Design Hydraulic Study

Jellys Ferry Road over Sacramento River, Bridge 8C-0043, and

over Sacramento River Overflow (North Overflow/Overflow No. 2)

Tehama County

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Executive Summary

Purpose:	Replace deficient bridge
Funding Program:	HBP
Design Flood:	Sacramento River - Standard Design Flood (Q50, 183000-cfs) North overflow channel – Standard Design Flood (Q50, 11500-cfs)
Clearance for Drift:	3.0-feet in Sacramento River channel, 2.0-feet in north overflow channel
Design Exception:	No design exception is required at either bridge for hydraulic conditions

Jellys Ferry Road over Sacramento River

Recommendations:	Min. Soffit Elevation –	352.0-feet NAVD-88 (to meet recommendations of Caltrans and FHWA)
	Pier Scour Elevation –	P2 & P3: 285.1-feet P4, P5, & P6: 313.8-feet
	Abutment Scour Elevation –	A1: Out of 100-year floodplain A7: 325.0-feet
	Abutment Protection –	Recommended to minimize risk of long term potential for damage to abutments from bank erosion and bank migration.

Preferred Bridge Characteristics:

Soffit Elevation –	352.5-feet NAVD-88 (1.8-ft above Q100, 3.5-ft above Q50)
Overtopping Flood –	207000-cfs, 200-year recurrence, overtopping at north overflow
Impact on Flood Risk –	No increased risk of damage to structures during floods up to and including the most probable 100-year flood.
Impact on Channel –	The preferred bridge is not expected to aggravate channel instability.

Jellys Ferry Road over North Overflow/Overflow No. 2 of Sacramento River

Recommendations:	Min. Soffit Elevation –	353.3-feet NAVD-88 (to meet recommendations of Caltrans and FHWA)
	Pier Scour Elevation –	All piers: 331.3-feet
	Abutment Scour Elevation –	Both abutments: 339.0-feet
	Abutment Protection –	Recommended to minimize risk of long term potential for damage to abutments from bank erosion and bank migration.

Preferred Bridge Characteristics:

Soffit Elevation –	353.4-feet NAVD-88 (0.5-ft above Q100, 2.1-ft above Q50)
Overtopping Flood –	20000-cfs, 200-year recurrence (227,000-cfs in Sacramento River)
Impact on Flood Risk –	No increased risk of damage to structures during floods up to and including the most probable 100-year flood.
Impact on Channel –	The preferred bridge is not expected to aggravate channel instability.

Note regarding estimates of potential scour: Potential scour has been estimated using empirical equations presented in FHWA HEC-18. These equations do not consider geotechnical conditions and therefore assume all substrate is erodible. The potential scour estimates identified in this report may be inappropriate if a geotechnical investigation identifies material resistant to erosion at higher elevations.

Draft Design Hydraulic Study
Jellys Ferry Road over Sacramento River and over Sacramento River Overflow

INTRODUCTION

Background: This bridge hydraulic analysis has been prepared for the sole purpose of meeting the requirements of 23 CFR §650.115 and §650.117 dealing with bridges, structures, and hydraulics. Although potentially useful for other purposes, this analysis has not been prepared for any other purpose. Reuse of information contained in this report for purposes other than those for which this analysis and report are intended is not endorsed or encouraged by the author and is at the sole risk of the entity reusing information herein contained.

Analyses to meet the requirements of FEMA, the State of California Reclamation Board, low flow environmental or construction concerns and for other purposes may be provided as additional services.

Initial studies for replacement of the existing Jellys Ferry Road bridge over the Sacramento River were limited to replacement of the existing bridge in kind. The existing bridge spans the low flow channel of the Sacramento River with overflow channels crossing Jellys Ferry Road immediately north of the existing bridge (South Overflow Channel/Overflow No. 1) and approximately ½-mile north of the existing bridge (North Overflow Channel/Overflow No. 2). It was recognized, however, that replacement of the confined, narrow existing bridge having an elevated north abutment which quickly drops into the south overflow area with a new open, wide concrete bridge having a matching wide north approach dropping into the floodplain would present a substantial safety concern for the public, especially if travelling at night during stormy weather. The initial replacement concept was modified to consider a replacement bridge that spanned the Sacramento River channel and had an elevated north approach roadway to span across the south overflow area. Subsequent to this decision a value engineering effort conducted by Caltrans, Tehama County, and the consultant team concluded that it was prudent and cost effective to include a new bridge to span over the North Overflow Channel/Overflow No. 2 rather than leaving correction of the north overflow section of Jellys Ferry Road for a separate project. This DHS report documents the flood hydraulic analysis for evaluation and design of the bridge over the Sacramento River plus south overflow channel and the bridge over the north overflow channel. The locations of the preferred bridges with respect to the Sacramento River and overflow channels are shown in Figure 1 (page 20).

Design Standards: Hydraulic design of the preferred bridge is based on standards recommended by Caltrans (Local Programs Manual - reference 1). Exceptions to these design standards are considered only if meeting the standard is found to be impractical or unreasonably costly for the proposed project and the exception does not result in an increased risk of damage during floods. Local design standards that have been provided in writing prior to the preparation of the hydraulic analysis have also been considered.

Funding:	HBP
Existing Bridge:	Year Constructed – 1949 Length – 941-feet nominal, 850-ft effective hydraulic Skew – 28-degrees from perpendicular to flood flow Clear Width – 17.7-ft Total Width – 21.5-ft Lanes – Currently striped as one lane Speed Limit – 15-mph on bridge Load Limit – 17 tons per vehicle, 27 tons per semi-trailer, 32 tons per truck and full trailer Structure – 5-span Pratt Truss + 10-span RC flat slab approach Deficiency – Bridge, Alignment Sketch – Figure 2, page 21 Photos 1-4, pages 15, 16
Significance:	Vital Route – Yes Bus Route – No Road Classification – Rural Major Collector Present ADT – 350 (year 2005) Estimated future ADT – 1205 (year 2035) Trucks or Commercial Vehicles – 7% Description of Service – Local farms and ranches Length of Detour – 30-miles ± Description of Road – Straight, rolling
Sacramento River Preferred Bridge:	Length – 1264.0-ft nominal, 1215-ft effective hydraulic Skew – 15-degrees from perpendicular to flood flow Clear Width – 34.0-ft Total Width – 37.5-ft Lanes – 2 Speed Limit – 55-mph Load Limit – None Structure – 6-span CIP/PS concrete box on RC abutments and RC piers. Traffic During Construction – Maintained on existing bridge General Plan – Figure 3, page 22
North Overflow Preferred Bridge:	Length – 682.5-ft nominal, 510-ft effective hydraulic Skew – 40-degrees from perpendicular to flood flow Clear Width – 34.0-ft Total Width – 37.5-ft Lanes – 2 Speed Limit – 55-mph Load Limit – None Structure – 11-span CIP/PS concrete slab supported on RC abutments and CIDH piles with extensions. Traffic During Construction – Accommodated with local detour General Plan – Figure 4, page 23

DESCRIPTION OF BASIN

Geographic Location:	Upstream of Jellys Ferry Road, the Sacramento River drains a large basin including the east slopes of the coastal range, high mountain desert, southwest slopes of the most southerly reaches of the Cascade Range, and the Sacramento Valley floor.
Receiving Waters:	Pacific Ocean
Characteristics:	Area of basin – 8900-sq mi excluding Goose Lake basin Shape – n/a Highest elevation – 14162-feet on Mt Shasta Lowest elevation – 340-feet near bridge Elevation index – n/a Average annual precipitation (basin wide) – n/a Aspect – South
Land use:	Forest, ranch, farm, small farm, suburban, and urban uses
Vegetation:	Valley grasses with sparse oaks at low elevations to evergreen forest and sage at high elevations.
Geologic:	Topographic features indicate low potential for significant landslides capable of causing channel instability and risk to bridge integrity.

DESCRIPTION OF STREAM AND SITE

River Channel:	In the vicinity of Jellys Ferry Road, the Sacramento River has a very well defined, mildly meandering main channel. Streambed materials visible at the margins of the channel consist of gravel and cobbles with some sand. The Sacramento River is shown in Photos 5 and 6 (page 17).
River Banks:	In the vicinity of Jellys Ferry Road the right (south) bank of the Sacramento River is high, steep, and consists of cohesive alluvium with a cover of grasses and sparse oak. The left (north) bank of the Sacramento River is low, mildly to moderately steep at the channel edges, and consists of cohesive alluvium with a cover of grasses, shrubs, cottonwood, and sparse oak. Multiple overflow channels are present on the north overbank and are active during frequent flood events.
North Overflow:	The north overflow of the Sacramento River consists of a wide, shallow grassy swale with no distinct low flow channel or banks. The north overflow is shown in Photos 7 and 8 (page 18).
Existing Bridge:	Jellys Ferry Road crosses the Sacramento River channel at a skew approximately 24-degrees from perpendicular to the direction of flood flow.
Site Topography:	Figure 5 & 6, pages 24,25

EXTERNAL FLOOD HYDROLOGIC ANALYSIS

Hydrologic Stability: Infrequent floods in the Sacramento River are greatly influenced by the operation of Shasta Dam.

Flood History: Water was observed to flow over Jellys Ferry Road to the north of the existing bridge during the flood of January 1, 1997, a flood of approximately 10-year recurrence in the Sacramento River at this location. The exact location and source of this overflow was not reported. During infrequent floods in the Sacramento River flow may cross Jellys Ferry Road at a location approximately 500-feet north of the existing bridge and at another location approximately 2500-feet north of the existing bridge. Overflow at the more distant location may be due to flow leaving the Sacramento River at a location approximately 3-miles upstream of the Jellys Ferry Road bridge. Overflow at the location nearest the bridge is due to hydraulic conditions in the Sacramento River immediately upstream of the bridge. It is unlikely that hydraulic conditions in the Sacramento River near the Jellys Ferry Road bridge has much influence on overflow at the more distant location. As such, flow over Jellys Ferry Road at the more distant location is considered substantially independent of flood hydraulic conditions in the Sacramento River at Jellys Ferry Road.

Number of Methods: Two methods were investigated for estimating potential infrequent flood peak flows in the Sacramento River. These include development of flood frequency statistics from a representative river flow record and consideration of the FEMA hydrologic analysis prepared for the Sacramento River.

Frequency Statistics: Approach – A flood frequency relationship for the USGS Streamgage 1137710, "Sacramento River near Bend Bridge", was determined by plotting annual flood peaks and computing the normal probability Log-Pearson Type III curve fit (reference 7). A plot of the original data and Log-Pearson Type III curve fit is included in Appendix A. The small difference in basin area between the USGS streamgage and the Jellys Ferry Road bridge is not sufficient to justify adjustment of the flood frequency statistics at the USGS streamgage site, especially when considering the regulating effects of Shasta Dam.

FEMA FIS: Although the Jellys Ferry Road bridge is not in a reach of the Sacramento River having flood risk mapped by FEMA using detailed study methods, FEMA has conducted a detailed study of flood risk along the Sacramento River adjacent to the Lake California development located approximately 2-miles upstream of the bridge. Flood hydrologic conditions in the Sacramento River at the Jellys Ferry Road Bridge are identical to those adjacent to the Sacramento River along the Lake California development. Therefore, the FEMA estimate of infrequent flood peak flows have been considered as potentially appropriate for design of the replacement bridge without adjustment.

Flood Peak Flows: Candidate flood frequency relationship – All candidate flood frequency curves derived from regional analysis for the proposed project site are plotted and shown in Appendix A. Estimated 50- and 100-year flood peak flows from all methods investigated are summarized in Table 1.

TABLE 1
Estimated 50- and 100-year Flood Peak Flows

Estimated from	50-Year (cfs)	100-Year (cfs)
Sacramento River near Bend Bridge	173000	191000
FEMA FIS	183000	205000

Selected flood frequency relationship – The flood frequency relationship relied upon for the FEMA FIS was selected as most appropriate for design of the replacement bridge. This estimate was selected to be consistent with the FEMA analysis. The selected flood frequency relationship is shown in Figure 7 (page 26).

Flood of Record: Since construction of Shasta Dam, the flood of record (FOR) in the Sacramento River at Jellys Ferry Road is the flood of January 24, 1970 having a peak flow estimated to be 157,000-cfs. This represents a flood of approximately 20-year recurrence.

Other Floods: The Central Valley Flood Protection Board Design Flood for this reach of the Sacramento River is a flood having a peak flow of 140,000-cfs. According to CVFPB data, this represents a flood of approximately 10-year recurrence.

INTERNAL FLOOD HYDROLOGIC ANALYSIS

Purpose: At the location of the existing and preferred bridge over the Sacramento River, the peak flows in the Sacramento River channel during floods of interest are reduced from the peak flows estimated above by multiple overflow channels. The internal hydrologic analysis consisted of a flood hydraulic analysis conducted to estimate the division of flows between the Sacramento River channel and the overflow channels as necessary to identify the flood peak flows of concern for evaluation and design of the bridges over the Sacramento River channel (plus south overflow) and the north overflow channel.

Approach: The division of flood peak flows between the Sacramento River channel and the overflow channels was first estimated using an optimized steady state multiple channel linear HEC-RAS backwater model. This model estimated flow into the overflow channels as computed weir flow exiting the Sacramento River channel but was somewhat unstable and sensitive to the geometric data entered in the model at locations of flow splits. The model was improved some by entering fixed flows for the main and west overflow channels after the flows had been computed using the prior version of the model. This model was found useful for initial evaluation of candidate bridge configurations but confidence in the ability of the model to estimate the division of flows sufficient for design of the bridges, especially the north overflow bridge, was low. Therefore a 2D flow model capable of much more confidently estimating the division of flows and some other hydraulic parameters was prepared, calibrated, and run by TY Lin International to represent existing conditions. The divisions of flow from the 2D model were then used as a basis for interpolation of the design flood flows entered into the HEC-RAS backwater model (main and west overflows) and for verification of flow splits computed by the HEC-RAS model (north and south overflows).

After flow adjustments based on 2D model results, the HEC-RAS backwater model was used for evaluation and design of the preferred bridges because the specific requirements of agencies such as FEMA and CVFPB are better accommodated using the HEC-RAS program.

Results: Flows entered and computed for the HEC-RAS model are summarized in Table 2. Existing condition flood frequency curves for the Sacramento River and selected overflows are shown on Figure 7 (page 26).

