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Fuller Mossbarger Scott & May

FMSM ENGINEERS

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Report of Floodplain and Scour Analysis

Chevron Cincinnati Facility
Sheet Pile Barrier and River Bank Stabilization Project
Hamilton County, Ohio

Prepared for:
Trihydro Corporation
Laramie, Wyoming

December 4, 2007

FULLER, MOSSBARGER, SCOTT & MAY ENGINEERS, INC.

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December 4, 2007 O.1.1.CN2006064R01

Justin Pruis
Trihydro Corporation
1252 Commerce Drive
Laramie, Wyoming 82070

Re: Report of Floodplain and Scour Analysis
Chevron Cincinnati Facility
Sheet Pile Barrier and River Bank Stabilization Project
Hamilton County, Ohio

Dear Mr. Pruis:

Enclosed is our report of the floodplain and scour analysis to support your design of the bank stabilization along the Great Miami River at the Chevron Cincinnati Facility in Hamilton County, Ohio. This report summarizes FMSM's scope of services, analysis methodologies and results.

We appreciate the opportunity to assist Trihydro on this project. If you have any questions, please call at our office.

Respectfully submitted,

FULLER, MOSSBARGER, SCOTT AND MAY
ENGINEERS, INC.

Stan A. Harris, PE
Geotechnical Program Manager/Ohio

SAH/lfb

STATE OF OHIO
STAN A. HARRIS
53083
REGISTERED PROFESSIONAL ENGINEER
12/4/07

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Report of Floodplain and Scour Analysis

Chevron Cincinnati Facility
Sheet Pile Barrier and River Bank Stabilization Project
Hamilton County, Ohio

1. Study Description

The Chevron Cincinnati Facility is located in Hamilton County, Ohio along the Great Miami River, upstream of US 50. Since the closing of the old refinery, oil sheening has been observed on the Great Miami River in an area of river bank erosion. The river bank erosion has exposed a deposit of sand and gravel containing refinery oil.

This project addresses the erosion of the bank and potential impacts on the floodplain and scour from the proposed conditions. The proposed improvements include the construction of sheet pile cut-off wall to address environmental issues involved with the exposed sand and gravel deposit. Dredging of material from the river channel and removal of the berm from a storm water management pond located in the Great Miami River floodplain have been proposed as means to mitigate increased water surface elevations caused by the proposed sheet pile wall construction and grading.

Proposed improvements include construction of the sheet pile barrier wall and grading of the right bank from approximate river mile 8.76 to 9.11, removal of the berm from the storm water management pond (SWMU) located between approximate river miles 9.11 and 9.30 and dredging of the East Island Channel from the US 50 bridge (river mile 8.62) to river mile 9.30. The locations of the proposed improvements are presented on Figure 1 in Appendix A.

Fuller, Mossbarger, Scott and May Engineers, Inc. (FMSM) has been requested to perform floodplain modeling to determine the project's impact on floodplain elevations for the 1-percent exceedance event and perform scour calculations to support design of sheet pile wall. FMSM has conducted a hydraulic analysis of the Great Miami River from river mile 7.0 to river mile 16.1 above the confluence with the Ohio River; the study reach is located between river miles 7.25 and 10.72. A mobile boundary analysis of the channel bed was performed to determine potential scour depth for proposed conditions.

This report describes the development of the computer models using the U.S. Army Corps of Engineers (USACE) HEC-RAS software, the results of the hydraulic and mobile boundary modeling and a summary of the floodplain impacts and scour analysis.

2. Hydraulic Analysis

2.1. Hydraulic Models

Current Conditions Model:

The Louisville District Office of the US Army Corps of Engineers provided a digital copy of the Great Miami River HEC-2 model used to define the effective flood profiles and floodway for the Federal Emergency Management Agency (FEMA) May 17, 2004 Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) for Hamilton County and Incorporated Areas, Ohio.

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The model data file was checked and executed using the HEC-2 software. The results of this model run were comparable to the water surface elevations published in the 2004 FIS.

HEC-RAS software, version 4.0 Beta, has improved capabilities in both hydraulic modeling and mobile boundary analysis. The HEC-2 model was imported into the HEC-RAS software and converted to HEC-RAS format. This conversion included making corrections to the bridge data in HEC-RAS. Also, the working model was truncated to the study reach extending from above the confluence of the Whitewater River to the upstream limits of the Chevron property.

Calibration of the HEC-RAS model was performed to generate results closely approximating the HEC-2 model output. Expansion and contraction coefficients were adjusted until the HEC-RAS model results closely approximated the HEC-2 model output and FIS report.

Within the project reach, the original HEC-2 model had few cross sections, with about one-half of the included cross sections interpolated from adjacent field-surveyed cross sections. Also, the Great Miami River channel has migrated since the original HEC-2 model development, and bars have formed that are considerably different from the effective FIS study. To supplement the data, Trihydro provided to FMSM surveyed cross sections of the river and floodplain. These cross sections were inserted into the HEC-RAS modeling to update the existing condition geometry and provide greater detail. Locations of the cross sections used in this study are presented in the plan drawing in Appendix A.

Additional cross sections were added to evaluate the sheet-pile wall and several mitigation alternatives. The Manning's roughness factors from the original HEC-2 model were used as appropriate in the new HEC-RAS model. The largest difference in the modeling was in the expansion and contraction coefficients used in the Rail Road and US 50 bridge routines. These coefficients were increased in the HEC-RAS model in accordance with bridge modeling guidance provided by the USACE.

Proposed Conditions Model:

A proposed conditions model was created to evaluate the placement of the proposed sheet pile wall and grading on the water surface profile. The location of the wall was represented in the cross section geometry by grading and roughness coefficients associated with the proposed fill. These cross sections were substituted into the HEC-RAS model and results were produced. Existing and proposed condition cross section geometry is presented in Appendix B.

The proposed conditions created changes in velocity, shear and water surface elevation that require mitigation. The tabulated results are presented in Appendix B.

2.2. Mitigation Modeling

The proposed sheet pile wall affects both cross sectional area of the channel and roughness of the channel. Attempting to mitigate for this effect by simply excavating the channel deeper will not provide satisfactory results for the high flow velocities associated with this steep gravel riffle. Grading the channel bottom will change the velocity head faster than the water surface elevation, as the water slows down, the flow gets deeper.

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Several alternatives were considered for mitigation. Alternatives that only modified cross sectional area did not produce a beneficial result; however, one alternative to restore the blocked channel on the east side of the Chevron Island was capable of mitigating for the proposed sheet pile wall. This alternative involves opening up several blockages along this eastern channel that would both increase cross sectional flow area and reduce the roughness of this cleaned out channel. Opening this channel would also feed flood flows into the eastern spans of the three downstream bridges more efficiently.

Given that these blockages are a result of access roads for the six pipelines that fed crude to the refinery and returned product to the Ohio River docks, removing these blockage appears to be an effective solution. Chevron has already removed the six pipelines, so these access roads are no longer necessary.

This mitigation model provides the basis of the "no-rise" condition necessary to meet floodplain permitting requirements. The model demonstrates that the proposed work can be accomplished with no adverse impact on the floodplain. Appendix C contains a table documenting the "no-rise" condition produced by the proposed geometry including the above mitigation strategy.

2.3. Mobile Boundary Transport Analysis

HEC-RAS, version 4.0 Beta, includes a new modeling routine that considers the stability of river beds during flooding events. The mobile boundary analysis routine was developed to evaluate the average response of a river to a flood event. Given that river engineering is currently oriented to re-establishing natural stability in a given river channel, a routine is now provided in HEC-RAS to assess river bed stability. This modeling requires three modifications to the HEC-RAS input. First, the river bed must be locked in place at the downstream end as a boundary condition. Second, in cross sections above this terminus, the gradation of the river bed is added to the model. The gravel bars along the Great Miami River were sampled and sieved to provide this information.

Since scour is a function of both flow magnitude and duration, a hydrograph is the third piece of information required for this model. The 1959 flood was chosen as a template for this hydrograph. The 1959 flood is the largest flood of record since the five flood control dams in the watershed and several levees along the river were built by the Miami Conservancy District. It was assumed that given the distance from the project area and watershed size, that the Brookville Dam on the East Fork of the Whitewater River wouldn't adversely impact this analysis.

The results of this model over a wide range of flows and across several cross sections near the proposed sheet pile wall indicate that the project reach is primarily depositional. The mobile boundary analysis provides channel-wide results at each cross section, with 0.31 feet being the largest depth of scour produced. These results confirm that the backwater effects of the Ohio River and the impediment of the three downstream bridges dominate the sediment characteristics of the project reach. The steepness of this reach is a result of gravel deposition in a backwater condition.

Results of the mobile boundary transport analysis are presented in Appendix D.

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2.4. Scour Potential Analysis

The HEC-RAS computer program is a one-dimensional model of river flow; however, river bends are dynamic and have complicated three-dimensional flows. The problem of determining scour potential in river bends can be approached in two ways. First, a two-dimensional approximation is assessed, then an additional dimensional approximation is used.

One-dimensional shear is determined using the hydraulic radius of the river channel. The hydraulic radius is an averaging technique that, when combined with water density and the slope of the water surface, produces a shear stress. This averaged shear stress was used in the mobile bed analysis.

Two-dimensional shear stress effects are determined using point shears. In-lieu-of the hydraulic average of the channel, the maximum depth of the channel is used. This is appropriate given that the maximum depth of the channel is likely to be adjacent to the proposed sheet pile wall.

The third dimension of shear represents the vorticity of river bends. As water enters a bend, the surface water flows towards the outside of the bend, causing a flow circulation down the river bank that adds shear stress in the downstream direction. This situation can be solved using a three-dimensional hydraulic model; however, these models are extremely hard to develop and are unstable in fast flow environments. The USACE has developed a two-dimensional hydraulic flow model called RMA2. This model has a vorticity estimating routine built into the program.

The theory of this vorticity estimating routine is developed in the attached calculation summary in Appendix E. The documented solution is appropriate for the information found in a two-dimensional hydraulic model. Conveniently, there is a point in this derivation where the equations are still one-dimensional. Solving the one-dimensional vorticity equation for maximum vorticity provides an equation that can be applied to the results of a HEC-RAS model. This derived equation has in its denominator, the radius of curvature of the river bend. Intuitively, the tighter the bend, the stronger the vorticity will become. This derivation assumes that the river bend is long enough (has enough time) to fully develop its maximum vorticity. At the Great Miami River bend, it is unlikely that the river reaches this maximum condition; however, to determine the actual vorticity would require building the RMA2 model.

The theoretical equations are all in metric units, so when a 200 meter radius of curvature is used, the river produces a point shear and a vorticity shear that is a factor of eight (8) greater than that produced by the hydraulic average condition. Both the point shear and the vorticity shear would increase linearly with additional channel depth, so a factor of safety should be applied to this analysis. Given that scour is a function of both magnitude and duration the applied factor of safety should be appropriate to the risk associated with failure. A factor of safety of three (3) for a simple stone toe on the sheet-pile wall would be appropriate.

The bed scour from the mobile bed analysis has a maximum value of 0.31 feet. This is the result of the un-mitigated condition set up to produce the most severe flow conditions in the model. For an extremely tight bend for a river of this size, which could evolve on its own in the future, the conservative figure scales directly to 2.5 feet. Applying a factor of safety to account for dynamic conditions produces an estimated maximum scour depth of 7.5 feet. The shear calculations on the project reach are included in Appendix E.

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3. Discussion of Flow Conditions

The project reach has a unique flow environment. While the adjacent gravel riffle is steep at low flows, at flood flows this reach is dominated by the backwater effects from the Ohio River and three downstream bridges. A series of bankfull flows over the last few years has greatly eroded the river bank. This series of flows has exposed a sand and gravel layer along the bank.

Deep overbank flooding can stabilize a meandering river, provided that natural floodplain to channel flows are occurring. On the Great Miami River, the natural flood conditions are not occurring due to the five upstream flood control dams. These dams cause the long bankfull flow conditions that are distressing at the steep gravel riffle next to the Chevron site.

The location of the bank erosion was noticed early on to be coincidental with a storm water management pond located in the floodplain. A channel splay feature was found on the river bank just downstream of the constriction point caused by the levee around this pond. This splay feature looked to be creating turbulence along the bank that would have added to the shear stress erosion downstream. This turbulence also looked to be causing a low spot in the gravel bar that allowed river flow to cross over and run down the eroded bank. This cross-over flow had an adverse impact on bank vegetation and may have moved some of the gravel that was protecting this bank downstream.

The proposed conditions model developed for this study includes the removal of the levee around the storm water management pond in the floodplain. Removing this levee did not help with mitigation for the water surface rise associated with the proposed sheet pile wall; however, removing this levee will have positive effects on the river upstream of the sheet pile wall. The benefit associated with removing this levee will be to improve the floodplain to channel transfer of water during floodflows.

4. Summary and Recommendations

The HEC-RAS models developed for the current conditions and proposed conditions modeling demonstrated that the proposed work, including the mitigation, would not have an adverse impact on the floodplain. This floodplain mitigation will benefit the Chevron property by creating a more natural floodplain that will help improve the stability of the proposed river work.

For the scour analysis, the new capabilities of HEC-RAS, version 4.0 Beta, were used. The proposed condition model was modified for the scour analysis to provide information on the main channel that would maximize the scour results. Even with this deliberate attempt to maximize these results, the mobile boundary routine largely reported a gravel depositional environment in the project reach. The reported scour was scaled upwards by utilizing point shear values and vorticity shear values that estimate for the three-dimensional environment in the river bend where the proposed sheet pile wall is to be located. To account for the additional dynamics of scour, a factor of safety was applied to the estimated maximum scour depth.

The HEC-RAS computer program is limited due to its one-dimensional characteristics. Some of the benefits of the proposed work and the accuracy of hydraulic modeling in a river bend can only be improved by applying a two-dimensional hydraulic model like RMA2. The same

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would be true of applying a two-dimensional model to the very complex triple bridges that are located downstream of the project site. However a two-dimensional bridge model would most likely increase the backwater effects on the project reach and a two-dimensional bend model could only reduce vorticity. In either case the HEC-RAS model created in this report would be used to establish the boundary conditions for any two-dimensional follow up study. The use of a two-dimensional hydraulic model is not necessary to document the “no-rise” condition. The provided models are adequate for this regulatory review.

If the risk associated with this proposed river work is perceived by Chevron to be very high, then the HEC-RAS models produced by this study will be adequate as a starting point for a more definitive and extensive hydraulic modeling effort of the affected channel. Two-dimensional modeling of steep reaches like that found at the project site are very difficult to develop. There are no guarantees that two-dimensional modeling on a steep reach will produce useful results at the flow environments of interest; however, if the concern is the reach below the proposed work down to the bridges, which has a much lower hydraulic gradient, then a two-dimensional study of this area would be much more likely to produce useful results.

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Appendix A

Project Location and Model Cross Section Mapping

Notes:

1. Base mapping is USGS 7 1/2 – minute Topographic Quadrangles; Addyston (1987) and Hooven (1987).
2. Vertical Datum: NGVD29
   Horizontal Datum: NAD83
3. Cross Sections 8.51, 8.62, 8.66, 8.70, 8.76, 8.85, 8.94, 9.01, 9.11, 9.19, 9.30, 9.42, 9.55, 9.75 were taken from survey data provided by Trihydro.
4. Cross Sections 7.25, 7.75, 10.72, 11.74, 12.63, 13.75, and 14.33 were taken from effective FIS HEC–2 Model for Great Miami River provided by USACE.

Legend:

- Proposed Sheet Pile Wall
- Proposed Borrow Areas
- Sta. Surveyed Cross Sections
- Sta. HEC–2 Model Cross Sections

500 0 1,000 2,000 FEET
GRAPHIC SCALE

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PROPOSED IMPROVEMENTS AND HYDRAULIC MODEL

REPORT OF FLOODPLAIN AND SCOUR ANALYSIS
SHEET PILE BARRIER AND RIVER BANK STABILIZATION
CHEVRON CINCINNATI FACILITY
HAMILTON COUNTY, OHIO

PROJECT NO.	CN2006064
DATE	DEC., 2007
DRAWN BY	CW
CHECKED BY	DNB
CHECKED BY	JSM
SCALE	1"=1,000'
REVISED	
1.	
2.	
3.	
4.	
5.	
6.	
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8.	

SHEET

1 OF 1

CN2006064\DESIGN\06064_SITEPLAN.DWG

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Appendix B

HEC-RAS Output

HEC-RAS Plan: Existing

Reach	Model Cross Section ID	River Station	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(mi)		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	52	14.57	100yr	128900	467.5	511.76		512.81	0.000631	9.13	25723.04	2274.58	0.26
Reach-1	52	14.57	500yr	163000	467.5	515.17		516.18	0.000601	9.44	33568.3	2325.23	0.26
Reach-1	52	14.57	50yr	116273	467.5	510.34		511.41	0.000643	8.99	22519.75	2254.77	0.26
Reach-1	52	14.57	10yr	82314	467.5	505.97		507.01	0.000651	8.31	12794.33	2193.56	0.26
Reach-1	52	14.57	50k	50000	467.5	500.84		501.41	0.000447	6.13	8575.25	444.23	0.21
Reach-1	52	14.57	30k	30000	467.5	495.96		496.28	0.000318	4.52	6678.57	341.08	0.17
Reach-1	52	14.57	10k	10000	467.5	487.04		487.14	0.000171	2.49	4008.72	282.08	0.12
Reach-1	51	14.33	100yr	128900	467.47	511.27		511.99	0.000507	7.96	29278.15	1929.91	0.23
Reach-1	51	14.33	500yr	163000	467.47	514.65		515.4	0.000505	8.43	35916.57	1996.41	0.24
Reach-1	51	14.33	50yr	116273	467.47	509.86		510.57	0.00051	7.77	26585.41	1901.25	0.23
Reach-1	51	14.33	10yr	82314	467.47	505.47		506.16	0.000523	7.19	18504.35	1782.8	0.23
Reach-1	51	14.33	50k	50000	467.47	500.24		500.82	0.00049	6.14	9375.04	1711.27	0.22
Reach-1	51	14.33	30k	30000	467.47	495.53		495.85	0.000359	4.58	6628.53	408.62	0.18
Reach-1	51	14.33	10k	10000	467.47	486.82		486.91	0.000179	2.53	3953.56	281.55	0.12
Reach-1	50	14.00	100yr	128900	471.3	510.65		511.3	0.000362	7.38	29247.54	1668.23	0.24
Reach-1	50	14.00	500yr	163000	471.3	514		514.73	0.000367	7.97	34873.96	1685.01	0.24
Reach-1	50	14.00	50yr	116273	471.3	509.25		509.87	0.000362	7.15	26918.29	1658.97	0.23
Reach-1	50	14.00	10yr	82314	471.3	504.85		505.41	0.000374	6.51	19699.72	1612.72	0.23
Reach-1	50	14.00	50k	50000	471.3	499.66		500.07	0.000354	5.41	12415.37	1209.69	0.22
Reach-1	50	14.00	30k	30000	471.3	494.95		495.27	0.000333	4.58	7126.9	676.51	0.2
Reach-1	50	14.00	10k	10000	471.3	486.35		486.51	0.000326	3.19	3131.86	336.07	0.18
Reach-1	49	13.75	100yr	128900	471.26	510.16		510.78	0.00041	8.08	31026.24	1530.64	0.25
Reach-1	49	13.75	500yr	163000	471.26	513.5		514.2	0.000426	8.79	36175.41	1556.43	0.26
Reach-1	49	13.75	50yr	116273	471.26	508.77		509.35	0.000406	7.81	28897.76	1519.85	0.25
Reach-1	49	13.75	10yr	82314	471.26	504.36		504.88	0.00041	7.09	22271.38	1485.75	0.24
Reach-1	49	13.75	50k	50000	471.26	499.07		499.55	0.000434	6.31	14531.73	1446.55	0.24
Reach-1	49	13.75	30k	30000	471.26	494.31		494.75	0.000438	5.63	8421.36	1168.31	0.23
Reach-1	49	13.75	10k	10000	471.26	485.8		486.04	0.000373	3.87	2587.17	227.75	0.2
Reach-1	48	13.51	100yr	128900	471.3	509.01		510.09	0.000616	10.04	22575.73	1074.06	0.31
Reach-1	48	13.51	500yr	163000	471.3	512.17		513.47	0.000671	11.14	26005.89	1099.53	0.33
Reach-1	48	13.51	50yr	116273	471.3	507.68		508.68	0.000599	9.62	21146.52	1066.05	0.3
Reach-1	48	13.51	10yr	82314	471.3	503.42		504.24	0.000559	8.43	16669.48	1031.01	0.29
Reach-1	48	13.51	50k	50000	471.3	498.32		498.93	0.000502	6.99	11598.56	952.39	0.26
Reach-1	48	13.51	30k	30000	471.3	493.62		494.14	0.000482	6.06	7186.2	927.18	0.25
Reach-1	48	13.51	10k	10000	471.3	485.31		485.54	0.000384	3.91	2621.89	250.55	0.21
Reach-1	47	13.29	100yr	128900	460.2	508.26		509.41	0.000536	9.5	20939.28	1049.76	0.29
Reach-1	47	13.29	500yr	163000	460.2	511.19		512.68	0.000632	10.9	24241.32	1218.47	0.32
Reach-1	47	13.29	50yr	116273	460.2	507.02		508.04	0.000498	8.93	19675.69	985.19	0.28
Reach-1	47	13.29	10yr	82314	460.2	502.94		503.65	0.000404	7.35	16018.42	843	0.24
Reach-1	47	13.29	50k	50000	460.2	497.99		498.43	0.000309	5.66	12047.74	769.92	0.21
Reach-1	47	13.29	30k	30000	460.2	493.39		493.67	0.000257	4.46	8627.09	702.95	0.18
Reach-1	47	13.29	10k	10000	460.2	485.12		485.23	0.00016	2.75	3889.93	408.69	0.13
Reach-1	46	13.12	100yr	128900	460.15	507.97		508.93	0.000449	8.22	20184.89	1063.46	0.26
Reach-1	46	13.12	500yr	163000	460.15	510.8		512.12	0.000544	9.6	23611.92	1568.28	0.29
Reach-1	46	13.12	50yr	116273	460.15	506.72		507.6	0.000428	7.81	18873.48	1041.02	0.25
Reach-1	46	13.12	10yr	82314	460.15	502.64		503.29	0.000377	6.63	14792.97	951.02	0.23
Reach-1	46	13.12	50k	50000	460.15	497.74		498.15	0.000295	5.17	10453.61	812.81	0.2
Reach-1	46	13.12	30k	30000	460.15	493.21		493.45	0.000222	3.97	7557.22	432.02	0.17
Reach-1	46	13.12	10k	10000	460.15	485.02		485.1	0.000113	2.32	4315.26	332.99	0.11
Reach-1	45	12.87	100yr	128900	473.6	506.77		508.1	0.000838	9.68	17961.14	1225.63	0.34
Reach-1	45	12.87	500yr	163000	473.6	509.55		511.17	0.000902	10.79	21775.37	1517.61	0.36
Reach-1	45	12.87	50yr	116273	473.6	505.59		506.8	0.000813	9.22	16585.4	1101.48	0.34
Reach-1	45	12.87	10yr	82314	473.6	501.63		502.61	0.000666	8.11	12593.87	957.74	0.3
Reach-1	45	12.87	50k	50000	473.6	496.98		497.61	0.000531	6.43	8443.9	789.1	0.26
Reach-1	45	12.87	30k	30000	473.6	492.63		493.03	0.000442	5.05	5944.07	399.6	0.23
Reach-1	45	12.87	10k	10000	473.6	484.63		484.82	0.000476	3.46	2888.53	364.28	0.22
Reach-1	44	12.63	100yr	128900	473.6	506.07		507.12	0.000604	8.54	19604.22	1317.32	0.3
Reach-1	44	12.63	500yr	163000	473.6	508.83		510.1	0.000654	9.51	23514.51	1516.05	0.31
Reach-1	44	12.63	50yr	116273	473.6	504.89		505.86	0.000587	8.16	18100.19	1235.86	0.29
Reach-1	44	12.63	10yr	82314	473.6	501.01		501.77	0.000563	7.13	13593.58	1087.57	0.28
Reach-1	44	12.63	50k	50000	473.6	496.42		496.93	0.00049	5.73	9086.41	846.29	0.25
Reach-1	44	12.63	30k	30000	473.6	492.15		492.47	0.000407	4.6	6523.81	478.68	0.22
Reach-1	44	12.63	10k	10000	473.6	484.06		484.23	0.000454	3.32	3007.74	390.81	0.21
Reach-1	43	12.45	100yr	128900	468.5	505.09		506.39	0.000995	10.08	20758.72	1701.13	0.32
Reach-1	43	12.45	500yr	163000	468.5	507.97		509.35	0.001009	10.78	25691.34	1735.58	0.33
Reach-1	43	12.45	50yr	116273	468.5	503.92		505.15	0.000972	9.71	18819.09	1579.58	0.32
Reach-1	43	12.45	10yr	82314	468.5	500.11		501.1	0.000885	8.44	13616.9	1157.66	0.29
Reach-1	43	12.45	50k	50000	468.5	495.74		496.38	0.000694	6.59	9179.73	876.63	0.25
Reach-1	43	12.45	30k	30000	468.5	491.66		492.04	0.000537	5.03	6547.18	527.92	0.21
Reach-1	43	12.45	10k	10000	468.5	483.62		483.78	0.000509	3.25	3088.12	350.84	0.19

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Reach-1	42	12.31	100yr	128900	468.47	505.06		505.58	0.000588	6.72	30815.08	2210.57	0.24
Reach-1	42	12.31	500yr	163000	468.47	507.98		508.53	0.000566	7.1	37302.62	2236.83	0.24
Reach-1	42	12.31	50yr	116273	468.47	503.84		504.35	0.000604	6.58	28121.05	2197.25	0.24
Reach-1	42	12.31	10yr	82314	468.47	499.83		500.36	0.000724	6.35	19399.77	2139.4	0.25
Reach-1	42	12.31	50k	50000	468.47	495.24		495.75	0.000881	5.85	10557.57	1715	0.27
Reach-1	42	12.31	30k	30000	468.47	491.18		491.56	0.000745	4.94	6180.38	661.23	0.24
Reach-1	42	12.31	10k	10000	468.47	483.19		483.36	0.000601	3.39	2945.78	339.82	0.2
Reach-1	41	12.08	100yr	128900	468.5	504.71		505.01	0.000368	5.71	40710.39	2502.64	0.19
Reach-1	41	12.08	500yr	163000	468.5	507.63		507.97	0.000371	6.14	50018.17	3257.9	0.2
Reach-1	41	12.08	50yr	116273	468.5	503.47		503.77	0.000373	5.58	37625.15	2492.76	0.19
Reach-1	41	12.08	10yr	82314	468.5	499.36		499.67	0.000434	5.37	27454.19	2453.52	0.2
Reach-1	41	12.08	50k	50000	468.5	494.53		494.88	0.000574	5.23	15816	2351.11	0.22
Reach-1	41	12.08	30k	30000	468.5	490.19		490.61	0.000833	5.19	6084.75	2129.59	0.26
Reach-1	41	12.08	10k	10000	468.5	482.35		482.55	0.000747	3.65	2739.84	334.4	0.22
Reach-1	40	11.74	100yr	128900	468.84	503.94		504.41	0.000458	6.94	34369.19	2048.4	0.22
Reach-1	40	11.74	500yr	163000	468.84	506.86		507.37	0.000471	7.46	40363.59	2061.55	0.22
Reach-1	40	11.74	50yr	116273	468.84	502.7		503.16	0.000457	6.75	31833.6	2042.81	0.22
Reach-1	40	11.74	10yr	82314	468.84	498.48		498.94	0.000505	6.42	23249.85	2023.78	0.22
Reach-1	40	11.74	50k	50000	468.84	493.37		493.88	0.000606	6.1	12974.59	2000.77	0.23
Reach-1	40	11.74	30k	30000	468.84	488.89		489.32	0.000615	5.27	5687.87	337.46	0.23
Reach-1	40	11.74	10k	10000	468.84	481.43		481.57	0.000402	3.08	3243.61	317.3	0.17
Reach-1	39	11.24	100yr	128900	470.13	501.39		502.66	0.001012	9.87	18890.96	1194.45	0.33
Reach-1	39	11.24	500yr	163000	470.13	504.01		505.52	0.001109	10.95	22068.6	1231.13	0.35
Reach-1	39	11.24	50yr	116273	470.13	500.25		501.44	0.000981	9.45	17535.13	1178.45	0.32
Reach-1	39	11.24	10yr	82314	470.13	496.17		497.15	0.000952	8.36	13015.41	1033.25	0.31
Reach-1	39	11.24	50k	50000	470.13	491.25		491.97	0.000891	6.91	8394.67	843.75	0.28
Reach-1	39	11.24	30k	30000	470.13	487.01		487.49	0.000799	5.55	5488.72	470.23	0.26
Reach-1	39	11.24	10k	10000	470.13	480.02		480.21	0.000693	3.52	2837.75	355.17	0.22
Reach-1	38	10.72	100yr	128900	468.41	499.68		500.55	0.000639	8.32	22920.09	1329.03	0.27
Reach-1	38	10.72	500yr	163000	468.41	502.08		503.18	0.000738	9.44	26201.19	1397.07	0.3
Reach-1	38	10.72	50yr	116273	468.41	498.59		499.39	0.00061	7.92	21492.36	1291.99	0.27
Reach-1	38	10.72	10yr	82314	468.41	494.48		495.13	0.00059	6.99	16473.62	1151.82	0.26
Reach-1	38	10.72	50k	50000	468.41	489.58		490.05	0.000547	5.75	11226.07	997.06	0.24
Reach-1	38	10.72	30k	30000	468.41	485.28		485.64	0.000554	4.84	7079.55	933.84	0.23
Reach-1	38	10.72	10k	10000	468.41	478.1		478.28	0.000701	3.38	3005.81	449.72	0.23
Reach-1	37	10.09	100yr	128900	459.55	497.54		498.37	0.000686	8.24	30588.99	3796.48	0.28
Reach-1	37	10.09	500yr	163000	459.55	500.06		500.85	0.000641	8.45	40201.62	3897.2	0.28
Reach-1	37	10.09	50yr	116273	459.55	496.26		497.17	0.000751	8.34	25726.87	3775.5	0.29
Reach-1	37	10.09	10yr	82314	459.55	492.31		493.02	0.000703	7.21	16487.04	1513.49	0.27
Reach-1	37	10.09	50k	50000	459.55	487.47		488	0.000703	6.08	10366.57	1103.47	0.26
Reach-1	37	10.09	30k	30000	459.55	483.02		483.44	0.000802	5.28	6144.26	755.26	0.27
Reach-1	37	10.09	10k	10000	459.55	476.09		476.29	0.000519	3.61	2767.12	289.1	0.21
Reach-1	36	9.75	100yr	128900	460.48	493.83	483.75	496.38	0.001934	13.22	12330.33	1718.08	0.45
Reach-1	36	9.75	500yr	163000	460.48	496.54	486.62	499.03	0.001841	13.74	20554.1	1760.21	0.44
Reach-1	36	9.75	50yr	116273	460.48	492.84	482.56	495.12	0.001809	12.47	11615.8	1668.18	0.43
Reach-1	36	9.75	10yr	82314	460.48	489.62	478.69	491.22	0.001475	10.32	9409.97	879.5	0.38
Reach-1	36	9.75	50k	50000	460.48	485.49	474.92	486.43	0.001105	7.82	6915.27	505.82	0.32
Reach-1	36	9.75	30k	30000	460.48	481.31	472.08	481.89	0.000917	6.1	4990.34	379.94	0.28
Reach-1	36	9.75	10k	10000	460.48	475.19	468.03	475.37	0.000496	3.37	2963.22	308.25	0.19
Reach-1	35.5	9.55	100yr	128900	461.49	493.44	480.46	494.64	0.001062	9.33	20766.27	1806.96	0.32
Reach-1	35.5	9.55	500yr	163000	461.49	495.97	482.84	497.35	0.001124	10.21	25375.41	1826.86	0.34
Reach-1	35.5	9.55	50yr	116273	461.49	492.41	479.54	493.51	0.001007	8.85	18930.35	1747.66	0.31
Reach-1	35.5	9.55	10yr	82314	461.49	489.04	476.9	489.91	0.000913	7.65	13458.24	1476.44	0.29
Reach-1	35.5	9.55	50k	50000	461.49	484.9	473.99	485.46	0.000746	6.01	8580.78	939.5	0.25
Reach-1	35.5	9.55	30k	30000	461.49	480.75	471.73	481.09	0.000647	4.73	6349.05	465.47	0.23
Reach-1	35.5	9.55	10k	10000	461.49	474.79	468.59	474.9	0.000442	2.76	3620.92	449.91	0.17
Reach-1	35	9.42	100yr	128900	463.22	493.09	480.54	493.85	0.000876	7.3	23938.66	1976.79	0.28
Reach-1	35	9.42	500yr	163000	463.22	495.66	482.73	496.51	0.000893	7.92	29033.31	1997.66	0.28
Reach-1	35	9.42	50yr	116273	463.22	492.04	479.8	492.75	0.00087	7.04	21862.53	1951.59	0.27
Reach-1	35	9.42	10yr	82314	463.22	488.63	477.65	489.21	0.000861	6.24	15434.57	1446.89	0.27
Reach-1	35	9.42	50k	50000	463.22	484.45	475.26	484.86	0.000842	5.2	9879.7	1050.04	0.25
Reach-1	35	9.42	30k	30000	463.22	480.27	473.24	480.58	0.000798	4.46	6728.88	633.03	0.24
Reach-1	35	9.42	10k	10000	463.22	474.29	470.19	474.46	0.000978	3.3	3032.63	582.66	0.25
Reach-1	34.8	9.30	100yr	128900	462.67	492.17	481.61	493.19	0.001182	8.91	22660.28	1970.1	0.33
Reach-1	34.8	9.30	500yr	163000	462.67	494.73	485.48	495.85	0.001181	9.57	27823.73	2040.58	0.34
Reach-1	34.8	9.30	50yr	116273	462.67	491.11	480.34	492.1	0.001187	8.65	20593.93	1941.49	0.33
Reach-1	34.8	9.30	10yr	82314	462.67	487.71	477.46	488.56	0.001213	7.79	14847.63	1608.36	0.32
Reach-1	34.8	9.30	50k	50000	462.67	483.49	474.41	484.19	0.001306	6.79	8429.84	1277.68	0.32
Reach-1	34.8	9.30	30k	30000	462.67	479.51	472.13	480	0.001043	5.63	5324.78	429.67	0.28
Reach-1	34.8	9.30	10k	10000	462.67	473.71	469.1	473.9	0.000828	3.46	2894.01	413.07	0.23
Reach-1	34.6	9.19	100yr	128900	463.06	491.62	480.19	492.5	0.000973	8.16	23823.64	2031.23	0.3
Reach-1	34.6	9.19	500yr	163000	463.06	494.14	482.25	495.15	0.001025	8.94	28319.26	2096.09	0.31

