APPENDIX G3. HYDRAULIC ANALYSIS REPORT

Huntington Flood Damage Reduction Study

Hydraulic Analysis Report

Appendix G3

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Purpose

The purpose of the Huntington Flood Study is to determine the effectiveness of various alternative designs with the goal of reducing flood damages in the Huntington community caused by the Cameron Run.

Modeling Details

The hydraulic modeling was completed using the Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 3.3. The original model is a HEC-RAS model created by the Virginia Department of Transportation (VDOT) and has been subsequently updated by the US Army Corps of Engineers (COE). The HEC-RAS model includes the Route 1 improvements that VDOT has recently completed, however, it does not include the proposed improvements to Telegraph Road and the Capital Beltway (I-495/I-95) upstream of Huntington. The original model has been georeferenced to include GIS information and updated to the latest version of HEC-RAS (version 3.1.3). The hydrologic flow values have also been updated to reflect changes based on a new hydrologic study performed by the US Army Corps of Engineers. Table1 lists the titles of the previous studies and dates they were completed.

Table 1: Previous Studies of the Huntington Community and the Cameron Run Watershed

Previous Study Title	Date Completed	Study Author	Study Description
Arlington Terrace Storm Drainage Study	April 1982	Water Resources Division of Camp Dresser & McKee Inc.	Hydrologic and Hydraulic Study of the Cameron Run Watershed including possible flooding solutions.
Woodrow Wilson Bridge Project: Cameron Run Hydrologic and Hydraulic Study	February 2002	Virginia Department of Transportation	Original HEC-RAS model studying the effects of new bridge construction on Cameron Run.
June 2006 Flood Investigation for Cameron Run Fairfax County, VA	January 2007	US Army Corps of Engineers	Study prepared for Fairfax Co., VA Updated VDOT model studying the flood event of June 2006.
Hydrologic and Hydraulic Analysis for the Cameron Run Watershed in Northern Virginia	May 2007	US Army Corps of Engineers	Study prepared for FEMA including updated hydrology and hydraulic models on which this study is based.

Study Location and Areas of Interest

The study focused on the Huntington and Huntington Station communities located in Fairfax County, Virginia adjacent to the Cameron Run. The area of interest extends from the Washington Metro bridge crossing Cameron Run to the Riverside Apartment development downstream of the community. The hydraulic model covers a much larger area extending from the Beltway (I-495) bridge upstream to the confluence with the Potomac River downstream.

Modeling

Original HEC-RAS Model

The original HEC-RAS model for the Woodrow Wilson Bridge Project was completed in February 2002 by VDOT. The channel geometry, Manning's n values, and bridge geometries were taken directly from this model. The VDOT model was completed using HEC-RAS version 2.2.

The original model appears to have surveyed cross-sections for the channel portion of each cross-section with the overbanks using either 10 or 20 foot contour data picked from a map.

Updating the Model

The model was updated by loading the older files into the newest version of HEC-RAS and rerunning the plan data to recalculate the water surface profiles. A comparison of the outputs from RAS version 3.1.3 and version 2.2 showed a negligible difference in water surface profiles and no further investigation into the differences was deemed necessary.

Georeferencing the Model

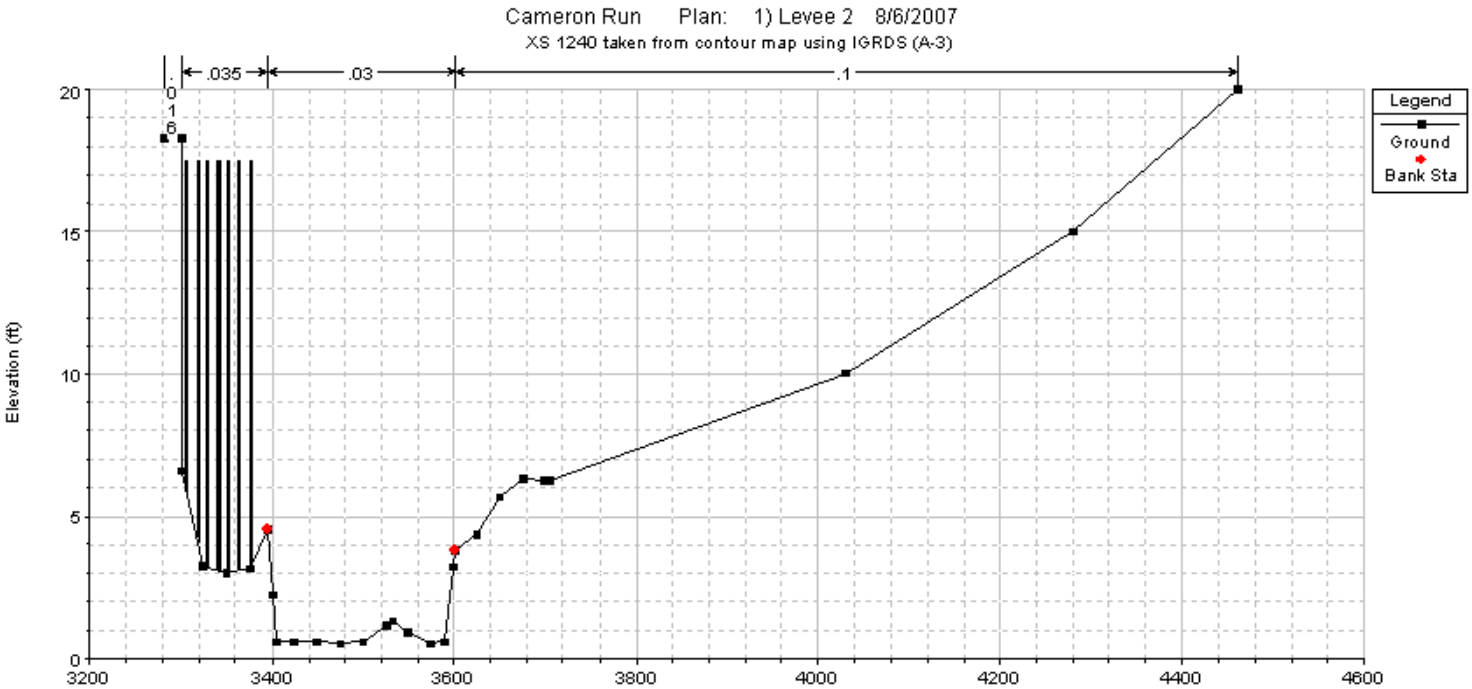
The original model did not have any georeferencing information associated with the cross-sections or stream centerline. Georeferenced information places the surveyed information into a coordinate system that allows the model to be displayed or "georeferenced" in any GIS software package. This allows for easy location and comparison to other GIS layers of information and is valuable for mapping the locations of the model results. The georeferencing was accomplished using ESRI ArcMap software in conjunction with the HEC-GeoRAS extension. The cross-section locations were determined using existing GIS information including layers and aerial photos provided by Fairfax County. See Appendix A for maps with the georeferenced cross-sections.

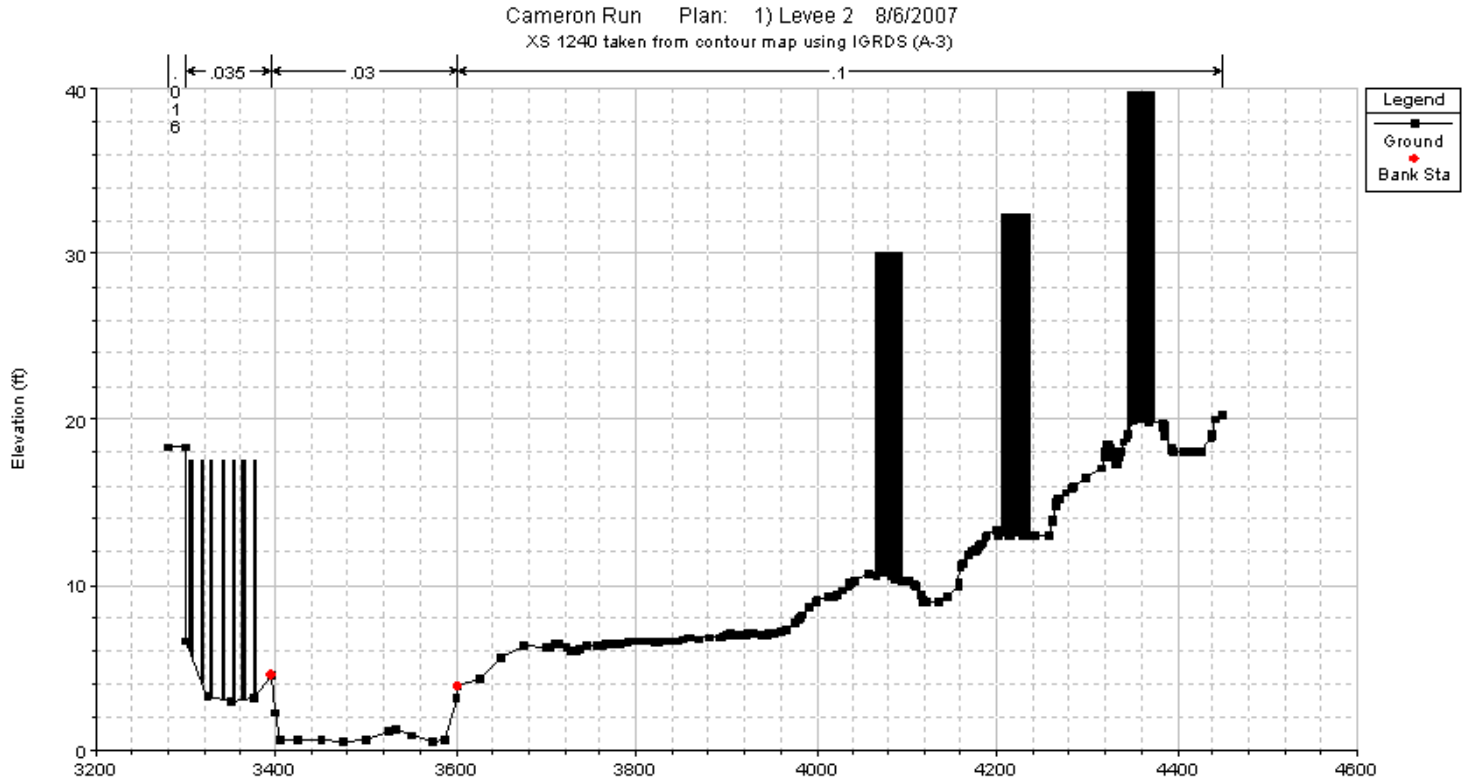
Refining the Overbank Areas

The overbank areas in the original model were most likely picked from a 10 or 20 foot contour map and therefore were inaccurate. GIS data was used for the overbank areas including 1 foot contour maps and points provided by Fairfax County. The overbank areas were imported from GIS into the HEC-RAS model. The old information was replaced by the newer contour information. The surveyed channel information was not changed. Buildings were also shown in each cross-section as a blocked obstruction.

Figure 1 shows the difference between the original cross-section and the cross-section with the refined overbanks.

Figure 1. Cross-section comparison





Preliminary Plans and Alternatives

A number of alternative solutions were modeled for the Huntington FDRS. Many of the alternatives are combinations of several hydraulic designs. The two main hydraulic designs used in the study are levees and channel dredging.

Table 2 is a list of the plans and alternatives with a description of the features that are modeled in HEC-RAS.

Table 2: List of Plans and Alternatives with Descriptions

Plan	Geometry	Flow	Description
Existing w/ updated HMS flows	Existing Georeferenced	Updated flows from new HMS model	Existing georeferenced model with the HMS updated flows
Levee Alignment #1	Levee #1	Updated flows from new HMS model	Existing georeferenced model with the Levee #1 alignment closest to the stream banks
Levee Alignment #2	Levee #2	Updated flows from new HMS model	Existing georeferenced model with the Levee #2 alignment half way between the housing and the stream banks
Levee Alignment #3 *Concept Plan 2*	Levee #2	Updated flows from new HMS model	Alignment refined to avoid wetlands which causes negligible hydraulics effects, therefore used the model with Levee #2 alignment
Dredging Alternative #1	With dredging 5 ft deep full length to river	Updated flows from new HMS model	Model with dredging from the Potomac river to upstream of Huntington
Dredging Alternative #2	With dredging 5 ft deep to Rt 1 bridge	Updated flows from new HMS model	Shorter dredging from Metro bridge to upstream of US Route 1 bridge
Dredging Alternative #3	With dredging 5 ft deep to sanitary siphon	Updated flows from new HMS model	Shorter dredging from Metro bridge to just upstream of sanitary siphon that goes under the channel
Combined Dredging #2 and Levee #2	Dredging #2 and Levee #2	Updated flows from new HMS model	Combination of dredging alternative #2 and levee alignment #2
Combined Dredging #3 and Levee #3	Dredging #3 and Levee #2	Updated flows from new HMS model	Combination of dredging alternative #3 and levee alignment #3 (same model as Levee #2)
Combined Dredging #4 and Levee #3 *Concept Plan 1*	Dredging #4 (2.5 ft deep to siphon) and Levee #2	Updated flows from new HMS model	Combination of dredging alternative #4 (dredge 2.5 ft deep from Metro Bridge to siphon) and levee alignment #3 (same model as Levee #2)

Levee Alignment #1

The Levee Alignment #1 alternative studied the hydraulic effects of a full levee protecting the community of Huntington. The levee alignment was placed as close to Cameron Run as possible. Advantages of this alternative include more available storage area behind the levee for interior flooding storage. Levee Alternative #1 also allows room for the existing recreational areas to maintain their function. Disadvantages of the alternative include higher flood levels that may cause flooding on the opposite bank across the Beltway and upstream. The alignment also affected some small "wetland" areas near the channel banks.

See Appendix B for maps of the features for this alternative.

Results
Levee Alternative #1 raised the water surface profile as much as 0.7 feet for the 1% annual chance flood event upstream of Huntington with the increase stretching as far as the Telegraph Road bridge (0.3 feet).

See Appendix C for the output table for this alternative.

