Appendix B

Update San Joaquin River In-channel Capacity Analysis

August 2015

San Joaquin River In-channel Capacity Analysis

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1. INTRODUCTION

An in-channel capacity evaluation of the San Joaquin River and the Eastside and Mariposa Bypasses between Friant Dam and the confluence with the Merced River was previously conducted in 2013 by the California Department of Water Resources (DWR) and Tetra Tech (DWR, 2013). The focus of the work was to:

1. Determine the in-channel capacity of each reach, defined as the highest flow that can be conveyed through the reach where the water-surface elevation does not exceed the landside (or outside) ground elevation near the base of the levee for any part of the reach.

2. Determine the approximate length of left- and right-bank levee for each reach where the water-surface elevation of an in-channel flow of 2,000 cfs exceeds the landside ground elevation near the base of the levee.

3. Determine the approximate length of left- and right-bank levee for each reach where the water-surface elevation of an in-channel flow of 4,500 cfs exceeds the landside ground elevation near the base of the levee.

At the time, only limited data were available regarding characteristics and performance criteria (including Factor of Safety) for levees along the San Joaquin River. To provide information that the Bureau of Reclamation (Reclamation) could use to limit the release of Interim and Restoration flows, as necessary, prior to sufficient data becoming available to determine the Factor of Safety, as well as to prioritize future data collection and analysis activities, landside ground elevations near the base of the levees were determined and compared to computed water-surface elevations over a range of flows. The evaluation was conducted using the HEC-RAS 1-D steady-state hydraulic models developed by Tetra Tech for the San Joaquin River Restoration Program (SJRRP), and was based purely on the comparison of water surface and landside ground elevations independent of levee characteristics.

Since completion of the initial in-channel capacity analysis (DWR, 2013), geotechnical information along the levees have been collected and developed for Reach 2A and the Middle Eastside Bypass (MESB), and in portions of Reach 4A and the Upper Eastside Bypass (UESB) to identify a maximum water-surface elevation on portions of the levees that would not exceed geotechnical criteria for seepage and slope stability (Kleinfelder, 2015; URS, 2015). Preliminary capacity assessments have been conducted using this information (Tetra Tech, 2015a and 2015b). To provide a more direct means of comparing the geotechnical-based results to the in-channel capacity results, the 2013 in-channel capacity analysis has been updated to partition the results between areas along each reach where geotechnical information has, and has not, been collected.

The 2013 results have also been updated to reflect the impact of subsidence in reaches where data indicate that subsidence has affected existing in-channel capacity (Tetra Tech, 2015c). These reaches include Reach 3, Reach 4A, and the MESB. In addition to partitioning of the results within certain reaches and accounting for subsidence that has occurred, updates also include verification of and revisions to a small number of outside ground elevations, an assessment of the impacts of different operational conditions of two weirs in the MESB that direct flow to a nearby wildlife refuge, and further consideration of an isolated portion of levee in Reach 5. This memorandum summarizes the methods and results of the revised in-channel capacity analysis, and represents an update to Appendix C of the Channel Capacity Report 2015 Restoration Year (DWR, 2015). All results herein shall supersede those presented in Appendix C (DWR, 2015).

2. METHODOLOGY AND ASSUMPTIONS

The following sections describe the methodology and assumptions that were used in performing the in-channel capacity analysis. The analysis specifically focused on identifying the maximum discharge that can be conveyed through each reach where the water-surface elevation does not exceed the landside (outside) ground elevation near the base of the levee (i.e., in-channel flow capacity), and included an estimate of the length along the levee where outside ground elevations are exceeded by water-surface elevations at 2,000 and 4,500 cfs. The 2,000- and 4,500-cfs flows represent the potential low and high range of flows that may be needed to achieve the Restoration goal of the settlement.

2.1. River Reaches

The in-channel capacity was evaluated for each area that is bounded by levees in Reaches 2A, 2B, 3, 4A, 4B2, 5, Middle Eastside Bypass, Lower Eastside Bypass, and the Mariposa Bypass (**Figure 1**). As part of the SJRRP, new setback levees are being evaluated for Reach 4B1 to safely convey restoration flows. Since the current capacity is assumed to be negligible, it is assumed that no restoration flows will be conveyed in this reach until channel capacity improvements are made. Therefore, Reach 4B1 was not included in this analysis. Setback levees may also be constructed in Reach 2B, but because Restoration Flow releases will be routed through this reach prior to construction, capacity of the outside ground along the levees upstream from the direct impacts of Mendota Pool was evaluated.

2.2. Hydraulic Models and Topographic Data

Hydraulic models for the study reaches are based primarily on 2008 LiDAR mapping, and 2009-2011 bathymetry, where available. However, various surveys, including those conducted by Reclamation (2013), have demonstrated that considerable elevation changes due to subsidence have occurred along Reaches 3, 4A, and the MESB that also impact in-channel capacities. Therefore, the models used to estimate in-channel capacities in these reaches were modified to reflect subsidence that has occurred since the bathymetry was initially collected (Tetra Tech, 2015c). The magnitude of the elevation adjustments made to the models to account for subsidence are indicated in **Figure 2**. Elevation changes in Reach 3 range from near zero at the upstream end to about -2.3 feet at the downstream end. The largest change in elevation (-2.7 feet) occurs just below the upstream end of Reach 4A, which decreases in the downstream direction to about -1.3 feet at the boundary between Reach 4A and the MESB (Figure 2). Elevation changes in the MESB range from about -1.3 feet at the upstream end to near zero at the downstream end of the reach (Figure 2). The model topography sources (base mapping and subsidence adjustments) used for each reach are summarized in **Table 1**.

Table 1. Summary of basis for topography in each modeled reach.

Reach	Topographic Data Source	Reference
2A	2008 overbank LiDAR; 2010 in-channel bathymetry	Tt-MEI[1], 2012a
2B	2008 overbank LiDAR; 2009-2010 in-channel bathymetry	Tt-MEI[1], 2012a
3	2008 overbank LiDAR; 2009-2010 in-channel bathymetry; with 2013/2014 elevation adjustments for subsidence	Tetra Tech, 2013 Tetra Tech, 2015c
4A	2008 overbank LiDAR; 2010-2011 in-channel bathymetry; with 2013/2014 elevation adjustments for subsidence	Tetra Tech, 2013 Tetra Tech, 2015c
4B2	2008 overbank LiDAR; 2010-2011 in-channel bathymetry	Tt-MEI, 2012b
5	2008 overbank LiDAR; 2011 in-channel bathymetry	Tt-MEI, 2012c
Middle Eastside Bypass	2008 overbank LiDAR; 2010-2011 in-channel bathymetry; with 2013/2014 elevation adjustments for subsidence and 2015 elevation adjustments at the Merced National Wildlife Refuge weirs.	Tetra Tech, 2013 Tetra Tech, 2015c
Lower Eastside Bypass	2008 overbank LiDAR; 2010-2011 in-channel bathymetry	Tt-MEI, 2012d
Mariposa Bypass	2008 overbank LiDAR (includes in-channel data)	Tt-MEI, 2012e

[1] Tetra Tech (dba Mussetter Engineering, Inc.)

Two weirs are located in the MESB that are used to divert water into the Merced National Wildlife Refuge (Refuge) between the months of September through March. To divert the irrigation water, boards are inserted into the weir bays. The number of boards needed depends on which portion of the Refuge is being irrigated. To provide information regarding the sensitivity of the weir settings on the in-channel capacities, three weir configurations were evaluated based on a topographic survey completed by DWR in 2015, and from interviews between DWR and Refuge staff. One configuration assumes that both the upstream weir (Sta 804+61; 12 bays) and downstream weir (Sta 732+46; 14 bays) remain fully open. This configuration is representative of when the Refuge is not diverting flows and is referred to as Boards Out. The second weir configuration is representative of the most common setting required by the refuge to divert flows during most years, and is referred to as Typical Boards. The elevation of the boards in this configuration was surveyed by DWR in 2015 and represents a partial closure of the downstream weir and the upstream weir is completely open. The third weir configuration assumes that both the up- and downstream weirs are completely closed. According to refuge staff, if water is available, the Refuge will occasionally place all of the boards into the weir bays to fill ponds within the bypass that are approximately 3 miles upstream of the weirs. This condition is referred to as Boards In.

Along with the 2015 elevations surveyed at the weirs, the subsidence-adjusted hydraulic model along the MESB was used as the basis to assess the impacts of the different configurations of the Refuge weirs on in-channel capacity.

Based on the topography and operational conditions described above, the hydraulic models were used to develop computed water-surface profiles over a range of local discharges with downstream boundary conditions based on the same local discharges for each reach.

2.3. Outside Ground Elevations

Elevations of land protected by and adjacent to the levees (outside ground) for all reaches were previously developed for the 2013 in-channel capacity assessment based on the 2008 LiDAR data incorporated into the updated hydraulic models. Elevations were initially identified at each model cross section primarily through inspection of the cross-sectional topography and verified through review of the aerial photography and contour mapping (2008 LiDAR). In general, the landside ground elevations adjacent to the overall levee structure were selected, regardless of whether the terrain was flat or sloped to or away from the levee. A series of examples indicating where the outside ground elevations were selected is shown in **Appendix A**. The outside ground elevations were confirmed by DWR through review of aerial photography and mapping, as well as field inspections and surveys.

In accordance with the elevation adjustments made to the hydraulic model geometry to account for subsidence, equivalent elevation adjustments were also made to the outside ground elevations in Reaches 3, 4A, and the MESB (Figure 2; Tetra Tech, 2015c). The subsidence-adjusted outside ground elevations were used in these three reaches in determination of the in-channel capacity.

2.4. Geotechnical Condition Report

Since completion of the initial in-channel capacity analysis (DWR, 2013), geotechnical data and information along the levees have been collected and evaluated in Reaches 2A and 4A, UESB, and MESB to identify a maximum water-surface elevation on the levees that would not exceed geotechnical criteria for seepage and slope stability. These evaluations included the entire length of levees in Reach 2A and the MESB, the lower 2 miles of the UESB, and the lower 2.5 miles of Reach 4A, and were summarized in two Geotechnical Condition Reports (GCR) (Kleinfelder, 2015; URS, 2015). This information was used to assess levee capacity based on a specified height of water on the levees (Tetra Tech, 2015a and 2015b). In order to continue to provide information about capacity if no water can be placed on the levees, in-channel capacities based on the outside ground elevations were identified and reported separately for areas where geotechnical information has, and has not, been collected.

3. RESULTS

Computed water-surface profiles were compared to the outside ground elevations adjacent to both the left and right levees along the extent of each reach. The in-channel flow capacity of each reach was determined to be the highest flow rate through the reach where the water-surface elevation does not exceed the outside ground elevation for any part of the reach. Approximate lengths of each site where the outside ground elevations are overtopped by the water-surface elevations associated with a local discharge of 2,000 and 4,500 cfs were then estimated from the available mapping, topography at adjacent cross sections, and the actual length along the levee as indicated in aerial photography.

3.1. Reach 2A

Reach 2A is approximately 13 miles long and extends from Gravelly Ford (near the upstream end of the project levees) downstream to the Chowchilla Bypass Bifurcation Structure. Computed water-surface profiles are based on a downstream boundary condition that corresponds with observed water-surface elevations surveyed over a range of flows. Along the right and left levees in Reach 2A, the highest local discharge for which the water surface is at or below the outside ground elevation is 1,630 and 2,430 cfs, respectively (**Figures 3 and 4**). At 2,000 cfs, water-surface elevations exceed the outside ground elevations only along the right levee, at a total length of 1,240 feet. At 4,500 cfs, water-surface elevations exceed the outside ground elevations along 7,410 feet of left levee, and 10,100 feet of right levee (**Table 2**). Segments of levee where ground elevations are exceeded by water-surface elevations at a local discharge of 2,000 and 4,500 cfs are delineated in **Figures 5 and 6**.

3.2. Reach 2B

Reach 2B is approximately 11 miles long and extends from the Chowchilla Bypass Bifurcation Structure downstream to Mendota Dam. Outside ground elevations along the lower portion of this reach (downstream from approximately Sta 4765+00) are generally lower than the normal pool elevation at Mendota Dam. As a result, the existing flow capacity was evaluated for the entire reach as well as only for the portion of the reach upstream from the influence of the pool.

When considering the entire reach, including Mendota Pool, the capacity along both sides of the channel is 0 cfs (**Figures 7 and 8**). At a local discharge of 2,000 cfs, water-surface elevations exceed ground elevations over approximately 4 miles (21,200 feet) along the left levee and 3.6 miles (18,800 feet) along the right levee (Table 2). At 4,500 cfs[1], the length where water-surface elevations exceed ground elevations along the left levee increases to about 10 miles (53,300 feet), and the length along the right levee increases to about 7.7 miles (40,400 feet). If only the portion of the reach upstream from the influence of the pool is considered, the highest local discharge in which the water surface is at or below the outside ground elevation is about 1,120 cfs along the left levee and 1,550 cfs along the right levee (Table 2). In this portion of the reach, water-surface elevations at 2,000 cfs exceed the outside ground elevations along 8,730 feet of levee on the left side of the channel and 8,320 feet along the right. At a local flow of 4,500 cfs, the lengths increase significantly to 7 miles (36,800 feet) along the left levee and 4.5 miles (23,900 feet) along the right levee. The portions of levee along the entire reach where ground elevations are exceeded by water-surface elevations at a local discharge of 2,000 and 4,500 cfs are delineated in **Figures 9 and 10**.

3.3. Reach 3

Reach 3 is about 22 miles long and extends from Mendota Dam downstream to Sack Dam (Figure 1). Recent studies have indicated that subsidence in this reach has resulted in significant changes in channel and levee elevations (Tetra Tech, 2015c). As a result, both the hydraulic model and outside ground elevations have been updated based on 2013/2014 surveys, and in-channel capacity results in this reach are based on those updates (Tetra Tech, 2015c). Outside ground elevations are reasonably high along much of the reach except for the area immediately upstream of Sack Dam (**Figures 11 and 12**). Discharge capacity in this area is limited by a depression on the right side that has a capacity of 2,860 cfs. On the left side of the channel, the capacity of the outside ground elevation is 3,960 cfs (Table 2). The 2,000-cfs discharge profile does not exceed any of the outside ground elevations. At 4,500 cfs, water-surface elevations exceed outside ground elevations along approximately 1.7 miles (8,740 feet) of levee on the left side and 2.6 miles (13,840 feet) of levee on the right side of the river (Table 2; **Figure 13**).

[1]In-channel capacity results for 4,500 cfs in Reach 2B are included. However, model results show that 4,500 cfs will also overtop portions of the existing levees, indicating that 4,500 cfs cannot be conveyed in Reach 2B under existing conditions.

Table 2. Summary of in-channel capacity discharge and approximate length of levee in each reach where the outside ground elevation is below the water-surface elevation at 2,000 and 4,500 cfs.

Reach	Levee Side	Discharge Capacity[1] (cfs)	Length of Levee at 2,000 cfs (ft)	Length of Levee at 4,500 cfs (ft)	Update[6]
Reach 2A	Left	2,430	0	7,410	
Reach 2A	Right	1,630	1,240	10,100	
Reach 2B (Entire Reach)[2]	Left	0	21,200	53,300	
Reach 2B (Entire Reach) [2]	Right	0	18,800	40,400	
Reach 2B (Excluding Mendota Pool)[3]	Left	1,120	8,730	36,800	
Reach 2B (Excluding Mendota Pool) [3]	Right	1,550	8,320	23,900	
Reach 3	Left	3,960	0	8,740	X
Reach 3	Right	2,860	0	13,840	X
Reach 4A (Entire Reach)	Left	980	4,640	51,280	X
Reach 4A (Entire Reach)	Right	1,340	4,140	52,800	X
Reach 4A (Inside GCR Study Area)	Left	980	4,640	11,960	X
Reach 4A (Inside GCR Study Area)	Right	1,340	4,140	12,840	X
Reach 4A (Outside GCR Study Area)	Left	2,840	0	39,320	X
Reach 4A (Outside GCR Study Area)	Right	2,840	0	39,960	X
Reach 4B2	Left	1,370	6,060	35,480	
Reach 4B2	Right	930[4]	14,750	38,670	
Reach 5	Left	2,350	0	14,440	X
Reach 5	Right	2,500	0	3,970	
Middle Eastside Bypass (Boards Out)	Left	10[5]	39,530	50,230	X
Middle Eastside Bypass (Boards Out)	Right	340[5]	26,280	47,700	X
Lower Eastside Bypass	Left	2,970	0	10,650	
Lower Eastside Bypass	Right	2,890	0	8,400	
Mariposa Bypass	Left	650	15,700	17,570	
Mariposa Bypass	Right	350	13,700	17,570	

[1]Capacity based on outside ground elevations.
[2]Entire reach including Mendota Pool.
[3]Portion of reach above influence of Mendota Pool (upstream of Sta 4765+00).
[4]Capacity assumes deep depressions are excluded, otherwise capacity would decrease to 50 cfs.
[5]Under Typical Boards and Boards In conditions, in-channel capacity is essentially 0 cfs.
[6]Results indicate an update of the previous in-channel capacity report (DWR, 2013).

3.4. Reach 4A

Reach 4A is about 23 miles long and extends from Sack Dam downstream to the Sand Slough Control Structure (SSCS). The boundary condition is based on Restoration Flows and assumes that all flow in Reach 4A is directed into the Eastside Bypass, without any additional flow contribution from the Chowchilla Bypass. Because recent studies have indicated that significant subsidence has also occurred in this reach, in-channel capacity results are based on updated models that reflect those elevation changes (Tetra Tech, 2015c). In addition, geotechnical data have been collected along the lower part of Reach 4A (URS, 2015; Tetra Tech, 2015a), thus, the results in this reach have been partitioned to report in-channel capacities both within, and outside of, the GCR study area.

Accounting for subsidence, computed water-surface profiles indicate that the maximum local discharge for which the water surface is at or below the outside ground elevation in the entire Reach 4A is 1,340 cfs for the right levee and 980 cfs for the left levee (**Figures 14 and 15**). The locations that limit these capacities happen to occur within the GCR study area. Excluding the GCR study area in Reach 4A, the maximum local discharge is 2,840 cfs for both the left and right levee (Table 2). At a local flow of 2,000 cfs, computed water-surface elevations exceed 4,140 feet of outside ground along the right levee and 4,640 feet along the left levee, all of which occur within the GCR study area (Table 2). At 4,500 cfs, water-surface elevations exceed outside ground over a total length of about 9.7 miles (51,280 feet) along the left levee and 10.0 miles (52,800 feet) along the right levee. Of those totals, approximately 11,960 feet along the left levee and 12,840 feet along the right levee occur within the GCR study area (Table 2; **Figures 16 and 17**). Outside of the GCR study area, 7.4 miles (39,320 feet) of ground along the left levee are exceeded, and 7.6 miles (39,960 feet) of ground are exceeded along the right levee.

3.5. Reach 4B2

Reach 4B2 extends approximately 12 miles from the Mariposa Bypass downstream to the confluence with the Lower Eastside Bypass and Bear Creek (Figure 1). Computed water-surface elevations in this reach were developed based on a downstream boundary condition that assumes no additional flow from the Eastside Bypass. The ground adjacent to the right levee in Reach 4B2 has a localized, but deep depression, near Sta 1205+89, which is similar to many other depressions in this reach (see Figure A.3) that limits the in-channel capacity to about 50 cfs (**Figure 18**; Table 2). However, aerial photographs and contour mapping indicate that these depressions are not on or adjacent to agricultural land, are relatively small, and can contain water even at low flows (Tt-MEI, 2011). If these local, right-side depressions are excluded from the analysis, the capacity along the right levee increases to about 930 cfs (Figure 18). The outside ground along the left levee is not as low, which results in an in-channel capacity of approximately 1,370 cfs (**Figure 19**; Table 2). Based on a local discharge of 2,000 cfs, water-surface elevations would exceed ground elevations along about 6,060 feet of the left levee and about 14,750 feet along the right levee (Table 2). At, 4,500 cfs, water-surface elevations exceed the outside ground elevations on either side of the channel over approximately 7 miles of the reach. Segments of levee in Reach 4B2 where ground elevations are exceeded by water-surface elevations at a local discharge of 2,000 and 4,500 cfs are presented in **Figures 20 and 21**.

3.6. Reach 5

Reach 5 extends downstream from Bear Creek to the confluence with the Merced River. Computed water-surface profiles in this reach were developed based on a downstream boundary condition that corresponds to a published discharge rating curve at the San Joaquin River at Newman gage, and assumes that the contribution of flow from the Merced River is added based on an equivalent occurrence frequency and hydrologic year type specified in the Settlement Agreement (Tt-MEI, 2012f). In addition, the analysis is based on the assumption that no flow is added at Salt and Mud Sloughs. Because most of the areas with limited capacities occur along the mid- to upper portion of this reach, assumptions regarding the downstream boundary condition have very little impact on the results. The one exception is a levee feature that exists along the left side of the channel near the downstream end of the reach (approx. Sta 340+00). The previous analysis considered in-channel capacity with and without this entire levee segment. However, this levee segment is located along one of the many side channels that occur in this portion of Reach 5. Based on further analysis, it was determined that the side channel nearest this levee segment is not hydraulically connected to the main channel at flows less than 4,500 cfs. Therefore, the small portion of this levee segment that would not see water at flows less than 4,500 cfs was removed from this analysis.

When considering the entire reach in the analysis, including the above-mentioned changes to the left downstream levee segment, the highest local discharge for which the water surface is at or below the outside ground elevation is 2,350 and 2,500 cfs along the left and right levees, respectively (**Figures 22 and 23**; Table 2). However, since much of the outside ground adjacent to the left levee contains many local depressions (Tt-MEI, 2011), these results likely represent a conservative estimate of the in-channel discharge capacity in this reach. At a local discharge of 2,000 cfs, computed water-surface elevations do not exceed the outside ground elevations along either the right or left levees (Table 2). At 4,500 cfs, the length along the left levee where water-surface elevations exceed the outside ground elevations is about 2.7 miles (14,440 feet), and the length along the right levee is almost 4,000 feet. The portions of levee along the entire reach where ground elevations are exceeded by estimated water-surface elevations at a local discharge of 4,500 cfs are delineated in **Figure 24**.

3.7. Middle Eastside Bypass

The Middle Eastside Bypass extends downstream approximately 9 miles from the confluence of the Upper Eastside Bypass near the Sand Slough Connector Channel to the Mariposa Bypass (Figure 1). Computed water-surface profiles in this reach were developed based on the assumption that all flows pass through the Eastside Bypass Control Structure (EBCS) into the Lower Eastside Bypass (i.e., no flow is diverted into the Mariposa Bypass), and the downstream boundary condition is based on computed water-surface elevations for the adjacent Lower Eastside Bypass model; however, the water-surface elevations in the MESB are actually controlled by the EBCS (Tetra Tech, 2014).

Recent studies have indicated that significant subsidence has also occurred in this reach. As a result, in-channel capacity results are based on updated models that reflect those elevation changes (Tetra Tech, 2015c). Geotechnical data have also been collected in the MESB, and capacity assessments based on that information have been performed (URS, 2015; Tetra Tech, 2015a). However, because the geotechnical evaluations were conducted over the entire length of the reach, in-channel capacity results for the MESB are not partitioned.

At the upstream end of this reach, the channel bed is very near the elevation of the ground outside of the levees on both the right and left sides (**Figures 25 and 26**). The slightly raised El Nido Road also creates a backwater condition that has the potential to impact the water-surface elevations in the upper portion of the reach. Accounting for subsidence and assuming a Boards Out condition, computed water-surface profiles indicate that the highest local discharge for which the water-surface is at or below the outside ground elevation along the left levee is only about 10 cfs, and along the right levee is only 340 cfs (Table 2). It is important to note that this result is based solely on comparison of elevations, and does not account for the proximity of the in-channel flows to the levees. At 2,000 cfs in the MESB with the Boards Out, a length of approximately 7.5 miles (39,530 feet) was identified where the outside ground elevations are at or below the water-surface elevation on the left side of the river, and 5 miles (26,280 feet) were identified along the right side (Table 2; **Figure 27**). At 4,500 cfs, approximately 9.5 miles (50,230 feet) of levee on the left side and 9.0 miles (47,700 feet) of levee on the right side of the river would be exceeded (**Figure 28**).

