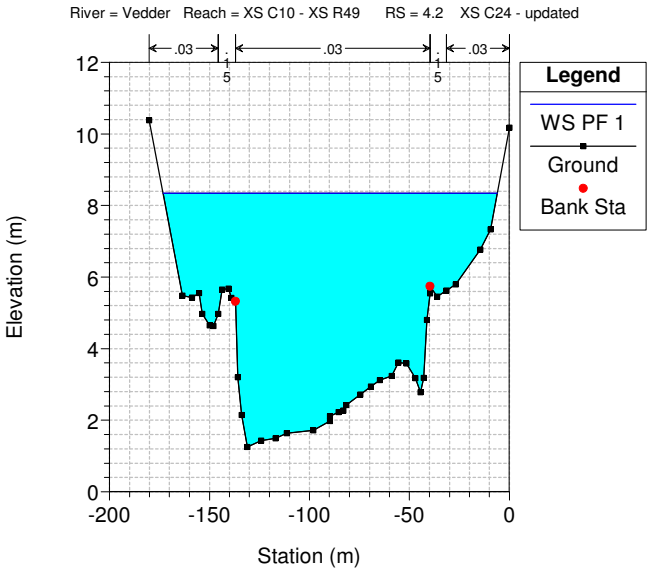
Appendix C

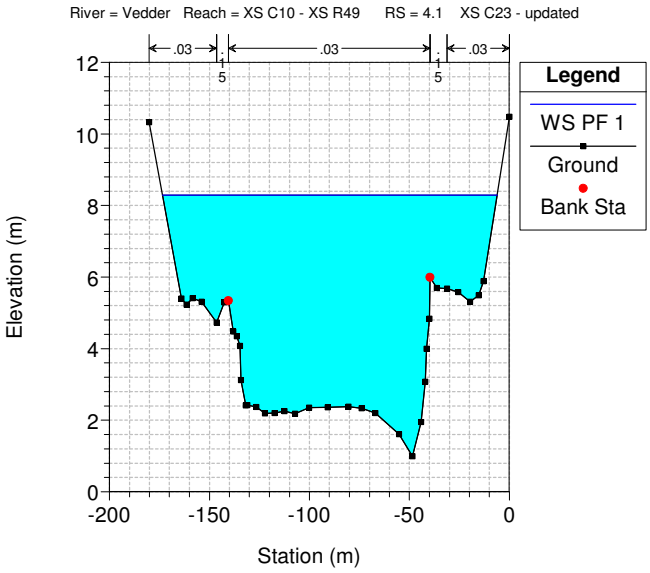

River = Vedder Reach = XS C10 - XS R49 RS = 6.5 BR K-W bridge
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


River = Vedder Reach = XS C10 - XS R49 RS = 6 XS C27 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

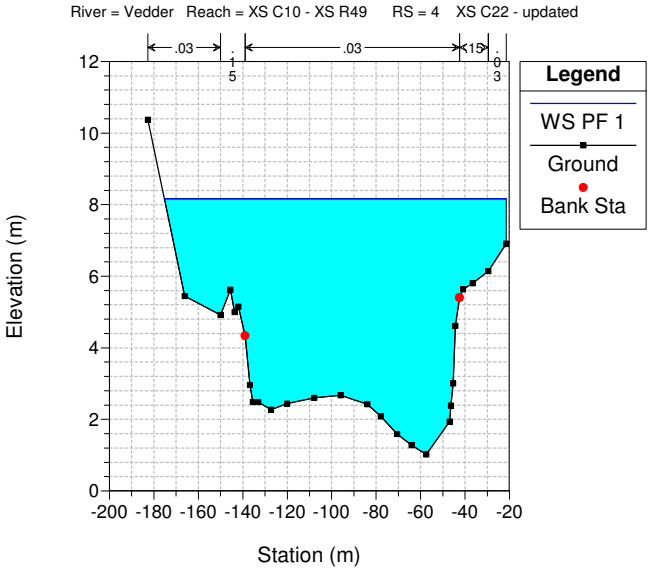

River = Vedder Reach = XS C10 - XS R49 RS = 5 XS C26 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

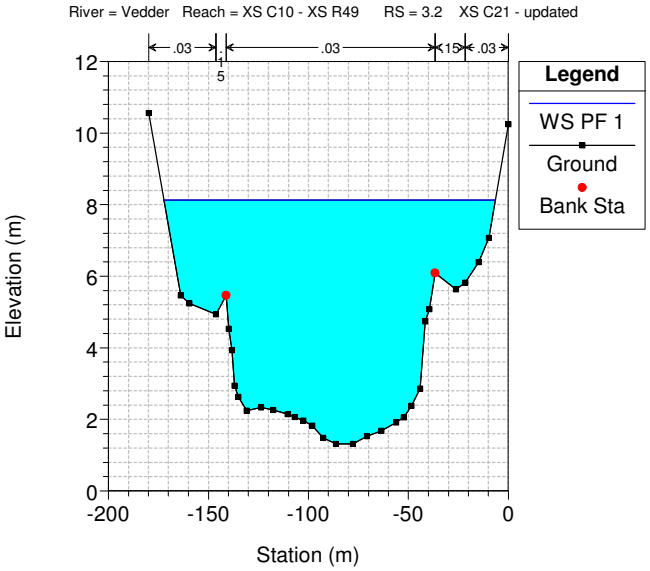

River = Vedder Reach = XS C10 - XS R49 RS = 4.3 XS C25 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