Table 2: Estimated Sacramento River and Overflow Channel Flood Flows (CFS)

	Location	100-year	50-year	1-24-1970 FOR	3-1-1983 Calibration
Existing	Sacramento River Total	205000	183000	157000	152000
	Main Overflow	47460	39490	31540	29290
	West Overflow	26380	20000	13750	12080
	North Overflow	14770	11070	7550	6860
	South Overflow	19690	13840	7340	6330
Preferred	Sacramento River Total	205000	183000	157000	152000
	Main Overflow	47000	39270	31410	29170
	West Overflow	25600	19550	13420	11810
	North Overflow	15230	11480	7860	7170
	South Overflow[1]	0	0	0	0

Notes: 1) Redirected to Sacramento River upstream of Jellys Ferry Road.

HYDRAULIC ANALYSIS

Backwater Model: Backwater program – The Corps of Engineers' HEC-RAS version 4.1.0 backwater program (reference 3) has been selected for modeling hydraulic characteristics representing existing conditions, preliminary bridge configurations and the preferred bridges. This program has been selected because of its long history of use (derived from HEC-2), wide acceptance and great flexibility for evaluating bridge configurations.

Cross-section data – Stream cross-sections and Manning's roughness coefficients upstream and downstream of the proposed project have been assumed constant for all backwater model runs. Interpolated cross-sections have been included as appropriate to improve model reliability. Cross-sections used in the backwater models were from a recent ground survey. Locations of cross-sections used in the backwater model are shown on Figure 8 (page 27). Cross-sections have been adjusted for skew as appropriate.

Elevation Datum – NAVD-88 (subtract 2.47' for elevations in NGVD-29)

Manning's Roughness Coefficients – Mannings Roughness Coefficients for the channel and banks were initially estimated by observing channel and bank conditions and comparing with similar channels identified in Roughness Coefficients of Natural Channels (reference 6). These were subsequently adjusted within reason to reproduce flood hydraulic conditions observed

during the flood of March 1, 1983 and reasonably match the FEMA Base Flood profile at Lake California. High water during the March 1, 1983 flood is shown in Photo 9 (page 19). Manning's roughness coefficients used in the models are as follows:

Sacramento River: channel 0.042 – 0.045, overbanks 0.055
Main overflow: channel 0.045 – 0.060, overbanks 0.050 – 0.060
North overflow: 0.040
West overflow: 0.050

Contraction and Expansion Coefficients – Contraction and expansion coefficients of 0.1 and 0.3 respectively were used to represent natural channels. These values were raised to 0.3 and 0.5 respectively in the vicinity of bridges.

Downstream starting water surface elevation assumption – The normal depth method in HEC-RAS was selected for estimating the downstream water surface elevation. A slope of 0.0005, estimated from the 2D flow model, was used as the starting slopes in the Sacramento River and north overflow channel. A minimum of four surveyed and/or interpolated cross-sections were used to isolate the effects of downstream starting water surface elevation assumption from water surface elevations at the existing Sacramento River bridge and the preferred north overflow bridge site.

Existing Sacramento River Bridge:

Purpose – The existing condition Sacramento River backwater model has been prepared to identify and document existing hydraulic conditions and to serve as a basis of comparison with which to evaluate preliminary and proposed bridge configurations.

Channel roughness coefficient at bridge – 0.044 DS, 0.045 US
Overbank roughness coefficient at bridge – 0.055
Contraction coefficient – 0.3 (at bridge)
Expansion coefficient – 0.5 (at bridge)
Bridge modeling method – Energy
Drift assumption – Effective pier widths assumed 6.0 to 12.0-feet
(up to 3 times actual width)
Figure 9 (page 28) shows how existing bridge is represented in model.

Model results – Existing hydraulic conditions are summarized in Table 3. Existing condition flood profiles and a stage discharge curve at cross-section 4480 are shown in Figures 11 and 12 (pages 30, 31). Summary output tables from the existing condition HEC-RAS backwater model are included in Appendix B.

TABLE 3: Existing Sacramento River Hydraulic Conditions (with drift)

Flood	Flow (cfs)	Recurrence (years)	W.S. Elevation[1] (feet)	Avg. Channel Velocity[2] (fps)
Standard Design	158100[3]	50	349.4	9.3
Base	170500[3]	100	351.1	9.4
Flood of Record	142100[3]	20	347.0	9.1
Overtopping Flood[4]	85000	<2	340.5	<9
CVFPB Design Flood	140000	10[5]	346.8[6]	9.1

Notes:
1) At cross-section 4480 located approximately 400-feet upstream of the existing bridge.
2) Highest average channel velocity in vicinity of bridge.
3) Sacramento River upstream minus north and south overflows.
4) Overtopping of Jellys Ferry Road at north overflow swale
5) CVFPB estimate
6) Estimate from existing condition stage-discharge curve

Existing North Overflow Channel: Purpose – The existing condition north overflow backwater model has been prepared to identify and document existing hydraulic conditions and to serve as a basis of comparison with which to evaluate preliminary and proposed bridge configurations.

Channel roughness coefficient at bridge site – 0.040
Overbank roughness coefficient at bridge – 0.040
Contraction coefficient – 0.1 (at bridge site)
Expansion coefficient – 0.3 (at bridge site)
Bridge modeling method – Energy
Drift assumption – None (no structure)
Figure 13 (page 32) shows how existing crossing is represented in model.

Model results – Existing hydraulic conditions are summarized in Table 4. Existing condition flood profiles and a stage discharge curve at cross-section 4.88 are shown in Figures 14 - 16 (pages 33 - 35). Summary output tables from the existing condition HEC-RAS backwater model are included in Appendix B.

TABLE 4: Existing North Overflow Hydraulic Conditions (no drift)

Flood	Flow (cfs)	Recurrence (years)	W.S. Elevation[1] (feet)	Avg. Channel Velocity[2] (fps)
Standard Design	11100	50	351.1	2.3
Base	14800	100	352.7	2.5
Flood of Record	7600	2	349.1	2.1
Overtopping Flood[3]	1	<2	341.0	<1

Notes:
1) At cross-section 4.88 located approximately 50-feet upstream of the existing road.
2) Highest average channel velocity in immediate vicinity of bridge site.
3) All flow in north overflow channel overtops Jellys Ferry Road.

Preliminary Bridges: Backwater models were prepared to represent several candidate bridge configurations. Results from these models were provided to project staff in the form of a preliminary hydraulic analysis report. Using information

provided in the preliminary hydraulic analysis report and considering additional factors not related to hydraulic conditions, a bridge configuration was selected as the preferred bridge for final design.

Preferred Sacramento River Bridge: The preferred Sacramento River bridge model has been prepared to identify hydraulic requirements and impacts of the preferred bridge.

Channel roughness coefficient at bridge – 0.045
Bank roughness coefficient at bridge – 0.055
Contraction coefficient – 0.3 (at bridge)
Expansion coefficient – 0.5 (at bridge)
Bridge modeling method – Energy
Drift assumption – Effective pier widths assumed to be 10- and 15-feet (6- and 9-feet actual)
Figure 10 (page 29) shows how preferred bridge is represented in model.

Model results – Preferred bridge hydraulic conditions are summarized in Table 5. Preferred bridge flood profiles and a stage discharge curve at cross-section 4480 are shown in Figures 11 and 12 (pages 30, 31). Summary output tables from the preferred bridge HEC-RAS backwater model are included in Appendix B.

TABLE 5: Sacramento River Preferred Bridge Hydraulic Conditions (with drift)

Flood	Flow (cfs)	Recurrence (years)	W.S. Elevation[1] (feet)	Avg. Channel Velocity[2] (fps)
Standard Design	171500[3]	50	349.0	9.3
Base	190000[3]	100	350.7	9.5
Flood of Record	149100[3]	20	346.8	9.0
Overtopping Flood[4]	207000	200	352.1	10±
CVFPB Design Flood	140000	10[5]	345.8[6]	<9

Notes: 1) At cross-section 4480 located approximately 400-feet upstream of the existing bridge.
2) Highest average channel velocity in vicinity of bridge.
3) Sacramento River upstream minus north overflow.
4) Overtopping of Jellys Ferry Road at north overflow bridge.
5) CVFPB estimate
6) Estimate from existing condition stage-discharge curve

Preferred North Overflow Bridge: The preferred bridge backwater model has been prepared to identify hydraulic requirements and impacts of the preferred bridge.

Channel roughness coefficient at bridge – 0.040
Bank roughness coefficient at bridge – 0.040
Contraction coefficient – 0.3 (at bridge)
Expansion coefficient – 0.5 (at bridge)
Bridge modeling method – Energy
Drift assumption – Effective pier width assumed 4-feet (2 x actual)
Figure 13 (page 32) shows how preferred bridge is represented in model.

Model results – Preferred bridge hydraulic conditions are summarized in Table 6. Preferred bridge flood profiles and a stage discharge curve at cross-section 4.88 are shown in Figures 14 - 16 (pages 33 - 35). A stage discharge curve at cross-section 6.0 on the main overflow channel for flood risk assessment is shown in Figure 17 (page 36). Summary output tables from the preferred bridge HEC-RAS backwater model are included in Appendix B.

TABLE 6: North Overflow Preferred Bridge Hydraulic Conditions (with drift)

Flood	Flow (cfs)	Recurrence (years)	W.S. Elevation[1] (feet)	Avg. Channel Velocity[2] (fps)
Standard Design	11500	50	351.3	2.0
Base	15200	100	352.9	2.3
Flood of Record	7900	20	349.3	1.7
Overtopping Flood	20000	200	356.0	3.0±

Notes: 1) At cross-section 4.88 located approximately 50-feet upstream of the existing road.
2) Highest average channel velocity in immediate vicinity of bridge site.

SCOUR AND EROSION

Channel Stability: Prior to construction of Shasta Dam in the early 1940s, the Sacramento River in the vicinity of Jellys Ferry Road was fully unregulated. Large floods would inundate the entire inside of the river bend north of the existing bridge. Sediment from upstream in the Sacramento River and from tributaries would replenish the river bed and bank materials. Since construction of Shasta Dam, floods up to and including the most probable 100-year flood at Jellys Ferry Road are substantially but not entirely confined to the river channel. Although sediment from upstream sources in the Sacramento River has been reduced, sediment from unregulated tributaries below Shasta Dam continues to enter the river channel. The net reduced sediment supply to the Sacramento River enters a channel with a reduced capability to transport sediment due to flood regulation. No distinct evidence of channel incision or of aggradation was observed along the Sacramento River channel in the vicinity of Jellys Ferry Road. Considering the balancing factors of reduced sediment supply with reduced transport capability and the lack of distinct evidence of channel instability, it is reasonable to believe that the channel is presently stable (maintaining a constant profile over time, not physically static).

The south approach of the Jellys Ferry Road bridge is located on a high terrace on the outside of a large bend in the Sacramento River. Regardless of the condition of stability of the Sacramento River, erosion at the outside of bends can be expected, although at rates much less than during times before regulation of floods by Shasta Dam. Additionally, as is the nature of alluvial river channels, the thalweg of the channel may migrate to any location within and adjacent to the active channel during the expected life of the bridge.

Replacement of the existing bridge with the preferred bridge is not expected to affect energy slope or sediment transport to a significant degree and therefore is not expected to aggravate channel instability.

Contraction Local: Potential contraction scour was estimated using the modified Laursen equation for live bed conditions presented in HEC-18 (reference 4).

Pier Local: Potential pier scour has been estimated using the CSU equation presented in FHWA HEC-18. It is possible for the thalweg of the Sacramento River to migrate to any location between the existing banks of the Sacramento River during the expected life of the replacement bridge. Therefore the existing thalweg elevation has been identified as the ground elevation for the purpose of estimating potential pier scour in the river channel. Similarly, the lowest ground elevation in the north overbank area has been identified as the ground elevation for the purpose of estimating potential pier scour in the overbank area.

Abutment Local: Total potential abutment scour (contraction scour included) was estimated using the NCHRP 24-20 approach identified in FHWA HEC-18.

Total Scour: Total potential scour and potential scour elevations at piers and abutments are summarized in Table 7. Scour computations and data are included in Appendix C.

TABLE 7: Total Potential Scour (feet)

Location	Ground Elev.	Degradation	Contraction Scour	Local Scour	Total Scour	Scour Elev.
Sac R piers 2 & 3	307.0	0	2.8	19.1	21.9	285.1
Sac R piers 4, 5, & 6	330.0	0	1.8	14.4	16.2	313.8
Sac R abutment 7	330.0	0	0[1]	5.0	5.0	325.0
North overflow piers	339.0	0	1.8	5.9	7.7	331.3
North overflow abuts	344.0	0	0[1]	5.0	5.0	339.0

Notes: 1) NCHRP 24-20 approach for estimating local abutment scour includes contraction scour.

OTHER CONSIDERATIONS:

Drift: There is a moderate potential for significant volumes of drift of all sizes in the Sacramento River. Drift has been considered in the design of the preferred bridge by selection of a structure with longer spans, by use of large diameter piers that are less prone to catching drift, by considering an accumulation of drift when identifying bridge hydraulic design requirements, and by providing the minimum recommended clearance for drift. When drift does accumulate at piers during flood events, the "Y" shaped geometry of the piers may cause accumulated drift at the surface to creep down the pier allowing more drift to accumulate at the water surface. Therefore it will be important to monitor drift accumulation and remove any accumulated drift prior to each flood season or when significant during a flood season.

FEMA: The preferred bridges are not within a reach of channel having flood risk mapped by FEMA using detailed study methods but project flood risk impacts have the potential to propagate upstream within an area of channel and overflow floodplain having flood risk mapped by FEMA using detailed study methods. As such, the replacement bridge project may increase Base Flood

water surface elevations as much as 1.0-foot provided that the increase in water surface elevation does not represent an increased risk of damage to properties. However, the project may not increase Base Flood water surface elevations within the reach of channel and overflow floodplain having flood risk mapped by FEMA using detailed study methods unless the increased risk of damage during the Base Flood is first mitigated and the FEMA flood study and maps are corrected. Existing condition and preferred project Base Flood water surface elevations in the Sacramento River channel at cross-section 4660 (upstream of the bridge project) and in the main overflow at cross-section 6.0 (downstream extent of FEMA FIRM in overflow floodplain) are summarized in Table 8. A copy of applicable portions of the FEMA flood insurance rate map (FIRM) is included in Appendix B.

TABLE 8: Base Flood Water Surface Elevations (feet, no drift)

Location	Existing Cond.	Preferred Bridge	Increase
Sacramento River, Cross-section 4660	351.4	351.0	-0.4
Main Overflow, Cross-section 6.0	354.4	354.4	0.0

Given the slight reduction in Base Flood water surface elevations in the Sacramento River channel and no increase in the Base Flood water surface elevation at the downstream extent of the FEMA FIRM in the main overflow channel, no FEMA applications are believed necessary for the bridge replacement project.

