Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Geomorphology Study (Study 6.5)

Susitna River Historical Cross Section Comparison
(1980s to Current)
Technical Memorandum

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
1-D	one-dimensional
AEA	Alaska Energy Authority
cfs	Cubic feet per second
FERC	Federal Energy Regulatory Commission
FIPS	Federal Information Processing Standard
HEC	Hydraulic Engineering Center
HEC-RAS	Hydraulic Engineering Center River Analysis System
GIS	Geographic Information System
GPS	Global Positioning System
LiDAR	Light Detection and Ranging
LRX	1980s Lower reach one-dimensional hydraulic model
NAD	North American Datum
NAVD	North American Vertical Datum
NGVD	National Geodetic Vertical Datum
NGS	National Geodetic Survey
PDF	Portable document file
PRM	Project River Mile
RM	River Mile(s)
URX	1980s Upper reach one-dimensional hydraulic model
USACE	United States Army Corps of Engineers
USGS	U.S. Geological Survey
WSE	Water Surface Elevation

SUMMARY

Data describing the cross-sectional geometry of the Middle Susitna River channel are available from two sources spanning three decades. During the 1980s studies of the Susitna Hydroelectric Project, various efforts were carried out to characterize sediment supply and sediment transport capacity. Modeling of hydraulics of the Susitna River below the proposed Project was performed in the 1980s using a one-dimensional HEC-2 hydraulic model to calculate water-surface profiles and channel hydraulics (Acres 1983). The river cross sections used in developing the model provide information on the Susitna River channel dimensions and elevations in the 1980s. For the current Project, a one-dimensional bed evolution model is being developed as part of the Fluvial Geomorphology Modeling Study (Study 6.6) to simulate fluvial geomorphic processes that influence the morphology of the Susitna River channel and floodplain downstream of Watana Dam (Tetra Tech 2014) as well as supporting 1-D models being developed in the Fish and Aquatics Instream Flow Study (Study 8.5), the Ice Processes the Susitna River Study (Study 7.6) and the Water Quality Modeling Study (Study 5.6).

The bathymetry and topography surveyed in both the 1980s and for the current project permits the opportunity to compare the cross-sectional geometry from the two sets of surveys collected approximately three decades a part. For instances where a cross section from the 1980s and one from the current effort were surveyed near each other, a comparison of these data provides a valuable resource to quantify channel change over the past three decades, as well as providing an additional data source for validation of the current 1-D bed evolution model. Thirty-eight pairs of cross sections were compared and changes in average bed elevation and cross sectional area were determined. Channel profiles determined from thalweg elevations were also compared to assess longitudinal bed elevation differences.

Overall, the results show that the Middle Susitna River was generally stable in terms of bed elevation change over the three decade period between the 1980s studies and the current effort. Changes were typically on the order of several feet or less and there was not a consistent trend toward aggradation (bed elevation increase) or degradation (bed elevation decrease) throughout the Middle River segment. The area with the most consistent trend were geomorphic reaches MR-7 and MR-8 in which the majority of the length was aggradational; however, there were still cross sections within these two reaches that showed degradation over the period of comparison. MR-2 showed the least change, with all cross sections having minimal change in bed elevation and area with the exception of the cross section at PRM 179.5, which aggraded by 2.3 ft and increased in area by 490 sq. ft. The remaining reaches had more of a mix between aggradation and degradation. Results of this work were used in the validation of the 1-D bed evolution model currently under development as part of the Fluvial Geomorphology Modeling Study (Study 6.6) (Tetra Tech 2014).

1. INTRODUCTION

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project using the Integrated Licensing Process. The Project is located on the Susitna River, an approximately 300-mile-long river in the south-central region of Alaska. The Project's dam site will be located at Project River Mile (PRM) 187.1. The results of this study will provide information needed to support the FERC's National Environmental Policy Act analysis for the Project license.

During the 1980s studies of the Susitna Hydroelectric Project, various efforts were carried out to characterize sediment supply and sediment transport capacity. Modeling of hydraulics of the Susitna River below the proposed Project was performed in the 1980s using a one-dimensional HEC-2 hydraulic model to calculate of water-surface profiles and channel hydraulics (Acres 1983). The river cross sections used in developing the model provide information on the Susitna River channel dimensions and elevations in the 1980s.

For the current Project, a one-dimensional bed evolution model is being developed as part of the Fluvial Geomorphology Modeling Study (Study 6.6) to simulate fluvial geomorphic processes that influence the morphology of the Susitna River channel and floodplain downstream of Watana Dam (Tetra Tech 2014) as well as supporting 1-D models being developed in the Fish and Aquatics Instream Flow Study (Study 8.5), the Ice Processes the Susitna River Study (Study 7.6) and the Water Quality Modeling Study (Study 5.6).

The bathymetry and topography surveyed in both the 1980s and for the current project permits the opportunity to compare the cross-sectional geometry from the two sets of surveys collected approximately three decades a part. For instances where a cross section from the 1980s and one from the current effort were surveyed near each other, a comparison of these data provides a valuable resource to quantify channel change over the past three decades, as well as providing an additional data source for validation of the current 1-D bed evolution model.

This effort was identified in RSP 6.5.4.1.2.3 as part of the Geomorphic Characterization of the Susitna River task. Channel profiles from the two periods were developed using the surveyed thalweg at each cross section and the profiles compared. As the layout of the surveyed cross sections differs between the two periods, locations with cross sections in close proximity of each other were identified and cross-sectional geometries at these locations were compared. The magnitude and locations of change within the Susitna River can be used to validate the one-dimensional sediment-transport model currently under development (Tetra Tech 2014).

2. STUDY OBJECTIVES

The overall goal of the Geomorphology Study (Study 6.5) is to characterize the geomorphology of the Susitna River, and evaluate the effects of the Project on the geomorphology and dynamics of the river by predicting the trend and magnitude of geomorphic response. The objective of the work detailed in this memorandum is to identify changes within the main and side channels of the Susitna River by comparing historical survey data from the 1980s with survey data from the current project.

3. STUDY AREA

The Susitna River, located in South-central Alaska, drains an area of approximately 20,010 square miles and flows about 320 miles from its headwaters at the Susitna, West Fork Susitna, and East Fork Susitna glaciers to the Cook Inlet (USGS 2012). The Susitna River basin is bounded on the west and north by the Alaska Range, on the east by the Talkeetna Mountains and Copper River Lowlands and on the South by the Cook Inlet. The highest elevations in the basin are at Mt. McKinley at 20,320 feet while its lowest elevations are at sea level where the river discharges into Cook Inlet. Major tributaries to the Susitna River between the headwaters and Cook Inlet include the Chulitna, Talkeetna, and Yentna rivers that are also glacially fed in their respective headwaters. The basin receives, on average, 35 inches of precipitation annually with average air temperatures of approximately 29°F.

In the 1980s, a one-dimensional, steady-state hydraulic HEC-2 model (U.S. Army Corps of Engineers 1976) was developed by R&M Consultants (1982). The HEC-2 model consisted of two reaches, as shown in Figure 3-1. An upper reach (URX) consisting of 23 cross sections extended from the confluence with Deadman Creek at PRM 189.3 to the confluence with Devil Creek at PRM 165.5. The upper cross sections were surveyed in March 1981, by drilling through ice. A lower reach (LRX) consisted of 66 cross sections, and extended from below Devils Canyon at PRM 153.6 to just above the confluence with the Chulitna River at PRM 102.3. The cross sections for the lower reach of the 1980s HEC-2 model were surveyed in the fall of 1980. The lower model was later extended by the Harza-EBASCO Susitna Joint Venture (1984) downstream to the USGS gaging station at Sunshine. The additional cross sections were surveyed in 1982; however, downstream of PRM 98.4, the additional cross sections were interpolated from topographic maps and are not suitable for comparison with the current surveyed cross sections. To avoid confusion, it needs to be noted that the 1980s LRX and URX reaches do not correspond to the current Lower Susitna River segment (downstream of PRM 102.4) and Upper Susitna River segment (upstream of the proposed dam site at PRM 187.1).

A one-dimensional unsteady hydraulic model is being developed using HEC-RAS version 5 beta for the current Project as part of the Fluvial Geomorphology Modeling Study (Study 6.5). Cross sections used in the current HEC-RAS model were surveyed between 2012 and 2013. The current HEC-RAS model extends from PRM 187.2 just above the Dam site to PRM 29.9, just downstream of the confluence with the Yentna River.

There is overlap between the extents of the two models, the 1980s and current, from PRM 187.2 to PRM 165.5, and from PRM 153.6 to PRM 98.4. It is in these two reaches of the Susitna River that the cross-sectional geometries from the two time periods were compared and evaluated for changes.

4. METHODS

Surveyed cross-sectional geometries are available from the 1980s in the form of survey notes, as well as printouts of HEC-2 input files. Cross section locations for the HEC-2 URX and LRX models are available as maps. The survey notes, HEC-2 input files, and maps were digitized for the purpose of comparing geometries to the surveyed cross sections used in the current HEC-RAS model. As the cross-section locations differ between the two time periods, not all cross sections were comparable. The cross sections best suited for comparison were selected between the two models. Average bed elevation and cross-sectional areas below the water surface elevation (WSE) modeled using 2-year return period discharge at Gold Creek were compared. Also, channel thalwegs from each time period were compared to assess any changes within the channel profile.

4.1. Development of 1980s cross sections

As part of the 1980s studies, a one-dimensional HEC-2 model was developed from cross sections which had been field surveyed in 1980-1982. In order to compare with current cross sections, it was necessary to determine the location of the 1980s cross sections in relation to the current cross sections. To facilitate the cross section comparison, the horizontal locations of 1980s cross sections were digitized in GIS from maps (Harza-EBASCO 1984) displaying their locations. As the 1980s cross section locations were digitized from maps as opposed to surveyed coordinates, the 1980s cross section locations are approximate.

Cross-sectional geometries were digitized from survey notes where available, and from the HEC-2 input files where survey notes were unavailable. The 1980s cross sections were referenced to the National Geodetic Vertical Datum of 1929 (NGVD29), and needed adjustment to be consistent with the current cross sections, which are referenced to the North American Vertical Datum of 1988 (NAVD88). As part of the 1980s studies, survey control points were placed along the Susitna River (R&M Consultants, 1981b). A GIS shapefile of National Geodetic Survey (NGS) control points in Alaska was acquired from the NGS website (NGS 2014), which included the control points placed in the 1980s study, as well as any subsequently placed control points. All of the control points which had surveyed elevations referenced to both NGVD29 and NAVD88 were used to develop a correction between the vertical datums. Elevations in the 1980s cross-sectional geometries were then corrected based upon the difference in NGVD29 and NAVD88 elevations at the control point nearest the particular cross section. The corrections ranged from an addition of 5.83 to 5.95 feet to the NGVD29 elevation.

4.2. Development of Current Cross Sections

A one-dimensional unsteady bed-evolution HEC-RAS model is currently being developed as part of the current Project and will be used to simulate fluvial geomorphic processes in the Susitna River. The HEC-RAS model geometry was developed using bathymetry surveyed between 2012 and 2014, as well as LiDAR acquired in 2011 (Matanuska-Susitna Borough, 2011) and 2013 (Tetra Tech 2014). The cross sections were filtered to reduce the amount of computational nodes while still maintaining an accurate representation of the surface. Each current cross section with a comparable 1980s cross section was plotted with the 1980s section for a visual comparison.

4.3. Comparison of 1980s and Current Cross Sections

While there is overlap in the domains of the HEC-2 and HEC-RAS models, the layout of cross sections in the two models differs. As such, not all 1980s cross sections were suitable for comparison to current cross sections as some were located too far from current cross sections. The 1980s cross section locations in relation to the current cross section locations is shown in Figures 4.3-1 through 4.3-9. Any 1980s cross sections where the nearest current cross section was deemed too far to provide an adequate comparison between the two time periods was not included in this study. Also, while some cross sections were near each other, the skew across channels occasionally differed significantly or crossed the leading or trailing end of a mid-channel bar, and were not included in this study. All of the cross sections that were included in this study are identified in Table 4.3-1, with the distances between the cross sections being compared. Distances between compared cross sections varied between 25 ft and 350 ft.

Changes in cross-sectional geometry were evaluated in part by calculating the change in average bed elevation between the left and right toe of bank in each channel. In cross sections with multiple channels, average bed elevations between the left and right toe of bank for each channel were calculated separately. Cross-sectional area below a specific water surface elevation (WSE) was also calculated. As with the average bed elevation, cross-sectional area was only calculated between the left and right toe of bank in each channel. The specific WSE was determined for each cross section from a steady simulation of the current calibrated HEC-RAS hydraulic model using the 2-year return period discharge at Gold Creek of 43,500 cfs (Study 6.5 ISR Section 5.6.1.1).

4.4. Comparison of 1980s and Current Thalweg/Channel Profile

Channel bed profiles between the 1980s and current conditions were also compared by plotting channel thalwegs at each cross section for both time periods. Thalweg elevations for the 1980s were surveyed in NGVD29 (R&M Consultants 1982) and were adjusted to account for differences between NGVD29 and NAVD88 datums as described in Section 4.1 of this document. As surveys for the 1980s URX cross sections were performed by drilling through ice, thalwegs may not have been captured in the 1980s cross sections upstream of Devils Canyon. Thalweg elevations for the current cross sections represent the lowest elevation surveyed in each cross section.

5. RESULTS

Selected cross sections surveyed for the 1980s HEC-2 model were digitized from survey notes and HEC-2 input files, and were compared to cross sections surveyed for the current HEC-RAS model. Comparable cross sections were plotted for a visual comparison, and average bed elevation and area below the WSE resulting from the 2-year return period discharge at Gold Creek were calculated. A total of 38 cross sections were compared. Of these 38 cross sections, eleven had multiple channels with 10 having 2 channels and 1 having three channels. The thalweg profiles were also compared.

5.1. 1980s Cross Sections

Each 1980s cross section with a corresponding current cross section was digitized from survey notes or HEC-2 input files and plotted per the methods described in Section 4.1. An example of a resulting cross section is shown in Figure 5.2-1, while all cross section plots are included in Appendix A.

5.2. Current Cross Sections

Current cross sections were extracted from the HEC-RAS model geometry per the methods described in Section 4.2 and plotted along with the corresponding 1980s cross section. The horizontal stationing along the cross section used in the 1980s survey differed from the stationing used for the current survey, so an offset was applied to the plots of the current geometry. An example of a current cross section is shown in Figure 5.2-1 while all cross section plots are included in Appendix A. The cross section plots show both the 1980s and current cross section overlaid.

5.3. Comparison of 1980s and Current Cross Sections

Changes in average bed elevation and cross-sectional area within channels were calculated for each 1980s cross section and comparable current cross section per the methods described in Section 4.3. When an increase (bed aggradation) or decrease (bed degradation) is indicated it refers to the direction of change from the 1980s to current condition. When the change in bed elevation was within plus or minus a foot it was considered to be minimal or no change. Twenty-five of the cross sections showed no change in average bed elevation, and of the remaining cross sections, eight cross sections had an increase (aggradation) of greater than 1 foot and five had a decrease in elevation (degradation) of greater than one foot. The most consistent and some of the largest elevation changes were noted in reaches MR-8 and LR-1 and corresponded to bed aggradation.

Assessing the difference of area allowed incorporation of the changes in channel width in the consideration of channel change. Changes in area of less than 450 sq. ft. are considered to be minimal. Twenty-one of the cross sections had minimal change in cross-sectional area. Of the remaining cross sections, only five had an increase in area while twelve had a decrease in area. In general, the changes in area mimicked the trends in changes in average bed elevation, except where channel width also changed by greater than ten percent.

5.3.1. Change in Average Bed Elevation

Average bed elevations were calculated for each channel and are listed in Table 5.3-1. In cross sections with multiple channels, an overall average bed elevation was determined by calculating the average bed elevation for each channel and then averaging the elevations weighted by the width of the respective channel. Twenty-five of the 38 cross sections had minimal change in average bed elevation. Of the remaining cross sections, five degraded and eight aggraded. Three cross sections had a decrease of one to two feet, one had a decrease of three to five feet, and one had a decrease of greater than five feet in elevation. One cross section had an increase of one to two feet, four had an increase of two to three feet, and three had an increase of three to five feet in elevation. The largest increase in average bed elevation of 4.8 ft was observed in the cross sections at PRM 153.7, at the downstream end of Devils Canyon at the upstream limit of MR-5. The cross sections being compared at PRM 153.7 are approximately 300 ft apart and are on the outside of a bend. A large pool present in the 1980s was filled in the current cross section, accounting for the large increase in average bed elevation.

Some trends can be seen in the average bed elevation changes. The average bed elevation for all cross sections in MR-2, from PRM 184.9 to PRM 170.1, had a minimal change in elevation with the exception of the cross section at PRM 179.5 which had an increase of 2.3 ft of aggradation The magnitude of elevation changes tend to increase approaching the Three Rivers confluence in MR-8, with all channels downstream of PRM 115.4 having a change of greater than one ft, with the exception of cross section at PRM 104.1, which had a decrease of less than one foot. The downstream most cross section, at PRM 98.4 in LR-1, had degradation in the channel of 3.6 feet. However, due to the proximity to the Three Rivers Confluence, the Susitna River channels changed substantially over the three decade period. When expanding the average bed elevation beyond the channels to the entire braid plain at PRM 98.4, the cross section aggraded, with an increase in elevation of 2.9 feet. Most changes throughout all cross section were minimal, with the average change in bed elevation for all cross sections being an increase of 0.3 ft.

When looking at individual channels with cross sections containing multiple channels, the maximum change in elevation was an apparent decrease of 7.8 ft in elevation (degradation) within the main channel in the cross sections at PRM 130.9. The side channel at PRM 130.9 on river right also had a significant decrease in elevation of 4.5 ft. The main channel in the cross sections at PRM 104.1 changed the least, showing almost no change. However, the two side channels at PRM 104.1 showed more change, with the left most channel degrading with a 1.9 ft decrease in elevation and the middle channel aggrading with a 1.7 ft increase in elevation.

5.3.2. Change in Area below 2-Year Return Period WSE

The cross-sectional areas below the 2-year WSE were determined per the methods described in Section 4.3 and the results are presented in Table 5.3-1. Changes in area of less than 450 sq. ft. (average current width for all cross sections multiplied by 1 foot depth) are considered to be minimal. In general, changes in cross-sectional area should mimic those in average bed elevation. The exceptions occur where the elevation change was also accompanied by a change in width. Overall area for cross sections with multiple channels was determined by summing the area of each individual channel in the respective cross section.

Similar to the average bed elevation, a majority of the cross sections, 21 of 38, showed minimal change in area. Of the remaining cross sections, five had an increase in area (aggradation) while twelve had a decrease in area (degradation). Upstream of Devils Canyon, all cross sections in MR-1 through MR-3 had minimal change in area, with two exceptions. The cross section at PRM 185.2 showed a slight decrease in area of 490 sq. ft., a 13 percent reduction. At PRM 179.5 the cross sections showed an increase in area of 470 sq. ft., a 24 percent increase.

Twenty-four cross sections shared trends between change in average elevation and change in area, where minimal changes in average bed elevation corresponded with minimal changes in area for 16 cross sections, and greater than one-foot changes in average bed elevation corresponded to greater than 450 sq. ft. change in area in eight cross sections. Of the remaining cross sections, all showed a greater than ten percent change in channel width. For example, the cross section at PRM 132.1 showed a minimal decrease in average bed elevation of 0.5 ft, had the width not changed, the area would have increased. However, the channel also narrowed by twenty two percent, which led to the area decreasing by 1,200 sq. ft., a reduction of 25 percent. Overall, the average change in cross-sectional area for all channels was an increase in area of only three percent.

When looking at individual channels in cross sections with multiple channels, the channels that showed the largest changes in area (greater than 200 percent) also had large decreases in average bed elevation of greater than 2 ft. Similar to the overall cross sections, the area of each individual channel followed the trend of changes in average bed elevation, except where the width changed by greater than ten percent. Also, the channels in MR-8 showed typically a larger magnitude of changes in area; however, they also showed large changes in width, with the exception of the main channel at PRM 104.1.

5.4. Comparison of 1980s and Current Channel Thalweg Profiles

Thalweg profiles for the 1980s and current data above Devils Canyon (PRM 169.5 to 187.2) are shown in Figure 5.4-1 and for below Devils Canyon (PRM 98.4 to PRM 153.7) in Figure 5.4-2. In general, the trends mimic those of bed elevation and cross-sectional area comparisons. It might be expected that the thalweg profile would be more dynamic than the channel change identified by average bed elevations or the channel area, but this is generally not the case for the data compared. Most profile changes are on the order of several feet or less with many portions of the profile showing only minor changes of less than 1 foot.

Looking closer at the portion of the thalweg profile upstream of Devils Canyon, Figure 5.4-1, no large changes are apparent between the 1980s profile and the current profile. The current thalweg is consistently at a lower elevation than the 1980s thalweg between PRM 170 and PRM 174 by one to two feet. Other areas of difference are less consistent and switch between aggradation and degradation on the order of one foot or less.

Similar to above Devils Canyon the thalweg profile below Devils Canyon (PRM 98.4 to PRM 153.7) provided in Figure 5.4-2, large changes are generally not observed. The majority of the profile depicted shows changes of less than 2 feet and few areas of consistent aggradation or degradation. Some of the more discernable and consistent differences are in the area of PRM 102 to PRM 122 where the trend is for no change or slight aggradation for vast majority of this area. The aggradation is only interrupted between PRM 112.5 to PRM 115 where up to four feet of degradation is indicated. This area consists of geomorphic reaches MR-7 and MR-8.

The two largest exceptions to lack of large change below Devils Canyon in the thalweg profile occur at the upstream and downstream extents of the figure. At PRM 153.7, at the very upstream point of the profile, a pool that was on the order of 12 feet deep in the 1980s was filled in the current cross section (Note: the cross sections are located 300 feet apart so some of the apparent change may be attributable to the difference in locations). At the downstream end of the profile, PRM 98.4, the opposite response is noted with about seven feet of degradation. This was the only pair of cross sections compared in the Lower River. As discussed earlier, this is a location where a much larger portion of the flow was confined to the main channel as secondary channels were filled including portions of the braid plain becoming vegetated.

6. SUMMARY AND CONCLUSIONS

Cross sections were surveyed as part of the 1980s studies for the use in developing a one-dimensional HEC-2 hydraulic model. Cross sections were also surveyed for the current Project for use in developing a one-dimensional bed evolution model. The portion of the Susitna River with the two sets of cross sections covered the Middle River segment and the very upper portion of geomorphic reach LR-1 in the Lower River segment. A comparison of the two sets of cross sections was performed and provides an additional resource in assessing geomorphic changes in the Susitna River as well as for verification of the 1-D bed evolution model being developed in the Fluvial Geomorphology Modeling Study (Study 6.6).

To develop the comparison, 1980s cross sections were digitized from survey notes and HEC-2 input files from documentation of the 1980s study efforts. The 1980s elevations were adjusted from NGVD29 datum to the NAVD88 datum, to be consistent with the datum for current cross sections. The 1980s and current cross sections were plotted together to provide a visual comparison. Average bed elevations between the toe of banks were calculated for each channel and time period to assess whether average bed elevation had increased or decreased. In order to compare cross-sectional areas, a reference water surface elevation was assigned to each cross section and the area below the reference elevation determined. The reference water surface was used to calculate changes in cross-sectional area between the toe of banks and below the simulated WSE. Lastly, channel profiles from the 1980s and current conditions were plotted using thalweg elevations from each cross section.

Overall, the results show that the Middle Susitna River was generally stable in terms of bed elevation change over the 3 decade period between the 1980s studies and the current effort. Changes were typically on the order of several feet or less and there was not a consistent trend toward aggradation (bed elevation increase) or degradation (bed elevation decrease) throughout the Middle River segment. The area with the most consistent trend were geomorphic reaches MR-7 and MR-8 in which the majority of the length was aggradational; however, there were still cross sections within these two reaches that showed degradation over the period of comparison. MR-2 showed the least change, with all cross sections having minimal change in bed elevation and area with the exception of the cross section at PRM 179.5, which aggraded by 2.3 ft and increased in area by 490 sq. ft. The remaining reaches had more of a mix between aggradation and degradation.