Levee Alignment #2

The Levee Alignment #2 alternative studied the hydraulic effects of placing the levee further away from the channel bank. Advantages of Levee Alignment #2 include increased flood capacity of the channel and floodplain and avoidance of wetland areas. Disadvantages include decreased interior flooding storage and destruction of recreational areas.

See Appendix B for maps of the features for this alternative

Results
Levee Alternative #2 raised the water surface profile as much as 0.6 feet for the 1% annual chance flood event upstream of Huntington with the increase stretching as far as the Telegraph Road bridge (0.2 feet).

See Appendix C for the output table for this alternative.

Dredging Alternative #1

Dredging Alternative #1 looked at the hydraulic effects of dredging the Cameron Run channel 5 feet below the current channel invert. The dredging extends from upstream of the Huntington community downstream to the confluence with the Potomac River.

Originally this alternative called for a 200 foot channel width but this was revised to 150 feet because of channel and dredging restraints. Advantages of this alternative are more flood capacity within the channel. Disadvantages include project sustainability because the effectiveness of dredging is based on periodic maintenance.

See Appendix B for maps of the features for this alternative.

Results

Dredging Alternative #1 lowered the flood stages approximately 1.7 feet for the 1% annual chance flood event. The channel invert slope was set at 0.0004 to maintain a constant slope throughout the system. Problems with this alternative include dredging around the piers along and within the channel and a sewer pipe that runs beneath the channel that would need to be relocated to dredge to the designed depth.

See Appendix C for the output table for this alternative.

Dredging Alternative #2

Dredging Alternative #2 is the same as Dredging Alternative #1 except that the extent of the dredging is limited. The dredging in this alternative extends from the Metro bridge to upstream of the US Route 1 bridge. The advantages and disadvantages are the same as Dredging Alternative #1.

See Appendix B for maps of the features for this alternative.

Results

Dredging Alternative #2 lowered the flood stages approximately 1.3 feet for 1% annual chance flood event. The dredging is stopped upstream of Route 1 and as a result an inverse slope is created at the Route 1 bridge.

See Appendix C for the output table for this alternative.

Dredging Alternative #3

Dredging Alternative #3 is the same as Dredging Alternative #2 except that the extent of the dredging is more limited than the previous two alternatives to avoid relocating the sanitary siphon. The dredging in this alternative extends from upstream of the Huntington community (Cross-section 1389) to upstream of the siphon sewer line (Cross-section #595). The advantages and disadvantages are the same as Dredging Alternative #1 and #2.

See Appendix B for maps of the features for this alternative.

Results
Dredging Alternative #3 lowered the flood stages approximately 0.6 feet for the 1% annual chance flood event. The dredging is stopped upstream of the siphon sewer pipe and as a result an inverse slope is created at the siphon sewer pipe.

See Appendix C for the output table for this alternative.

Combined Alternatives Dredging #2 and Levee Alignment #2

Another alternative was to combine alternatives into a single solution. In this case the shorter dredging option (#2) with the Levee Alignment #2 was used so that the dredging would lower the flood stages enough to offset the increase created by constructing the levee.

See Appendix B for maps of the features for this alternative.

Results
The combined alternative succeeded in lowering the flood stage approximately 1.0 feet for the 1% annual chance flood event just upstream of the Huntington levee.

See Appendix C for the output table for this alternative.

Combined Alternatives Dredging #3 and Levee Alignment #3

The second combination of alternatives is to combine a short dredging option (Dredging Alternative #3) with a refined levee alignment (Levee Alignment #3).

The third dredging option extends from the upstream of Huntington to the siphon sewer pipe at a depth of 5 feet. Levee Alignment #3 is very similar to Levee Alignment #2 with some refinements made to avoid wetland areas and to tie into high ground. Levee Alignment #2 was used to model Levee Alignment #3 because the minor differences in the alignments have a negligible hydraulic effect on the flood stages.

Advantages of this combination of alternatives are largely based on constructability and cost rather than hydraulic factors, but do include the benefits of the dredging offsetting the increased flooding created by the levee. Disadvantages are the same as those associated with Levee Alignment #2, including decreased interior flooding storage.

See Appendix B for maps of the features for this alternative.

Results

The combined alternative lowers the flood stages about 0.4 feet for the 1% annual chance flood event just upstream of the Huntington levee. Dredging alternative #3 does offset the stage increase caused by the levee alignment #3.

See Appendix C for the output table for this alternative.

Final Concept Plans:

Two plans were considered for further study, Plan 1 and Plan 2. Plan 1 is a combination of a new Dredging Alternative #4 and Levee Alignment #3. The dredging in this alternative #4 is 2.5 feet deep and extends from upstream of the Huntington community (cross-section 1389) to upstream of the siphon sewer line (cross-section #595). The initial dredging will be 5 feet deep, to allow for sediment to fill in. When the sediment fills in to 2.5 feet deep, the channel will be dredged again. The Hec-Ras model reflects a dredging depth of 2.5 feet. Plan 2 is the Levee alignment #3 alone.

Each plan was considered with three top of protection profiles:

1. Plans 1a and 2a: The top of protection protects for a 1% annual chance flood event without any additional amount to account for risk and uncertainty.

2. Plans 1b and 2b: The top of protection protects for a 2% annual chance flood event. An additional amount was added to the top of protection to account for risk and uncertainty. An amount of 3.4 ft was added at the upstream tie-out and 2.4 ft was added at the downstream tie-out. The top of protection profile was extended by straight line from the upstream tie-out elevation to the downstream tie-out elevation.

3. Plans 1c and 2c: The top of protection protects for a 1% annual chance flood event. An additional amount was added to the top of protection to account for risk and uncertainty. An amount of 4 ft was added at the upstream tie-out and 3 ft was added at the downstream tie-out. The top of protection profile was extended by straight line from the upstream tie-out elevation to the downstream tie-out elevation.

It was decided to go forward with Plan 1c and Plan 2c. See Appendix C for the output tables for these alternatives.

Risk and Uncertainty Analysis:

At the request of Fairfax County, a risk and uncertainty analysis was performed for Plan 1c and Plan 2c although this is currently not a requirement by FEMA for levee certification. The FEMA requirement is that the levee needs to be a minimum of 3 feet higher than the 1% annual chance flood elevation. If the county constructs this project without the Corps' involvement, they are required to meet that standard. The risk and

uncertainty analysis that was conducted is a U.S. Army Corps of Engineers (USACE) requirement for levee certification.

The analysis was performed using the Hydrologic Engineering Center's programs, HEC-RAS (River Analysis System) and HEC-FDA (Flood Damage Analysis). EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies", dated 1 August 1996, and TL 1110-2-570 Draft, "Certification of Levee Systems", dated 12 September 2007, were used as guidance.

The procedure for risk analysis for levee certification is as follows:

U.S. Army Corps of Engineers standards outlined in TL 1110-2-570 Draft require a risk-based analysis for levee certification, using EM-1110-2-1619 as guidance.

There are 3 "areas" to consider: geotechnical, hydrology, and hydraulics. Information for hydrology and hydraulics is input to HEC-FDA to compute a measure of assurance for containing a certain frequency event, typically a 1% annual chance flood event.

Geotechnical:

For a Corps-designed levee that is relatively new and well maintained, it is assumed that the levee will not fail. The Huntington flood damage reduction project includes a levee that is assumed will be well maintained. Therefore, non-failure is a valid assumption as long as the levee is not overtopped.

Hydrology:

To determine the existing peak flows for the 2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-year flood events a HEC-HMS (Hydrologic Modeling System) watershed model was developed by others for a Federal Emergency Management Agency (FEMA) study of the entire Cameron Run watershed. Although the watershed contains a streamflow gage operated by the U.S. Geological Survey (USGS), with 50+ years of record, a HEC-HMS rainfall-runoff model was developed to determine the peak flow frequency data for multiple locations in the watershed, including at Huntington. This is due to the theory that the data record at the USGS gage is not homogeneous due to increasing levels of watershed development throughout the period of record. USACE Engineering Regulation 1110-2-1464 states that a rainfall-runoff model is desirable where urbanization has changed the runoff response during the gaging record. FEMA guidelines and specifications state that rainfall-runoff models should be used in lieu of a gage analysis where the data is non-homogeneous. The resulting discharge-probability data was input graphically into the HEC-FDA model and is presented in the table below. The HEC-FDA model calculates the confidence limit curves assuming a normal distribution of errors in computing flow vs. frequency.

Exceedance Probability Function Report

File Help

Huntington FDR Study
Discharge-Probability Function Report for Plan 1c DF
(Graphical)

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves (standard error) Discharge (cfs)			
		-2 SD	-1 SD	+1 SD	+2 SD
0.9990	3571	3548	3559	3582	3593
0.9900	3600	3577	3589	3611	3623
0.9500	3632	3609	3620	3643	3655
0.9000	3649	3626	3638	3660	3672
0.8000	3670	3651	3660	3679	3689
0.7000	3685	3668	3676	3694	3702
0.5000	3710	3137	3411	4035	4388
0.3000	5719	4222	4913	6656	7747
0.2000	7430	5237	6238	8850	10541
0.1000	11200	7472	9148	13713	16789
0.0400	15920	9565	12340	20539	26497
0.0200	20400	11306	15187	27403	36810
0.0100	25410	13072	18225	35427	49393
0.0040	32872	15462	22544	47931	69888
0.0020	39190	17321	26054	58949	88670
0.0010	46216	19257	29832	71597	110917

Hydraulics:

The discharge-probability information is used to perform steady-flow simulations in the HEC-RAS model for the eight frequency events (2, 5, 10, 25, 50, 100, 200, and 500 yr). This develops a relationship between stage and flow and is the “expected risk” or “best estimate” of the with project conditions. This data is exported from a HEC-RAS table and used in the HEC-FDA software program.

An uncertainty estimate must be created for the hydraulic model. The uncertainty in the flood stages are computed by calculating a low estimate and a high estimate for the relationship between stages and flows. For the risk and uncertainty analysis, it is assumed that these estimates capture 95% of the distribution of the variability in our best estimates (the resulting water surface elevations are assumed to be normally distributed). The difference in water surface elevations at "index" locations is computed and the standard deviation about the mean (best) estimate is calculated as follows:

Standard Deviation = 95% band/4 = (high estimate stage-low estimate stage)/4

The HEC-RAS model for the Huntington FDRS was developed from surveyed channel cross sections with the overbanks determined using digital mapping with 1 foot contours.

The model was calibrated using one storm, June 2006. Taking this into consideration, the high and low estimates were established by identifying ranges of channel roughness (or Mannings n-values), bridge loss coefficients, and pier debris to reflect uncertainty in mapping and modeling that could affect the water surface profiles. These ranges are shown below.

High Risk Estimate:

- Manning's n values increased 20%
- Bridges modeled as abrupt transitions so contraction and expansion coefficients increased at bridges to 0.6 and 0.8 respectively
- Bridge debris modeled as floating debris. Pier width increased by 50% for 50% of the submerged pier height.

Low Risk Estimate:

- Manning's n values decreased 15%
- No change in contraction and expansion coefficients
- No bridge debris modeled

HEC Flood Damage Analysis Program (HEC-FDA):

HEC-FDA requires inputs from the hydrology, hydraulics, geotechnical, and economic analyses. The economic data does not affect the risk and uncertainty calculations.

The proposed line of protection is on the right bank of a fairly straight, congruous reach of Cameron Run. Therefore, for this phase of study one stream reach was determined to sufficiently model the characteristics of the channel. The reach was assigned an index cross-section to assess the entire length of the levee section. The risk and uncertainty analysis was completed with the assumption that the minimum increment between the preliminary levee elevation and the best estimate of the 1% chance exceedance event water surface elevation is 3 feet.

HEC- FDA determines the degree of "assurance" (i.e., conditional non-exceedance probability) that each frequency event will be contained by the levee in each reach. A value of at least 90% assurance is required to meet COE levee certification requirements. FEMA does not require a risk and uncertainty analysis for levee certification requirements. Instead FEMA requires a minimum of 3 ft of freeboard with additional freeboard upstream of significant structures such as bridges.

The HEC-FDA analysis was performed for the Plan 1c, which consists of a line of protection along the right bank of Cameron Run and 2.5' minimum depth of dredging to reduce flood damages at Huntington from a 1% annual chance flood event, and for Plan 2c, which is the same as Plan 1c but without dredging.

The table below presents the HEC-FDA results for the Huntington FDRS for Plan 1c and Plan 2c.

Table 3: HEC-FDA Results for Plan 1c and Plan 2c

Huntington FDA Study Project Performance Risk and Uncertainty Analysis Results Plan 1c and Plan 2c						
	Conditional Non-Exceedance Probability by Events					
Plan	10%	4%	2%	1%	0.4%	0.2%
Plan 1c	0.9998	0.9998	0.9992	0.9949	0.9836	0.9751
Plan 2c	0.9999	0.9997	0.9986	0.9921	0.9783	0.9705

As shown in the table, the conditional non-exceedance probability is above the required 90% for the stream reach for Plan 1c and Plan 2c for the 1% annual chance flood event. Therefore, the Huntington flood damage reduction plans meet the levee certification requirements for assuring that it provides a 1% annual chance level of flood protection. The non-exceedance probability for the 1% flood is 99.49% for Plan 1c and 99.21% for Plan 2c. The non-exceedance probability for the two plans were much larger than required, which indicates that a lower top of protection may be possible.

It was decided to investigate the possibility of decreasing the top of protection profile for Plan 1c. The HEC-RAS model for Plan 1c was rerun with the top of protection profile decreased by 0.5 feet, reducing the minimum increment between the top of levee and the 1% chance exceedance event water surface elevation to 2.5 feet. The results of the HEC-RAS analysis were used to determine the standard deviations and revise the input into the FDA model. The result of lowering the top of protection (TOP) profile by 0.5 feet is presented in the table below.