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Reach-1	34.6	9.19	50yr	116273	463.06	490.58	479.38	491.4	0.000957	7.86	21993.31	2017.3	0.29
Reach-1	34.6	9.19	10yr	82314	463.06	487.15	477.02	487.86	0.000952	7.06	16091.13	1958.99	0.29
Reach-1	34.6	9.19	50k	50000	463.06	482.9	473.74	483.47	0.000953	6.04	8630.53	1726.55	0.28
Reach-1	34.6	9.19	30k	30000	463.06	478.97	471.46	479.36	0.000931	5	6034.34	828.1	0.27
Reach-1	34.6	9.19	10k	10000	463.06	473.25	468.2	473.41	0.000735	3.28	3051.46	633.35	0.22
Reach-1	34.5	9.11	100yr	128900	463.46	491.41	479.81	492.05	0.00086	6.91	26625.11	2304.33	0.27
Reach-1	34.5	9.11	500yr	163000	463.46	493.95	482.38	494.67	0.000885	7.47	32055.69	2413.95	0.27
Reach-1	34.5	9.11	50yr	116273	463.46	490.35	478.77	490.96	0.000856	6.7	24396.73	2285.34	0.27
Reach-1	34.5	9.11	10yr	82314	463.46	486.9	476.46	487.43	0.000857	6.06	17012.63	1991.11	0.27
Reach-1	34.5	9.11	50k	50000	463.46	482.62	473.82	483.04	0.00087	5.3	10819.99	1502.64	0.27
Reach-1	34.5	9.11	30k	30000	463.46	478.6	471.57	478.95	0.000979	4.79	6267.84	682.97	0.26
Reach-1	34.5	9.11	10k	10000	463.46	472.88	468.38	473.06	0.000991	3.35	2982.04	554.93	0.25
Reach-1	34.4	9.01	100yr	128900	463.53	491.13	479.99	491.58	0.000744	5.71	29342.49	2556.76	0.23
Reach-1	34.4	9.01	500yr	163000	463.53	493.7	481.8	494.19	0.000735	6.05	35940.25	2571.18	0.23
Reach-1	34.4	9.01	50yr	116273	463.53	490.06	479.15	490.5	0.000751	5.58	26613.61	2536.4	0.24
Reach-1	34.4	9.01	10yr	82314	463.53	486.57	476.6	486.97	0.000793	5.22	17582.58	1992.42	0.25
Reach-1	34.4	9.01	50k	50000	463.53	482.22	473.8	482.58	0.000852	4.8	11170.6	1429.29	0.27
Reach-1	34.4	9.01	30k	30000	463.53	478.07	471.81	478.43	0.00104	4.77	6329.53	805.18	0.29
Reach-1	34.4	9.01	10k	10000	463.53	472.23	469.09	472.45	0.001389	3.76	2661.91	538.83	0.3
Reach-1	34.2	8.94	100yr	128900	462.66	490.89	479.09	491.28	0.00081	5.09	29419.29	2542.12	0.22
Reach-1	34.2	8.94	500yr	163000	462.66	493.47	480.68	493.89	0.000802	5.42	36109.18	2626.85	0.22
Reach-1	34.2	8.94	50yr	116273	462.66	489.82	478.47	490.19	0.000819	4.96	26708.33	2515.86	0.22
Reach-1	34.2	8.94	10yr	82314	462.66	486.3	476.53	486.63	0.000893	4.66	17854.39	1958.51	0.23
Reach-1	34.2	8.94	50k	50000	462.66	481.92	474.16	482.21	0.001	4.36	11467.66	1323.59	0.26
Reach-1	34.2	8.94	30k	30000	462.66	477.67	472.31	477.97	0.001326	4.45	6735.32	944.06	0.29
Reach-1	34.2	8.94	10k	10000	462.66	470.94	469.49	471.45	0.006314	5.72	1747.36	608.95	0.56
Reach-1	34	8.85	100yr	128900	456.72	489.95	480.95	490.78	0.001181	7.83	24625.36	2472.99	0.32
Reach-1	34	8.85	500yr	163000	456.72	492.56	482.49	493.41	0.00116	8.18	31261.59	2605.06	0.31
Reach-1	34	8.85	50yr	116273	456.72	488.87	477.87	489.69	0.00119	7.68	21989.96	2392.54	0.32
Reach-1	34	8.85	10yr	82314	456.72	485.46	475.14	486.13	0.0011	6.88	15282.43	1438.11	0.32
Reach-1	34	8.85	50k	50000	456.72	481.08	472.02	481.68	0.00109	6.34	9258.28	1323.78	0.35
Reach-1	34	8.85	30k	30000	456.72	476.89	469.43	477.38	0.00108	5.64	5323.36	541.2	0.29
Reach-1	34	8.85	10k	10000	456.72	469.88	465.81	470.17	0.001352	4.29	2329.27	377.95	0.3
Reach-1	33.5	8.76	100yr	128900	457.07	489.42	480.41	490.3	0.00093	7.98	23730.45	2429.27	0.33
Reach-1	33.5	8.76	500yr	163000	457.07	492.01	482	492.94	0.00093	8.37	29942.92	2759.35	0.32
Reach-1	33.5	8.76	50yr	116273	457.07	488.33	479.71	489.21	0.000934	7.83	21131.91	2389.82	0.33
Reach-1	33.5	8.76	10yr	82314	457.07	484.98	475.28	485.7	0.000841	7	14576.1	1520.21	0.33
Reach-1	33.5	8.76	50k	50000	457.07	480.65	471.22	481.27	0.000778	6.36	8991.95	1207.61	0.36
Reach-1	33.5	8.76	30k	30000	457.07	476.42	468.35	476.97	0.000724	6	5003	620.08	0.32
Reach-1	33.5	8.76	10k	10000	457.07	469.51	463.8	469.78	0.000565	4.14	2415.5	321.01	0.27
Reach-1	33.4	8.70	100yr	128900	458.41	488.66	479.82	489.92	0.001182	9.19	17966.75	2347.48	0.37
Reach-1	33.4	8.70	500yr	163000	458.41	491.14	481.56	492.54	0.001246	9.89	22531.51	2622.07	0.38
Reach-1	33.4	8.70	50yr	116273	458.41	487.63	479.14	488.83	0.001155	8.91	16062.31	2315.77	0.37
Reach-1	33.4	8.70	10yr	82314	458.41	484.41	474.14	485.36	0.001015	7.87	11123.35	969.02	0.36
Reach-1	33.4	8.70	50k	50000	458.41	480.29	470.66	480.99	0.000834	6.7	7458.75	732.34	0.36
Reach-1	33.4	8.70	30k	30000	458.41	476.19	468.03	476.73	0.000695	5.88	5098.95	393.7	0.29
Reach-1	33.4	8.70	10k	10000	458.41	469.34	464.07	469.58	0.000586	3.9	2561.32	347.72	0.25
Reach-1	33.2	8.66	100yr	128900	459.87	488.26	479.37	489.65	0.00133	9.64	16163	2298.74	0.39
Reach-1	33.2	8.66	500yr	163000	459.87	490.64	481.21	492.25	0.001416	10.52	20268.18	2344.85	0.4
Reach-1	33.2	8.66	50yr	116273	459.87	487.28	478.65	488.57	0.001288	9.25	14847.24	2261.9	0.38
Reach-1	33.2	8.66	10yr	82314	459.87	484.09	475.74	485.13	0.001184	8.19	10081.33	1155.65	0.37
Reach-1	33.2	8.66	50k	50000	459.87	480.1	471.78	480.8	0.000989	6.73	7426.42	683.33	0.35
Reach-1	33.2	8.66	30k	30000	459.87	475.95	469.12	476.55	0.001029	6.21	4830.35	513.7	0.36
Reach-1	33.2	8.66	10k	10000	459.87	469.05	465.48	469.4	0.001134	4.77	2098.02	341.35	0.34
Reach-1	33	8.62	100yr	128900	459.76	488.09		489.38	0.001118	9.27	15817.26	2096.73	0.37
Reach-1	33	8.62	500yr	163000	459.76	490.38		491.98	0.001247	10.35	18273.51	2474.88	0.39
Reach-1	33	8.62	50yr	116273	459.76	487.12		488.31	0.00107	8.84	14791.54	2068.18	0.36
Reach-1	33	8.62	10yr	82314	459.76	483.97		484.88	0.000954	7.67	11489.21	1011.31	0.35
Reach-1	33	8.62	50k	50000	459.76	479.97		480.6	0.000823	6.37	7945.67	772.05	0.33
Reach-1	33	8.62	30k	30000	459.76	475.8		476.35	0.000867	5.98	5014.99	615.43	0.37
Reach-1	33	8.62	10k	10000	459.76	468.8		469.18	0.001116	4.93	2028.87	325.23	0.35
Reach-1	32	8.61	100yr	128900	454.28	488.34	476.32	489.2	0.000516	7.43	17341.44	2267.65	0.29
Reach-1	32	8.61	500yr	163000	454.28	490.67	478.14	491.77	0.000583	8.41	19385.33	3052	0.32
Reach-1	32	8.61	50yr	116273	454.28	487.36	475.57	488.13	0.000493	7.05	16484.74	2115.79	0.29
Reach-1	32	8.61	10yr	82314	454.28	484.17	473.37	484.73	0.000443	6.01	13704.01	1619.87	0.27
Reach-1	32	8.61	50k	50000	454.28	480.11	470.93	480.49	0.000401	4.9	10196.68	928.6	0.25
Reach-1	32	8.61	30k	30000	454.28	475.94	468.97	476.23	0.000421	4.31	6968.6	726.46	0.24
Reach-1	32	8.61	10k	10000	454.28	468.8	465.94	469.07	0.001051	4.19	2385.96	534.99	0.35
Reach-1	31.5			Bridge									
Reach-1	31	8.60	100yr	128900	454.28	488.31	476.32	489.17	0.000519	7.44	17317.57	2263.42	0.29
Reach-1	31	8.60	500yr	163000	454.28	490.64	478.14	491.74	0.000585	8.42	19357.88	3048.3	0.32
Reach-1	31	8.60	50yr	116273	454.28	487.33	475.57	488.11	0.000495	7.06	16462.12	2111.78	0.29

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Reach-1	31	8.60	10yr	82314	454.28	484.15	473.37	484.71	0.000445	6.02	13684.05	1616.29	0.27
Reach-1	31	8.60	50k	50000	454.28	480.09	470.93	480.47	0.000403	4.91	10179.64	922.72	0.25
Reach-1	31	8.60	30k	30000	454.28	475.92	468.97	476.21	0.000424	4.31	6952.96	725.97	0.25
Reach-1	31	8.60	10k	10000	454.28	468.74	465.94	469.02	0.00109	4.25	2354.32	531.85	0.36
Reach-1	30	8.594	100yr	128900	454.26	488.33	475.73	489.12	0.000381	7.12	18092.62	2291.07	0.28
Reach-1	30	8.594	500yr	163000	454.26	490.66	477.52	491.68	0.000426	8.08	20179.47	3073.77	0.3
Reach-1	30	8.594	50yr	116273	454.26	487.35	474.99	488.06	0.000365	6.75	17217.9	2138.42	0.27
Reach-1	30	8.594	10yr	82314	454.26	484.16	472.84	484.67	0.000332	5.73	14376.56	1641.47	0.25
Reach-1	30	8.594	50k	50000	454.26	480.1	470.47	480.43	0.000303	4.64	10780.94	950.88	0.23
Reach-1	30	8.594	30k	30000	454.26	475.93	468.51	476.18	0.000316	4.03	7444.47	753.51	0.23
Reach-1	30	8.594	10k	10000	454.26	468.74	464.39	468.97	0.000773	3.81	2623.69	565.94	0.31
Reach-1	29	8.591	100yr	128900	454.06	488.33	475.46	489.11	0.000377	7.09	18187.98	2819.97	0.28
Reach-1	29	8.591	500yr	163000	454.06	490.66	477.22	491.67	0.000423	8.04	20276.91	3075.86	0.3
Reach-1	29	8.591	50yr	116273	454.06	487.35	474.73	488.05	0.000361	6.72	17312.86	2711.19	0.27
Reach-1	29	8.591	10yr	82314	454.06	484.16	472.66	484.66	0.000327	5.69	14471.15	2357.13	0.25
Reach-1	29	8.591	50k	50000	454.06	480.1	470.2	480.43	0.00031	4.6	10868.57	1906.44	0.23
Reach-1	29	8.591	30k	30000	454.06	475.93	468.12	476.17	0.000293	3.95	7596.28	743.66	0.22
Reach-1	29	8.591	10k	10000	454.06	468.74	465.05	468.94	0.000622	3.59	2784	555.5	0.28
Reach-1	28	8.589	100yr	128900	454.28	488.12	476.83	489.04	0.000589	7.71	16710.91	2198.51	0.31
Reach-1	28	8.589	500yr	163000	454.28	490.41	478.63	491.59	0.000665	8.72	18685.03	2996.53	0.33
Reach-1	28	8.589	50yr	116273	454.28	487.16	476.1	487.99	0.000562	7.32	15880.42	2045.62	0.3
Reach-1	28	8.589	10yr	82314	454.28	484.01	473.92	484.61	0.000508	6.25	13169.51	1545.37	0.28
Reach-1	28	8.589	50k	50000	454.28	479.98	471.51	480.39	0.000493	5.15	9715.63	905.07	0.27
Reach-1	28	8.589	30k	30000	454.28	475.8	469.34	476.13	0.000526	4.6	6515.49	719.59	0.27
Reach-1	28	8.589	10k	10000	454.28	468.46	466.08	468.85	0.001594	5.02	1993.73	462.06	0.43
Reach-1	27.5			Bridge									
Reach-1	27	8.580	100yr	128900	454.28	488.09	476.83	489.02	0.000592	7.73	16684.89	2193.73	0.31
Reach-1	27	8.580	500yr	163000	454.28	490.37	478.63	491.56	0.000669	8.74	18655.07	2992.77	0.33
Reach-1	27	8.580	50yr	116273	454.28	487.13	476.1	487.96	0.000565	7.33	15855.77	2041.08	0.3
Reach-1	27	8.580	10yr	82314	454.28	483.98	473.92	484.59	0.000511	6.26	13147.65	1541.33	0.28
Reach-1	27	8.580	50k	50000	454.28	479.95	471.51	480.37	0.000497	5.16	9694.65	901.17	0.27
Reach-1	27	8.580	30k	30000	454.28	475.77	469.34	476.11	0.00053	4.62	6496.63	719.01	0.27
Reach-1	27	8.580	10k	10000	454.28	468.36	466.08	468.77	0.001693	5.13	1948.98	457.16	0.44
Reach-1	26	8.574	100yr	128900	454.06	488.13	475.49	488.91	0.00039	7.09	18177.81	2798.38	0.28
Reach-1	26	8.574	500yr	163000	454.06	490.43	477.25	491.43	0.000432	8.03	20291.91	3050.76	0.3
Reach-1	26	8.574	50yr	116273	454.06	487.17	474.74	487.87	0.000375	6.73	17287.44	2691.13	0.27
Reach-1	26	8.574	10yr	82314	454.06	484.01	472.66	484.52	0.000348	5.73	14376.4	2340.47	0.26
Reach-1	26	8.574	50k	50000	454.06	479.97	470.19	480.31	0.000348	4.69	10653.36	1892.01	0.24
Reach-1	26	8.574	30k	30000	454.06	475.79	468.13	476.05	0.000305	4.03	7445.81	741.94	0.22
Reach-1	26	8.574	10k	10000	454.06	468.4	465.04	468.63	0.000753	3.85	2595.14	537.56	0.31
Reach-1	25	8.568	100yr	128900	454.06	488.12	475.47	488.9	0.000391	7.1	18163.55	2796.66	0.28
Reach-1	25	8.568	500yr	163000	454.06	490.41	477.24	491.41	0.000433	8.04	20275.79	3048.89	0.3
Reach-1	25	8.568	50yr	116273	454.06	487.15	474.74	487.86	0.000376	6.73	17273.83	2689.49	0.27
Reach-1	25	8.568	10yr	82314	454.06	483.99	472.66	484.5	0.000349	5.73	14364	2338.98	0.26
Reach-1	25	8.568	50k	50000	454.06	479.95	470.19	480.3	0.00035	4.7	10641.08	1890.53	0.24
Reach-1	25	8.568	30k	30000	454.06	475.78	468.12	476.03	0.000306	4.03	7437.33	741.79	0.22
Reach-1	25	8.568	10k	10000	454.06	468.37	465.04	468.61	0.000766	3.88	2578.61	536.1	0.31
Reach-1	24	8.564	100yr	128900	454.06	488.02	476.12	488.87	0.000554	7.37	17483.55	2571.82	0.29
Reach-1	24	8.564	500yr	163000	454.06	490.28	478.1	491.37	0.000644	8.36	19489.03	3011.2	0.32
Reach-1	24	8.564	50yr	116273	454.06	487.07	475.29	487.83	0.000524	6.99	16644.04	2375.62	0.28
Reach-1	24	8.564	10yr	82314	454.06	483.94	473.04	484.48	0.000459	5.92	13894.2	1732.05	0.26
Reach-1	24	8.564	50k	50000	454.06	479.92	470.54	480.28	0.000424	4.82	10375.73	906.54	0.25
Reach-1	24	8.564	30k	30000	454.06	475.73	468.44	476.01	0.000436	4.3	6969.88	732.33	0.24
Reach-1	24	8.564	10k	10000	454.06	468.29	465.25	468.57	0.001055	4.26	2344.75	502.19	0.35
Reach-1	23.5			Bridge									
Reach-1	23	8.555	100yr	128900	454.06	487.96	476.12	488.81	0.000559	7.4	17428.17	2558.88	0.29
Reach-1	23	8.555	500yr	163000	454.06	490.2	478.1	491.3	0.000652	8.4	19414.24	3002.25	0.32
Reach-1	23	8.555	50yr	116273	454.06	487.01	475.29	487.77	0.000529	7.01	16594.46	2364.03	0.28
Reach-1	23	8.555	10yr	82314	454.06	483.9	473.04	484.45	0.000463	5.94	13858.66	1723.72	0.26
Reach-1	23	8.555	50k	50000	454.06	479.89	470.54	480.26	0.000427	4.83	10350.49	900.61	0.25
Reach-1	23	8.555	30k	30000	454.06	475.7	468.44	475.99	0.000439	4.31	6952.69	731.21	0.24
Reach-1	23	8.555	10k	10000	454.06	468.23	465.25	468.52	0.001091	4.32	2315.67	499.43	0.35
Reach-1	22	8.54	100yr	128900	438.21	488.05	470.58	488.62	0.000194	6.04	21349.48	1887.37	0.23
Reach-1	22	8.54	500yr	163000	438.21	490.32	472.69	491.06	0.000238	6.93	23531.23	2618.6	0.25
Reach-1	22	8.54	50yr	116273	438.21	487.1	469.75	487.6	0.000177	5.69	20430.67	1840.47	0.22
Reach-1	22	8.54	10yr	82314	438.21	483.96	466.61	484.31	0.000134	4.72	17427.7	1658.4	0.19
Reach-1	22	8.54	50k	50000	438.21	479.95	462.28	480.16	0.00009	3.67	13605.46	1351.02	0.17
Reach-1	22	8.54	30k	30000	438.21	475.75	459.29	475.89	0.000068	2.98	10056.68	863.63	0.15
Reach-1	22	8.54	10k	10000	438.21	468.32	451.76	468.37	0.00004	1.84	5427.18	533.81	0.1
Reach-1	21	8.51	100yr	128900	453.4	487.6		488.48	0.000266	7.88	21636.15	1288.4	0.29
Reach-1	21	8.51	500yr	163000	453.4	489.76		490.9	0.000308	8.99	24421.58	1291.68	0.31

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Reach-1	21	8.51	50yr	116273	453.4	486.68		487.48	0.000251	7.45	20453.27	1287.48	0.28
Reach-1	21	8.51	10yr	82314	453.4	483.64		484.21	0.000214	6.25	16544.8	1284.44	0.25
Reach-1	21	8.51	50k	50000	453.4	479.72		480.09	0.000179	4.91	11518.21	1280.52	0.22
Reach-1	21	8.51	30k	30000	453.4	475.59		475.84	0.000183	4.03	7964.43	760.65	0.21
Reach-1	21	8.51	10k	10000	453.4	468.1		468.31	0.000455	3.64	2825.52	606.52	0.29
Reach-1	20	7.75	100yr	128900	450.95	485.03		486.72	0.000901	14.37	26119.24	2317	0.46
Reach-1	20	7.75	500yr	163000	450.95	487.3		489	0.000903	15.1	31418.04	2337.49	0.47
Reach-1	20	7.75	50yr	116273	450.95	484.06		485.75	0.000905	14.09	23875.68	2285.97	0.46
Reach-1	20	7.75	10yr	82314	450.95	481.24		482.7	0.000802	12.41	17923.64	1936.38	0.43
Reach-1	20	7.75	50k	50000	450.95	477.46		478.75	0.000728	10.66	11314.91	1664.91	0.39
Reach-1	20	7.75	30k	30000	450.95	473.69		474.6	0.000585	8.47	5745.07	533.33	0.34
Reach-1	20	7.75	10k	10000	450.95	466.04		466.45	0.000471	5.38	2473.49	345.38	0.28
Reach-1	19	7.25	100yr	128900	452.15	482.87	478.53	484.46	0.000872	13.79	26142.41	2599.24	0.45
Reach-1	19	7.25	500yr	163000	452.15	485.15	480.35	486.75	0.000873	14.51	32300.58	2758	0.46
Reach-1	19	7.25	50yr	116273	452.15	481.89	477.72	483.48	0.000876	13.5	23644.19	2499.28	0.45
Reach-1	19	7.25	10yr	82314	452.15	479.16	473.52	480.64	0.000823	12.23	17201.36	2217.76	0.43
Reach-1	19	7.25	50k	50000	452.15	475.68	468.04	476.9	0.000704	10.24	10723.64	1395.8	0.39
Reach-1	19	7.25	30k	30000	452.15	472.08	464.13	473.05	0.000619	8.52	6350.62	1017.34	0.35
Reach-1	19	7.25	10k	10000	452.15	464.81	458.7	465.23	0.00047	5.29	2260.45	312.32	0.28

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HEC-RAS Plan: Proposed

Reach	Model Cross Section ID	River Station	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(mi)		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	52	14.57	100yr	128900	467.5	511.73		512.78	0.000633	9.15	25661.76	2274.2	0.26
Reach-1	52	14.57	500yr	163000	467.5	515.15		516.16	0.000603	9.45	33518.06	2324.56	0.26
Reach-1	52	14.57	50yr	116273	467.5	510.33		511.4	0.000645	9	22485.7	2254.56	0.26
Reach-1	52	14.57	10yr	82314	467.5	505.96		507.01	0.000652	8.31	12783.08	2193.49	0.26
Reach-1	52	14.57	50k	50000	467.5	500.84		501.41	0.000447	6.13	8575.37	444.24	0.21
Reach-1	52	14.57	30k	30000	467.5	495.96		496.28	0.000318	4.53	6676.73	340.98	0.17
Reach-1	52	14.57	10k	10000	467.5	487.04		487.14	0.000171	2.49	4008.09	282.08	0.12
Reach-1	51	14.33	100yr	128900	467.47	511.24		511.96	0.000509	7.97	29222.32	1929.34	0.23
Reach-1	51	14.33	500yr	163000	467.47	514.62		515.38	0.000507	8.44	35870.52	1995.96	0.24
Reach-1	51	14.33	50yr	116273	467.47	509.84		510.56	0.000511	7.78	26554.55	1900.81	0.23
Reach-1	51	14.33	10yr	82314	467.47	505.47		506.16	0.000524	7.2	18494.17	1782.65	0.23
Reach-1	51	14.33	50k	50000	467.47	500.24		500.82	0.00049	6.14	9375.56	1711.28	0.22
Reach-1	51	14.33	30k	30000	467.47	495.52		495.85	0.000359	4.58	6626.17	408.33	0.18
Reach-1	51	14.33	10k	10000	467.47	486.81		486.91	0.000179	2.53	3952.91	281.55	0.12
Reach-1	50	14.00	100yr	128900	471.3	510.61		511.27	0.000363	7.39	29194.65	1668.07	0.24
Reach-1	50	14.00	500yr	163000	471.3	513.98		514.71	0.000369	7.98	34831.79	1684.89	0.24
Reach-1	50	14.00	50yr	116273	471.3	509.23		509.86	0.000363	7.16	26888.62	1658.83	0.23
Reach-1	50	14.00	10yr	82314	471.3	504.84		505.41	0.000374	6.52	19689.48	1612.2	0.23
Reach-1	50	14.00	50k	50000	471.3	499.66		500.08	0.000354	5.41	12415.82	1209.7	0.22
Reach-1	50	14.00	30k	30000	471.3	494.94		495.26	0.000333	4.58	7122.46	676.15	0.2
Reach-1	50	14.00	10k	10000	471.3	486.35		486.51	0.000326	3.19	3130.98	336.02	0.18
Reach-1	49	13.75	100yr	128900	471.26	510.13		510.74	0.000412	8.09	30974.16	1530.37	0.25
Reach-1	49	13.75	500yr	163000	471.26	513.47		514.17	0.000427	8.8	36133.9	1556.22	0.26
Reach-1	49	13.75	50yr	116273	471.26	508.75		509.33	0.000407	7.82	28868.49	1519.7	0.25
Reach-1	49	13.75	10yr	82314	471.26	504.35		504.87	0.00041	7.1	22260.99	1485.7	0.24
Reach-1	49	13.75	50k	50000	471.26	499.08		499.55	0.000434	6.31	14532.35	1446.55	0.24
Reach-1	49	13.75	30k	30000	471.26	494.31		494.74	0.000439	5.64	8412.13	1168.15	0.23
Reach-1	49	13.75	10k	10000	471.26	485.8		486.03	0.000374	3.87	2586.48	227.74	0.2
Reach-1	48	13.51	100yr	128900	471.3	508.97		510.06	0.000619	10.05	22533.58	1073.83	0.31
Reach-1	48	13.51	500yr	163000	471.3	512.14		513.44	0.000673	11.15	25972	1099.25	0.33
Reach-1	48	13.51	50yr	116273	471.3	507.65		508.66	0.0006	9.63	21122.87	1065.92	0.3
Reach-1	48	13.51	10yr	82314	471.3	503.41		504.23	0.00056	8.44	16661.17	1030.91	0.29
Reach-1	48	13.51	50k	50000	471.3	498.32		498.93	0.000502	6.99	11599.06	952.4	0.26
Reach-1	48	13.51	30k	30000	471.3	493.61		494.13	0.000483	6.06	7177.54	927.13	0.25
Reach-1	48	13.51	10k	10000	471.3	485.3		485.54	0.000384	3.91	2621.01	250.53	0.21
Reach-1	47	13.29	100yr	128900	460.2	508.22		509.38	0.000538	9.51	20895.63	1047.6	0.29
Reach-1	47	13.29	500yr	163000	460.2	511.16		512.65	0.000634	10.91	24200.49	1216.26	0.32
Reach-1	47	13.29	50yr	116273	460.2	507		508.02	0.000499	8.94	19652.86	983.98	0.28
Reach-1	47	13.29	10yr	82314	460.2	502.94		503.64	0.000404	7.36	16011.22	842.85	0.24
Reach-1	47	13.29	50k	50000	460.2	497.99		498.43	0.000309	5.66	12048.16	769.92	0.21
Reach-1	47	13.29	30k	30000	460.2	493.38		493.66	0.000258	4.47	8620.25	702.73	0.18
Reach-1	47	13.29	10k	10000	460.2	485.11		485.23	0.00016	2.75	3888.41	408.53	0.13
Reach-1	46	13.12	100yr	128900	460.15	507.93		508.89	0.000451	8.23	20138.14	1062.66	0.26
Reach-1	46	13.12	500yr	163000	460.15	510.76		512.09	0.000546	9.61	23555.35	1565.42	0.29
Reach-1	46	13.12	50yr	116273	460.15	506.7		507.58	0.000429	7.81	18847.91	1040.58	0.25
Reach-1	46	13.12	10yr	82314	460.15	502.63		503.29	0.000377	6.64	14784.41	950.8	0.23
Reach-1	46	13.12	50k	50000	460.15	497.74		498.16	0.000295	5.17	10454.08	812.83	0.2
Reach-1	46	13.12	30k	30000	460.15	493.2		493.44	0.000223	3.97	7552.87	431.95	0.17
Reach-1	46	13.12	10k	10000	460.15	485.02		485.1	0.000113	2.32	4314	332.91	0.11
Reach-1	45	12.87	100yr	128900	473.6	506.72		508.05	0.000844	9.7	17896.92	1220.11	0.35
Reach-1	45	12.87	500yr	163000	473.6	509.51		511.13	0.000907	10.81	21709.29	1513.03	0.37
Reach-1	45	12.87	50yr	116273	473.6	505.56		506.77	0.000816	9.24	16553.51	1098.43	0.34
Reach-1	45	12.87	10yr	82314	473.6	501.62		502.6	0.000667	8.11	12583.73	957.48	0.3
Reach-1	45	12.87	50k	50000	473.6	496.98		497.61	0.000531	6.43	8444.4	789.13	0.26
Reach-1	45	12.87	30k	30000	473.6	492.62		493.02	0.000443	5.05	5939.6	399.55	0.23
Reach-1	45	12.87	10k	10000	473.6	484.63		484.81	0.000477	3.46	2886.99	364.26	0.22
Reach-1	44	12.63	100yr	128900	473.6	506.01		507.07	0.00061	8.56	19525.68	1313.02	0.3
Reach-1	44	12.63	500yr	163000	473.6	508.78		510.06	0.000658	9.53	23439.92	1512.51	0.32
Reach-1	44	12.63	50yr	116273	473.6	504.86		505.83	0.00059	8.17	18059.14	1234.56	0.29
Reach-1	44	12.63	10yr	82314	473.6	501		501.76	0.000565	7.13	13580.77	1087.32	0.28
Reach-1	44	12.63	50k	50000	473.6	496.42		496.93	0.00049	5.73	9087.03	846.33	0.25
Reach-1	44	12.63	30k	30000	473.6	492.13		492.46	0.000408	4.6	6517.81	478.54	0.22
Reach-1	44	12.63	10k	10000	473.6	484.05		484.22	0.000455	3.33	3005.65	390.76	0.21
Reach-1	43	12.45	100yr	128900	468.5	505.02		506.33	0.001008	10.13	20629.18	1700.22	0.32
Reach-1	43	12.45	500yr	163000	468.5	507.9		509.3	0.001019	10.82	25585.96	1734.85	0.33
Reach-1	43	12.45	50yr	116273	468.5	503.87		505.11	0.000978	9.73	18755.6	1575.11	0.32
Reach-1	43	12.45	10yr	82314	468.5	500.1		501.09	0.000887	8.45	13601.19	1156.15	0.29
Reach-1	43	12.45	50k	50000	468.5	495.74		496.38	0.000694	6.59	9180.45	876.68	0.25
Reach-1	43	12.45	30k	30000	468.5	491.64		492.02	0.000538	5.03	6539.87	527.58	0.21
Reach-1	43	12.45	10k	10000	468.5	483.61		483.78	0.00051	3.25	3085.92	350.74	0.19