CVFPB: The Central Valley Flood Protection Board (CVFPB) design flood at this location is a flood having a peak flow of 140,000-cfs, a flood of approximately 10-year recurrence. Replacement of the existing bridge with the preferred bridge is expected to result in a minor reduction of the water surface elevation during the CVFPB Design Flood. No variance to the requirements of the CVFPB is believed necessary.

Conveyance Improvement: The preferred bridge project includes the excavation and grading of ground at the Jellys Ferry Road crossing of the north overflow channel depicted on the road plan sheets at the north overflow. Anticipated grading is reflected in the topography shown on Figure 18 (page 37). This excavation and grading constitutes a channel conveyance improvement necessary for the project to avoid increasing Base Flood water surface elevations at the downstream extent of the FEMA Special Flood Hazard Area (SFHA) and has been relied upon by the hydraulic analysis supporting this report.

Existing Bridge: Removal of the existing bridge and north approach has been identified as part of the bridge replacement project and has been relied upon by this analysis.

CONCLUSIONS AND RECOMMENDATIONS

Design Flood: Caltrans and FHWA recommend that new and replacement bridges be designed with a minimum soffit elevation equal to the water surface elevation of the most probable 50-year flood (Standard Design Flood) plus appropriate clearance for drift or to the water surface elevation of the most probable 100-year flood (Base Flood) with no clearance for drift, whichever is higher. The CVFPB requires that new and replacement bridges have a lowest soffit elevation 3.0-feet above the CVFPB Design Flood. Given that the CVFPB Design Flood in this reach of the Sacramento River is a 10-year flood, the Caltrans and FHWA criteria are the critical criteria governing the minimum design standards for this bridge project.

Clearance for Drift: The minimum clearance for drift recommended by Caltrans and FHWA for bridges over large streams and rivers is 3.0-feet and for small streams is 2.0-feet. A clearance for drift of 3.0-feet is appropriate for the bridge over the Sacramento River. Unlike the Sacramento River channel, the size of drift and potential for accumulation of drift at the North Overflow/Overflow No. 2 bridge is reasonably low due to the limited opportunity for drift to leave the Sacramento River channel, be conveyed down the main overflow channel, and enter the north overflow channel. Therefore a clearance for drift of 2.0-feet is appropriate for the bridge over the north overflow channel.

Design Exception: The preferred bridge structures meet the minimum recommended hydraulic design requirements of Caltrans and FHWA therefore no design exception will be required for either bridge due to hydraulic conditions.

Recommendations: Minimum Soffit Elevation – The minimum soffit elevation of a bridge over the Sacramento River meeting the recommendations of Caltrans and FHWA is 352.0-feet NAVD-88. This represents the water surface elevation of the Standard Design Flood (50-year flood with drift) plus 3.0-feet of clearance for drift. The minimum soffit elevation of a bridge over the north overflow meeting the recommendations of Caltrans and FHWA is 353.3-feet NAVD-88. This represents the water surface elevation of the Standard Design Flood (50-year flood with drift) plus 2.0-feet of clearance for drift.

Pier Scour – Piers 2 and 3 of the bridge over the Sacramento River channel should be designed considering potential scour to an elevation of 285.1-feet NAVD-88. Piers 4, 5, and 6 of the bridge over the Sacramento River channel should be designed considering potential scour to an elevation of 313.8-feet NAVD-88. All piers of the bridge over the north overflow should be designed considering potential scour to an elevation of 331.3-feet NAVD-88.

Abutment Scour – Abutment 7 of the bridge over the Sacramento River channel should be designed considering or protected against total potential scour to an elevation of 325.0-feet NAVD-88. Both abutments of the bridge over the north overflow channel should be designed considering or protected against potential scour to an elevation of 339.0-feet NAVD-88

Abutment Protection – Abutment protection is recommended to reduce the potential for damage to abutments from bank erosion and bank migration. Bank protection should be designed such that the protection does not represent a new encroachment in the floodplain.

Note regarding estimates of potential scour: Potential scour has been estimated using empirical equations presented in FHWA HEC-18. These equations do not consider geotechnical conditions and therefore assume all substrate is erodible. The potential scour estimates identified in this report may be inappropriate if a geotechnical investigation identifies material resistant to erosion at higher elevations.

Sacramento River Preferred Bridge Characteristics:

Soffit Elevation –	352.5-feet NAVD-88 (1.8-ft above Q100 with drift, 3.5-ft above Q50 with drift)
Overtopping Flood –	227000-cfs, 200-year recurrence, overtopping at north overflow
Impact on Flood Risk –	No increased risk of damage to structures during floods up to and including the most probable 100-year flood.
Impact on Channel –	The preferred bridge is not expected to aggravate channel instability.

North Overflow Preferred Bridge Characteristics:

Soffit Elevation –	353.4-feet NAVD-88 (0.5-ft above Q100 with drift, 2.1-ft above Q50 with drift)
Overtopping Flood –	20000-cfs, 200-year recurrence (227,000-cfs in Sacramento River)
Impact on Flood Risk –	No increased risk of damage to structures during floods up to and including the most probable 100-year flood.
Impact on Channel –	The preferred bridge is not expected to aggravate channel instability.

Photo 1: Looking downstream (east) at Bridge 8C-0043, Jellys Ferry Road Bridge over Sacramento River

Photo 2: Looking downstream (southeast) at Bridge 8C-0043, Jellys Ferry Road over Sacramento River

Photo 3: Looking north across Bridge 8C-0043,
Jellys Ferry Road over Sacramento River.

Photo 4: Looking south across Bridge 8C-0043,
Jellys Ferry Road over Sacramento River.

Photo 5: Looking downstream (east) at Sacramento River from Bridge 8C-0043, Jellys Ferry Road.

Photo 6: Looking upstream (west) at Sacramento River from Bridge 8C-0043, Jellys Ferry Road.

Photo 7: Looking north at North Overflow over Jellys Ferry Road

Photo 8: Looking east (downstream) at North Overflow from Jellys Ferry Road

Photo 9: Aerial during March 1983 Flood

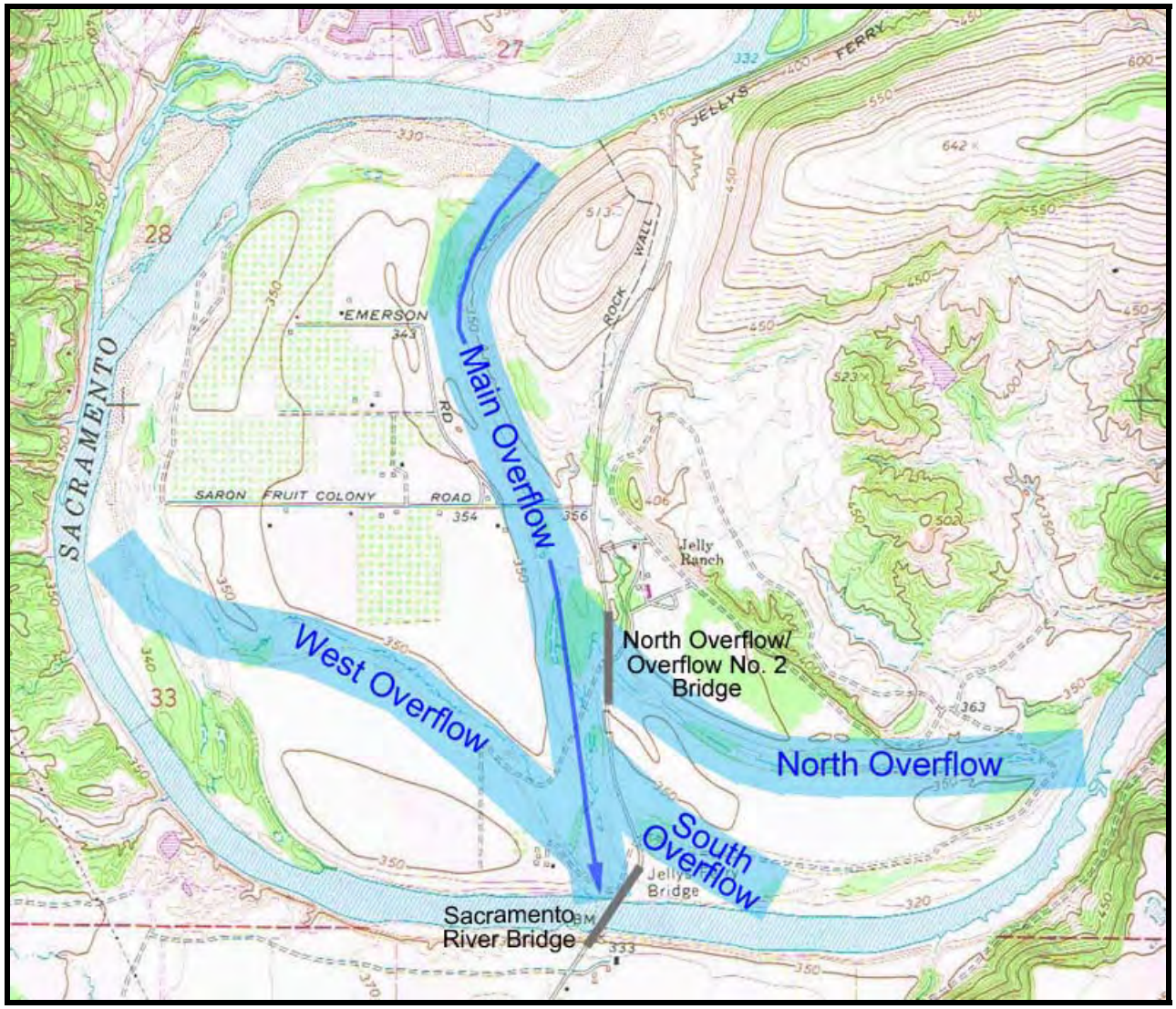


Figure 1: Sacramento River and Overflow Channels

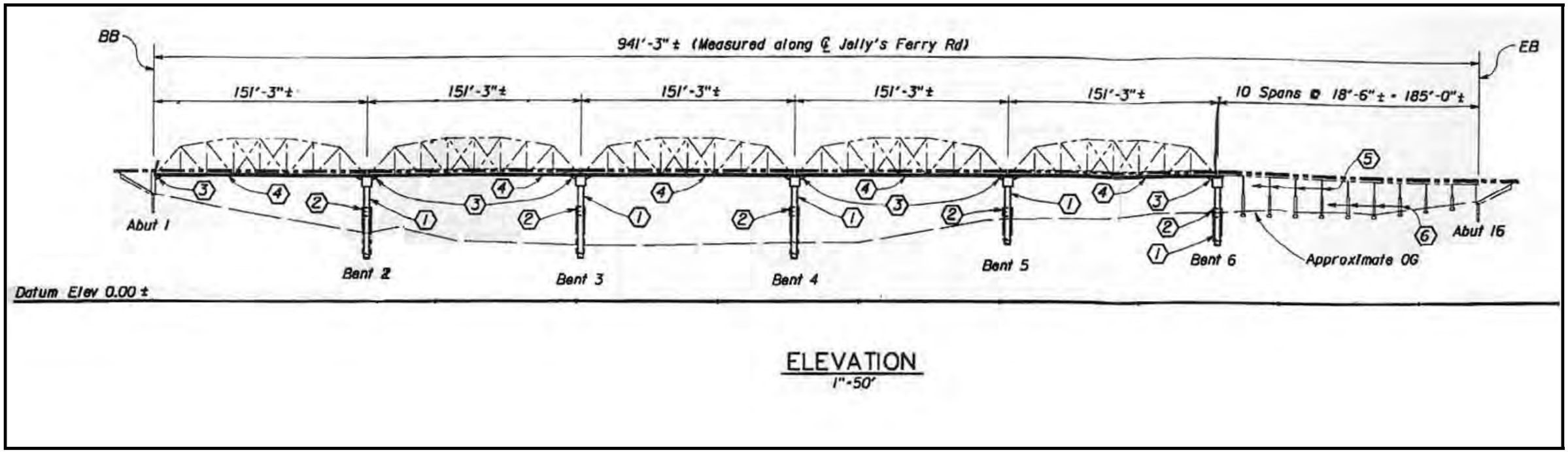


Figure 2: Sketch of Existing Bridge (looking upstream)