Only one cross section was compared in the Lower River PRM 98.4 so data in the Lower River were insufficient to make a generalization about trends the bed elevation or area changes.

Results of this work were used in the validation of the 1-D bed evolution model currently under development as part of the Fluvial Geomorphology Modeling Study (Study 6.6) (Tetra Tech 2014). An additional 48 cross sections were surveyed in 2014 and of these, 3 are located sufficiently close to 1980s cross sections to perform comparisons to assess channel change. These cross sections will be used to update this technical memorandum in 2015. The results will also be incorporated into the Comprehensive Geomorphology Technical Memorandum to be developed in 2015 (Study 6.5 ISR Section 7.2.2.1.3).

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8. TABLES

Table 4.3-1. Summary of compared cross sections and distances between cross sections.

1980s HEC-2 XS	Current HEC-RAS XS	Approximate Distance (ft)	1980s HEC-2 XS	Current HEC-RAS XS	Approximate Distance (ft)
URX-208	186.2	250	LRX-43	139	150
URX-109	185.5	75	LRX-41	138.1	350
URX-110	185.2	25	LRX-40	137.6	50
URX-111	184.9	275	LRX-35	134.1	25
URX-112	184.4	25	LRX-34	133.8	100
URX-113	183.3	200	LRX-31	132.1	350
URX-114	182.9	50	LRX-30	130.9	175
URX-115	181.6	25	LRX-29	129.7	50
URX-116	179.5	75	LRX-27	126.8	175
URX-120	170.1	100	LRX-26	126.1	25
LRX-68	153.7	350	LRX-21	122.6	250
LRX-59	148.3	200	LRX-20	120.7	175
LRX-56	145.5	225	LRX-19	119.9	150
LRX-54	144.3	75	LRX-18	116.6	300
LRX-51	142.2	350	LRX-15	115.4	225
LRX-50	141.9	100	LRX-9	107.1	25
LRX-49	141.7	350	LRX-7	105.3	175
LRX-45	140	75	LRX-5	104.1	300
LRX-44	139.8	325	0.4	98.4	125

Table 5.3-1. Summary of cross sections comparison results.

1980s HEC-2 XS	Current HEC-RAS XS[1]	1980s Avg. Elev. (ft)	Current Avg. Elev. (ft)	Diff. (ft)	1980s width (ft)	Current width (ft)	1980s Area below 2-yr WSE (ft^2)	Current Area below 2-yr WSE (ft^2)	% Change
URX-208	186.2	1449.8	1449.1	-0.76	330	330	3320	3490	5%
URX-109	185.5	1443.7	1444.2	0.59	260	240	2580	2240	-13%
URX-110	185.2 L	1442.5	1441.2	-1.33	230	240	2080	2180	5%
URX-110	185.2 R	1442.8	1441.6	-1.21	140	70	1200	720	-40%
URX-110	185.2[2]	1442.6	1441.3	-1.34	370	310	3280	2900	-12%
URX-111	184.9	1437.0	1437.7	0.70	350	320	3670	3180	-13%
URX-112	184.4	1428.1	1428.6	0.50	140	170	1720	1660	-3%
URX-113	183.3	1415.6	1416.0	0.39	400	400	3810	3660	-4%
URX-114	182.9	1411.3	1411.3	0.07	260	330	1910	2240	17%
URX-115	181.6	1393.6	1393.9	0.29	400	440	4010	3860	-4%

Table 5.3-1. Summary of cross sections comparison results (cont.).

1980s HEC-2 XS	Current HEC-RAS XS[1]	1980s Avg. Elev. (ft)	Current Avg. Elev. (ft)	Diff. (ft)	1980s width (ft)	Current width (ft)	1980s Area below 2-yr WSE (ft^2)	Current Area below 2-yr WSE (ft^2)	% Change
URX-116	179.5	1368.2	1370.5	2.31	150	230	1950	2420	24%
URX-120	170.1	1276.6	1276.8	0.14	390	440	3060	3150	3%
LRX-68	153.7	846.6	851.4	4.80	280	260	5010	3310	-34%
LRX-59	148.3	785.4	785.7	0.26	280	250	3500	2880	-18%
LRX-56	145.5	752.4	751.7	-0.70	370	400	3290	3430	4%
LRX-54	144.3 L	739.2	740.1	0.92	340	340	1780	1400	-21%
LRX-54	144.3 R	734.5	734.5	-0.02	390	320	4160	3230	-22%
LRX-54	144.3[2]	736.7	737.4	0.70	730	660	5940	4630	-22%
LRX-51	142.2	710.4	709.5	-0.85	610	590	4720	4720	0%
LRX-50	141.9	702.4	703.1	0.76	360	360	4430	4270	-4%
LRX-49	141.7	700.2	703.6	3.41	160	190	2060	1720	-17%
LRX-45	140	683.0	682.9	-0.04	290	270	3840	3100	-19%
LRX-44	139.8	682.5	683.0	0.55	300	230	2970	1370	-54%
LRX-43	139 L	681.6	678.9	-2.73	180	130	60	180	200%
LRX-43	139 R	664.0	665.0	0.99	90	80	1710	1600	-6%
LRX-43	139[2]	675.7	673.6	-2.15	270	220	1770	1780	1%
LRX-41	138.1 L	659.4	663.9	4.50	110	190	1340	460	-66%
LRX-41	138.1 R	662.0	663.5	1.47	360	440	3360	3050	-9%
LRX-41	138.1[2]	661.4	663.6	2.21	460	630	4700	3510	-25%
LRX-40	137.6	656.8	657.8	0.97	500	600	4330	4450	3%
LRX-35	134.1	616.3	616.1	-0.15	300	330	3950	4420	12%
LRX-34	133.8	617.9	617.4	-0.47	530	530	3970	4380	10%
LRX-31	132.1	594.6	594.1	-0.52	400	310	4600	3470	-25%
LRX-30	130.9 L	588.5	584.0	-4.52	150	130	850	170	-80%
LRX-30	130.9 R	592.0	584.2	-7.77	280	150	270	1490	452%
LRX-30	130.9[2]	590.8	584.1	-6.66	420	280	1120	1660	48%
LRX-29	129.7	571.7	573.1	1.38	490	540	5070	5140	1%
LRX-27	126.8	544.4	544.5	0.12	450	450	5140	5590	9%
LRX-26	126.1 L	543.8	542.4	-1.40	60	60	350	220	-37%
LRX-26	126.1 R	539.0	540.1	1.06	450	520	4690	4220	-10%
LRX-26	126.1[2]	539.6	540.3	0.74	510	590	5040	4440	-12%
LRX-21	122.6 L	514.7	514.5	-0.14	110	110	640	490	-23%
LRX-21	122.6 R	510.6	509.0	-1.61	350	300	3660	2910	-20%
LRX-21	122.6[2]	511.5	510.5	-1.09	470	410	4300	3400	-21%
LRX-20	120.7 L	491.1	495.2	4.10	140	200	2020	1260	-38%
LRX-20	120.7 R	496.6	497.7	1.04	160	320	1430	2380	66%

Table 5.3-1. Summary of cross sections comparison results (cont.).

1980s HEC-2 XS	Current HEC-RAS XS[1]	1980s Avg. Elev. (ft)	Current Avg. Elev. (ft)	Diff. (ft)	1980s width (ft)	Current width (ft)	1980s Area below 2-yr WSE (ft^2)	Current Area below 2-yr WSE (ft^2)	% Change
LRX-20	120.7[2]	494.0	496.7	2.68	300	520	3450	3640	6%
LRX-19	119.9	488.2	488.3	0.13	420	440	4800	4650	-3%
LRX-18	116.6	462.2	462.3	0.06	550	470	6150	4810	-22%
LRX-15	115.4 L	456.2	457.5	1.28	170	230	850	1010	19%
LRX-15	115.4 R	455.1	453.5	-1.58	680	610	4690	4730	1%
LRX-15	115.4[2]	455.3	454.6	-0.72	850	850	5540	5740	4%
LRX-9	107.1	381.7	385.5	3.82	640	650	6730	5840	-13%
LRX-7	105.3 L	367.2	369.7	2.44	270	620	2790	4840	73%
LRX-7	105.3 R	369.0	370.4	1.43	160	320	1310	2200	68%
LRX-7	105.3[2]	367.9	369.9	2.04	430	940	4100	7040	72%
LRX-5	104.1 L	362.4	360.5	-1.86	500	310	2800	1990	-29%
LRX-5	104.1 R	361.3	363.1	1.77	190	300	1290	700	-46%
LRX-5	104.1 M	360.6	360.6	-0.01	480	460	3490	3720	7%
LRX-5	104.1[2]	361.5	361.3	-0.21	1170	1070	4780	4420	-8%
0.4	98.4	319.3	315.7	-3.61	130	320	800	2710	239%

Notes:

1 Cross sections with multiple channels are desginated as "L" for Left, "R" for right and "M" for main channel.

2 Overall changes in average elevation (weighted by width) and total cross sectional area are calculated for cross sections with multiple channels.

9. FIGURES

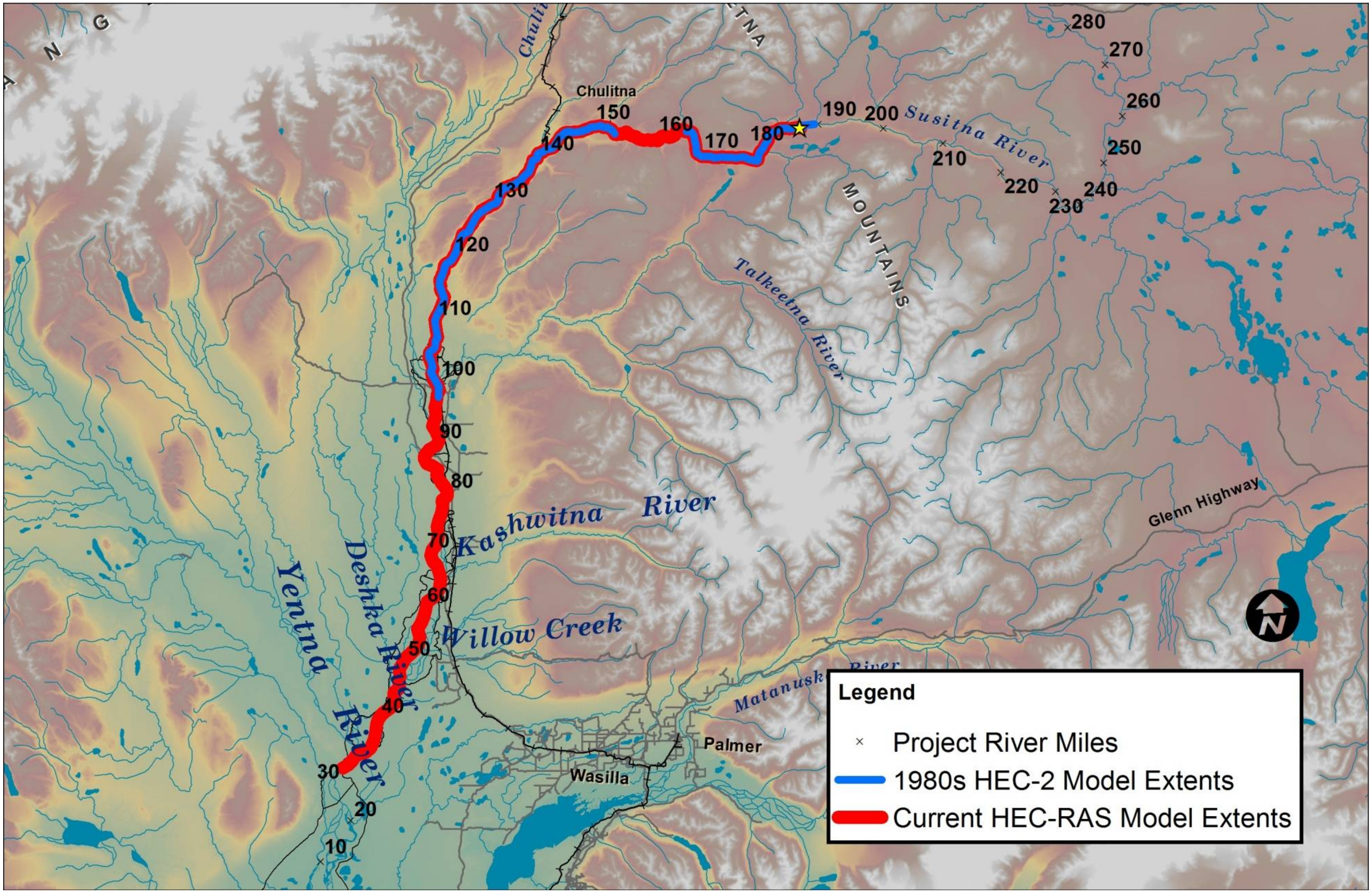

Figure 3-1 Extents of 1980s HEC-2 model and current HEC-RAS model.

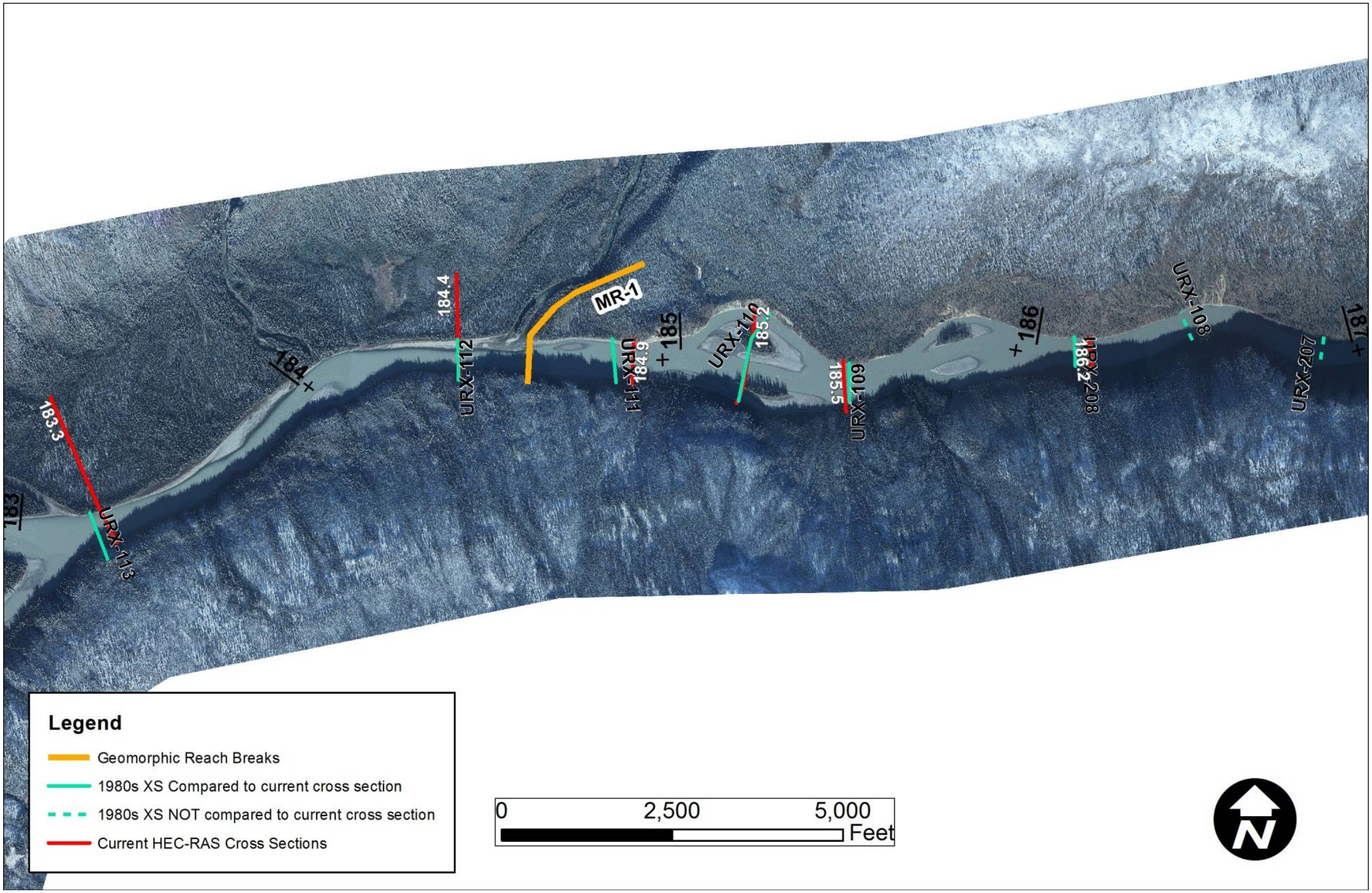

Figure 4.3-1 Cross section locations for 1980s HEC-2 cross sections and current HEC-RAS cross sections from PRM 187 to PRM 183.

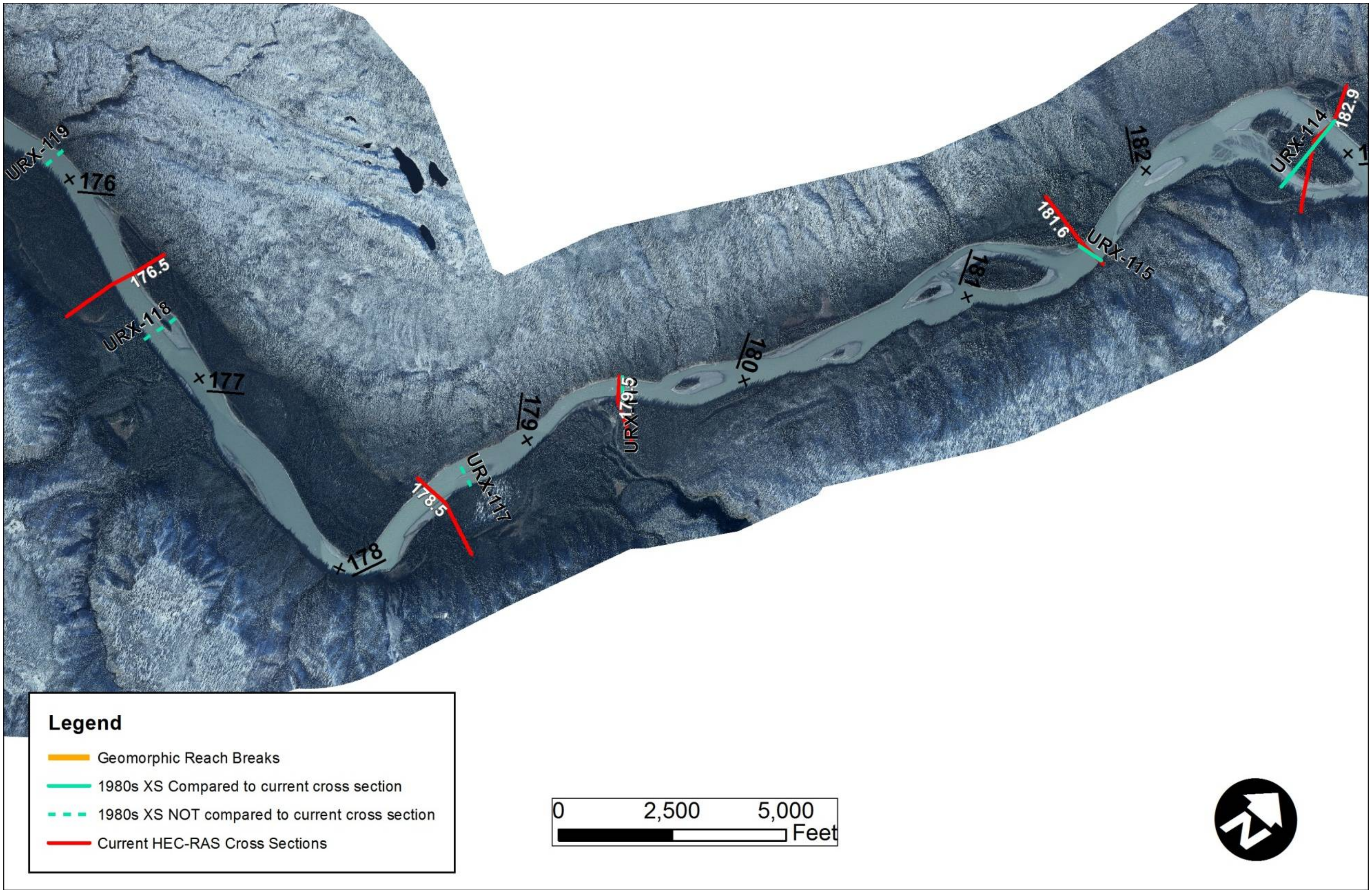

Figure 4.3-2 Cross section locations for 1980s HEC-2 cross sections and current HEC-RAS cross sections from PRM 183 to PRM 176.

Figure 4.3-3 Cross section locations for 1980s HEC-2 cross sections and current HEC-RAS cross sections from PRM 174 to PRM 164.

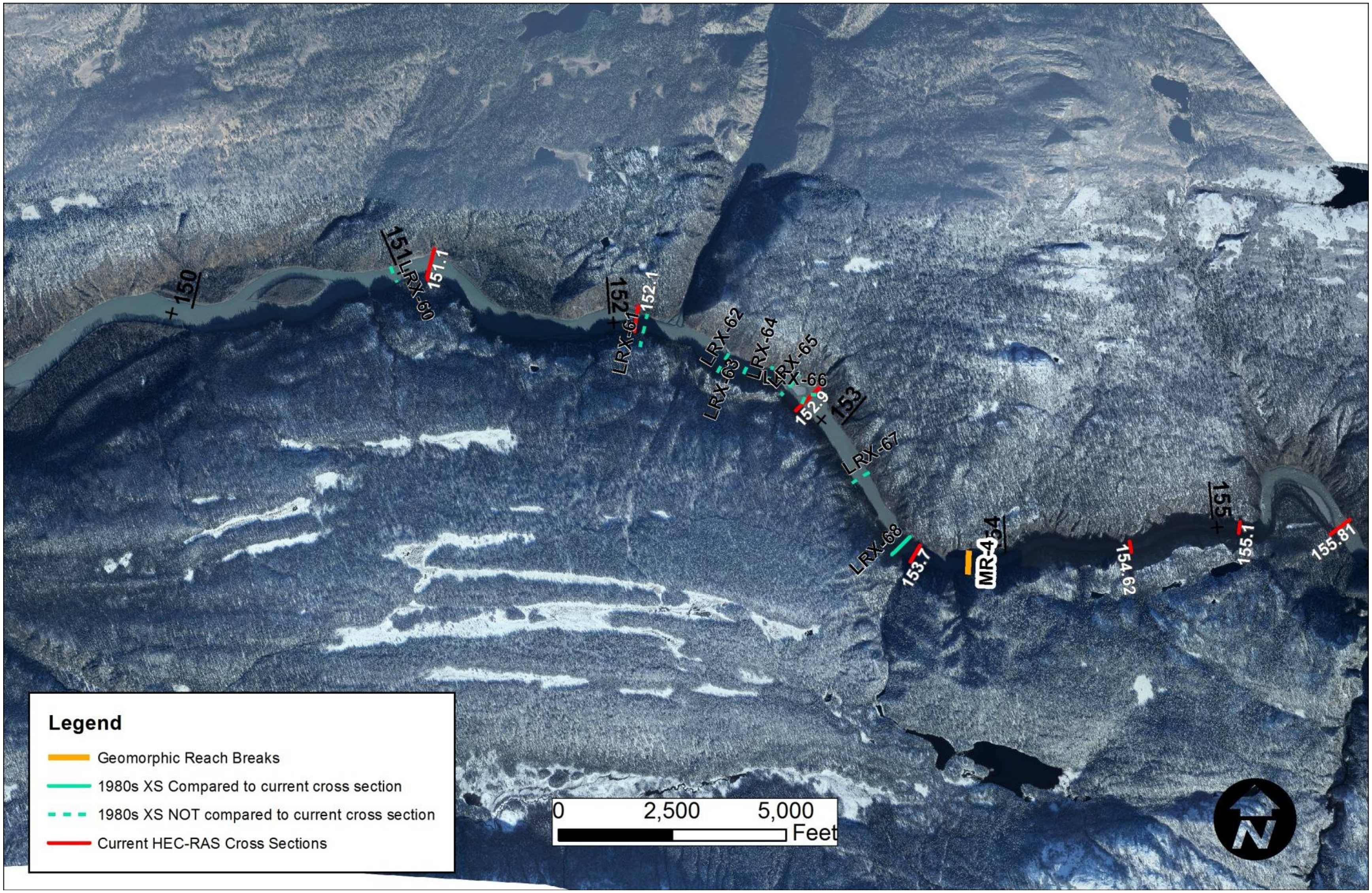

Figure 4.3-4 Cross section locations for 1980s HEC-2 cross sections and current HEC-RAS cross sections from PRM 156 to PRM 149.