As described above, a sensitivity analysis was also performed to determine how adjusting the board settings in the weirs; partially closing the downstream weir (Typical Boards) and completely closing both the up- and downstream weirs (Boards In) impacts the in-channel capacity. By modeling both weirs under the Typical Boards and Boards In conditions, the in-channel capacity is reduced to 0 cfs along both the left and right levees. At 2,000 and 4,500 cfs under the Typical Boards and Boards In settings, the length of outside ground exceeded along the left and right levees in the MESB do not change from the Boards Out condition.

3.8. Lower Eastside Bypass

The Lower Eastside Bypass continues downstream from the Eastside Bypass Control Structure for approximately 12 miles before merging with the mainstem of the San Joaquin River at the head of Reach 5. Computed water-surface elevations in this reach were developed based on a downstream boundary condition that was derived from water-surface elevations at the upper end of Reach 5 and the assumption of no additional flow from Reach 4B2. Bear Creek is a significant tributary that enters the bypass near Sta 211+24, but for this analysis, no flow contribution was assumed at this location. The computed water-surface profiles indicate that the highest local discharge for which the water surface is at or below the outside ground elevation along the left levee is 2,970 cfs and along the right levee is 2,890 cfs (**Figures 29 and 30**; Table 2). Outside ground elevations along the entire reach are higher than computed water-surface elevations at a local discharge of 2,000 cfs (Table 2). At 4,500 cfs, however, approximately 2 miles (10,650 feet) of left levee have outside ground elevations that are lower than the computed water-surface elevations, and about 1.6 miles (8,400 feet) of ground are lower along the right levee (Table 2; **Figure 31**).

3.9. Mariposa Bypass

The Mariposa Bypass is just over 4 miles long and spans between the Middle Eastside Bypass and Reach 4B2. It is a straight reach bound by the Mariposa Bypass Control Structure on the upstream end and the Mariposa Bypass Drop Structure on the downstream end. The downstream boundary condition for this model is based on computed water-surface elevations in Reach 4B2, but the drop structure on the downstream end is the actual hydraulic control for this reach. Along both the left and right levees in the Mariposa Bypass, the highest local discharge for which the water surface is at or below the outside ground elevation is 650 and 350 cfs, respectively (**Figures 32 and 33**; Table 2). As evident from the low in-channel capacity, the outside ground elevations in this reach are relatively low, but they are also relatively uniform. As a result, the lengths of levee where the outside ground elevations are below computed water-surface elevations do not change significantly between 2,000 and 4,500 cfs. At 2,000 cfs, 2.6 miles (13,700 feet) of outside ground elevations are lower than the water-surface elevations on the right side of the channel, and 2.9 miles (15,700 feet) are lower on the left side. At 4,500 cfs, 3.3 miles (17,570 feet) of outside ground are lower on both side sides of the channel (Table 2). The portions of levee along the reach where ground elevations are exceeded by estimated water-surface elevations at a local discharge of 2,000 and 4,500 cfs, which is almost the entire reach, are presented in **Figures 34 and 35**.

4. REFERENCES

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URS, 2015. Geotechnical Condition Report: San Joaquin River Restoration Program, Middle Eastside Bypass Study Area. Prepared for the California Department of Water Resources, Division of Flood Management, Sacramento, CA, April.

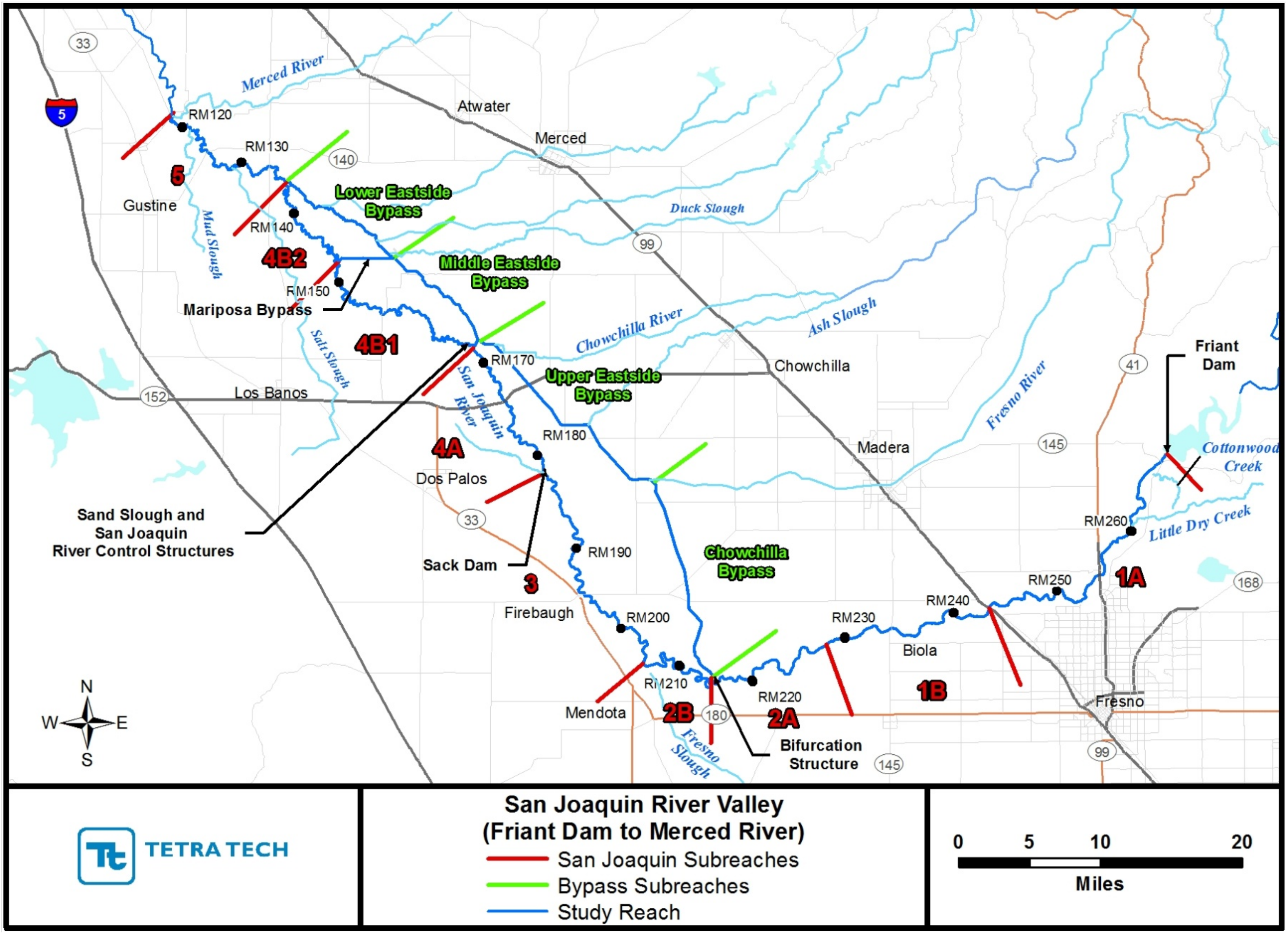

Figure 1. Map of the San Joaquin River Restoration Project Reach showing the subreach boundaries.

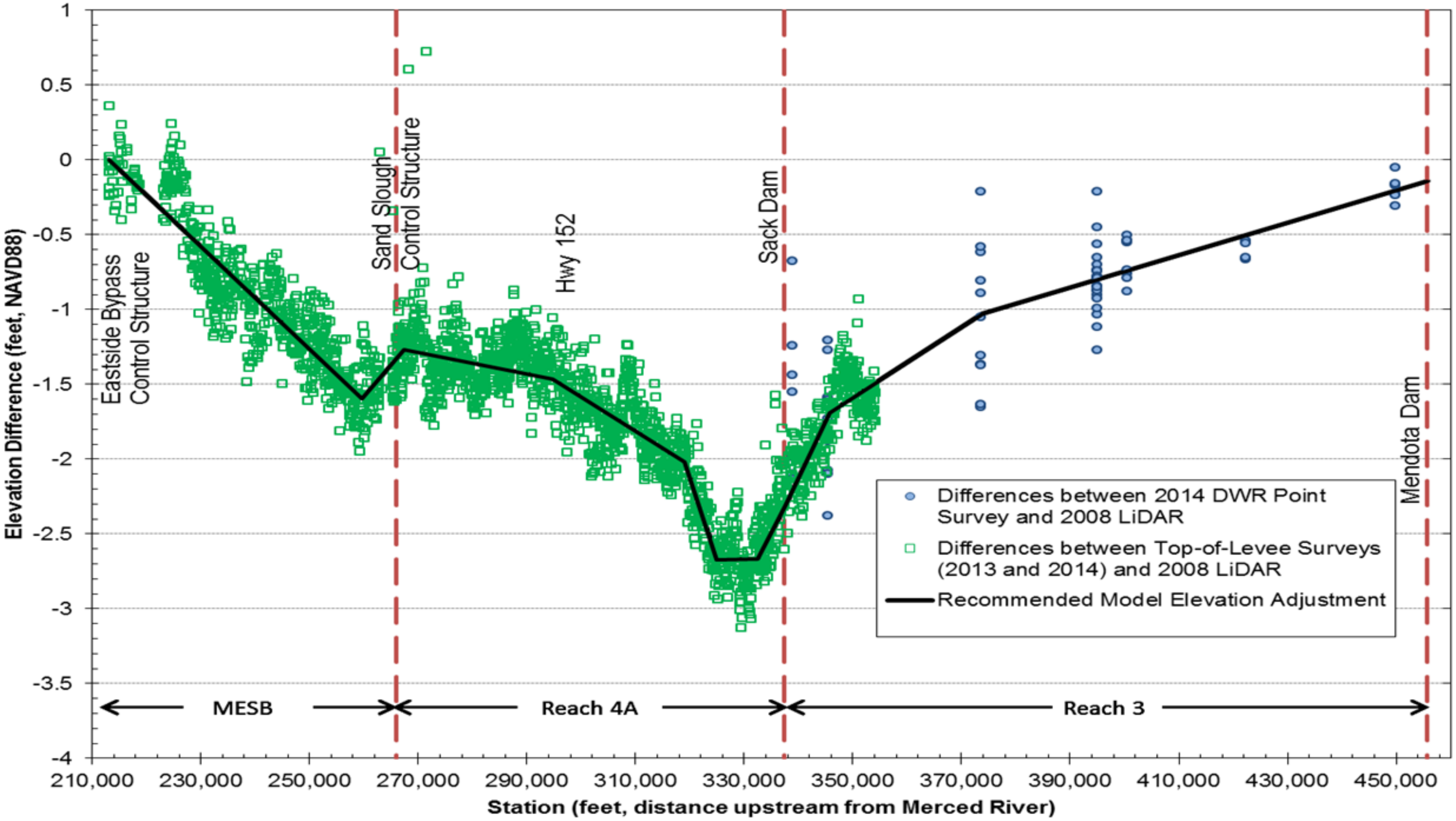

Figure 2. Differences between the 2013/2014 ground surveys and the 2008 LiDAR elevations. Negative values indicate that elevations have decreased from 2008 to 2013/14. Note: Stationing indicated in figure is based on river stationline; thus, values along the MESB are relative to the downstream end of Reach 4A (from Tetra Tech, 2015c).

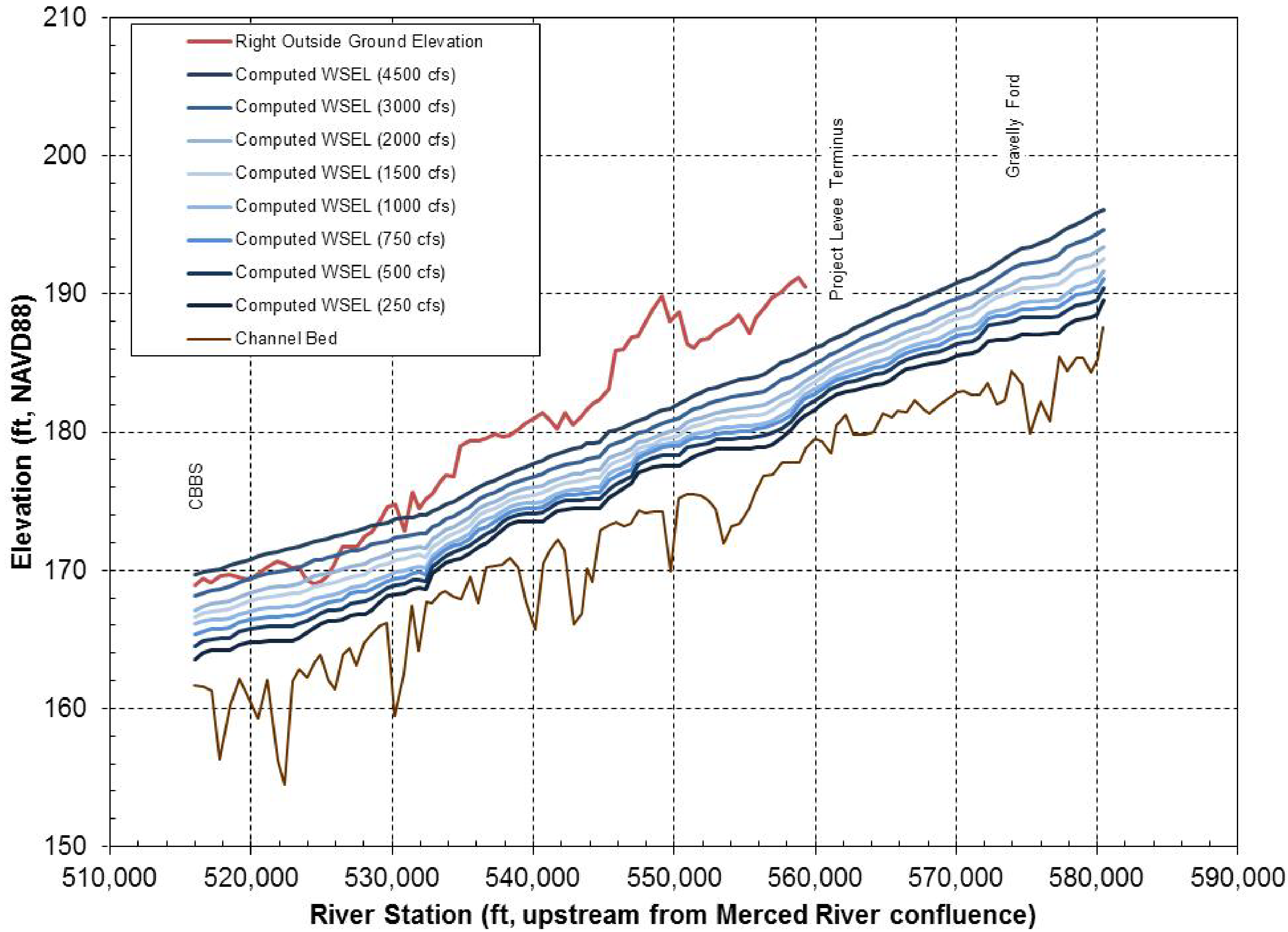

Figure 3. Comparison of outside ground profile with computed water-surface elevations along right levee in Reach 2A.

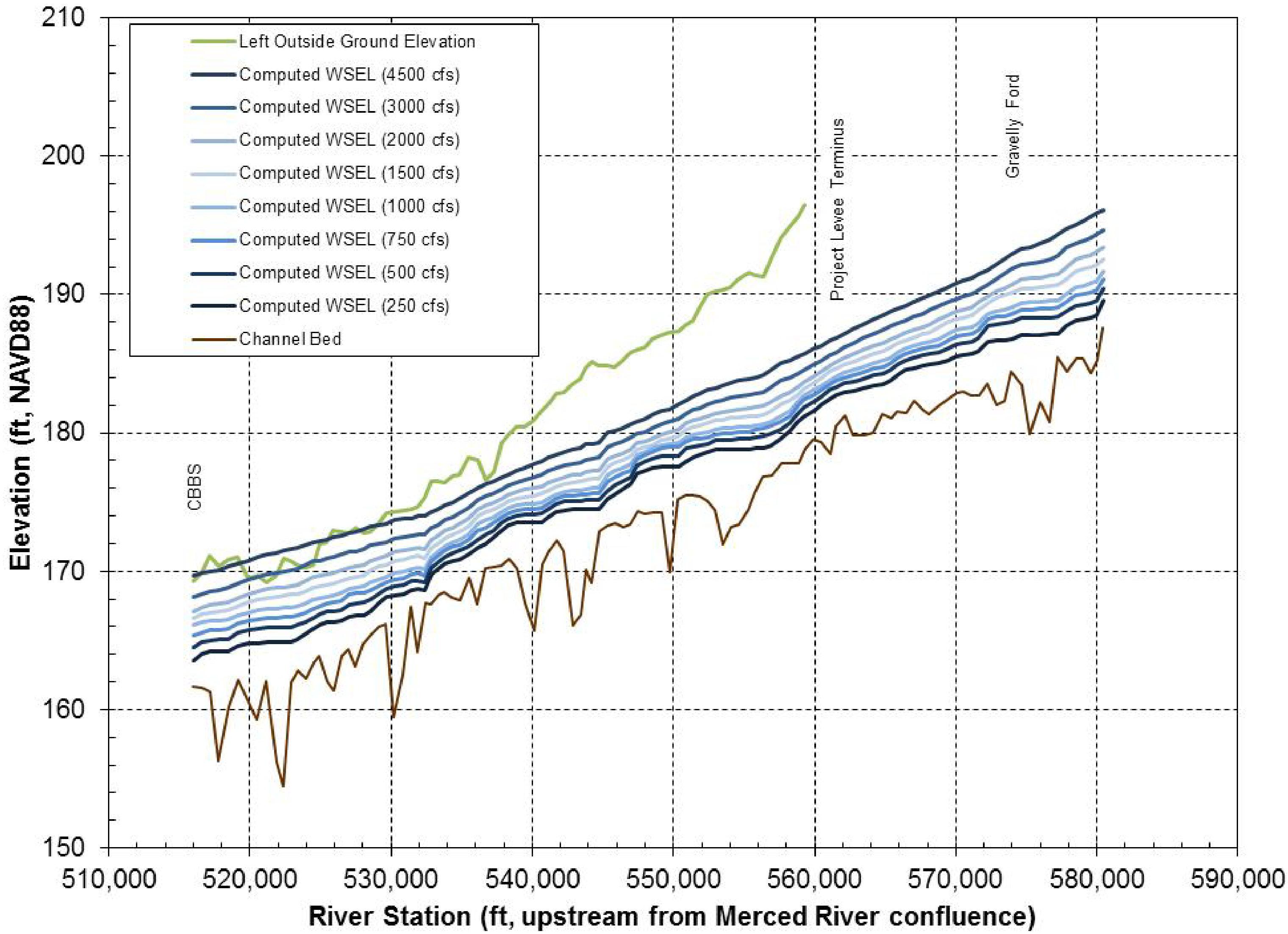

Figure 4. Comparison of outside ground profile with computed water-surface elevations along left levee in Reach 2A.

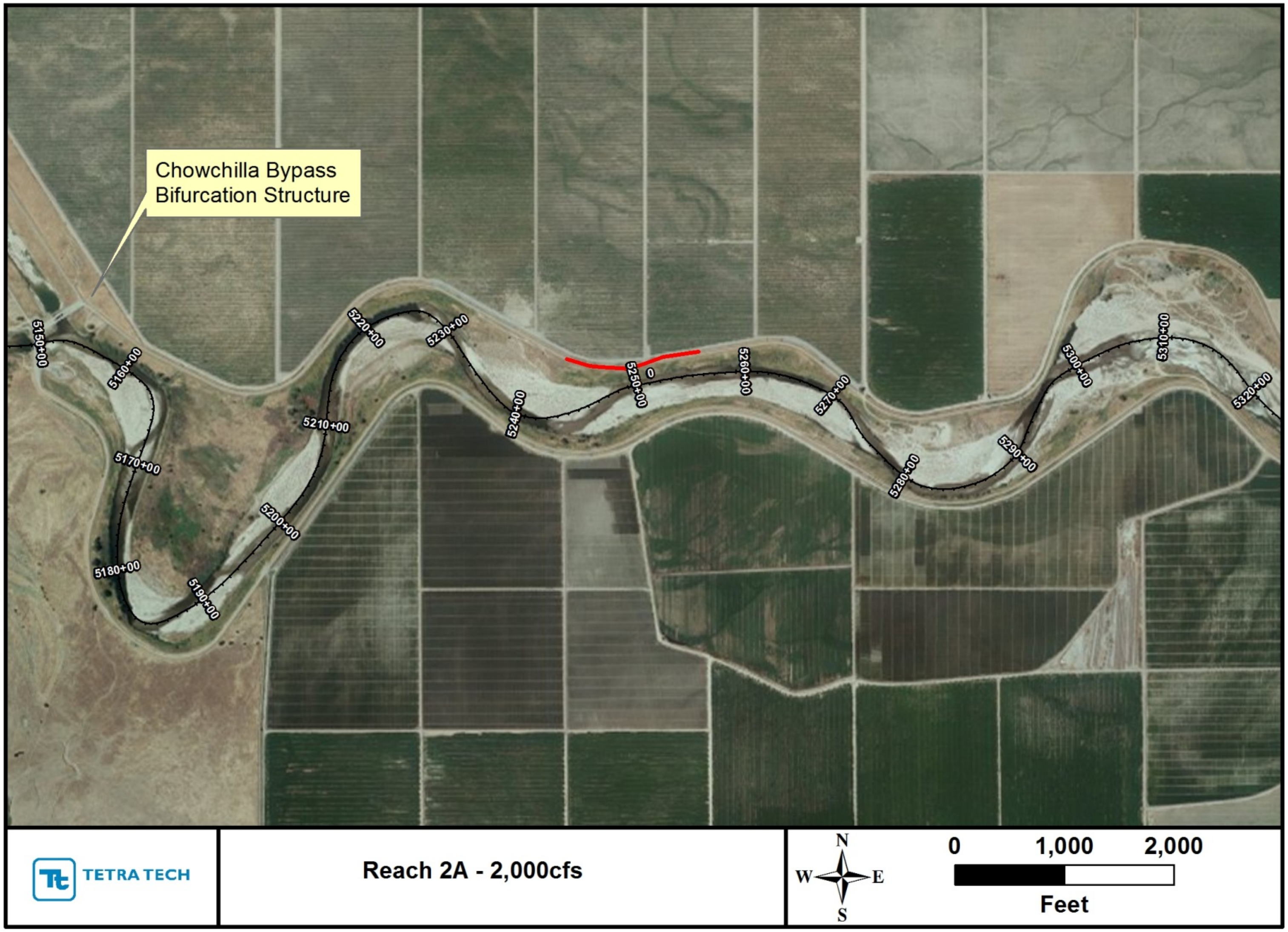

Figure 5. Portions of levee in Reach 2A where the 2,000-cfs water-surface elevation is above the outside ground elevation.