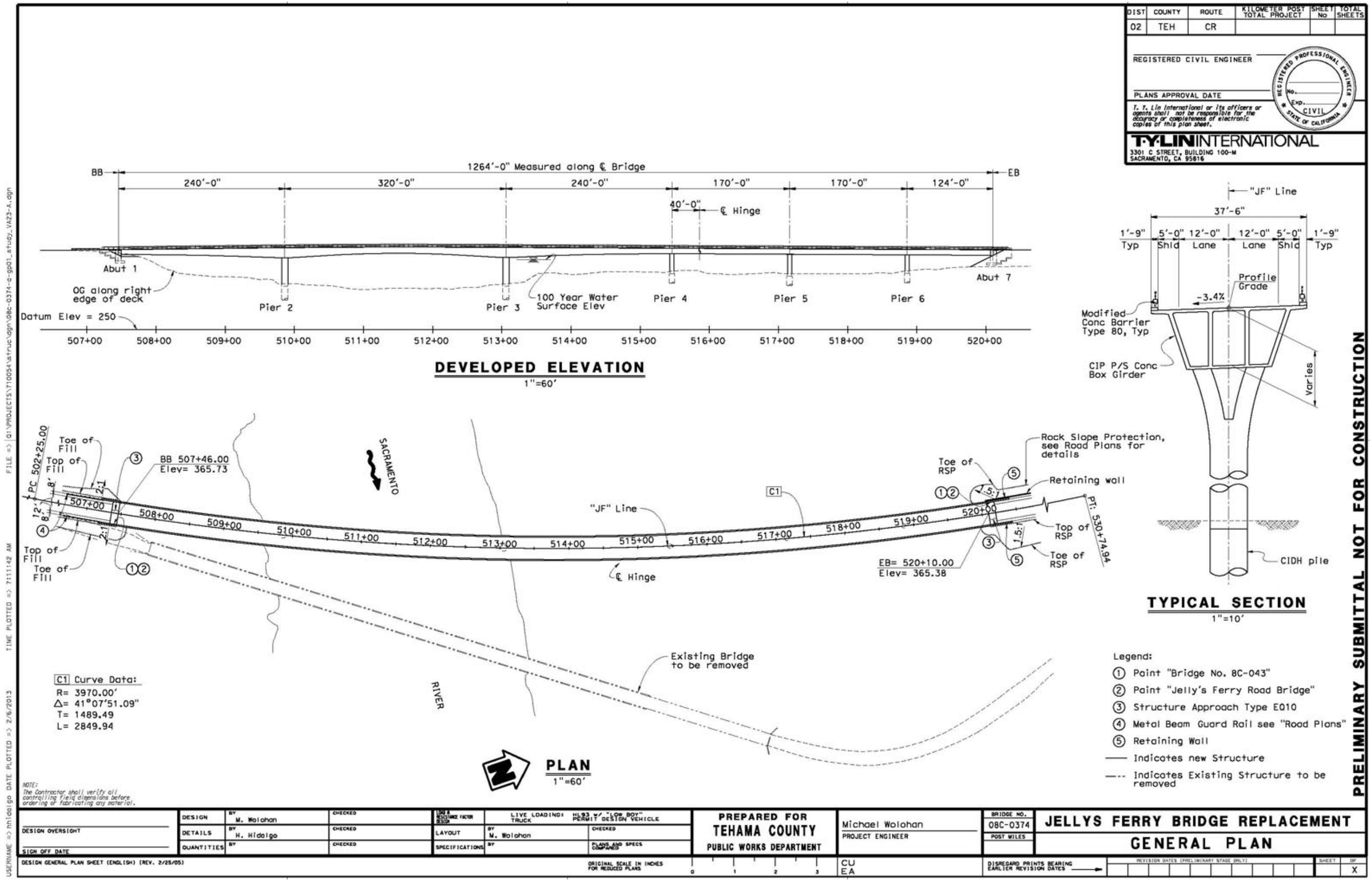
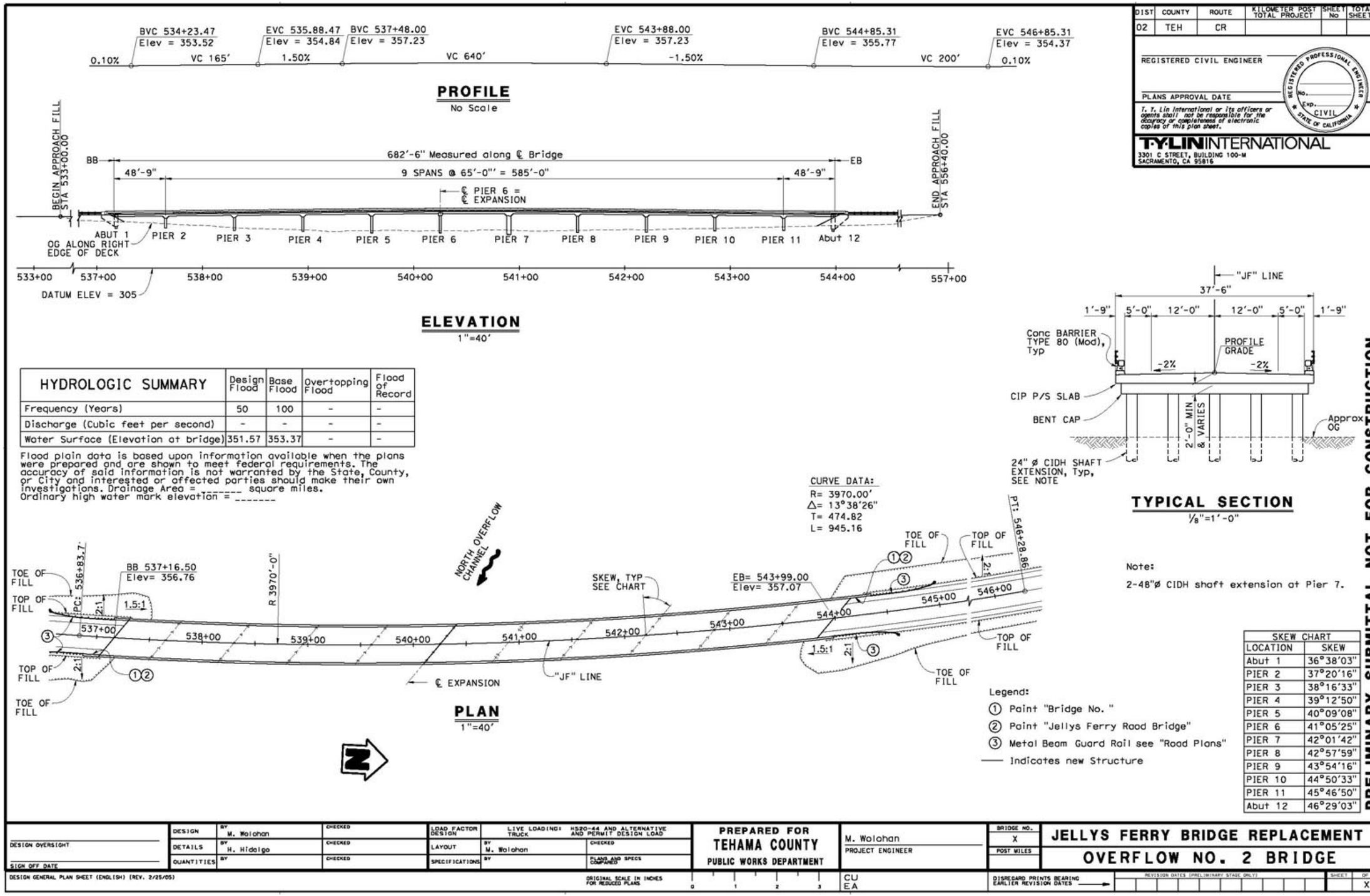


Figure 3: Preferred Bridge Preliminary General Plan, Sacramento River



SKEW CHART	
LOCATION	SKEW
Abut 1	36°38'03"
PIER 2	37°20'16"
PIER 3	38°16'33"
PIER 4	39°12'50"
PIER 5	40°09'08"
PIER 6	41°05'25"
PIER 7	42°01'42"
PIER 8	42°57'59"
PIER 9	43°54'16"
PIER 10	44°50'33"
PIER 11	45°46'50"
Abut 12	46°29'03"

HYDROLOGIC SUMMARY	Design Flood	Base Flood	Overtopping Flood	Flood of Record
Frequency (Years)	50	100	-	-
Discharge (Cubic feet per second)	-	-	-	-
Water Surface (Elevation at bridge)	351.57	353.37	-	-

Flood plain data is based upon information available when the plans were prepared and are shown to meet federal requirements. The accuracy of said information is not warranted by the State, County, or City and interested or affected parties should make their own investigations. Drainage Area = _____ square miles.
Ordinary high water mark elevation = _____