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Reach-1	42	12.31	100yr	128900	468.47	504.99		505.51	0.000597	6.75	30642.34	2209.84	0.24
Reach-1	42	12.31	500yr	163000	468.47	507.92		508.48	0.000572	7.13	37165.23	2236.28	0.24
Reach-1	42	12.31	50yr	116273	468.47	503.8		504.31	0.000609	6.6	28027.59	2196.79	0.24
Reach-1	42	12.31	10yr	82314	468.47	499.82		500.34	0.000726	6.36	19366.94	2137.98	0.26
Reach-1	42	12.31	50k	50000	468.47	495.24		495.75	0.000881	5.85	10559.25	1715.09	0.27
Reach-1	42	12.31	30k	30000	468.47	491.17		491.55	0.000747	4.95	6170.24	658.32	0.24
Reach-1	42	12.31	10k	10000	468.47	483.18		483.36	0.000603	3.4	2943.27	339.75	0.2
Reach-1	41	12.08	100yr	128900	468.5	504.62		504.93	0.000373	5.74	40500.23	2501.97	0.19
Reach-1	41	12.08	500yr	163000	468.5	507.57		507.91	0.000375	6.16	49803.42	3257.7	0.2
Reach-1	41	12.08	50yr	116273	468.5	503.42		503.73	0.000376	5.6	37510.37	2492.39	0.19
Reach-1	41	12.08	10yr	82314	468.5	499.34		499.65	0.000436	5.38	27411.37	2453.21	0.2
Reach-1	41	12.08	50k	50000	468.5	494.53		494.88	0.000573	5.23	15819.02	2351.18	0.22
Reach-1	41	12.08	30k	30000	468.5	490.17		490.59	0.000838	5.2	6041.09	2128.54	0.26
Reach-1	41	12.08	10k	10000	468.5	482.34		482.54	0.00075	3.65	2736.46	334.28	0.23
Reach-1	40	11.74	100yr	128900	468.84	503.84		504.32	0.000465	6.98	34172.11	2047.96	0.22
Reach-1	40	11.74	500yr	163000	468.84	506.78		507.3	0.000476	7.49	40211.1	2061.21	0.22
Reach-1	40	11.74	50yr	116273	468.84	502.65		503.11	0.000462	6.78	31724.82	2042.57	0.22
Reach-1	40	11.74	10yr	82314	468.84	498.46		498.92	0.000507	6.43	23206.19	2023.69	0.22
Reach-1	40	11.74	50k	50000	468.84	493.38		493.88	0.000606	6.1	12978.25	2000.78	0.23
Reach-1	40	11.74	30k	30000	468.84	488.86		489.3	0.000618	5.28	5678.33	337.38	0.23
Reach-1	40	11.74	10k	10000	468.84	481.41		481.56	0.000404	3.09	3239.21	317.26	0.17
Reach-1	39	11.24	100yr	128900	470.13	501.24		502.54	0.001034	9.94	18719.05	1192.43	0.33
Reach-1	39	11.24	500yr	163000	470.13	503.9		505.43	0.001126	11.01	21931.63	1229.57	0.35
Reach-1	39	11.24	50yr	116273	470.13	500.17		501.37	0.000994	9.5	17441.31	1177.33	0.32
Reach-1	39	11.24	10yr	82314	470.13	496.14		497.13	0.000957	8.38	12981.43	1032.03	0.31
Reach-1	39	11.24	50k	50000	470.13	491.25		491.97	0.000891	6.91	8397.15	843.87	0.28
Reach-1	39	11.24	30k	30000	470.13	486.97		487.45	0.000807	5.57	5468.31	468.06	0.26
Reach-1	39	11.24	10k	10000	470.13	479.99		480.19	0.0007	3.53	2829.36	355.1	0.22
Reach-1	38	10.72	100yr	128900	468.41	499.48		500.37	0.000657	8.4	22661.24	1322.39	0.28
Reach-1	38	10.72	500yr	163000	468.41	501.93		503.04	0.000753	9.5	25991.06	1392.94	0.3
Reach-1	38	10.72	50yr	116273	468.41	498.48		499.29	0.00062	7.97	21353.22	1288.32	0.27
Reach-1	38	10.72	10yr	82314	468.41	494.44		495.09	0.000594	7	16420.41	1150.2	0.26
Reach-1	38	10.72	50k	50000	468.41	489.58		490.05	0.000547	5.75	11230.51	997.12	0.24
Reach-1	38	10.72	30k	30000	468.41	485.21		485.57	0.000565	4.87	7011.3	932.83	0.23
Reach-1	38	10.72	10k	10000	468.41	478.04		478.22	0.000724	3.41	2976.09	449.5	0.23
Reach-1	37	10.09	100yr	128900	459.55	497.18		498.08	0.000745	8.51	29222.68	3790.6	0.29
Reach-1	37	10.09	500yr	163000	459.55	499.83		500.65	0.000667	8.58	39318.54	3833.85	0.28
Reach-1	37	10.09	50yr	116273	459.55	496.03		496.99	0.000793	8.52	24865	3771.77	0.3
Reach-1	37	10.09	10yr	82314	459.55	492.24		492.95	0.000713	7.25	16378.27	1504.6	0.28
Reach-1	37	10.09	50k	50000	459.55	487.48		488.01	0.000701	6.08	10374.96	1103.85	0.26
Reach-1	37	10.09	30k	30000	459.55	482.87		483.31	0.000838	5.35	6032.65	743.9	0.27
Reach-1	37	10.09	10k	10000	459.55	475.96		476.17	0.000531	3.66	2731.89	284.78	0.21
Reach-1	36	9.75	100yr	128900	460.48	493.77	483.75	496.07	0.001819	12.8	14655.33	1714.93	0.43
Reach-1	36	9.75	500yr	163000	460.48	496.25	486.62	498.77	0.00189	13.83	18982.01	1758.98	0.45
Reach-1	36	9.75	50yr	116273	460.48	492.73	482.18	494.91	0.001774	12.31	12892.11	1662.47	0.43
Reach-1	36	9.75	10yr	82314	460.48	489.51	478.71	491.13	0.001502	10.38	9335.57	873.43	0.38
Reach-1	36	9.75	50k	50000	460.48	485.5	474.93	486.44	0.001103	7.82	6920.92	506.09	0.32
Reach-1	36	9.75	30k	30000	460.48	481.08	472.1	481.68	0.000965	6.21	4827.95	374.08	0.29
Reach-1	36	9.75	10k	10000	460.48	475.03	468.03	475.21	0.000523	3.43	2914.07	307.81	0.2
Reach-1	35.5	9.55	100yr	128900	461.49	493.14	480.45	494.43	0.00113	9.55	18470.79	1804.72	0.33
Reach-1	35.5	9.55	500yr	163000	461.49	495.62	482.83	497.05	0.001178	10.36	22958.95	1824.01	0.34
Reach-1	35.5	9.55	50yr	116273	461.49	492.15	479.53	493.32	0.001069	9.05	16992.15	1730.7	0.32
Reach-1	35.5	9.55	10yr	82314	461.49	488.92	476.89	489.79	0.000932	7.7	13190.71	1463.98	0.29
Reach-1	35.5	9.55	50k	50000	461.49	484.91	473.99	485.47	0.000744	6	8589.21	940.45	0.25
Reach-1	35.5	9.55	30k	30000	461.49	480.47	471.74	480.83	0.00069	4.82	6221.96	464.75	0.23
Reach-1	35.5	9.55	10k	10000	461.49	474.6	468.59	474.72	0.000477	2.83	3535.6	449.41	0.18
Reach-1	35	9.42	100yr	128900	463.22	492.8		493.57	0.000929	7.38	22538.65	1974.44	0.28
Reach-1	35	9.42	500yr	163000	463.22	495.32		496.16	0.00092	7.89	27543.65	1994.86	0.29
Reach-1	35	9.42	50yr	116273	463.22	491.77		492.5	0.000927	7.14	20517.3	1942.17	0.28
Reach-1	35	9.42	10yr	82314	463.22	488.48		489.08	0.000903	6.3	15217.16	1444.39	0.27
Reach-1	35	9.42	50k	50000	463.22	484.45		484.87	0.000855	5.19	9889.68	1051.87	0.25
Reach-1	35	9.42	30k	30000	463.22	479.95		480.28	0.000887	4.6	6526.28	631.45	0.25
Reach-1	35	9.42	10k	10000	463.22	474.04		474.23	0.00111	3.46	2889.46	575.29	0.27
Reach-1	34.8	9.30	100yr	128900	462.67	491.78	481.61	492.87	0.001275	9.15	21897.73	1960.27	0.34
Reach-1	34.8	9.30	500yr	163000	462.67	494.26	485.48	495.46	0.001283	9.85	26866.99	2034.23	0.35
Reach-1	34.8	9.30	50yr	116273	462.67	490.76	480.34	491.8	0.001276	8.87	19909.02	1934.02	0.34
Reach-1	34.8	9.30	10yr	82314	462.67	487.51	477.46	488.39	0.001272	7.92	14522.38	1603.19	0.33
Reach-1	34.8	9.30	50k	50000	462.67	483.49	474.41	484.19	0.001305	6.79	8435.12	1278.01	0.32
Reach-1	34.8	9.30	30k	30000	462.67	479.11	472.13	479.64	0.001151	5.82	5155.34	426.8	0.3
Reach-1	34.8	9.30	10k	10000	462.67	473.38	469.1	473.58	0.000972	3.63	2755.73	412.29	0.25
Reach-1	34.6	9.19	100yr	128900	464.66	491.32	480.28	492.15	0.000882	8.04	26149.16	2108.78	0.3
Reach-1	34.6	9.19	500yr	163000	464.66	493.8	482.53	494.73	0.000906	8.74	31419.04	2159.62	0.31

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Reach-1	34.6	9.19	50yr	116273	464.66	490.3	479.47	491.09	0.000877	7.78	23990.48	2099.53	0.3
Reach-1	34.6	9.19	10yr	82314	464.66	486.98	477.15	487.68	0.000905	7.07	17087.09	2054.45	0.29
Reach-1	34.6	9.19	50k	50000	464.66	482.93	473.96	483.49	0.000908	6.02	9513.17	1518.67	0.28
Reach-1	34.6	9.19	30k	30000	464.66	478.48	471.52	478.91	0.001107	5.32	5638.63	562.32	0.3
Reach-1	34.6	9.19	10k	10000	464.66	472.78	468.27	472.98	0.00097	3.62	2762.16	431.54	0.25
Reach-1	34.5	9.11	100yr	128900	463.46	491.09	479.05	491.67	0.001108	6.66	27507.44	2328.92	0.26
Reach-1	34.5	9.11	500yr	163000	463.46	493.59	482	494.23	0.0011	7.16	33265.89	2409.19	0.26
Reach-1	34.5	9.11	50yr	116273	463.46	490.05	478.21	490.61	0.001122	6.48	25141.4	2304.72	0.26
Reach-1	34.5	9.11	10yr	82314	463.46	486.7	475.97	487.19	0.001188	5.89	17498.82	2012.71	0.26
Reach-1	34.5	9.11	50k	50000	463.46	482.6	473.32	482.99	0.001303	5.09	11104.49	1363.93	0.26
Reach-1	34.5	9.11	30k	30000	463.46	478.13	471.13	478.48	0.000875	4.75	6320.88	614.03	0.26
Reach-1	34.5	9.11	10k	10000	463.46	472.42	468.28	472.59	0.000865	3.32	3009.65	501.17	0.24
Reach-1	34.4	9.01	100yr	128900	463.53	490.75	479.2	491.24	0.000587	5.83	28320.94	2553.5	0.25
Reach-1	34.4	9.01	500yr	163000	463.53	493.26	481.82	493.8	0.000592	6.22	34746.83	2568.72	0.25
Reach-1	34.4	9.01	50yr	116273	463.53	489.71	478.45	490.18	0.000588	5.67	25669.29	2523.26	0.25
Reach-1	34.4	9.01	10yr	82314	463.53	486.33	476.49	486.74	0.000599	5.22	17177.54	1972.7	0.26
Reach-1	34.4	9.01	50k	50000	463.53	482.18	474	482.52	0.000616	4.75	11049.96	1447.74	0.28
Reach-1	34.4	9.01	30k	30000	463.53	477.69	471.64	478.03	0.000828	4.72	6359.21	799.7	0.29
Reach-1	34.4	9.01	10k	10000	463.53	471.77	468.87	472.03	0.001352	4.07	2456.36	493.76	0.32
Reach-1	34.2	8.94	100yr	128900	462.66	490.6	478.84	490.99	0.000603	5.11	29130.92	2530.54	0.22
Reach-1	34.2	8.94	500yr	163000	462.66	493.11	480.39	493.55	0.000615	5.49	35618.21	2623.67	0.22
Reach-1	34.2	8.94	50yr	116273	462.66	489.55	478.21	489.93	0.0006	4.97	26496.83	2511.23	0.22
Reach-1	34.2	8.94	10yr	82314	462.66	486.17	476.38	486.49	0.000611	4.58	18105.24	1930.79	0.23
Reach-1	34.2	8.94	50k	50000	462.66	482	474.14	482.27	0.000615	4.17	12000.27	1355.74	0.25
Reach-1	34.2	8.94	30k	30000	462.66	477.38	472.1	477.69	0.000946	4.46	6719.73	979.09	0.3
Reach-1	34.2	8.94	10k	10000	462.66	470.6	468.83	471.15	0.004505	5.96	1678.08	477.76	0.56
Reach-1	34	8.85	100yr	128900	456.81	489.74	480.97	490.49	0.001992	7.58	24156.27	2456	0.31
Reach-1	34	8.85	500yr	163000	456.81	492.3	482.37	493.07	0.001807	7.86	30672.47	2595.39	0.3
Reach-1	34	8.85	50yr	116273	456.81	488.66	478.49	489.41	0.002095	7.47	21560.3	2379.07	0.31
Reach-1	34	8.85	10yr	82314	456.81	485.36	475.49	485.97	0.002165	6.63	15183.48	1436.48	0.31
Reach-1	34	8.85	50k	50000	456.81	481.14	472.46	481.69	0.002923	6.12	9377.26	1324.7	0.34
Reach-1	34	8.85	30k	30000	456.81	476.71	469.83	477.22	0.000905	5.77	5198.61	549.36	0.31
Reach-1	34	8.85	10k	10000	456.81	469.76	466.67	470.09	0.001176	4.6	2175.16	381.02	0.34
Reach-1	33.5	8.76	100yr	128900	457.14	488.9	480.42	489.88	0.000931	8.28	22551.72	2417.88	0.34
Reach-1	33.5	8.76	500yr	163000	457.14	491.46	482	492.48	0.000927	8.7	28664.02	2753.1	0.34
Reach-1	33.5	8.76	50yr	116273	457.14	487.89	479.72	488.8	0.000899	7.97	18693.66	2284.99	0.34
Reach-1	33.5	8.76	10yr	82314	457.14	484.63	475.41	485.38	0.000832	7.17	14140.72	1356.47	0.34
Reach-1	33.5	8.76	50k	50000	457.14	480.42	471.33	481.06	0.000787	6.51	8734.66	1208.81	0.37
Reach-1	33.5	8.76	30k	30000	457.14	476.26	468.54	476.84	0.000775	6.1	4916.2	597.32	0.33
Reach-1	33.5	8.76	10k	10000	457.14	469.4	464.19	469.68	0.000665	4.29	2333.21	319.68	0.28
Reach-1	33.4	8.70	100yr	128900	458.41	488.31	479.1	489.58	0.000663	9.18	17821.68	2336.75	0.37
Reach-1	33.4	8.70	500yr	163000	458.41	490.67	480.85	492.17	0.000685	10.08	22171.37	2600.5	0.38
Reach-1	33.4	8.70	50yr	116273	458.41	487.33	476.61	488.52	0.000655	8.81	16018.7	2306.71	0.36
Reach-1	33.4	8.70	10yr	82314	458.41	484.21	473.7	485.12	0.000636	7.67	10772.3	961.16	0.35
Reach-1	33.4	8.70	50k	50000	458.41	480.19	470.43	480.81	0.000652	6.34	7888.78	729.75	0.33
Reach-1	33.4	8.70	30k	30000	458.41	476.1	467.95	476.57	0.000635	5.46	5499.29	442.02	0.27
Reach-1	33.4	8.70	10k	10000	458.41	469.22	464.06	469.44	0.000621	3.76	2659.39	382.69	0.25
Reach-1	33.2	8.66	100yr	128900	459.87	488.17	478.76	489.41	0.00102	10.27	16871.74	2294.41	0.39
Reach-1	33.2	8.66	500yr	163000	459.87	490.54	480.59	491.98	0.001093	11.28	20946.38	2343.37	0.4
Reach-1	33.2	8.66	50yr	116273	459.87	487.19	478.02	488.35	0.000984	9.83	15569.87	2259.08	0.38
Reach-1	33.2	8.66	10yr	82314	459.87	483.98	474.87	484.96	0.00091	8.62	10812.56	1189.58	0.36
Reach-1	33.2	8.66	50k	50000	459.87	480.02	471.51	480.67	0.00076	6.89	7982.62	730.16	0.33
Reach-1	33.2	8.66	30k	30000	459.87	475.89	469.03	476.42	0.000792	6.04	5216.55	553.12	0.33
Reach-1	33.2	8.66	10k	10000	459.87	468.94	465.53	469.27	0.000993	4.82	2213.72	372.56	0.32
Reach-1	33	8.62	100yr	128900	459.76	488.03	477.65	489.2	0.000809	8.78	16610.44	2095.1	0.34
Reach-1	33	8.62	500yr	163000	459.76	490.29	479.45	491.76	0.000917	9.9	19029.37	2468.15	0.37
Reach-1	33	8.62	50yr	116273	459.76	487.08	476.85	488.14	0.000768	8.35	15597.42	2066.9	0.33
Reach-1	33	8.62	10yr	82314	459.76	483.96	474.15	484.74	0.000668	7.12	12327.35	1010.67	0.31
Reach-1	33	8.62	50k	50000	459.76	479.98	470.73	480.49	0.000559	5.74	8803.67	772.1	0.29
Reach-1	33	8.62	30k	30000	459.76	475.84	468.48	476.24	0.000574	5.09	5892.27	617.43	0.29
Reach-1	33	8.62	10k	10000	459.76	468.8	465.28	469.07	0.000883	4.14	2416.37	427.35	0.31
Reach-1	32	8.61	100yr	128900	454.28	488.19	476.32	489.06	0.000528	7.49	17213.78	2245.03	0.3
Reach-1	32	8.61	500yr	163000	454.28	490.49	478.14	491.6	0.000598	8.48	19224.64	3031.97	0.32
Reach-1	32	8.61	50yr	116273	454.28	487.23	475.57	488.01	0.000504	7.1	16368.65	2095.21	0.29
Reach-1	32	8.61	10yr	82314	454.28	484.07	473.37	484.64	0.000452	6.04	13617.05	1604.28	0.27
Reach-1	32	8.61	50k	50000	454.28	480.04	470.93	480.42	0.000406	4.93	10137.47	908.14	0.25
Reach-1	32	8.61	30k	30000	454.28	475.88	468.97	476.17	0.000429	4.33	6923.75	725.05	0.25
Reach-1	32	8.61	10k	10000	454.28	468.71	465.94	468.99	0.001111	4.28	2337.97	530.22	0.36
Reach-1	31.5			Bridge									
Reach-1	31	8.60	100yr	128900	454.28	488.16	476.32	489.04	0.000531	7.5	17189.48	2240.72	0.3
Reach-1	31	8.60	500yr	163000	454.28	490.46	478.14	491.58	0.0006	8.49	19196.68	3028.62	0.32
Reach-1	31	8.60	50yr	116273	454.28	487.2	475.57	487.98	0.000506	7.11	16345.63	2091.12	0.29

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Reach-1	31	8.60	10yr	82314	454.28	484.05	473.37	484.62	0.000454	6.05	13596.8	1600.65	0.27
Reach-1	31	8.60	50k	50000	454.28	480.02	470.93	480.4	0.000407	4.94	10120.44	902.24	0.25
Reach-1	31	8.60	30k	30000	454.28	475.86	468.97	476.15	0.000432	4.34	6907.92	724.56	0.25
Reach-1	31	8.60	10k	10000	454.28	468.65	465.94	468.94	0.001154	4.34	2304.88	526.9	0.37
Reach-1	30	8.594	100yr	128900	454.26	488.19	475.73	488.99	0.00039	7.17	17969.04	2269.51	0.28
Reach-1	30	8.594	500yr	163000	454.26	490.49	477.52	491.52	0.000437	8.14	20023.85	3055.47	0.3
Reach-1	30	8.594	50yr	116273	454.26	487.22	474.99	487.94	0.000373	6.8	17105.54	2118.8	0.27
Reach-1	30	8.594	10yr	82314	454.26	484.07	472.84	484.58	0.000338	5.76	14292.43	1626.72	0.25
Reach-1	30	8.594	50k	50000	454.26	480.03	470.47	480.37	0.000306	4.66	10723.79	932.04	0.23
Reach-1	30	8.594	30k	30000	454.26	475.87	468.51	476.13	0.000322	4.05	7400.61	752.22	0.23
Reach-1	30	8.594	10k	10000	454.26	468.65	464.39	468.89	0.000815	3.88	2574.37	561.32	0.32
Reach-1	29	8.591	100yr	128900	454.06	488.19	475.46	488.98	0.000386	7.14	18065.05	2804.7	0.28
Reach-1	29	8.591	500yr	163000	454.06	490.49	477.22	491.51	0.000433	8.1	20121.76	3057.36	0.3
Reach-1	29	8.591	50yr	116273	454.06	487.22	474.73	487.93	0.000369	6.76	17201.17	2697.3	0.27
Reach-1	29	8.591	10yr	82314	454.06	484.06	472.66	484.57	0.000333	5.72	14387.59	2346.7	0.25
Reach-1	29	8.591	50k	50000	454.06	480.03	470.2	480.36	0.000316	4.63	10809.73	1899.06	0.23
Reach-1	29	8.591	30k	30000	454.06	475.87	468.12	476.12	0.000298	3.97	7553.77	742.93	0.22
Reach-1	29	8.591	10k	10000	454.06	468.66	465.05	468.86	0.000652	3.65	2737.18	551.47	0.29
Reach-1	28	8.589	100yr	128900	454.28	487.99	476.83	488.93	0.000601	7.76	16602.91	2178.64	0.31
Reach-1	28	8.589	500yr	163000	454.28	490.25	478.63	491.45	0.000681	8.79	18548.59	2979.39	0.33
Reach-1	28	8.589	50yr	116273	454.28	487.04	476.1	487.89	0.000573	7.37	15782.41	2027.57	0.3
Reach-1	28	8.589	10yr	82314	454.28	483.92	473.92	484.54	0.000517	6.29	13096.63	1531.89	0.28
Reach-1	28	8.589	50k	50000	454.28	479.92	471.51	480.33	0.000501	5.17	9664.96	895.66	0.27
Reach-1	28	8.589	30k	30000	454.28	475.75	469.34	476.08	0.000534	4.63	6479.7	718.49	0.27
Reach-1	28	8.589	10k	10000	454.28	468.39	466.08	468.79	0.00167	5.1	1959.05	458.27	0.44
Reach-1	27.5			Bridge									
Reach-1	27	8.580	100yr	128900	454.28	487.96	476.83	488.9	0.000604	7.78	16576.55	2173.79	0.31
Reach-1	27	8.580	500yr	163000	454.28	490.21	478.63	491.42	0.000684	8.8	18518.17	2975.57	0.34
Reach-1	27	8.580	50yr	116273	454.28	487.01	476.1	487.86	0.000576	7.38	15757.45	2022.97	0.3
Reach-1	27	8.580	10yr	82314	454.28	483.9	473.92	484.51	0.00052	6.3	13074.5	1527.8	0.28
Reach-1	27	8.580	50k	50000	454.28	479.89	471.51	480.31	0.000473	5.18	9645.29	846.52	0.26
Reach-1	27	8.580	30k	30000	454.28	475.72	469.34	476.06	0.000539	4.64	6460.67	717.91	0.27
Reach-1	27	8.580	10k	10000	454.28	468.28	466.08	468.71	0.00178	5.23	1912.82	453.16	0.45
Reach-1	26	8.574	100yr	128900	454.06	488.02	475.49	488.81	0.000397	7.13	18076.86	2786.21	0.28
Reach-1	26	8.574	500yr	163000	454.06	490.29	477.25	491.3	0.000441	8.08	20164.88	3036.01	0.3
Reach-1	26	8.574	50yr	116273	454.06	487.07	474.74	487.78	0.000382	6.76	17195.65	2680.07	0.28
Reach-1	26	8.574	10yr	82314	454.06	483.93	472.66	484.45	0.000353	5.75	14307.81	2332.21	0.26
Reach-1	26	8.574	50k	50000	454.06	479.92	470.19	480.26	0.000354	4.71	10606.63	1886.38	0.24
Reach-1	26	8.574	30k	30000	454.06	475.75	468.13	476.01	0.000309	4.05	7415.46	741.41	0.22
Reach-1	26	8.574	10k	10000	454.06	468.34	465.04	468.58	0.000778	3.9	2564.04	534.82	0.31
Reach-1	25	8.568	100yr	128900	454.06	488.01	475.47	488.8	0.000398	7.14	18062.43	2784.48	0.28
Reach-1	25	8.568	500yr	163000	454.06	490.27	477.24	491.29	0.000443	8.09	20148.54	3034.11	0.3
Reach-1	25	8.568	50yr	116273	454.06	487.05	474.74	487.76	0.000383	6.77	17181.88	2678.41	0.28
Reach-1	25	8.568	10yr	82314	454.06	483.92	472.66	484.44	0.000354	5.76	14295.27	2330.7	0.26
Reach-1	25	8.568	50k	50000	454.06	479.9	470.19	480.25	0.000355	4.72	10594.22	1884.89	0.25
Reach-1	25	8.568	30k	30000	454.06	475.74	468.12	476	0.00031	4.05	7406.92	741.26	0.22
Reach-1	25	8.568	10k	10000	454.06	468.31	465.04	468.55	0.000793	3.93	2547.13	533.33	0.32
Reach-1	24	8.564	100yr	128900	454.06	487.92	476.12	488.77	0.000563	7.41	17392.16	2550.46	0.29
Reach-1	24	8.564	500yr	163000	454.06	490.15	478.1	491.25	0.000657	8.41	19371.8	2997.17	0.32
Reach-1	24	8.564	50yr	116273	454.06	486.97	475.29	487.74	0.000532	7.02	16560.83	2356.16	0.29
Reach-1	24	8.564	10yr	82314	454.06	483.87	473.04	484.42	0.000466	5.95	13831.69	1717.4	0.26
Reach-1	24	8.564	50k	50000	454.06	479.87	470.54	480.24	0.000429	4.84	10332.65	896.42	0.25
Reach-1	24	8.564	30k	30000	454.06	475.69	468.44	475.98	0.000441	4.32	6942.15	730.53	0.25
Reach-1	24	8.564	10k	10000	454.06	468.23	465.25	468.52	0.00109	4.32	2316.72	499.53	0.35
Reach-1	23.5			Bridge									
Reach-1	23	8.555	100yr	128900	454.06	487.86	476.12	488.72	0.000568	7.43	17341.78	2538.69	0.3
Reach-1	23	8.555	500yr	163000	454.06	490.08	478.1	491.19	0.000664	8.44	19304.3	2989.09	0.32
Reach-1	23	8.555	50yr	116273	454.06	486.92	475.29	487.69	0.000537	7.04	16515.66	2345.6	0.29
Reach-1	23	8.555	10yr	82314	454.06	483.83	473.04	484.38	0.000469	5.97	13798.48	1709.62	0.27
Reach-1	23	8.555	50k	50000	454.06	479.85	470.54	480.21	0.000432	4.85	10308.32	893.55	0.25
Reach-1	23	8.555	30k	30000	454.06	475.66	468.44	475.96	0.000444	4.33	6925.1	729.42	0.25
Reach-1	23	8.555	10k	10000	454.06	468.17	465.25	468.47	0.001129	4.37	2286.99	496.7	0.36
Reach-1	22	8.54	100yr	128900	438.21	487.99	470.58	488.56	0.000195	6.06	21284.55	1884.06	0.23
Reach-1	22	8.54	500yr	163000	438.21	490.24	472.69	490.99	0.000241	6.95	23450	2591.91	0.25
Reach-1	22	8.54	50yr	116273	438.21	487.04	469.75	487.54	0.000178	5.71	20371.46	1837.44	0.22
Reach-1	22	8.54	10yr	82314	438.21	483.92	466.61	484.27	0.000134	4.74	17382.71	1656.69	0.2
Reach-1	22	8.54	50k	50000	438.21	479.91	462.28	480.12	0.00009	3.68	13575.48	1345.23	0.17
Reach-1	22	8.54	30k	30000	438.21	475.73	459.29	475.87	0.000068	2.99	10039.28	862.46	0.15
Reach-1	22	8.54	10k	10000	438.21	468.28	451.76	468.34	0.00004	1.85	5410.86	532.8	0.1
Reach-1	21	8.51	100yr	128900	453.4	487.6		488.48	0.000266	7.88	21636.15	1288.4	0.29
Reach-1	21	8.51	500yr	163000	453.4	489.76		490.9	0.000308	8.99	24421.58	1291.68	0.31

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Reach-1	21	8.51	50yr	116273	453.4	486.68		487.48	0.000251	7.45	20453.27	1287.48	0.28
Reach-1	21	8.51	10yr	82314	453.4	483.64		484.21	0.000214	6.25	16544.8	1284.44	0.25
Reach-1	21	8.51	50k	50000	453.4	479.72		480.09	0.000179	4.91	11518.21	1280.52	0.22
Reach-1	21	8.51	30k	30000	453.4	475.59		475.84	0.000183	4.03	7964.43	760.65	0.21
Reach-1	21	8.51	10k	10000	453.4	468.1		468.31	0.000455	3.64	2825.52	606.52	0.29
Reach-1	20	7.75	100yr	128900	450.95	485.03		486.72	0.000901	14.37	26119.24	2317	0.46
Reach-1	20	7.75	500yr	163000	450.95	487.3		489	0.000903	15.1	31418.04	2337.49	0.47
Reach-1	20	7.75	50yr	116273	450.95	484.06		485.75	0.000905	14.09	23875.68	2285.97	0.46
Reach-1	20	7.75	10yr	82314	450.95	481.24		482.7	0.000802	12.41	17923.64	1936.38	0.43
Reach-1	20	7.75	50k	50000	450.95	477.46		478.75	0.000728	10.66	11314.91	1664.91	0.39
Reach-1	20	7.75	30k	30000	450.95	473.69		474.6	0.000585	8.47	5745.07	533.33	0.34
Reach-1	20	7.75	10k	10000	450.95	466.04		466.45	0.000471	5.38	2473.49	345.38	0.28
Reach-1	19	7.25	100yr	128900	452.15	482.87	478.53	484.46	0.000872	13.79	26142.41	2599.24	0.45
Reach-1	19	7.25	500yr	163000	452.15	485.15	480.35	486.75	0.000873	14.51	32300.58	2758	0.46
Reach-1	19	7.25	50yr	116273	452.15	481.89	477.72	483.48	0.000876	13.5	23644.19	2499.28	0.45
Reach-1	19	7.25	10yr	82314	452.15	479.16	473.52	480.64	0.000823	12.23	17201.36	2217.76	0.43
Reach-1	19	7.25	50k	50000	452.15	475.68	468.04	476.9	0.000704	10.24	10723.64	1395.8	0.39
Reach-1	19	7.25	30k	30000	452.15	472.08	464.13	473.05	0.000619	8.52	6350.62	1017.34	0.35
Reach-1	19	7.25	10k	10000	452.15	464.81	458.7	465.23	0.00047	5.29	2260.45	312.32	0.28