Table 4: HEC-FDA Results for Plan 1c with Lower Top of Protection

Huntington FDA Study Project Performance Risk and Uncertainty Analysis Results Plan 1c with decreased top of protection profile						
	Conditional Non-Exceedance Probability by Events					
Plan	10%	4%	2%	1%	0.4%	0.2%
Plan 1c with TOP - 0.5ft	0.9998	0.9998	0.9946	0.9670	0.8986	0.8466

To meet Corps levee certification requirements for projects, levees that are 3 ft or higher above the 1% chance event water surface elevations must have a non-exceedance probability of at least 90%; whereas, those with less than a 3 ft increment must have a non-exceedance probability of at least 95%. The non-exceedance probability for the 1% event of the lower top of protection plan is 96.70%, which meets the requirement of 95%

for levees with less than a 3 ft increment above the 1% annual chance flood event water surface elevation. Therefore, the decreased top of protection still meets the Corps' risk and uncertainty requirements for levee certification.

Riprap Analysis

An analysis to determine the need for erosion protection for the Huntington project was conducted using the with-project Plan 1c and Plan 2c HEC-RAS model for the design event (100-year). The water depth and velocity information was determined at each cross section along the proposed project. The levee side slope of 2.5 horizontal to 1 vertical was used.

The Riprap16 models were developed for the cross sections where the channel velocity was greater than or equal to 5.7 fps. Results from the Riprap16 analysis showed that no riprap protection was required for both plans. Cameron Run is fairly straight and the levee slope is located away from the main channel, this coupled with the reasonable channel velocities contributed to the lack of required riprap protection.

To check how the project affects channel velocities upstream and downstream, a comparison was performed between the channel velocities from the Plan 1c and Plan 2c HEC-RAS model results and the channel velocities from the existing conditions HEC-RAS model results for the 1% annual chance flood event. There was no increase in channel velocity upstream or downstream of the proposed levee, therefore, no riprap protection is required upstream or downstream of the tie outs.