Figure 4: Preferred Bridge Preliminary General Plan, North Overflow

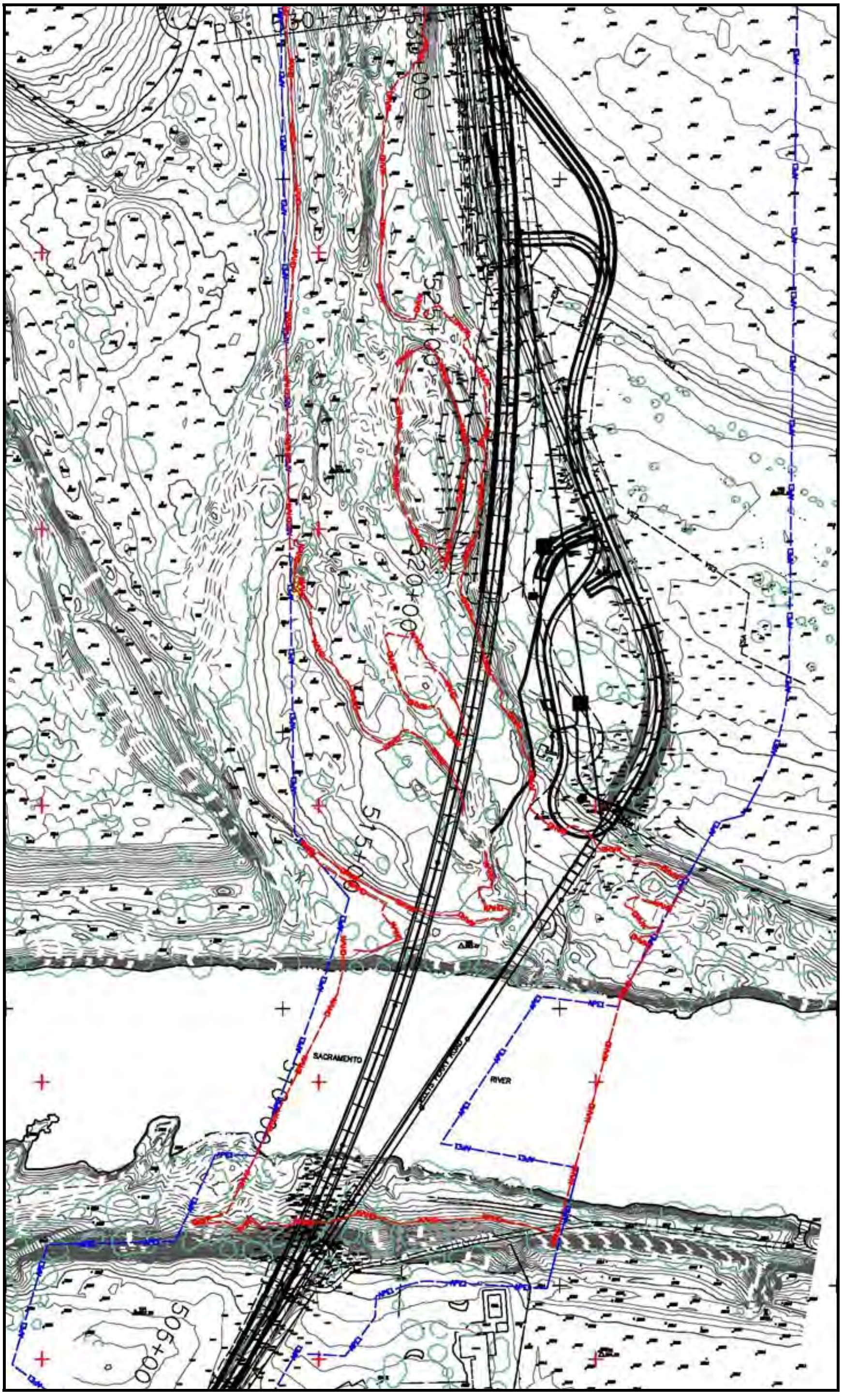


Figure 5: Site Topography, Sacramento River Bridge

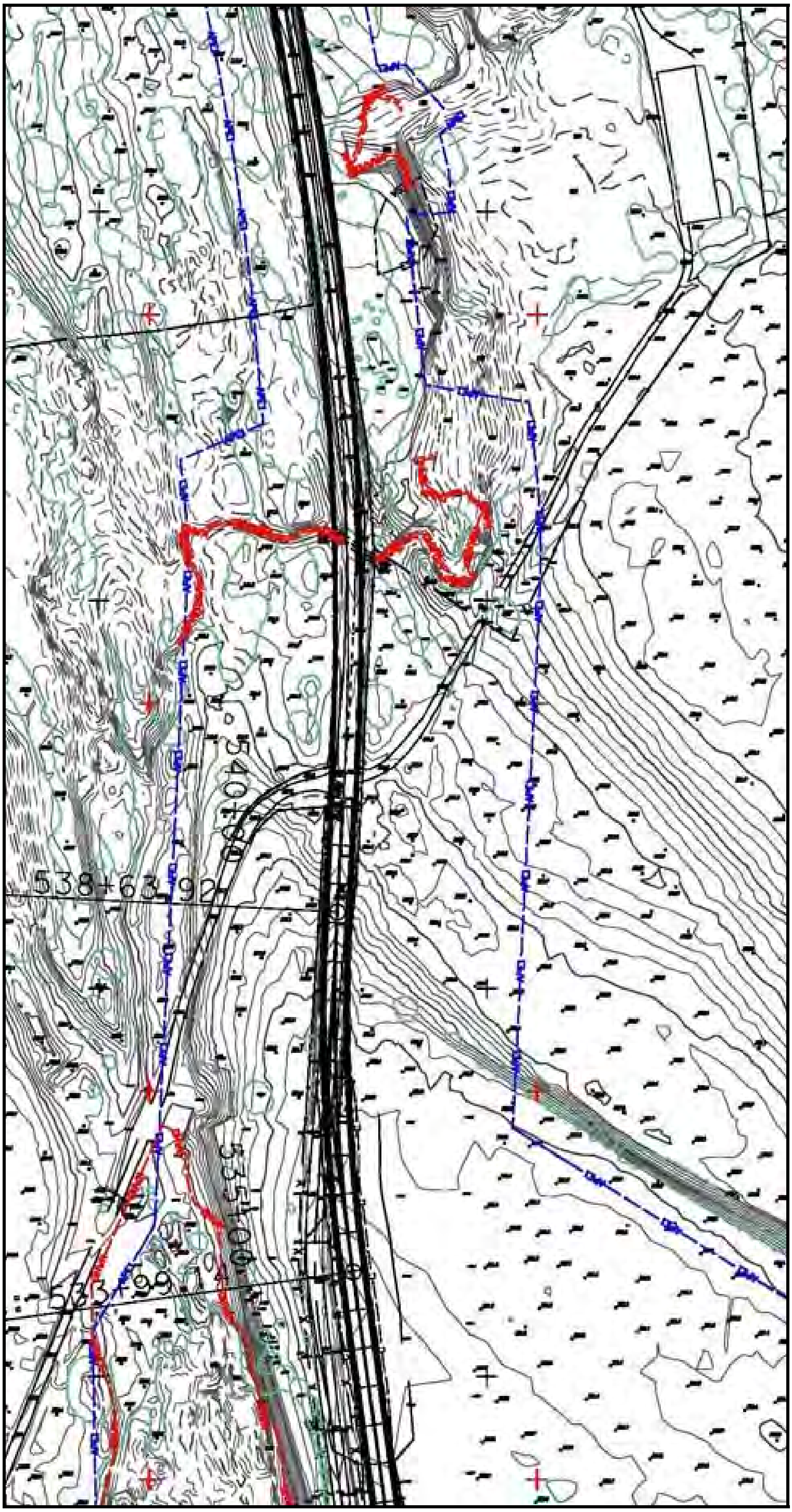


Figure 6: Site Topography, North Overflow

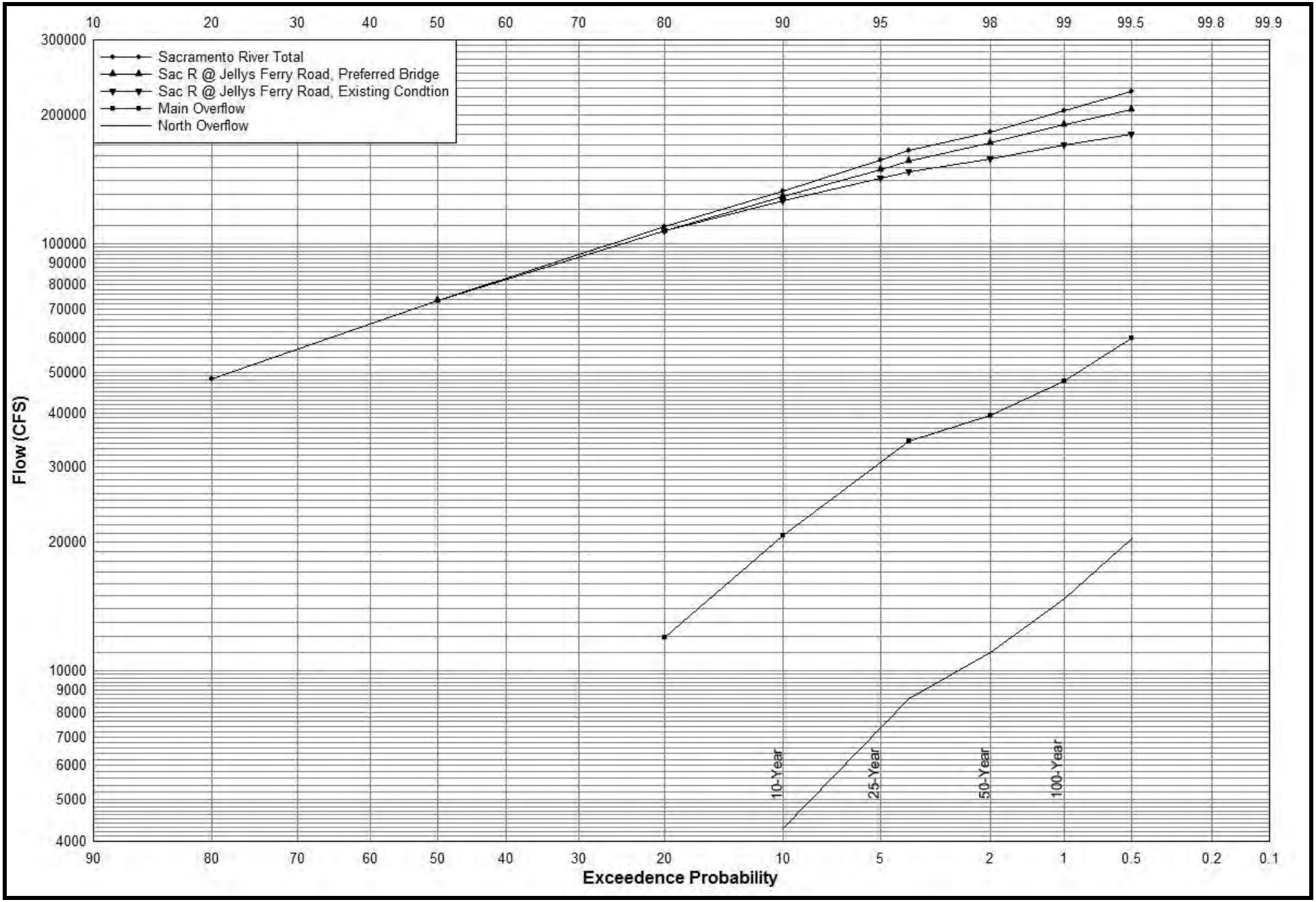


Figure 7: Flood Frequency Curves, Sacramento River and Selected Overflow Paths

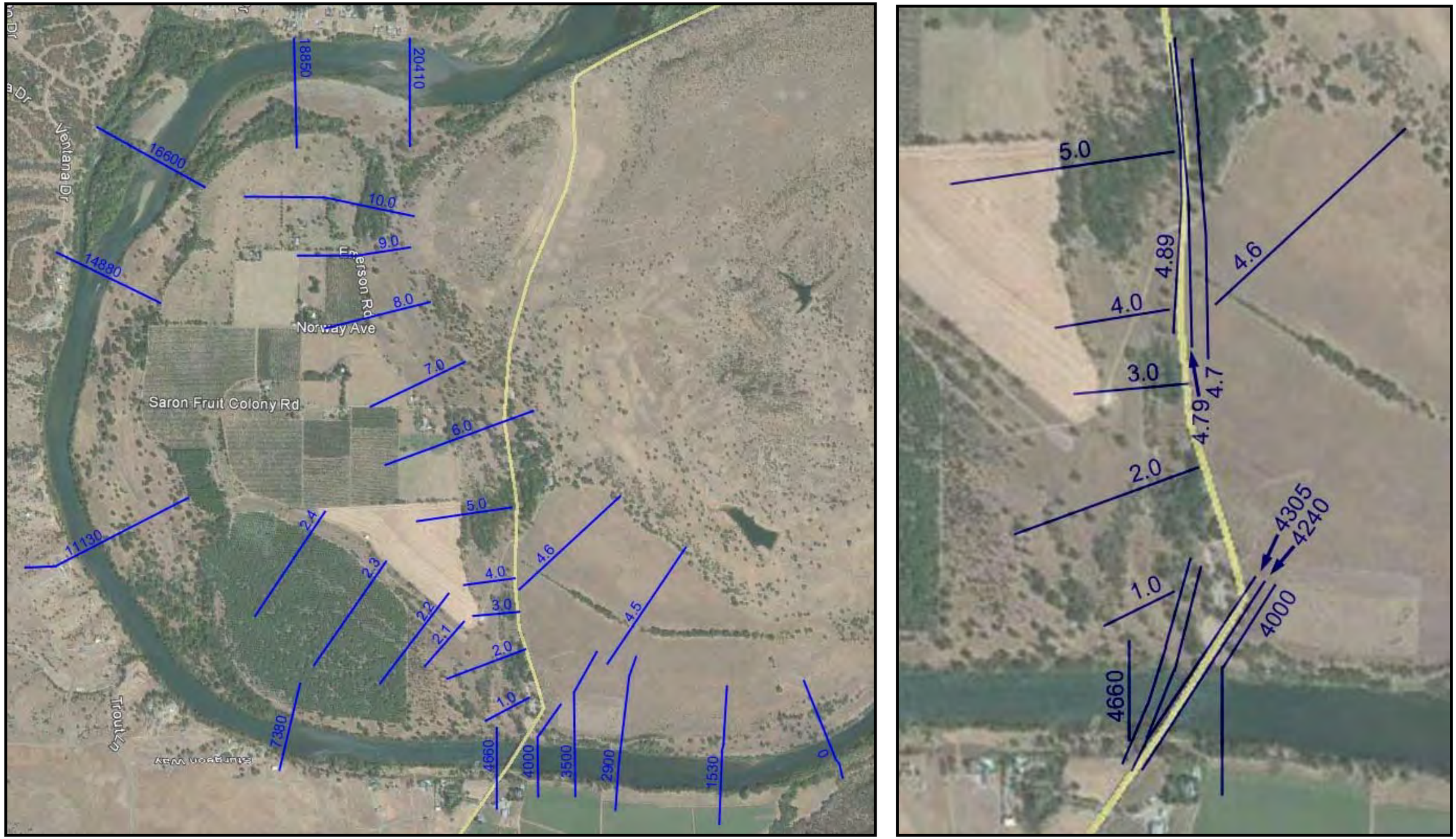


Figure 8: Locations of Cross-sections Used in Backwater Model

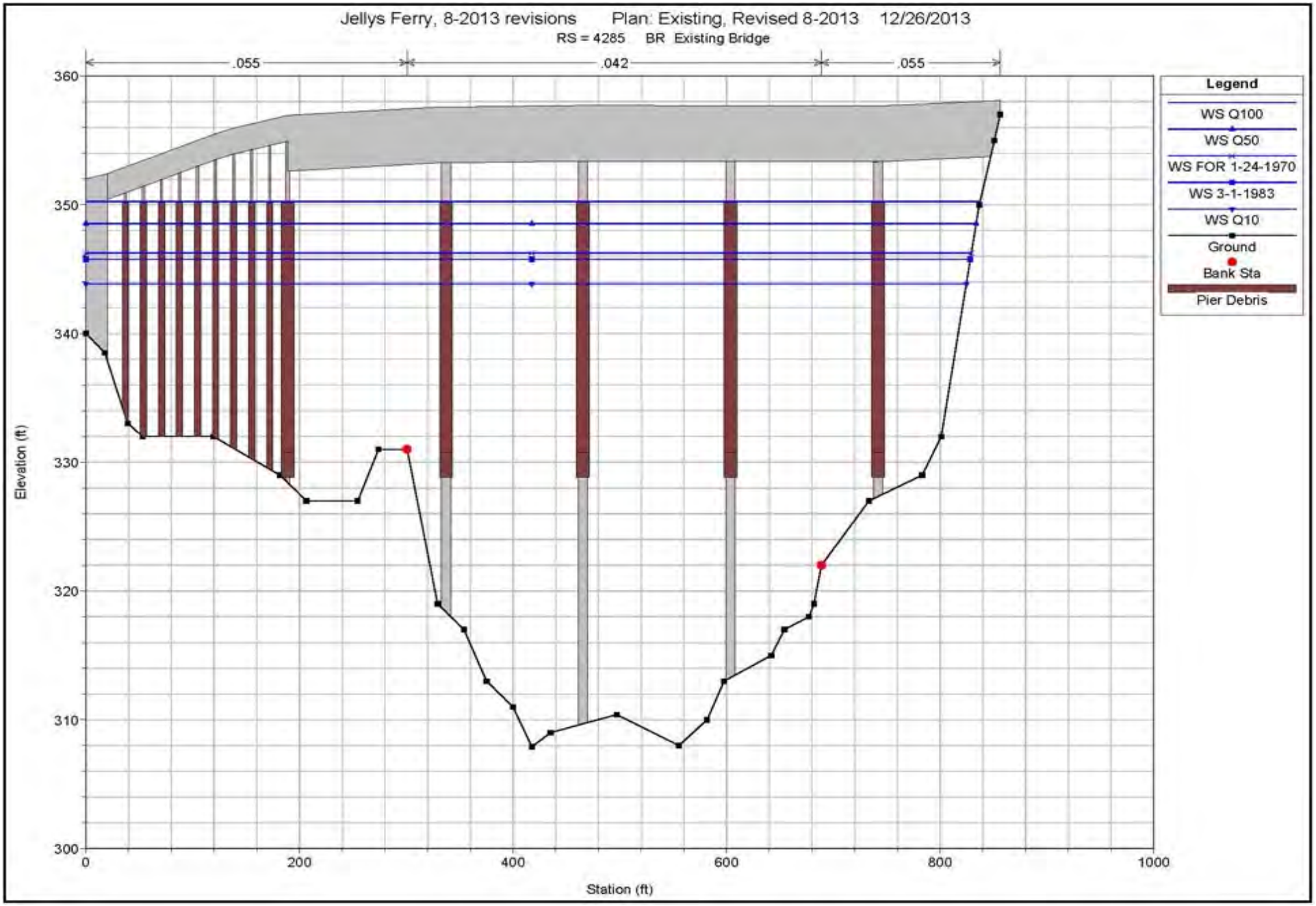


Figure 9: Existing Sacramento River Bridge as Represented in Backwater Model