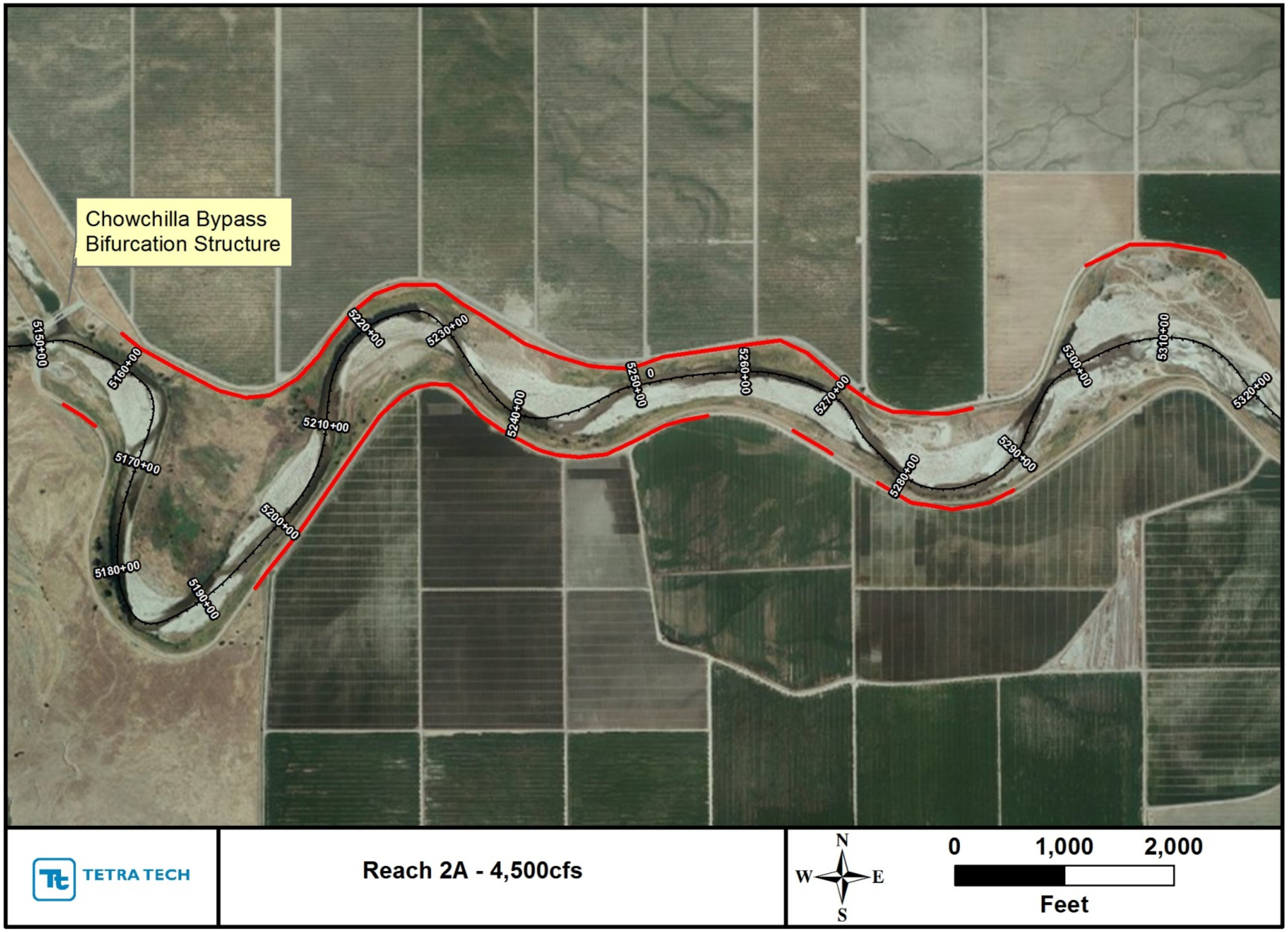

Figure 6. Portions of levee in Reach 2A where the 4,500-cfs water-surface elevation is above the existing outside ground elevation.

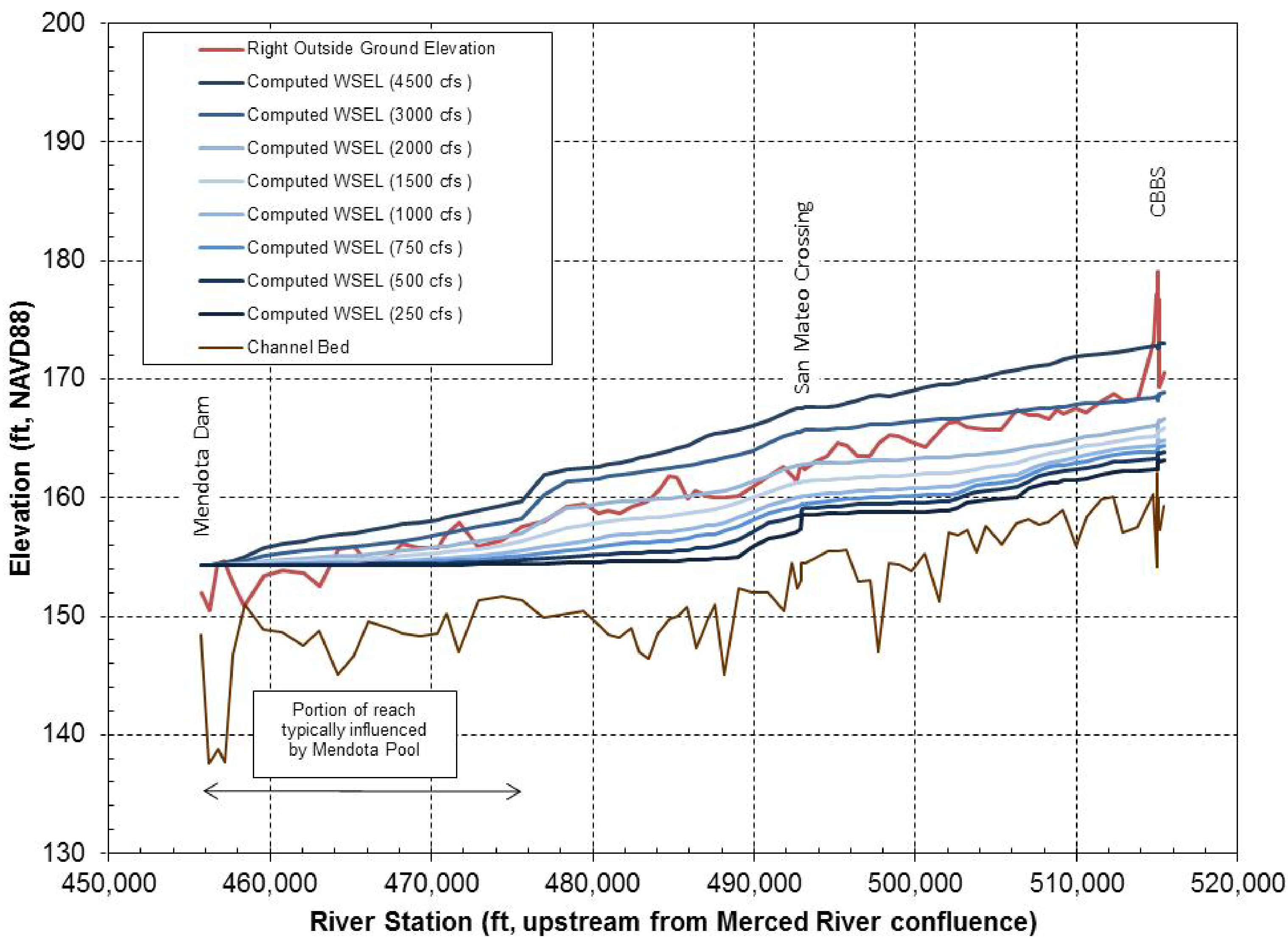

Figure 7. Comparison of outside ground elevation with computed water-surface elevations along right levee in Reach 2B.

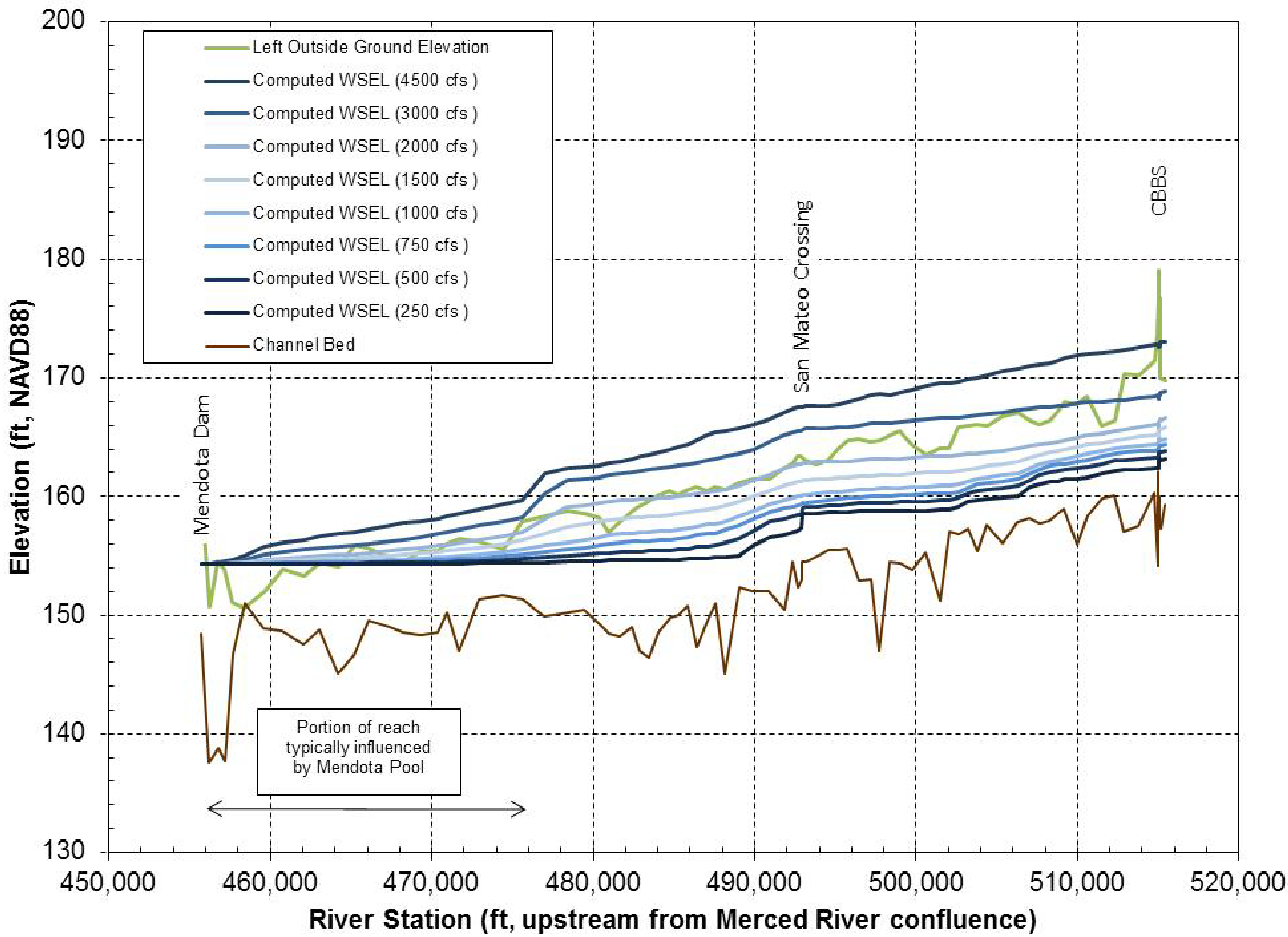

Figure 8. Comparison of outside ground elevation with computed water-surface elevations along left levee in Reach 2B.

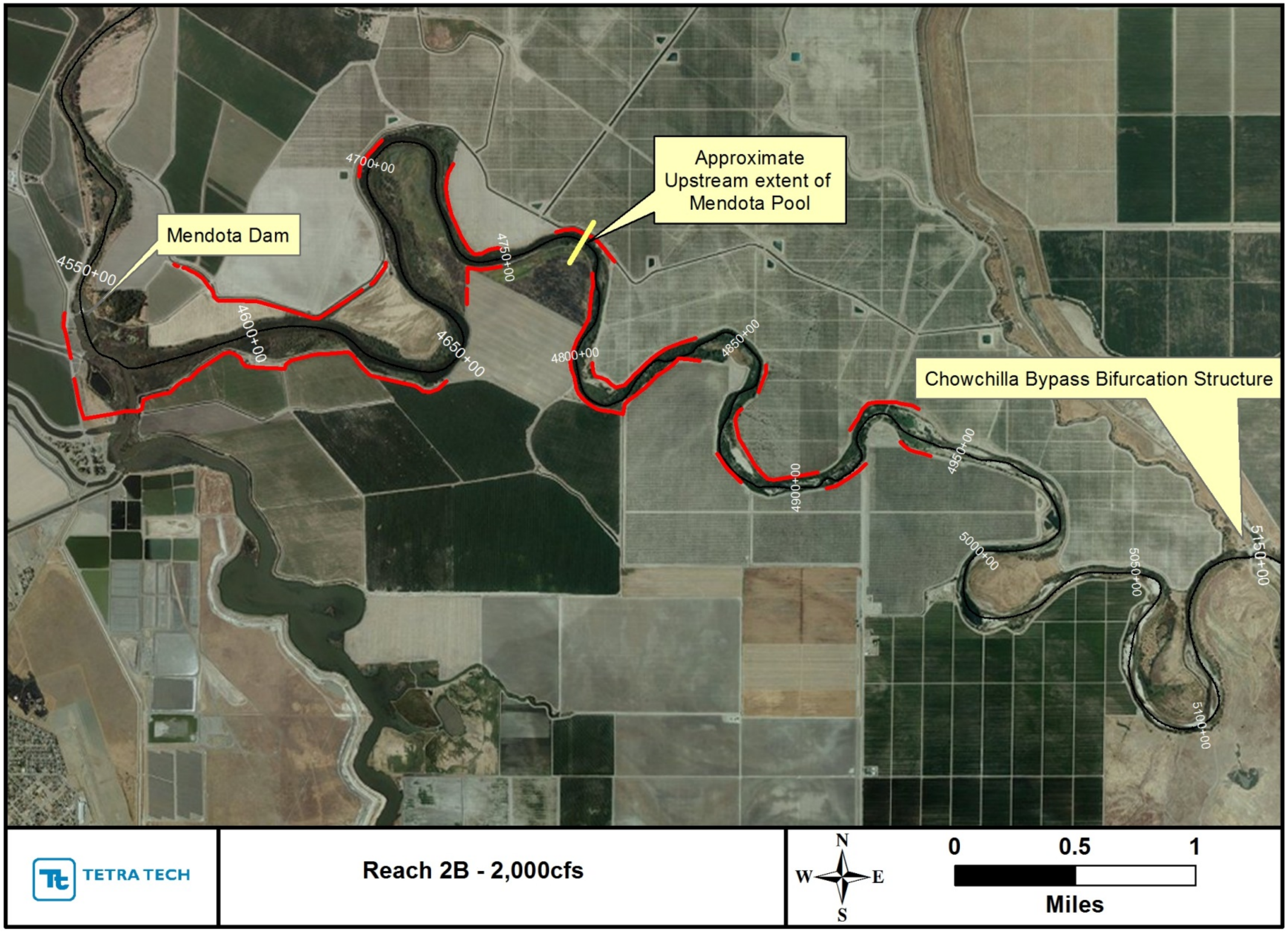

Figure 9. Portions of levee in Reach 2B where the 2,000-cfs water-surface elevation is above the outside ground elevation.

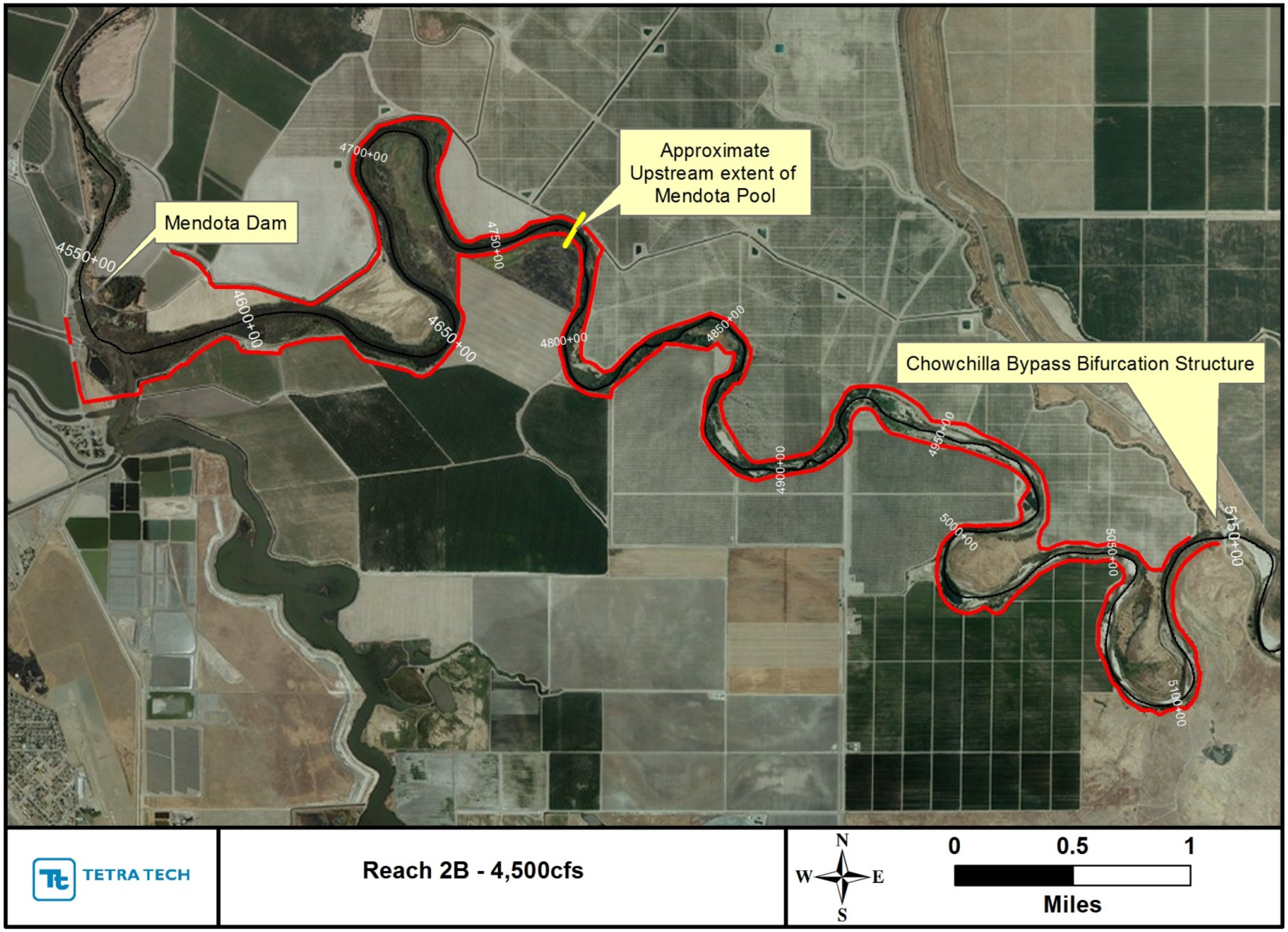

Figure 10. Portions of levee in Reach 2B where the 4,500-cfs water-surface elevation is above the outside ground elevation.

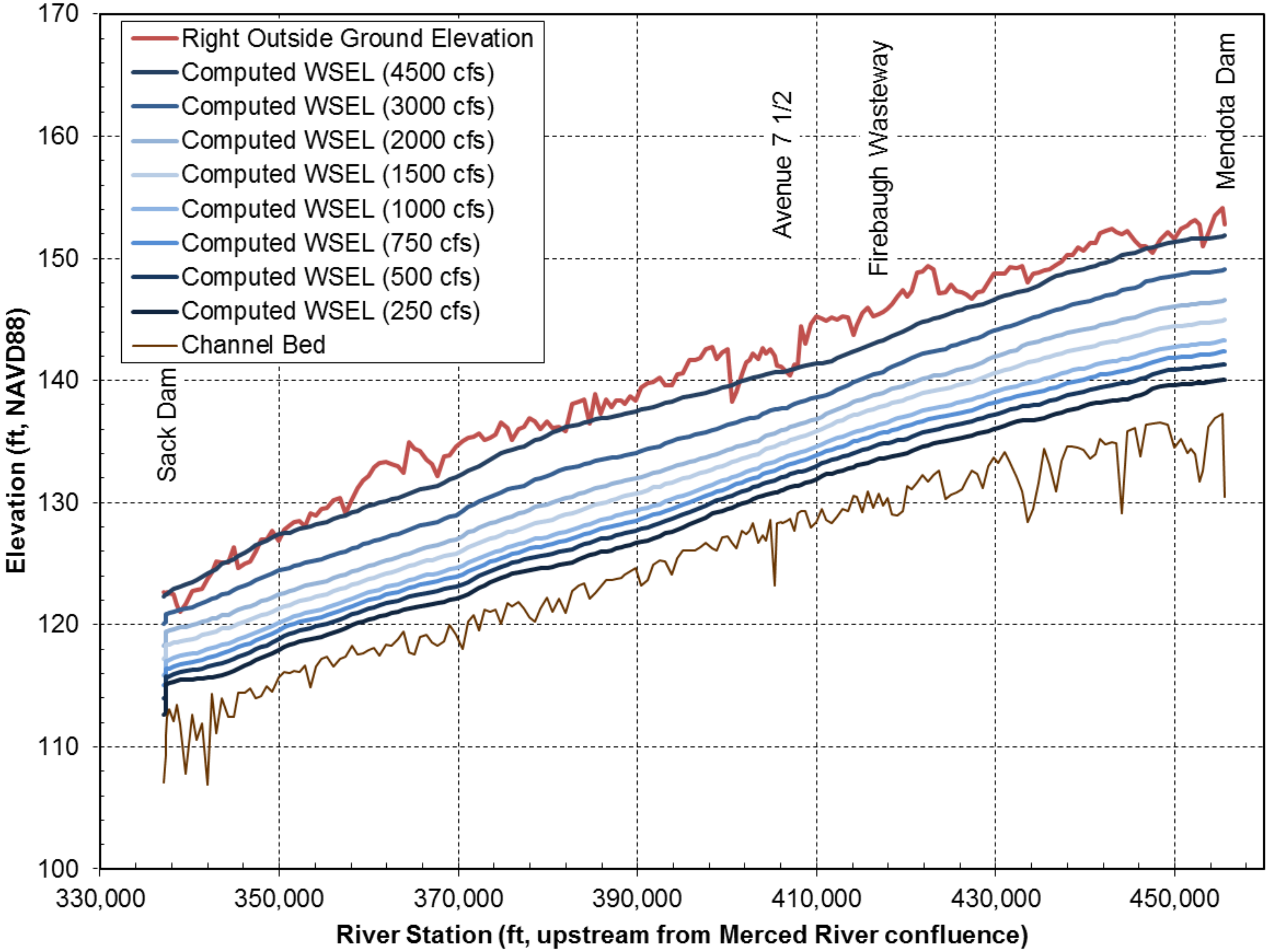

Figure 11. Comparison of outside ground elevation with computed water-surface elevations along right levee in Reach 3.