Appendices

APPENDIX A: HEC-RAS Cross-section location map

APPENDIX B: Maps showing features of each alternative

APPENDIX C: HEC-RAS output tables

APPENDIX A: HEC-RAS Cross-section location maps

Huntington HEC-RAS cross-sections

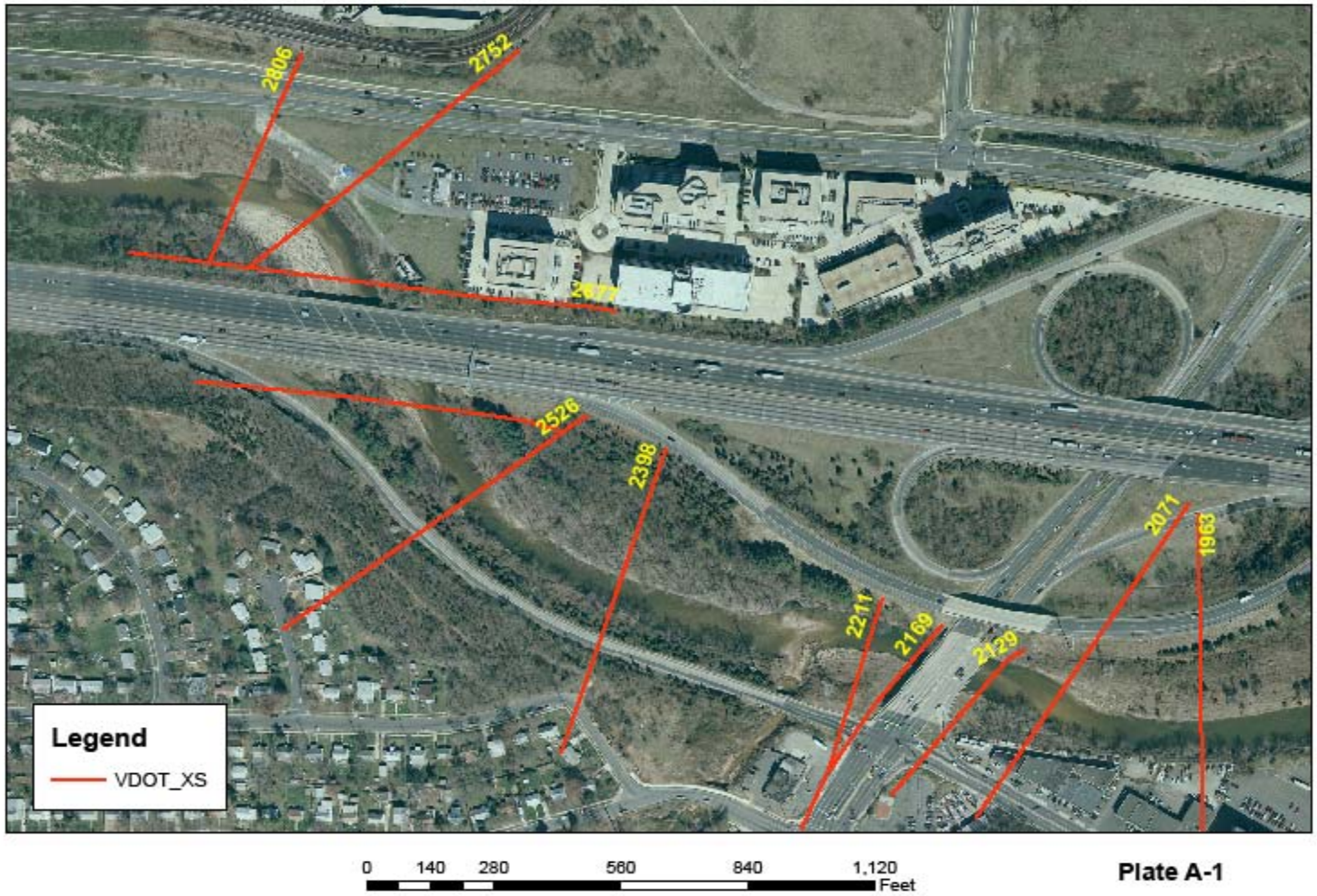


Plate A-1

Huntington HEC-RAS cross-sections

0 85 170 340 510 680 Feet

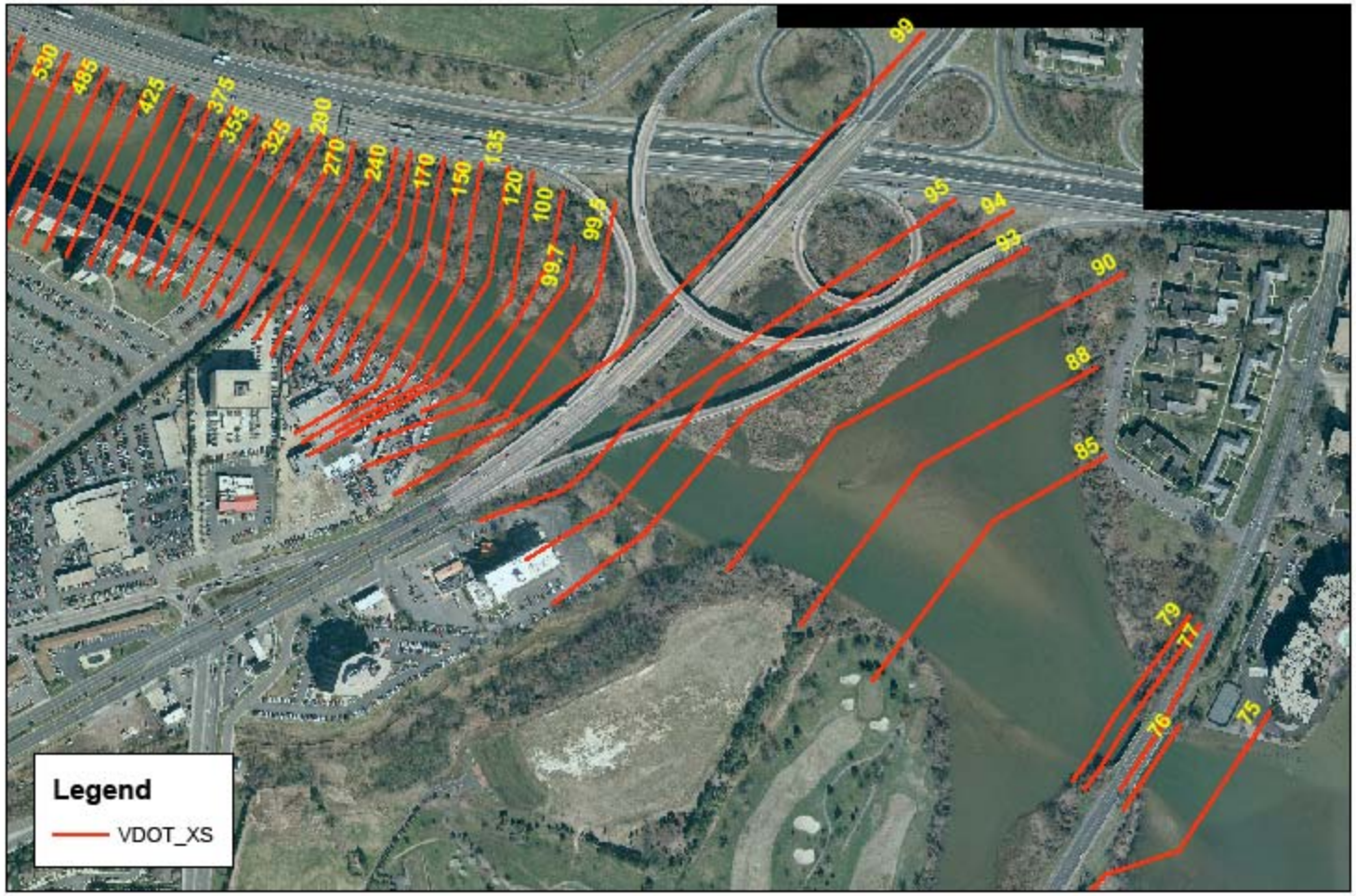
Plate A-2

Huntington HEC-RAS cross-sections

0 187.5 375 750 1,125 1,500 Feet

Plate A-3

Huntington HEC-RAS cross-sections



0 187.5 375 750 1,125 1,500 Feet

Plate A-4

APPENDIX B: Maps showing features of each alternative

Levee Alignment #1

Plate B-1

Levee Alignment #2

0 190 380 760 1,140 1,520 Feet

Plate B-2

Levee Alignment #3

0 180 360 720 1,080 1,440 Feet

Plate B-3

Dredging Alternative #1

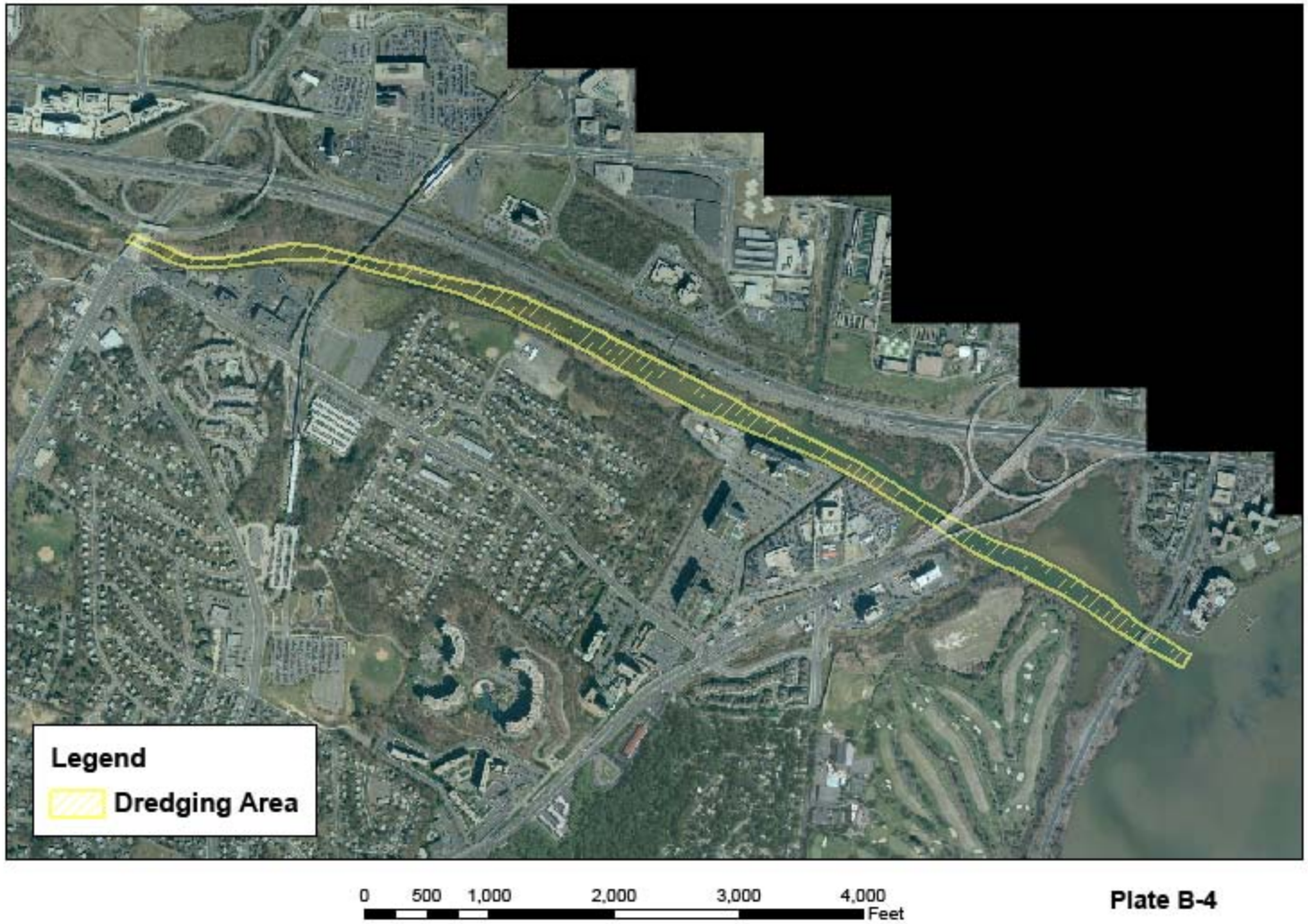


Plate B-4

Dredging Alternative #2

0 290 580 1,160 1,740 2,320 Feet

Plate B-5

Dredging Alternative #3

0 290 580 1,160 1,740 2,320 Feet

Plate B-6

APPENDIX C: HEC-RAS output tables

Table C-1: Existing Conditions Output Table

HEC-RAS Plan: existing est River: Cameron Run Reach: One Profile: 100-year

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	River Station	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
2650		Beltway Bridge			**659**	25414	-0.5	14.24
2623	100-year	25398	1.4	24.32	**640**	25414	-0.47	14.05
2526	100-year	25398	-0.2	23.83	**625**	25414	-1.7	14
2398	100-year	25398	-1.2	23.16	**610**	25414	-0.59	13.93
2211	100-year	25414	-2.4	21.76	**595**	25414	-2	13.92
2169	100-year	25414	0.14	22.05	**575**	25414	-1.26	13.82
2149		Telegraph Road Bridge			**555**	25414	-2	13.41
2129	100-year	25414	-1.21	19.21	**540**	25414	-1.82	13.34
2071	100-year	25414	0.7	18.18	**530**	25414	-2	13.14
1963	100-year	25414	-3.8	16.61	**510**	25414	-1.99	13.07
1823	100-year	25414	0.2	15.92	**485**	25414	-2.3	12.98
1707	100-year	25414	-0.2	15.9	**465**	25414	-1.61	12.63
1597	100-year	25414	-1.5	15.61	**445**	25414	-1.2	12.67
1389	100-year	25414	-1.5	15.41	**425**	25414	-0.91	12.55
1280	100-year	25414	0.53	15.29	**395**	25414	-2.5	12.48
1260	100-year	25414	0.45	15.21	**385**	25414	-2.12	12.41
1240	100-year	25414	0.5	15.15	**375**	25414	-3.5	12.39
1220	100-year	25414	0.41	15.09	**355**	25414	-3.5	12.15
1200	100-year	25414	0.27	15.01	**337**	25414	-2.23	12.08
1180	100-year	25414	0.25	14.93	**325**	25414	-2.25	12.09
1160	100-year	25414	0.22	14.91	**310**	25414	-2.25	11.9
1140	100-year	25414	0.22	14.89	**290**	25414	-2	12.02
1120	100-year	25414	0.31	14.87	**270**	25414	-2	11.79
1100	100-year	25414	0.06	14.85	**255**	25414	-2.27	11.81
1080	100-year	25414	0.06	14.82	**240**	25414	-2.27	11.39
1060	100-year	25414	0.06	14.79	**210**	25414	-2	11.4
1040	100-year	25414	0.14	14.78	**180**	25414	-2	11.26
1020	100-year	25414	0.2	14.76	**170**	25414	-2	11.24
1000	100-year	25414	0.2	14.73	**165**	25414	-2	11.25
980	100-year	25414	0.19	14.7	**160**	25414	-2	11.18
960	100-year	25414	0.19	14.69	**155**	25414	-2	11.18
940	100-year	25414	0.27	14.67	**150**	25414	-2.7	10.92
920	100-year	25414	0.27	14.7	**145**	25414	-2.7	10.97
900	100-year	25414	0.27	14.65	**135**	25414	-2.7	10.8
880	100-year	25414	0.27	14.55	**130**	25414	-2.7	10.86
860	100-year	25414	0.28	14.5	**120**	25414	-3.2	10.9
840	100-year	25414	0.27	14.48	**110**	25414	-3.2	10.87
820	100-year	25414	0.27	14.48	**100**	25414	-3.5	10.86
800	100-year	25414	0.3	14.45	**99.8**	25414	-3.5	10.89
720	100-year	25414	0.27	14.4	**99.7**	25414	-3.5	10.89
700	100-year	25414	0.28	14.41	**99.6**	25414	-3.5	10.8
680	100-year	25414	-0.37	14.34	**99.5**	25414	-3.5	10.85
660	100-year	25414	-0.46	14.26	**99**	25414	-4	10.9
					96	Route 1 Bridge		

Figure C-1: Profile of Existing Conditions

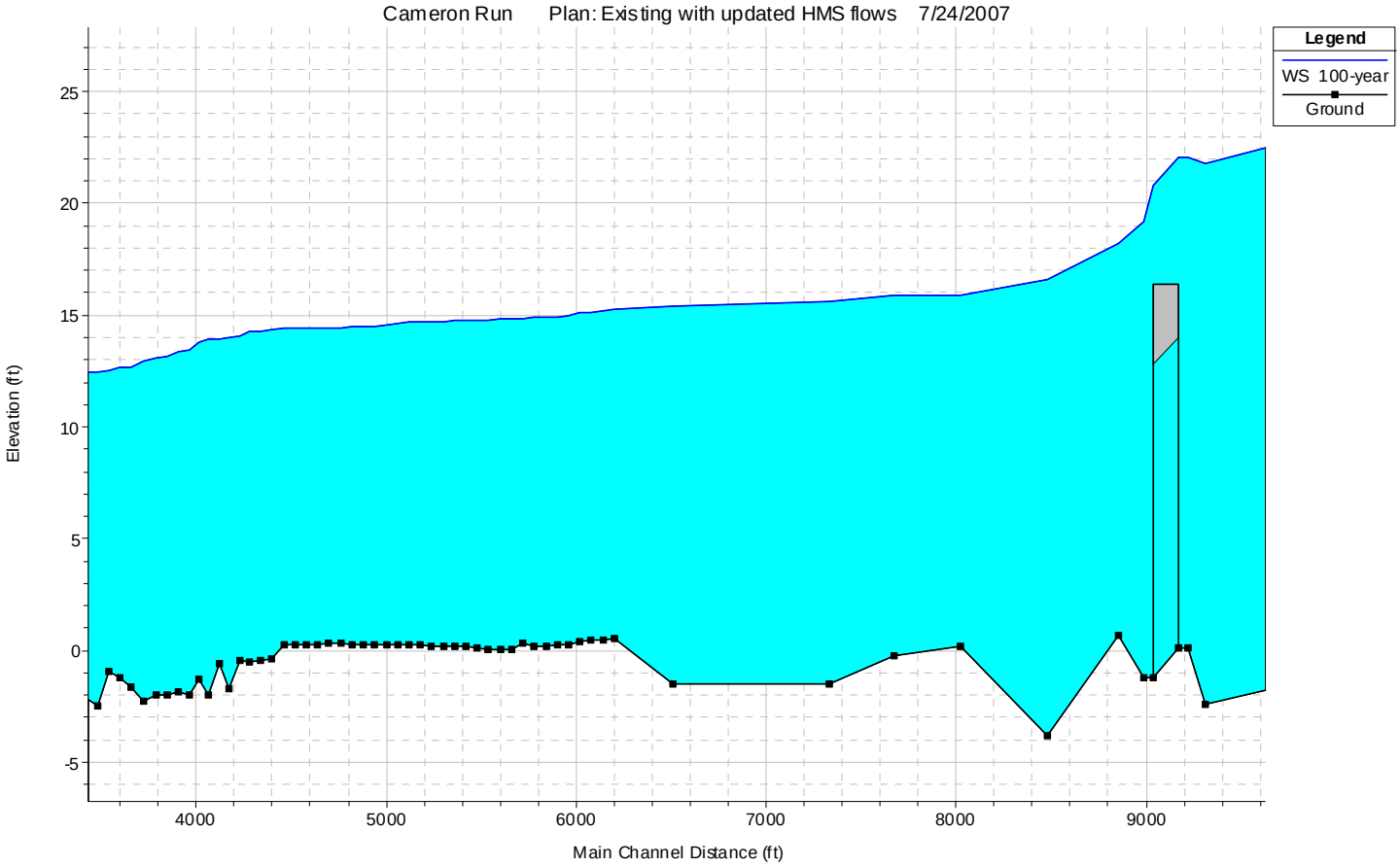


Table C-2: Output Table for Levee Alignment #1

HEC-RAS Plan: levee 1 River: Cameron Run Reach: One Profile: 100-year

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	River Station	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
2650		Bridge			**700**	25414	0.28	14.28
2623	100-year	25398	1.4	24.39	**680**	25414	-0.37	14.2
2526	100-year	25398	-0.2	23.91	**660**	25414	-0.46	13.89
2398	100-year	25398	-1.2	23.26	**659**	25414	-0.5	14.24
2211	100-year	25414	-2.4	21.9	**640**	25414	-0.47	14.05
2169	100-year	25414	0.14	22.18	**625**	25414	-1.7	14
2149		Bridge			**610**	25414	-0.59	13.93
2129	100-year	25414	-1.21	19.49	**595**	25414	-2	13.92
2071	100-year	25414	0.7	18.49	**575**	25414	-1.26	13.82
1963	100-year	25414	-3.8	17.09	**555**	25414	-2	13.41
1823	100-year	25414	0.2	16.57	**540**	25414	-1.82	13.34
1707	100-year	25414	-0.2	16.59	**530**	25414	-2	13.14
1597	100-year	25414	-1.5	16.36	**510**	25414	-1.99	13.07
1389	100-year	25414	-1.5	15.81	**485**	25414	-2.3	12.98
1280	100-year	25414	0.53	15.66	**465**	25414	-1.61	12.63
1260	100-year	25414	0.45	15.53	**445**	25414	-1.2	12.67
1240	100-year	25414	0.5	15.45	**425**	25414	-0.91	12.55
1220	100-year	25414	0.41	15.38	**395**	25414	-2.5	12.48
1200	100-year	25414	0.27	15.26	**385**	25414	-2.12	12.41
1180	100-year	25414	0.25	15.2	**375**	25414	-3.5	12.39
1160	100-year	25414	0.22	15.19	**355**	25414	-3.5	12.15
1140	100-year	25414	0.22	15.13	**337**	25414	-2.23	12.08
1120	100-year	25414	0.31	15.1	**325**	25414	-2.25	12.09
1100	100-year	25414	0.06	15.06	**310**	25414	-2.25	11.9
1080	100-year	25414	0.06	14.98	**290**	25414	-2	12.02
1060	100-year	25414	0.06	14.9	**270**	25414	-2	11.79
1040	100-year	25414	0.14	14.86	**255**	25414	-2.27	11.81
1020	100-year	25414	0.2	14.79	**240**	25414	-2.27	11.39
1000	100-year	25414	0.2	14.77	**210**	25414	-2	11.4
980	100-year	25414	0.19	14.76	**180**	25414	-2	11.26
960	100-year	25414	0.19	14.75	**170**	25414	-2	11.24
940	100-year	25414	0.27	14.71	**165**	25414	-2	11.25
920	100-year	25414	0.27	14.75	**160**	25414	-2	11.18
900	100-year	25414	0.27	14.7	**155**	25414	-2	11.18
880	100-year	25414	0.27	14.56	**150**	25414	-2.7	10.92
860	100-year	25414	0.28	14.53	**145**	25414	-2.7	10.97
840	100-year	25414	0.27	14.52	**135**	25414	-2.7	10.8
820	100-year	25414	0.27	14.5	**130**	25414	-2.7	10.86
800	100-year	25414	0.3	14.44	**120**	25414	-3.2	10.9
780	100-year	25414	0.3	14.41	**110**	25414	-3.2	10.87
760	100-year	25414	0.27	14.4	**100**	25414	-3.5	10.86
740	100-year	25414	0.27	14.38	**99.8**	25414	-3.5	10.89
720	100-year	25414	0.27	14.36	**99.7**	25414	-3.5	10.89

Figure C-2: Profile of Levee Alignment #1

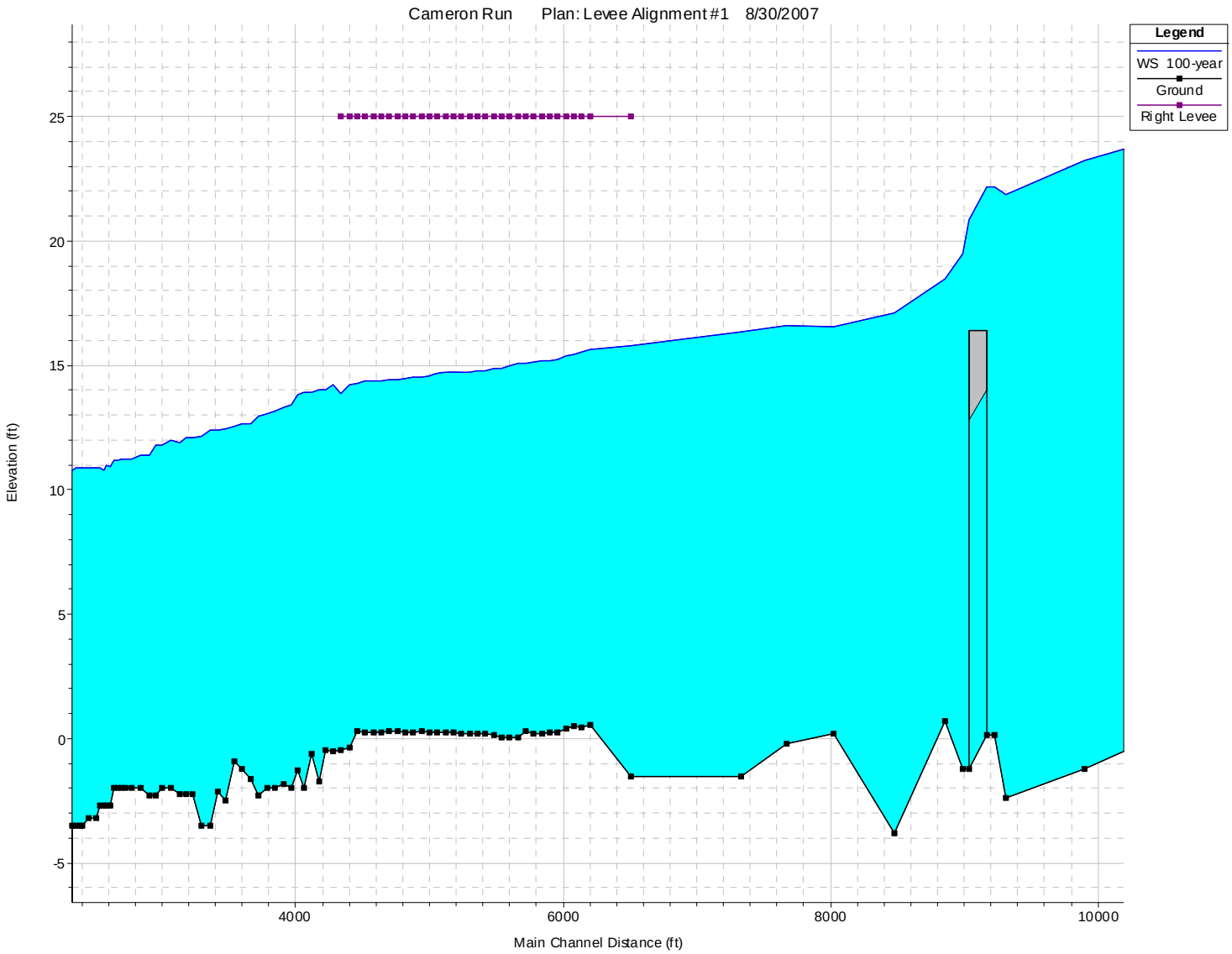


Table C-3: Output table for Levee Alignment #2 (equal to Levee Alignment #3 and Final Concept Plan 2c – Selected Plan)