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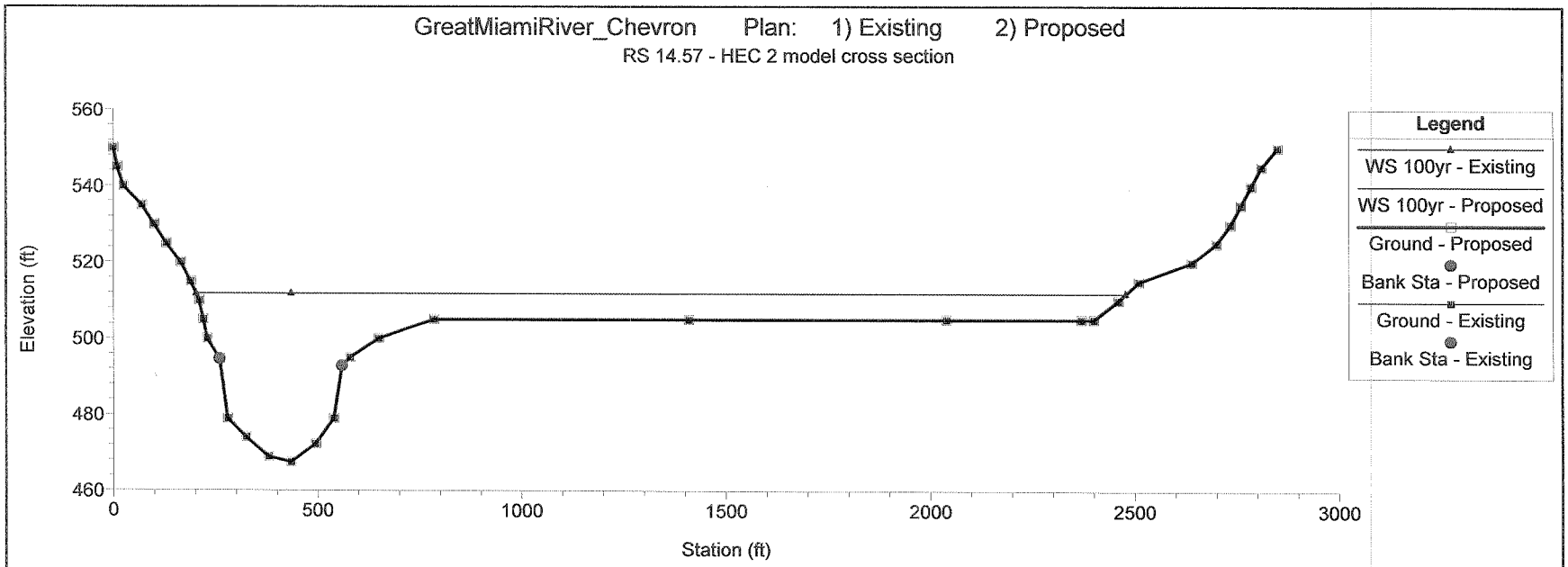
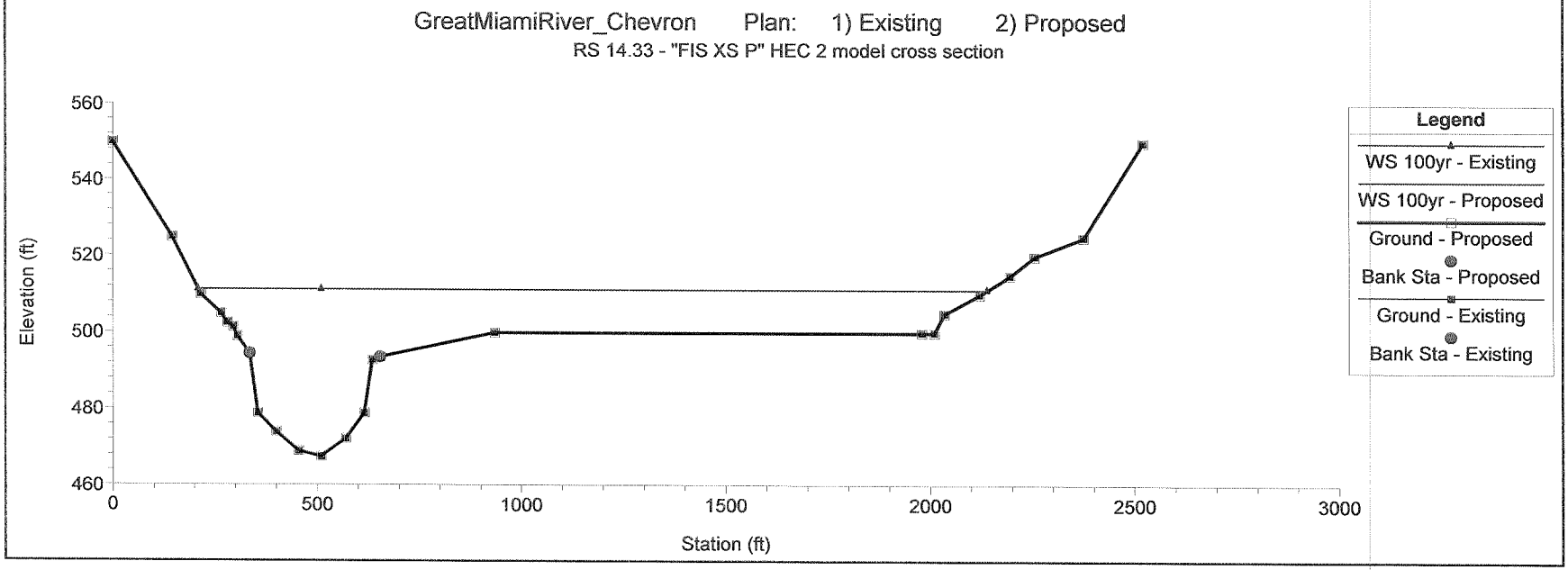
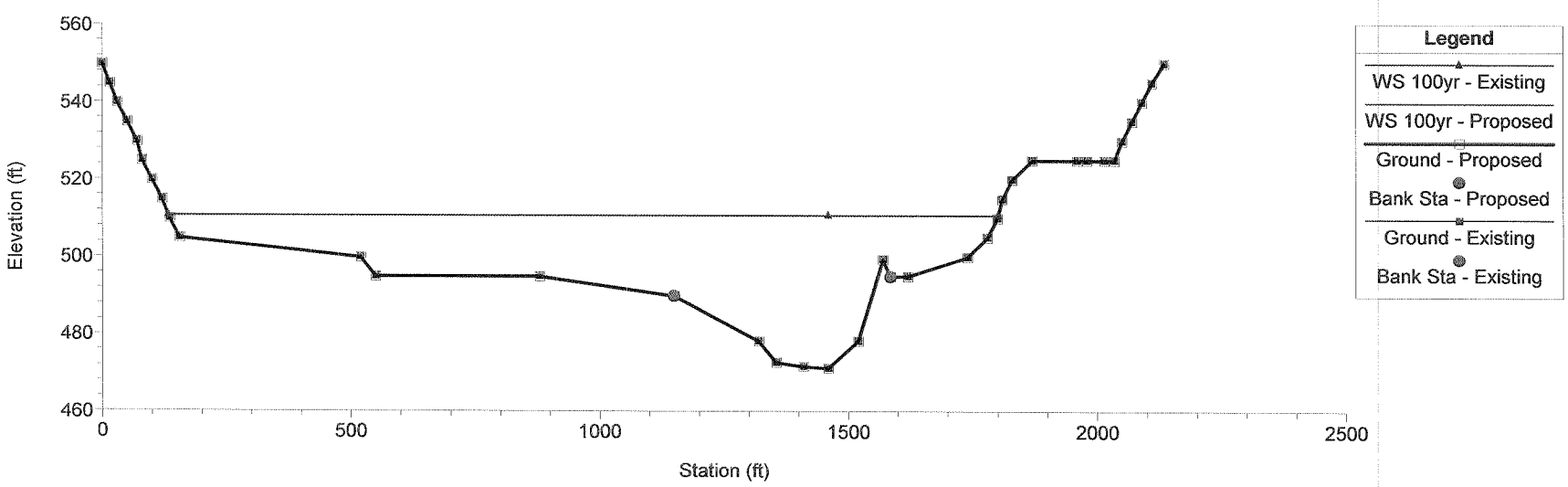
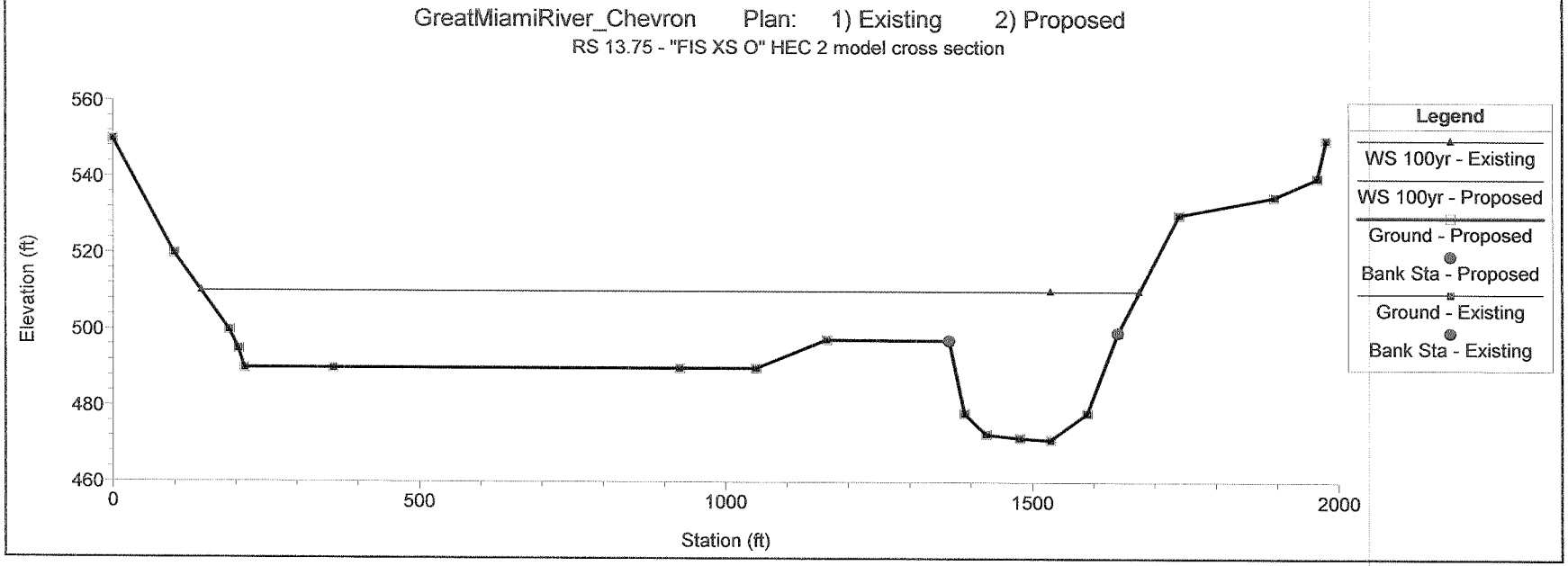
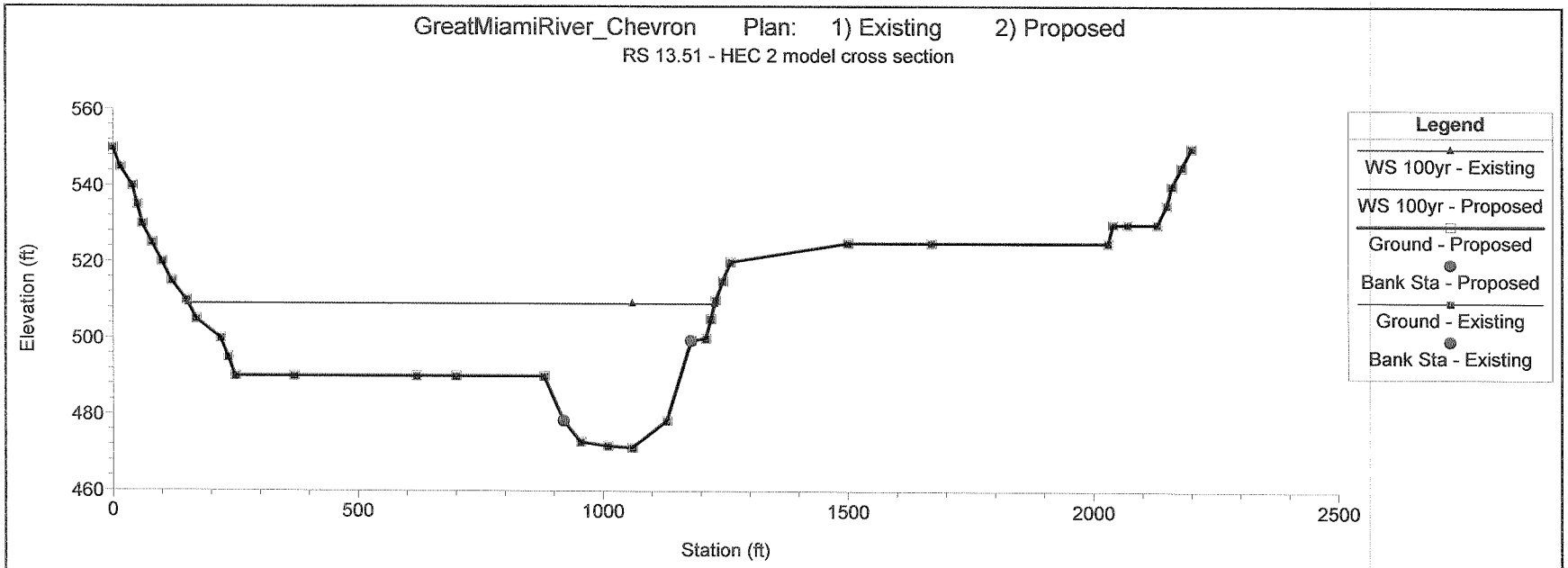
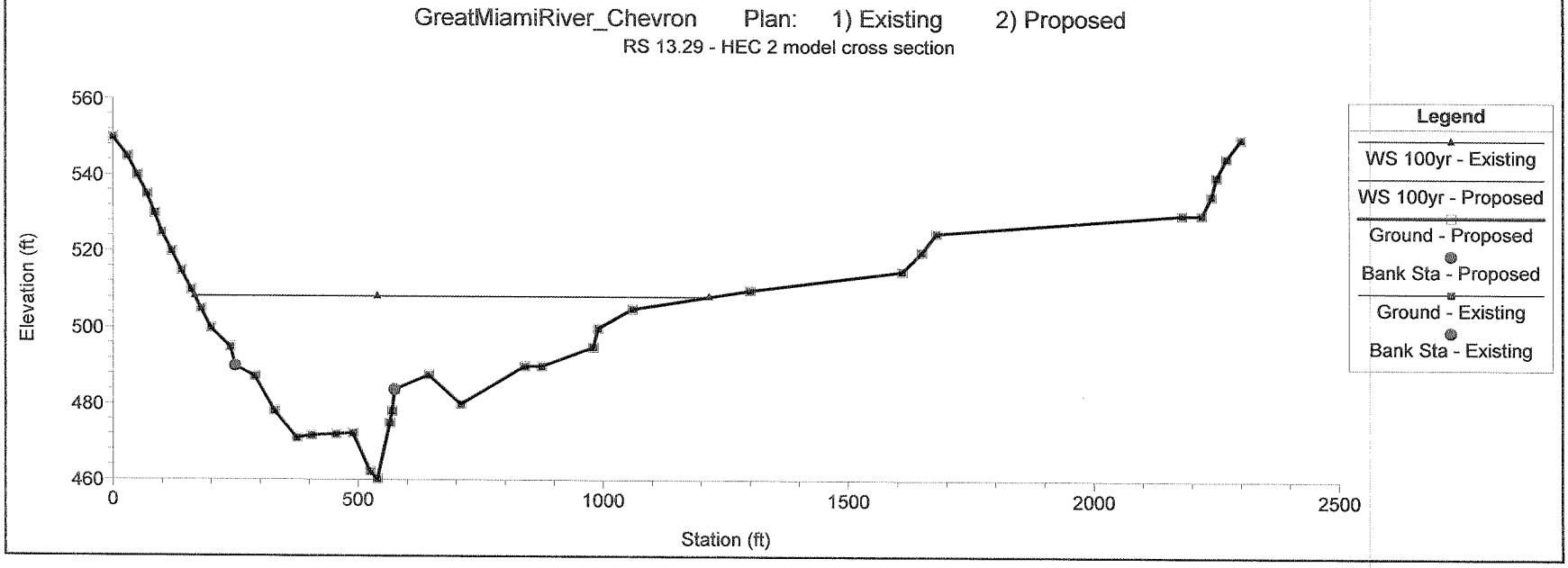

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 14.57 - HEC 2 model cross section
Elevation (ft)
560
540
520
500
480
460
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

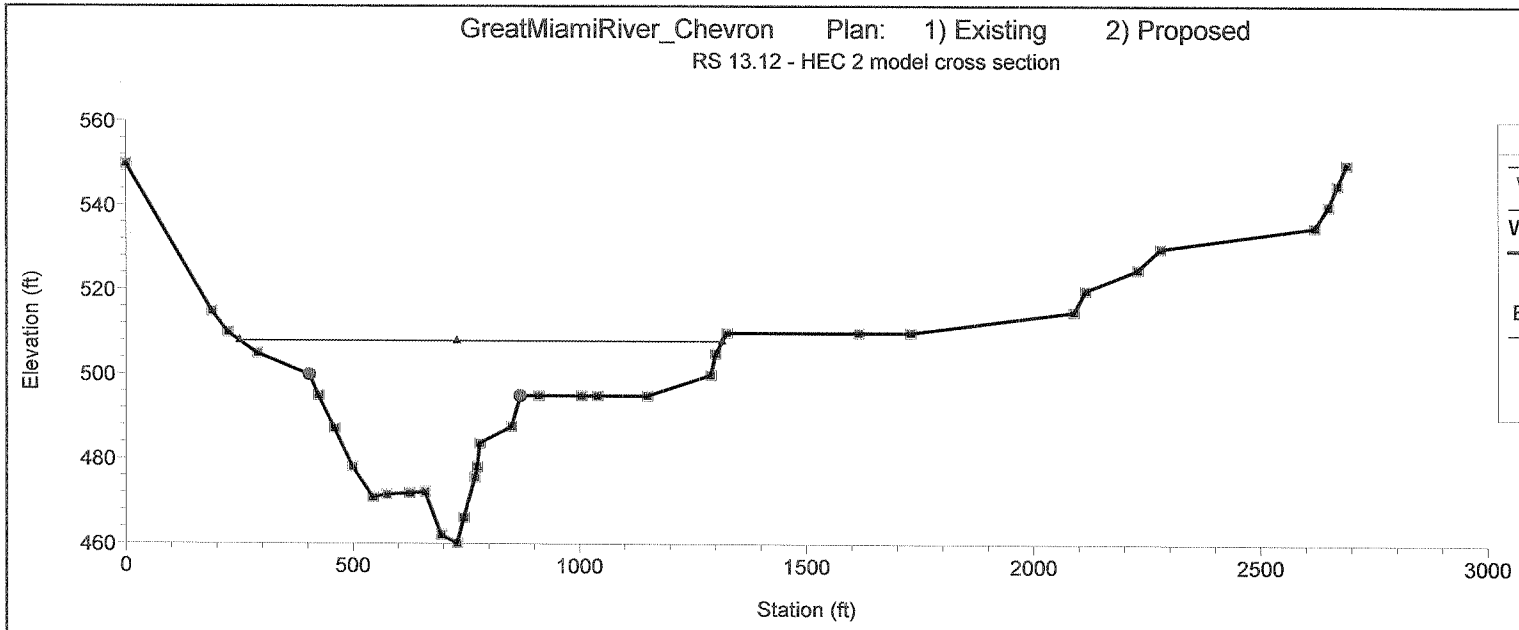

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 14.33 - "FIS XS P" HEC 2 model cross section
Elevation (ft)
560
540
520
500
480
460
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

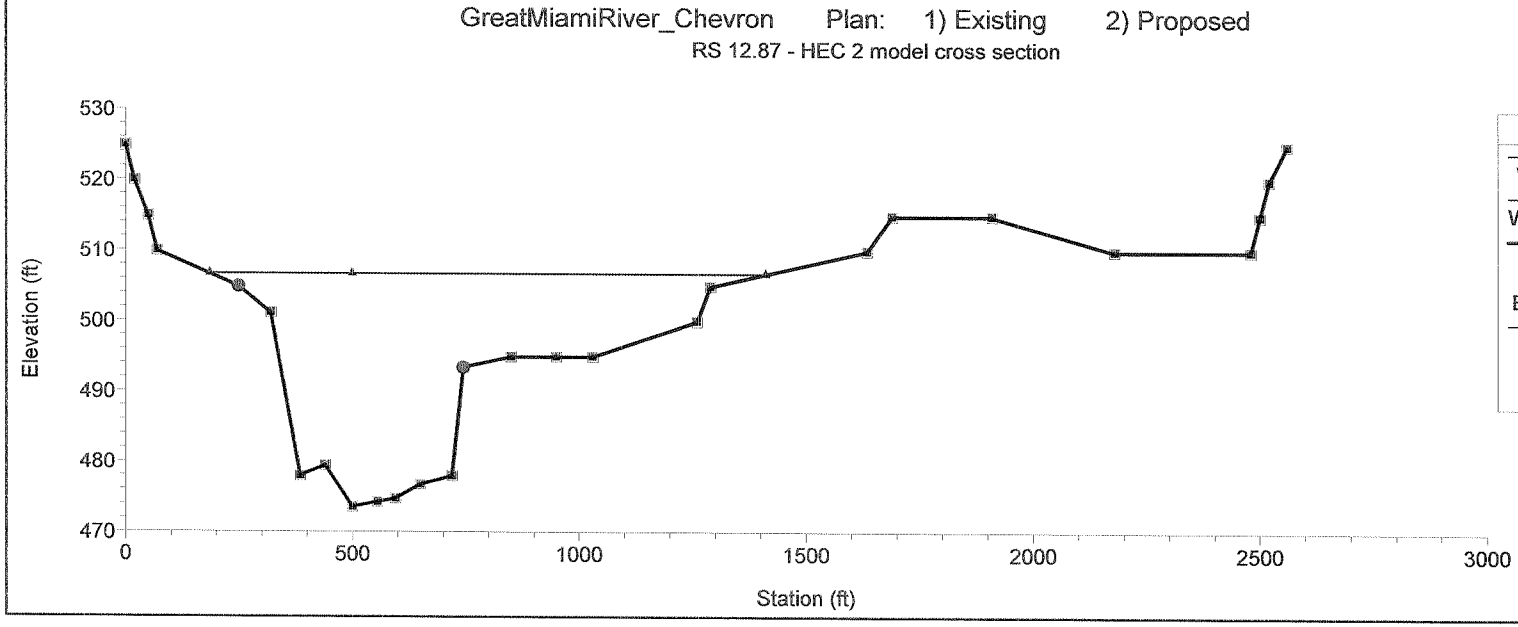

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 14.00 - HEC 2 model cross section
Elevation (ft)
560
540
520
500
480
460
0
500
1000
1500
2000
2500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

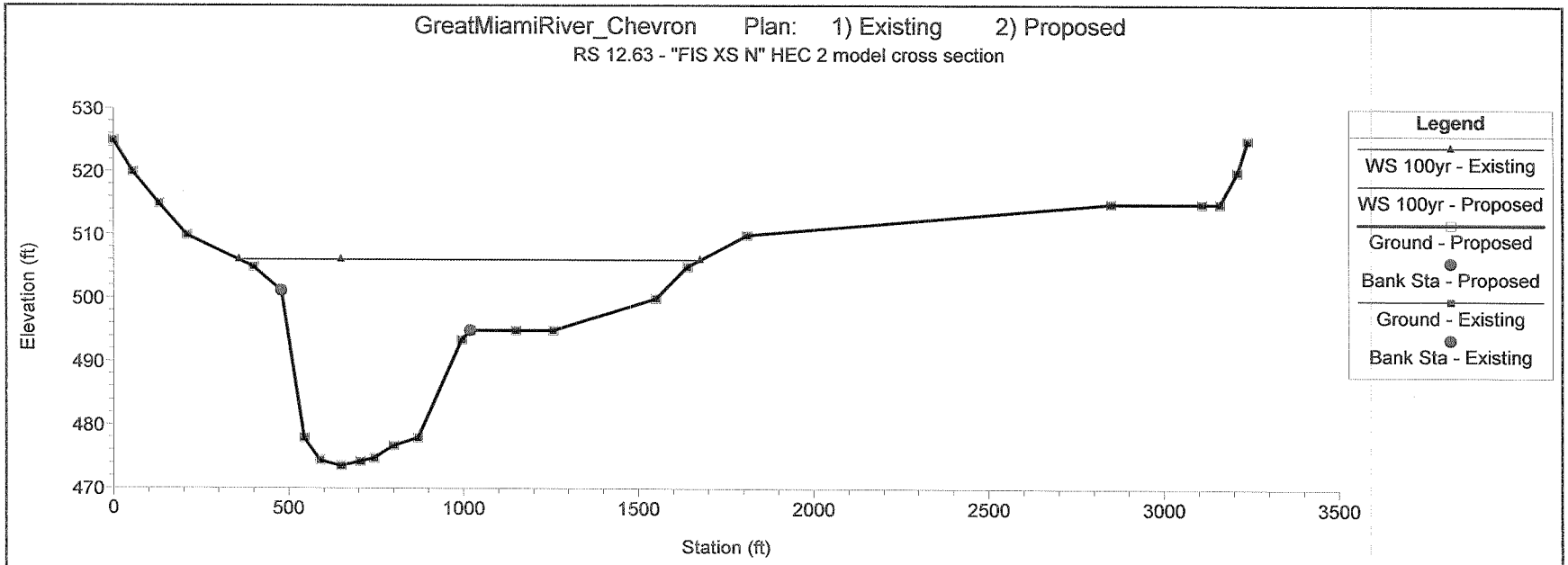

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 13.75 - "FIS XS O" HEC 2 model cross section
Elevation (ft)
560
540
520
500
480
460
0
500
1000
1500
2000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

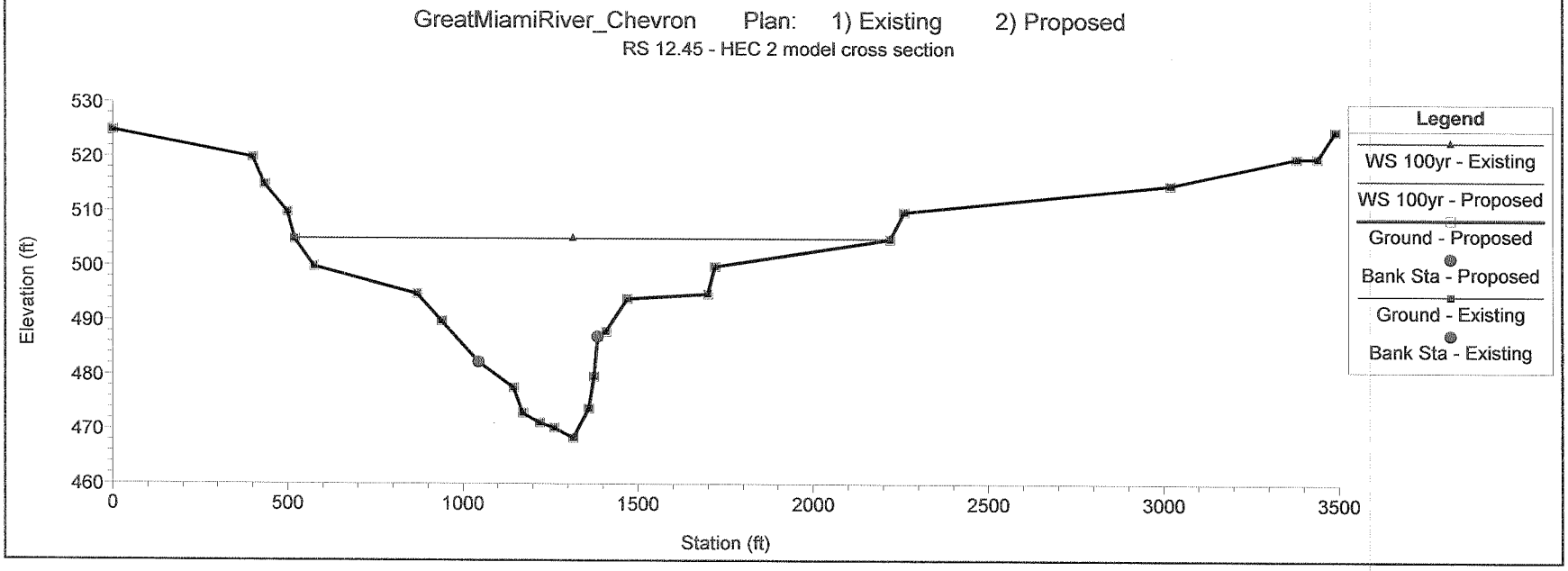

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 13.51 - HEC 2 model cross section
Elevation (ft)
560
540
520
500
480
460
0
500
1000
1500
2000
2500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

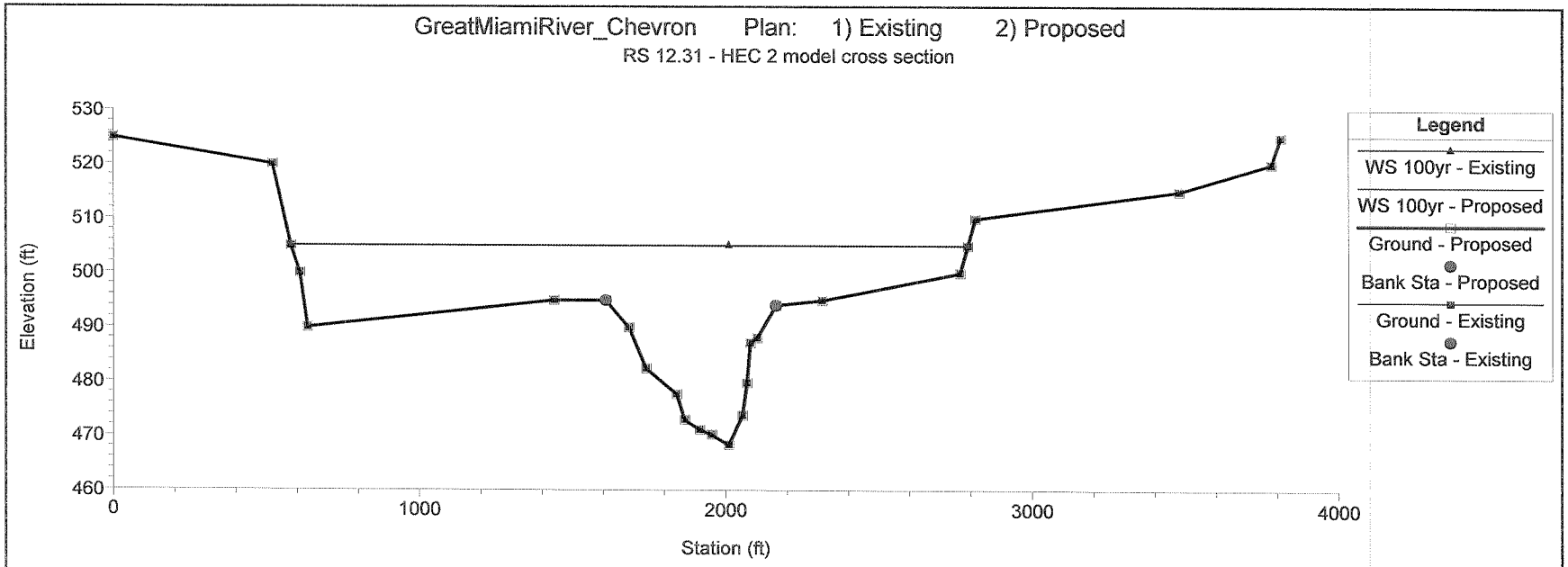

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 13.29 - HEC 2 model cross section
Elevation (ft)
560
540
520
500
480
460
0
500
1000
1500
2000
2500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