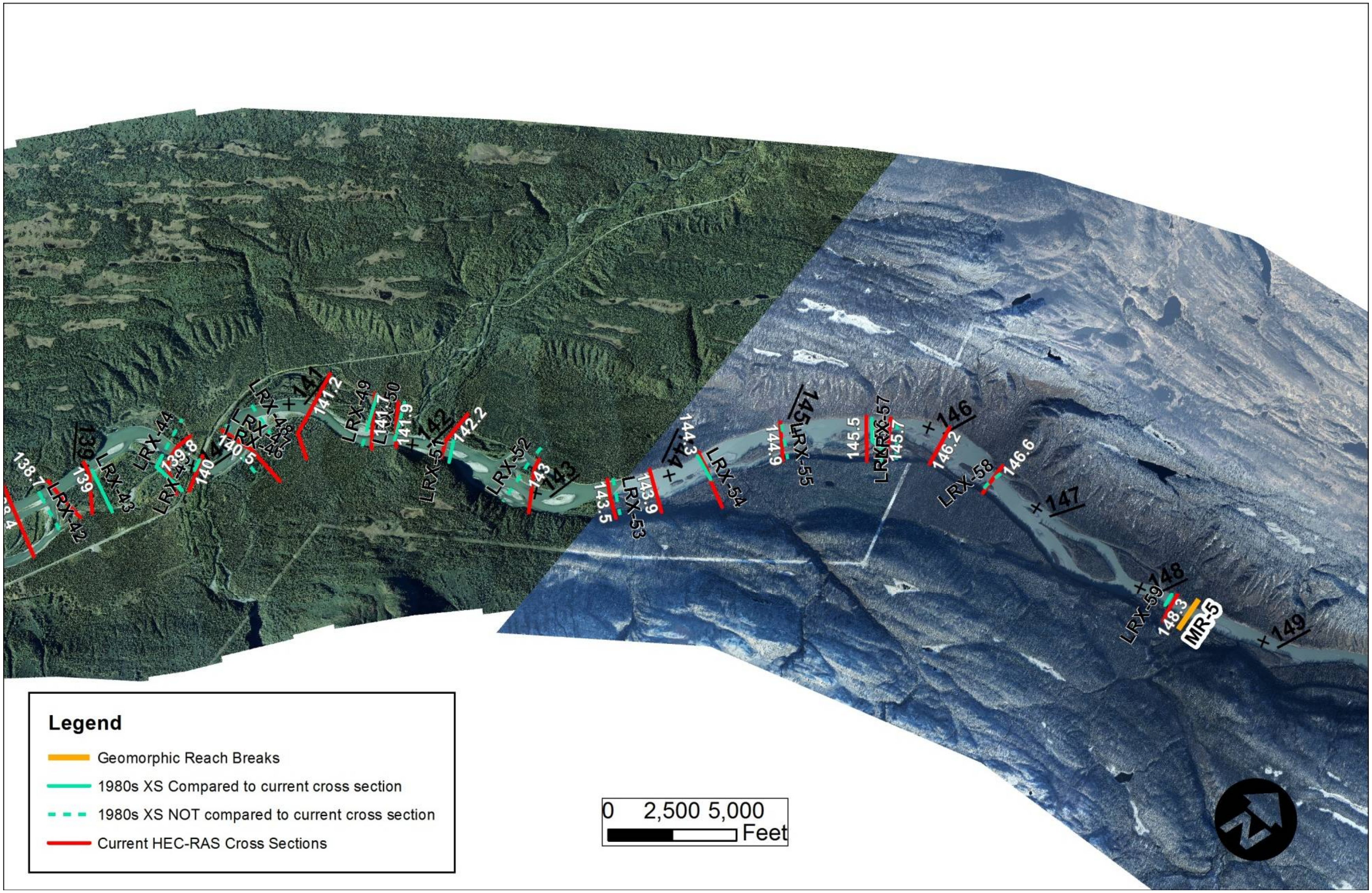

Figure 4.3-5 Cross section locations for 1980s HEC-2 cross sections and current HEC-RAS cross sections from PRM 150 to PRM 138.

Figure 4.3-6 Cross section locations for 1980s HEC-2 cross sections and current HEC-RAS cross sections from PRM 139 to PRM 128.

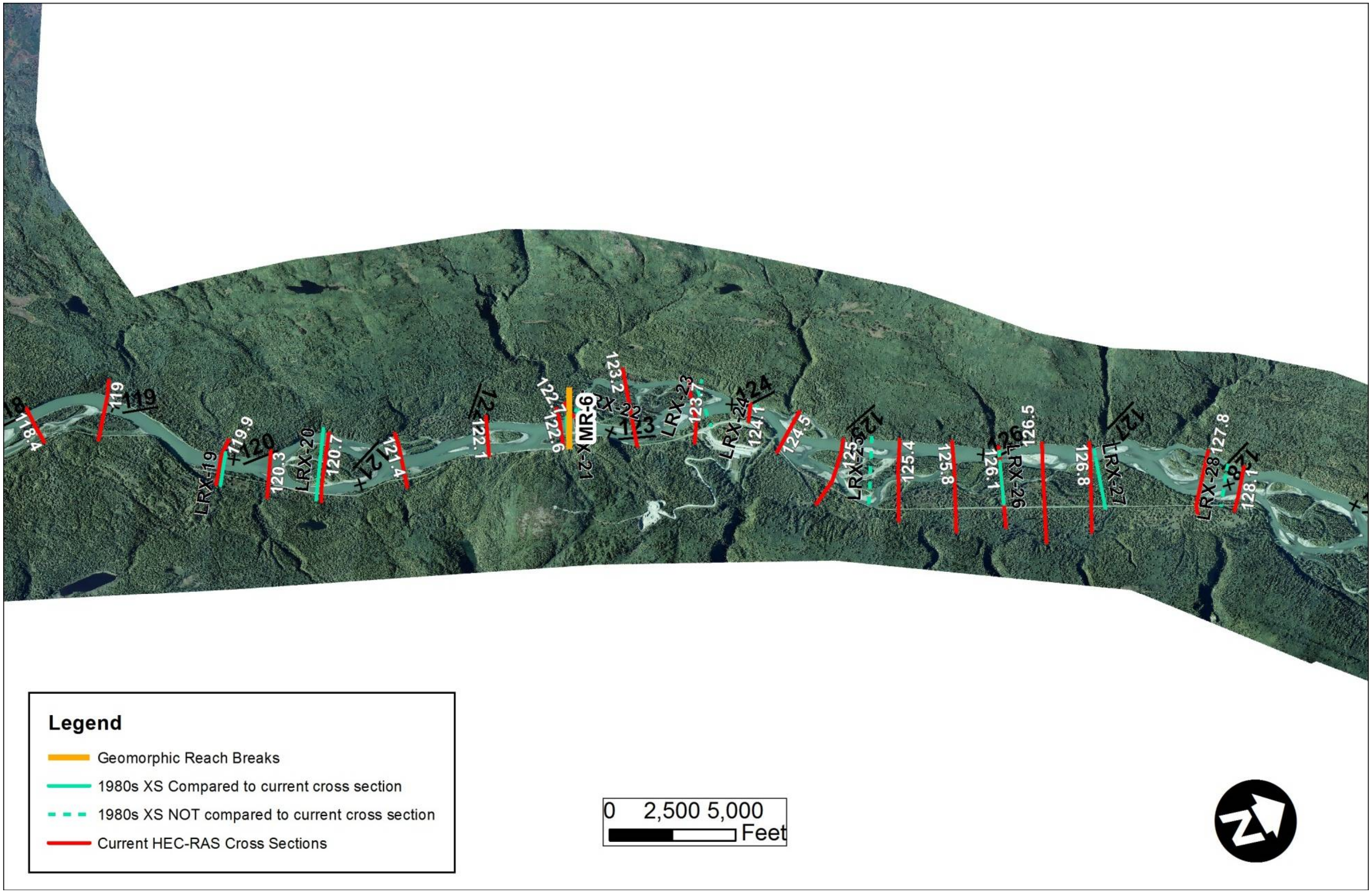

Figure 4.3-7 Cross section locations for 1980s HEC-2 cross sections and current HEC-RAS cross sections from PRM 129 to PRM 118.

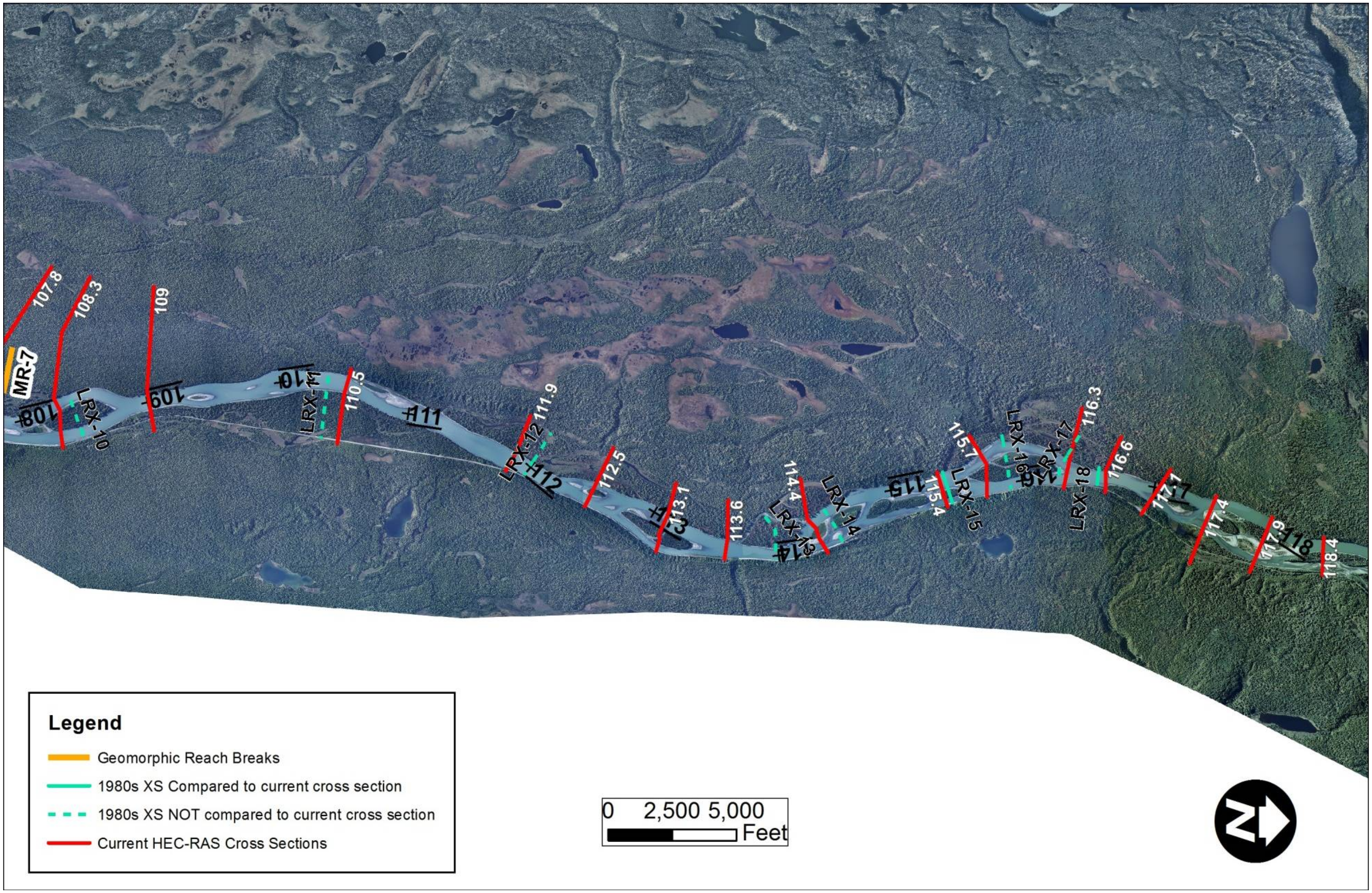

Figure 4.3-8 Cross section locations for 1980s HEC-2 cross sections and current HEC-RAS cross sections from PRM 118 to PRM 108.

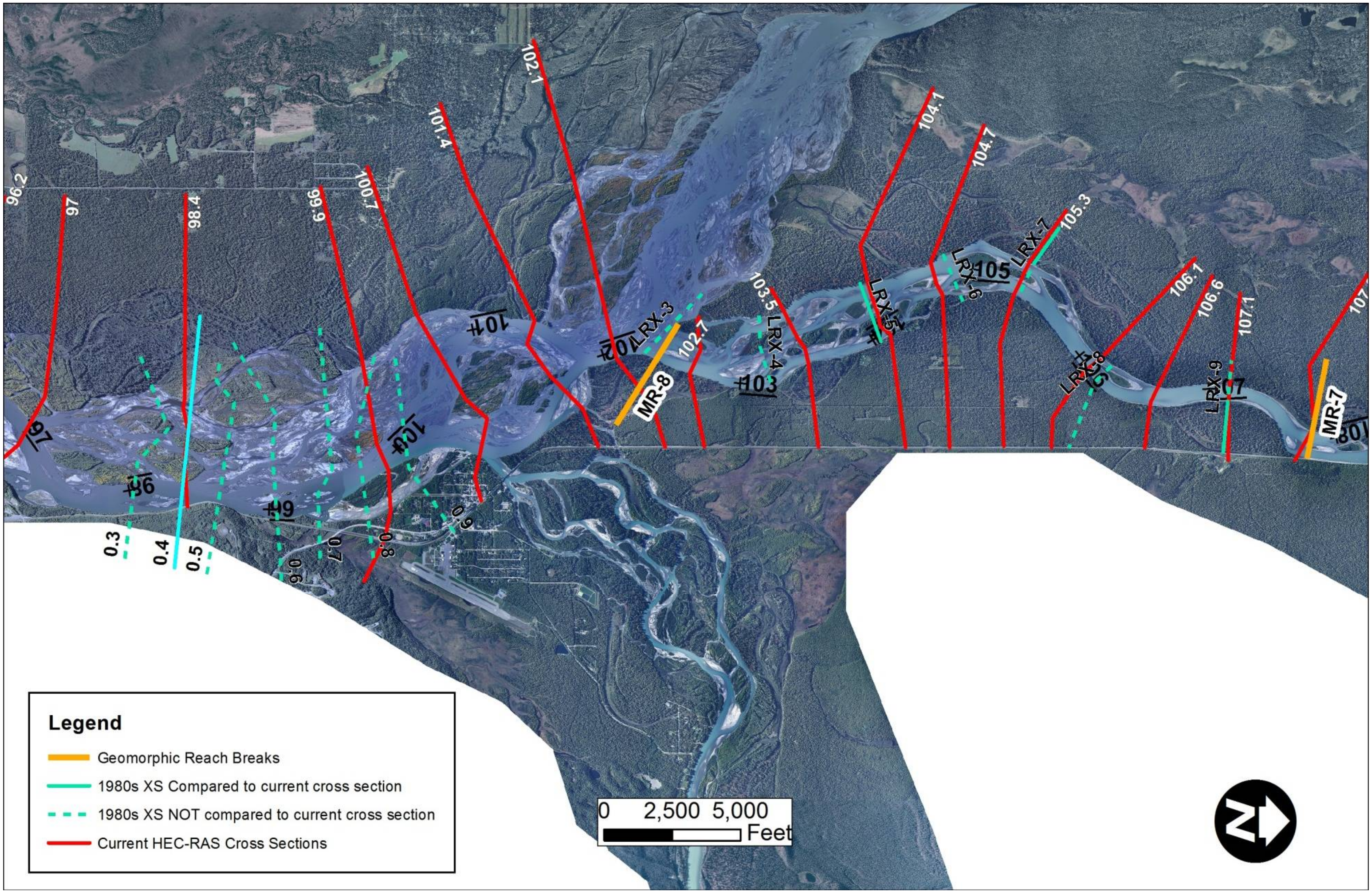

Figure 4.3-9 Cross section locations for 1980s HEC-2 cross sections and current HEC-RAS cross sections from PRM 108 to PRM 97.

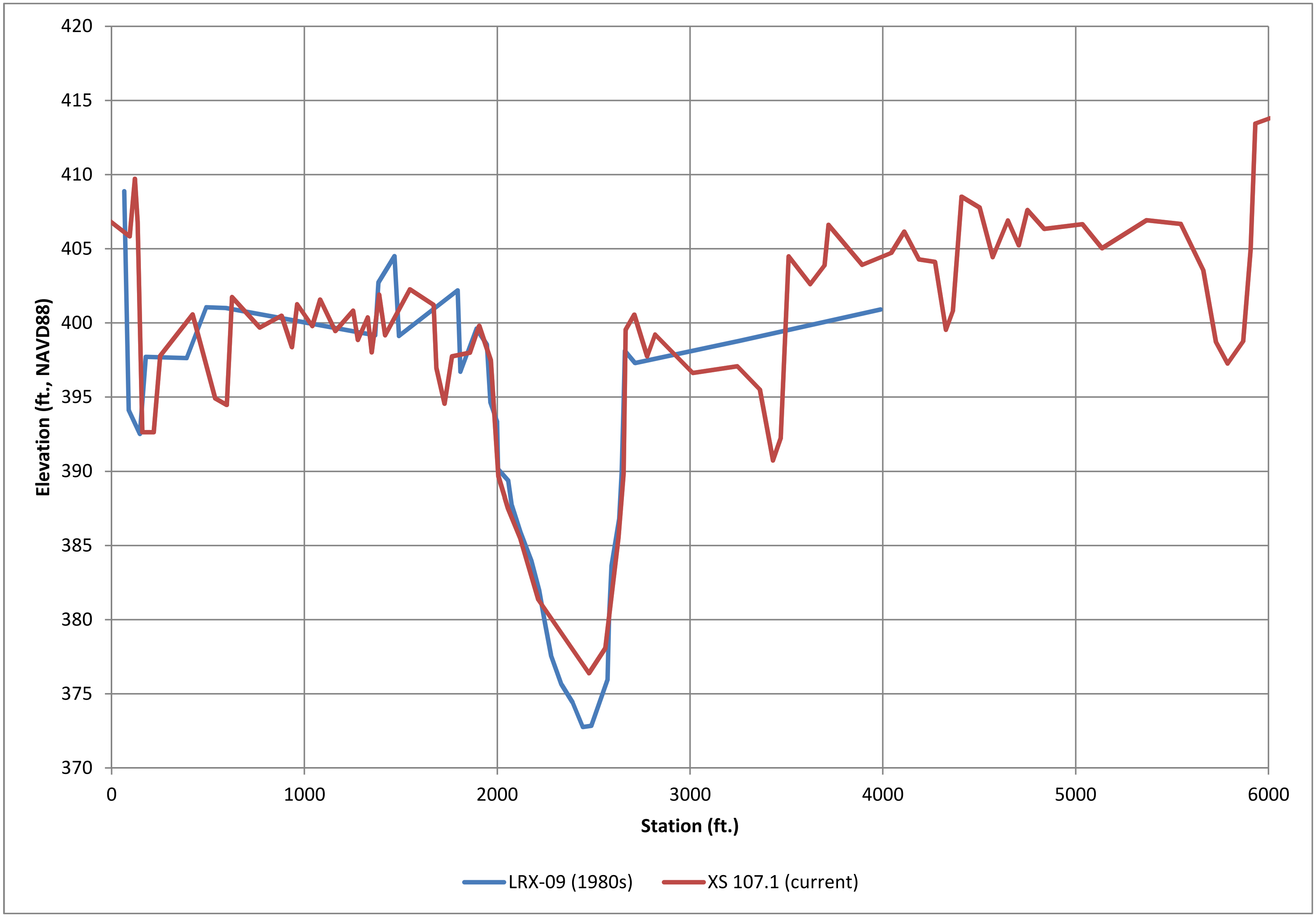

Figure 5.2-1 Example cross-sectional geometry from the 1980s HEC-2 model and the current HEC-RAS model.

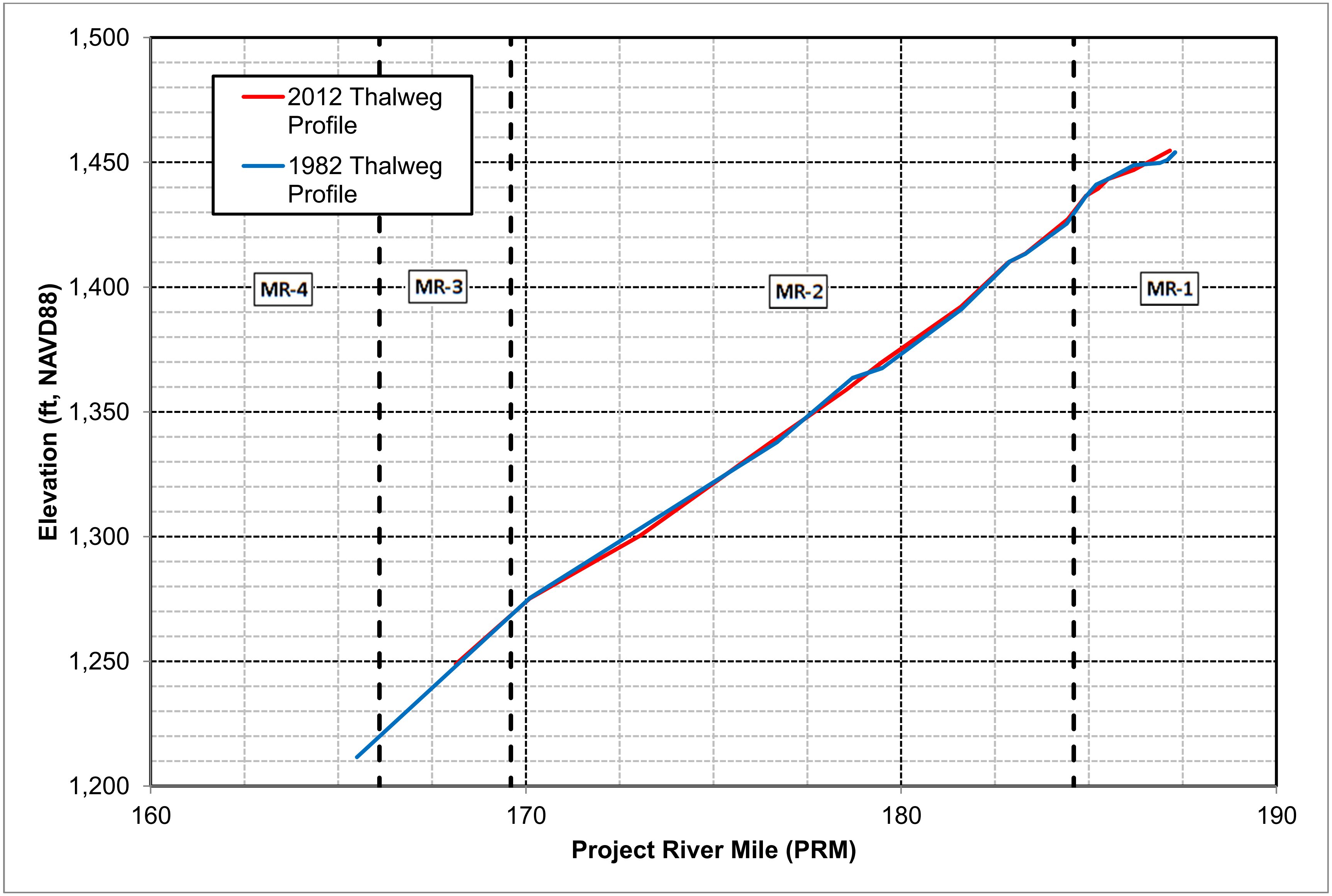

Figure 5.4-1 Comparison of thalweg profiles for the 1980s HEC-2 URX model and the current HEC-RAS model, PRM 187.2 to PRM 169.5.