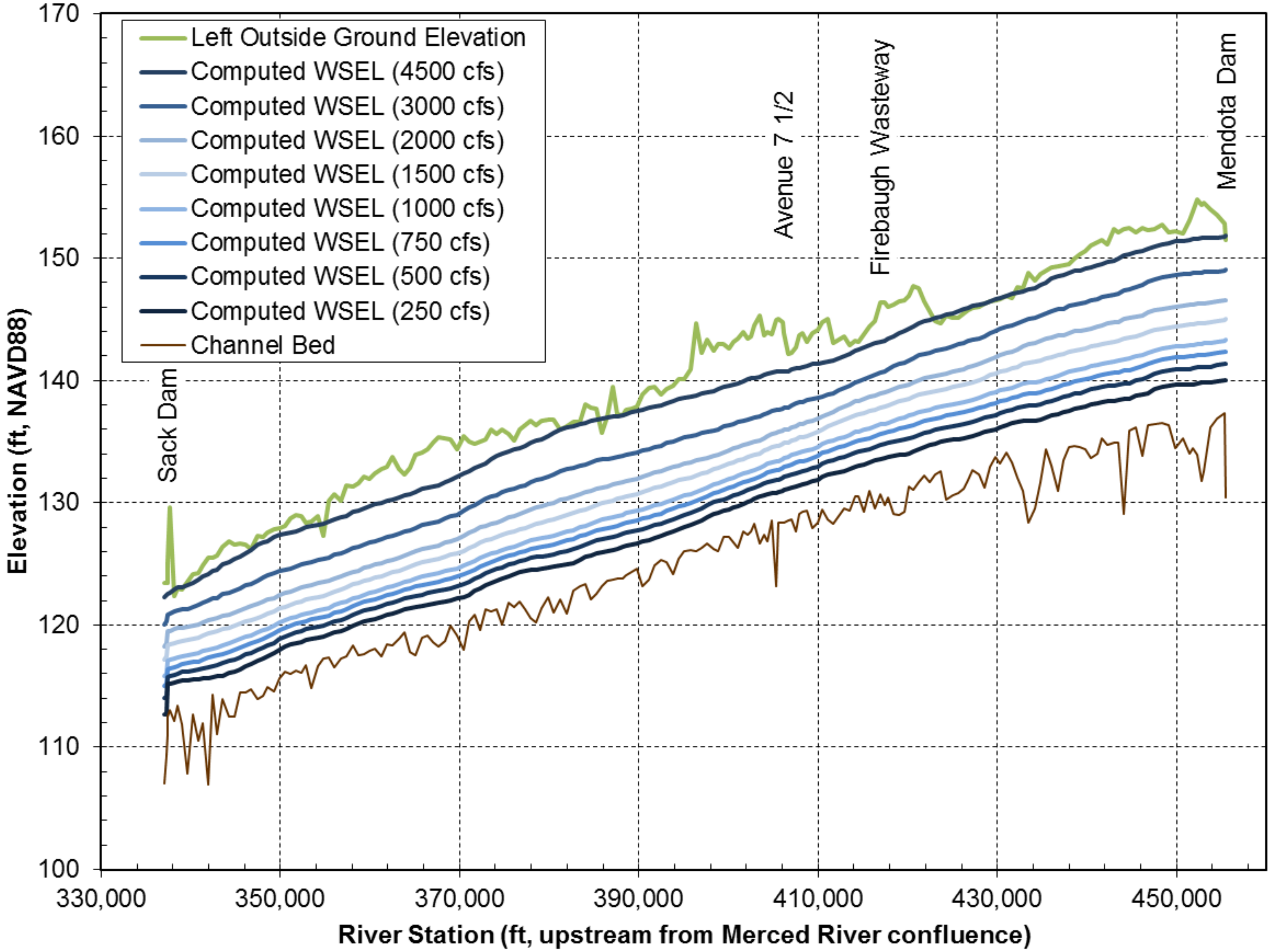

Figure 12. Comparison of outside ground elevation with computed water-surface elevations along left levee in Reach 3.

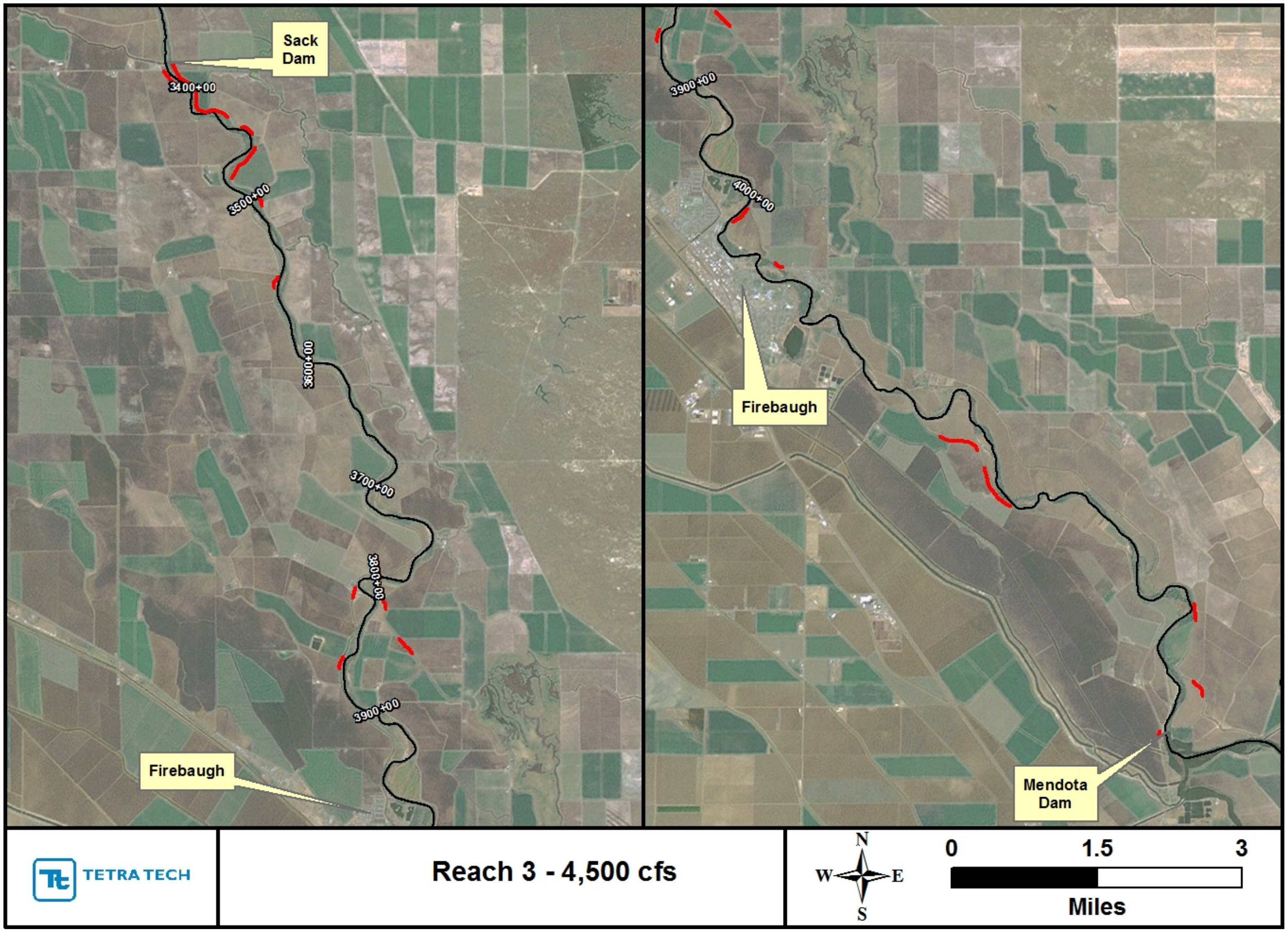

Figure 13. Portions of levee in Reach 3 where the 4,500-cfs water-surface elevation is above the existing outside ground elevation.

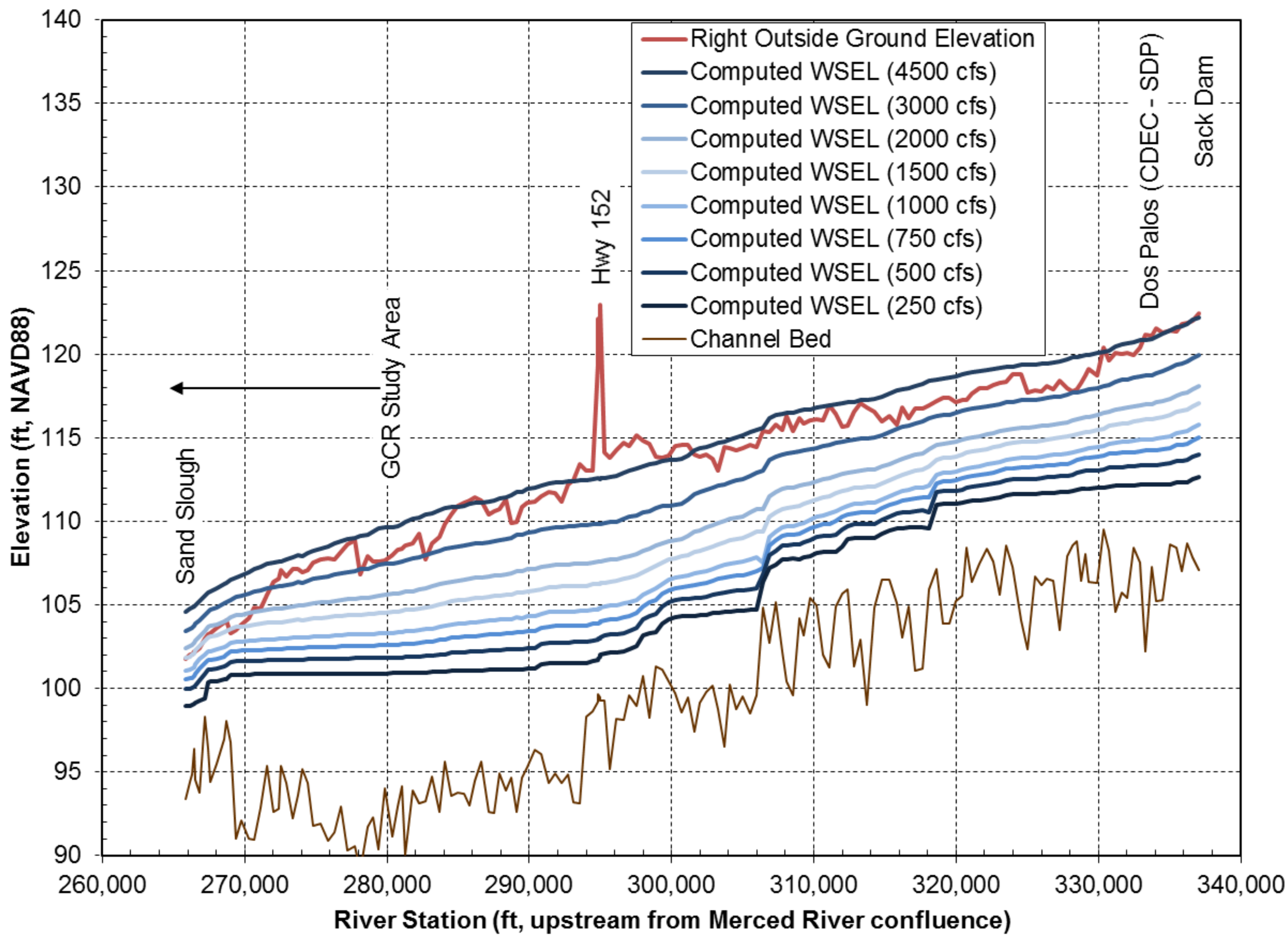

Figure 14. Comparison of outside ground elevation with computed water-surface elevations along right levee in Reach 4A.

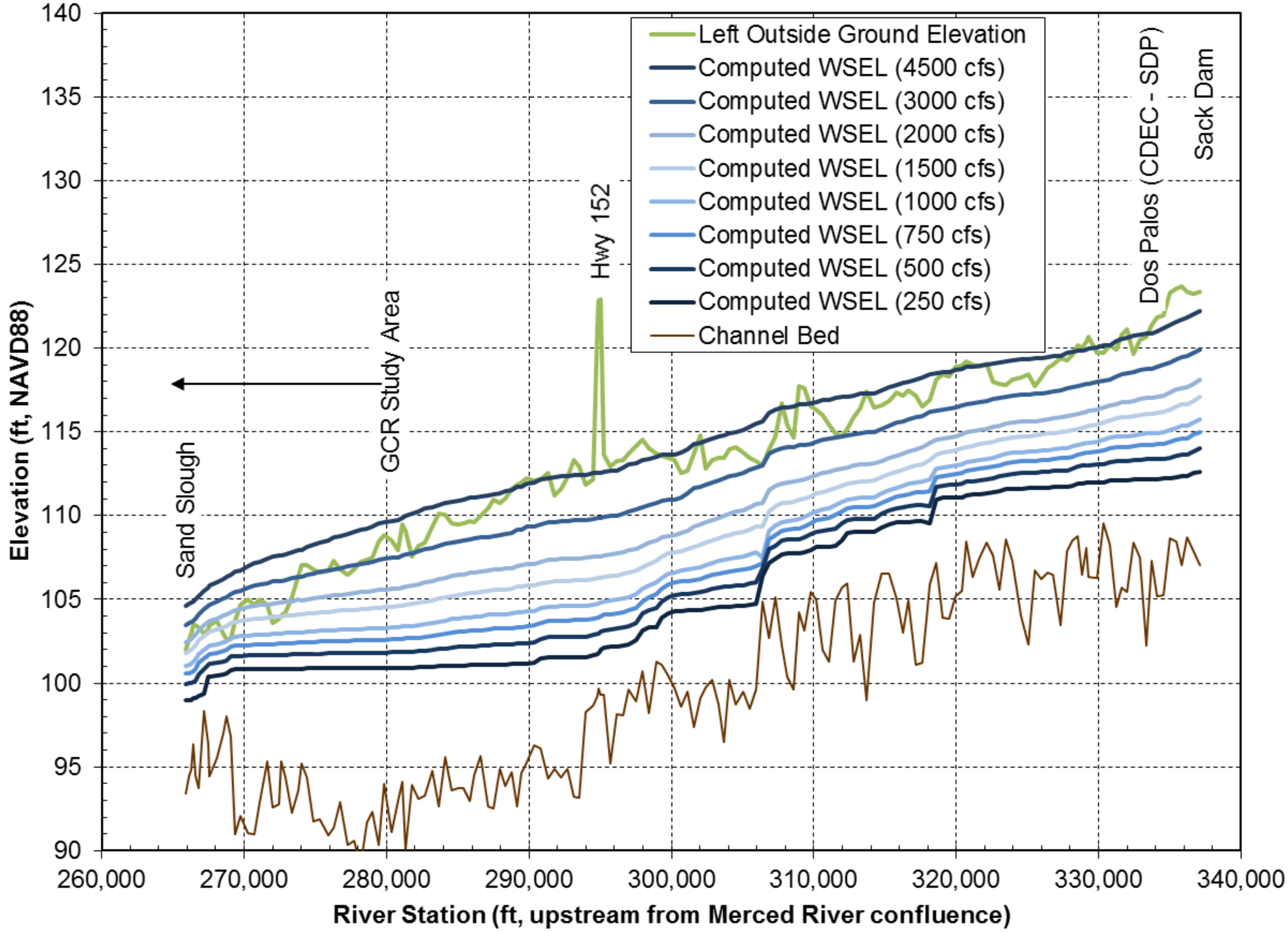

Figure 15. Comparison of outside ground elevation with computed water-surface elevations along left levee in Reach 4A.

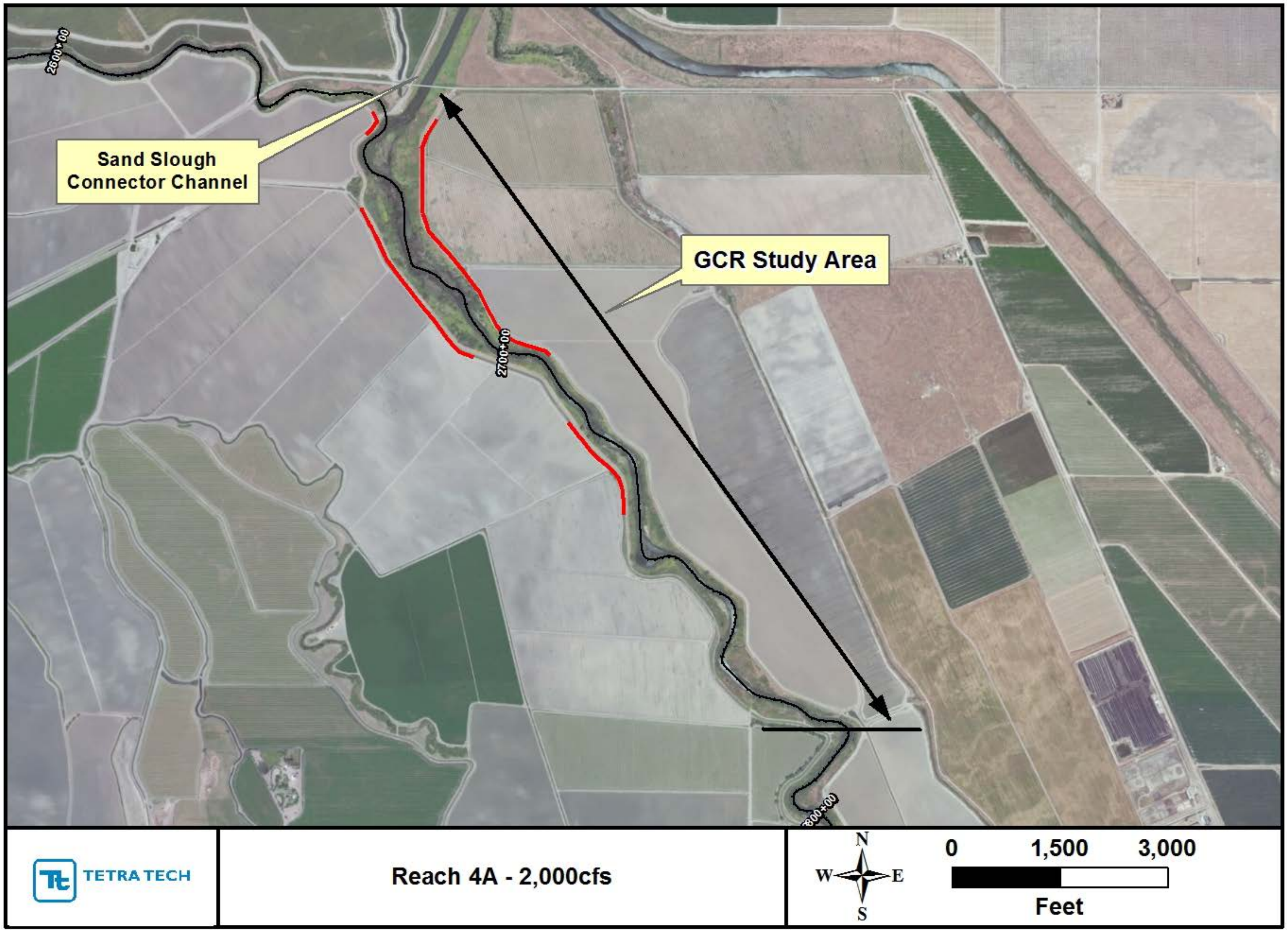

Figure 16. Portions of levee in Reach 4A where the 2,000-cfs water-surface elevation is above the existing outside ground elevation.

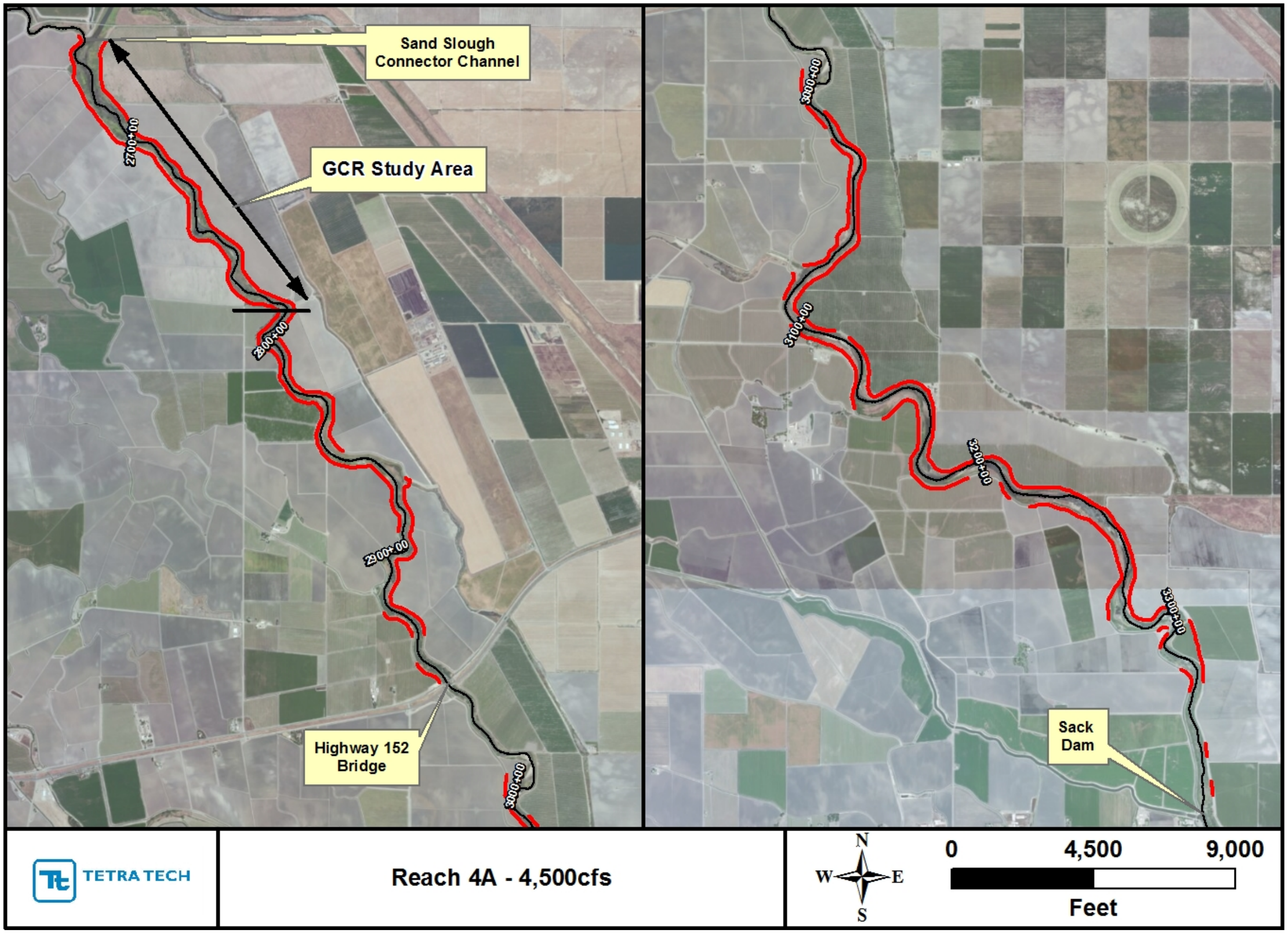

Figure 17. Portions of levee in Reach 4A where the 4,500-cfs water-surface elevation is above the existing outside ground elevation.