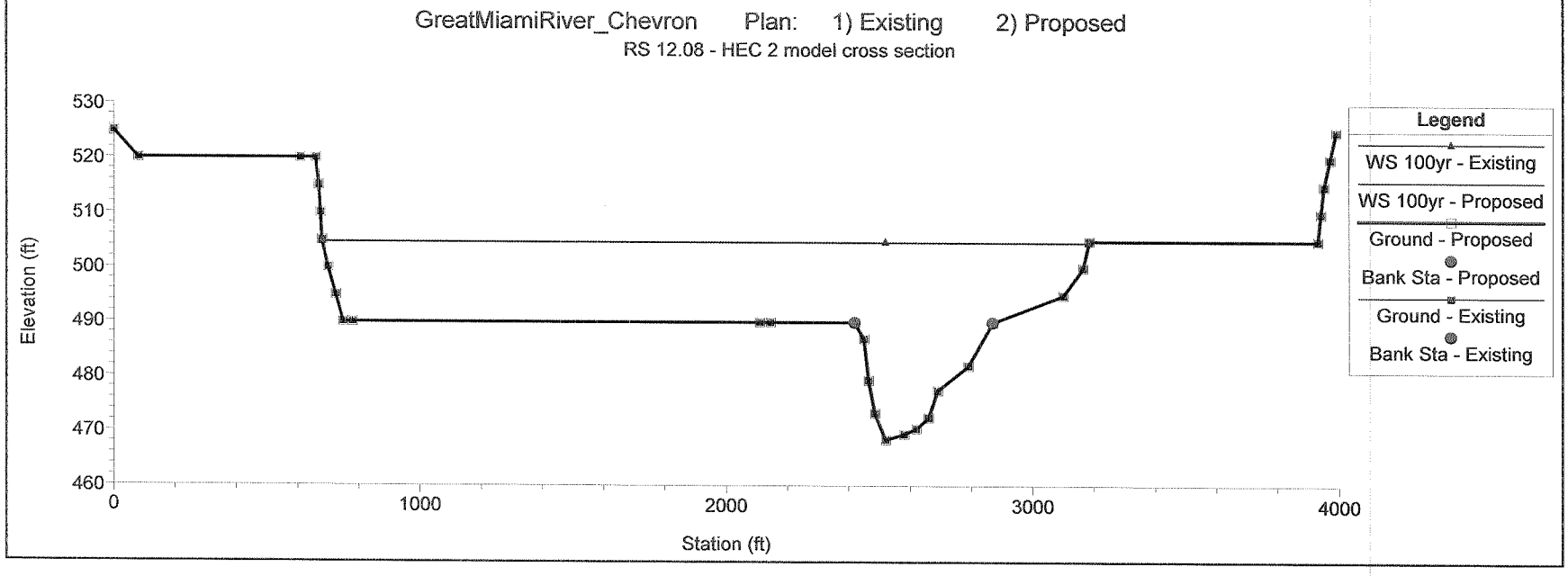

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 13.12 - HEC 2 model cross section
Elevation (ft)
560
540
520
500
480
460
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

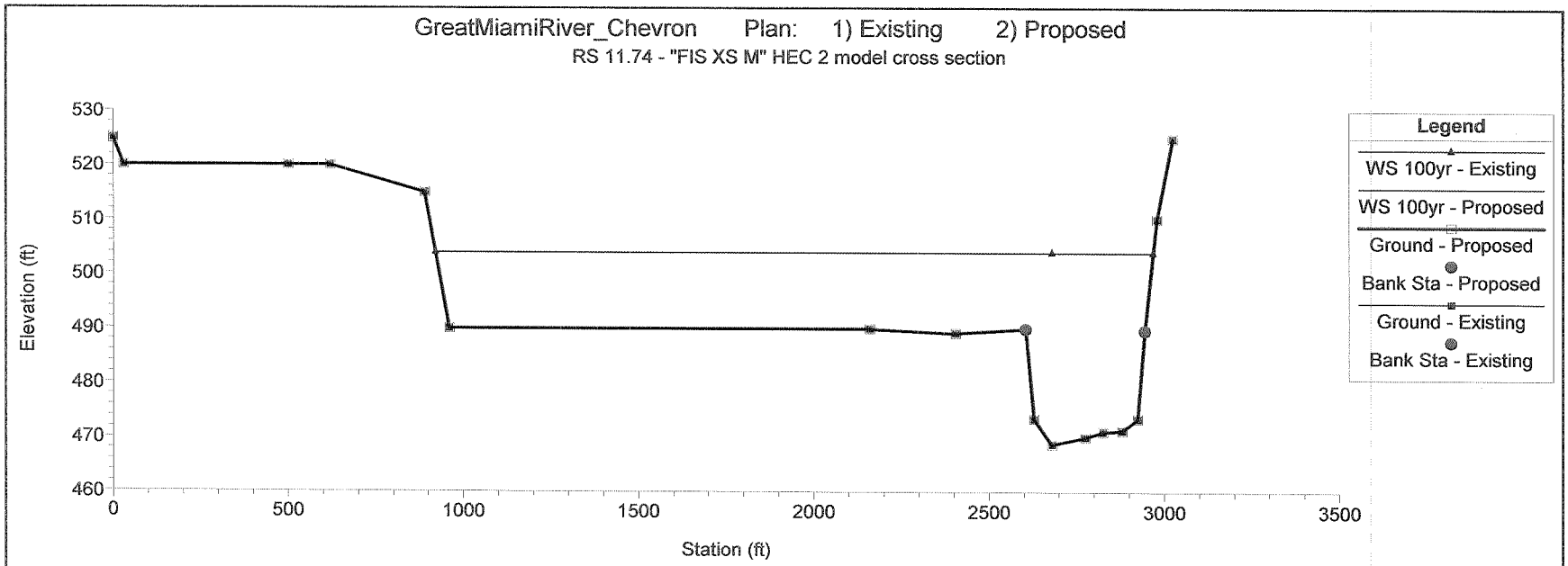

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 12.87 - HEC 2 model cross section
Elevation (ft)
530
520
510
500
490
480
470
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

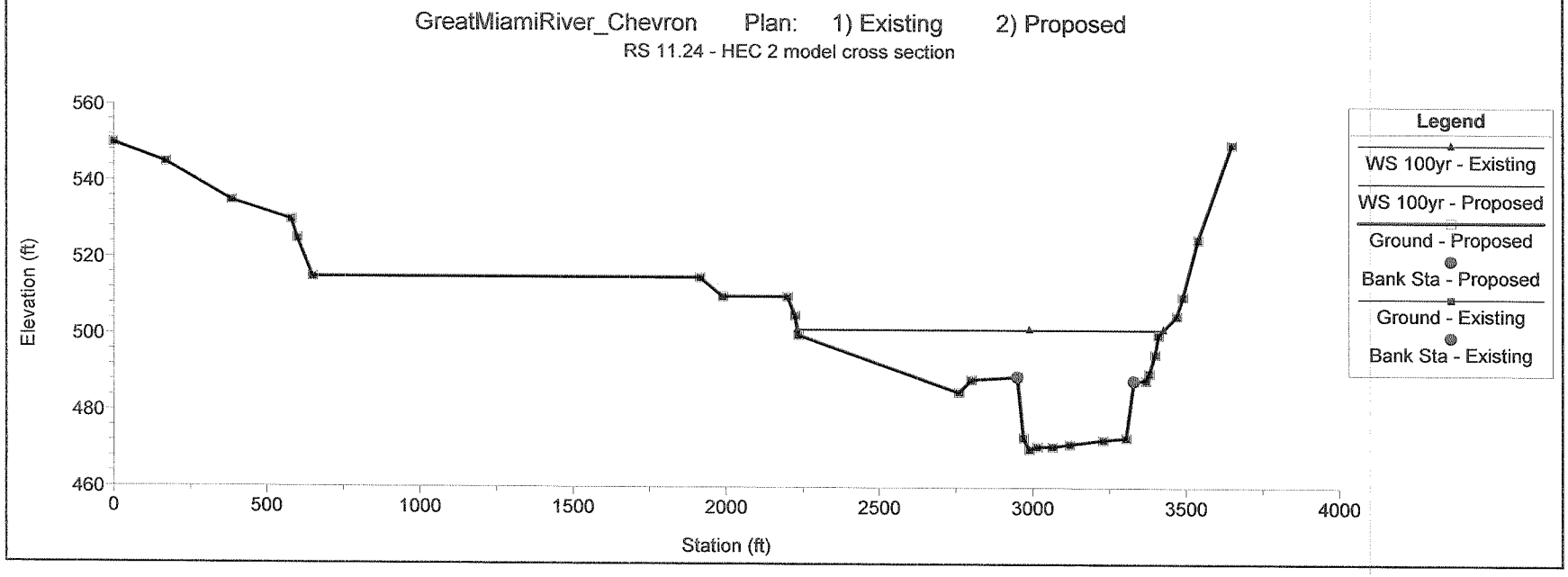

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 12.63 - "FIS XS N" HEC 2 model cross section
Elevation (ft)
530
520
510
500
490
480
470
0
500
1000
1500
2000
2500
3000
3500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

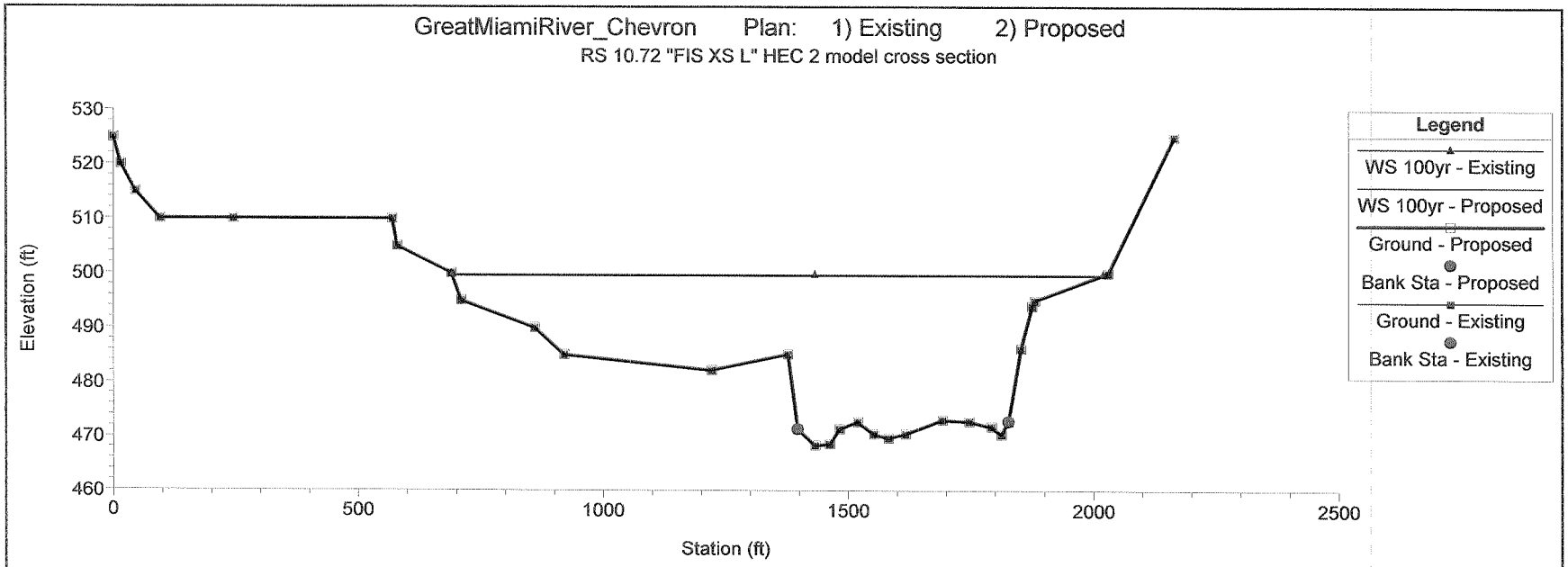

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 12.45 - HEC 2 model cross section
Elevation (ft)
530
520
510
500
490
480
470
460
0
500
1000
1500
2000
2500
3000
3500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

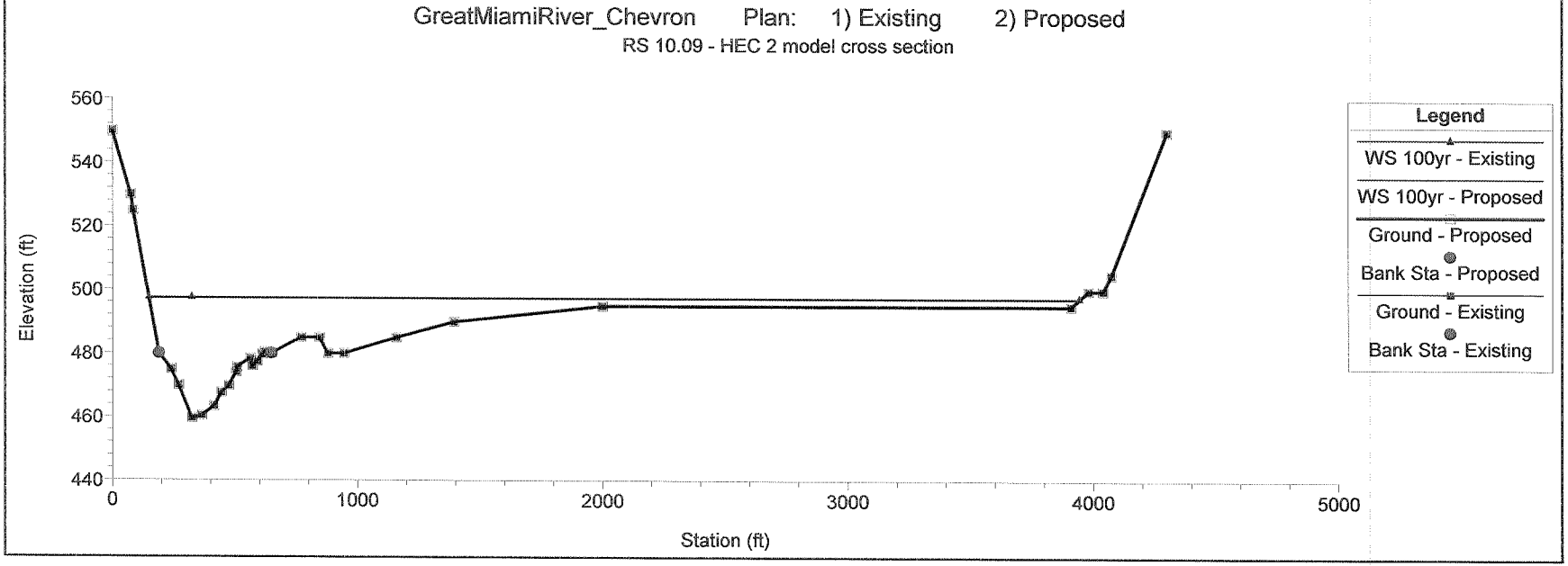

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 12.31 - HEC 2 model cross section
Elevation (ft)
530
520
510
500
490
480
470
460
0
1000
2000
3000
4000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

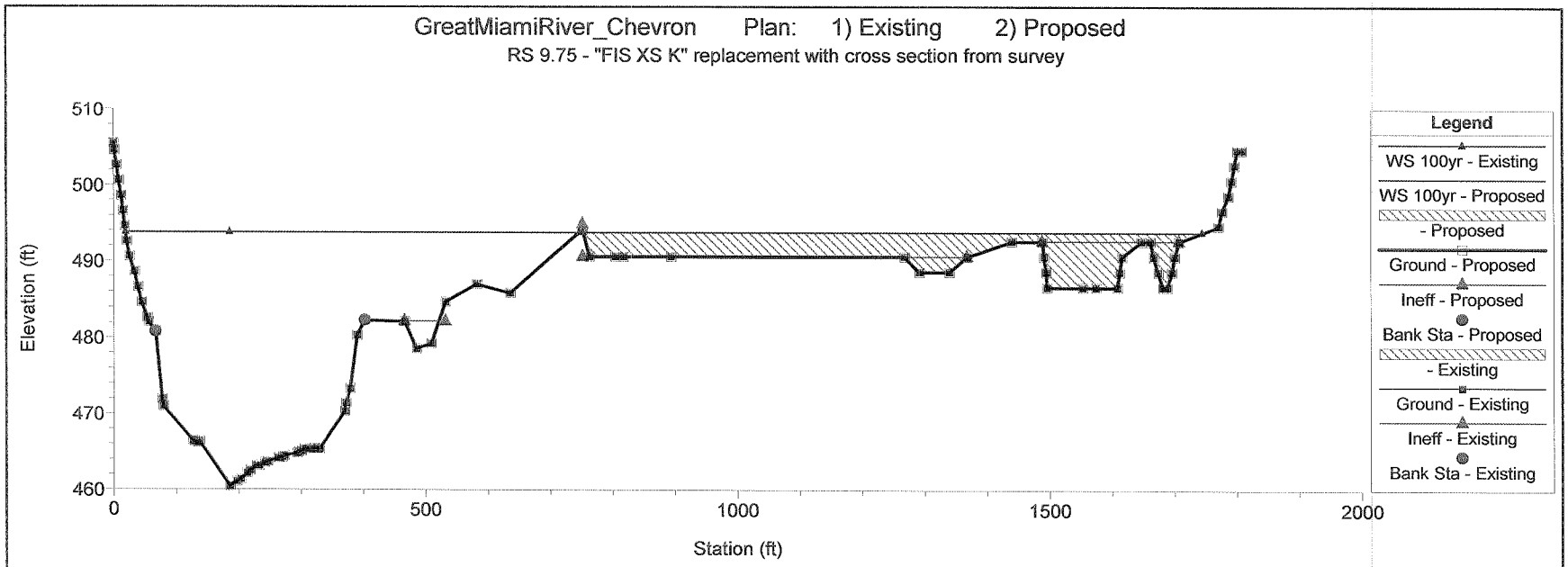

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 12.08 - HEC 2 model cross section
Elevation (ft)
530
520
510
500
490
480
470
460
0
1000
2000
3000
4000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

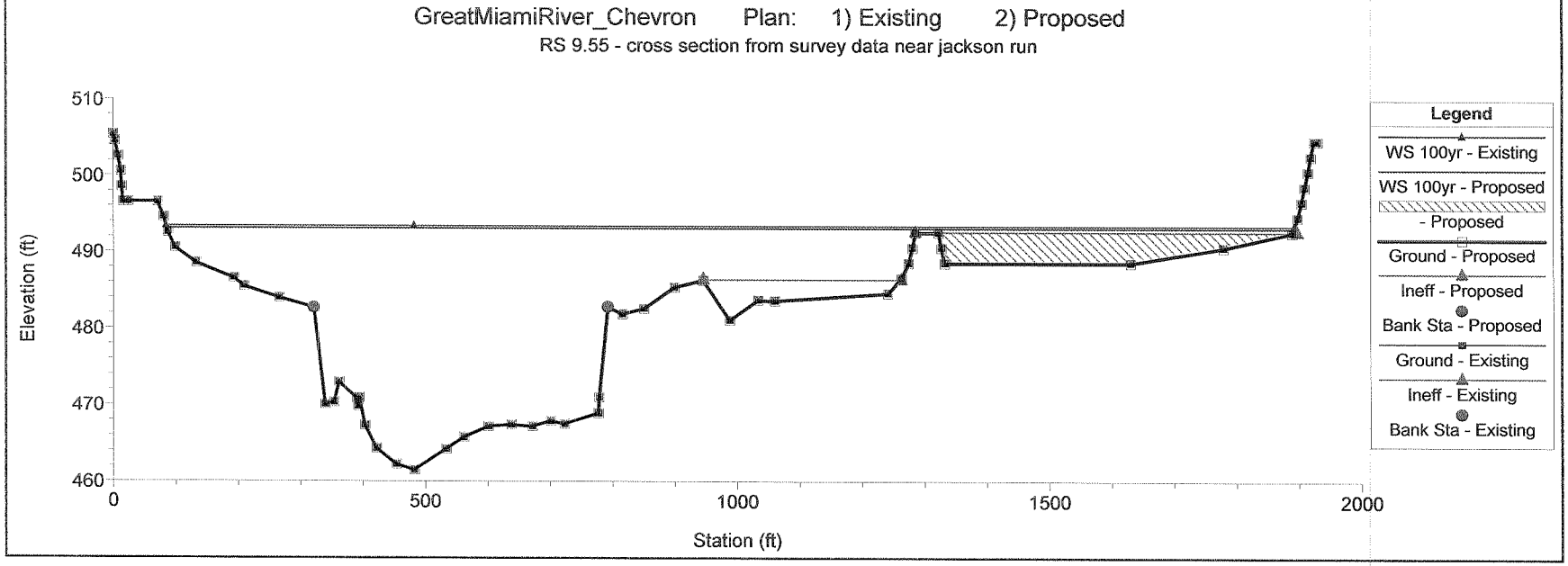

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 11.74 - "FIS XS M" HEC 2 model cross section
Elevation (ft)
530
520
510
500
490
480
470
460
0
500
1000
1500
2000
2500
3000
3500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

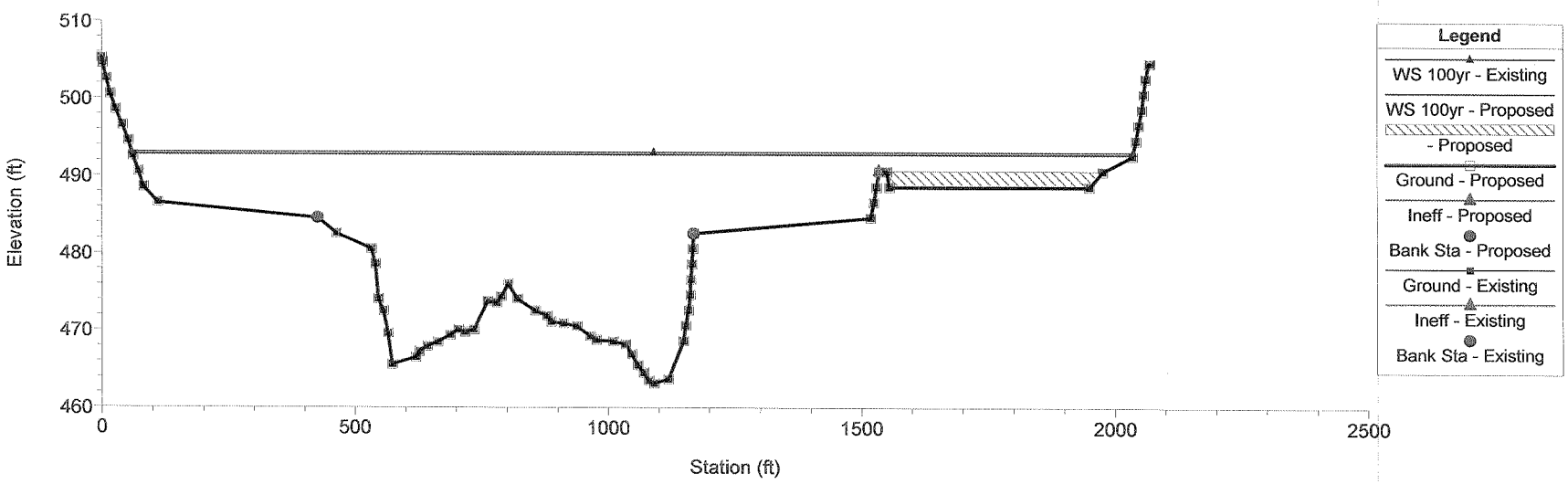

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 11.24 - HEC 2 model cross section
Elevation (ft)
560
540
520
500
480
460
0
500
1000
1500
2000
2500
3000
3500
4000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

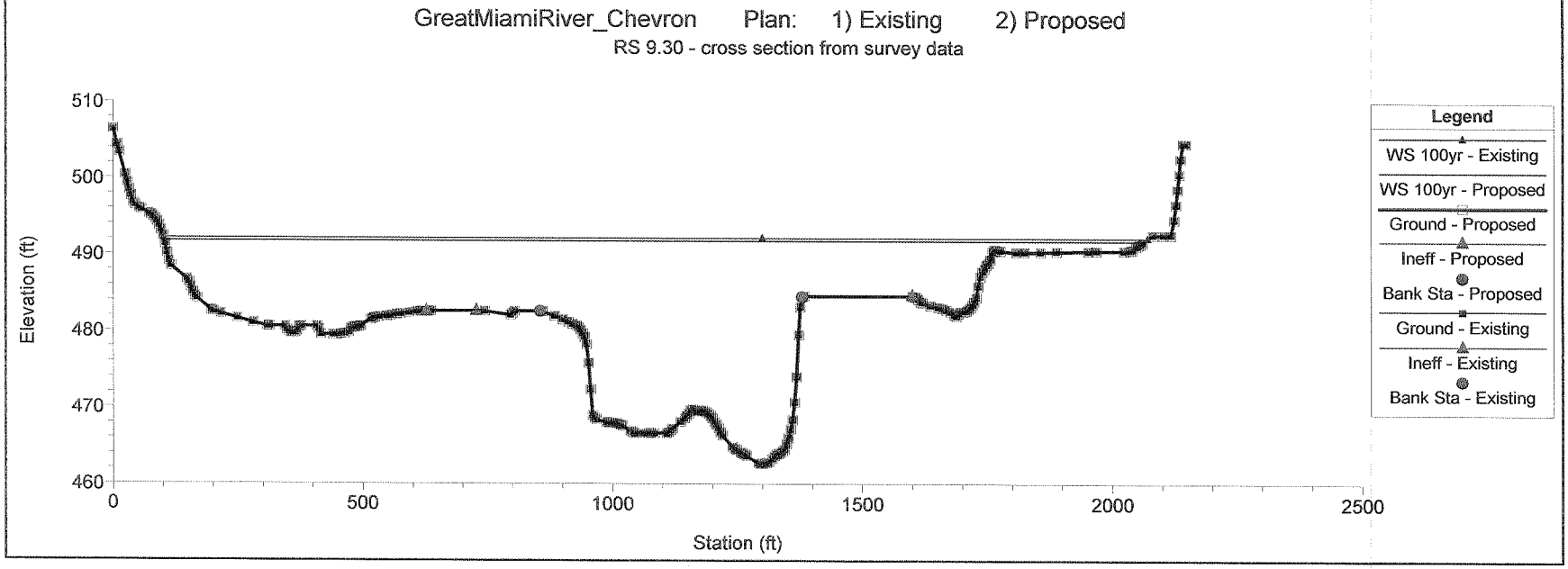

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 10.72 "FIS XS L" HEC 2 model cross section
Elevation (ft)
530
520
510
500
490
480
470
460
0
500
1000
1500
2000
2500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

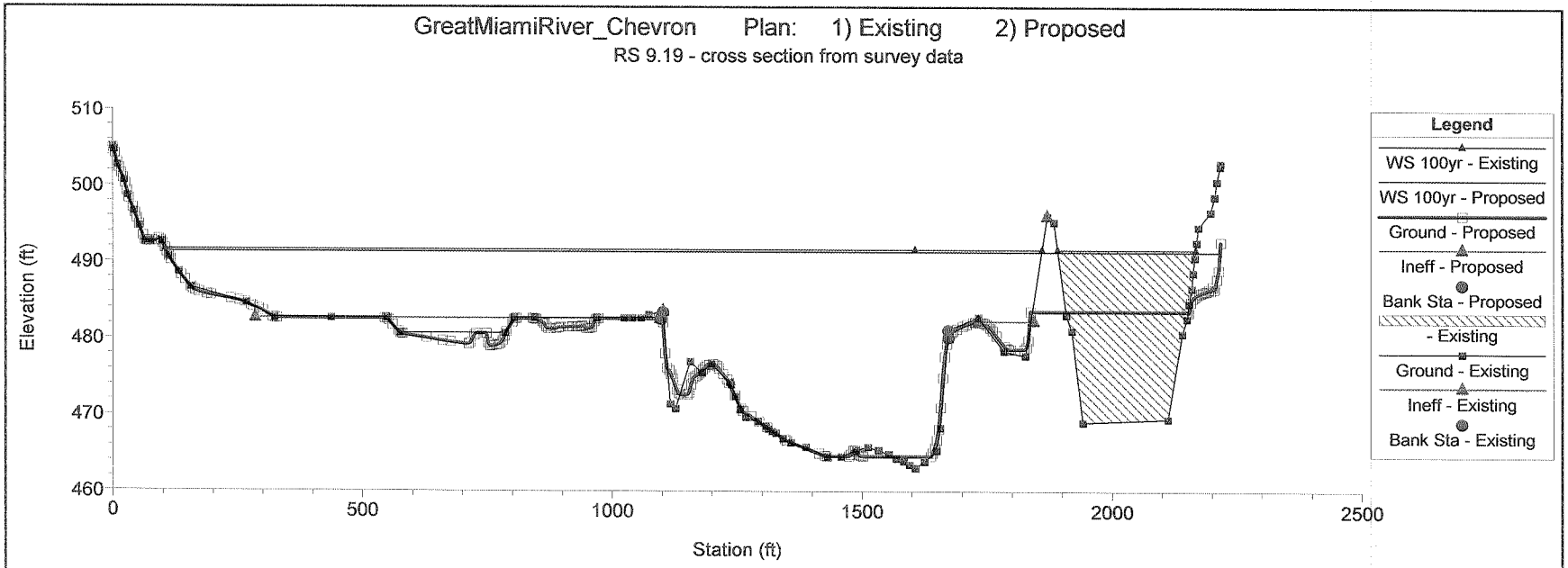

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 10.09 - HEC 2 model cross section
Elevation (ft)
560
540
520
500
480
460
440
0
1000
2000
3000
4000
5000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing

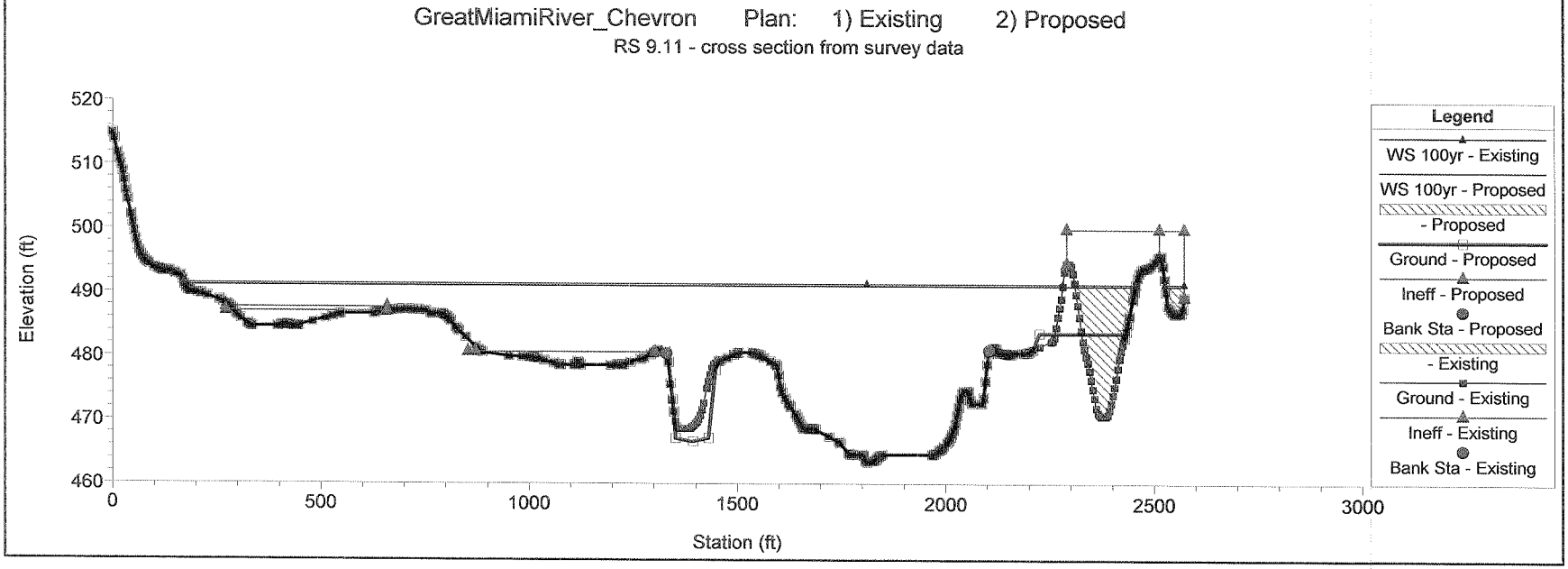

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 9.75 - "FIS XS K" replacement with cross section from survey
Elevation (ft)
510
500
490
480
470
460
0
500
1000
1500
2000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