HEC-RAS Plan: Levee 2 Locations: User Defined Profile: 100-year

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
2650		Bridge							
2623	100-year	25398	1.4	24.37	**720**	100-year	25414	0.27	14.45
2526	100-year	25398	-0.2	23.89	**700**	100-year	25414	0.28	14.34
2398	100-year	25398	-1.2	23.23	**680**	100-year	25414	-0.37	14.21
2211	100-year	25414	-2.4	21.86	**660**	100-year	25414	-0.46	13.89
2169	100-year	25414	0.14	22.14	**659**	100-year	25414	-0.5	14.24
2149		Bridge			**640**	100-year	25414	-0.47	14.05
2129	100-year	25414	-1.21	19.42	**625**	100-year	25414	-1.7	14
2071	100-year	25414	0.7	18.41	**610**	100-year	25414	-0.59	13.93
1963	100-year	25414	-3.8	16.97	**595**	100-year	25414	-2	13.92
1823	100-year	25414	0.2	16.4	**575**	100-year	25414	-1.26	13.82
1707	100-year	25414	-0.2	16.42	**555**	100-year	25414	-2	13.41
1597	100-year	25414	-1.5	16.17	**540**	100-year	25414	-1.82	13.34
1389	100-year	25414	-1.5	15.6	**530**	100-year	25414	-2	13.14
1280	100-year	25414	0.53	15.52	**510**	100-year	25414	-1.99	13.07
1260	100-year	25414	0.45	15.45	**485**	100-year	25414	-2.3	12.98
1240	100-year	25414	0.5	15.39	**465**	100-year	25414	-1.61	12.63
1220	100-year	25414	0.41	15.34	**445**	100-year	25414	-1.2	12.67
1200	100-year	25414	0.27	15.24	**425**	100-year	25414	-0.91	12.55
1180	100-year	25414	0.25	15.2	**395**	100-year	25414	-2.5	12.48
1160	100-year	25414	0.22	15.17	**385**	100-year	25414	-2.12	12.41
1140	100-year	25414	0.22	15.14	**375**	100-year	25414	-3.5	12.39
1120	100-year	25414	0.31	15.11	**355**	100-year	25414	-3.5	12.15
1100	100-year	25414	0.06	15.06	**337**	100-year	25414	-2.23	12.08
1080	100-year	25414	0.06	15	**325**	100-year	25414	-2.25	12.09
1060	100-year	25414	0.06	14.93	**310**	100-year	25414	-2.25	11.9
1040	100-year	25414	0.14	14.91	**290**	100-year	25414	-2	12.02
1020	100-year	25414	0.2	14.89	**270**	100-year	25414	-2	11.79
1000	100-year	25414	0.2	14.88	**255**	100-year	25414	-2.27	11.81
980	100-year	25414	0.19	14.85	**240**	100-year	25414	-2.27	11.39
960	100-year	25414	0.19	14.84	**210**	100-year	25414	-2	11.4
940	100-year	25414	0.27	14.82	**180**	100-year	25414	-2	11.26
920	100-year	25414	0.27	14.87	**170**	100-year	25414	-2	11.24
900	100-year	25414	0.27	14.81	**165**	100-year	25414	-2	11.25
880	100-year	25414	0.27	14.68	**160**	100-year	25414	-2	11.18
860	100-year	25414	0.28	14.63	**155**	100-year	25414	-2	11.18
840	100-year	25414	0.27	14.6	**150**	100-year	25414	-2.7	10.92
820	100-year	25414	0.27	14.6	**145**	100-year	25414	-2.7	10.97
800	100-year	25414	0.3	14.56	**135**	100-year	25414	-2.7	10.8
780	100-year	25414	0.3	14.54	**130**	100-year	25414	-2.7	10.86
760	100-year	25414	0.27	14.53	**120**	100-year	25414	-3.2	10.9
740	100-year	25414	0.27	14.5	**110**	100-year	25414	-3.2	10.87

Figure C-3: Profile for Levee Alignment #2 (equal to Levee Alignment #3 and Plan 2)

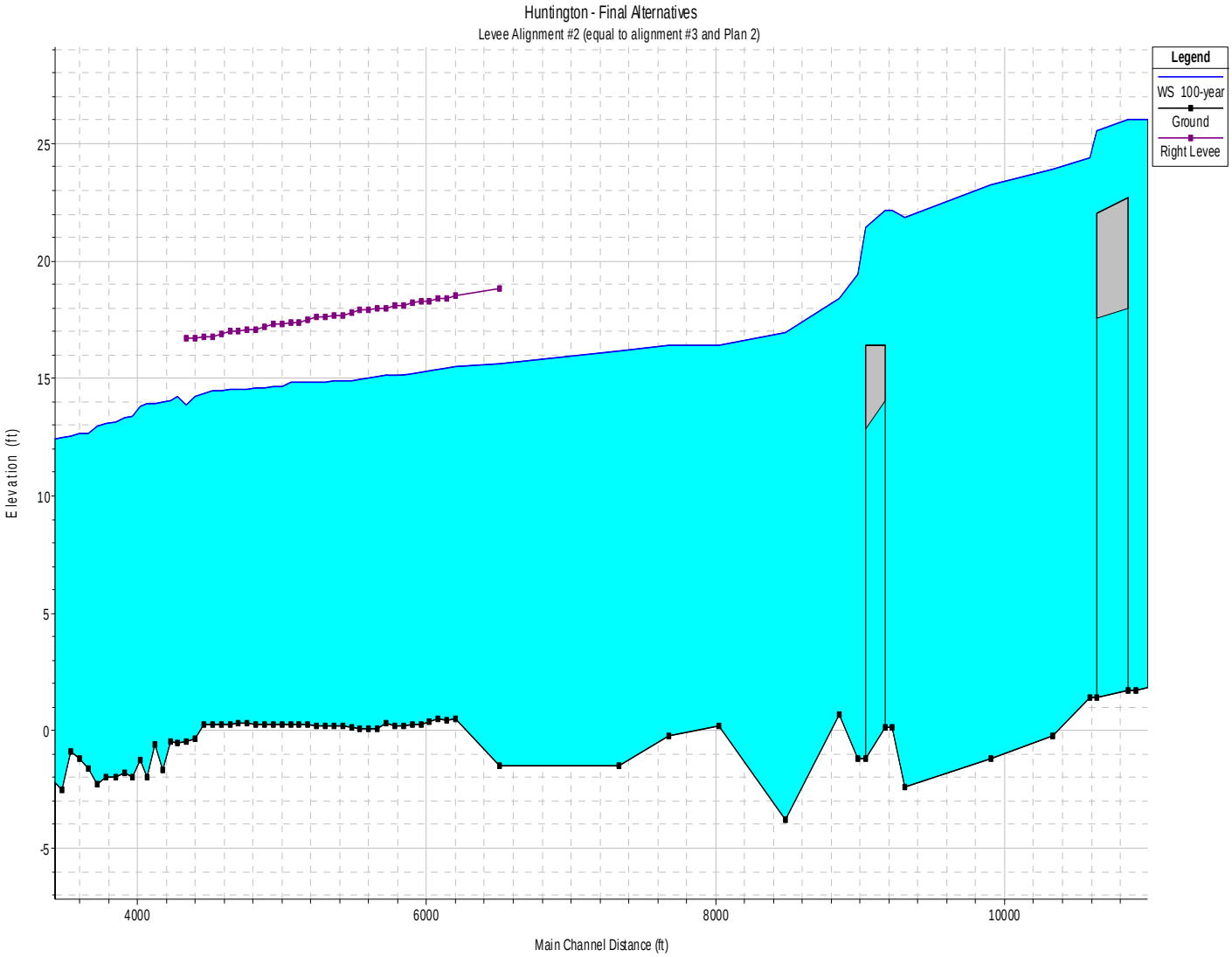


Table C-4: Output Table for Dredging Alternative #1

HEC-RAS Plan: full dredge Locations: User Defined Profile: 100-year

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
2650		Bridge							
2623	100-year	25398	1.4	23.62	**720**	100-year	25414	-5.17	13.02
2526	100-year	25398	-0.2	23.05	**700**	100-year	25414	-5.21	13.04
2398	100-year	25398	-1.2	22.15	**680**	100-year	25414	-5.23	12.98
2211	100-year	25414	-2.4	20.12	**660**	100-year	25414	-5.26	12.91
2169	100-year	25414	-2.55	20.53	**659**	100-year	25414	-5.28	12.9
2149		Bridge			**640**	100-year	25414	-5.3	12.76
2129	100-year	25414	-3.06	17.21	**625**	100-year	25414	-5.33	12.69
2071	100-year	25414	-3.33	16.93	**610**	100-year	25414	-5.35	12.66
1963	100-year	25414	-3.76	14.5	**595**	100-year	25414	-5.36	12.62
1823	100-year	25414	-3.88	14.36	**575**	100-year	25414	-5.38	12.53
1707	100-year	25414	-3.9	14.37	**555**	100-year	25414	-5.41	12.27
1597	100-year	25414	-3.97	13.9	**540**	100-year	25414	-5.43	12.22
1389	100-year	25414	-4.3	13.94	**530**	100-year	25414	-5.46	12.02
1280	100-year	25414	-4.44	13.78	**510**	100-year	25414	-5.48	12
1260	100-year	25414	-4.46	13.78	**485**	100-year	25414	-5.52	11.92
1240	100-year	25414	-4.49	13.65	**465**	100-year	25414	-5.54	11.74
1220	100-year	25414	-4.51	13.64	**445**	100-year	25414	-5.55	11.74
1200	100-year	25414	-4.54	13.59	**425**	100-year	25414	-5.58	11.7
1180	100-year	25414	-4.58	13.59	**395**	100-year	25414	-5.63	11.61
1160	100-year	25414	-4.6	13.5	**385**	100-year	25414	-5.63	11.6
1140	100-year	25414	-4.62	13.5	**375**	100-year	25414	-5.65	11.56
1120	100-year	25414	-4.65	13.48	**355**	100-year	25414	-5.69	11.42
1100	100-year	25414	-4.68	13.44	**337**	100-year	25414	-5.7	11.42
1080	100-year	25414	-4.7	13.38	**325**	100-year	25414	-5.73	11.39
1060	100-year	25414	-4.72	13.37	**310**	100-year	25414	-5.74	11.25
1040	100-year	25414	-4.75	13.37	**290**	100-year	25414	-5.77	11.34
1020	100-year	25414	-4.78	13.36	**270**	100-year	25414	-5.79	11.19
1000	100-year	25414	-4.8	13.34	**255**	100-year	25414	-5.81	11.21
980	100-year	25414	-4.83	13.32	**240**	100-year	25414	-5.84	10.96
960	100-year	25414	-4.87	13.31	**210**	100-year	25414	-5.86	10.95
940	100-year	25414	-4.89	13.24	**180**	100-year	25414	-5.88	10.96
920	100-year	25414	-4.91	13.28	**170**	100-year	25414	-5.89	10.91
900	100-year	25414	-4.94	13.21	**165**	100-year	25414	-5.9	10.9
880	100-year	25414	-4.96	13.12	**160**	100-year	25414	-5.9	10.89
860	100-year	25414	-4.99	13.09	**155**	100-year	25414	-5.93	10.86
840	100-year	25414	-5.02	13.09	**150**	100-year	25414	-5.94	10.7
820	100-year	25414	-5.04	13.09	**145**	100-year	25414	-5.95	10.73
800	100-year	25414	-5.07	13.08	**135**	100-year	25414	-5.96	10.61
780	100-year	25414	-5.09	13.04	**130**	100-year	25414	-5.97	10.66
760	100-year	25414	-5.12	13.05	**120**	100-year	25414	-5.99	10.69
740	100-year	25414	-5.15	13.04	**110**	100-year	25414	-6.01	10.67