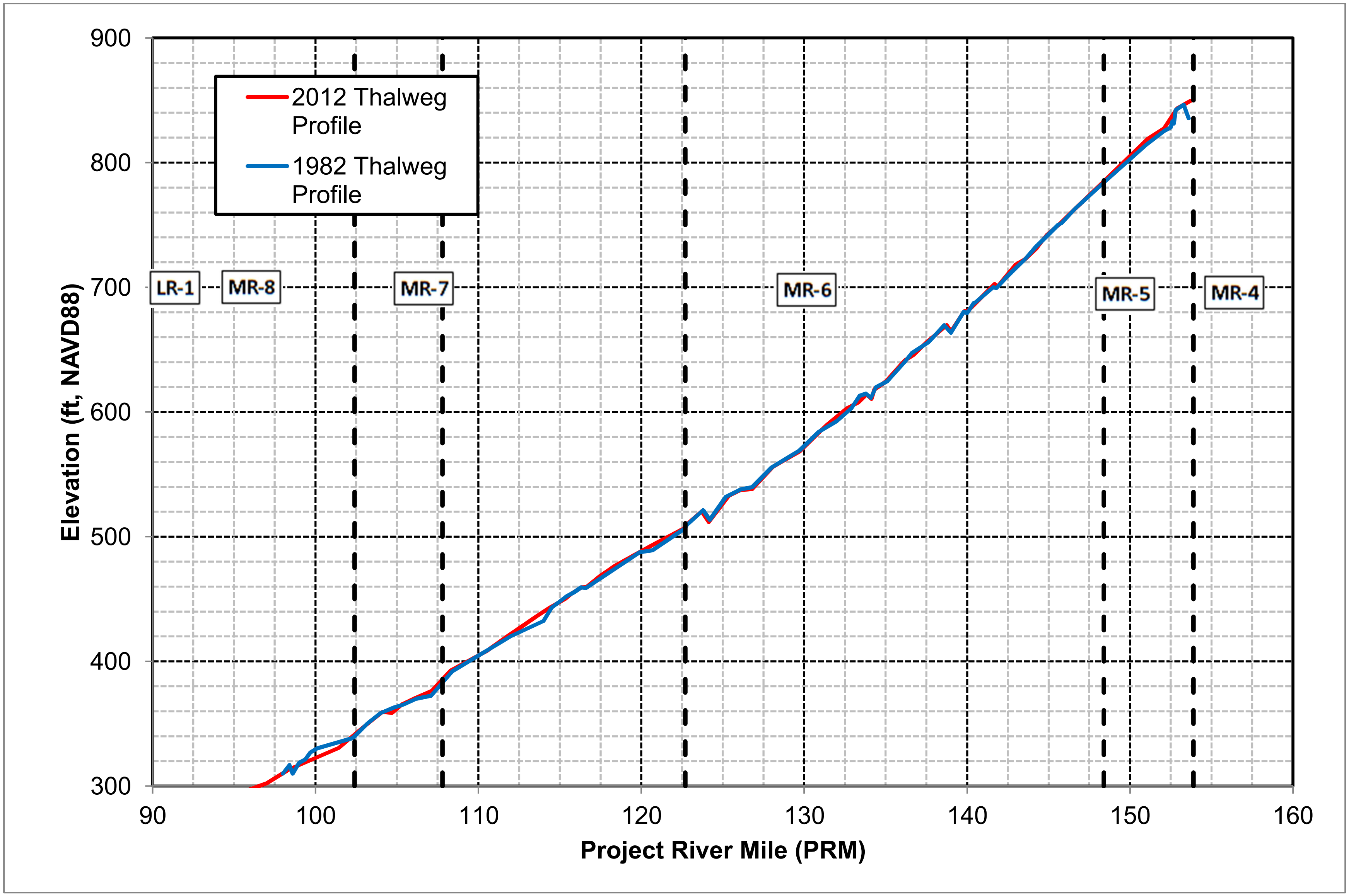

Figure 5.4-2. Comparison of thalweg profiles for the 1980s HEC-2 LRX model and the current HEC-RAS model, PRM 153.7 to PRM 98.4.

APPENDIX A. HISTORICAL CROSS SECTION COMPARISON PLOTS

Susitna-Watana Hydroelectric Project (FERC No. 14241)

Geomorphology Study (Study 6.5)

Susitna River Historical Cross Section Comparison (1980s to Current)

Technical Memorandum

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Tetra Tech, Inc.