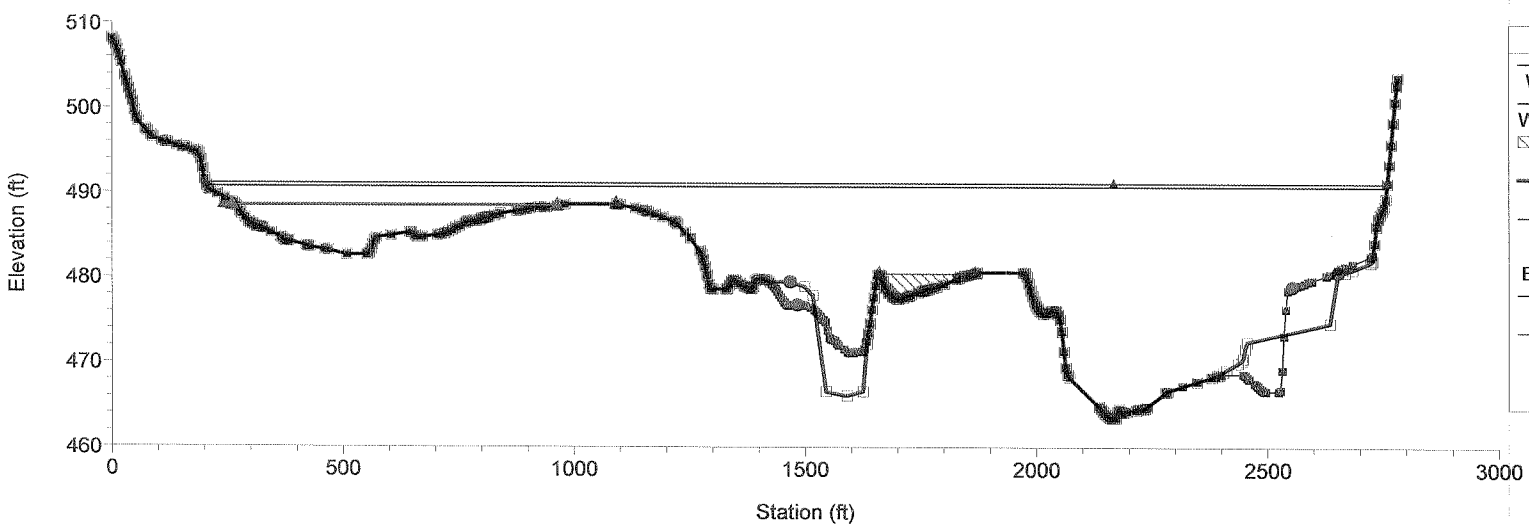

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 9.55 - cross section from survey data near jackson run
Elevation (ft)
510
500
490
480
470
460
0
500
1000
1500
2000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
Ground - Existing
Ineff - Existing
Bank Sta - Existing

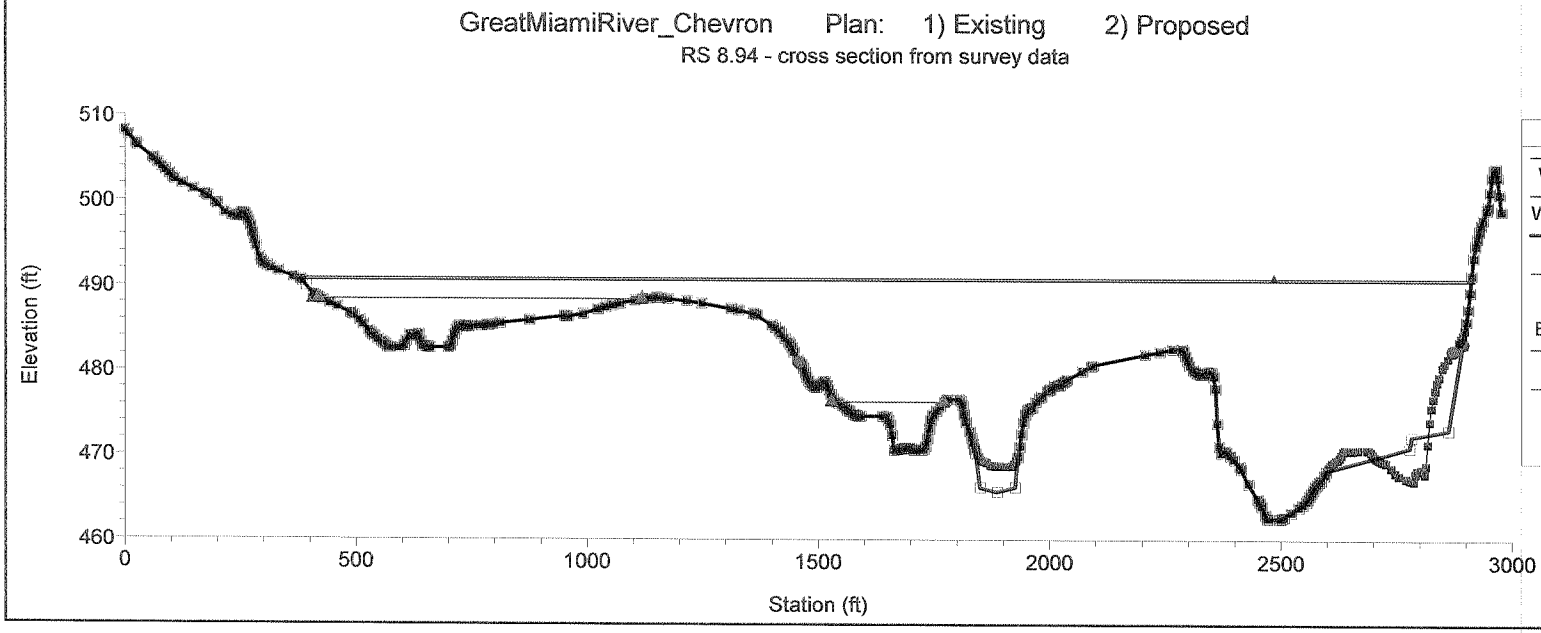

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 9.42 - cross section from survey data
Elevation (ft)
510
500
490
480
470
460
0
500
1000
1500
2000
2500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
Ground - Existing
Ineff - Existing
Bank Sta - Existing

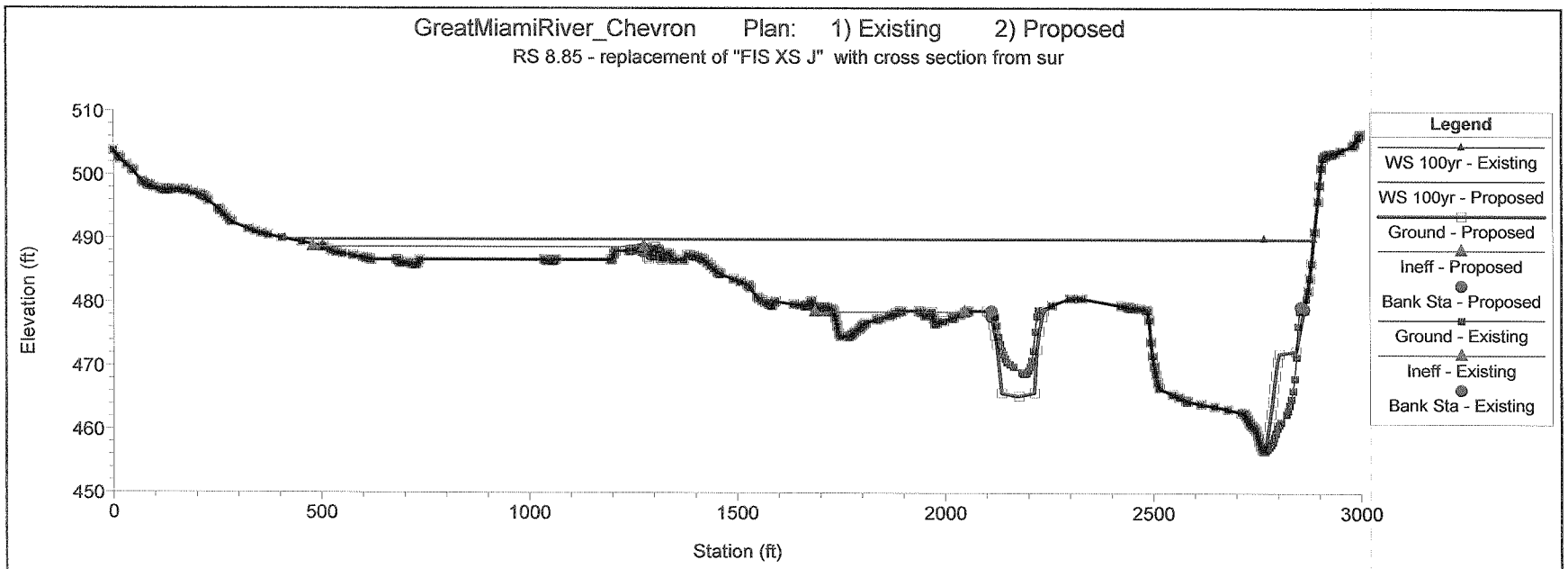

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 9.30 - cross section from survey data
Elevation (ft)
510
500
490
480
470
460
0
500
1000
1500
2000
2500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
Ground - Existing
Ineff - Existing
Bank Sta - Existing

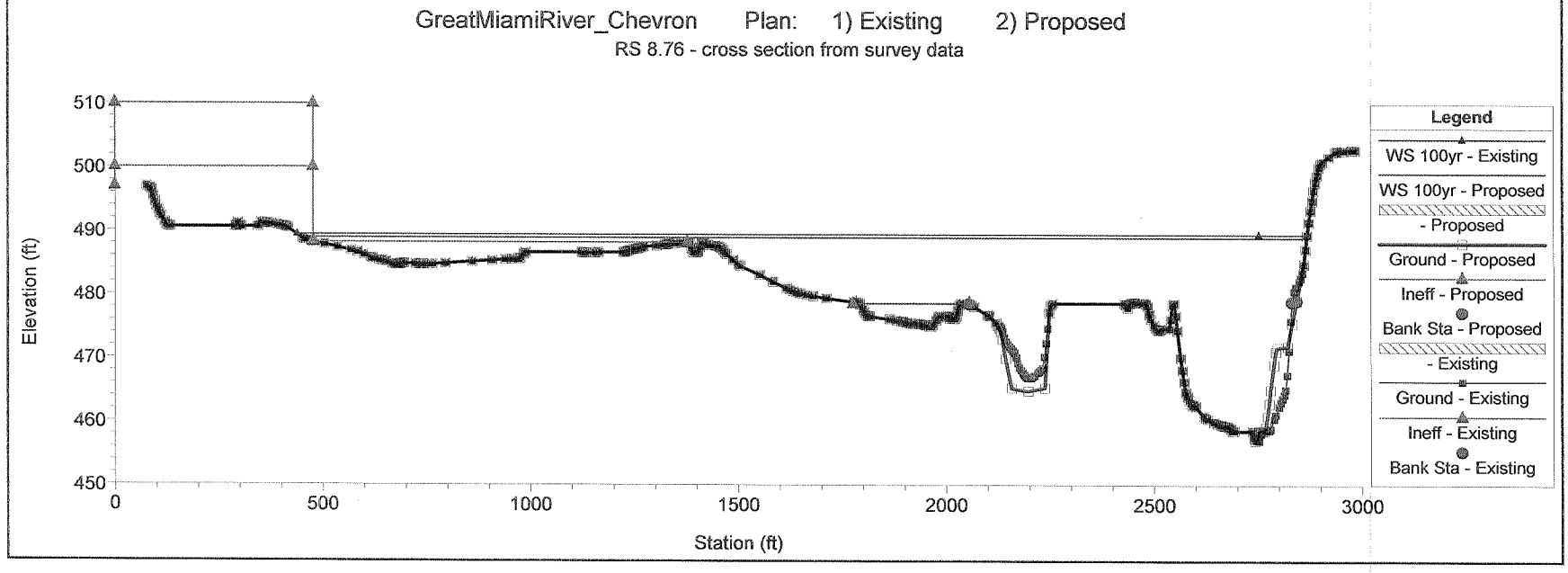

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 9.19 - cross section from survey data
Elevation (ft)
510
500
490
480
470
460
0
500
1000
1500
2000
2500
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

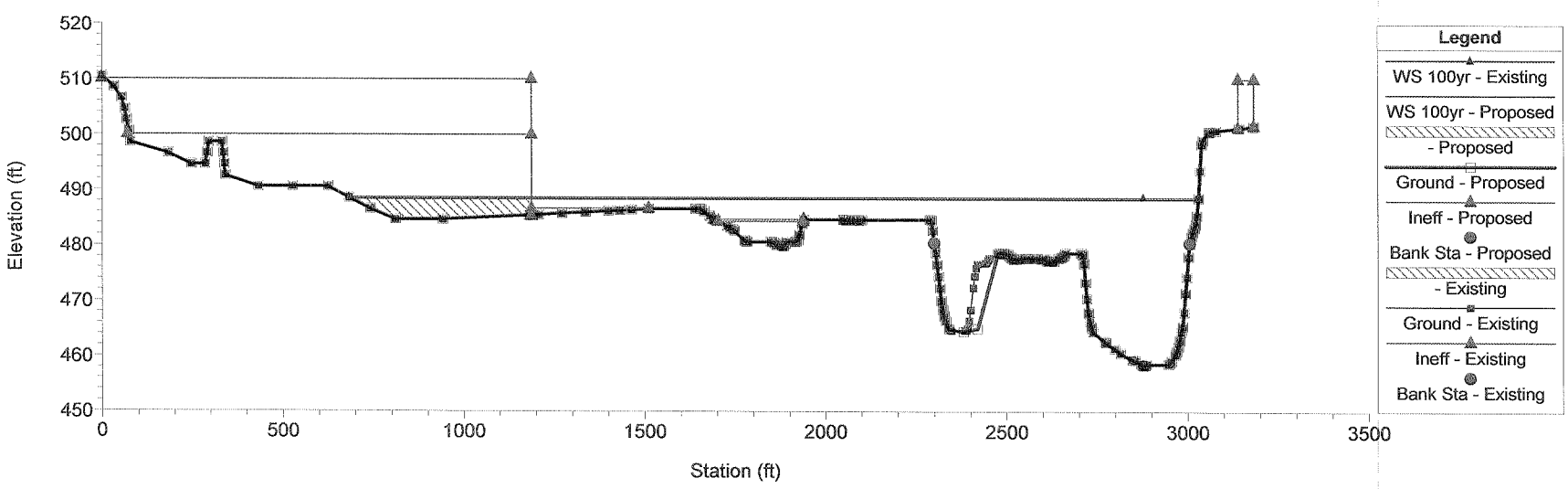

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 9.11 - cross section from survey data
Elevation (ft)
520
510
500
490
480
470
460
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

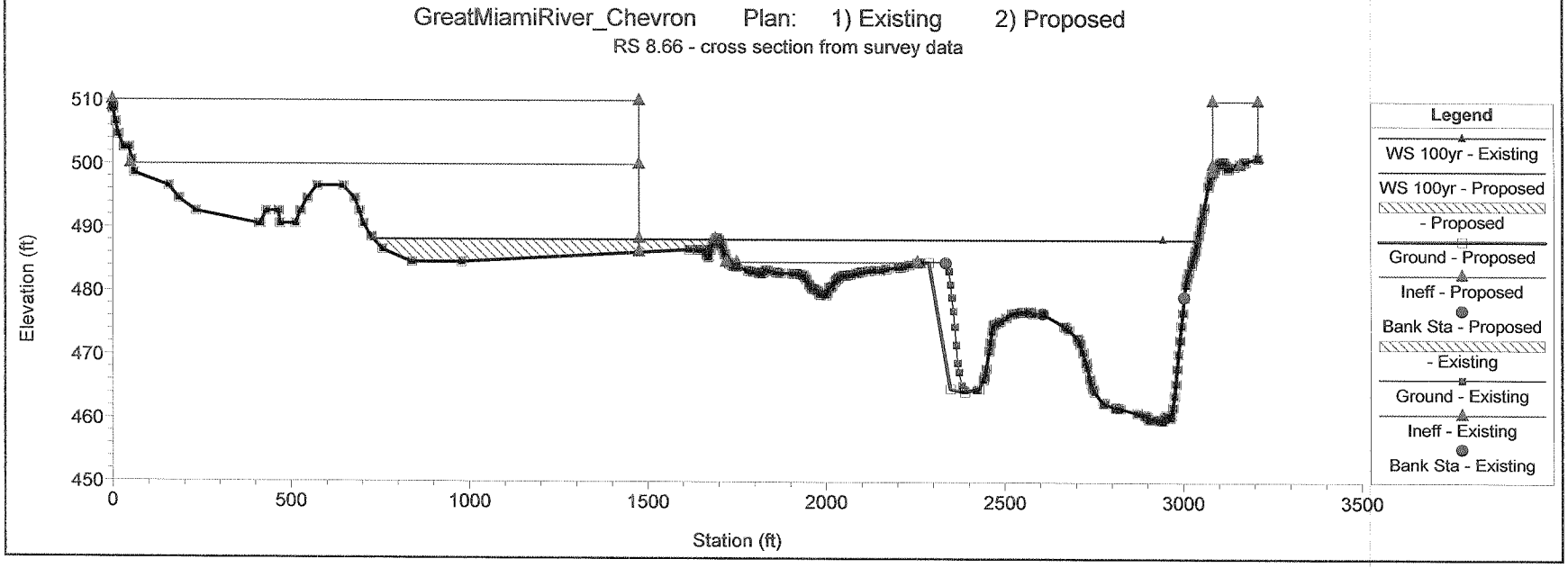

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 9.01 - cross section from survey data
Elevation (ft)
510
500
490
480
470
460
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
Ground - Existing
Ineff - Existing
Bank Sta - Existing

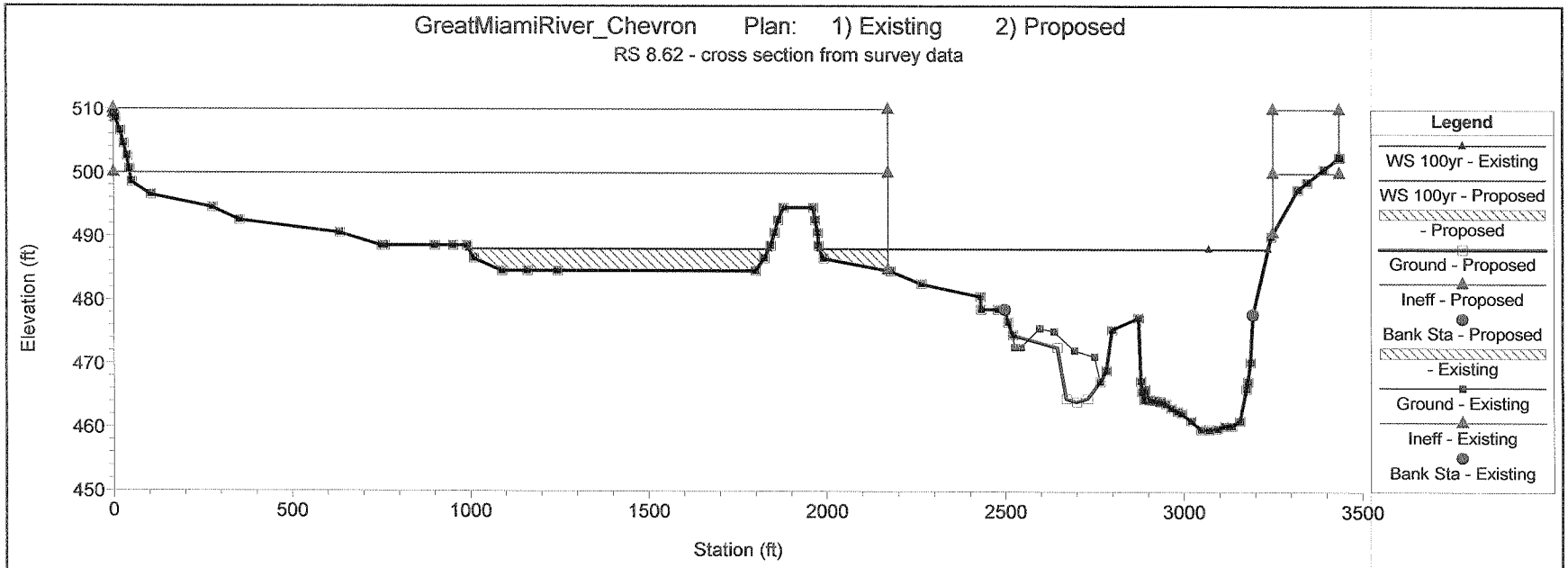

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.94 - cross section from survey data
Elevation (ft)
510
500
490
480
470
460
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
Ground - Existing
Ineff - Existing
Bank Sta - Existing

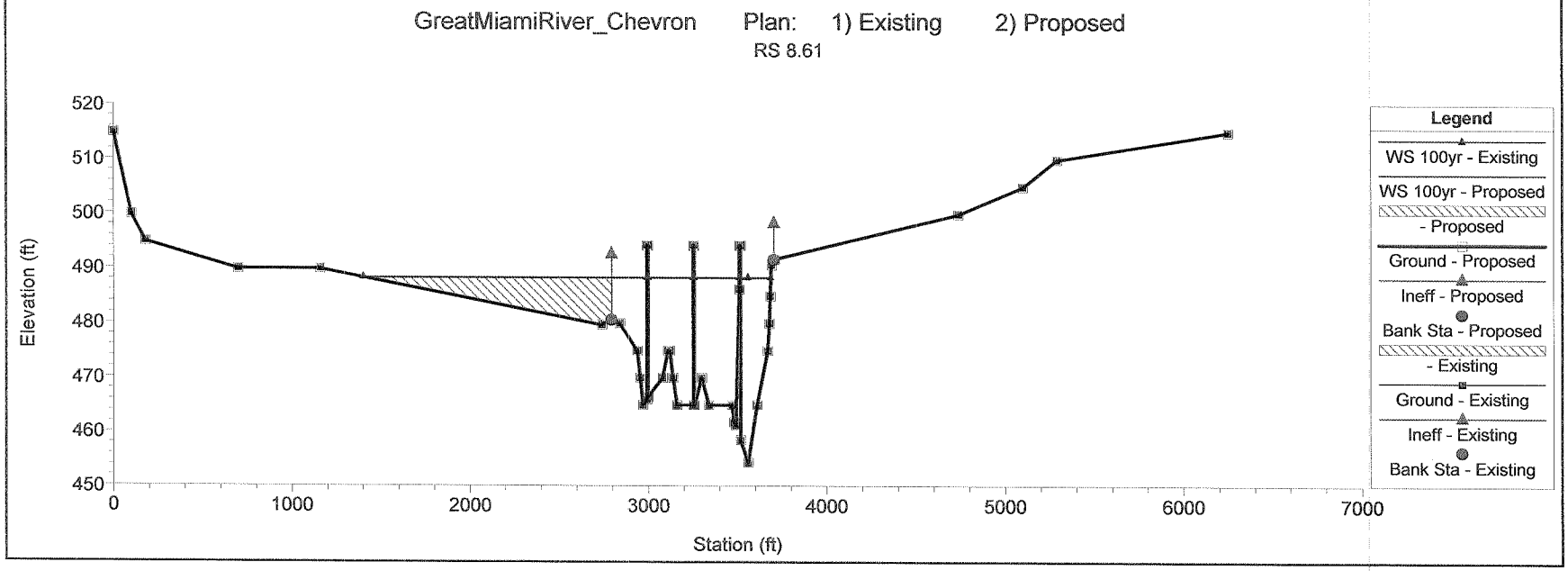

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.85 - replacement of "FIS XS J" with cross section from sur
Elevation (ft)
510
500
490
480
470
460
450
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
Ground - Existing
Ineff - Existing
Bank Sta - Existing

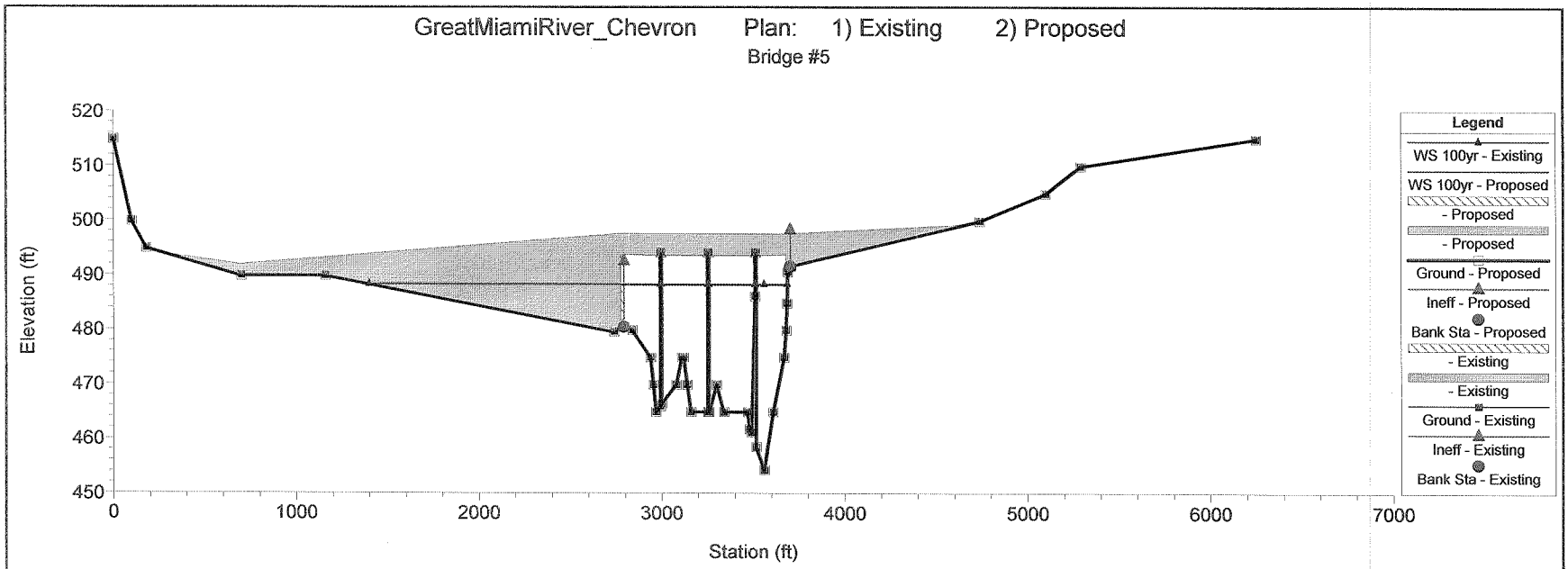

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.76 - cross section from survey data
Elevation (ft)
510
500
490
480
470
460
450
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

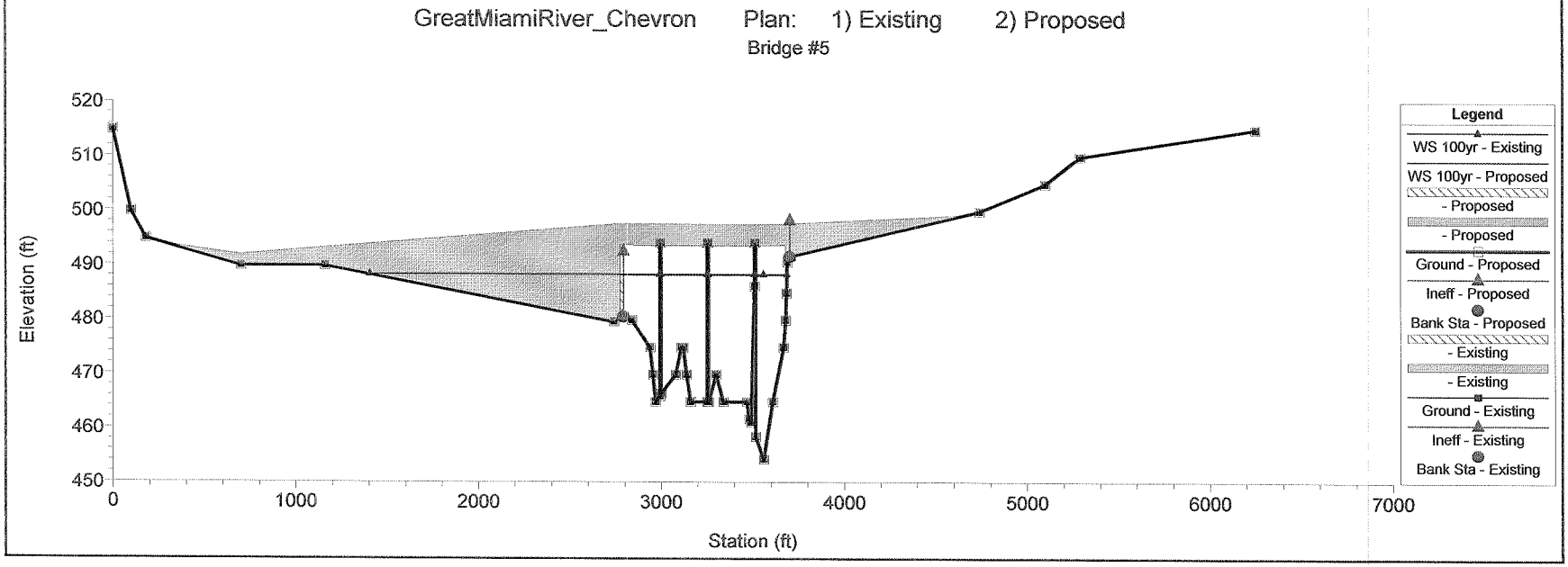

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.70 - cross section from survey data
Elevation (ft)
Station (ft)
520
510
500
490
480
470
460
450
0
500
1000
1500
2000
2500
3000
3500
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

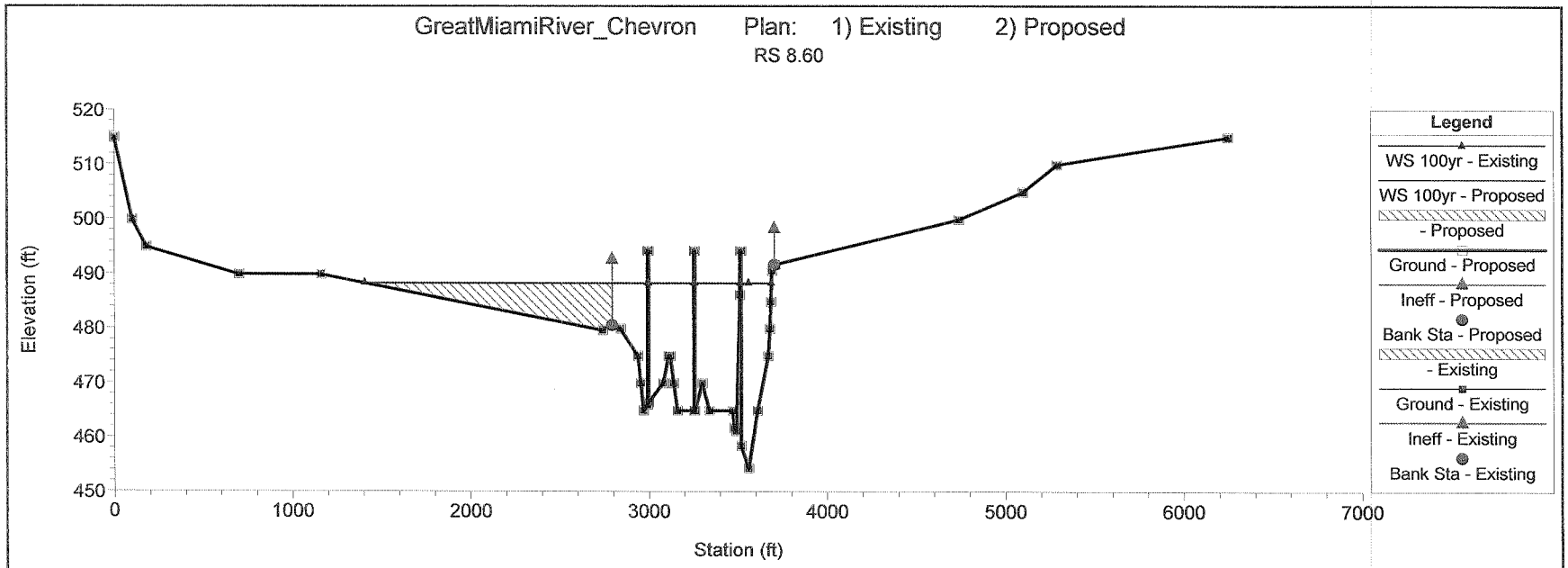

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.66 - cross section from survey data
Elevation (ft)
Station (ft)
510
500
490
480
470
460
450
0
500
1000
1500
2000
2500
3000
3500
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