Figure C-4: Profile for Dredging Alternative #1

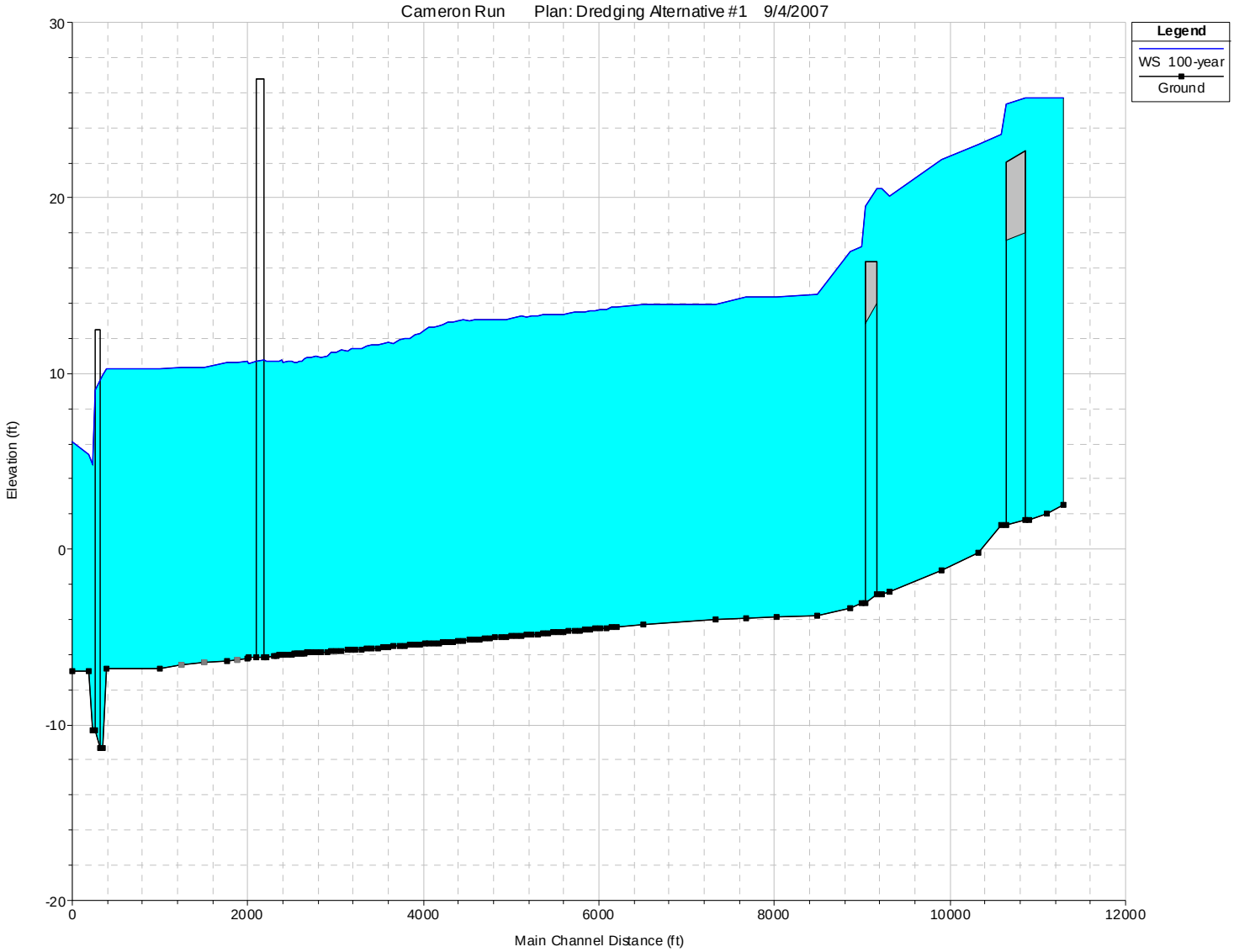


Table C-5: Output Table for Dredging Alternative #2

HEC-RAS Plan: dredging Locations: User Defined Profile: 100-year

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
2650		Bridge							
2623	100-year	25398	1.4	23.98	**720**	100-year	25414	-5.17	13.54
2526	100-year	25398	-0.2	23.46	**700**	100-year	25414	-5.21	13.55
2398	100-year	25398	-1.2	22.69	**680**	100-year	25414	-5.23	13.5
2211	100-year	25414	-2.4	21.06	**660**	100-year	25414	-5.26	13.45
2169	100-year	25414	0.14	21.36	**659**	100-year	25414	-5.28	13.44
2149		Bridge			**640**	100-year	25414	-5.3	13.32
2129	100-year	25414	-1.21	18.82	**625**	100-year	25414	-5.33	13.26
2071	100-year	25414	0.7	17.73	**610**	100-year	25414	-5.35	13.21
1963	100-year	25414	-3.8	15.78	**595**	100-year	25414	-5.36	13.19
1823	100-year	25414	0.2	14.77	**575**	100-year	25414	-5.38	13.11
1707	100-year	25414	-0.2	14.56	**555**	100-year	25414	-5.41	12.86
1597	100-year	25414	-3.97	14.32	**540**	100-year	25414	-5.43	12.81
1389	100-year	25414	-4.3	14.36	**530**	100-year	25414	-5.46	12.63
1280	100-year	25414	-4.44	14.21	**510**	100-year	25414	-5.48	12.61
1260	100-year	25414	-4.46	14.21	**485**	100-year	25414	-5.52	12.55
1240	100-year	25414	-4.49	14.1	**465**	100-year	25414	-5.54	12.39
1220	100-year	25414	-4.51	14.08	**445**	100-year	25414	-5.55	12.39
1200	100-year	25414	-4.54	14.05	**425**	100-year	25414	-5.58	12.35
1180	100-year	25414	-4.58	14.05	**395**	100-year	25414	-5.63	12.27
1160	100-year	25414	-4.6	13.96	**385**	100-year	25414	-5.63	12.27
1140	100-year	25414	-4.62	13.96	**375**	100-year	25414	-5.65	12.23
1120	100-year	25414	-4.65	13.95	**355**	100-year	25414	-5.69	12.09
1100	100-year	25414	-4.68	13.91	**337**	100-year	25414	-5.7	12.09
1080	100-year	25414	-4.7	13.86	**325**	100-year	25414	-5.73	12.07
1060	100-year	25414	-4.72	13.85	**310**	100-year	25414	-5.74	11.95
1040	100-year	25414	-4.75	13.85	**290**	100-year	25414	-5.77	12.04
1020	100-year	25414	-4.78	13.84	**270**	100-year	25414	-5.79	12
1000	100-year	25414	-4.8	13.82	**255**	100-year	25414	-5.81	11.95
980	100-year	25414	-4.83	13.8	**240**	100-year	25414	-2.27	11.39
960	100-year	25414	-4.87	13.8	**210**	100-year	25414	-2	11.4
940	100-year	25414	-4.89	13.74	**180**	100-year	25414	-2	11.26
920	100-year	25414	-4.91	13.77	**170**	100-year	25414	-2	11.24
900	100-year	25414	-4.94	13.71	**165**	100-year	25414	-2	11.25
880	100-year	25414	-4.96	13.63	**160**	100-year	25414	-2	11.18
860	100-year	25414	-4.99	13.6	**155**	100-year	25414	-2	11.18
840	100-year	25414	-5.02	13.6	**150**	100-year	25414	-2.7	10.92
820	100-year	25414	-5.04	13.6	**145**	100-year	25414	-2.7	10.97
800	100-year	25414	-5.07	13.59	**135**	100-year	25414	-2.7	10.8
780	100-year	25414	-5.09	13.56	**130**	100-year	25414	-2.7	10.86
760	100-year	25414	-5.12	13.57	**120**	100-year	25414	-3.2	10.9
740	100-year	25414	-5.15	13.55	**110**	100-year	25414	-3.2	10.87

Figure C-5: Profile for Dredging Alternative #2

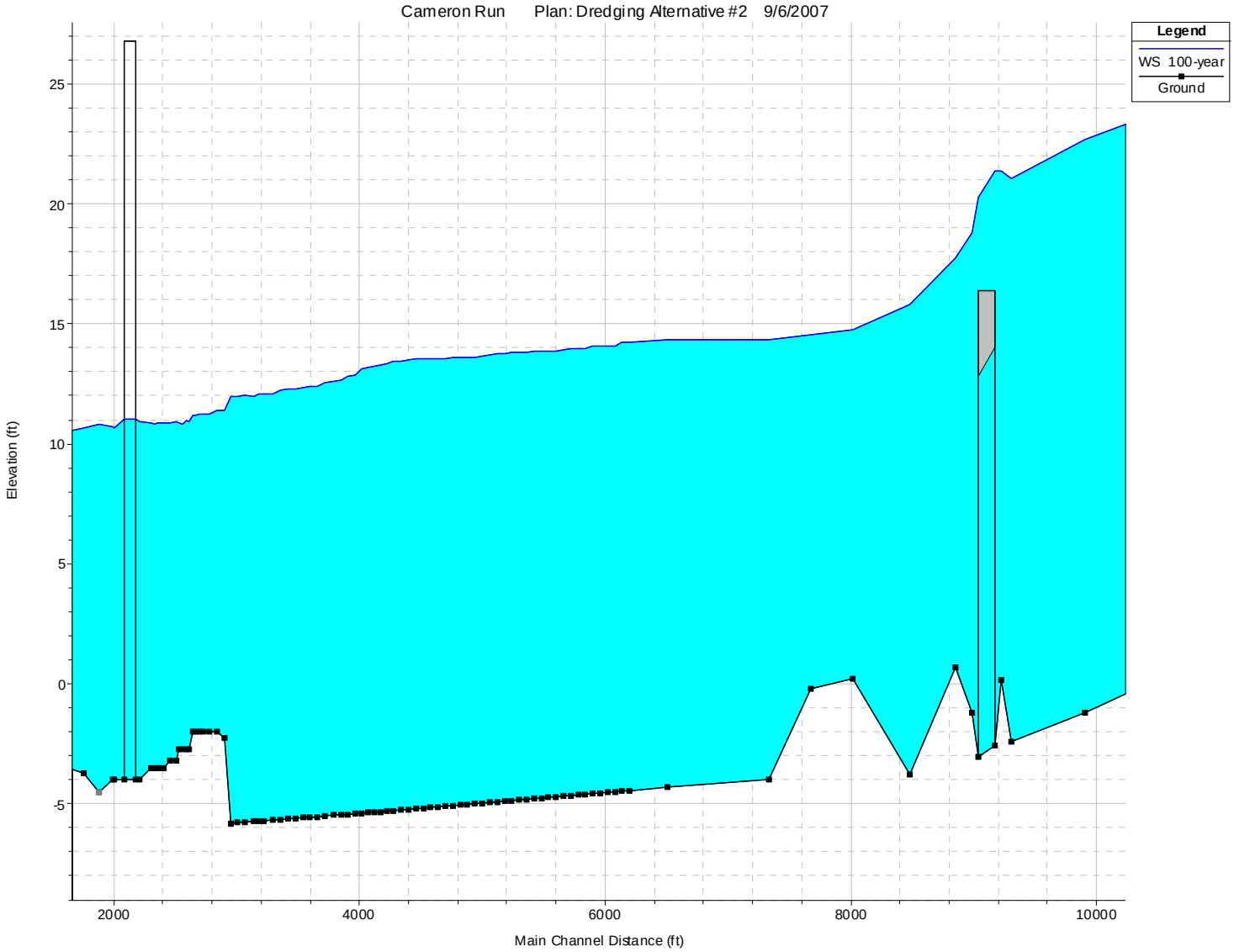


Table C-6: Output Table for Dredging Alternative #3

HEC-RAS Plan: dredge3 Locations: User Defined Profile: 100-year

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
2650		Bridge			**720**	100-year	25414	-5.17	14.33
2623	100-year	25398	1.4	24.27	**700**	100-year	25414	-5.21	14.34
2526	100-year	25398	-0.2	23.78	**680**	100-year	25414	-5.23	14.3
2398	100-year	25398	-1.2	23.09	**660**	100-year	25414	-5.26	14.25
2211	100-year	25414	-2.4	21.66	**659**	100-year	25414	-5.28	14.24
2169	100-year	25414	0.14	21.95	**640**	100-year	25414	-5.3	14.13
2149		Bridge			**625**	100-year	25414	-5.33	14.09
2129	100-year	25414	-1.21	19.01	**610**	100-year	25414	-5.35	14.06
2071	100-year	25414	0.7	17.95	**595**	100-year	25414	-5.36	14.04
1963	100-year	25414	-3.8	16.22	**575**	100-year	25414	-1.26	13.82
1823	100-year	25414	0.2	15.44	**555**	100-year	25414	-2	13.41
1707	100-year	25414	-0.2	15.34	**540**	100-year	25414	-1.82	13.34
1597	100-year	25414	-1.5	14.97	**530**	100-year	25414	-2	13.14
1389	100-year	25414	-4.3	14.99	**510**	100-year	25414	-1.99	13.07
1280	100-year	25414	-4.44	14.91	**485**	100-year	25414	-2.3	12.98
1260	100-year	25414	-4.46	14.91	**465**	100-year	25414	-1.61	12.63
1240	100-year	25414	-4.49	14.81	**445**	100-year	25414	-1.2	12.67
1220	100-year	25414	-4.51	14.8	**425**	100-year	25414	-0.91	12.55
1200	100-year	25414	-4.54	14.77	**395**	100-year	25414	-2.5	12.48
1180	100-year	25414	-4.58	14.77	**385**	100-year	25414	-2.12	12.41
1160	100-year	25414	-4.6	14.68	**375**	100-year	25414	-3.5	12.39
1140	100-year	25414	-4.62	14.68	**355**	100-year	25414	-3.5	12.15
1120	100-year	25414	-4.65	14.68	**337**	100-year	25414	-2.23	12.08
1100	100-year	25414	-4.68	14.66	**325**	100-year	25414	-2.25	12.09
1080	100-year	25414	-4.7	14.63	**310**	100-year	25414	-2.25	11.9
1060	100-year	25414	-4.72	14.6	**290**	100-year	25414	-2	12.02
1040	100-year	25414	-4.75	14.6	**270**	100-year	25414	-2	11.79
1020	100-year	25414	-4.78	14.61	**255**	100-year	25414	-2.27	11.81
1000	100-year	25414	-4.8	14.59	**240**	100-year	25414	-2.27	11.39
980	100-year	25414	-4.83	14.53	**210**	100-year	25414	-2	11.4
960	100-year	25414	-4.87	14.49	**180**	100-year	25414	-2	11.26
940	100-year	25414	-4.89	14.48	**170**	100-year	25414	-2	11.24
920	100-year	25414	-4.91	14.51	**165**	100-year	25414	-2	11.25
900	100-year	25414	-4.94	14.47	**160**	100-year	25414	-2	11.18
880	100-year	25414	-4.96	14.4	**155**	100-year	25414	-2	11.18
860	100-year	25414	-4.99	14.38	**150**	100-year	25414	-2.7	10.92
840	100-year	25414	-5.02	14.38	**145**	100-year	25414	-2.7	10.97
820	100-year	25414	-5.04	14.38	**135**	100-year	25414	-2.7	10.8
800	100-year	25414	-5.07	14.37	**130**	100-year	25414	-2.7	10.86
780	100-year	25414	-5.09	14.35	**120**	100-year	25414	-3.2	10.9
760	100-year	25414	-5.12	14.35	**110**	100-year	25414	-3.2	10.87
740	100-year	25414	-5.15	14.34					