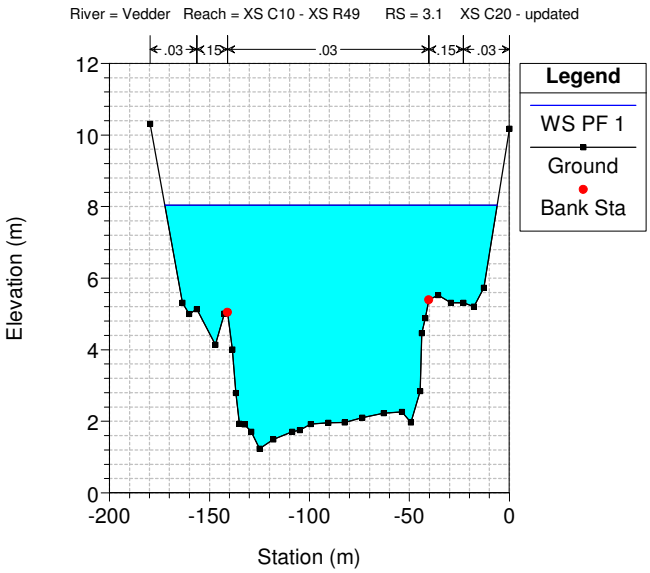

River = Vedder Reach = XS C10 - XS R49 RS = 4.2 XS C24 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

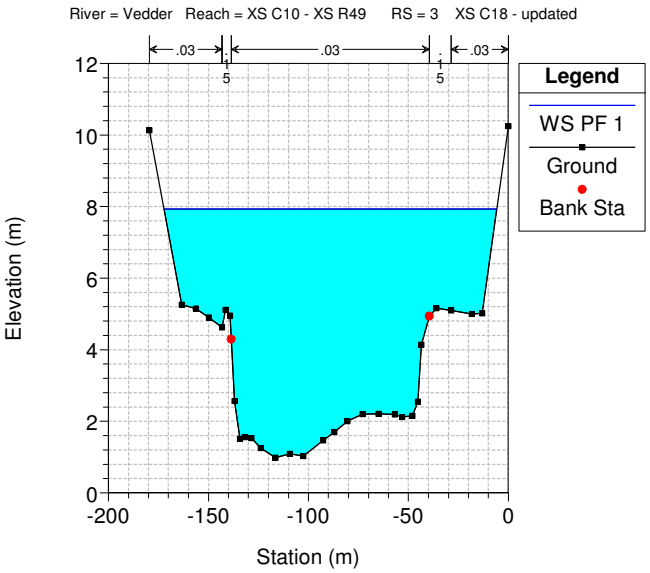

River = Vedder Reach = XS C10 - XS R49 RS = 4.1 XS C23 - updated
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

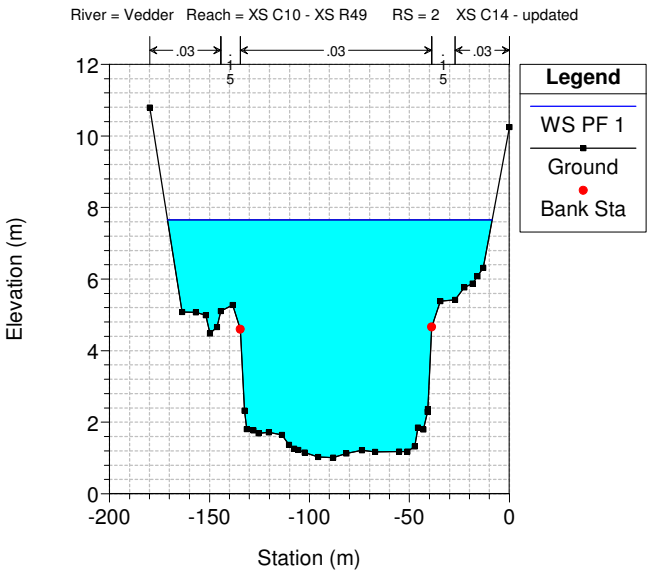
Appendix C


River = Vedder Reach = XS C10 - XS R49 RS = 4 XS C22 - updated
.03
.03
.15
.03
1
5
1
5
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -180 -160 -140 -120 -100 -80 -60 -40 -20


River = Vedder Reach = XS C10 - XS R49 RS = 3.2 XS C21 - updated
.03
.03
.15
.03
1
5
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -150 -100 -50 0


River = Vedder Reach = XS C10 - XS R49 RS = 3.1 XS C20 - updated
.03
.15
.03
.15
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -150 -100 -50 0


River = Vedder Reach = XS C10 - XS R49 RS = 3 XS C18 - updated
.03
.03
.03
1
5
1
5
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -150 -100 -50 0


River = Vedder Reach = XS C10 - XS R49 RS = 2 XS C14 - updated
.03
.03
.03
1
5
1
5
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
0
2
4
6
8
10
12
-200 -150 -100 -50 0