September 2014

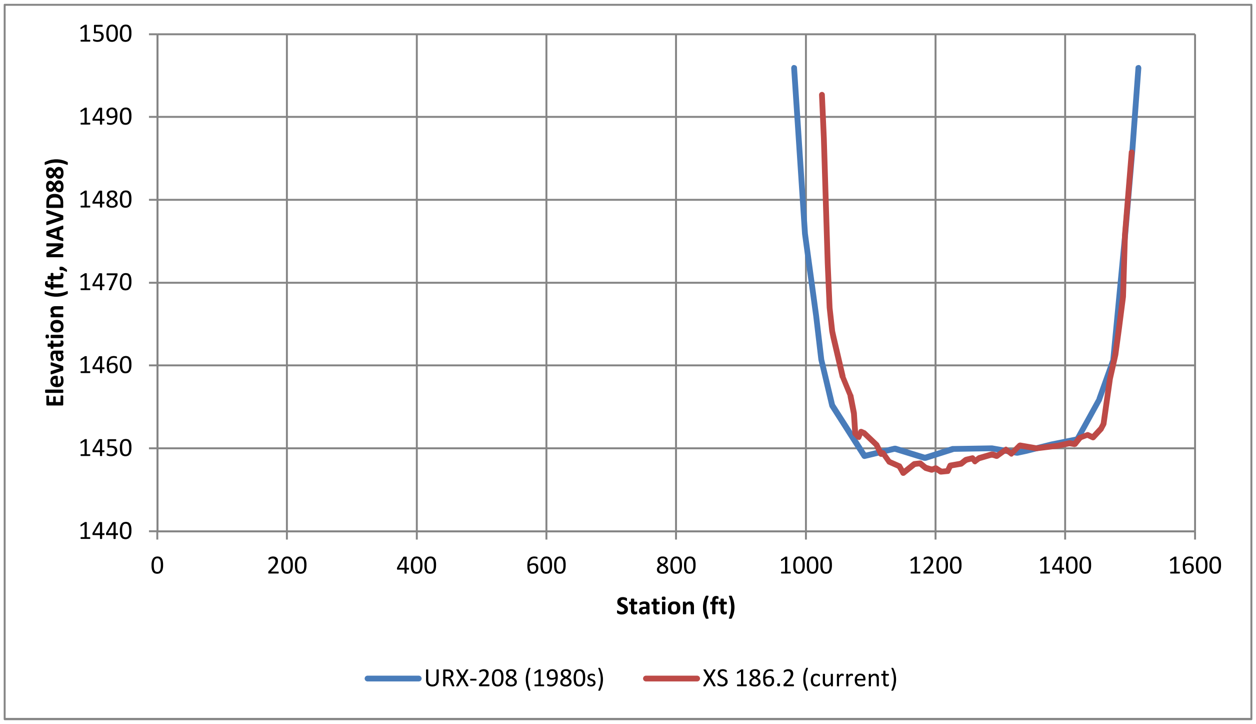

Figure A.1. Cross section comparison of 1980s URX-208 and current XS 186.2

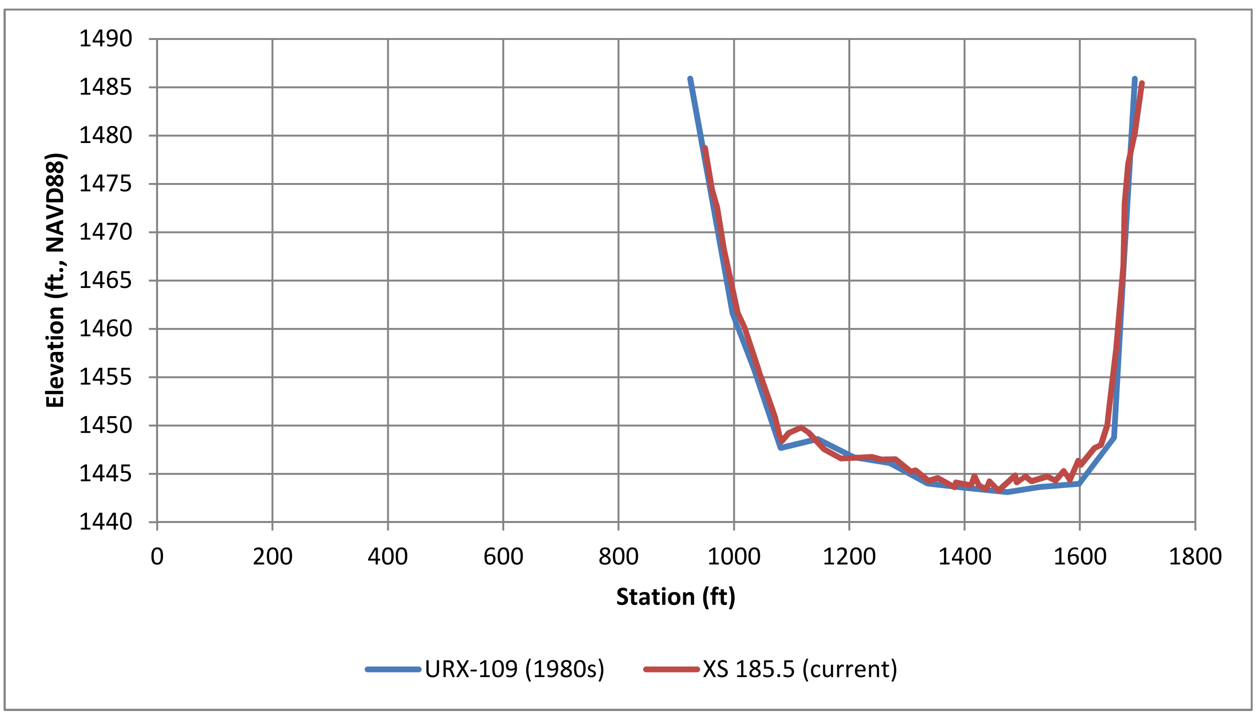

Figure A.2. Cross section comparison of 1980s URX-109 and current XS 185.5

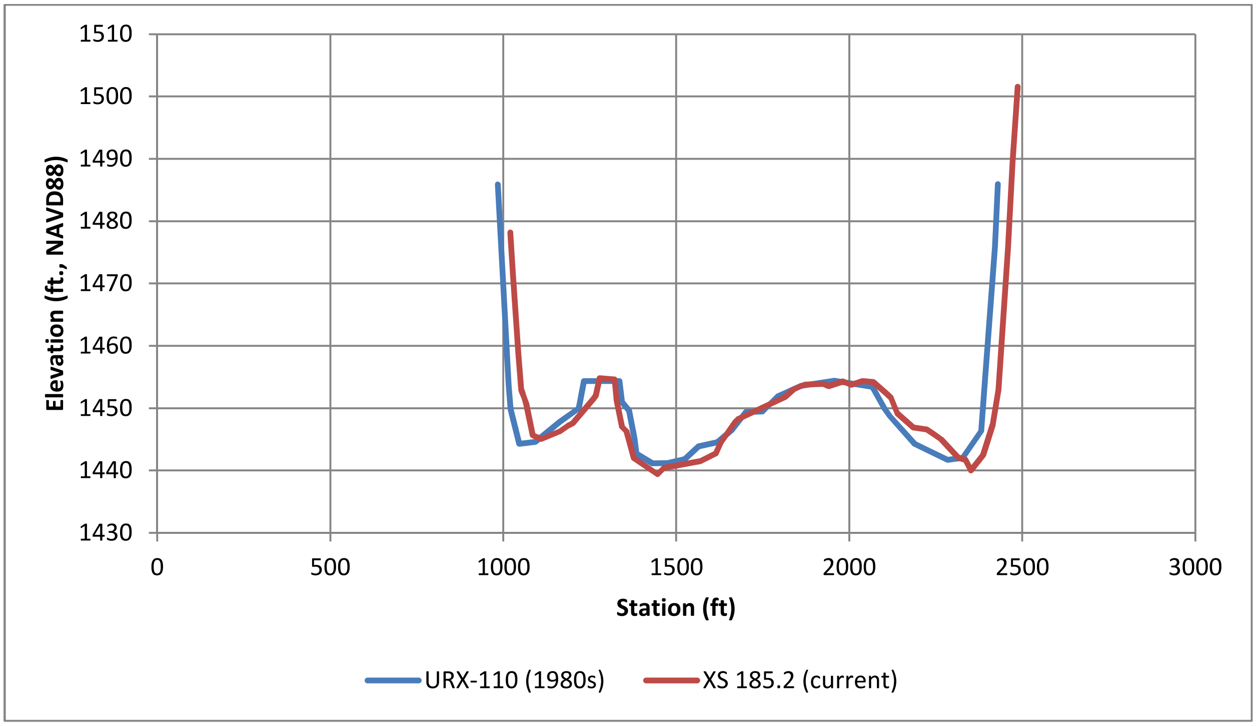

Figure A.3. Cross section comparison of 1980s URX-110 and current XS 185.2

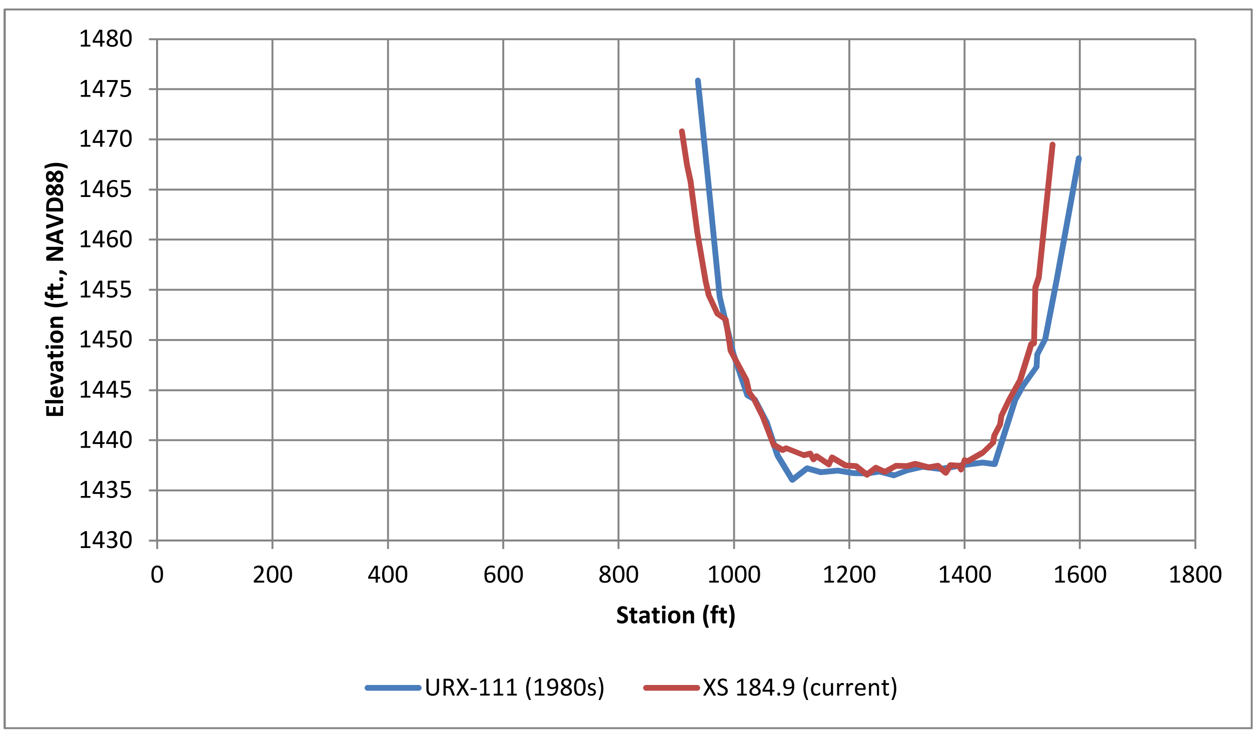

Figure A.4. Cross section comparison of 1980s URX-111 and current XS 184.9

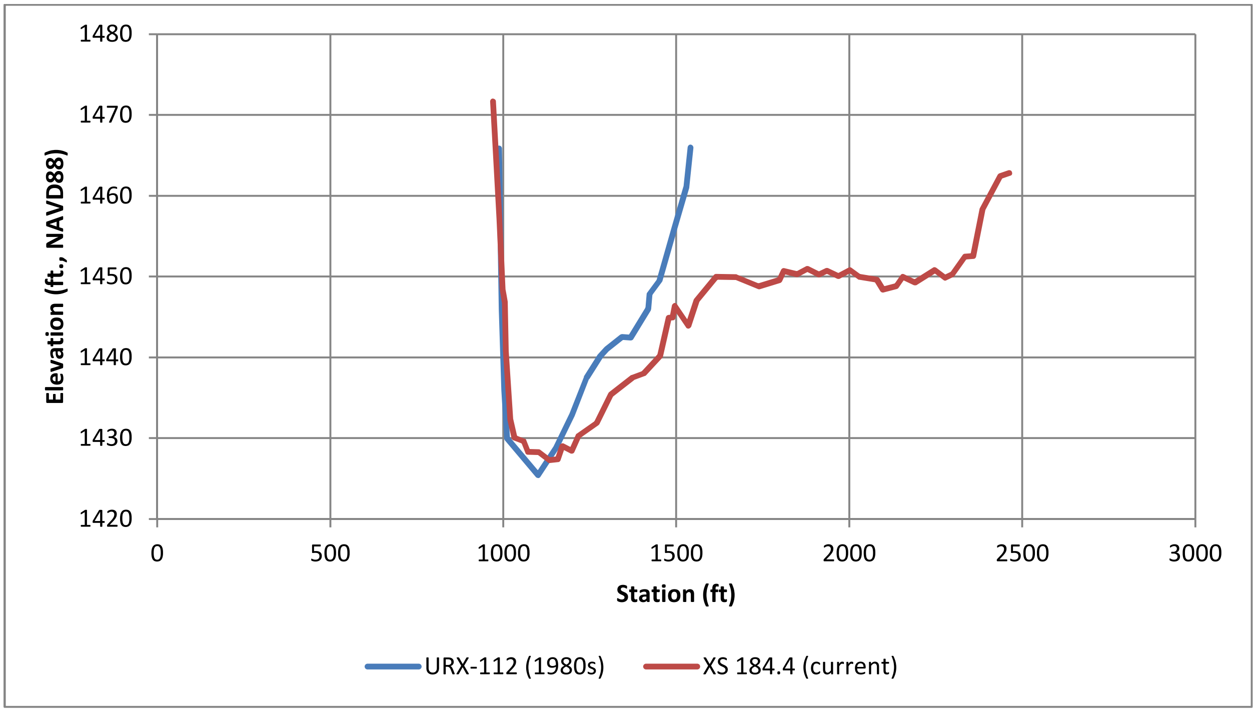

Figure A.5. Cross section comparison of 1980s URX-112 and current XS 184.4

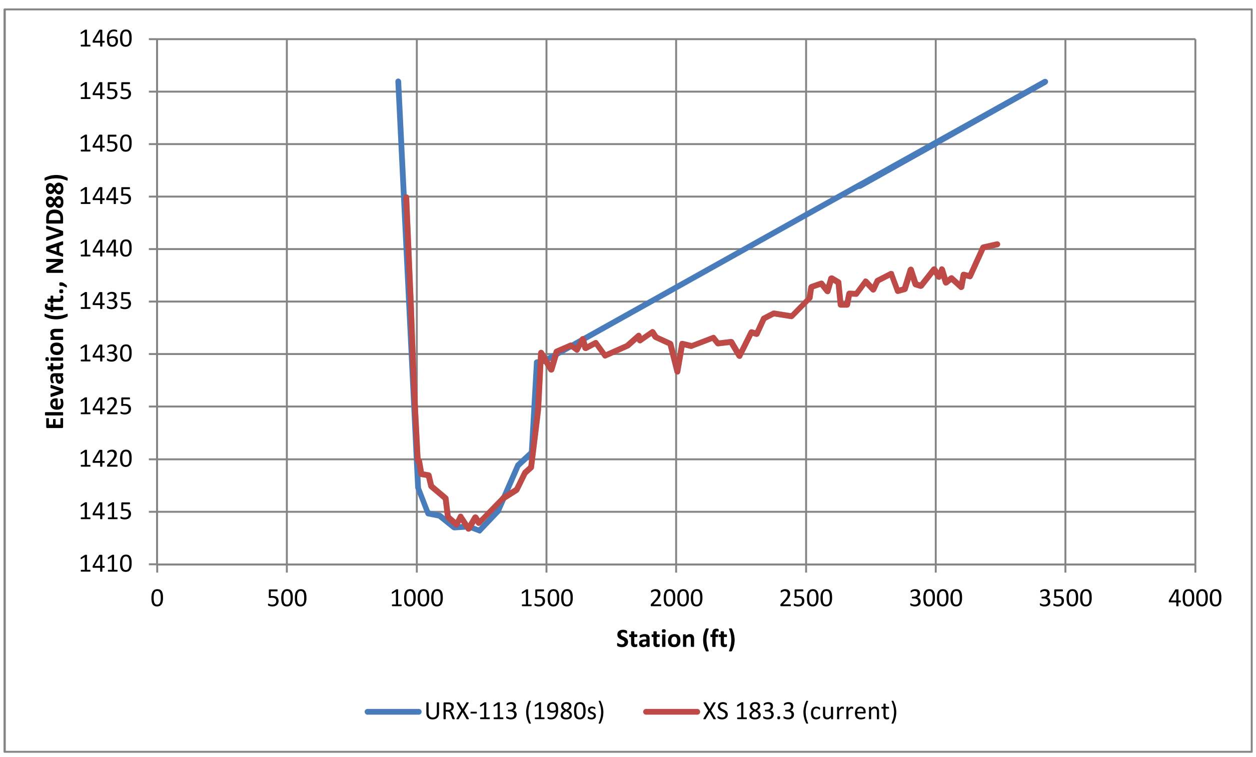

Figure A.6. Cross section comparison of 1980s URX-113 and current XS 183.3

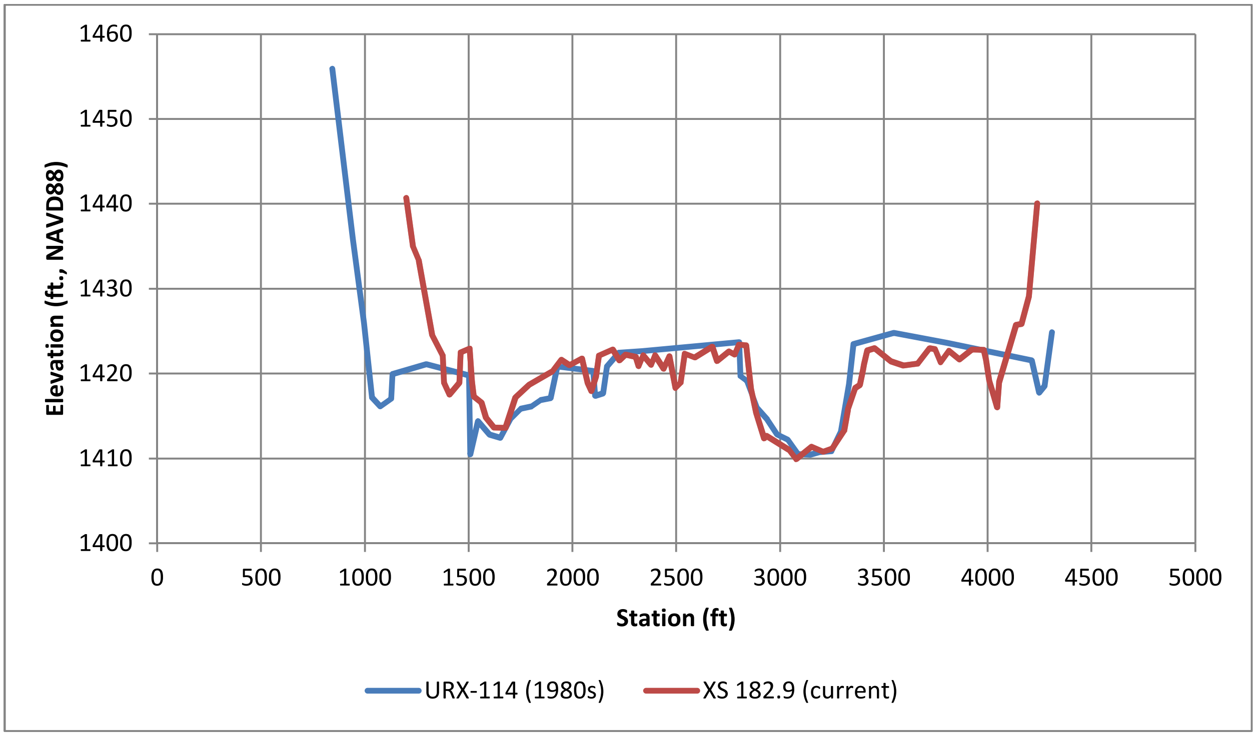

Figure A.7. Cross section comparison of 1980s URX-114 and current XS 182.9

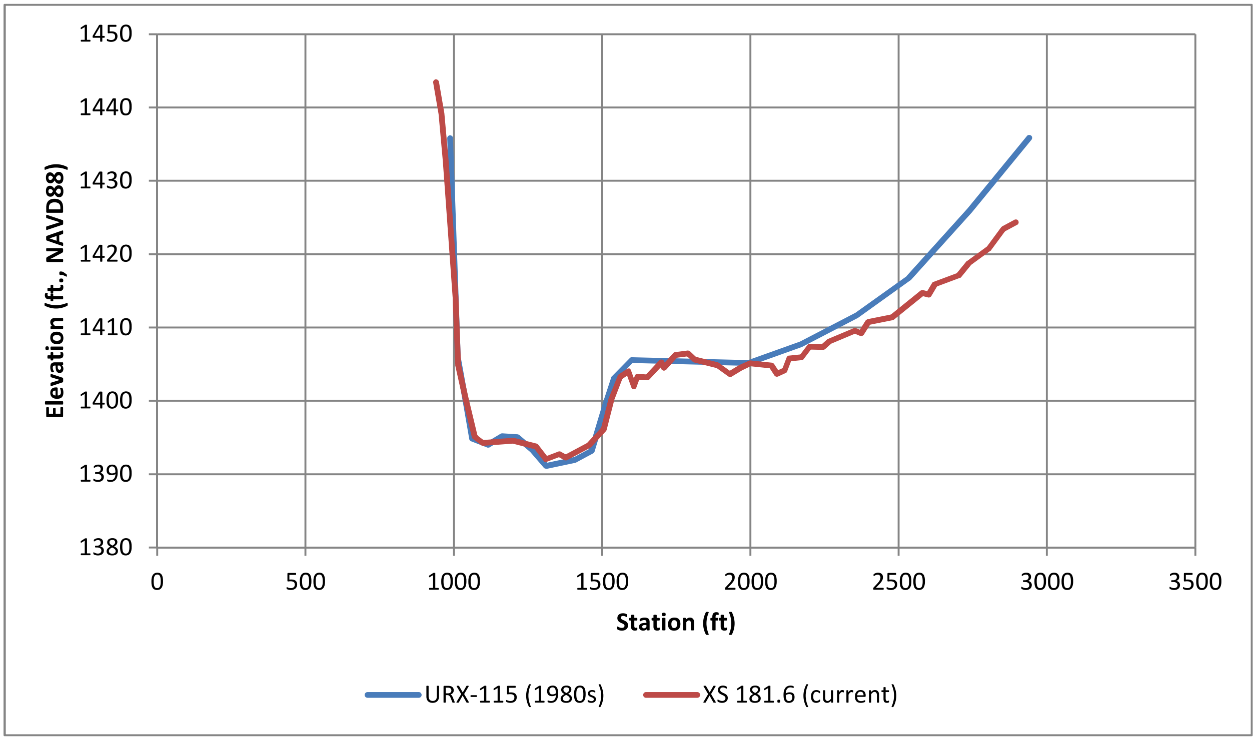

Figure A.8. Cross section comparison of 1980s URX-115 and current XS 181.6

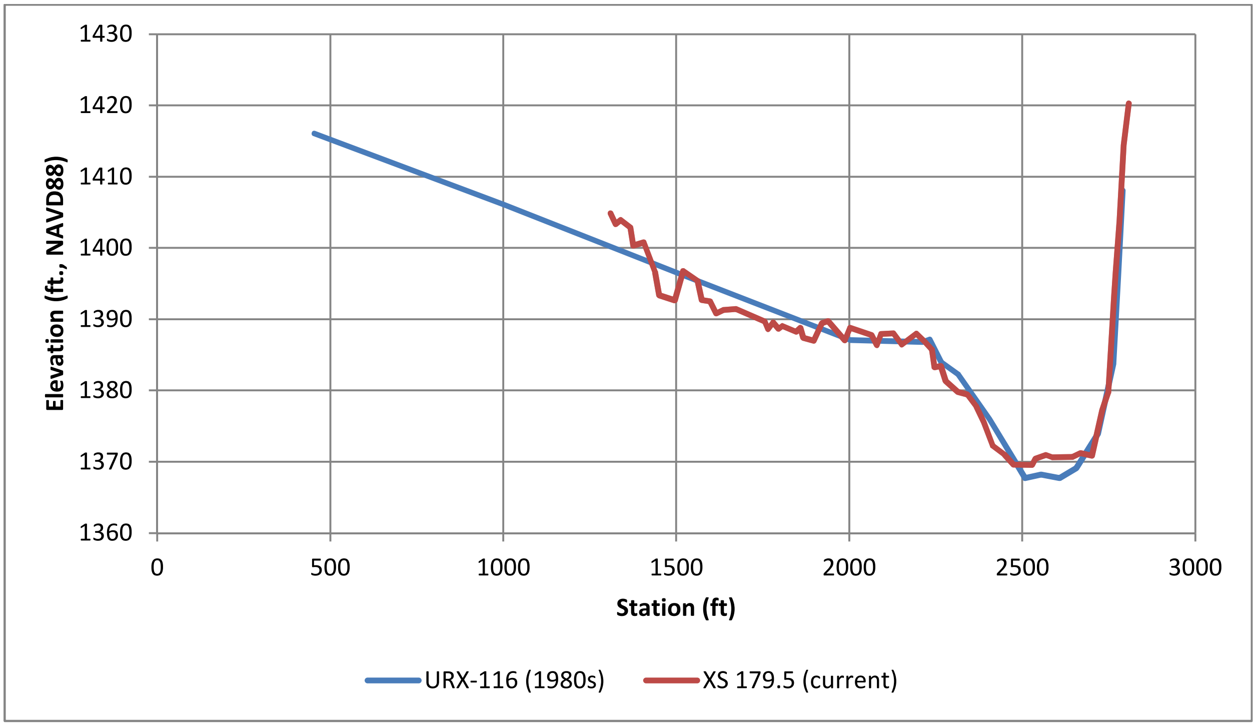

Figure A.9. Cross section comparison of 1980s URX-116 and current XS 179.5

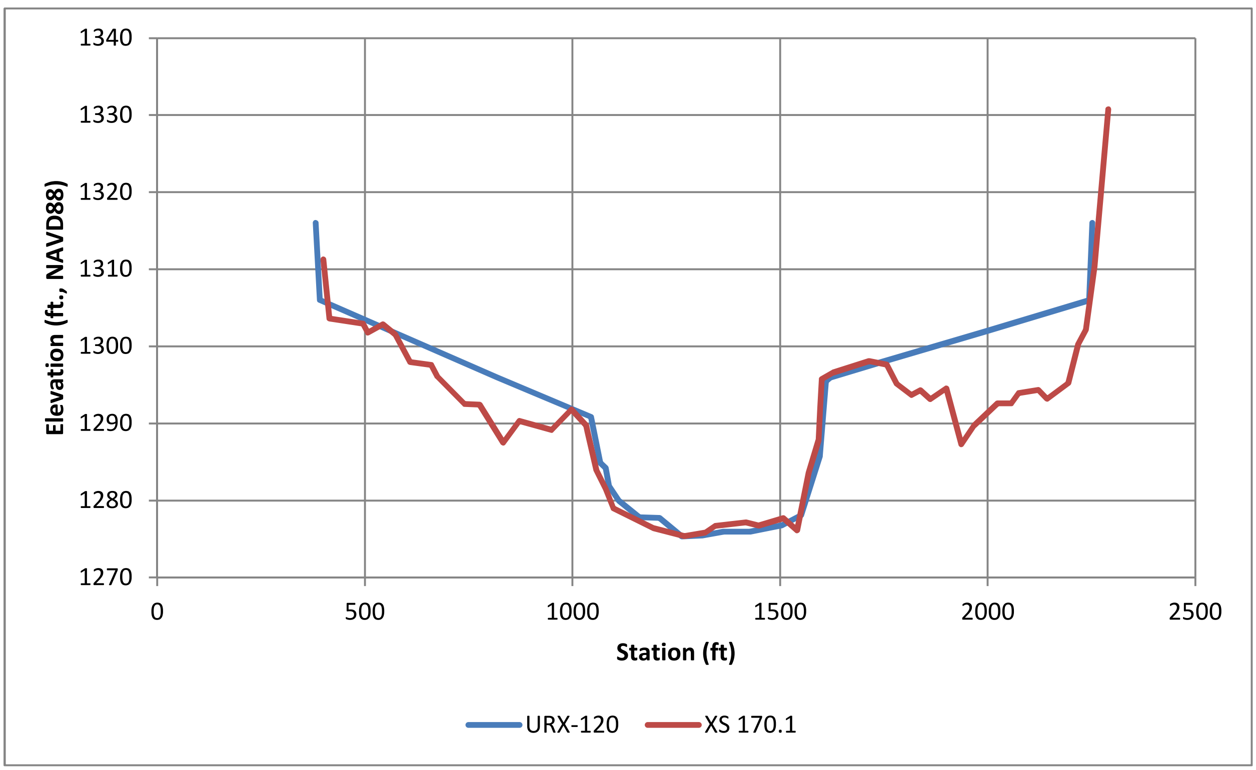