Figure C-6: Profile for Dredging Alternative #3

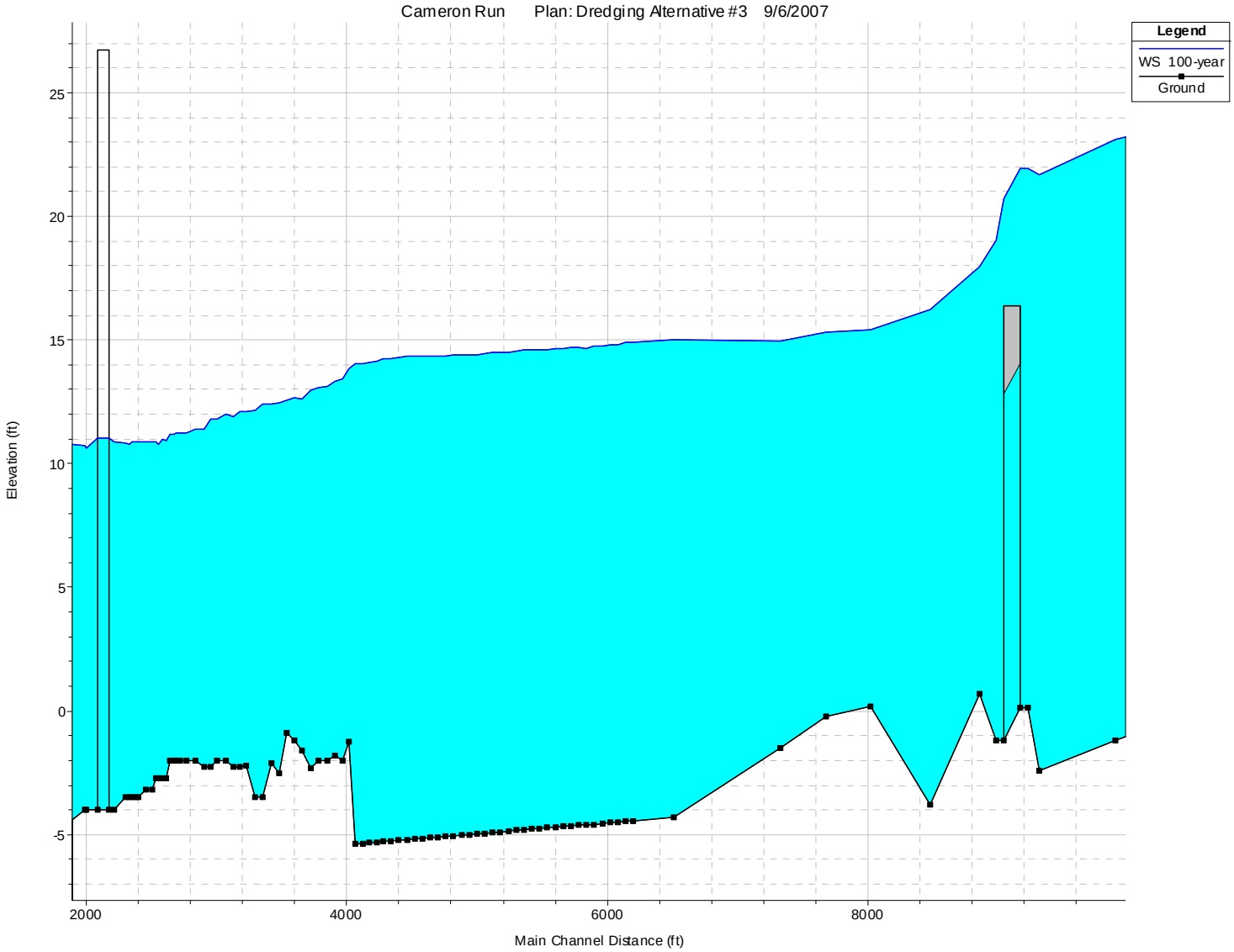


Table C-7: Output table for Combined Alternatives Levee #2 and Dredging #2

HEC-RAS Plan: combined Locations: User Defined Profile: 100-year

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
2650		Bridge			**720**	100-year	25414	-5.17	13.56
2623	100-year	25398	1.4	23.68	**700**	100-year	25414	-5.21	13.5
2526	100-year	25398	-0.2	23.12	**680**	100-year	25414	-5.23	13.42
2398	100-year	25398	-1.2	22.25	**660**	100-year	25414	-5.26	13.27
2211	100-year	25414	-2.4	20.3	**659**	100-year	25414	-5.28	13.44
2169	100-year	25414	-2.55	20.69	**640**	100-year	25414	-5.3	13.32
2149		Bridge			**625**	100-year	25414	-5.33	13.26
2129	100-year	25414	-3.06	17.48	**610**	100-year	25414	-5.35	13.21
2071	100-year	25414	-3.33	17.18	**595**	100-year	25414	-5.36	13.19
1963	100-year	25414	-3.76	14.98	**575**	100-year	25414	-5.38	13.11
1823	100-year	25414	-3.88	14.92	**555**	100-year	25414	-5.41	12.86
1707	100-year	25414	-3.9	14.95	**540**	100-year	25414	-5.43	12.81
1597	100-year	25414	-3.97	14.57	**530**	100-year	25414	-5.46	12.63
1389	100-year	25414	-4.3	14.4	**510**	100-year	25414	-5.48	12.61
1280	100-year	25414	-4.44	14.3	**485**	100-year	25414	-5.52	12.55
1260	100-year	25414	-4.46	14.31	**465**	100-year	25414	-5.54	12.39
1240	100-year	25414	-4.49	14.19	**445**	100-year	25414	-5.55	12.39
1220	100-year	25414	-4.51	14.18	**425**	100-year	25414	-5.58	12.35
1200	100-year	25414	-4.54	14.14	**395**	100-year	25414	-5.63	12.27
1180	100-year	25414	-4.58	14.15	**385**	100-year	25414	-5.63	12.27
1160	100-year	25414	-4.6	14.07	**375**	100-year	25414	-5.65	12.23
1140	100-year	25414	-4.62	14.05	**355**	100-year	25414	-5.69	12.09
1120	100-year	25414	-4.65	14.03	**337**	100-year	25414	-5.7	12.09
1100	100-year	25414	-4.68	13.98	**325**	100-year	25414	-5.73	12.07
1080	100-year	25414	-4.7	13.92	**310**	100-year	25414	-5.74	11.95
1060	100-year	25414	-4.72	13.9	**290**	100-year	25414	-5.77	12.04
1040	100-year	25414	-4.75	13.9	**270**	100-year	25414	-5.79	12
1020	100-year	25414	-4.78	13.88	**255**	100-year	25414	-5.81	11.95
1000	100-year	25414	-4.8	13.87	**240**	100-year	25414	-2.27	11.39
980	100-year	25414	-4.83	13.85	**210**	100-year	25414	-2	11.4
960	100-year	25414	-4.87	13.85	**180**	100-year	25414	-2	11.26
940	100-year	25414	-4.89	13.78	**170**	100-year	25414	-2	11.24
920	100-year	25414	-4.91	13.82	**165**	100-year	25414	-2	11.25
900	100-year	25414	-4.94	13.76	**160**	100-year	25414	-2	11.18
880	100-year	25414	-4.96	13.67	**155**	100-year	25414	-2	11.18
860	100-year	25414	-4.99	13.64	**150**	100-year	25414	-2.7	10.92
840	100-year	25414	-5.02	13.64	**145**	100-year	25414	-2.7	10.97
820	100-year	25414	-5.04	13.64	**135**	100-year	25414	-2.7	10.8
800	100-year	25414	-5.07	13.63	**130**	100-year	25414	-2.7	10.86
780	100-year	25414	-5.09	13.59	**120**	100-year	25414	-3.2	10.9
760	100-year	25414	-5.12	13.59	**110**	100-year	25414	-3.2	10.87
740	100-year	25414	-5.15	13.58					