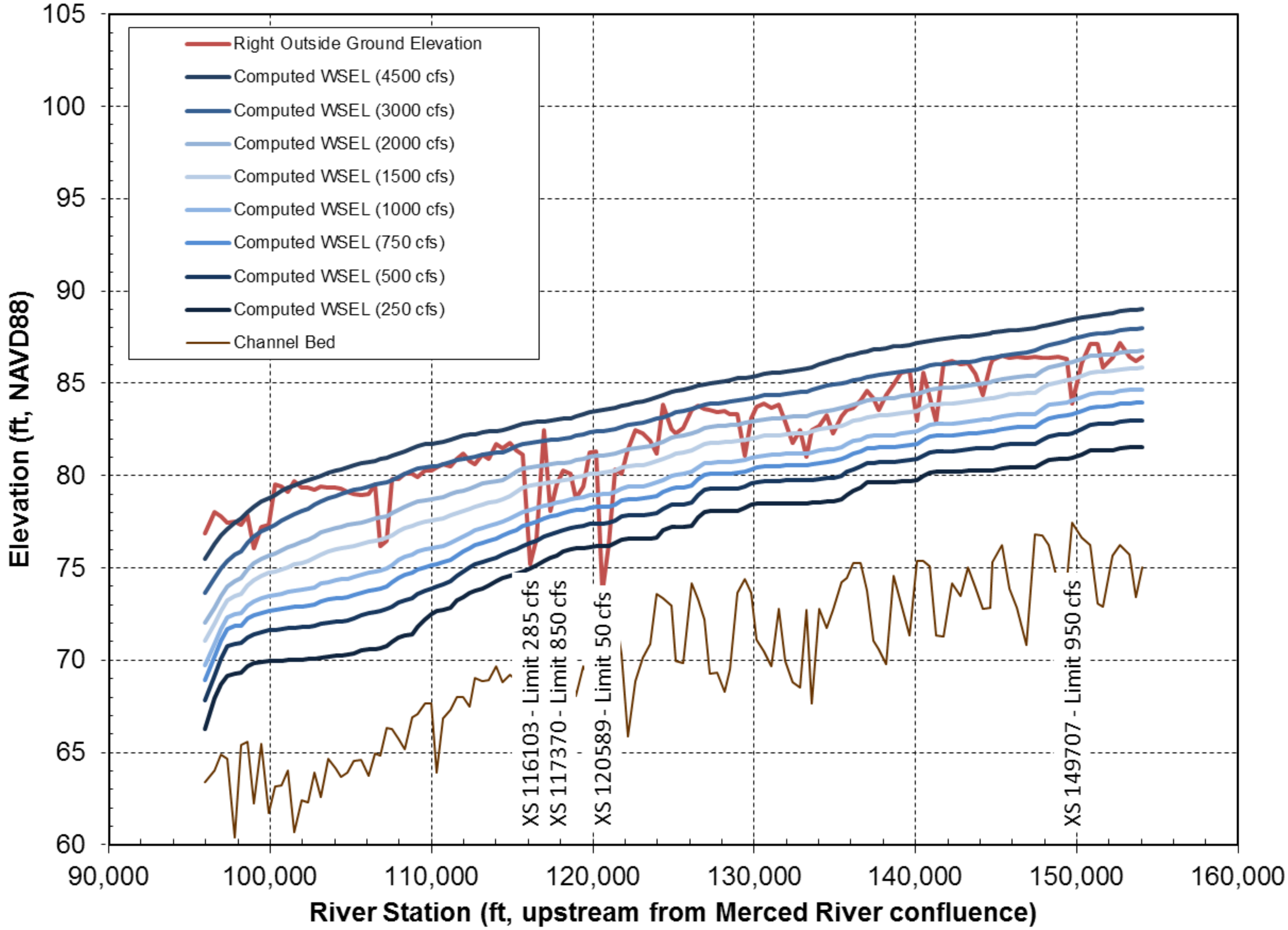

Figure 18. Comparison of outside ground elevation with computed water-surface elevations along right levee in Reach 4B2.

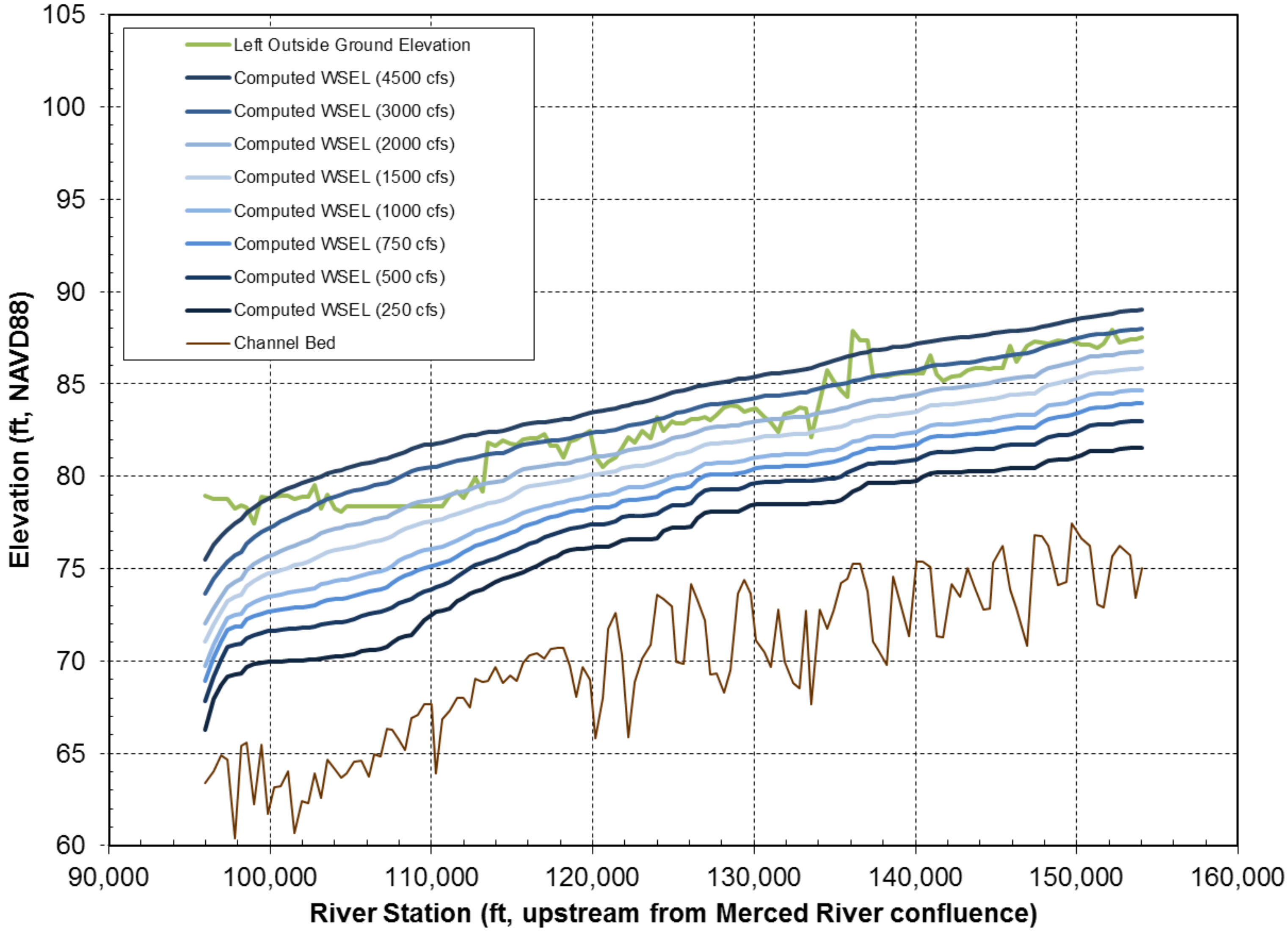

Figure 19. Comparison of outside ground elevation with computed water-surface elevations along left levee in Reach 4B2.

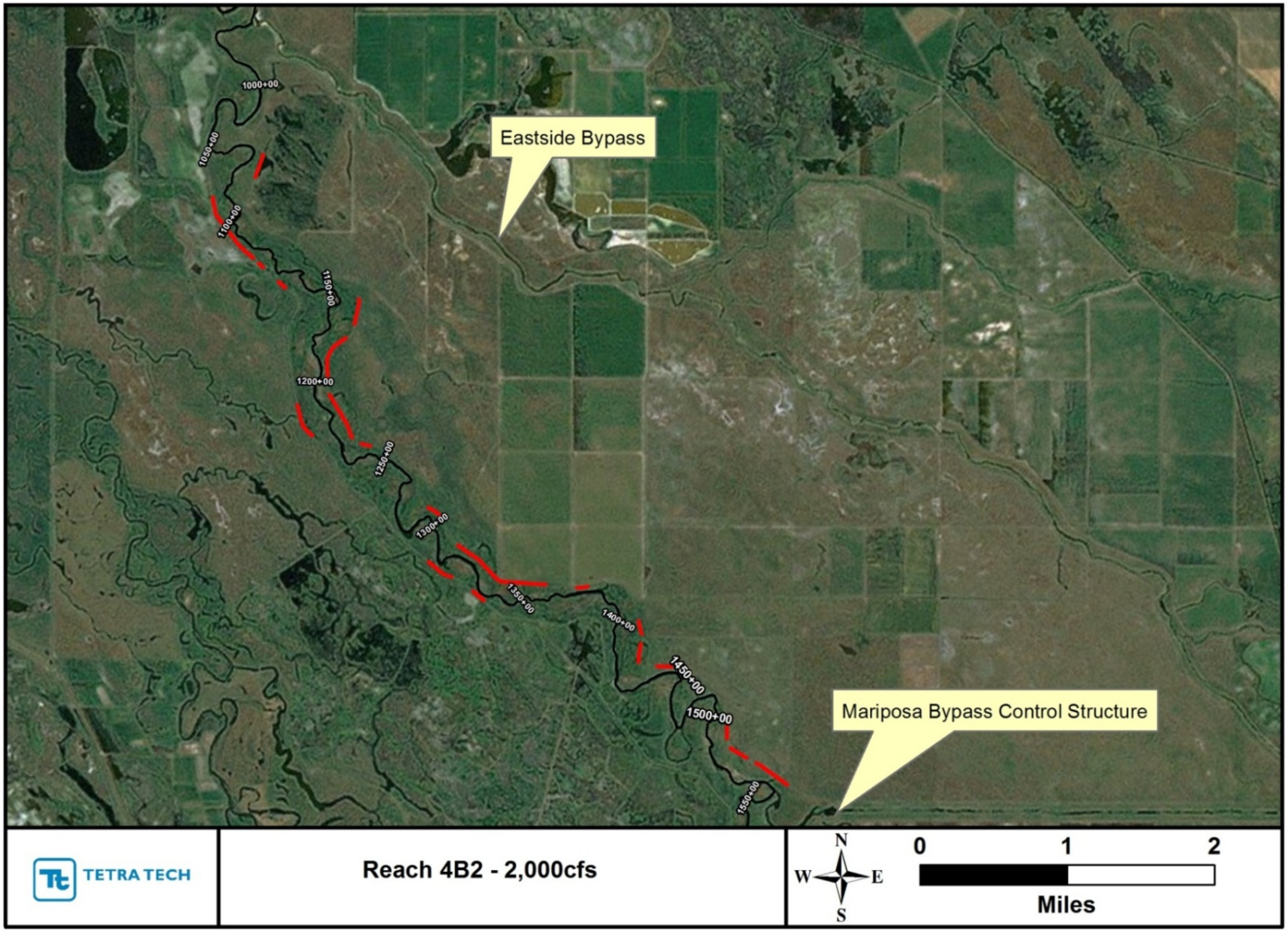

Figure 20. Portions of levee in Reach 4B2 where the 2,000-cfs water-surface elevation is above the existing outside ground elevation.

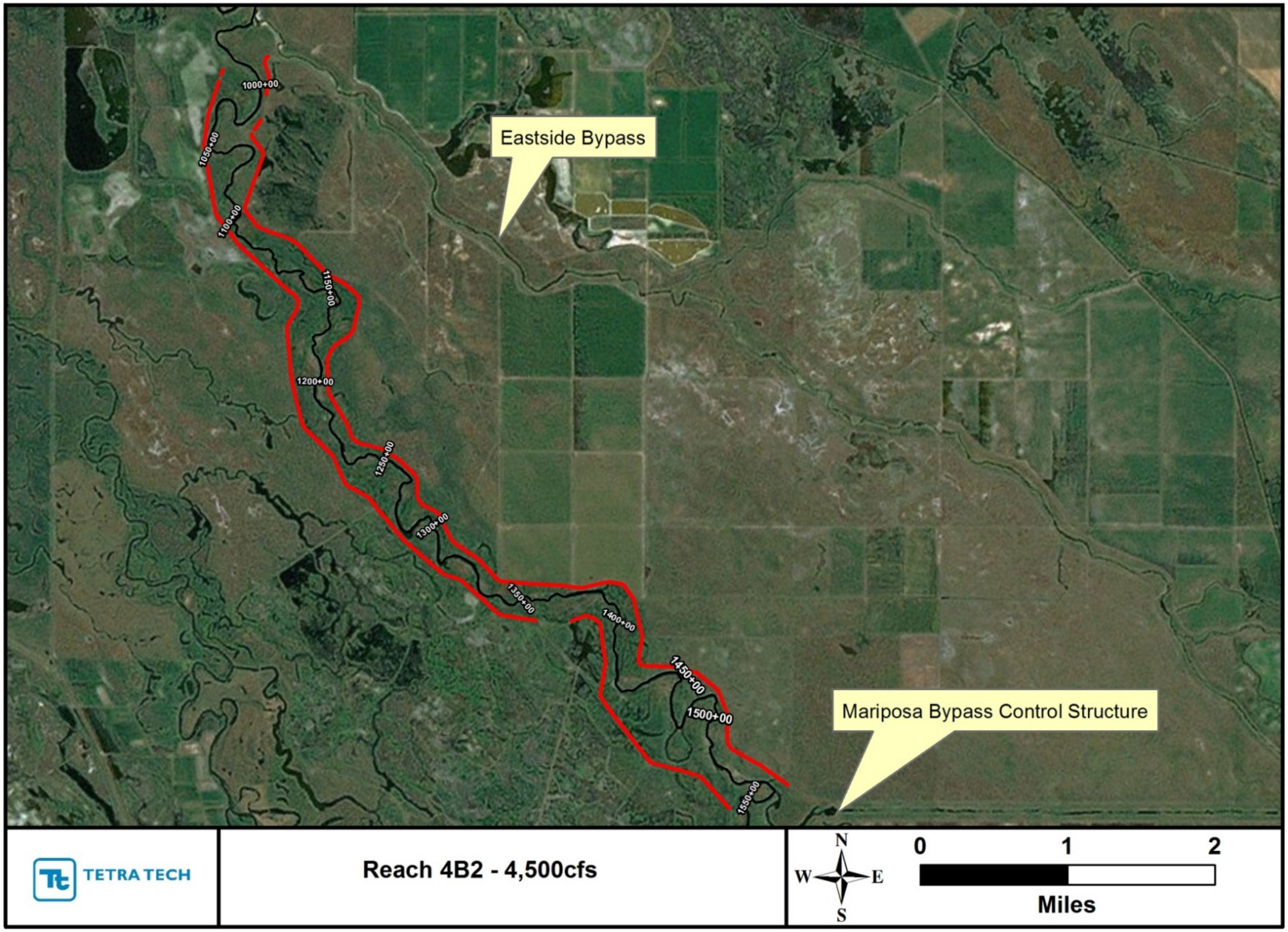

Figure 21. Portions of levee in Reach 4B2 where the 4,500-cfs water-surface elevation is above the existing outside ground elevation.

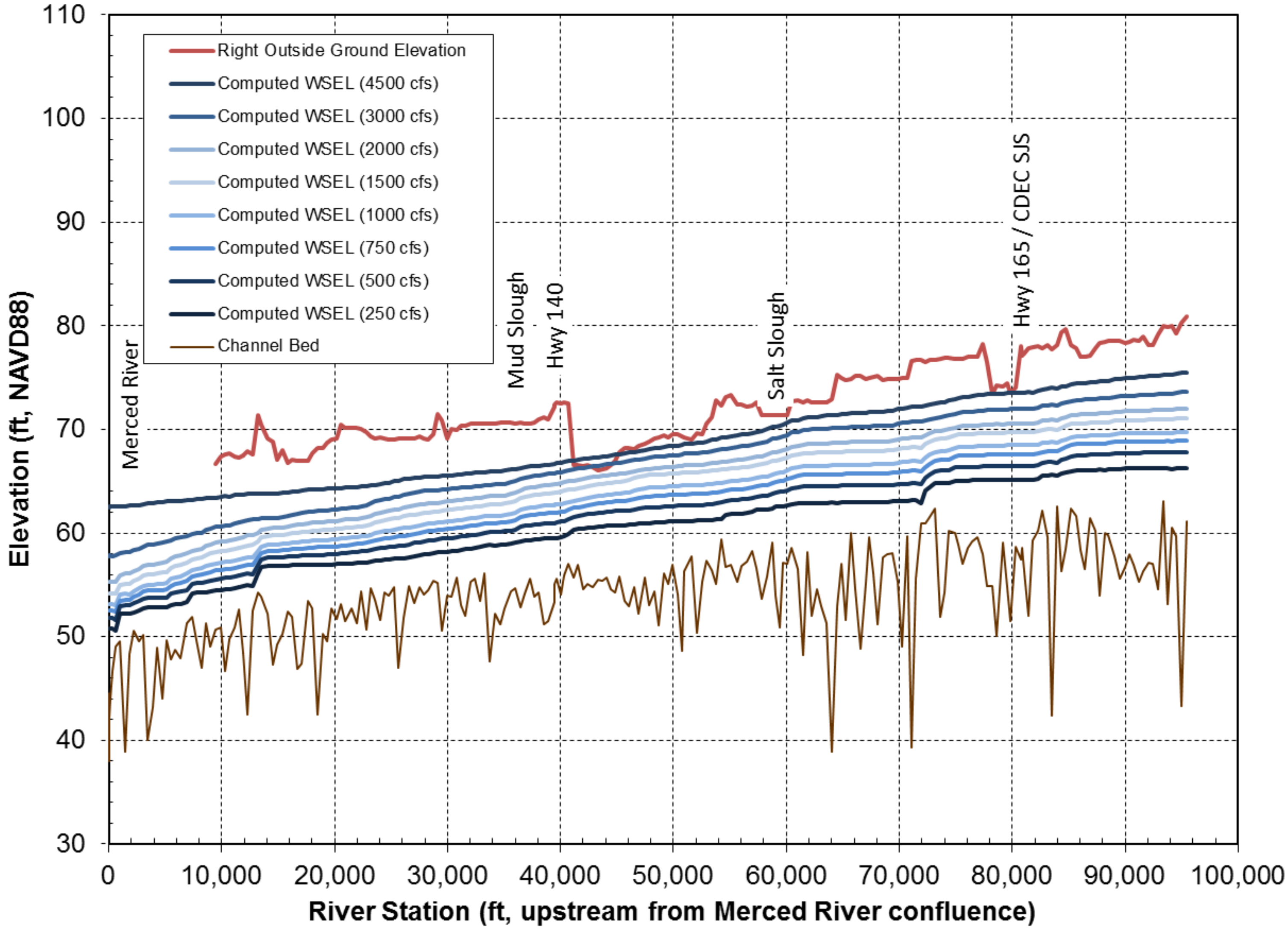

Figure 22. Comparison of outside ground elevation with computed water-surface elevations along right levee in Reach 5.

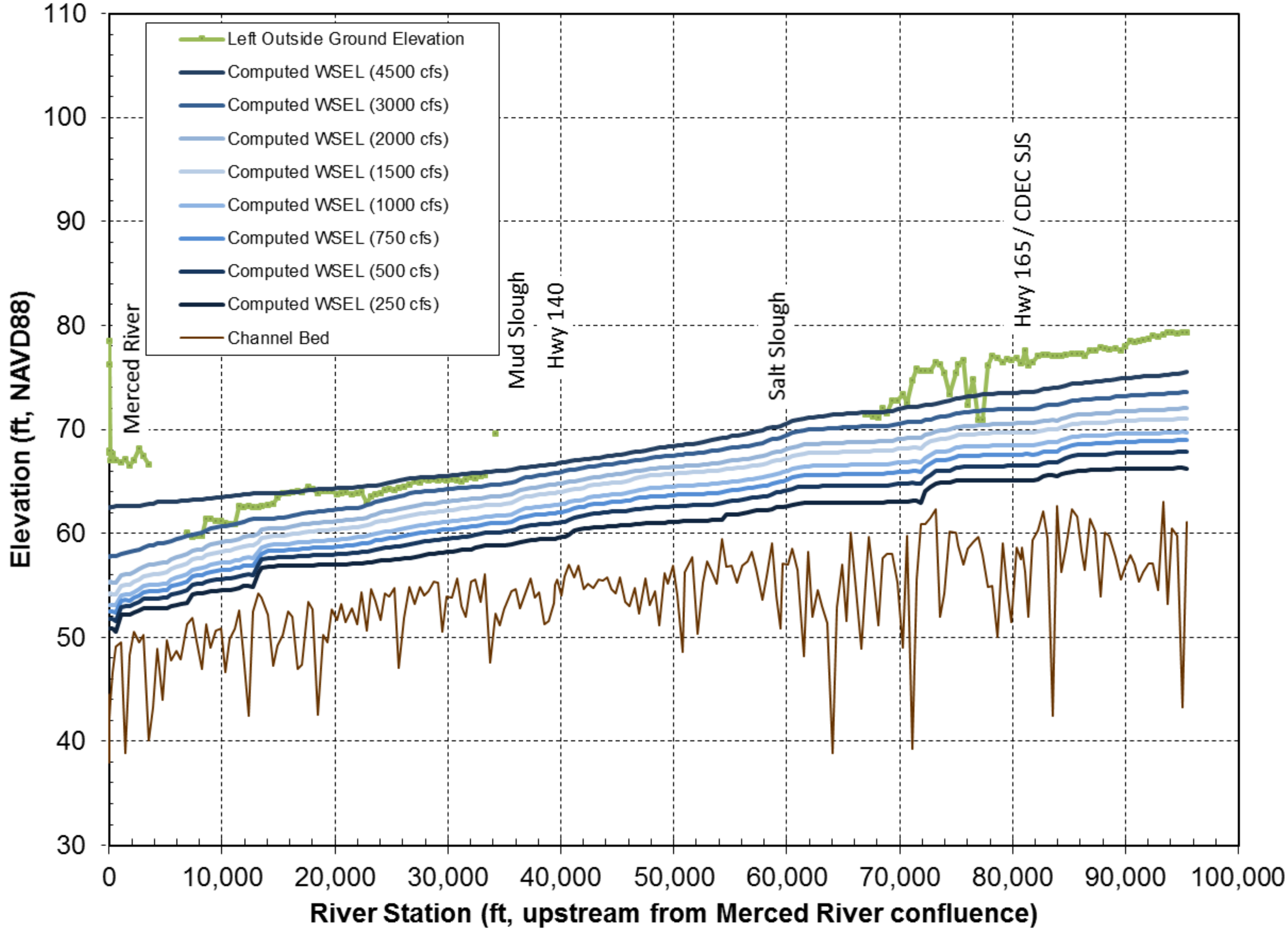

Figure 23. Comparison of outside ground elevation with computed water-surface elevations along left levee in Reach 5.

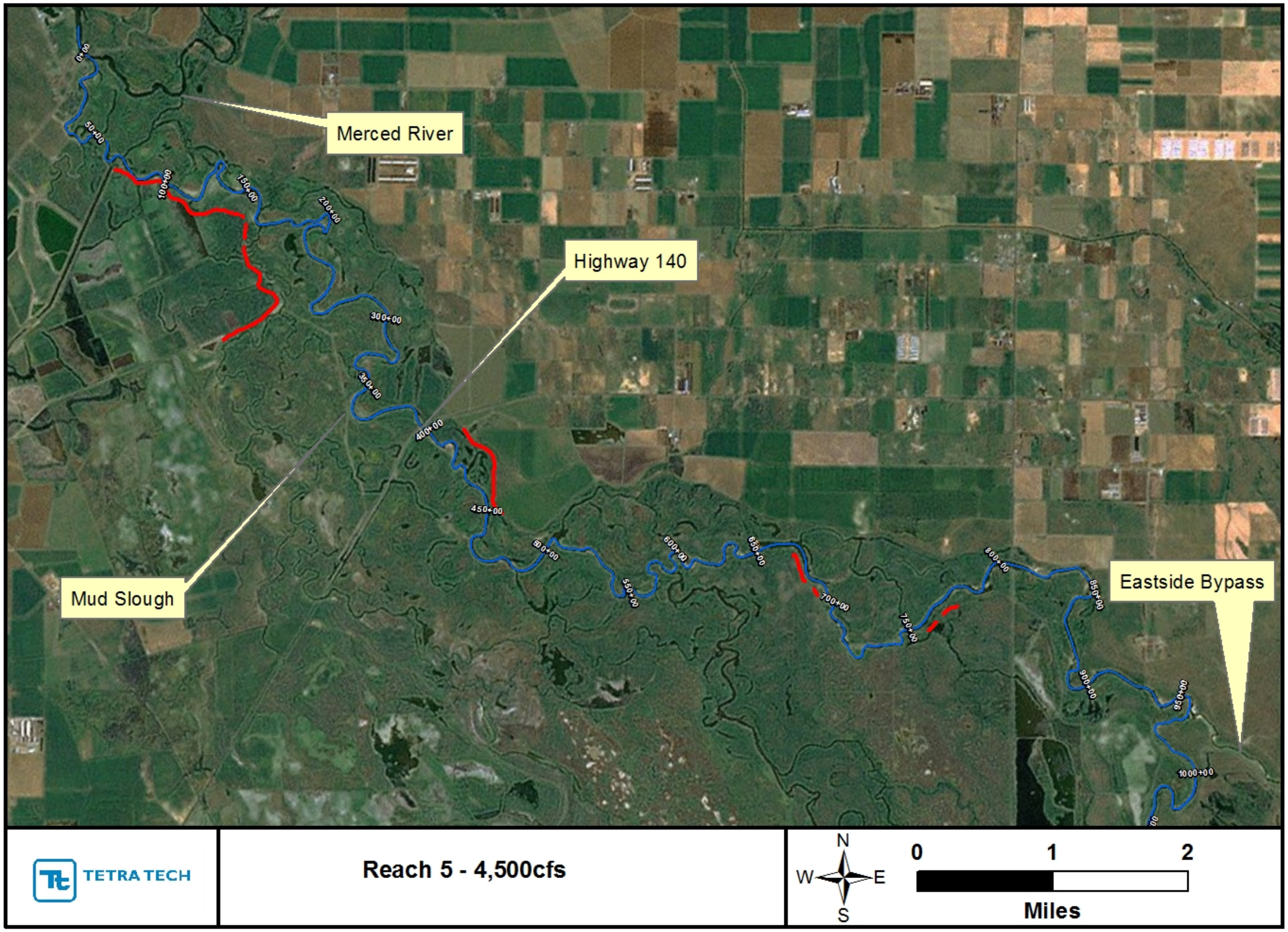

Figure 24. Portions of levee in Reach 5 where the 4,500-cfs water-surface elevation is above the existing outside ground elevation.