Figure A.10. Cross section comparison of 1980s URX-120 and current XS 170.1

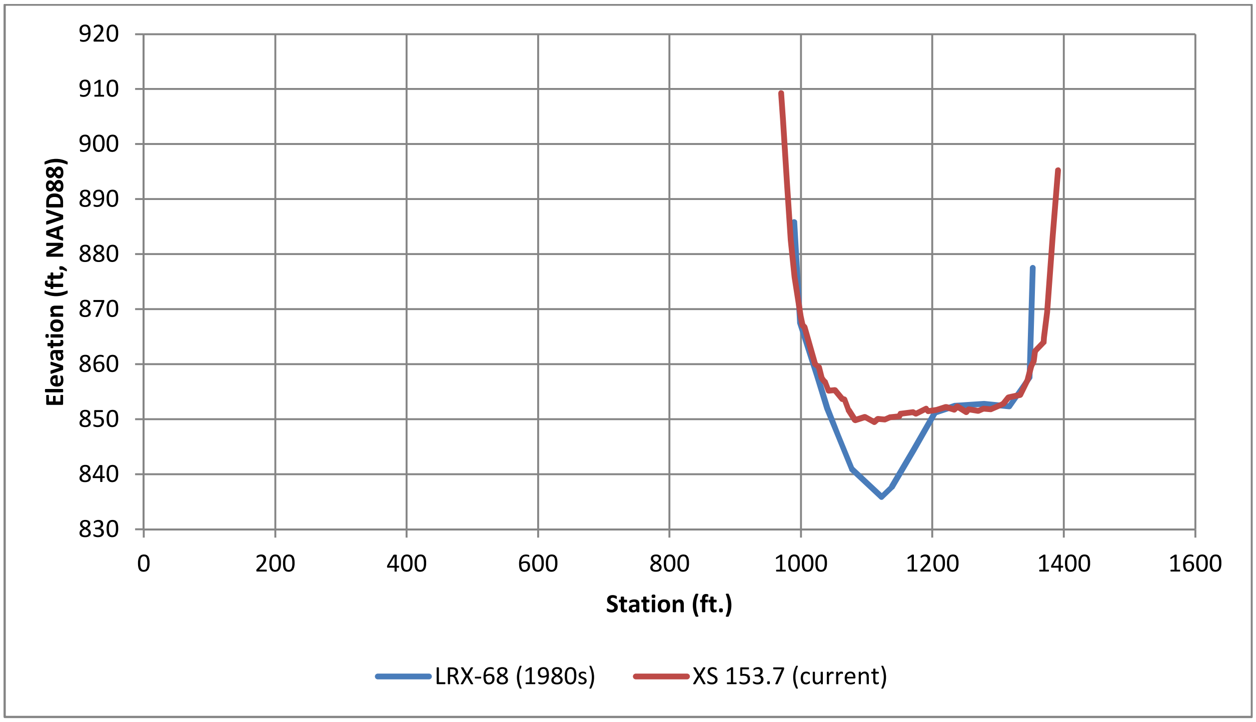

Figure A.11. Cross section comparison of 1980s LRX-68 and current XS 153.7

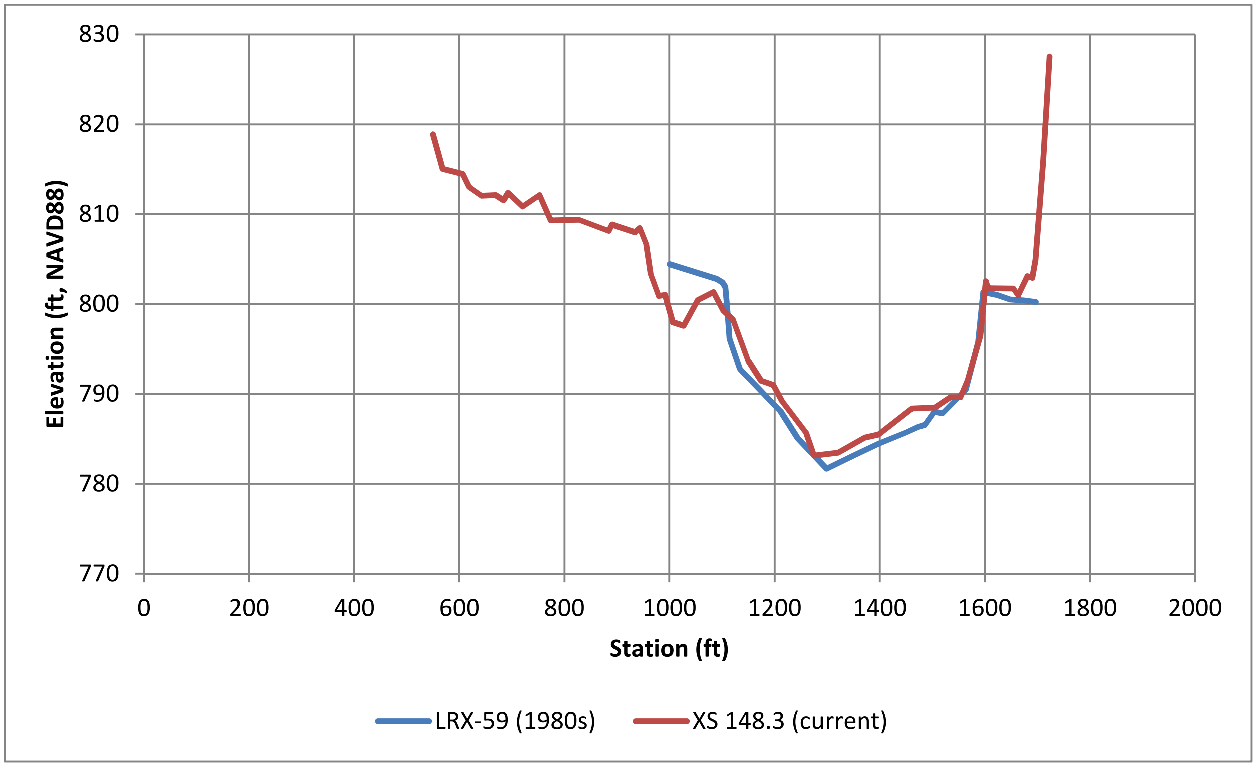

Figure A.12. Cross section comparison of 1980s LRX-59 and current XS 148.3

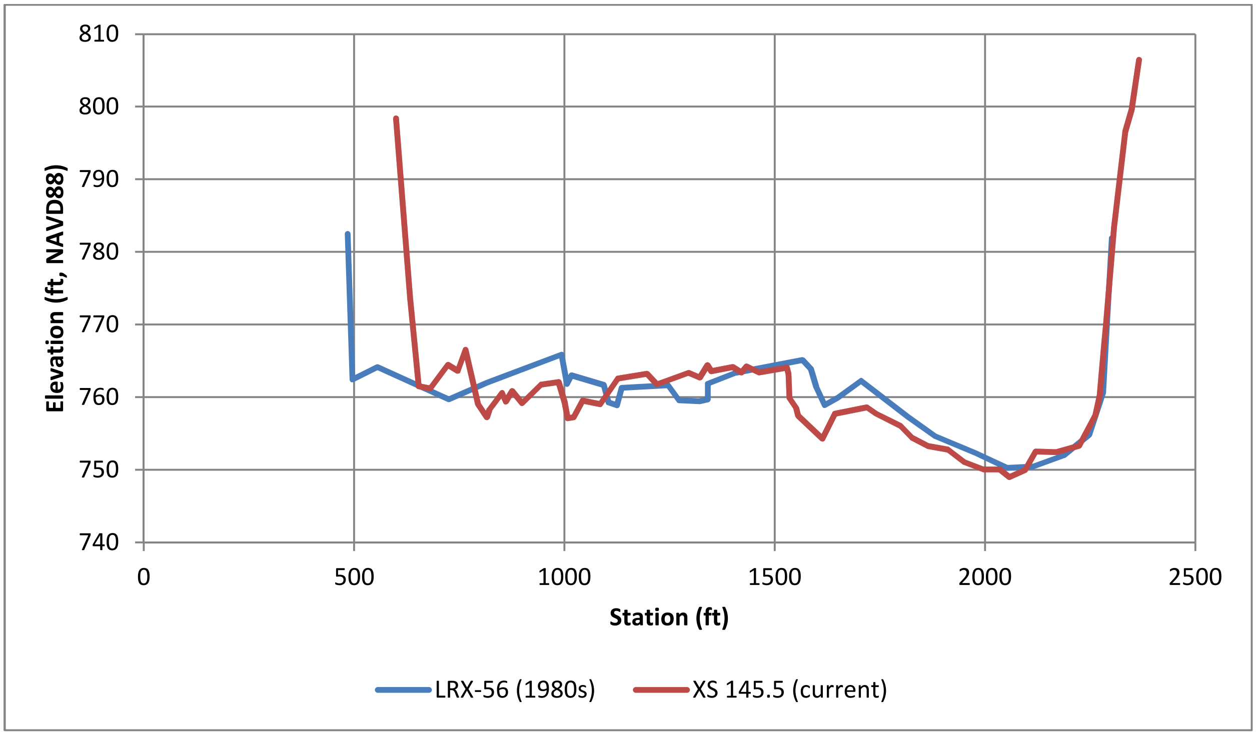

Figure A.13. Cross section comparison of 1980s LRX-56 and current XS 145.5

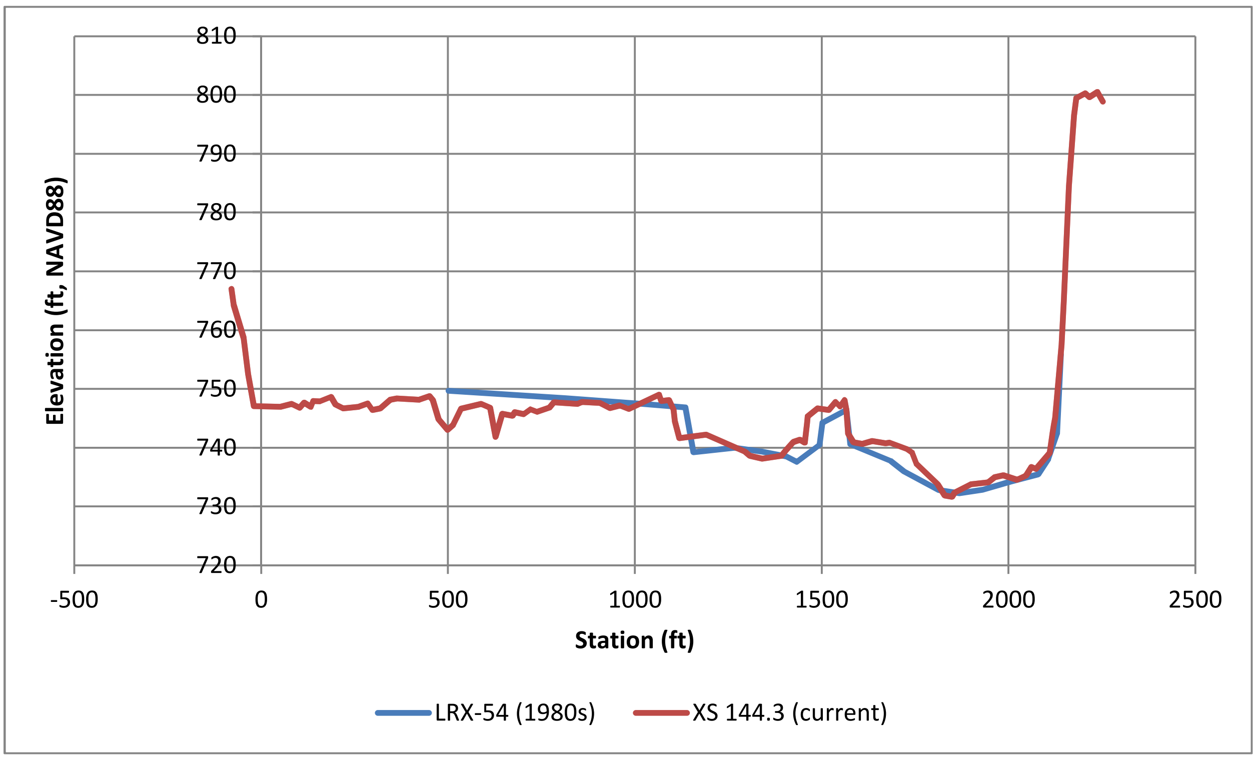

Figure A.14. Cross section comparison of 1980s LRX-54 and current XS 144.3

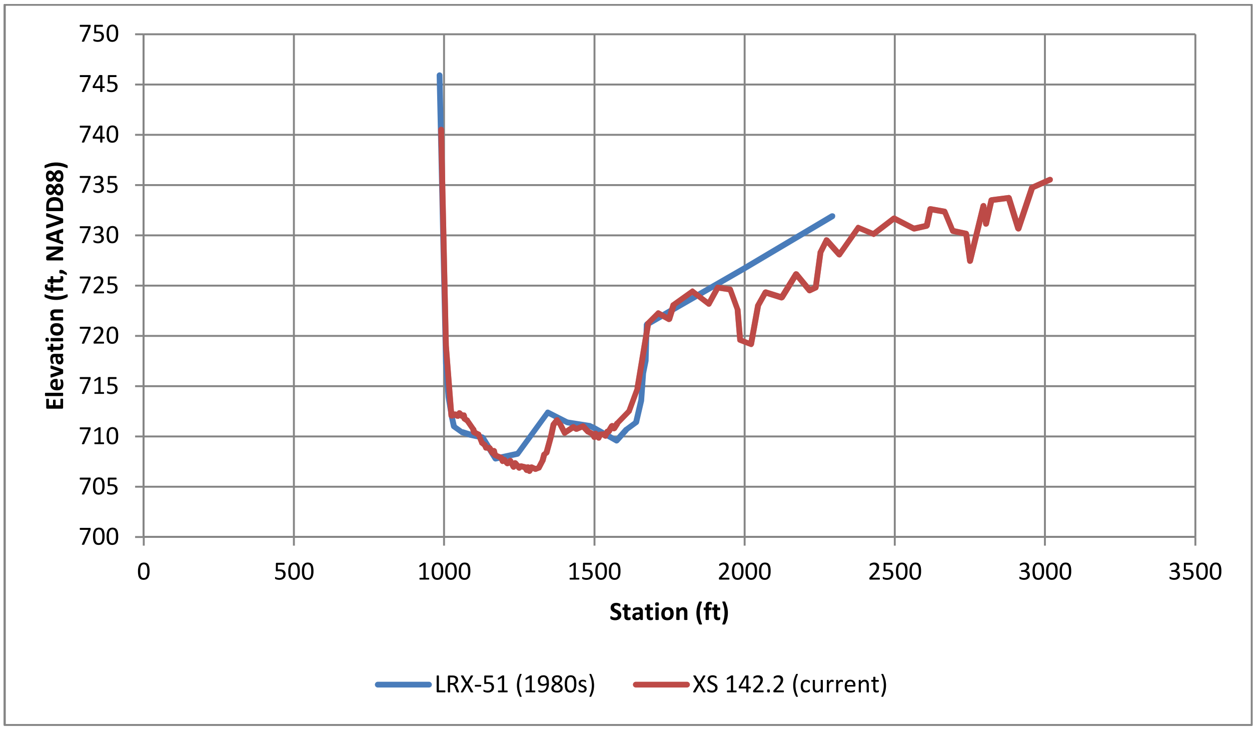

Figure A.15. Cross section comparison of 1980s LRX-51 and current XS 142.2

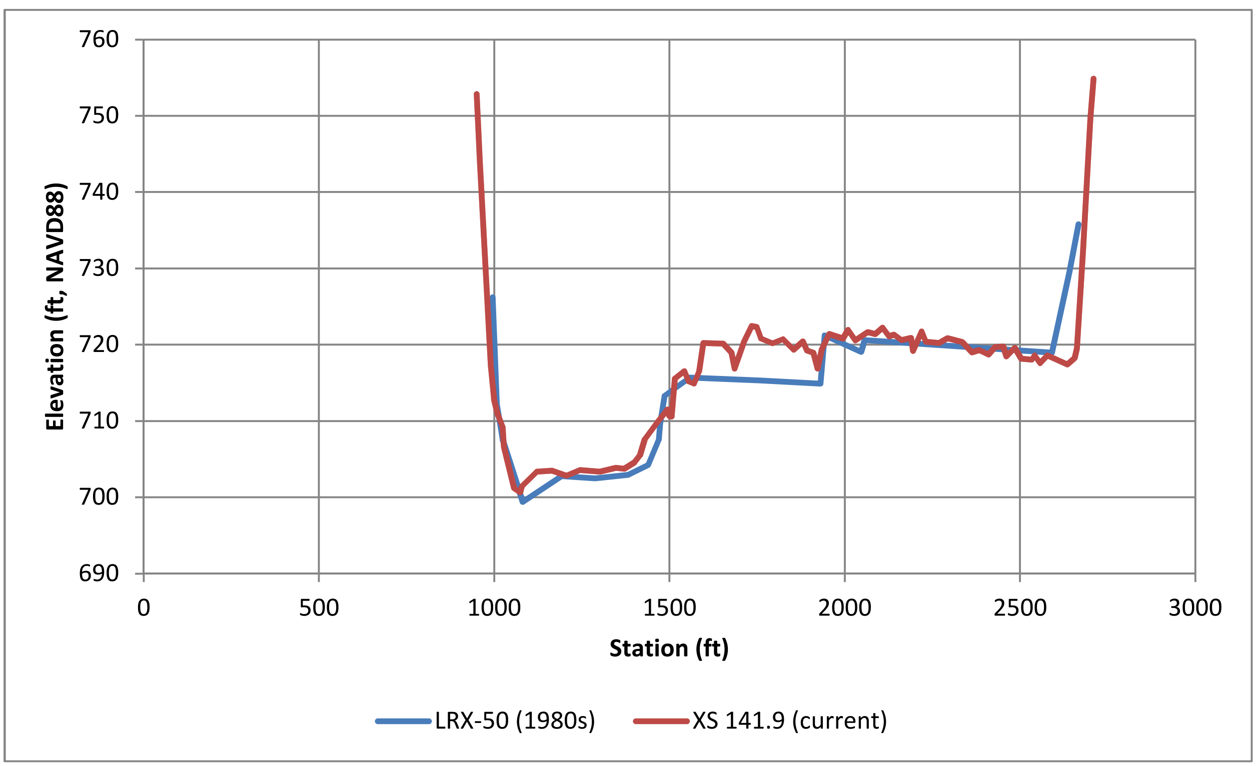

Figure A.16. Cross section comparison of 1980s LRX-50 and current XS 141.9

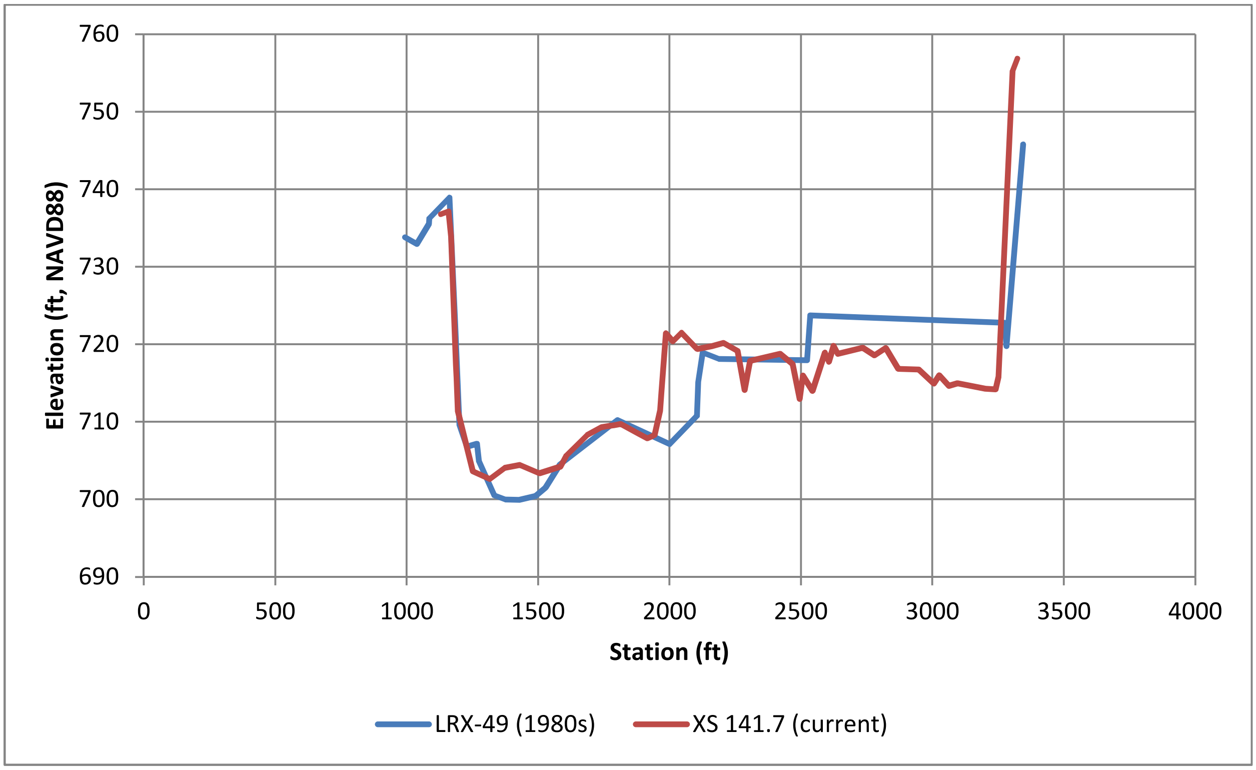

Figure A.17. Cross section comparison of 1980s LRX-49 and current XS 141.7

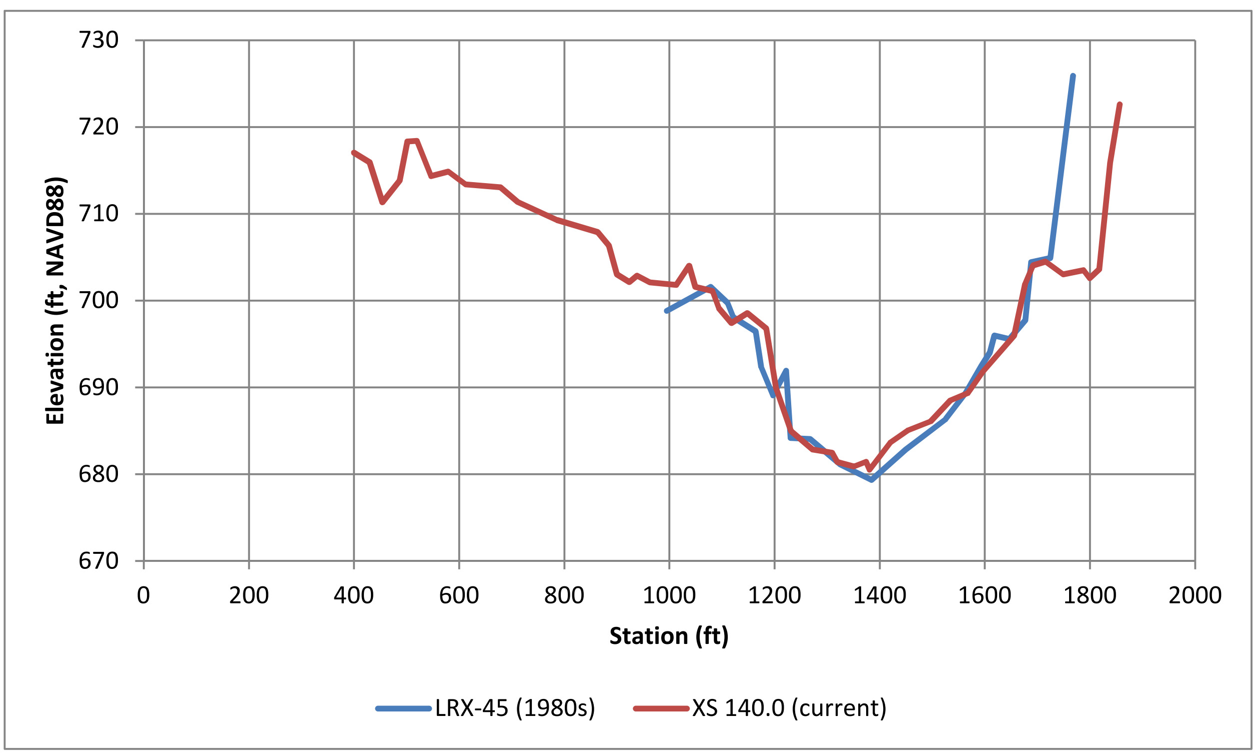

Figure A.18. Cross section comparison of 1980s LRX-45 and current XS 140.0

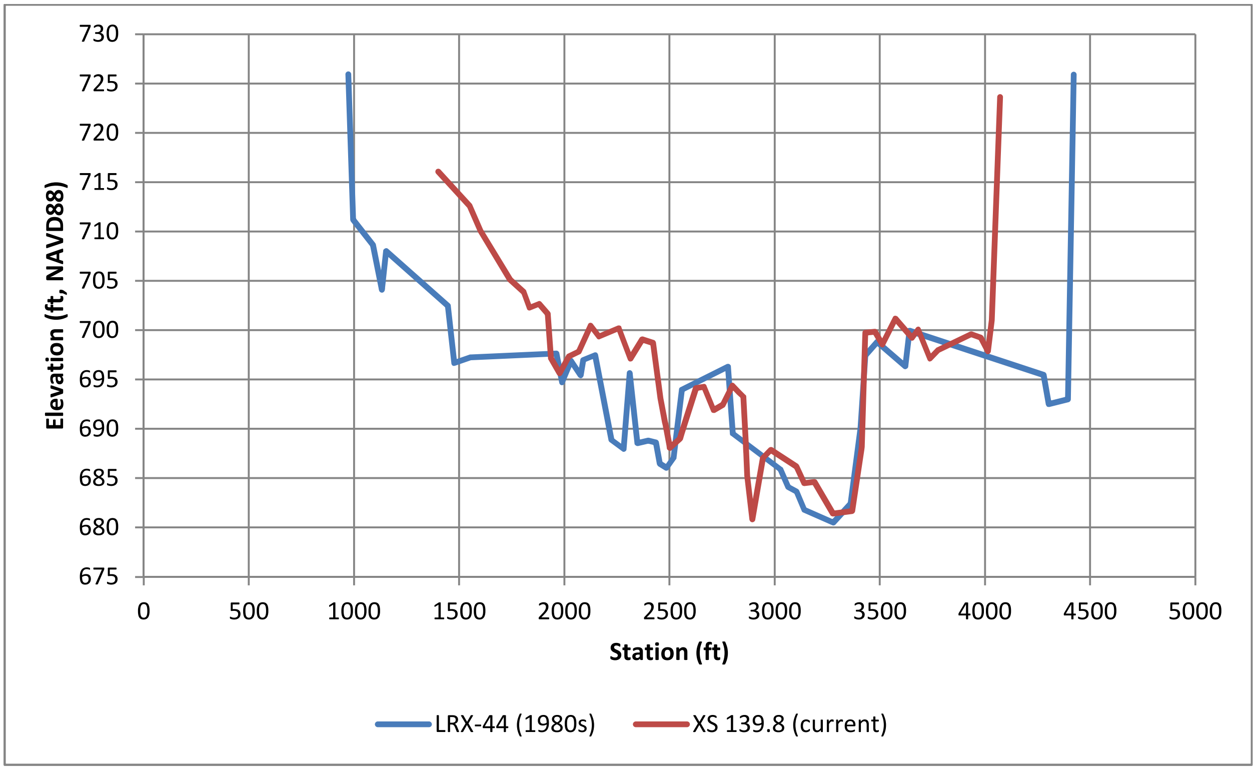

Figure A.19. Cross section comparison of 1980s LRX-44 and current XS 139.8