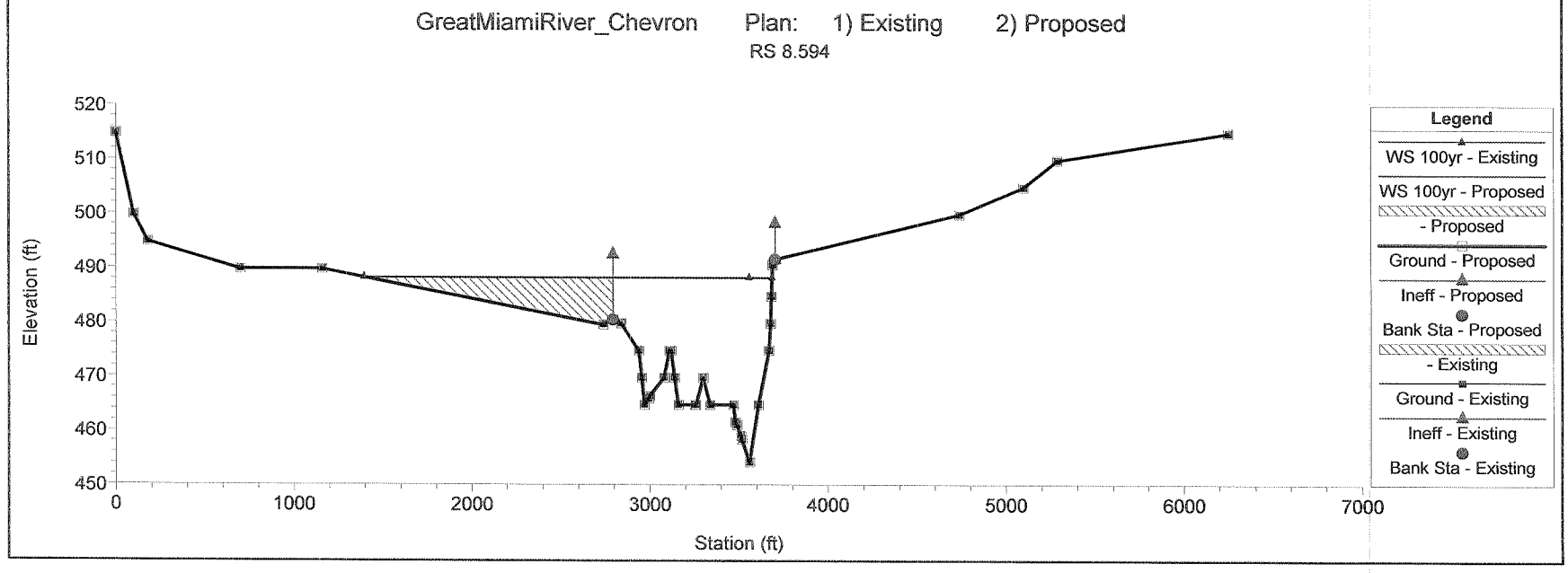

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.62 - cross section from survey data
Elevation (ft)
Station (ft)
510
500
490
480
470
460
450
0
500
1000
1500
2000
2500
3000
3500
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

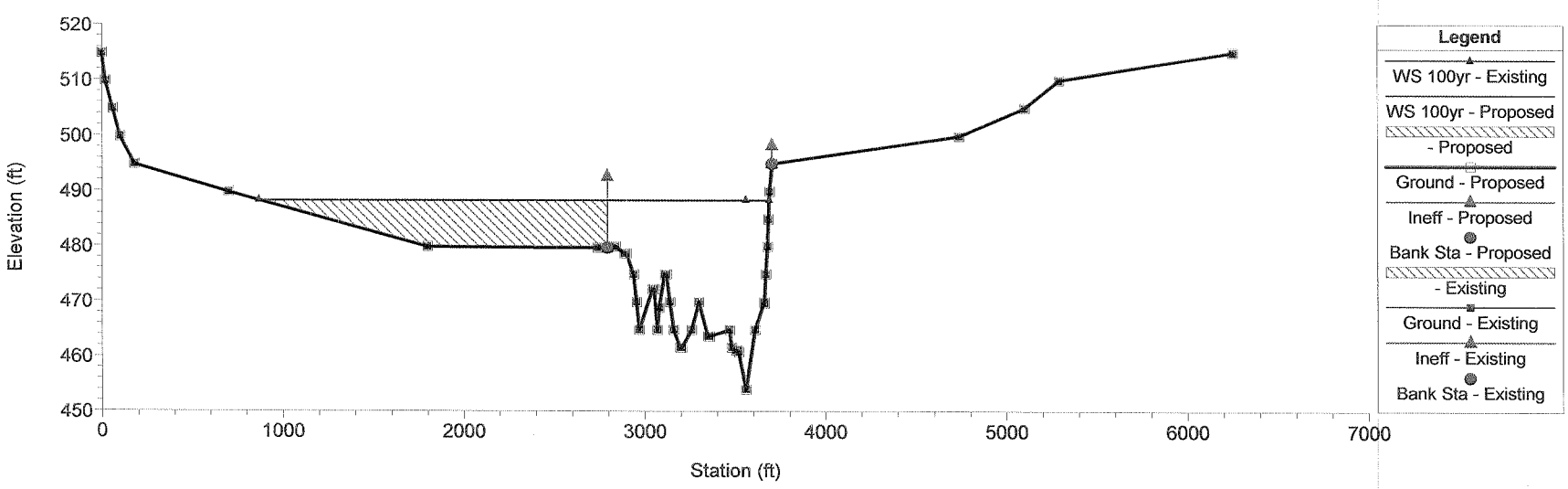

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.61
Elevation (ft)
Station (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

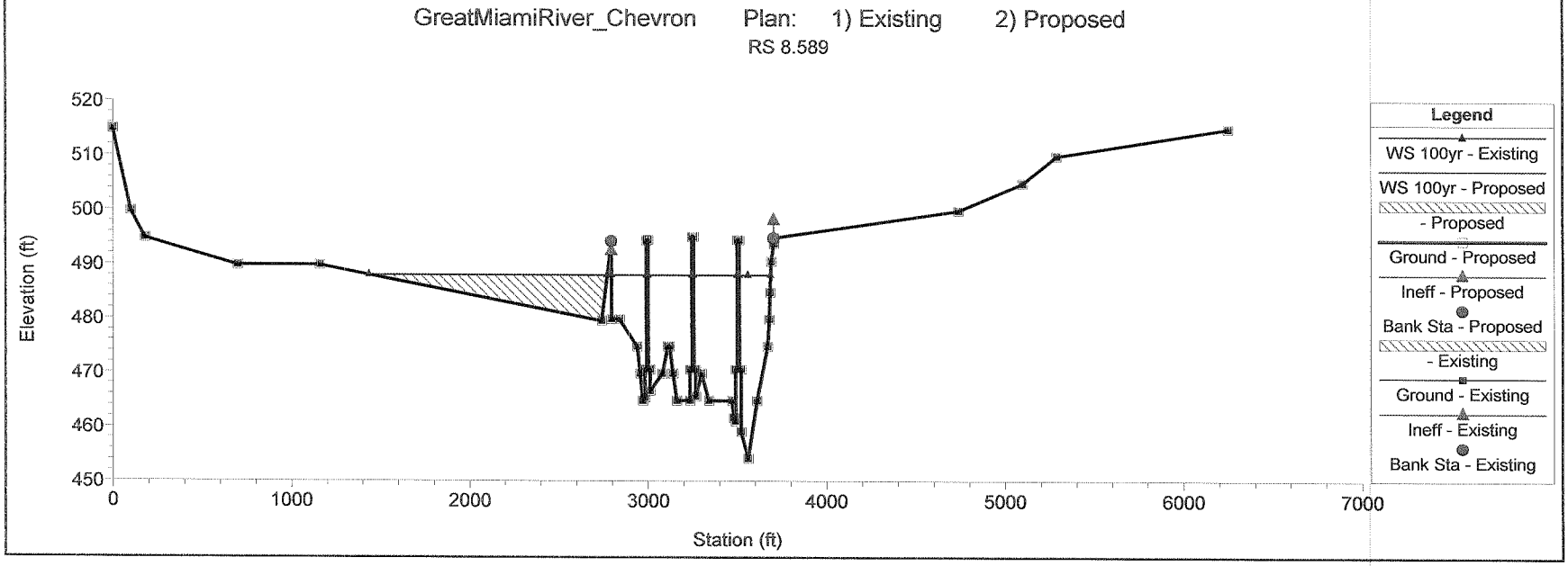

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
Bridge #5
Elevation (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

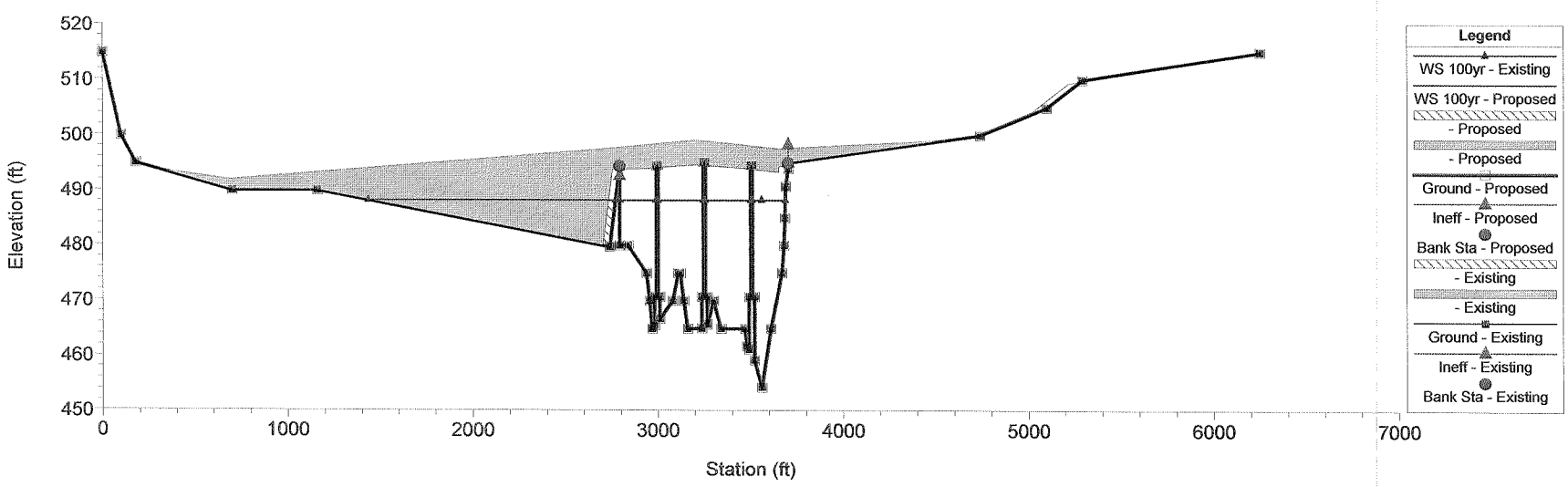

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
Bridge #5
Elevation (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

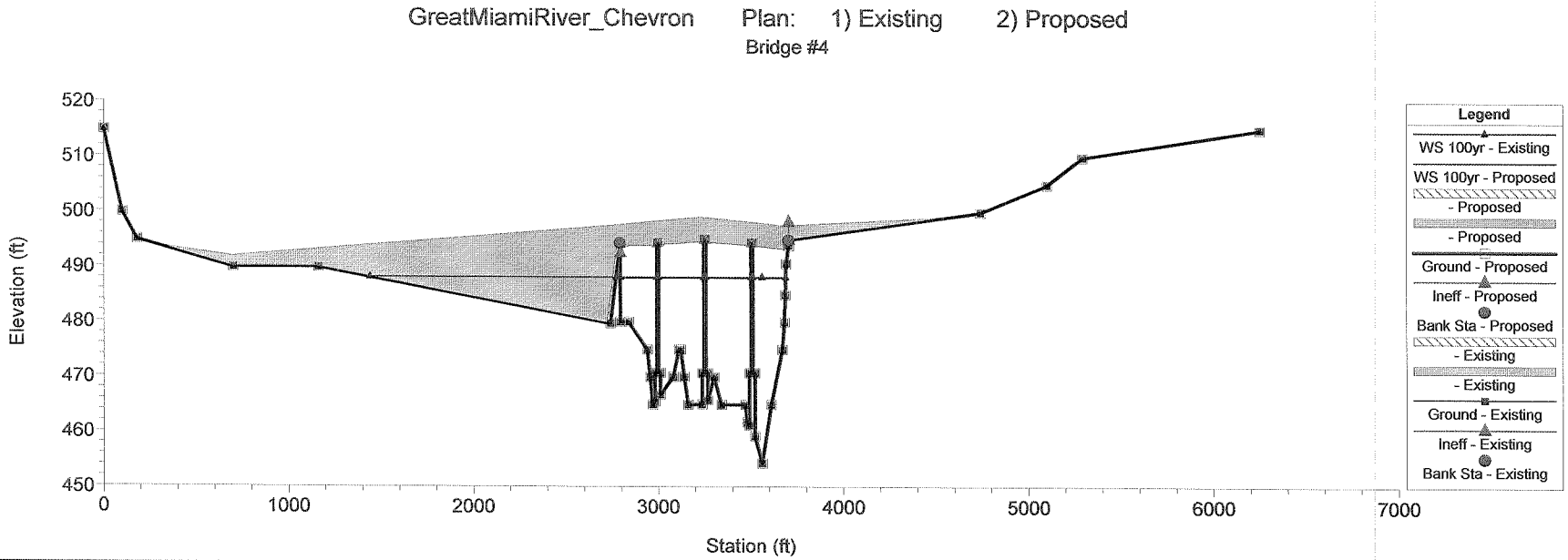

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.60
Elevation (ft)
Station (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

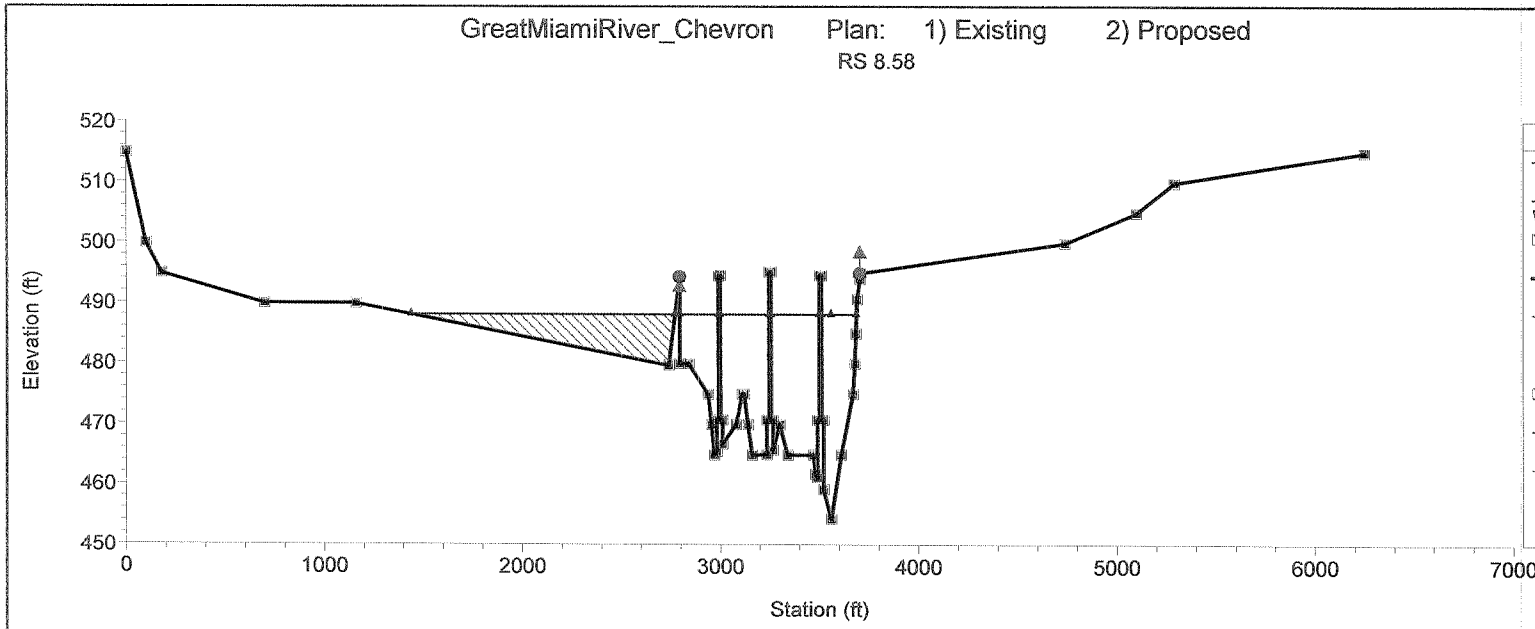

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.594
Elevation (ft)
Station (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

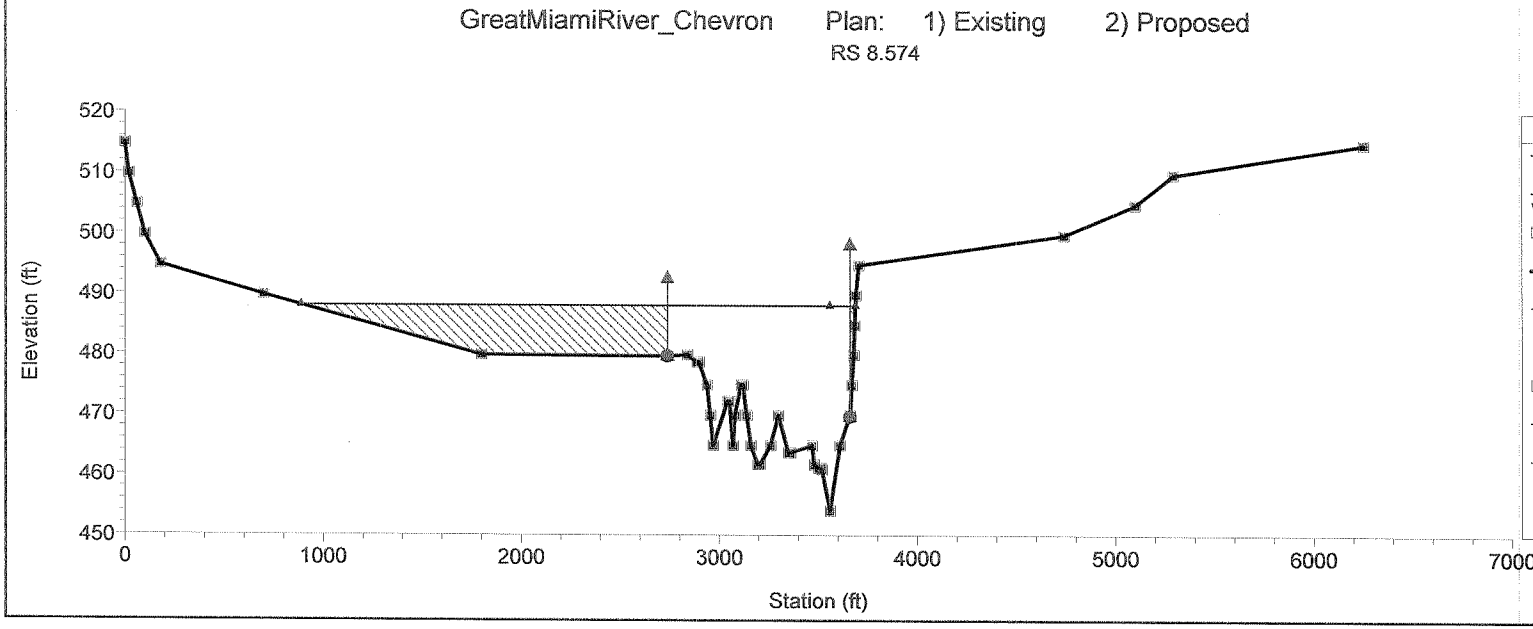

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.591
Elevation (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

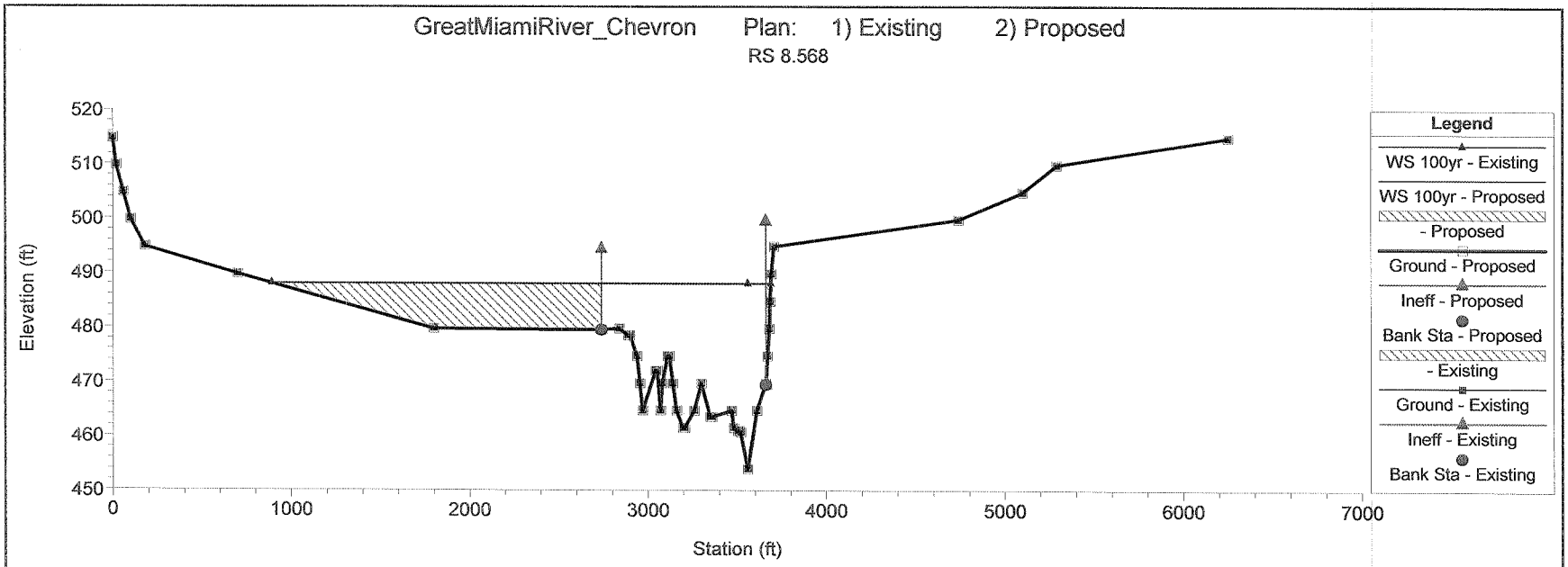

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.589
Elevation (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

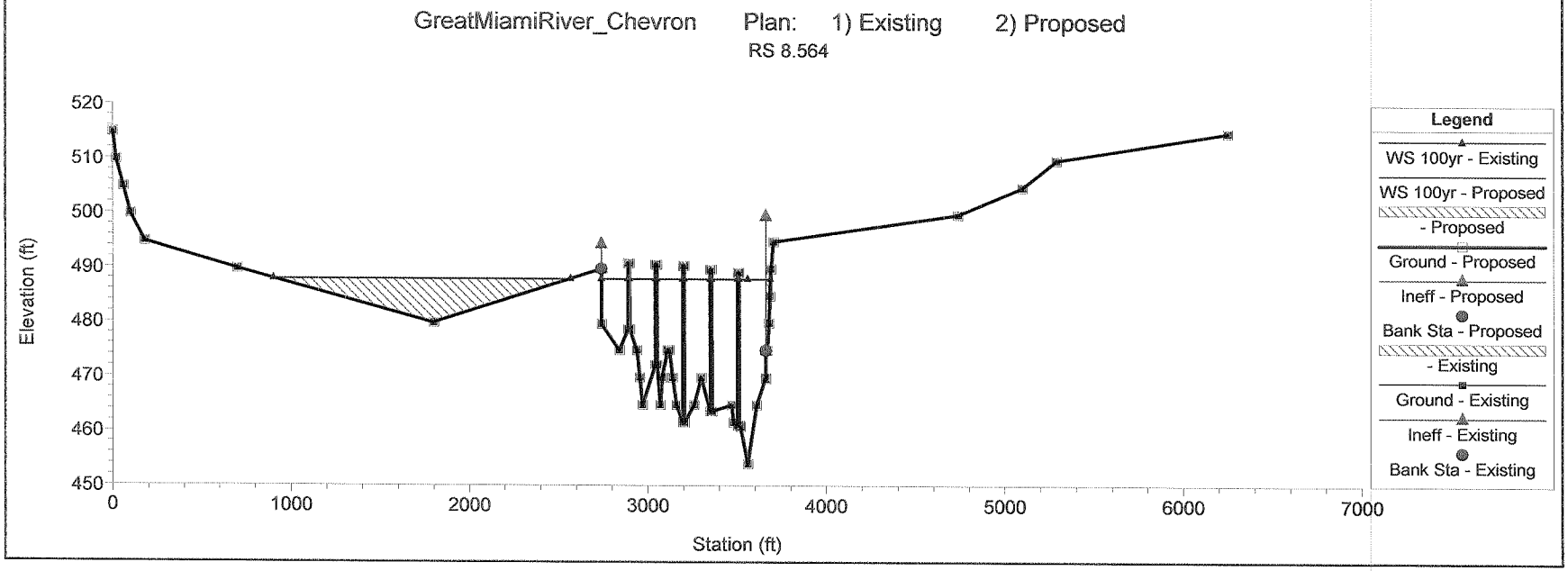

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
Bridge #4
Elevation (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

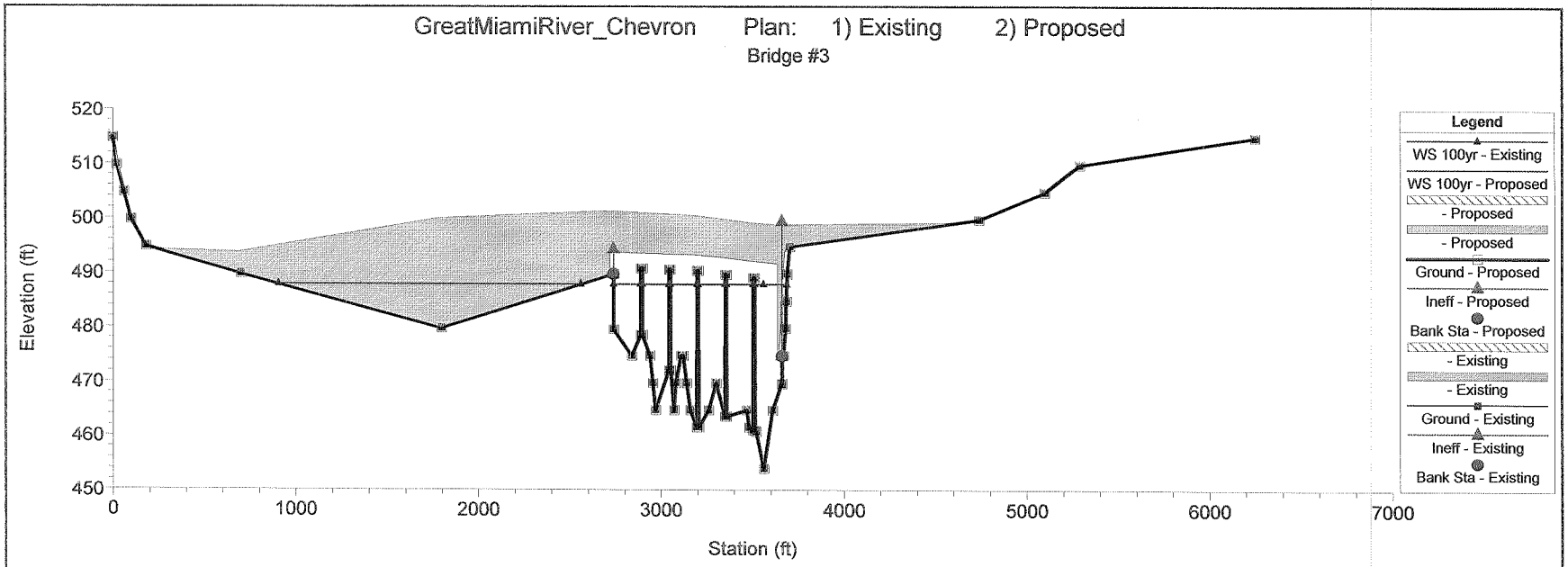

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
Bridge #4
Elevation (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

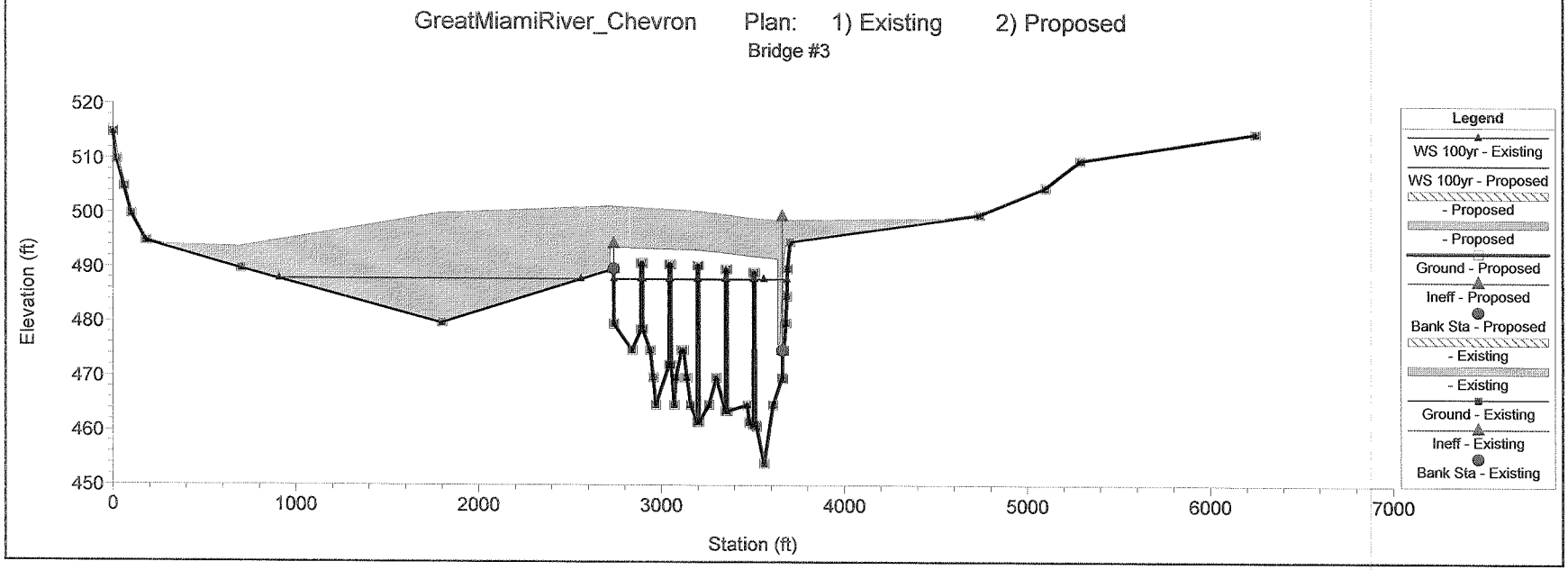

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.58
Elevation (ft)
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