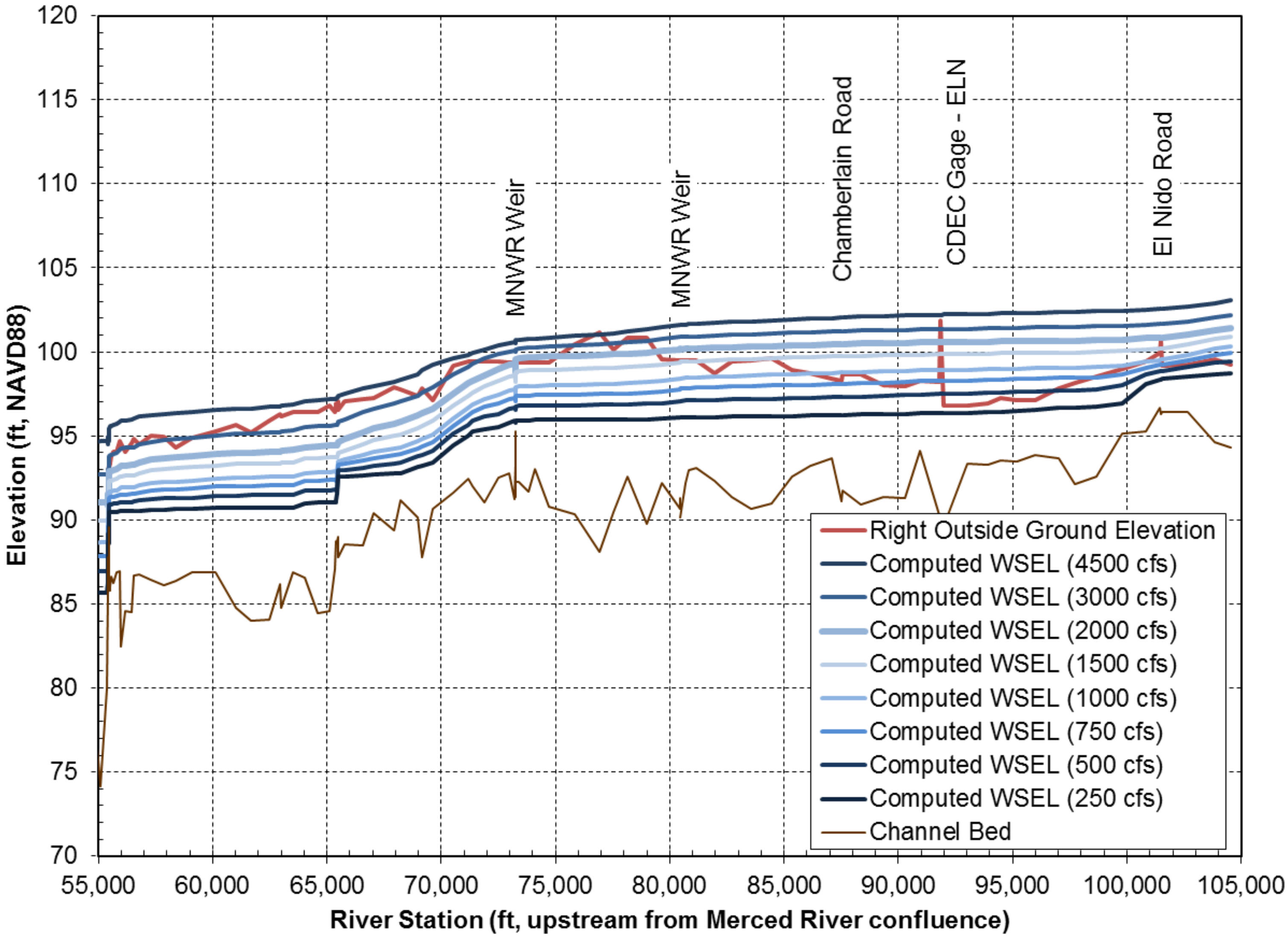

Figure 25. Comparison of outside ground elevation with computed water-surface elevations along right levee in Middle Eastside Bypass. Profiles represent the Boards Out condition.

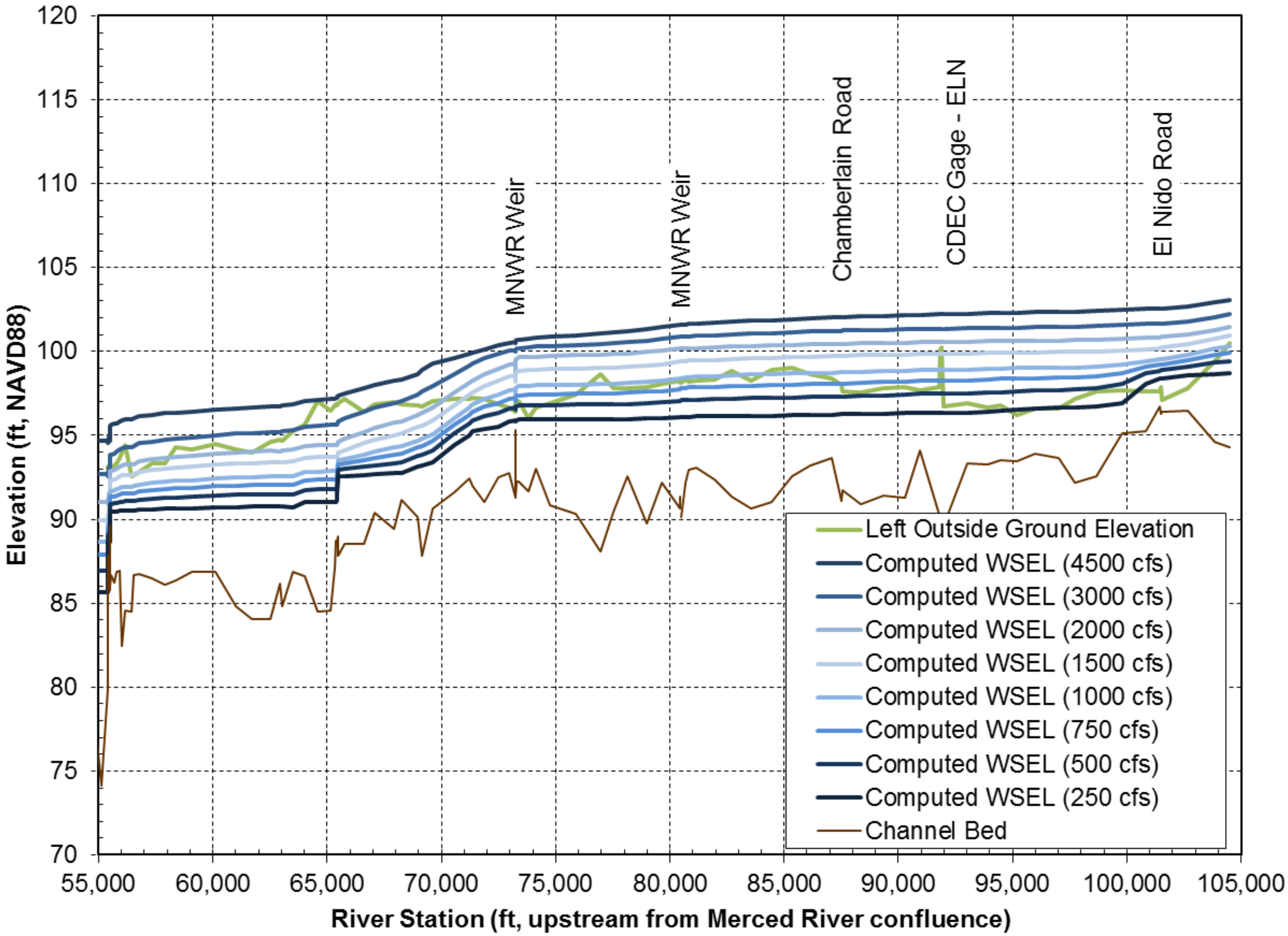

Figure 26. Comparison of outside ground elevation with computed water-surface elevations along left levee in Middle Eastside Bypass. Profiles represent the Boards Out condition.

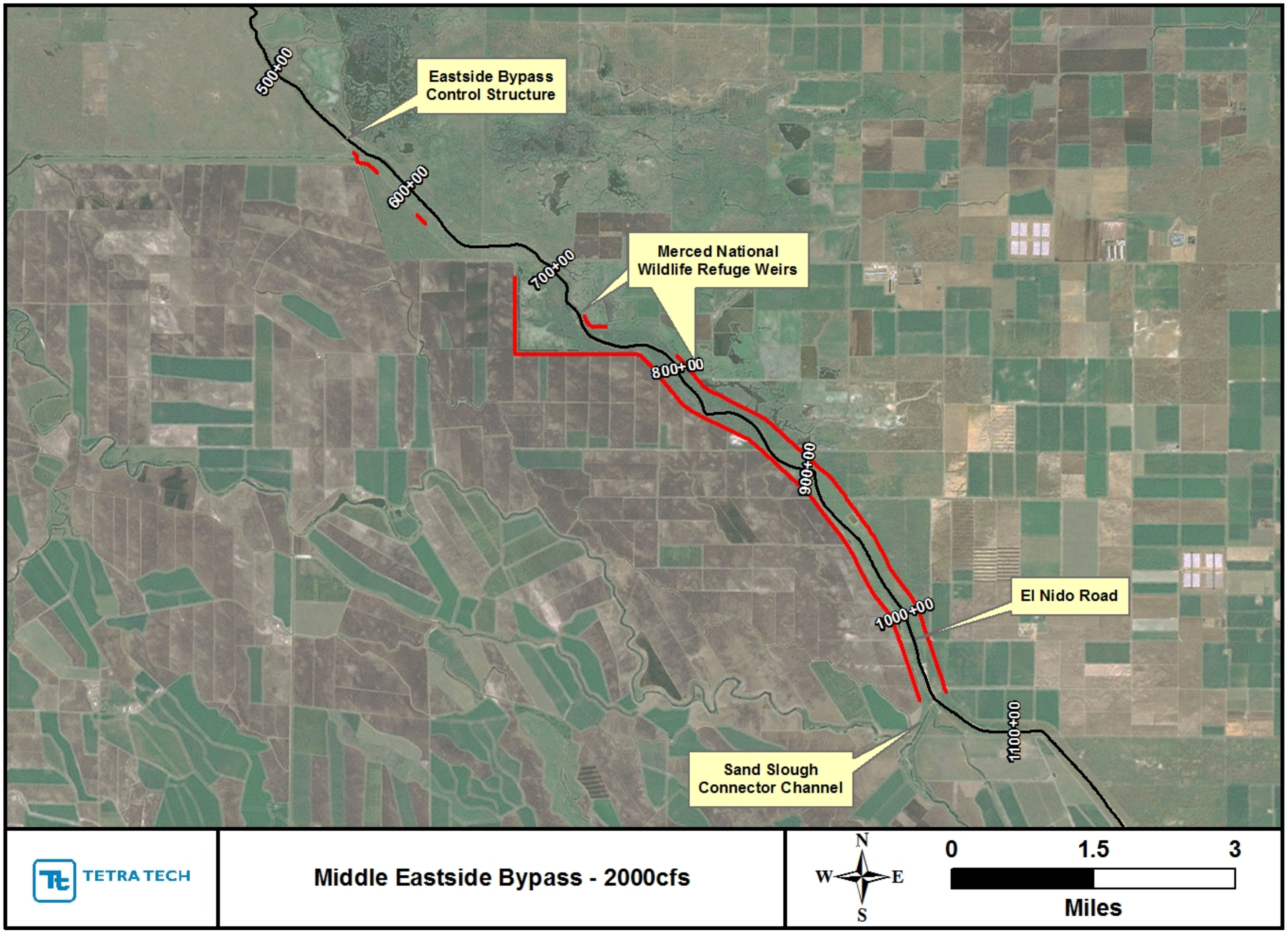

Figure 27. Portions of levee in the Middle Eastside Bypass where the 2,000-cfs water-surface elevation is above the existing outside ground elevation under the Boards Out condition.

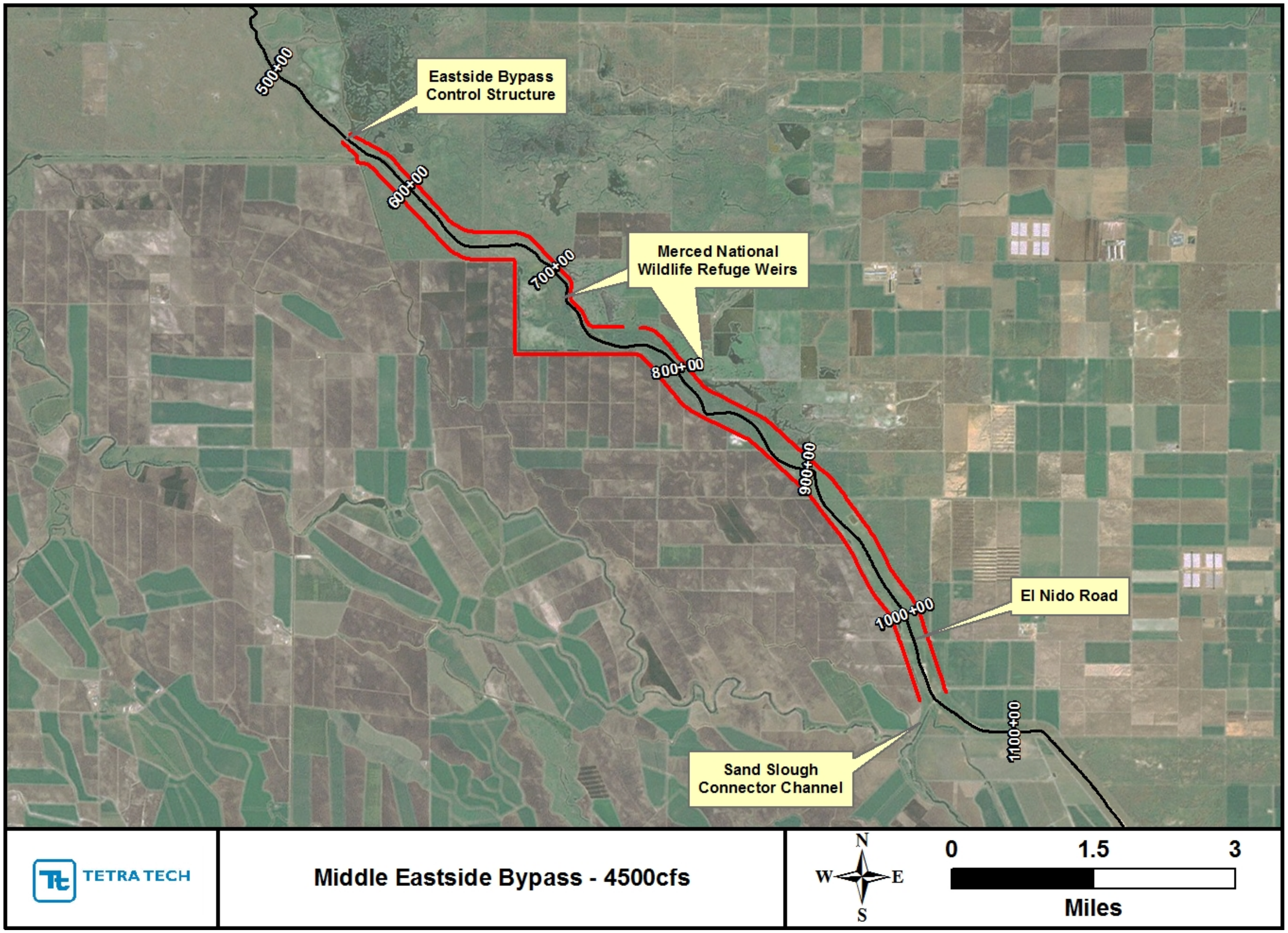

Figure 28. Portions of levee in the Middle Eastside Bypass where the 4,500-cfs water-surface elevation is above the existing outside ground elevation under the Boards Out condition.

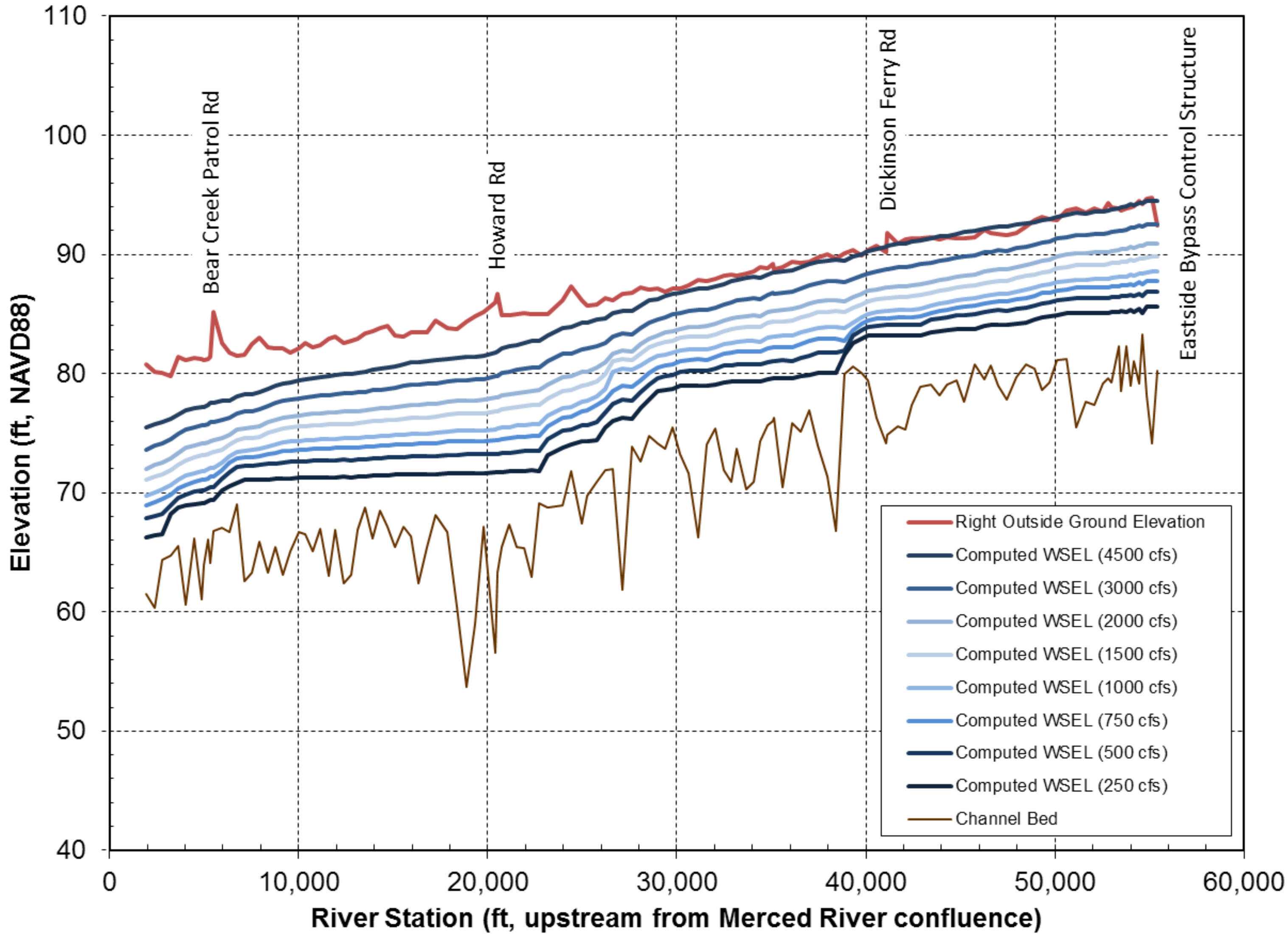

Figure 29. Comparison of outside ground elevations with computed water-surface elevations along right levee in Lower Eastside Bypass.

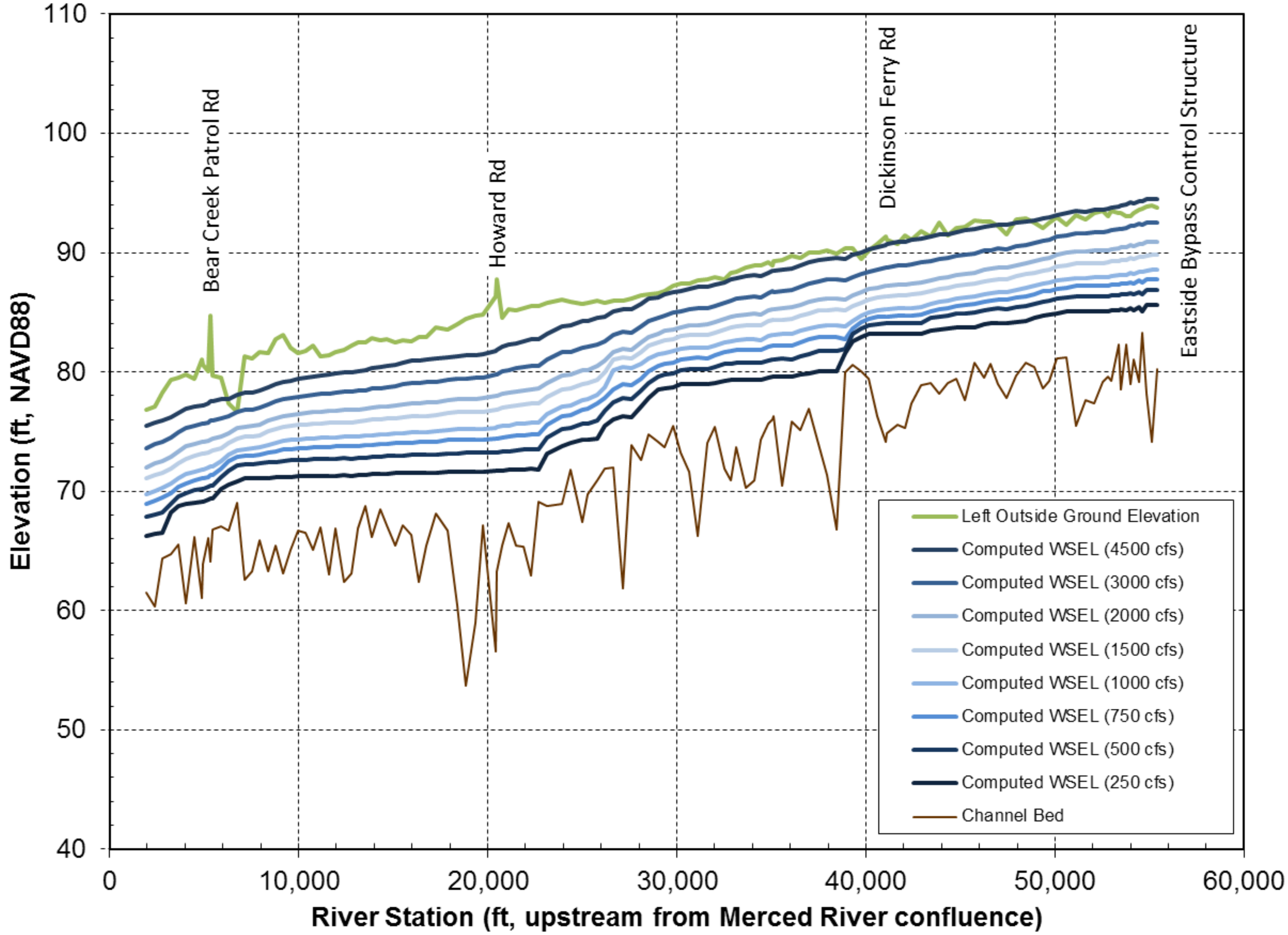

Figure 30. Comparison of outside ground elevations with computed water-surface elevations along left levee in Lower Eastside Bypass.