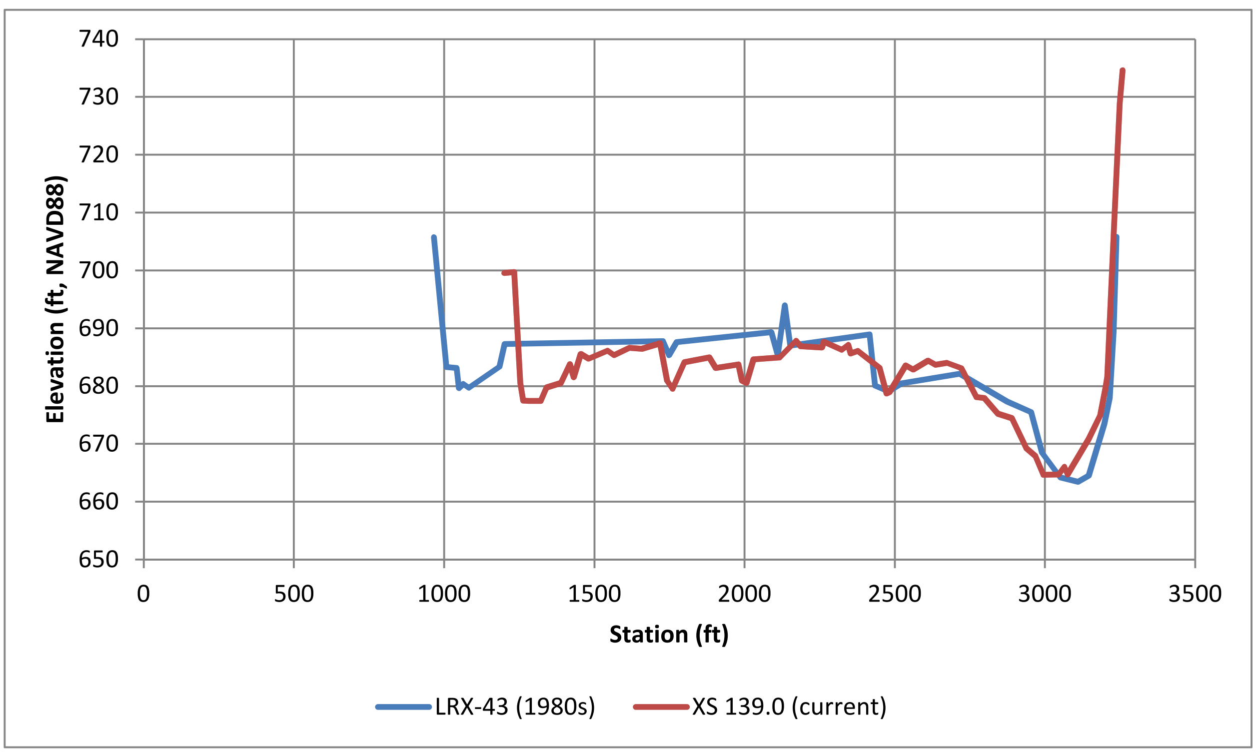

Figure A.20. Cross section comparison of 1980s URX-43 and current XS 139.0

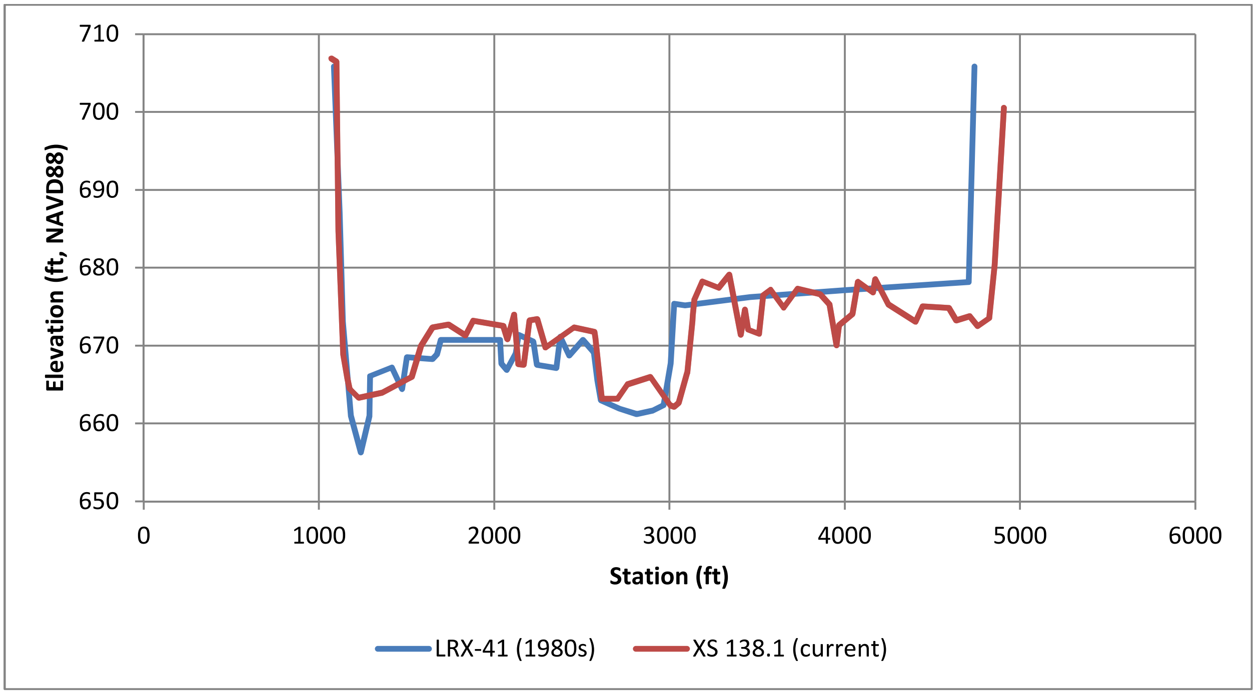

Figure A.21. Cross section comparison of 1980s LRX-41 and current XS 138.1

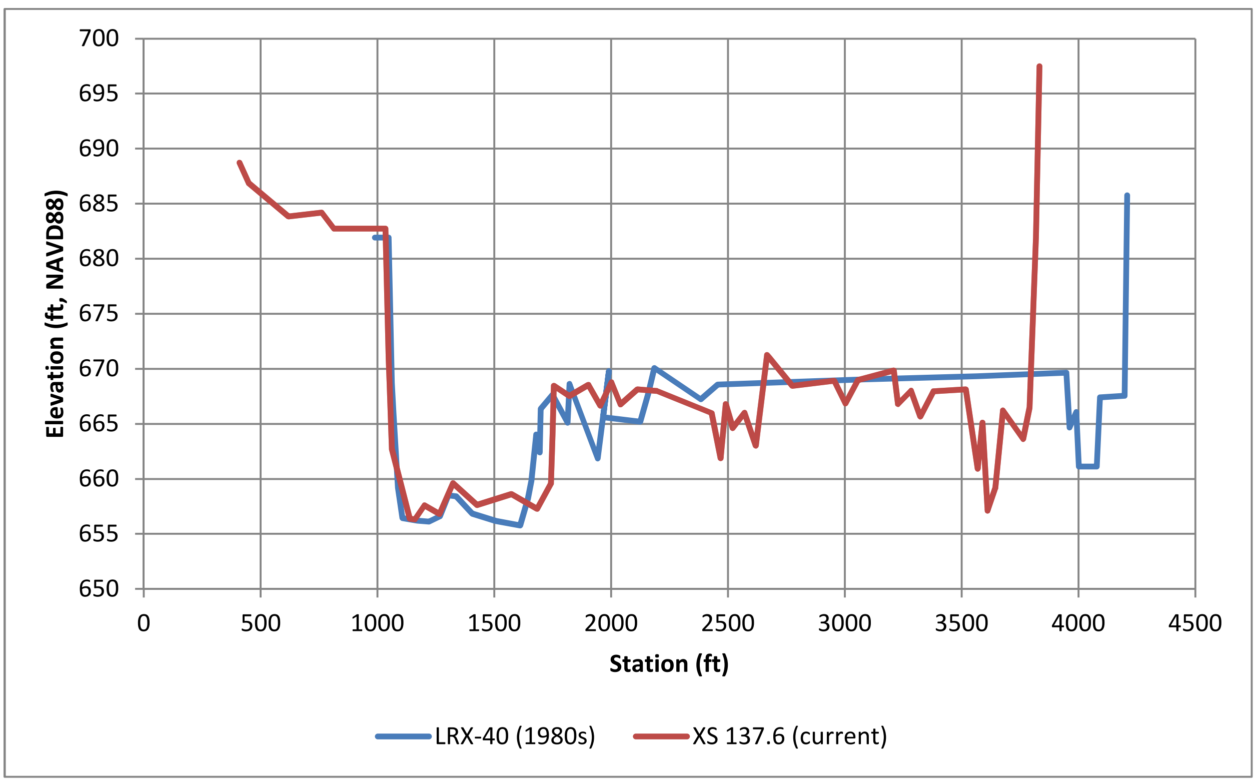

Figure A.22. Cross section comparison of 1980s LRX-40 and current XS 137.6

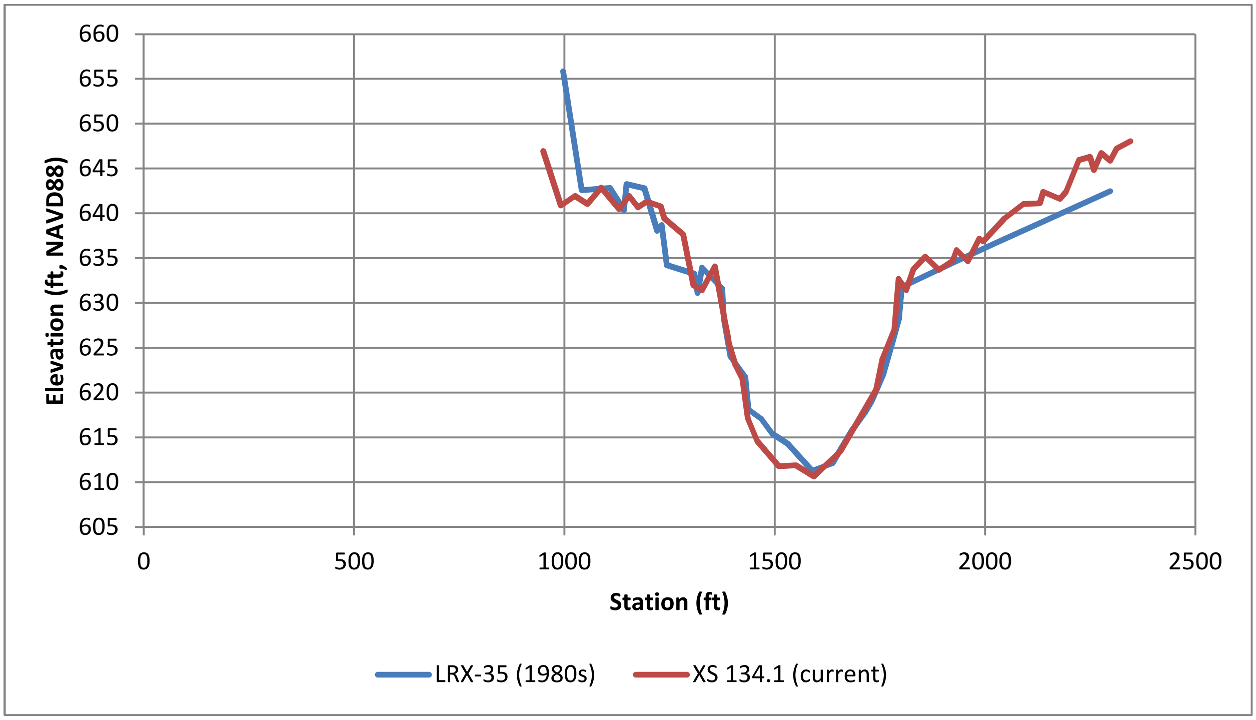

Figure A.23. Cross section comparison of 1980s LRX-35 and current XS 134.1

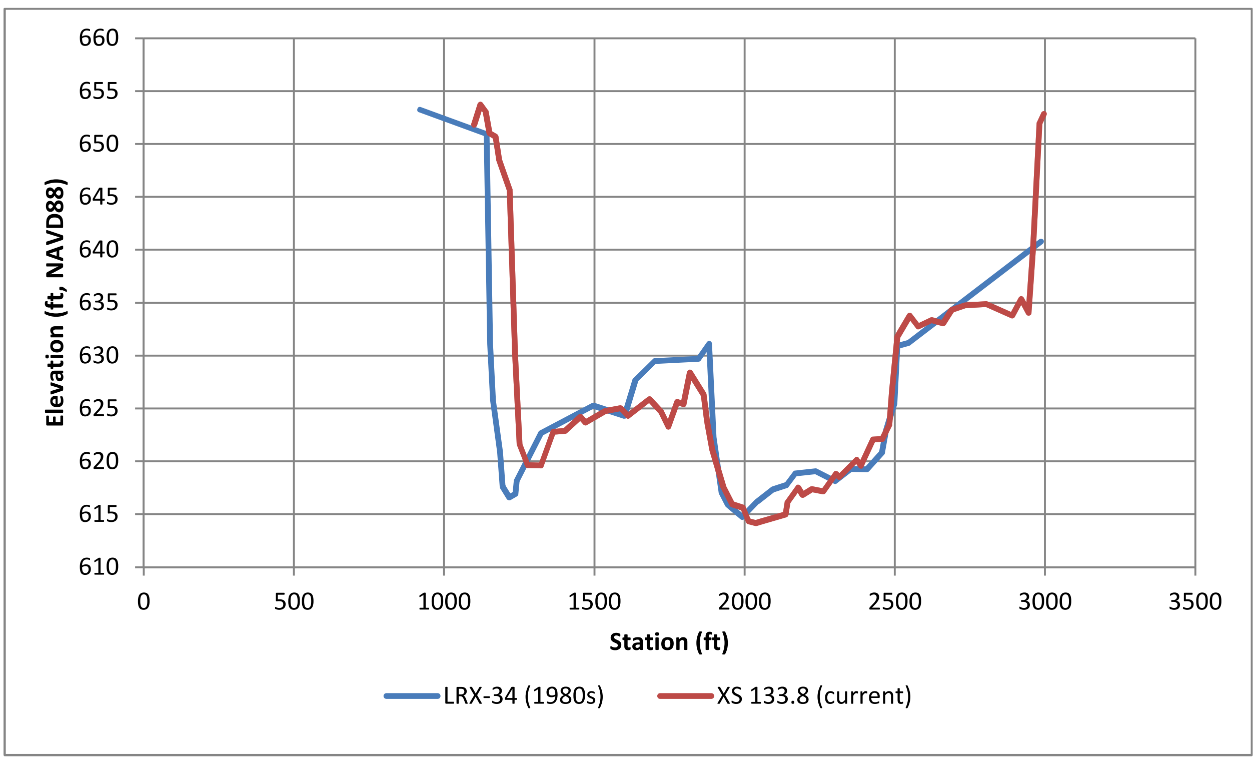

Figure A.24. Cross section comparison of 1980s LRX-34 and current XS 133.8

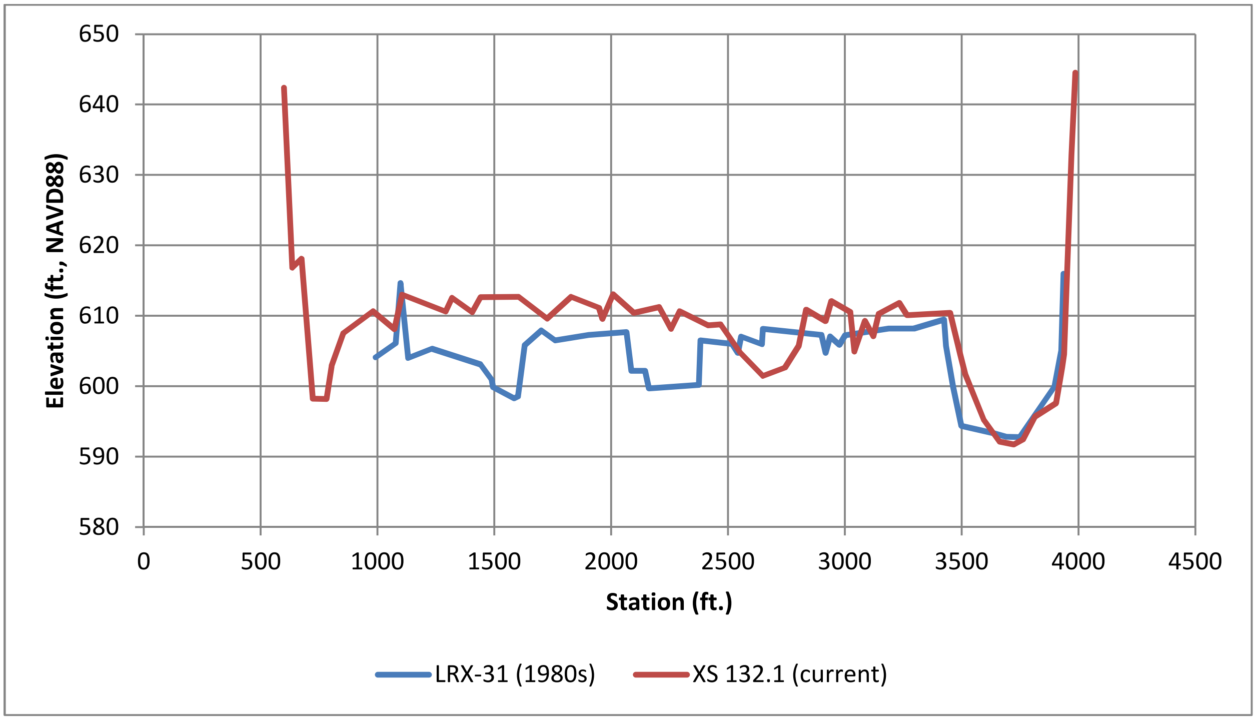

Figure A.25. Cross section comparison of 1980s LRX-31 and current XS 132.1

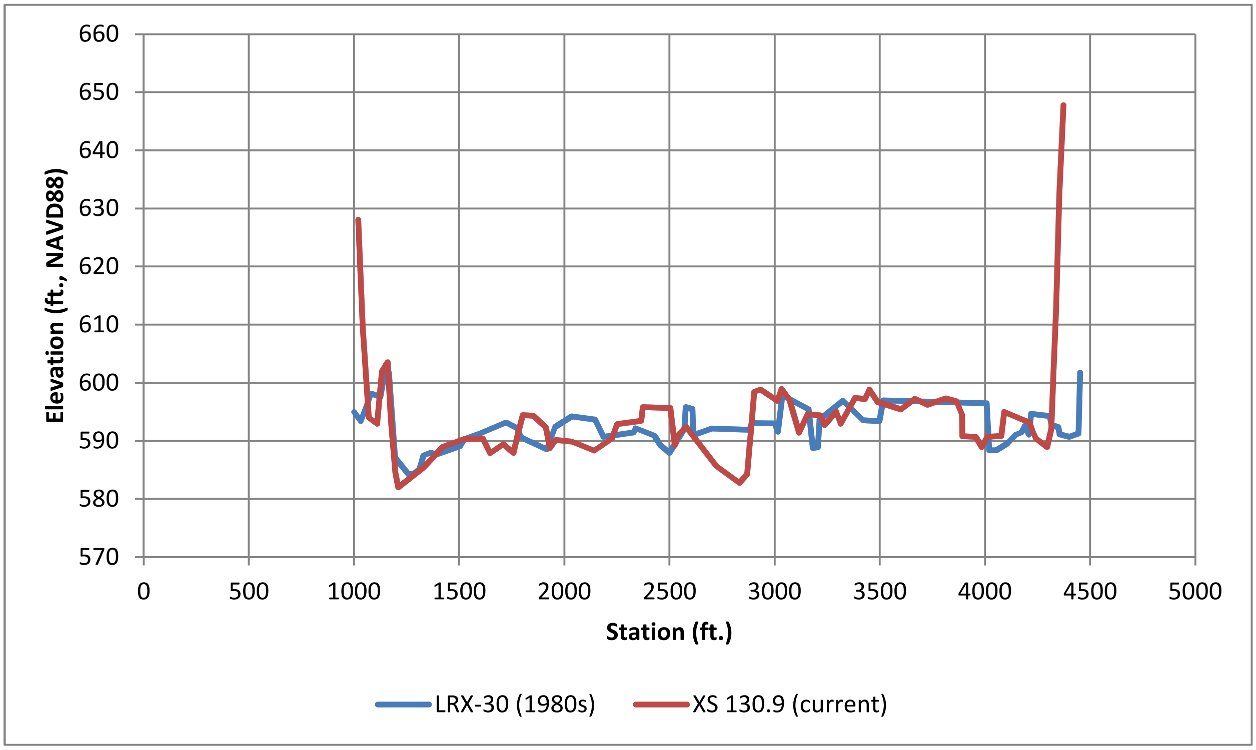

Figure A.26. Cross section comparison of 1980s LRX-30 and current XS 130.9

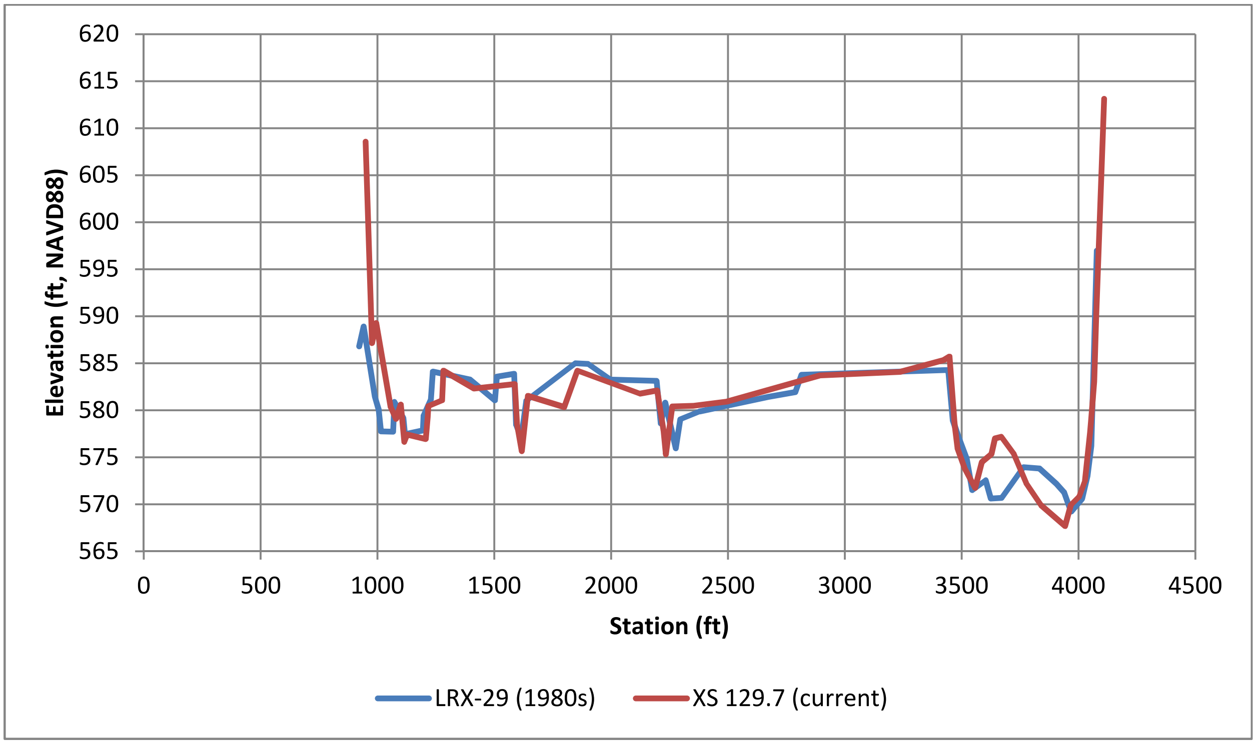

Figure A.27. Cross section comparison of 1980s LRX-29 and current XS 129.7

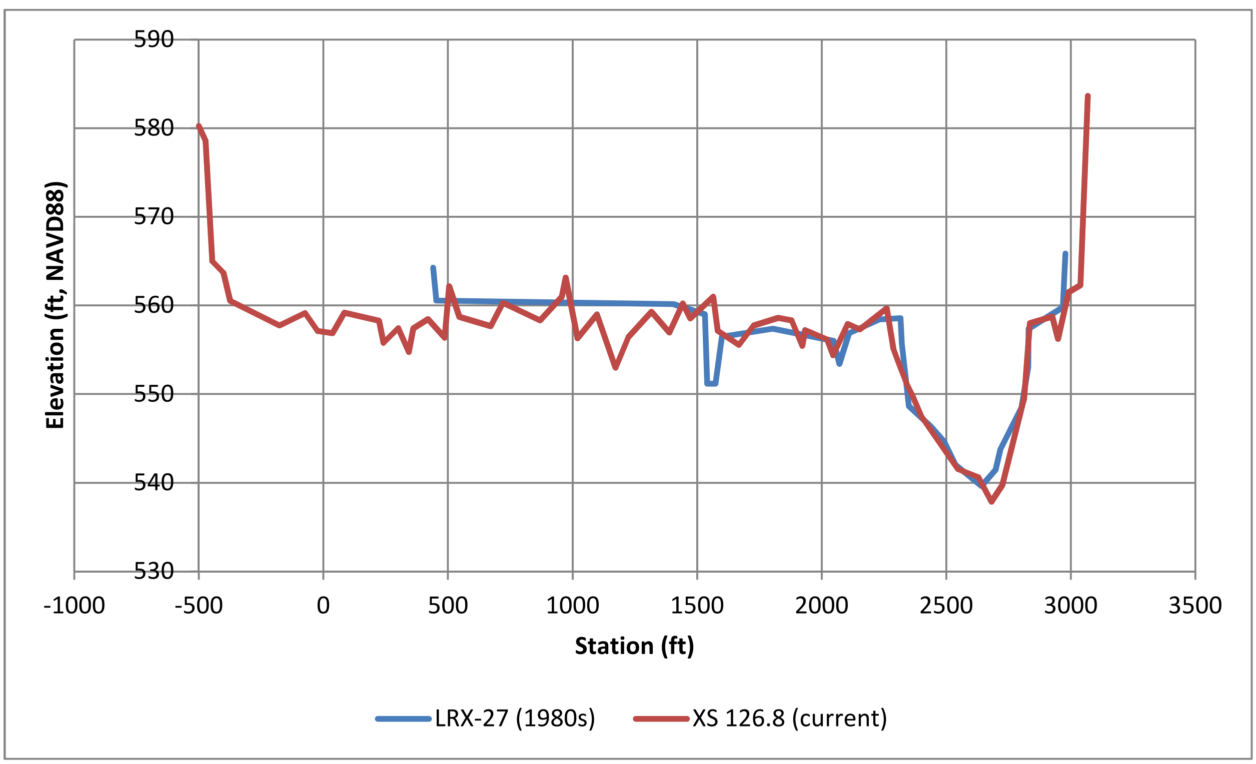

Figure A.28. Cross section comparison of 1980s LRX-27 and current XS 126.8

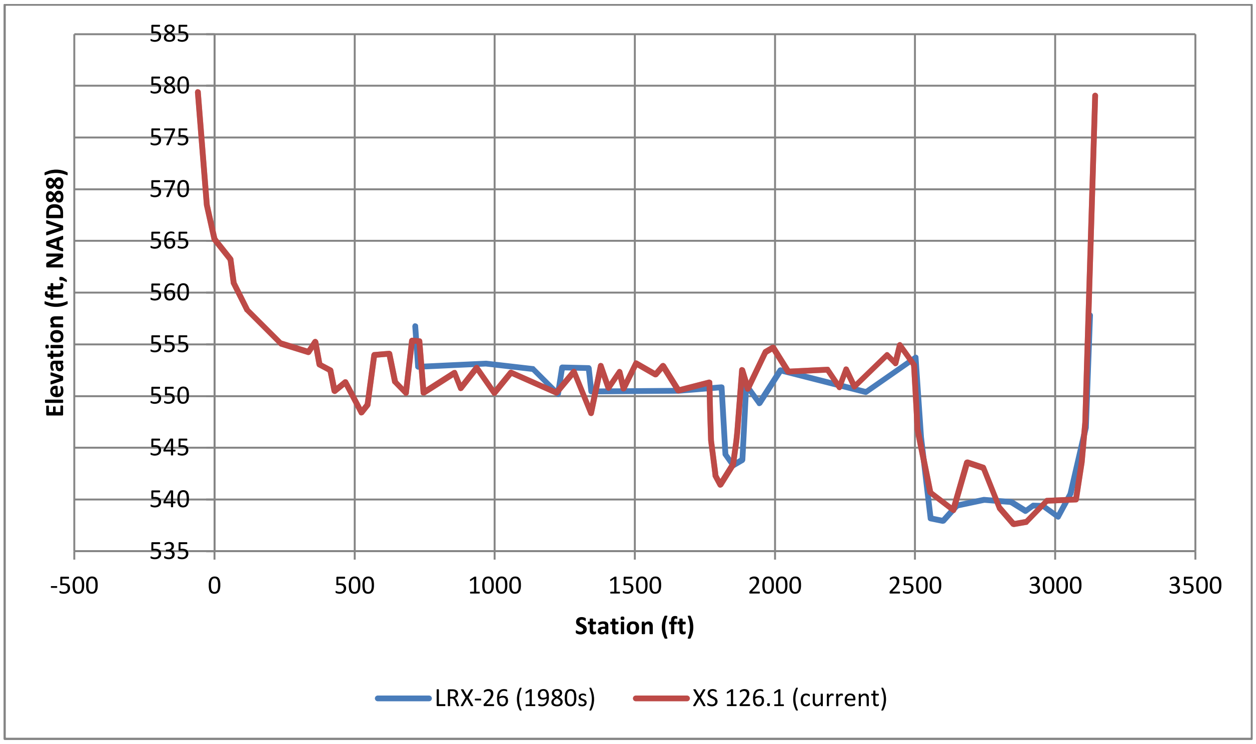