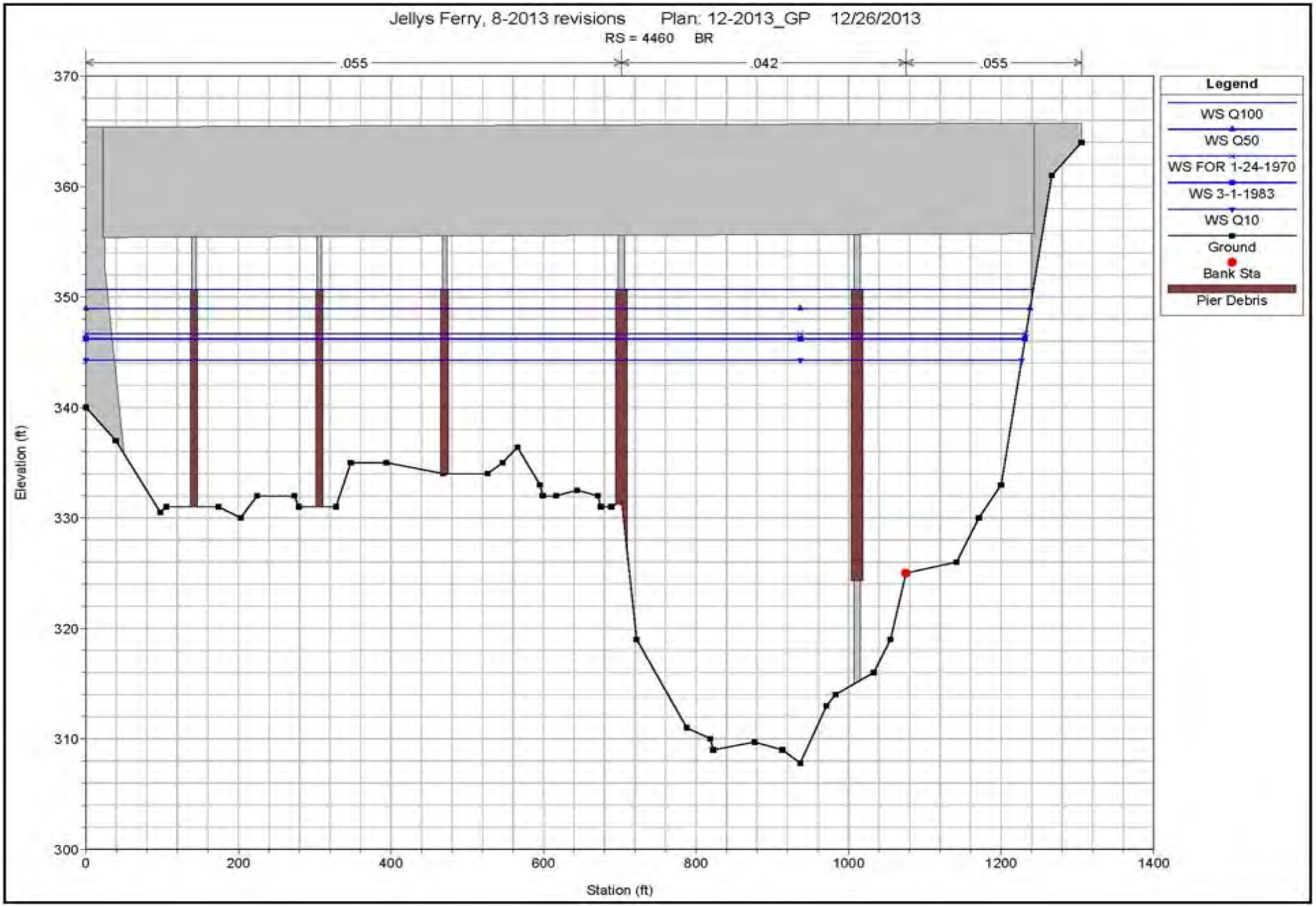


Figure 10: Preferred Sacramento River Bridge as Represented in Backwater Model

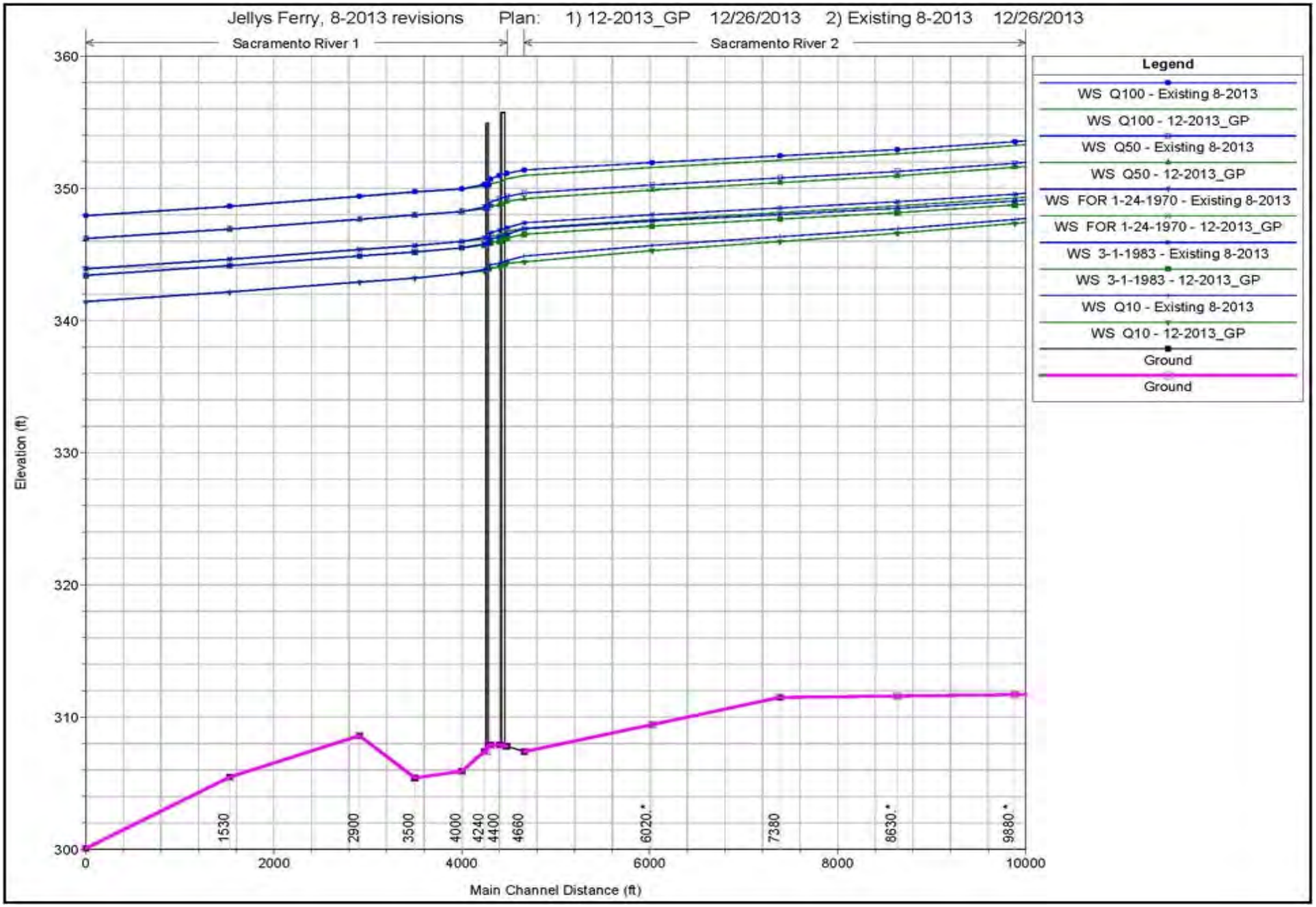


Figure 11: Sacramento River Flood Profiles for Existing Condition and Preferred Bridge

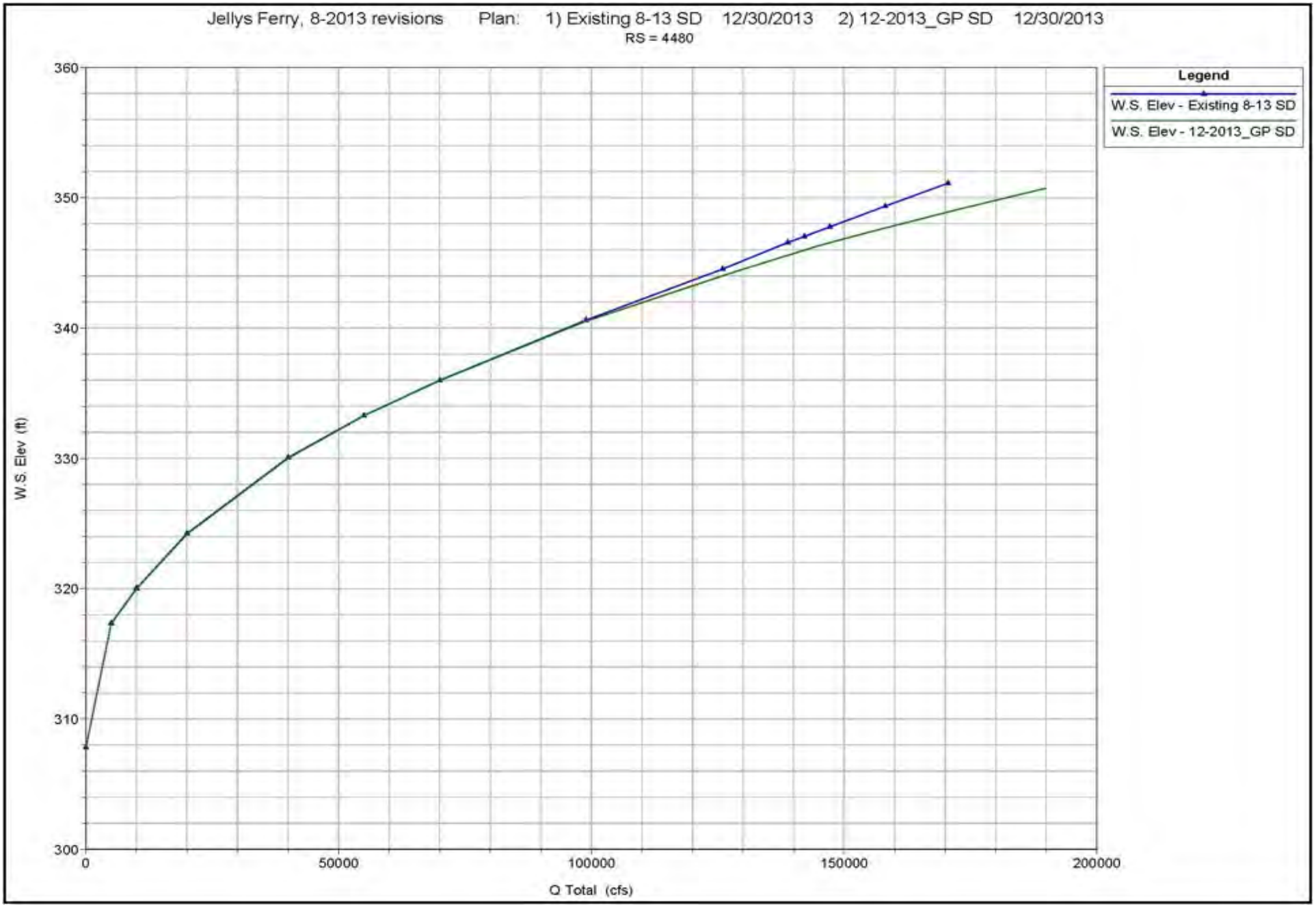


Figure 12: Sacramento River Stage Discharge Curves for Existing Conditions and Preferred Bridge at Cross-section 4480

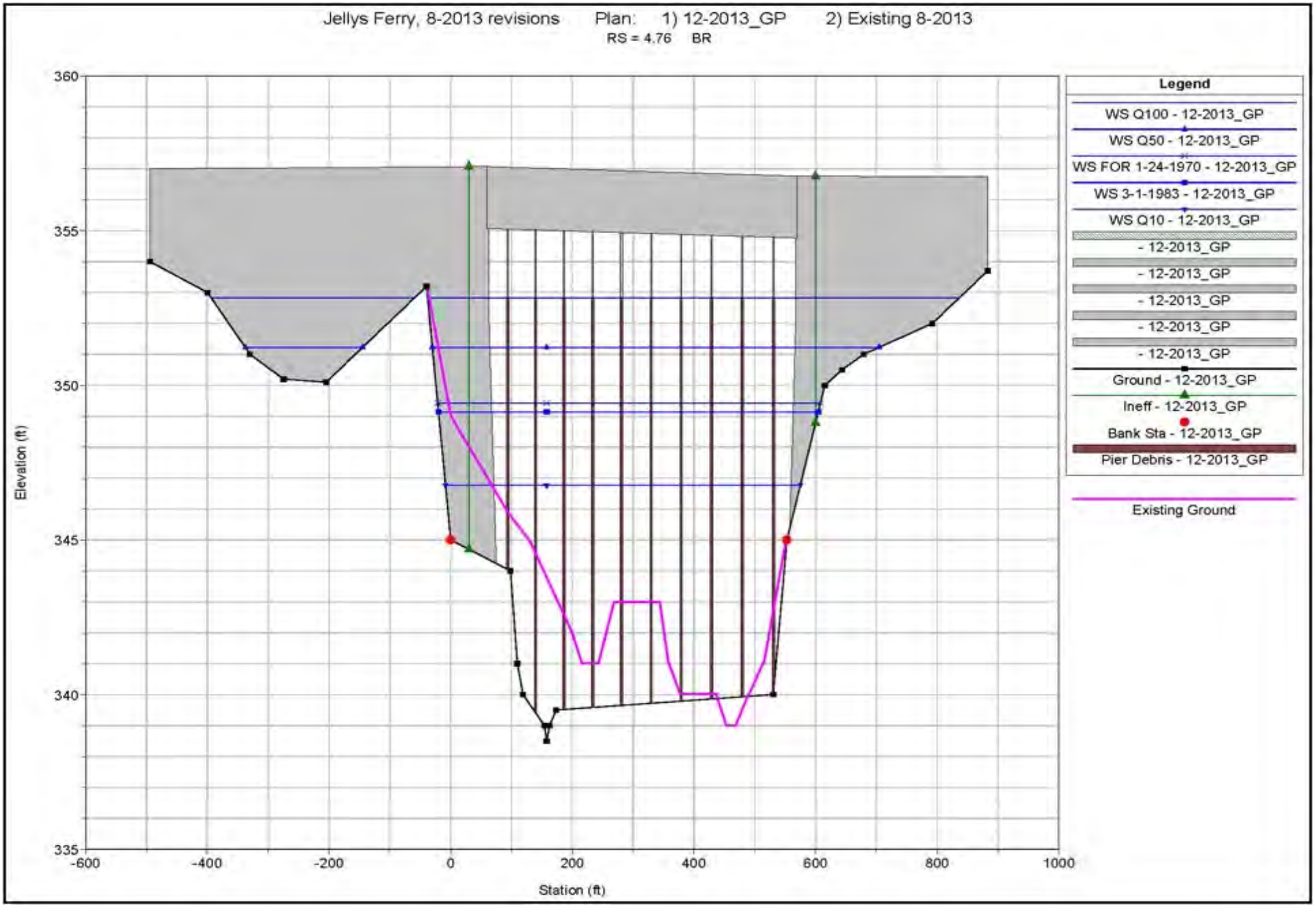


Figure 13: Existing Condition and Preferred North Overflow Bridge as Represented in Backwater Model