Figure C-7: Profile for Combined Alternatives Levee #2 and Dredging #2

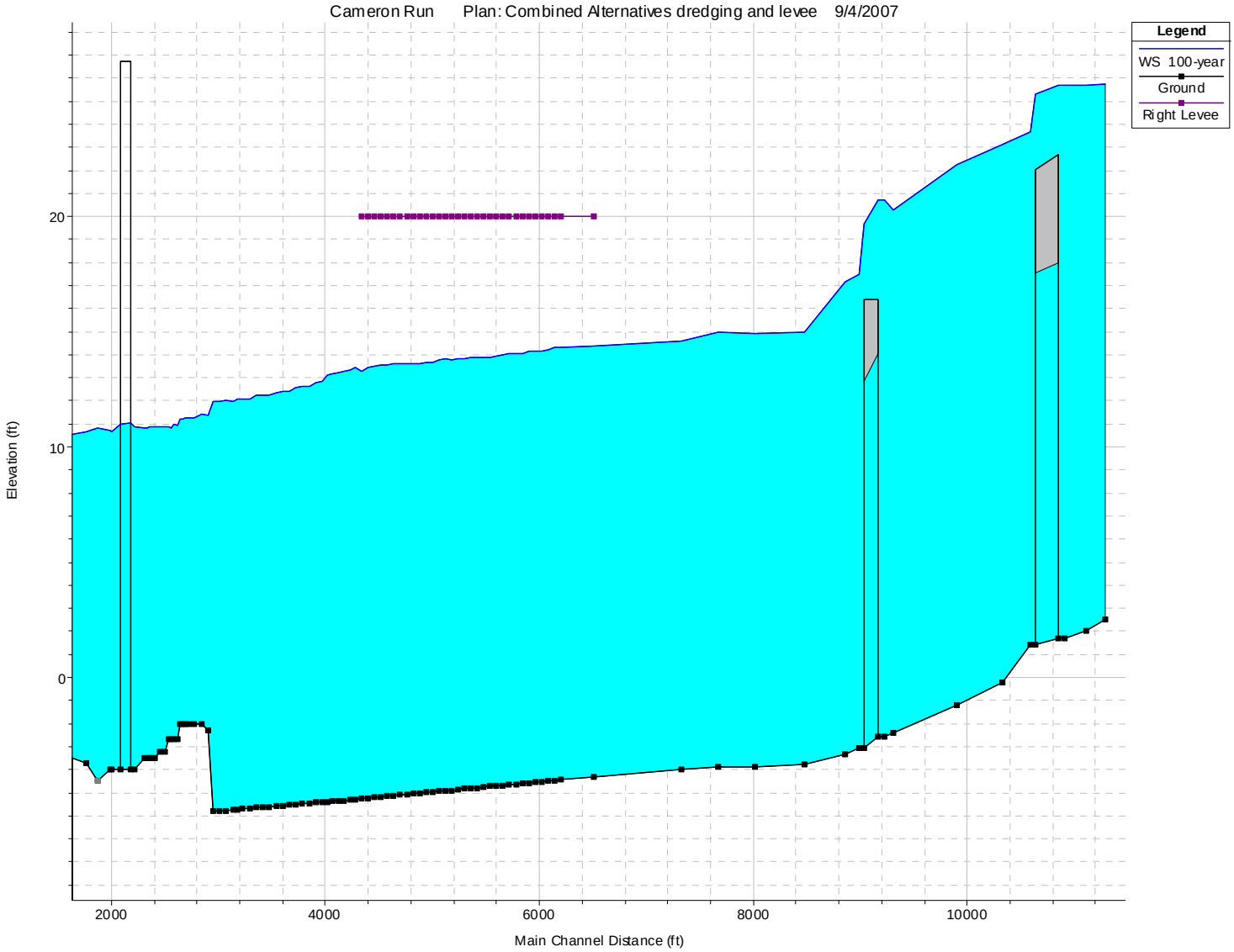


Table C-8: Output table for Combined Alternatives Levee #3 and Dredging #3

HEC-RAS Plan: dredge2sewer Locations: User Defined Profile: 100-year

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
2650		Bridge			**720**	100-year	25414	-5.17	14.33
2623	100-year	25398	1.4	24.29	**700**	100-year	25414	-5.21	14.28
2526	100-year	25398	-0.2	23.8	**680**	100-year	25414	-5.23	14.22
2398	100-year	25398	-1.2	23.12	**660**	100-year	25414	-5.26	14.08
2211	100-year	25414	-2.4	21.7	**659**	100-year	25414	-5.28	14.24
2169	100-year	25414	0.14	21.99	**640**	100-year	25414	-5.3	14.13
2149		Bridge			**625**	100-year	25414	-5.33	14.09
2129	100-year	25414	-1.21	19.09	**610**	100-year	25414	-5.35	14.06
2071	100-year	25414	0.7	18.04	**595**	100-year	25414	-5.36	14.04
1963	100-year	25414	-3.8	16.37	**575**	100-year	25414	-1.26	13.82
1823	100-year	25414	0.2	15.62	**555**	100-year	25414	-2	13.41
1707	100-year	25414	-0.2	15.56	**540**	100-year	25414	-1.82	13.34
1597	100-year	25414	-1.5	15.22	**530**	100-year	25414	-2	13.14
1389	100-year	25414	-4.3	15.07	**510**	100-year	25414	-1.99	13.07
1280	100-year	25414	-4.44	14.99	**485**	100-year	25414	-2.3	12.98
1260	100-year	25414	-4.46	15	**465**	100-year	25414	-1.61	12.63
1240	100-year	25414	-4.49	14.89	**445**	100-year	25414	-1.2	12.67
1220	100-year	25414	-4.51	14.88	**425**	100-year	25414	-0.91	12.55
1200	100-year	25414	-4.54	14.85	**395**	100-year	25414	-2.5	12.48
1180	100-year	25414	-4.58	14.86	**385**	100-year	25414	-2.12	12.41
1160	100-year	25414	-4.6	14.77	**375**	100-year	25414	-3.5	12.39
1140	100-year	25414	-4.62	14.76	**355**	100-year	25414	-3.5	12.15
1120	100-year	25414	-4.65	14.76	**337**	100-year	25414	-2.23	12.08
1100	100-year	25414	-4.68	14.71	**325**	100-year	25414	-2.25	12.09
1080	100-year	25414	-4.7	14.67	**310**	100-year	25414	-2.25	11.9
1060	100-year	25414	-4.72	14.64	**290**	100-year	25414	-2	12.02
1040	100-year	25414	-4.75	14.64	**270**	100-year	25414	-2	11.79
1020	100-year	25414	-4.78	14.64	**255**	100-year	25414	-2.27	11.81
1000	100-year	25414	-4.8	14.63	**240**	100-year	25414	-2.27	11.39
980	100-year	25414	-4.83	14.56	**210**	100-year	25414	-2	11.4
960	100-year	25414	-4.87	14.53	**180**	100-year	25414	-2	11.26
940	100-year	25414	-4.89	14.52	**170**	100-year	25414	-2	11.24
920	100-year	25414	-4.91	14.55	**165**	100-year	25414	-2	11.25
900	100-year	25414	-4.94	14.51	**160**	100-year	25414	-2	11.18
880	100-year	25414	-4.96	14.43	**155**	100-year	25414	-2	11.18
860	100-year	25414	-4.99	14.41	**150**	100-year	25414	-2.7	10.92
840	100-year	25414	-5.02	14.4	**145**	100-year	25414	-2.7	10.97
820	100-year	25414	-5.04	14.4	**135**	100-year	25414	-2.7	10.8
800	100-year	25414	-5.07	14.4	**130**	100-year	25414	-2.7	10.86
780	100-year	25414	-5.09	14.37	**120**	100-year	25414	-3.2	10.9
760	100-year	25414	-5.12	14.37	**110**	100-year	25414	-3.2	10.87
740	100-year	25414	-5.15	14.35					

Figure C-8: Profile for Combined Alternatives Levee #3 and Dredging #3

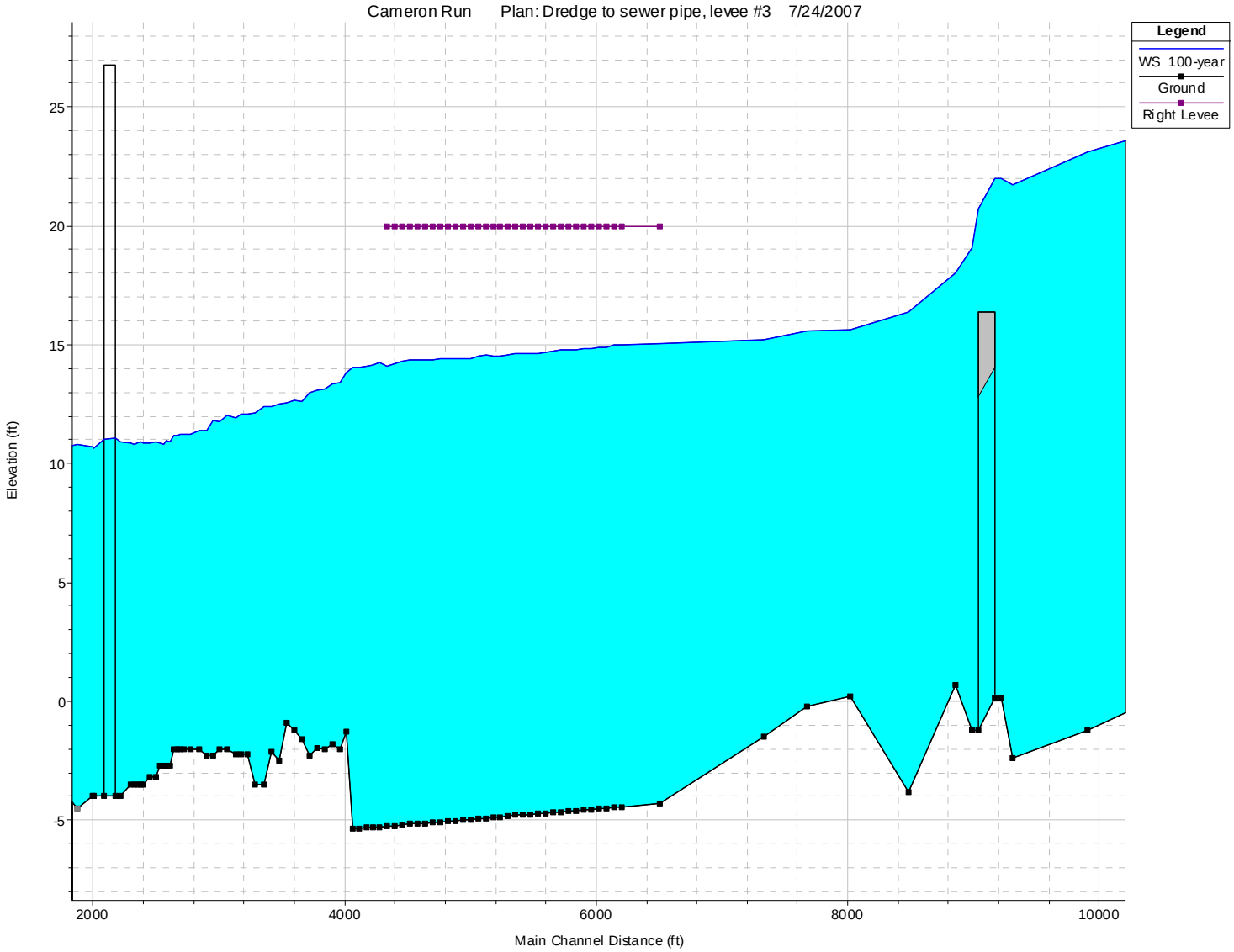


Table C-9: Output table for Combined Alternatives Levee #3 and Dredging #4

HEC-RAS Plan: Plan1c Locations: User Defined Profile: 100-year

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
2650		Bridge			**720**	100-year	25414	-2.71	14.37
2623	100-year	25398	1.40	24.32	**700**	100-year	25414	-2.73	14.30
2526	100-year	25398	-0.20	23.83	**680**	100-year	25414	-2.73	14.20
2398	100-year	25398	-1.20	23.16	**660**	100-year	25414	-2.76	14.00
2211	100-year	25414	-2.40	21.76	**659**	100-year	25414	-2.78	14.23
2169	100-year	25414	0.14	22.05	**640**	100-year	25414	-2.80	14.08
2149		Bridge			**625**	100-year	25414	-2.83	14.03
2129	100-year	25414	-1.21	19.22	**610**	100-year	25414	-2.85	14.00
2071	100-year	25414	0.70	18.19	**595**	100-year	25414	-2.86	13.98
1963	100-year	25414	-3.80	16.63	**575**	100-year	25414	-1.26	13.82
1823	100-year	25414	0.20	15.95	**555**	100-year	25414	-2.00	13.41
1707	100-year	25414	-0.20	15.93	**540**	100-year	25414	-1.82	13.34
1597	100-year	25414	-1.50	15.64	**530**	100-year	25414	-2	13.14
1389	100-year	25414	-1.80	15.29	**510**	100-year	25414	-1.99	13.07
1280	100-year	25414	-1.94	15.18	**485**	100-year	25414	-2.3	12.98
1260	100-year	25414	-1.96	15.18	**465**	100-year	25414	-1.61	12.63
1240	100-year	25414	-1.99	15.05	**445**	100-year	25414	-1.2	12.67
1220	100-year	25414	-2.01	15.03	**425**	100-year	25414	-0.91	12.55
1200	100-year	25414	-2.04	15.00	**395**	100-year	25414	-2.5	12.48
1180	100-year	25414	-2.08	15.00	**385**	100-year	25414	-2.12	12.41
1160	100-year	25414	-2.10	14.91	**375**	100-year	25414	-3.5	12.39
1140	100-year	25414	-2.12	14.89	**355**	100-year	25414	-3.5	12.15
1120	100-year	25414	-2.15	14.89	**337**	100-year	25414	-2.23	12.08
1100	100-year	25414	-2.18	14.84	**325**	100-year	25414	-2.25	12.09
1080	100-year	25414	-2.20	14.78	**310**	100-year	25414	-2.25	11.90
1060	100-year	25414	-2.22	14.75	**290**	100-year	25414	-2	12.02
1040	100-year	25414	-2.25	14.74	**270**	100-year	25414	-2	11.79
1020	100-year	25414	-2.28	14.73	**255**	100-year	25414	-2.27	11.81
1000	100-year	25414	-2.30	14.72	**240**	100-year	25414	-2.27	11.39
980	100-year	25414	-2.33	14.66	**210**	100-year	25414	-2	11.40
960	100-year	25414	-2.37	14.63	**180**	100-year	25414	-2	11.25
940	100-year	25414	-2.39	14.62	**170**	100-year	25414	-2	11.24
920	100-year	25414	-2.41	14.65	**165**	100-year	25414	-2	11.25
900	100-year	25414	-2.44	14.60	**160**	100-year	25414	-2	11.18
880	100-year	25414	-2.46	14.50	**155**	100-year	25414	-2	11.18
860	100-year	25414	-2.49	14.47	**150**	100-year	25414	-2.7	10.92
840	100-year	25414	-2.52	14.46	**145**	100-year	25414	-2.7	10.97
820	100-year	25414	-2.54	14.46	**135**	100-year	25414	-2.7	10.80
800	100-year	25414	-2.57	14.44	**130**	100-year	25414	-2.7	10.86
780	100-year	25414	-2.59	14.42	**120**	100-year	25414	-3.2	10.90
760	100-year	25414	-2.62	14.41	**110**	100-year	25414	-3.2	10.87
740	100-year	25414	-2.65	14.39					

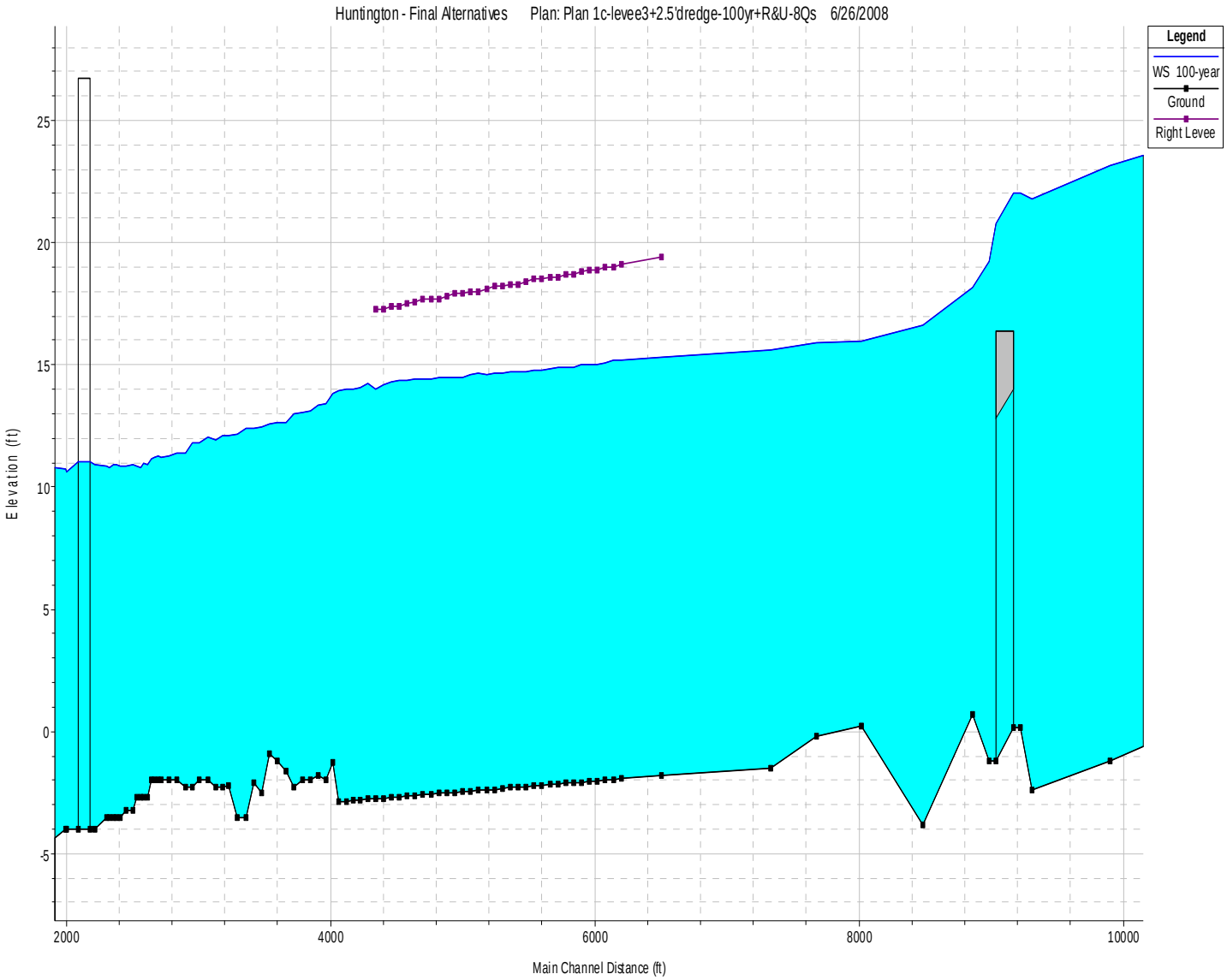



Figure C-9: Profile for Combined Alternatives Levee #3 and Dredging #4