Figure A.29. Cross section comparison of 1980s LRX-26 and current XS 126.1

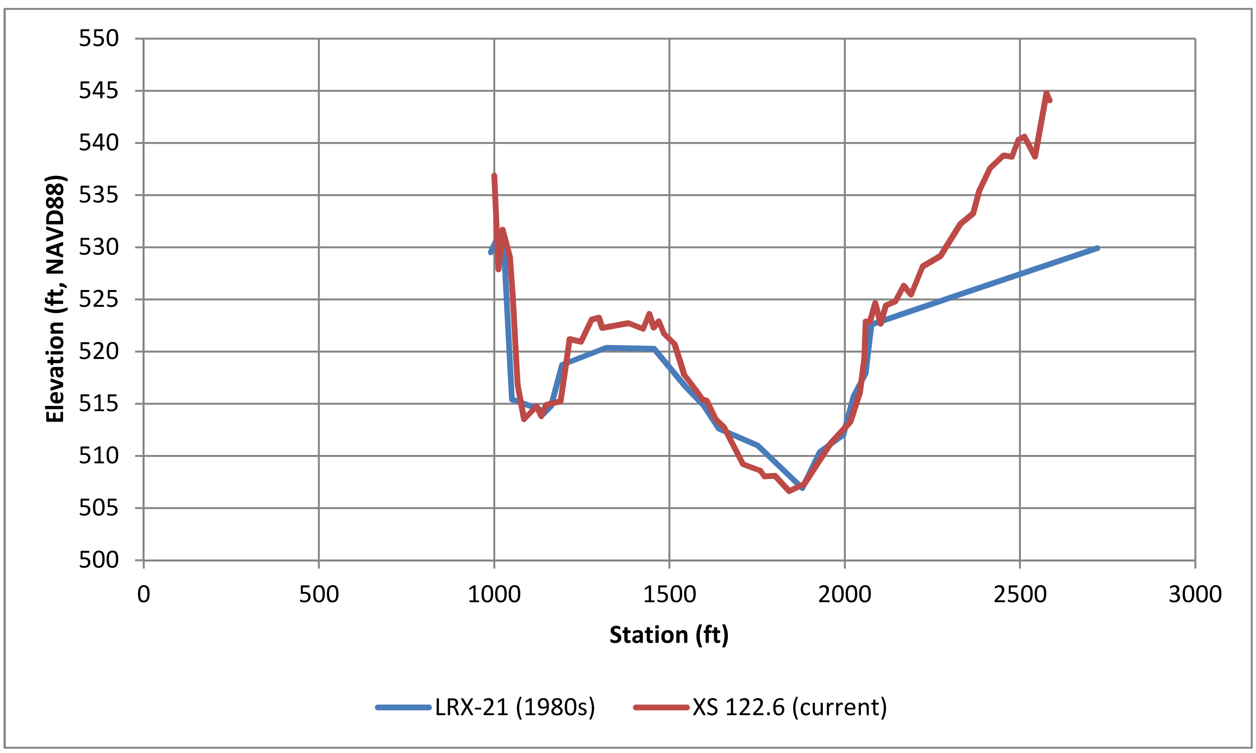

Figure A.30. Cross section comparison of 1980s LRX-21 and current XS 122.6

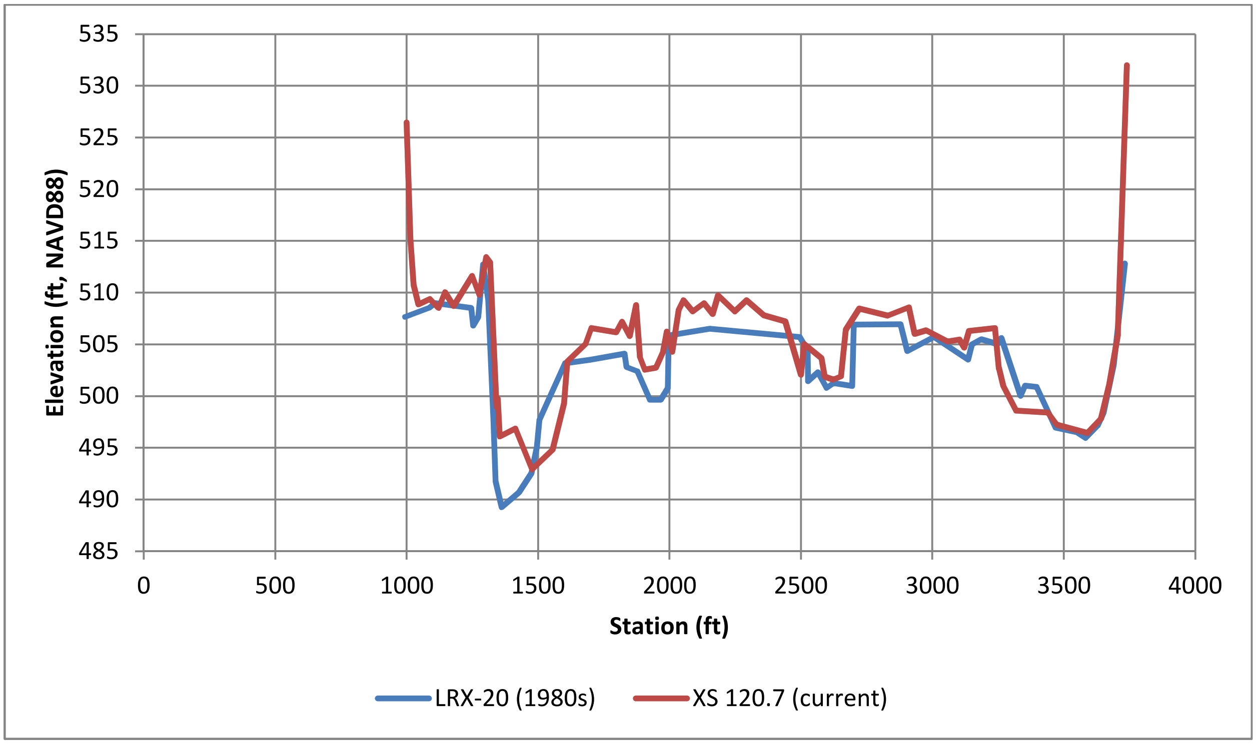

Figure A.31. Cross section comparison of 1980s LRX-20 and current XS 120.7

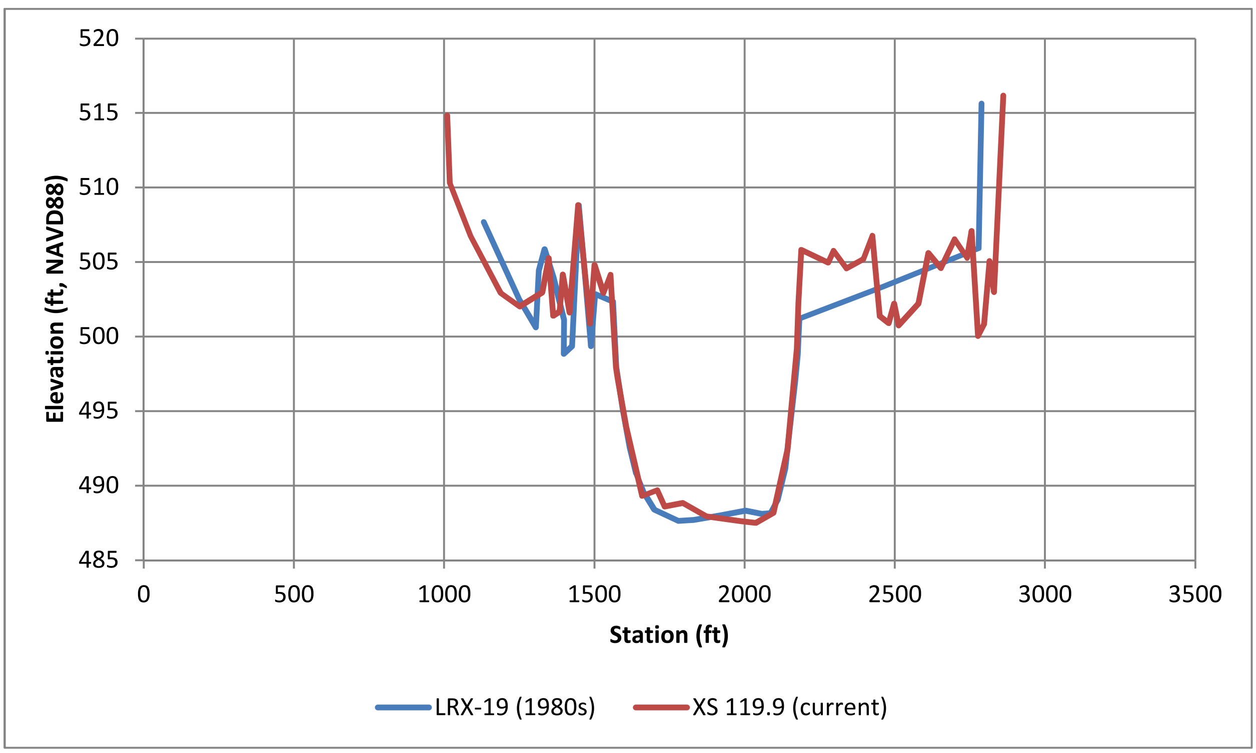

Figure A.32. Cross section comparison of 1980s LRX-19 and current XS 119.9

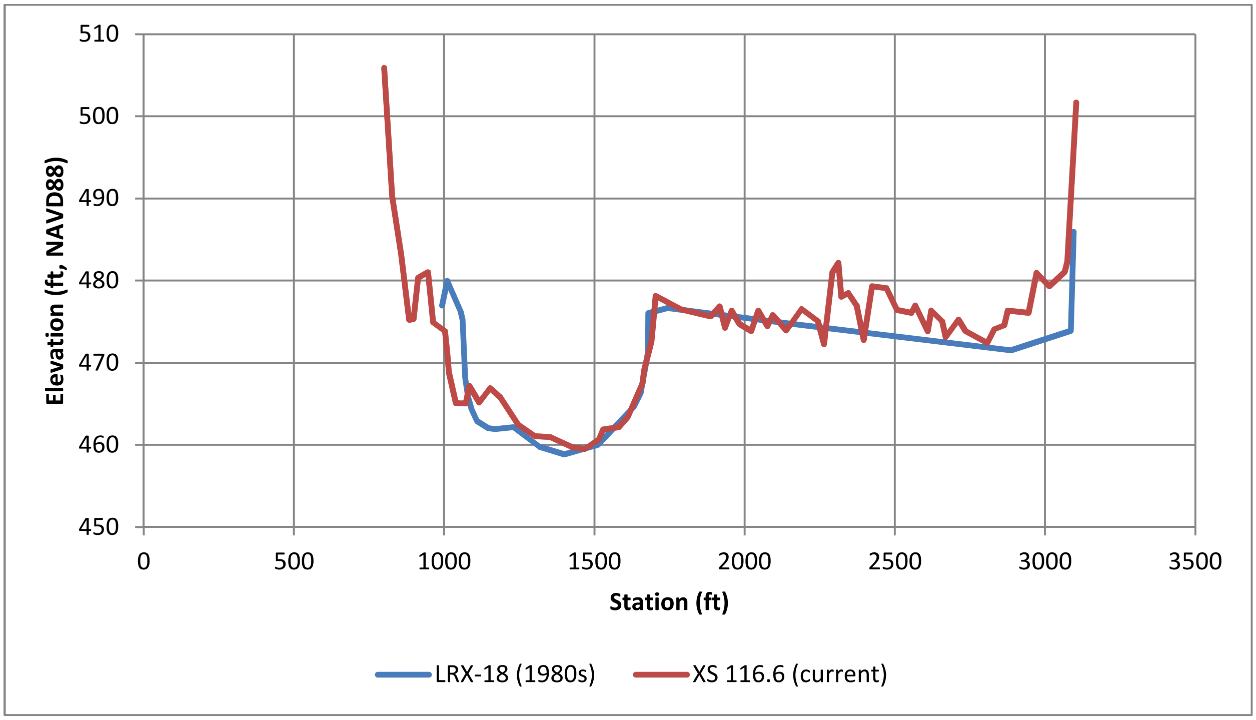

Figure A.33. Cross section comparison of 1980s LRX-18 and current XS 116.6

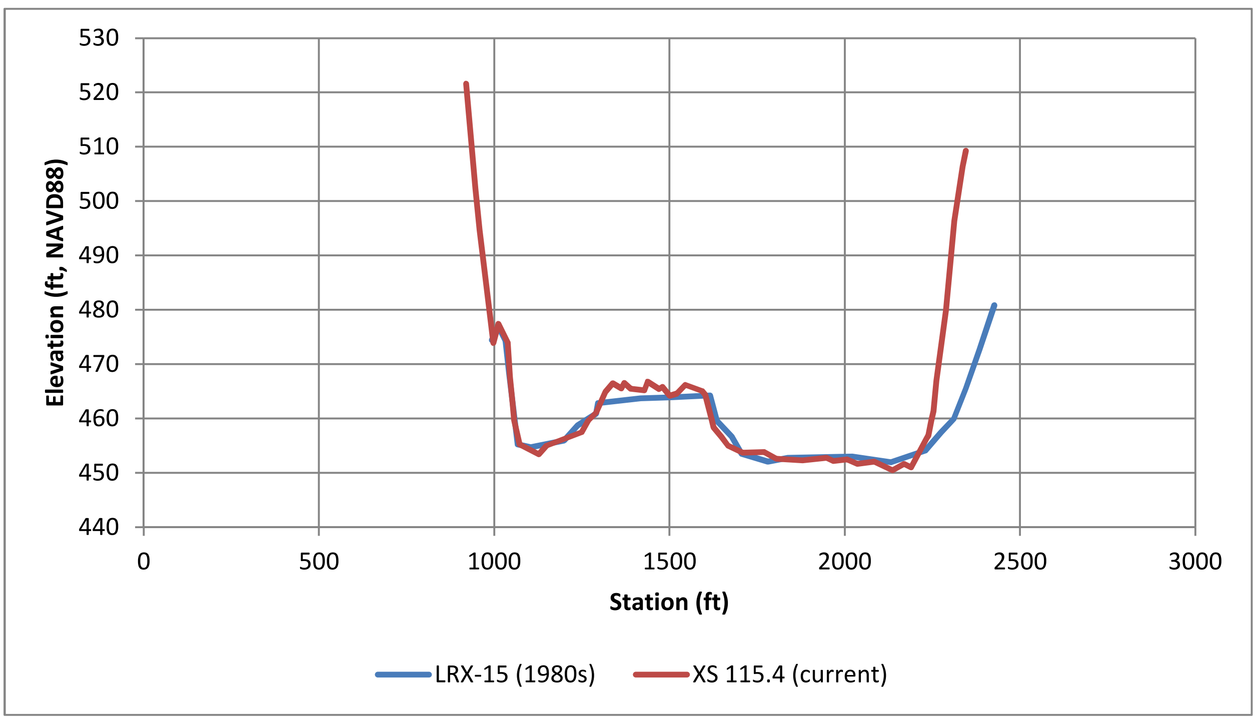

Figure A.34. Cross section comparison of 1980s LRX-15 and current XS 115.4

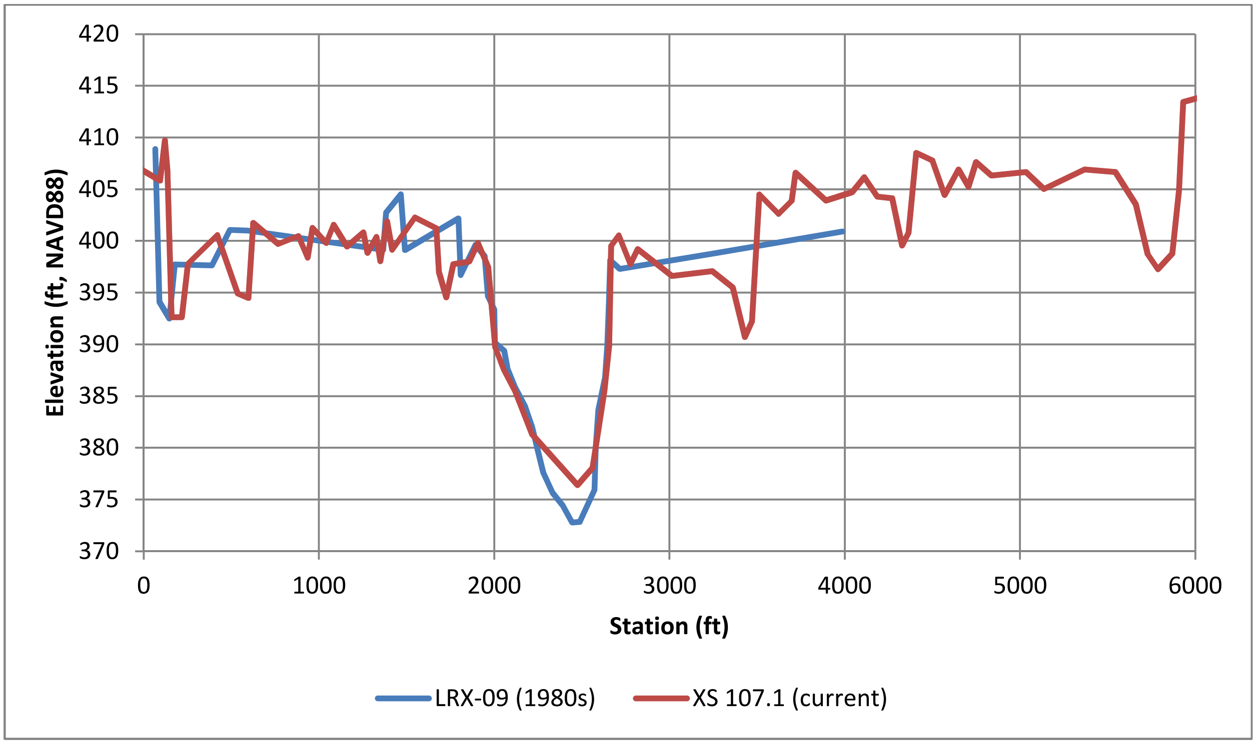

Figure A.35. Cross section comparison of 1980s LRX-09 and current XS 107.1

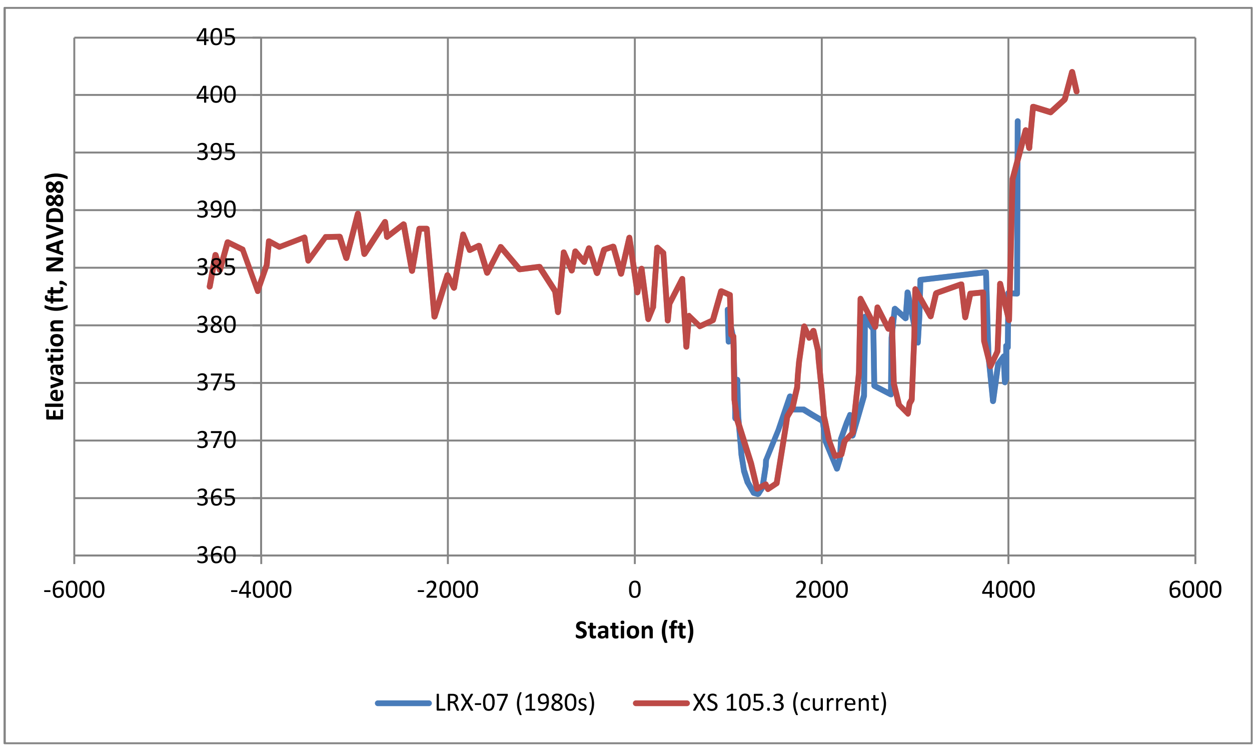

Figure A.36. Cross section comparison of 1980s LRX-07 and current XS 105.3

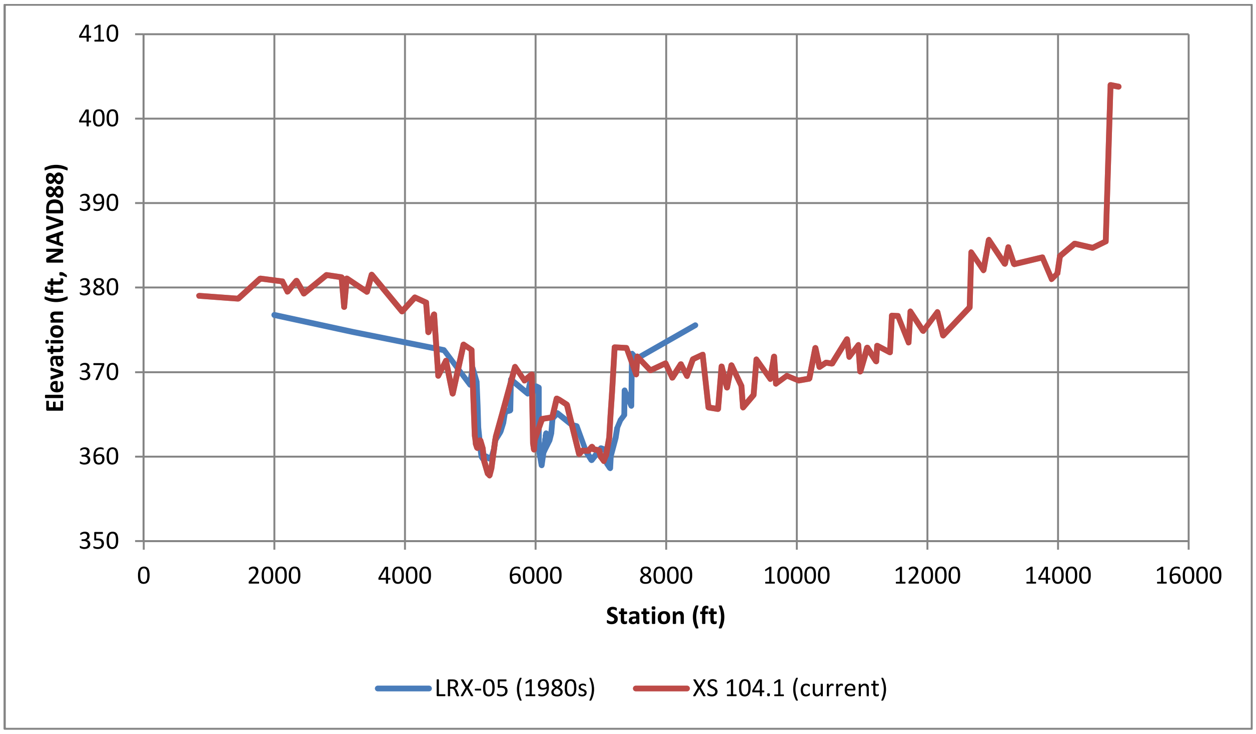

Figure A.37. Cross section comparison of 1980s LRX-05 and current XS 104.1

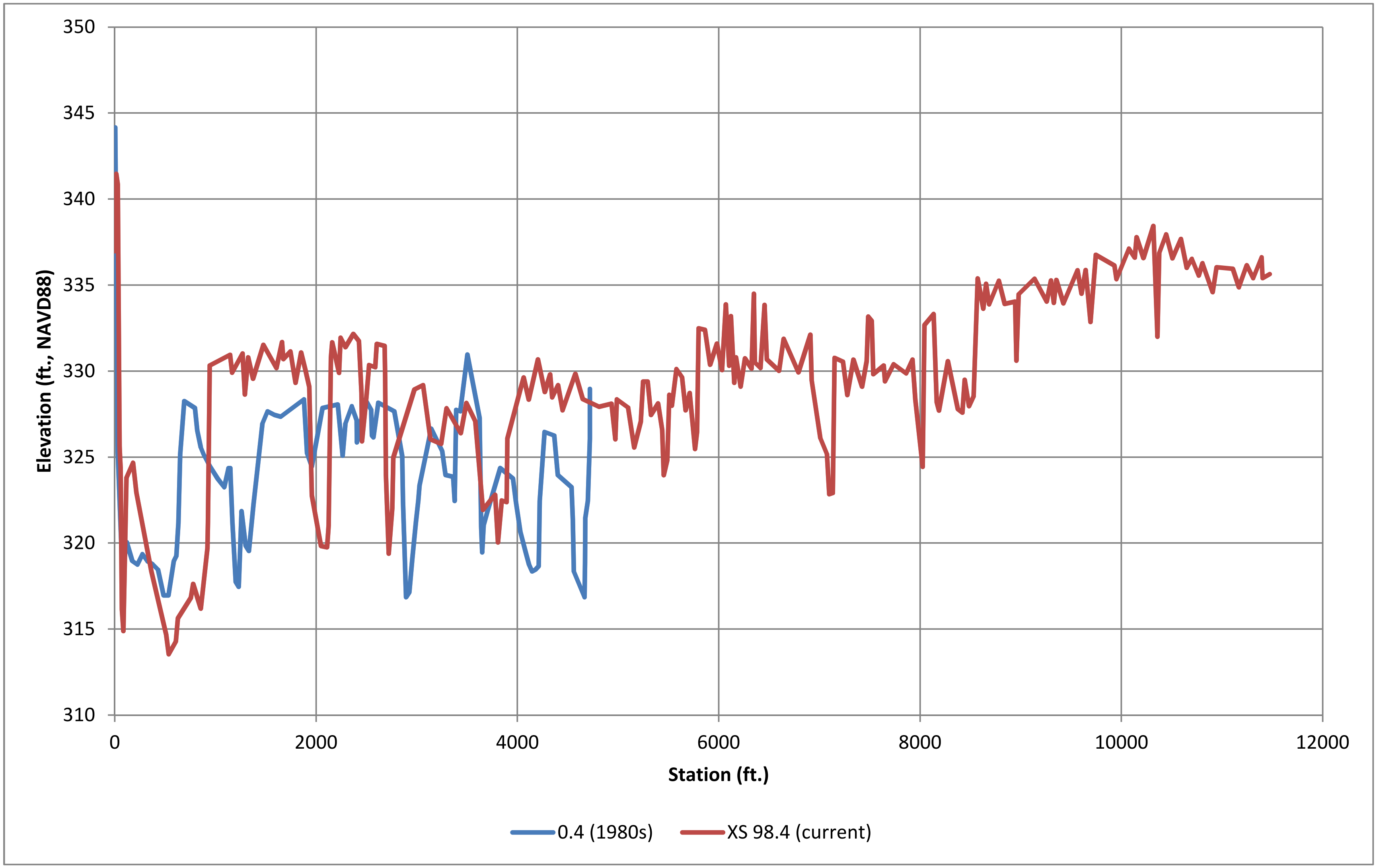

Figure A.38. Cross section comparison of 1980s 0.4 and current XS 98.4