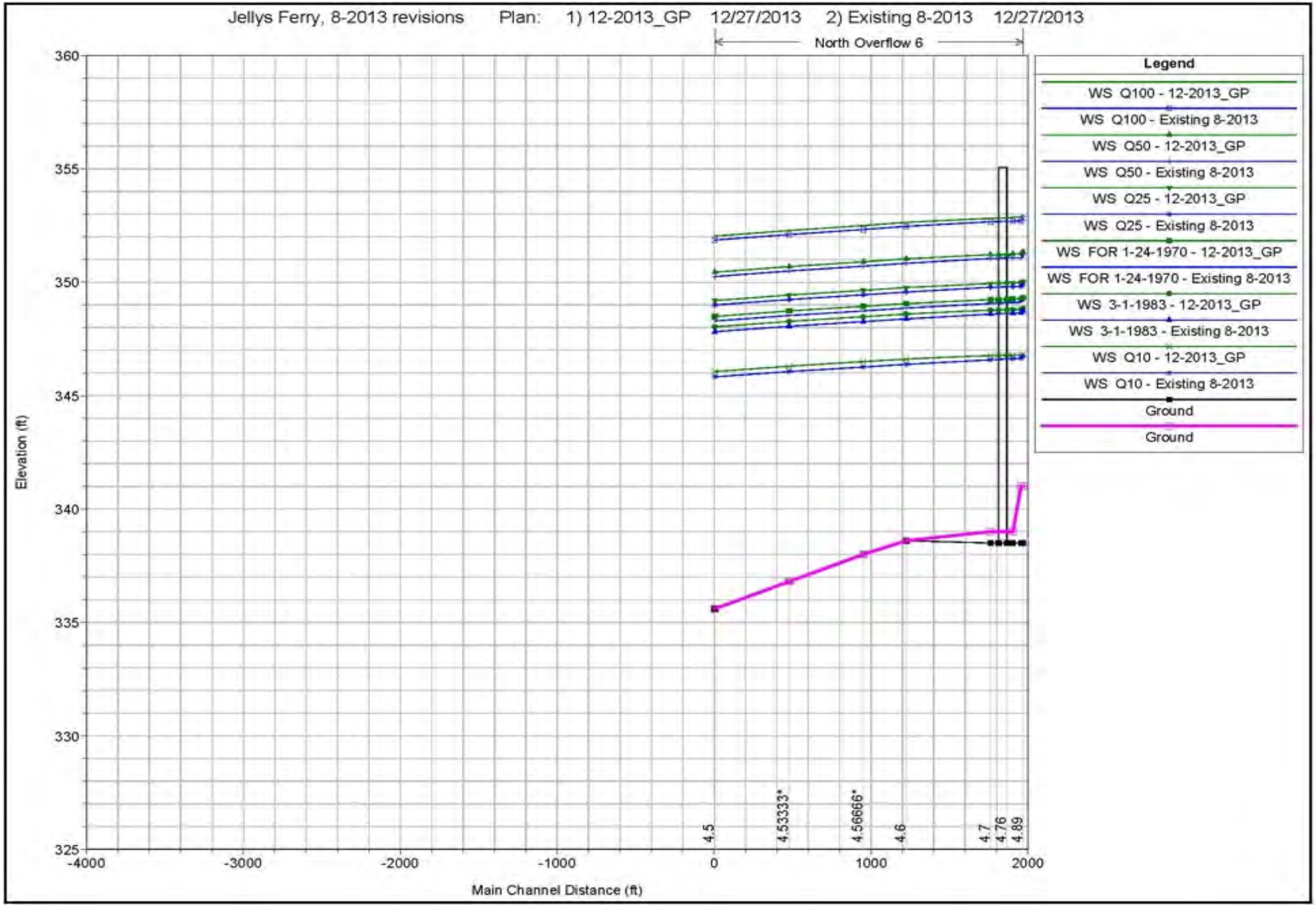


Figure 14: North Overflow Profiles for Existing Condition and Preferred Bridge

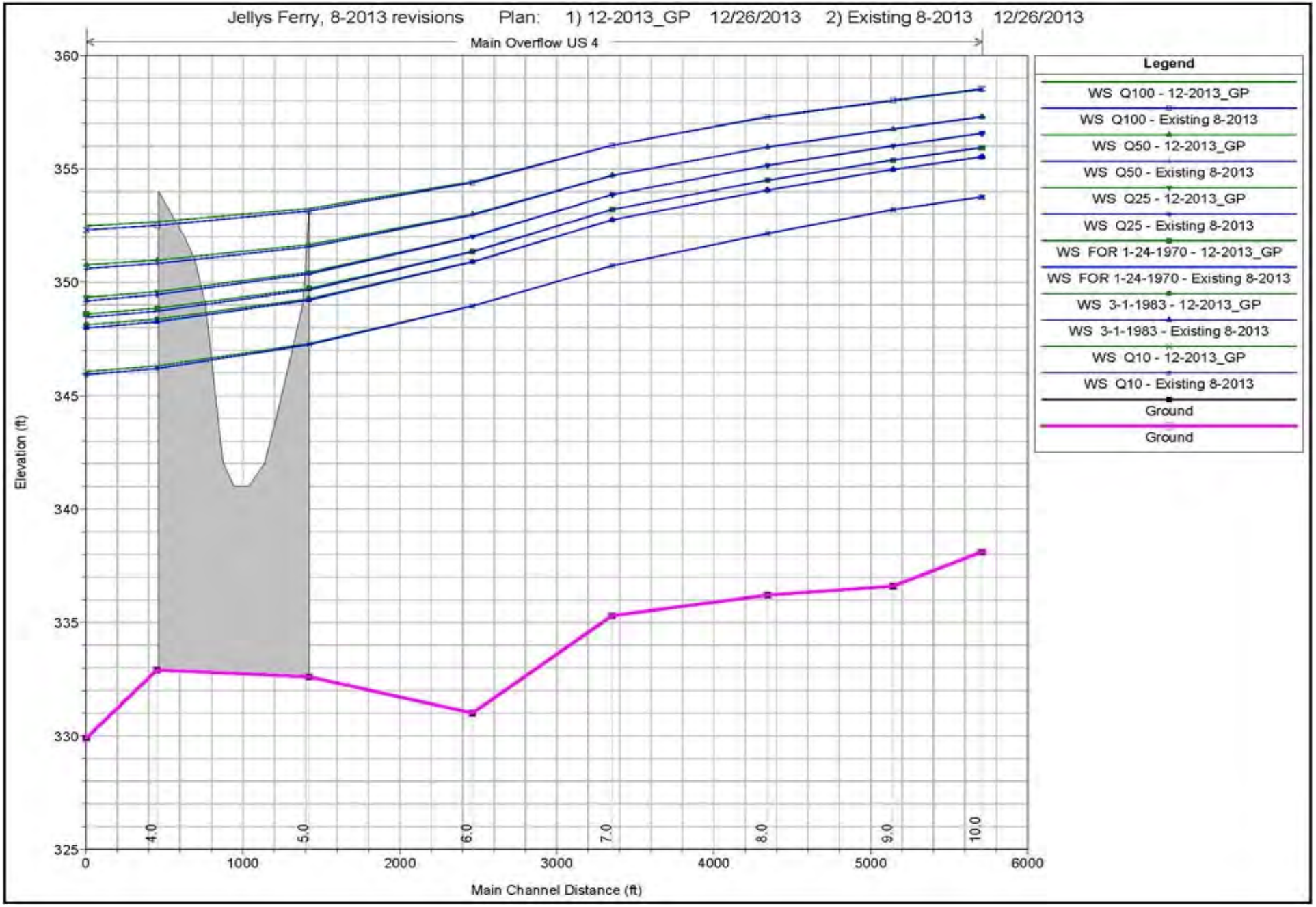


Figure 15: Main Overflow Profiles for Existing Condition and Preferred Bridge

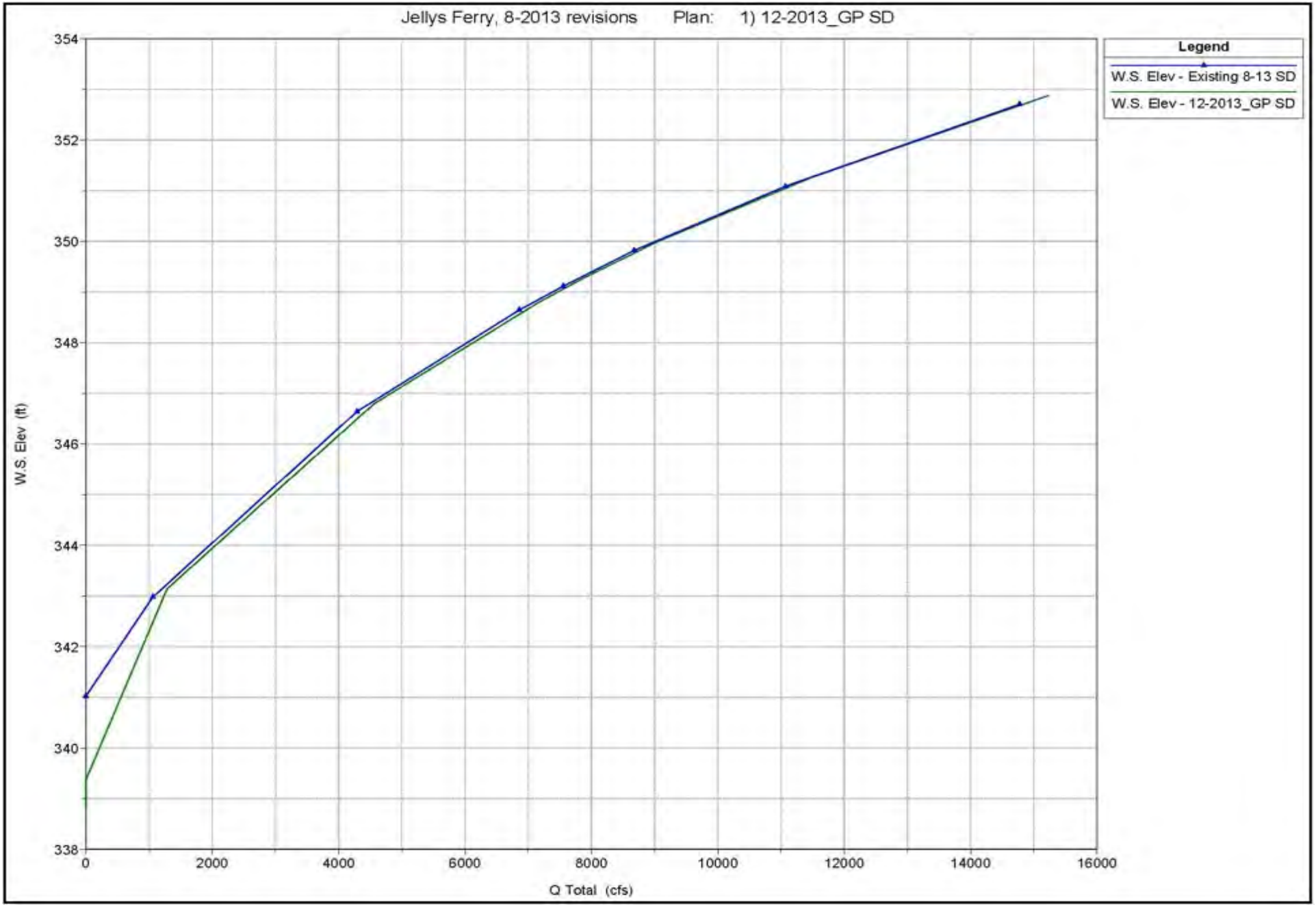


Figure 16: North Overflow Stage Discharge Curves for Existing Conditions and Preferred Bridge at Cross-section 4.88

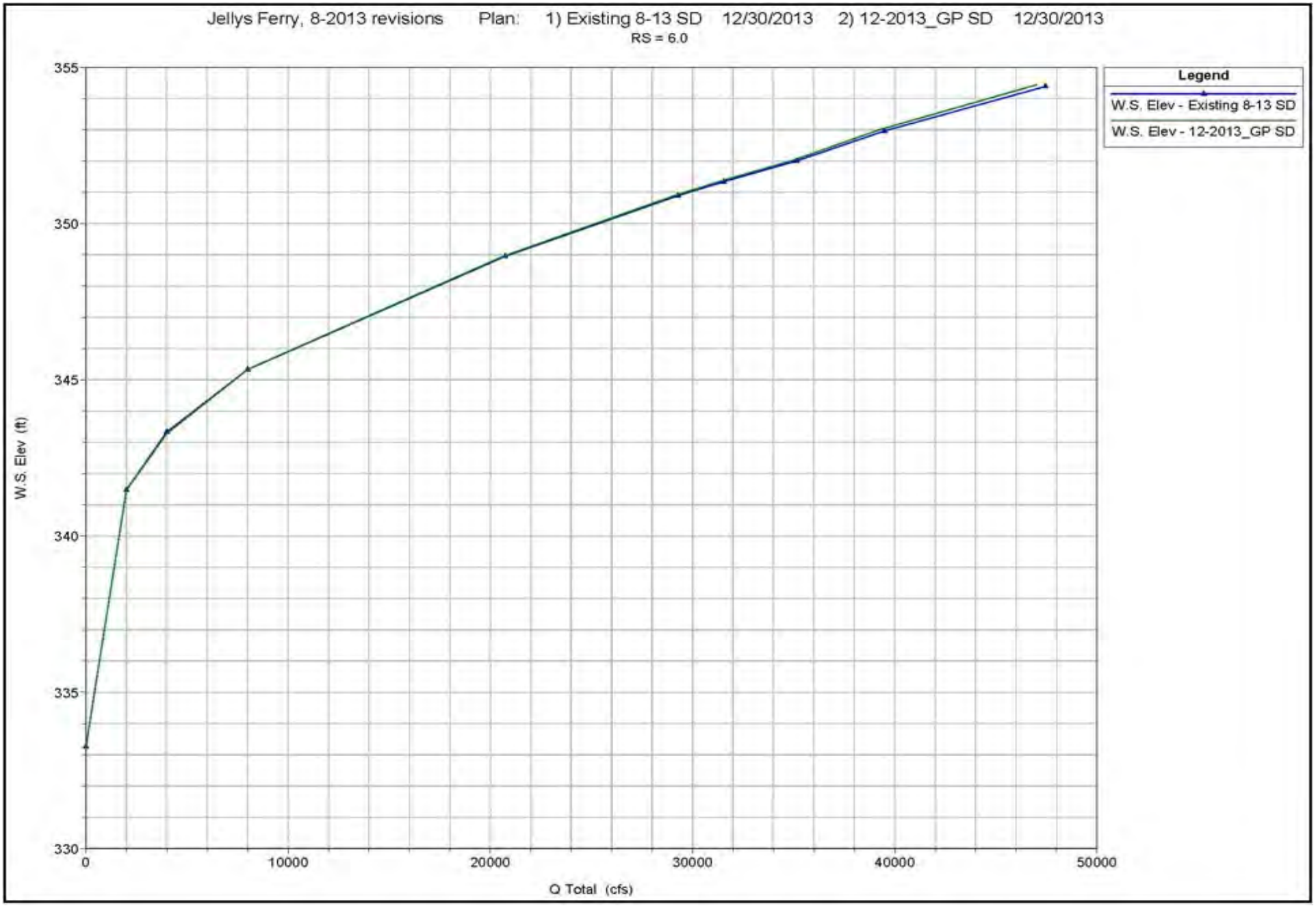


Figure 17: Main Overflow Stage Discharge Curve, Existing Condition and Preferred Bridge at Cross-section 6.0 (downstream limit of FEMA SHFA)