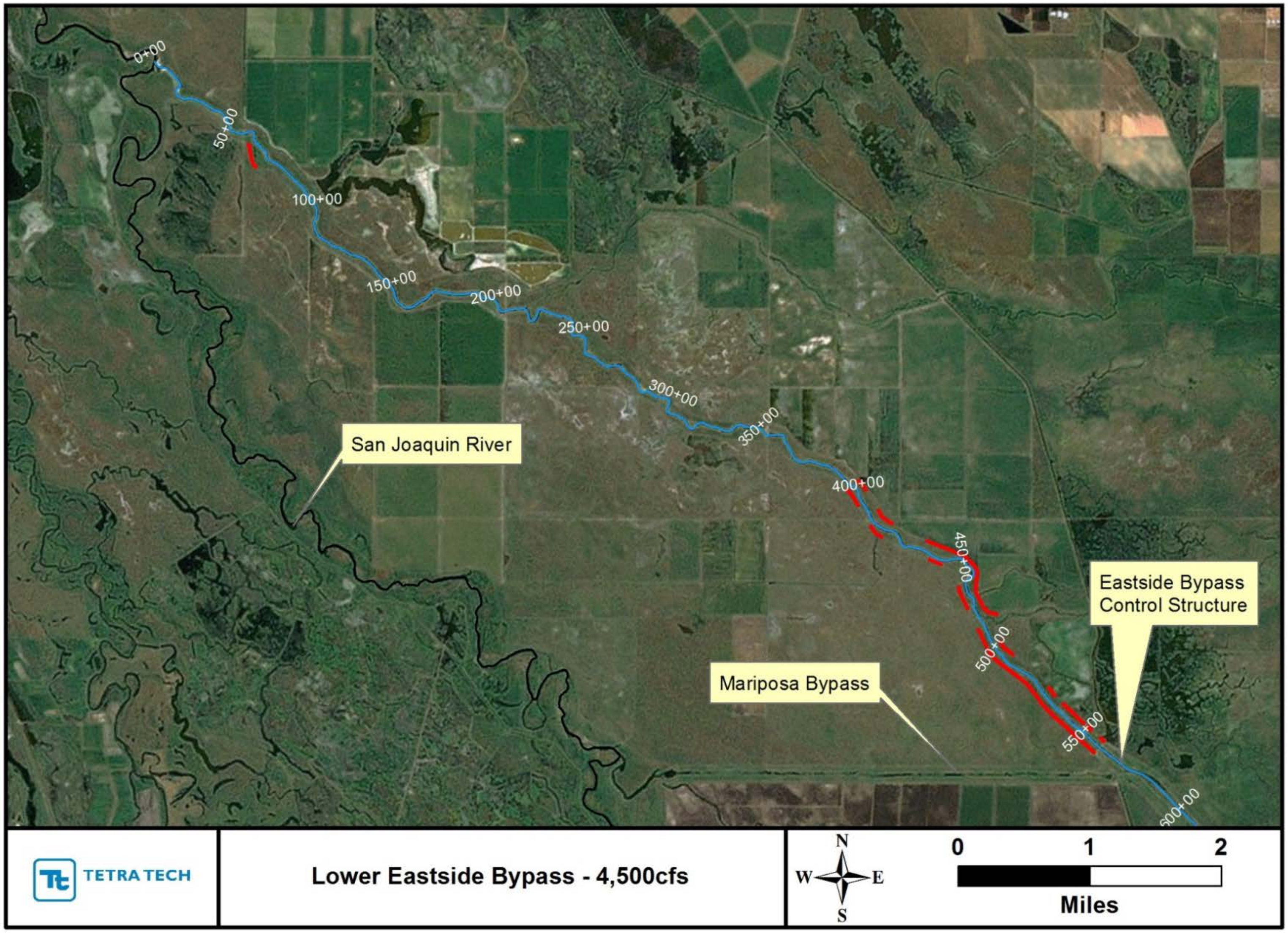

Figure 31. Portions of levee in the Lower Eastside Bypass where the 4,500-cfs water-surface elevation is above the existing outside ground elevation.

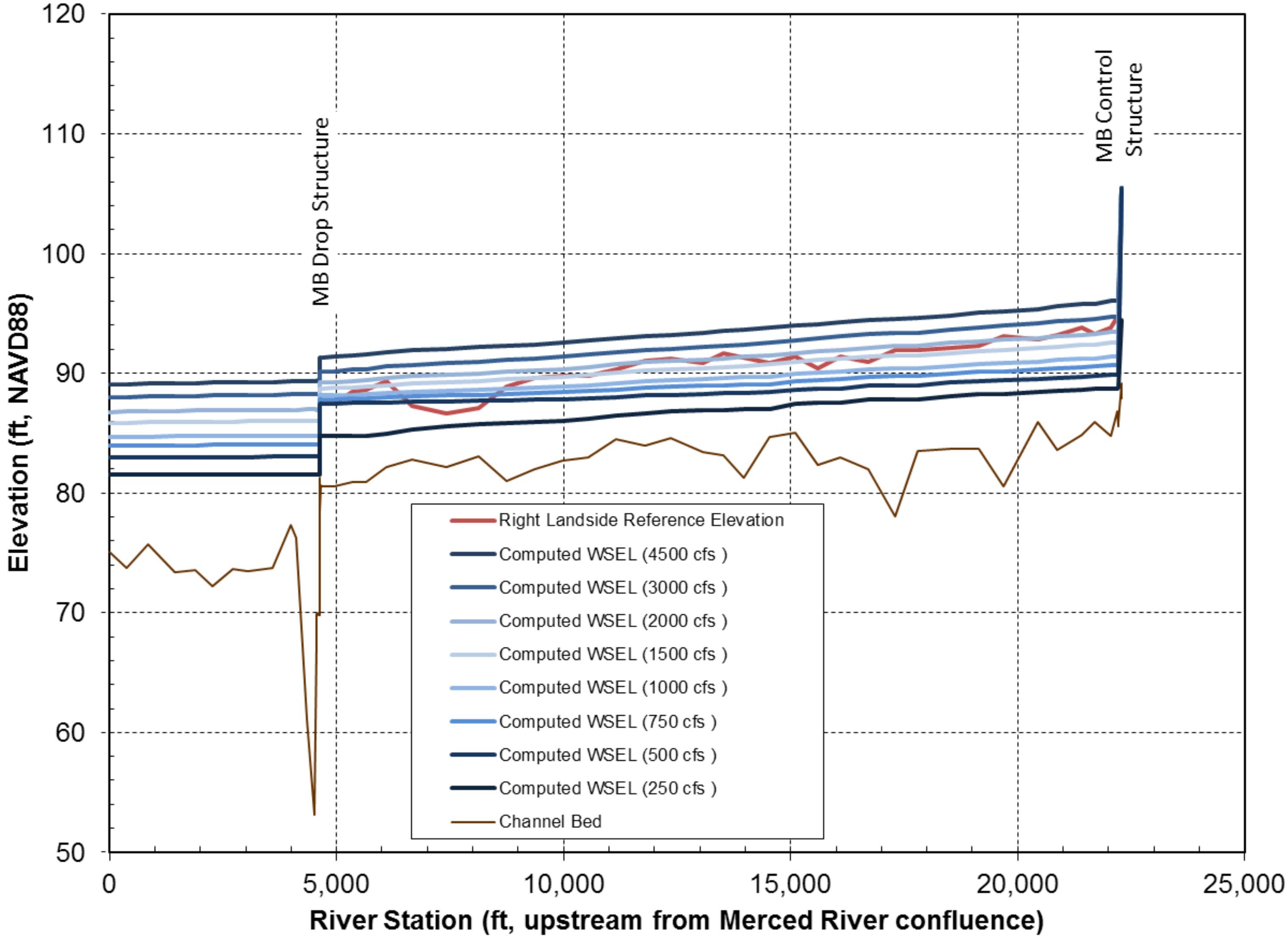

Figure 32. Comparison of outside ground elevation with computed water-surface elevations along right levee in Mariposa Bypass.

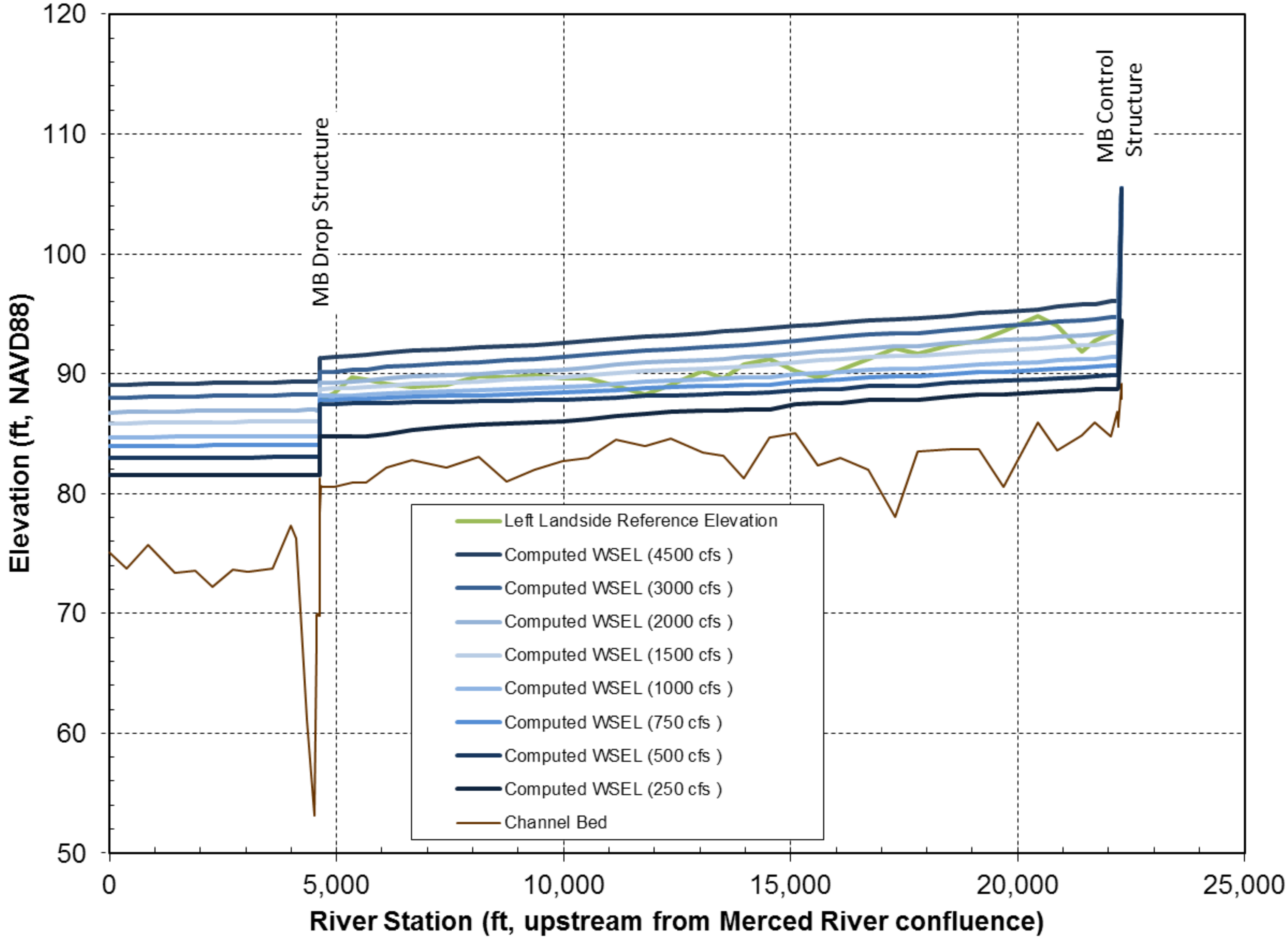

Figure 33. Comparison of outside ground elevation with computed water-surface elevations along left levee in Mariposa Bypass.

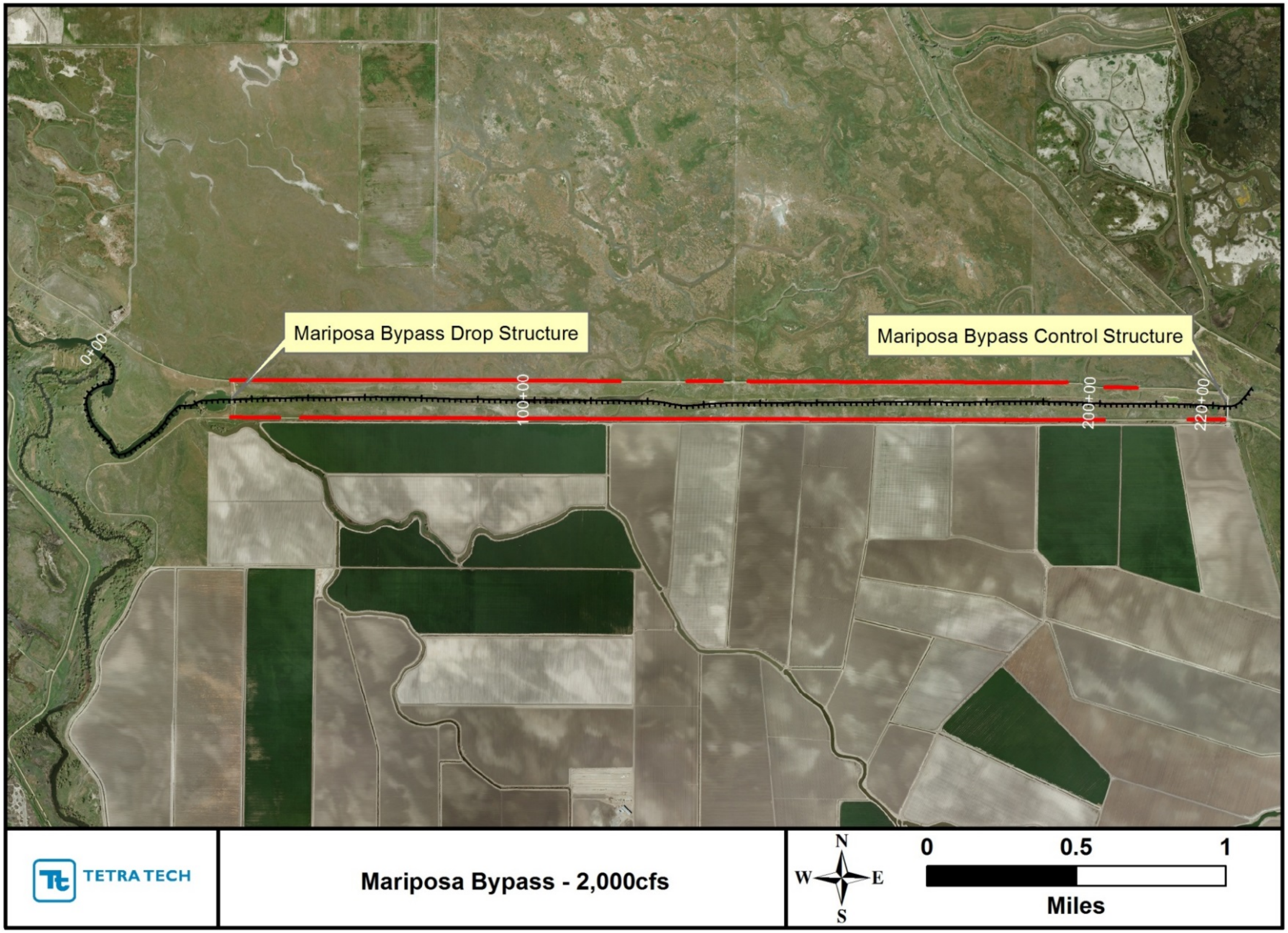

Figure 34. Portions of levee in the Mariposa Bypass where the 2,000-cfs water-surface elevation is above the existing outside ground elevation.

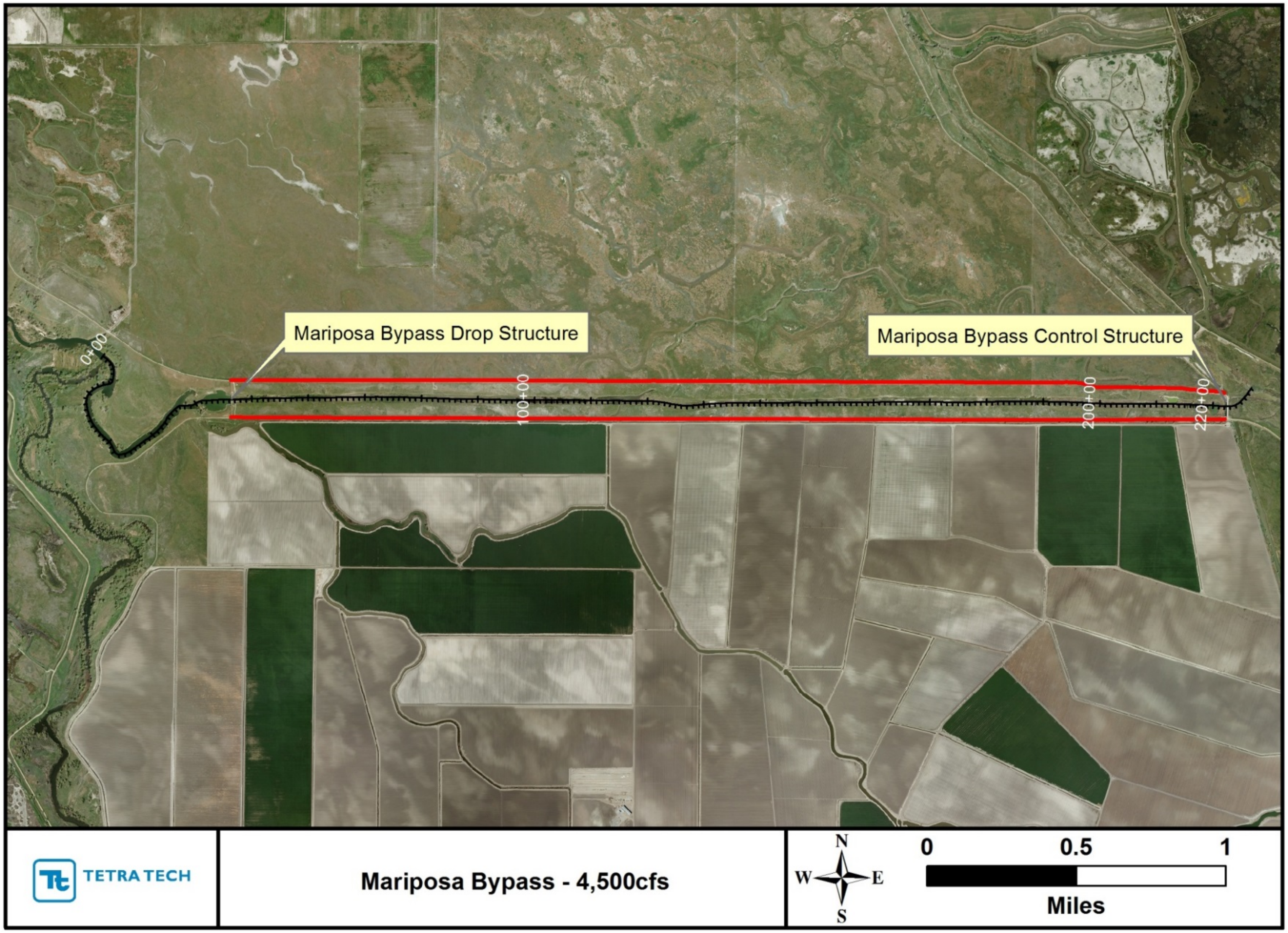

Figure 35. Portions of levee in the Mariposa Bypass where the 4,500-cfs water-surface elevation is above the existing outside ground elevation.

APPENDIX A

Examples of Selected Outside Ground Elevation Locations

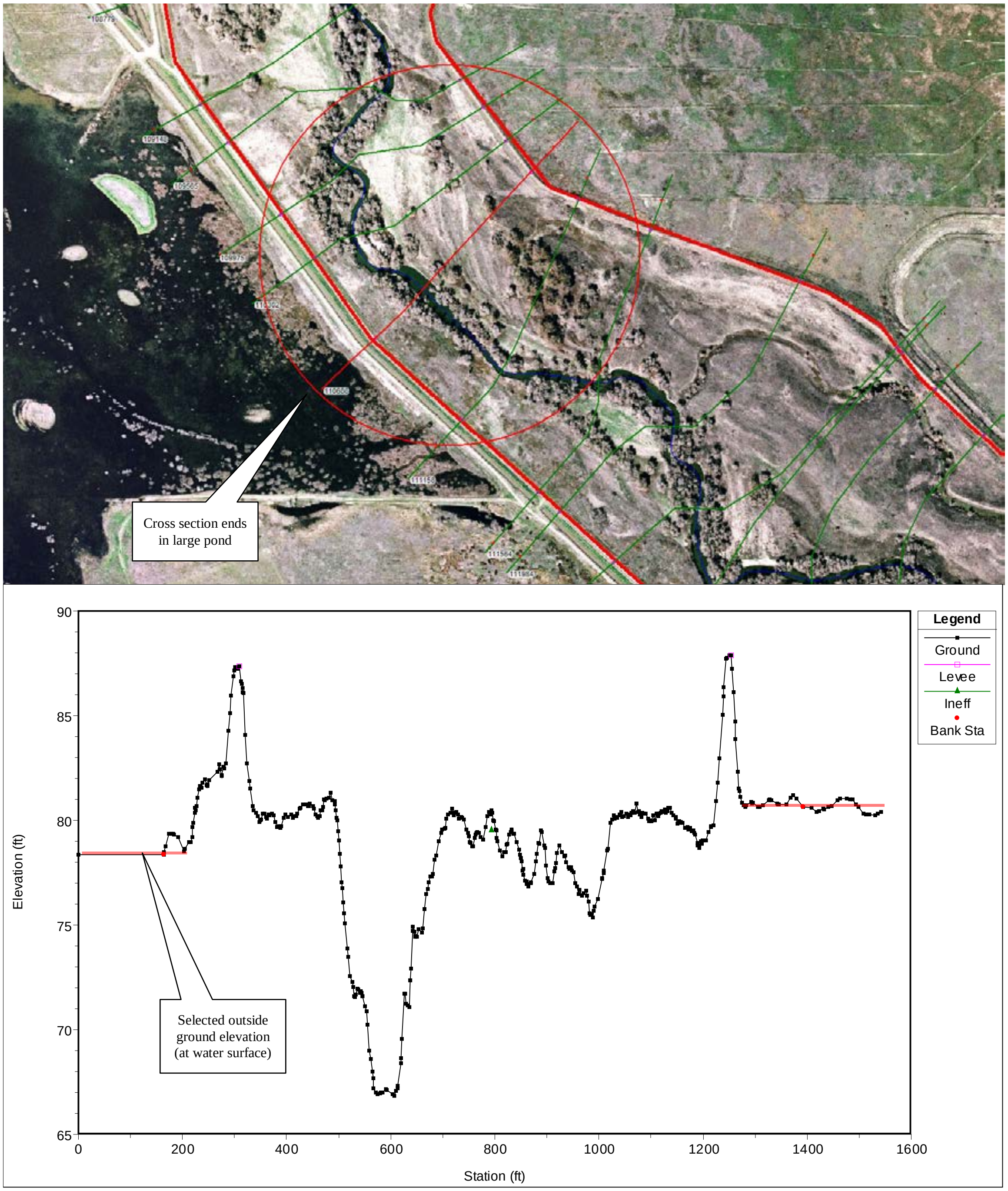

Figure A.1. Reach 4B2 – Plan and profile view of XS110688. The left side of the cross section terminates in a pond immediately adjacent to the levee.