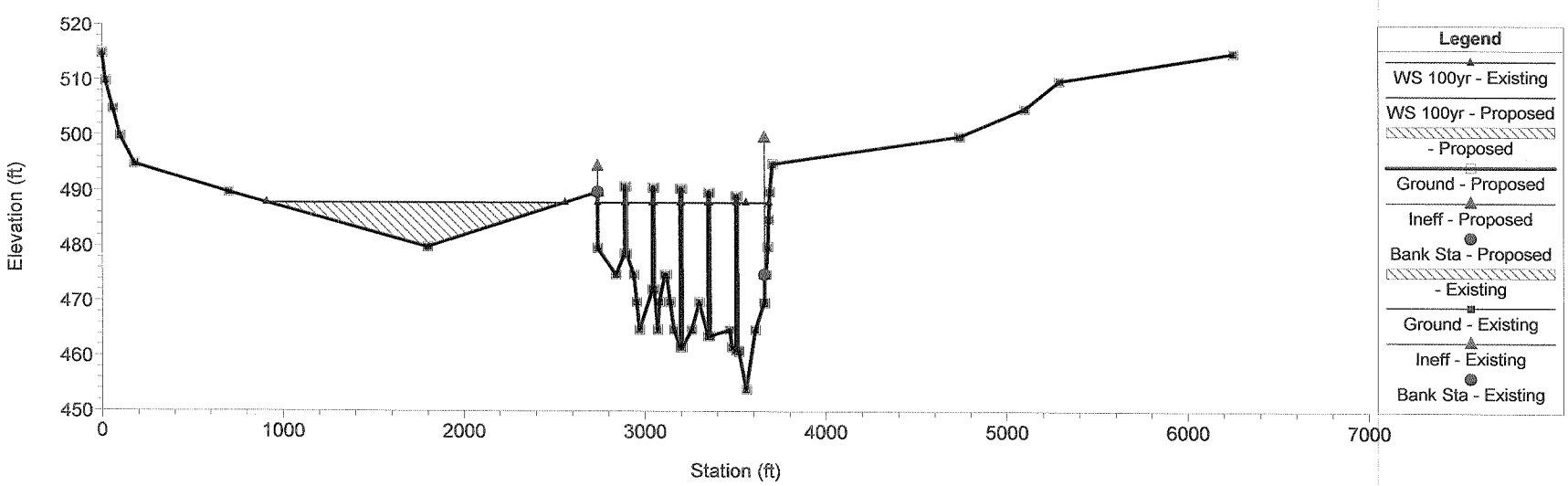

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.574
Elevation (ft)
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

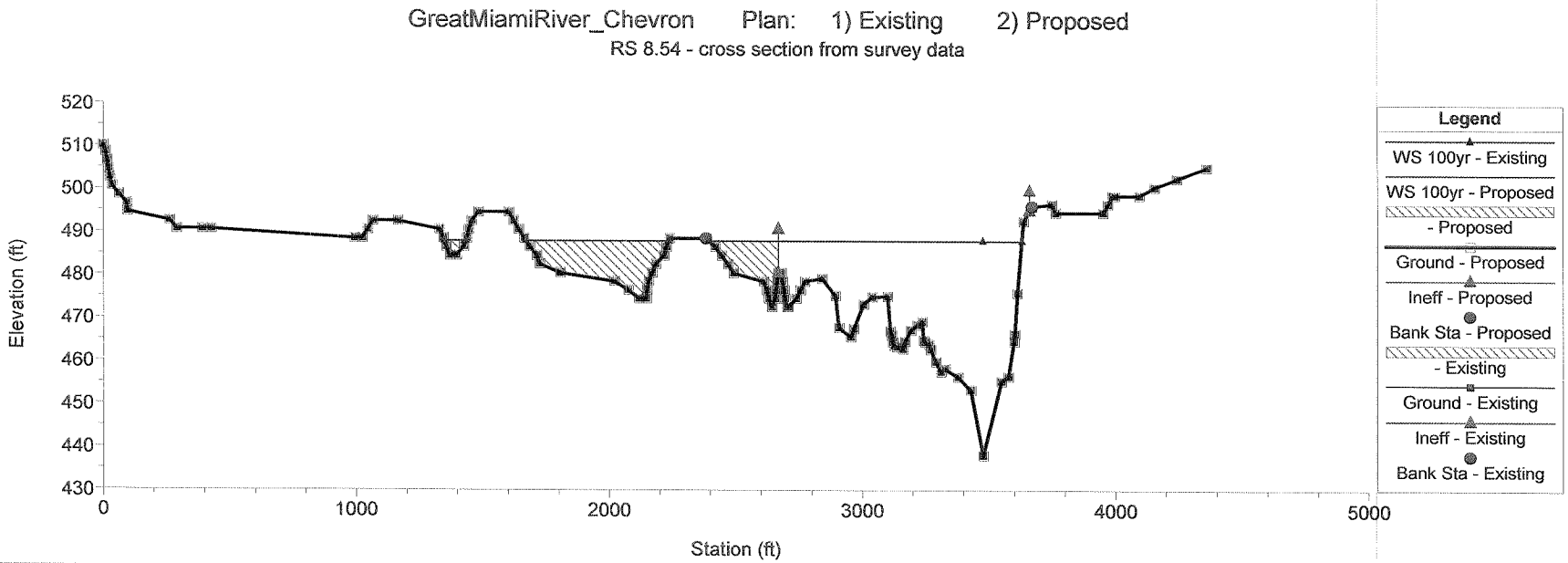

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.568
Elevation (ft)
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

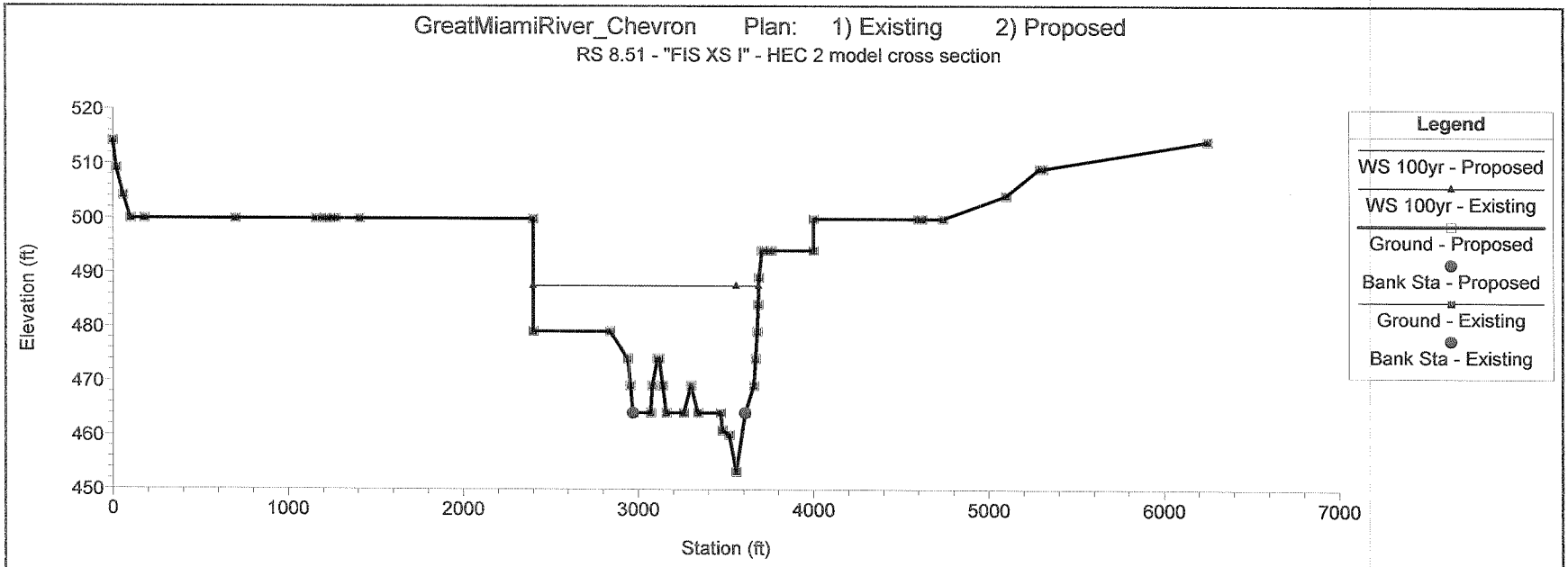

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.564
Elevation (ft)
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

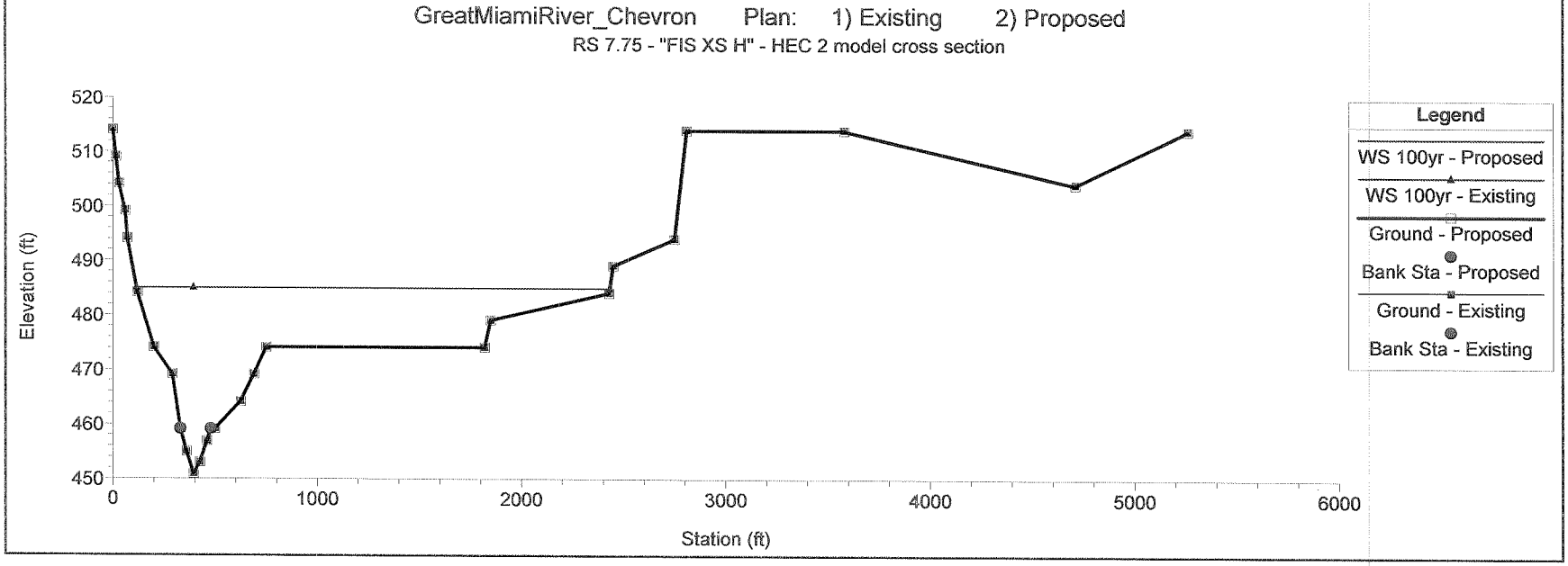

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
Bridge #3
Elevation (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

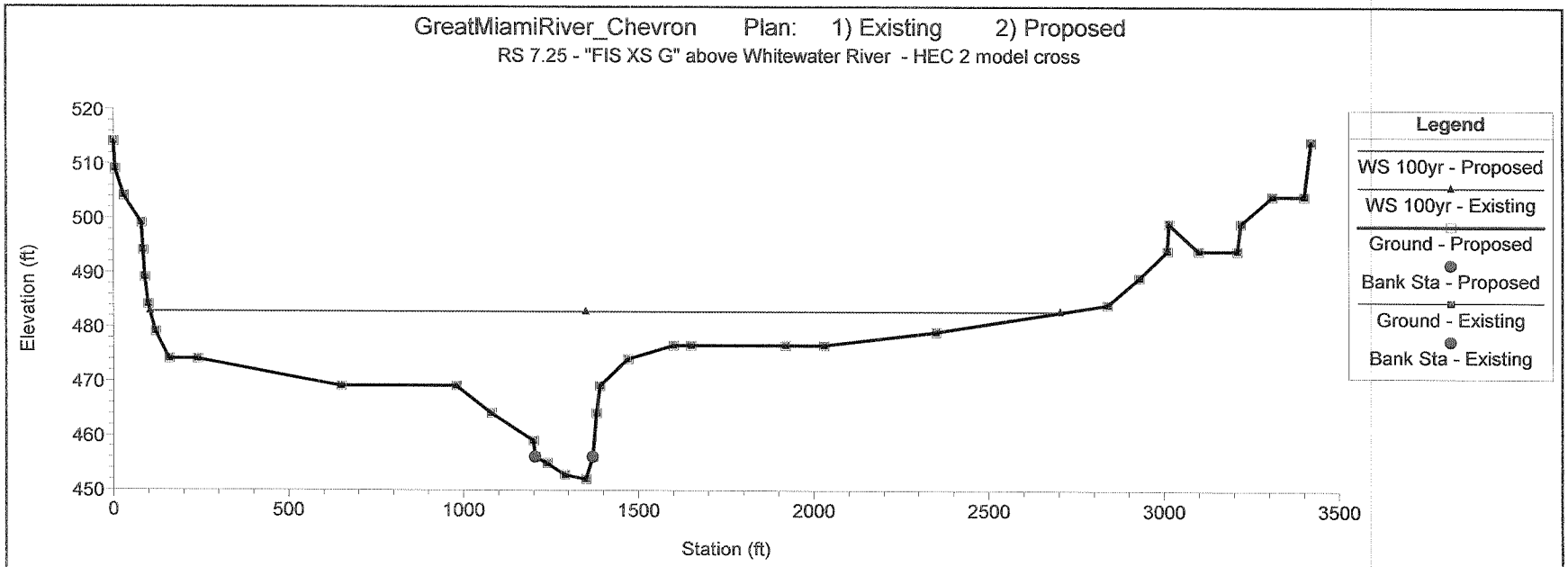

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
Bridge #3
Elevation (ft)
520
510
500
490
480
470
460
450
0
1000
2000
3000
4000
5000
6000
7000
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing

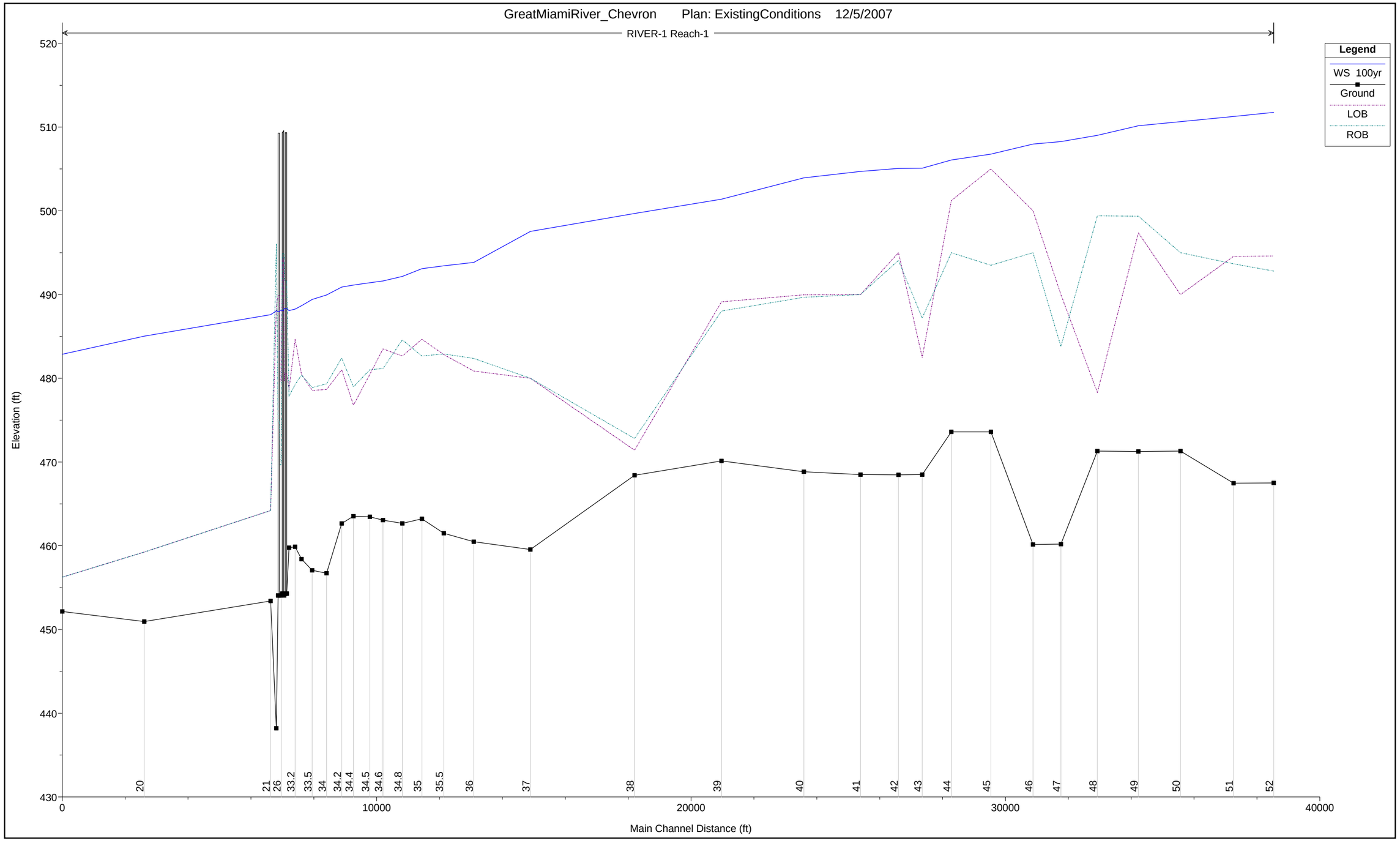

GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.555
Elevation (ft)
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing


GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.54 - cross section from survey data
Elevation (ft)
Station (ft)
Legend
WS 100yr - Existing
WS 100yr - Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing


GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 8.51 - "FIS XS I" - HEC 2 model cross section
Elevation (ft)
Station (ft)
Legend
WS 100yr - Proposed
WS 100yr - Existing
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing


GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 7.75 - "FIS XS H" - HEC 2 model cross section
Elevation (ft)
Station (ft)
Legend
WS 100yr - Proposed
WS 100yr - Existing
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing


GreatMiamiRiver_Chevron Plan: 1) Existing 2) Proposed
RS 7.25 - "FIS XS G" above Whitewater River - HEC 2 model cross
Elevation (ft)
520
510
500
490
480
470
460
450
0
500
1000
1500
2000
2500
3000
3500
Station (ft)
Legend
WS 100yr - Proposed
WS 100yr - Existing
Ground - Proposed
Bank Sta - Proposed
Ground - Existing
Bank Sta - Existing



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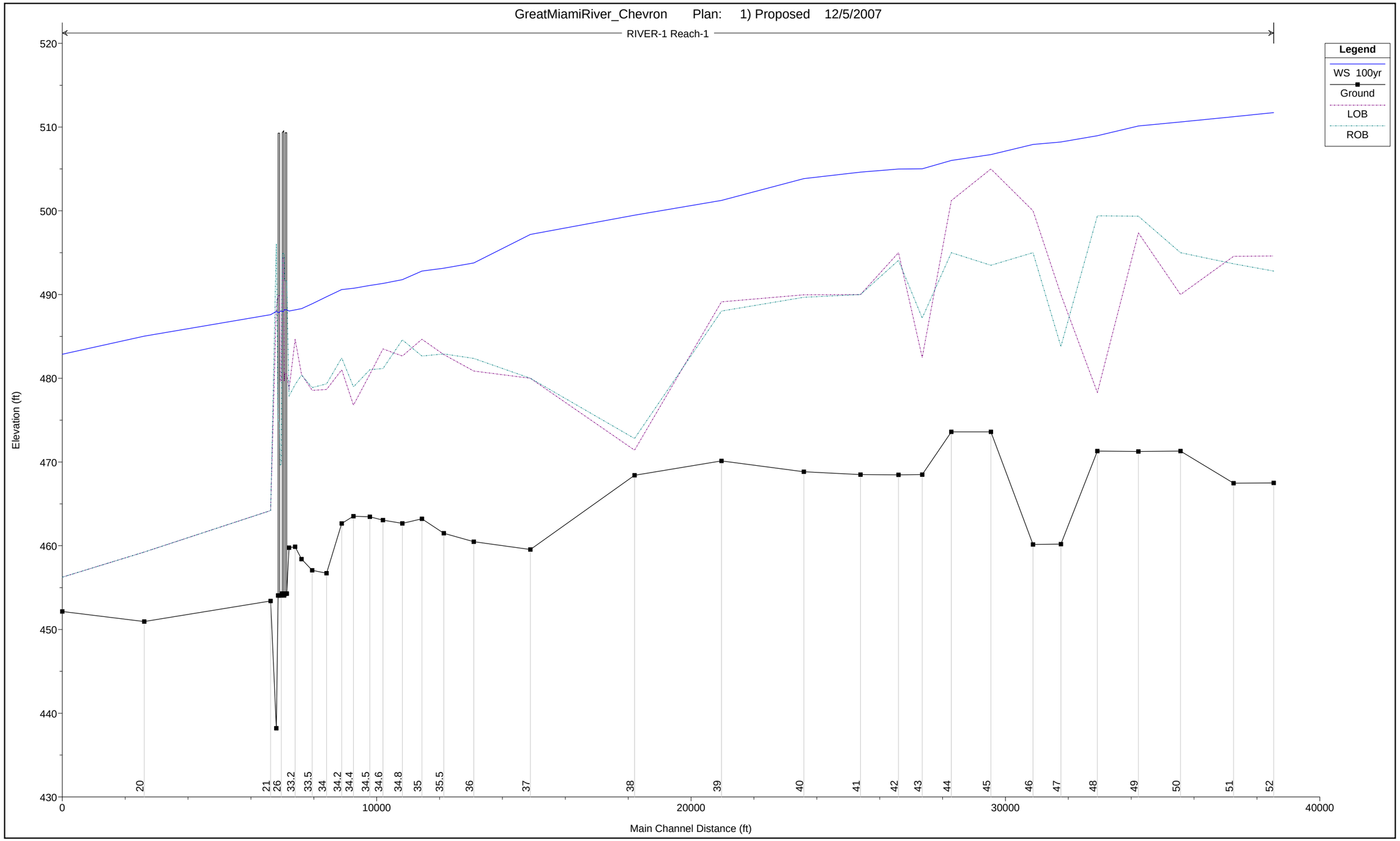

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Appendix C

Floodplain Impacts Analysis

APPENDIX C - FLOODPLAIN ANALYSIS RESULTS

1% ANNUAL CHANCE WATER SURFACE ELEVATION COMPARISON

		W.S. Elevations (feet)		
Model Cross Section ID	**Cross-Section Station (miles above Ohio River)**	**Proposed Conditions**	**Existing Conditions**	**ΔW.S.E.**
52	14.57	511.73	511.76	-0.03
51	14.33	511.24	511.27	-0.03
50	14.00	510.61	510.65	-0.04
49	13.75	510.13	510.16	-0.03
48	13.51	508.97	509.01	-0.04
47	13.29	508.22	508.26	-0.04
46	13.12	507.93	507.97	-0.04
45	12.87	506.72	506.77	-0.05
44	12.63	506.01	506.07	-0.06
43	12.45	505.02	505.09	-0.07
42	12.31	504.99	505.06	-0.07
41	12.08	504.62	504.71	-0.09
40	11.74	503.84	503.94	-0.10
39	11.24	501.24	501.39	-0.15
38	10.72	499.48	499.68	-0.20
37	10.09	497.18	497.54	-0.36
36	9.75	493.77	493.83	-0.06
35.5	9.55	493.14	493.44	-0.30
35	9.42	492.80	493.09	-0.29
34.8	9.30	491.78	492.17	-0.39
34.6	9.19	491.32	491.62	-0.30
34.5	9.11	491.09	491.41	-0.32
34.4	9.01	490.75	491.13	-0.38
34.2	8.94	490.60	490.89	-0.29
34	8.85	489.74	489.95	-0.21
33.5	8.76	488.90	489.42	-0.52
33.4	8.70	488.31	488.66	-0.35
33.2	8.66	488.17	488.26	-0.09
33	8.62	488.03	488.09	-0.06
32	8.61	488.19	488.34	-0.15
31	8.60	488.16	488.31	-0.15
30	8.594	488.19	488.33	-0.14
29	8.591	488.19	488.33	-0.14
28	8.589	487.99	488.12	-0.13
27	8.580	487.96	488.09	-0.13
26	8.574	488.02	488.13	-0.11
25	8.568	488.01	488.12	-0.11
24	8.564	487.92	488.02	-0.10
23	8.555	487.86	487.96	-0.10
22	8.54	487.99	488.05	-0.06
21	8.51	487.60	487.60	0.00
20	7.75	485.03	485.03	0.00
19	7.25	482.87	482.87	0.00

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Appendix D

Mobile Boundary Transport Analysis

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APPENDIX D - MOBILE BOUNDARY TRANSPORT ANALYSIS

Wilcock Transport Model - Active Layer - Ruby

Proposed Conditions Model

Cross-Section ID	Change in Bed Elevation (ft)						
	10,000 cfs	30,000 cfs	50,000 cfs	10% Annual Chance Exceedance Event	2% Annual Chance Exceedance Event	1% Annual Chance Exceedance Event	0.2% Annual Chance Exceedance Event
36	0.00	-0.01	-0.03	-0.09	-0.14	-0.13	-0.10
35.5	0.00	0.00	-0.03	-0.17	-0.35	-0.41	-0.59
35	0.00	0.01	0.04	0.15	0.27	0.29	0.35
34.8	0.00	0.01	0.03	0.10	0.21	0.23	0.31
34.6	0.00	0.00	0.02	0.06	0.09	0.09	0.10
34.5	0.00	0.00	-0.01	-0.01	0.01	0.01	0.03
34.4	0.00	0.01	0.01	0.00	0.06	0.08	0.13
34.2	-0.02	-0.03	-0.12	-0.19	-0.09	-0.07	0.00
34	-0.01	-0.02	-0.03	-0.08	-0.10	-0.09	-0.05
33.5	0.03	0.02	-0.04	-0.05	**-0.31**	-0.28	-0.16
33	0.00	0.02	0.05	-0.01	-0.23	-0.31	-0.37

Bold 'Change in Bed Elevation' value represents the most severe scour in the area of the sheetpile wall

Highlighted Cross-Sections Include Proposed Geometry From Sheet Pile Wall

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Appendix E

Scour Analysis

APPENDIX E – SCOUR ANALYSIS

RMA2 Shear Stress Calculations

RMA2 has a secondary flow correction in the model that is based on some good mathematics and has been verified with flume data at USACE Waterways Experiment Station. The additional shear stress induced by a bend has a direct equation:

$$\tau_s = \rho h |u| \Omega \sqrt{C_f}$$

Where C_f is the friction factor, h is the depth in meters, u the velocity in meters per second, ρ the density and Ω the vorticity

$$C_f = \frac{g}{C^2}$$

C being Chezy's C factor, which can be determined directly from "n"

The Ω bend vorticity is a balance between the forces creating it and that which slows it down. The starting equation is:

$$\frac{d\Omega}{dt} = \frac{1}{6} C_A^2 C_2^2 \sqrt{C_f} \frac{u^2}{rh} - 2C_C \sqrt{C_f} \Omega \frac{|u|}{h}$$

At its maximum value, the differential goes to zero. The equation simplifies to:

$$\frac{A_s}{r} u = D_s \Omega$$

r is the radius of curvature of the bend (in meters)

A_s=5 and D_s=0.5 from experimental data on bends, therefore:

$$\tau_s = \frac{10 \rho h (u)^2 \sqrt{C_f}}{r}$$

This gives the maximum streamwise shear stress associated with bends, in Pascals.

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APPENDIX E - SCOUR ANALYSIS

BEND SHEAR CALCULATIONS

Cross-Section ID	Flood Event	EG slope	Velocity	Velocity	WSE	Thalweg Elevation	Max. Depth	Max. Depth	Flow Shear	Manning's n Value	C	Cf	Radius of Bend	Bend Shear	Ratio of Bend to Flow Shear	Total Max. Shear	Shear From HEC-RAS	Ratio of Total Max. to HEC-RAS Shears
	YR	(ft/ft)	fps	mps	ft	ft	ft	m	Pascals				m	Pascals		lb/ft2	lb/ft2	
34.8	100	0.001275	9.15	2.789	491.78	462.72	29.06	8.86	110.75	0.045	31.96438	0.00960	200	337.48	3.0	9.36	1.83	5.1
	500	0.001283	9.85	3.002	494.26	462.72	31.54	9.61	120.96	0.045	32.40363	0.00934	200	418.71	3.5	11.27	2.01	5.6
	50	0.001276	8.87	2.704	490.76	462.72	28.04	8.55	106.95	0.045	31.77460	0.00971	200	307.84	2.9	8.66	1.72	5.0
	10	0.001272	7.92	2.414	487.51	462.72	24.79	7.56	94.25	0.045	31.12888	0.01012	200	221.48	2.3	6.59	1.55	4.3
34.6	100	0.000882	8.04	2.451	491.32	463.06	28.26	8.61	74.50	0.045	31.81601	0.00969	200	254.57	3.4	6.87	1.20	5.7
	500	0.000906	8.74	2.664	493.80	463.06	30.74	9.37	83.25	0.045	32.26518	0.00942	200	322.68	3.9	8.48	1.42	6.0
	50	0.000877	7.78	2.371	490.30	463.06	27.24	8.30	71.41	0.045	31.62169	0.00981	200	231.18	3.2	6.32	1.13	5.6
	10	0.000905	7.07	2.155	486.98	463.06	23.92	7.29	64.71	0.045	30.94409	0.01024	200	171.32	2.6	4.93	0.94	5.2
34.5	100	0.001108	6.66	2.030	491.09	464.67	26.42	8.05	87.50	0.045	31.46102	0.00991	200	165.15	1.9	5.28	1.11	4.8
	500	0.0011	7.16	2.182	493.59	464.67	28.92	8.81	95.09	0.045	31.93866	0.00961	200	205.82	2.2	6.28	1.27	4.9
	50	0.001122	6.48	1.975	490.05	464.67	25.38	7.74	85.12	0.045	31.25115	0.01004	200	151.20	1.8	4.94	1.06	4.7
	10	0.001188	5.89	1.795	486.70	464.67	22.03	6.71	78.23	0.045	30.52251	0.01053	200	111.02	1.4	3.95	0.89	4.4
34.4	100	0.000587	5.83	1.777	490.75	463.64	27.11	8.26	47.57	0.045	31.59649	0.00982	200	129.30	2.7	3.69	0.84	4.4
	500	0.000592	6.22	1.896	493.26	463.64	29.62	9.03	52.41	0.045	32.06622	0.00954	200	158.45	3.0	4.40	0.93	4.7
	50	0.000588	5.67	1.728	489.71	463.64	26.07	7.95	45.82	0.045	31.39117	0.00995	200	118.38	2.6	3.43	0.81	4.2
	10	0.000599	5.22	1.591	486.33	463.64	22.69	6.92	40.63	0.045	30.67304	0.01042	200	89.37	2.2	2.71	0.72	3.8
34.2	100	0.000603	5.11	1.558	490.60	462.66	27.94	8.52	50.36	0.045	31.75569	0.00972	200	101.86	2.0	3.18	0.93	3.4
	500	0.000615	5.49	1.673	493.11	462.66	30.45	9.28	55.98	0.045	32.21425	0.00945	200	126.32	2.3	3.81	1.04	3.7
	50	0.0006	4.97	1.515	489.55	462.66	26.89	8.20	48.23	0.045	31.55361	0.00985	200	93.33	1.9	2.96	0.90	3.3
	10	0.000611	4.58	1.396	486.17	462.66	23.51	7.17	42.94	0.045	30.85506	0.01030	200	70.87	1.7	2.38	0.74	3.2
34	100	0.001992	7.58	2.310	489.74	456.81	32.93	10.04	196.10	0.045	32.63804	0.00921	200	257.06	1.3	9.46	1.26	7.5
	500	0.001807	7.86	2.396	492.30	456.81	35.49	10.82	191.71	0.045	33.04778	0.00898	200	294.19	1.5	10.15	1.41	7.2
	50	0.002095	7.47	2.277	488.66	456.81	31.85	9.71	199.47	0.045	32.45718	0.00931	200	242.81	1.2	9.24	1.16	8.0
	10	0.002165	6.63	2.021	485.36	456.81	28.55	8.70	184.78	0.045	31.87094	0.00965	200	174.61	0.9	7.51	0.93	8.1

Based on results of the Sediment Transport analysis using HEC-RAS v4.0 sediment transport simulation:

Maximum bed scour in project area =	0.31 feet
Based on results of vorticity analysis, maximum ratio of Point and Vorticity Shear to Average Hydraulic Shear (from HEC-RAS) approximately =	8 (at XS 34 above)
For an extremely tight bend for the Great Miami River, conservative depth of scour scales to 0.31 x 8 =	2.5 feet
For FS = 3 for simple stone toe along the length of the wall, bed scour depth approximately =	7.5 feet

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