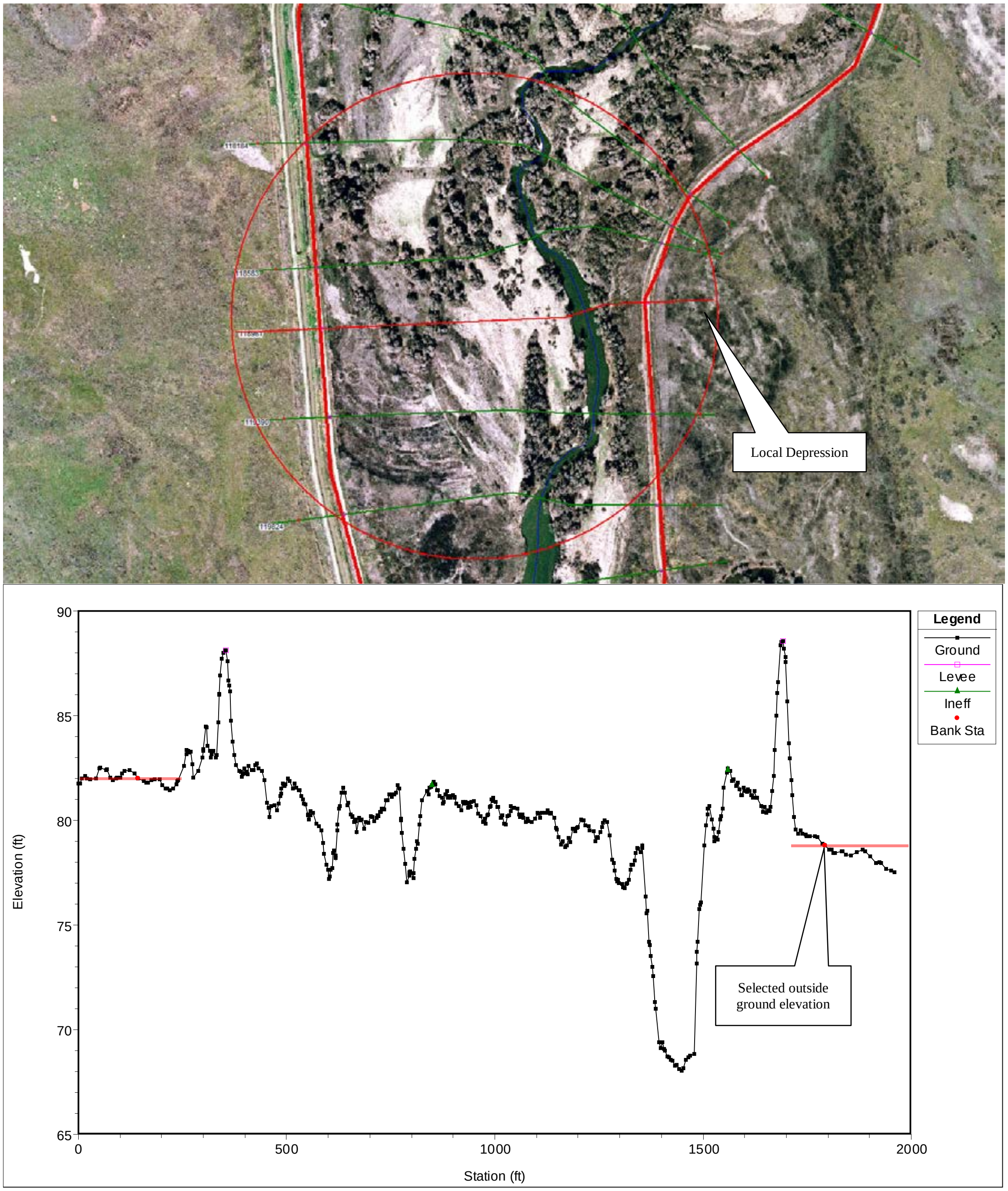

Figure A.2. Reach 4B2 – Plan and profile view of XS118961. The right overbank slopes away from the levee into an oxbow.

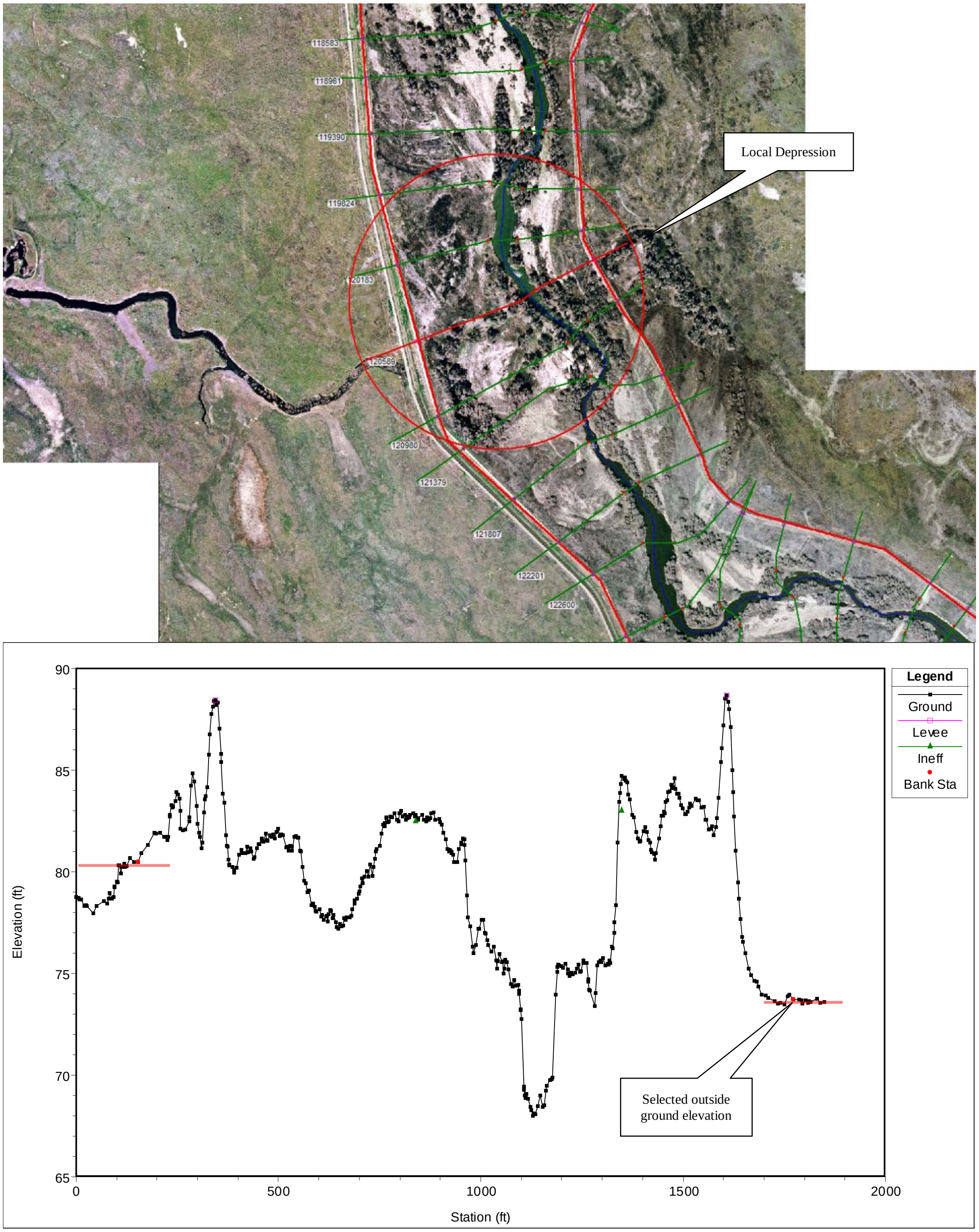

Figure A.3. Reach 4B2 – Plan and profile view of XS120589. The right overbank ends in a local depression.

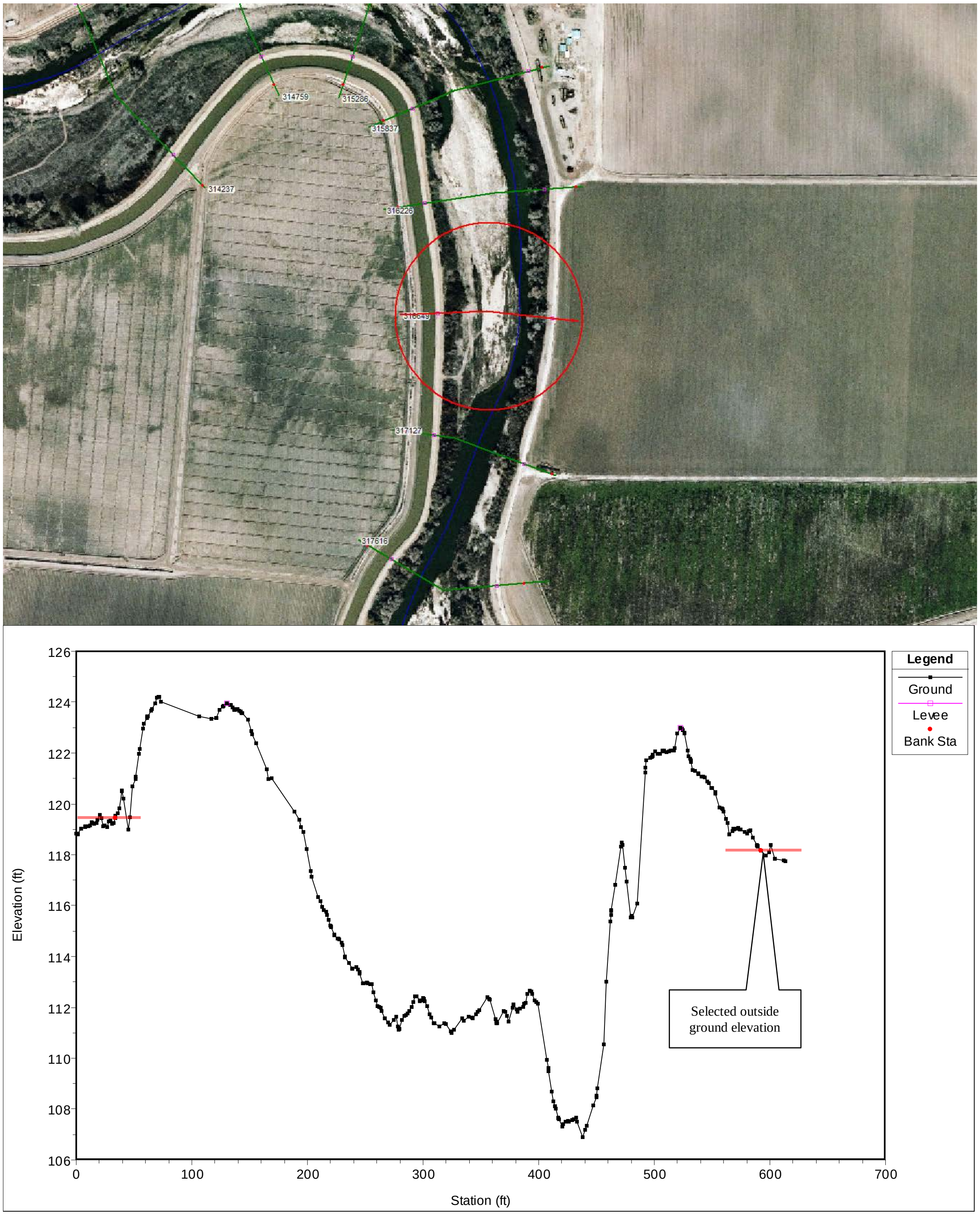

Figure A.4. Reach 4A – Plan and profile view of XS316649. The right overbank slopes away from the levee.

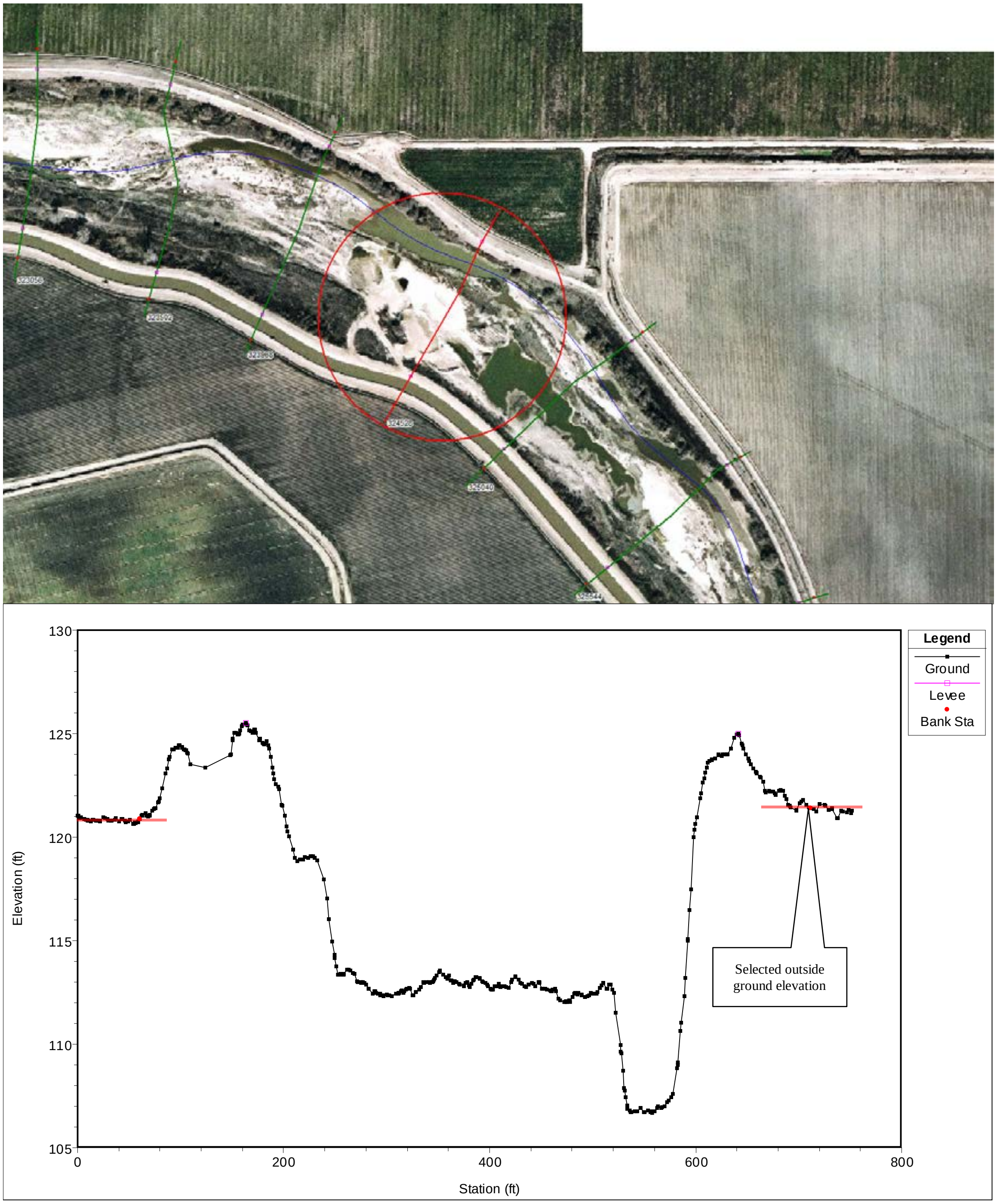

Figure A.5. Reach 4A – Plan and profile view of XS324528. The right overbank slopes gradually away from the levee.

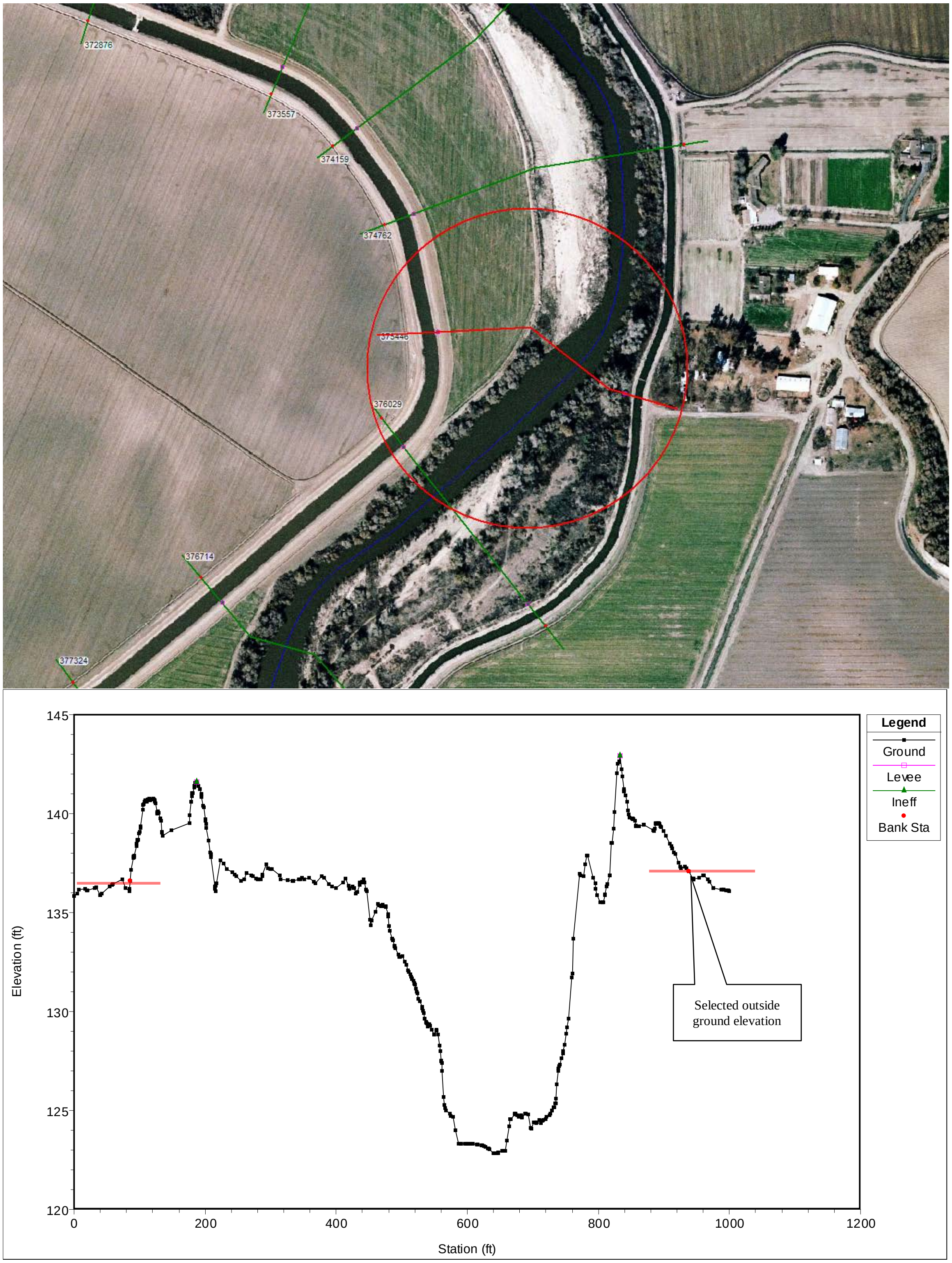

Figure A.6. Reach 3 – Plan and profile view of XS375446. The right overbank slopes away from the levee.

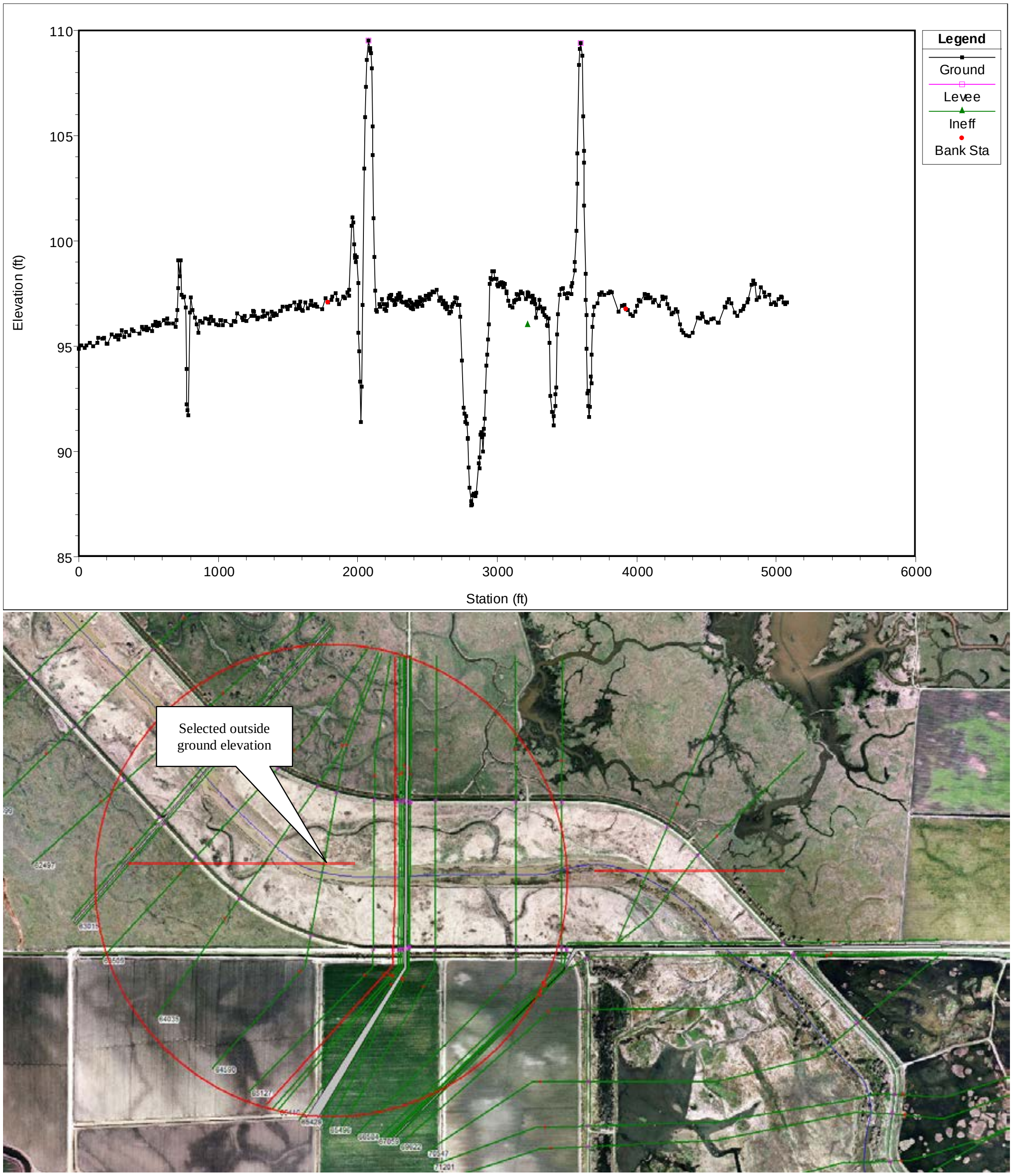

Figure A.7. Middle ESB – Plan and profile view of XS65344. The left overbank slopes away from levee.