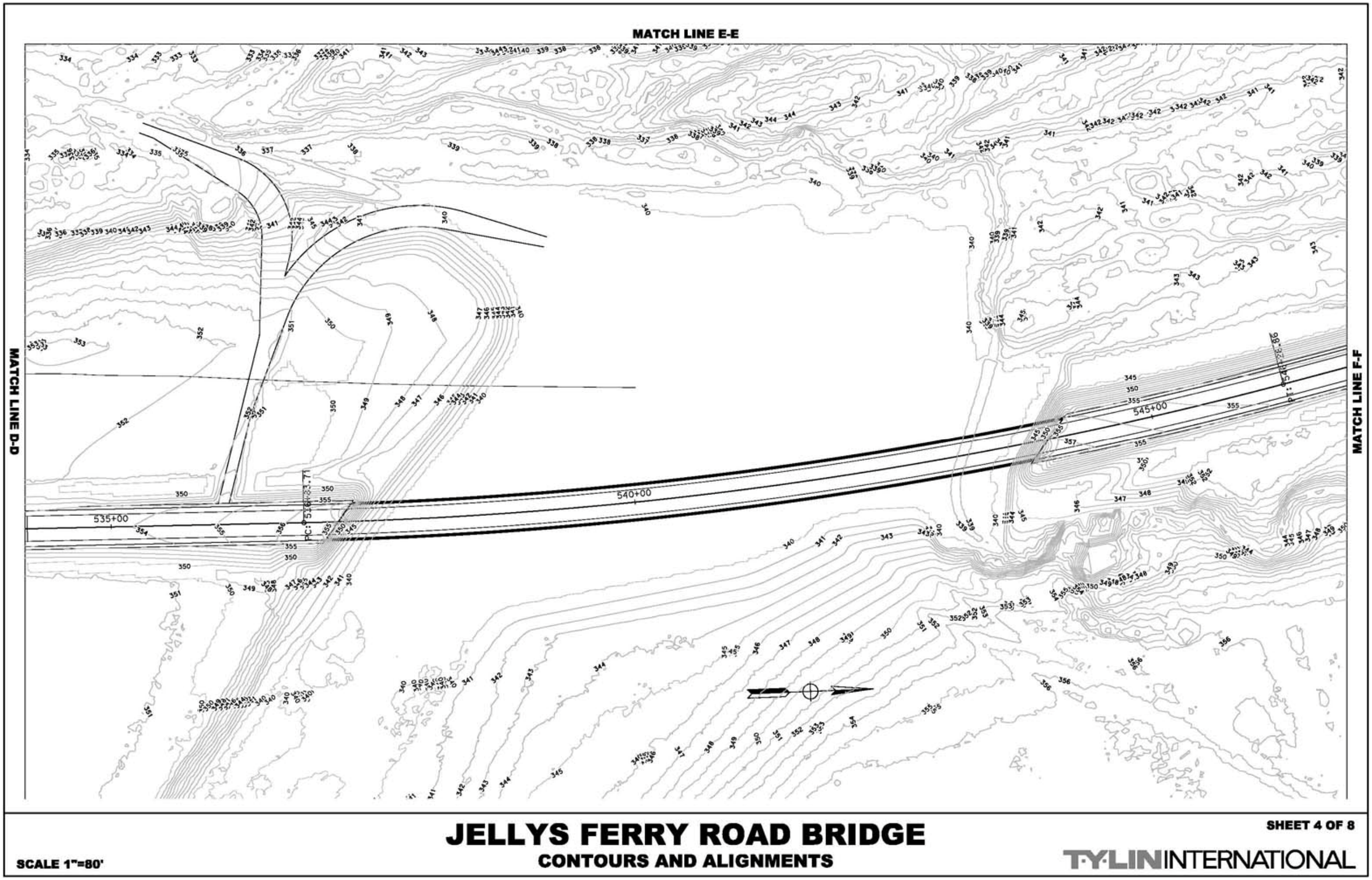


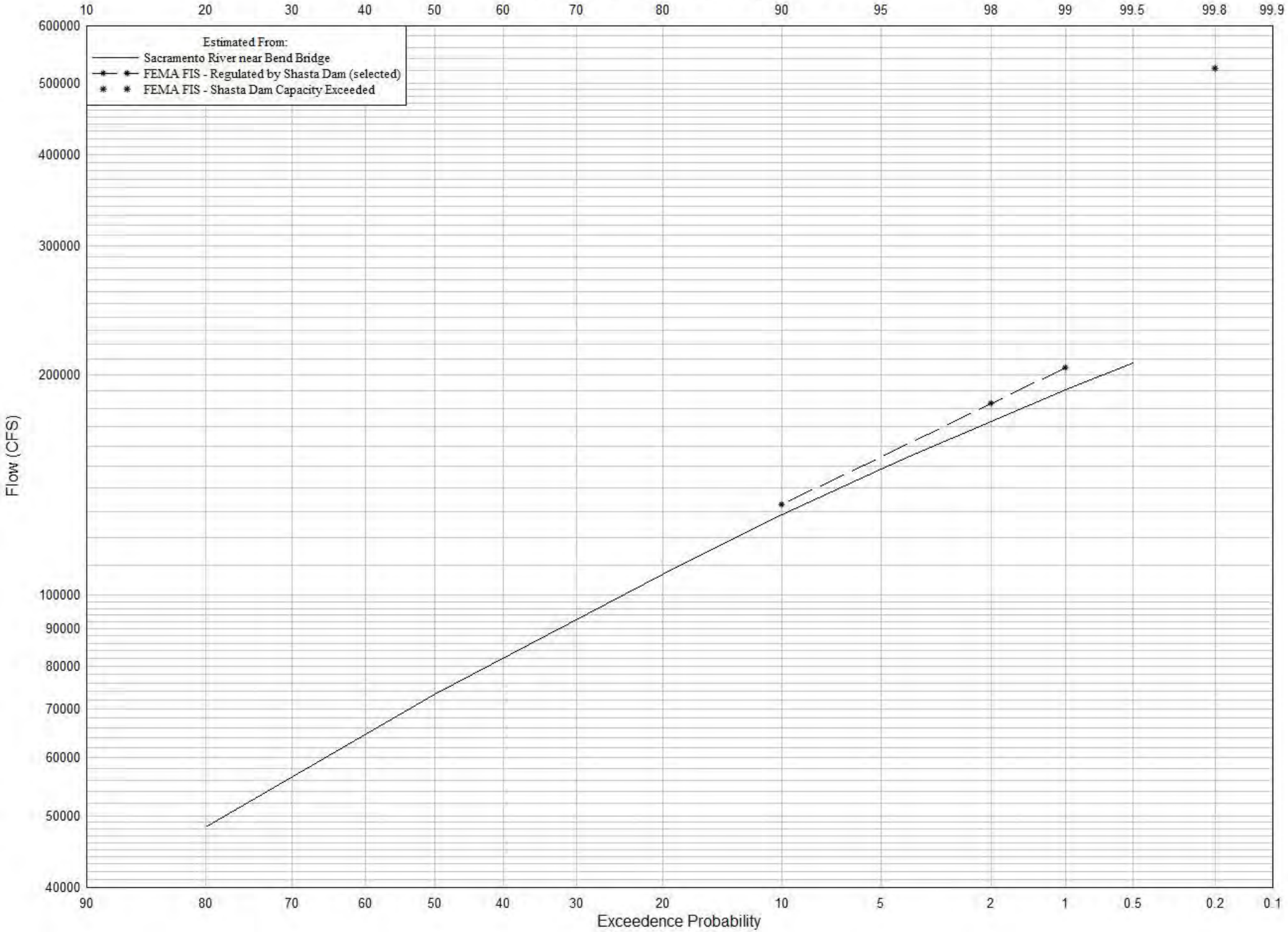
Figure 18: Grading Plan Reflecting Conveyance Improvement at North Overflow Split from Main Overflow

APPENDIX A

Additional Hydrologic Figures

Jellys Ferry Road over Sacramento River

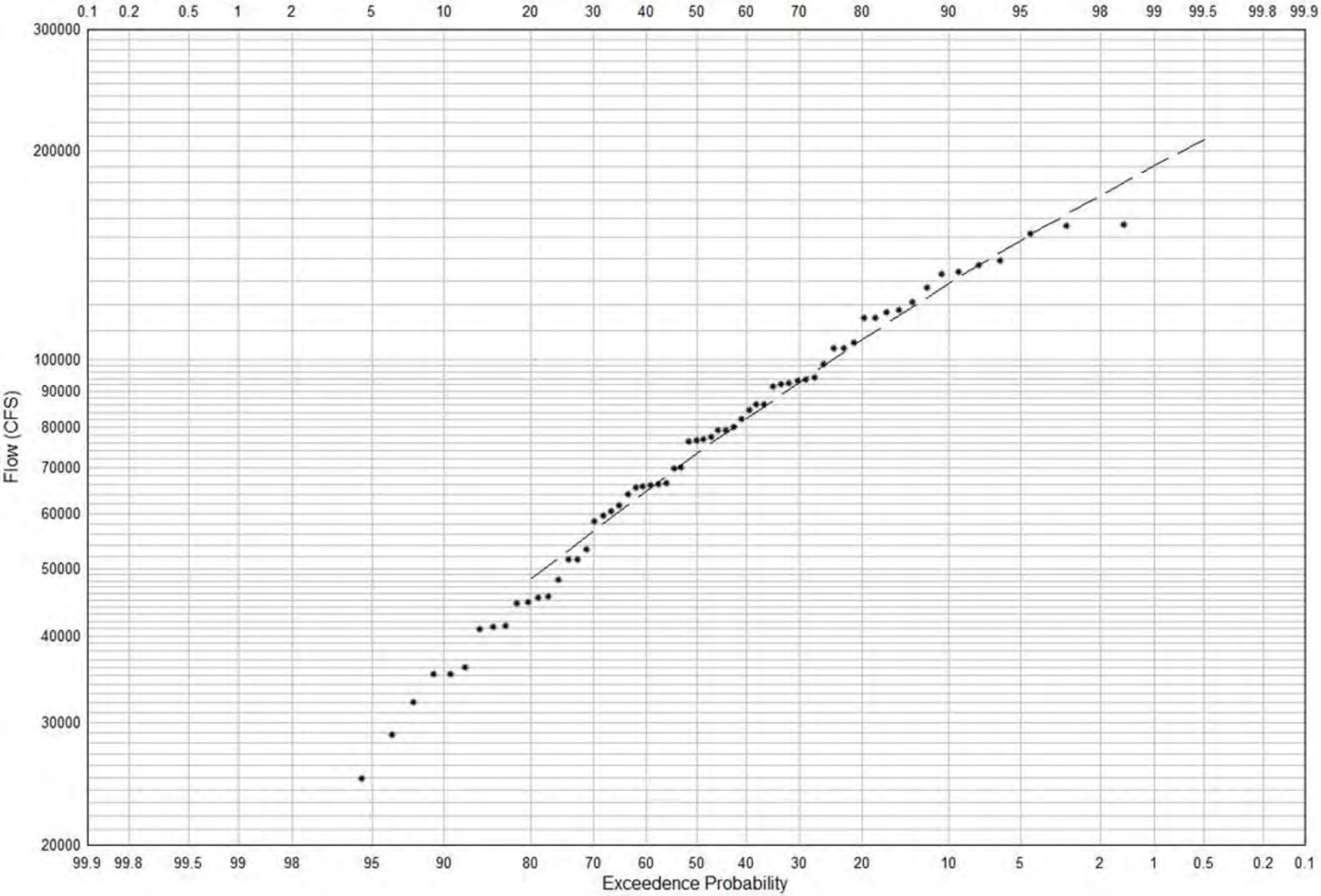
Candidate Flood Frequency Curves



Sacramento River near Bend Bridge

USGS Streamgage 113771000: 65-years, 8900 sq-mi effective

Operating



APPENDIX B

Additional Hydraulic Data

HEC-RAS Plan: Existing 8-2013 Backwater Model Summary Output, Existing Condition, No Drift

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Sacramento River	2	20410	Q100	205000	324.9	357.3		358.5	0.001025	10.0	26743	1465.1	0.32
Sacramento River	2	20410	Q50	183000	324.9	355.8		356.9	0.000985	9.4	24632	1450.5	0.31
Sacramento River	2	20410	FOR 1-24-1970	157000	324.9	353.9		354.9	0.001000	9.1	21893	1412.9	0.31
Sacramento River	2	18850	Q100	157544	323.7	356.7		357.2	0.000420	6.3	32144	1668.7	0.21
Sacramento River	2	18850	Q50	143512	323.7	355.3		355.7	0.000424	6.1	29673	1664.4	0.21
Sacramento River	2	18850	FOR 1-24-1970	125462	323.7	353.3		353.7	0.000447	6.0	26415	1626.3	0.21
Sacramento River	2	16600	Q100	157544	322.2	356.0		356.4	0.000320	5.5	35851	1659.2	0.18
Sacramento River	2	16600	Q50	143512	322.2	354.5		354.9	0.000332	5.4	33347	1657.5	0.18
Sacramento River	2	16600	FOR 1-24-1970	125462	322.2	352.5		352.8	0.000350	5.3	29990	1655.2	0.19
Sacramento River	2	14880	Q100	157544	315.7	355.3		355.8	0.000345	6.2	30801	1324.1	0.19
Sacramento River	2	14880	Q50	143512	315.7	353.8		354.3	0.000348	6.1	28801	1322.7	0.19
Sacramento River	2	14880	FOR 1-24-1970	125462	315.7	351.8		352.2	0.000352	5.8	26120	1320.9	0.19
Sacramento River	2	13630.*	Q100	157544	314.4	354.9		355.4	0.000333	6.1	32217	1469.8	0.19
Sacramento River	2	13630.*	Q50	143512	314.4	353.4		353.9	0.000339	6.0	29983	1465.6	0.19
Sacramento River	2	13630.*	FOR 1-24-1970	125462	314.4	351.3		351.8	0.000347	5.8	26994	1461.9	0.19
Sacramento River	2	12380.*	Q100	157544	313.1	354.5		355.0	0.000354	6.2	32584	1609.6	0.19
Sacramento River	2	12380.*	Q50	143512	313.1	352.9		353.4	0.000366	6.1	30104	1607.2	0.20
Sacramento River	2	12380.*	FOR 1-24-1970	125462	313.1	350.9		351.3	0.000383	6.0	26785	1592.9	0.20
Sacramento River	2	11130	Q100	131161	311.8	354.2		354.5	0.000281	5.4	32151	1747.0	0.17
Sacramento River	2	11130	Q50	123515	311.8	352.6		353.0	0.000320	5.5	29361	1743.7	0.18
Sacramento River	2	11130	FOR 1-24-1970	111714	311.8	350.4		350.9	0.000372	5.7	25654	1726.0	0.19
Sacramento River	2	9880.*	Q100	131161	311.7	353.5		354.1	0.000383	6.5	25163	1514.4	0.20
Sacramento River	2	9880.*	Q50	123515	311.7	351.9		352.5	0.000421	6.5	22748	1373.9	0.21
Sacramento River	2	9880.*	FOR 1-24-1970	111714	311.7	349.7		350.3	0.000471	6.6	19818	1307.0	0.22
Sacramento River	2	8630.*	Q100	131161	311.6	352.9		353.6	0.000403	6.9	21509	1041.3	0.21
Sacramento River	2	8630.*	Q50	123515	311.6	351.3		351.9	0.000429	6.9	19862	943.4	0.21
Sacramento River	2	8630.*	FOR 1-24-1970	111714	311.6	349.1		349.7	0.000452	6.7	18007	790.3	0.22
Sacramento River	2	7380	Q100	131161	311.5	352.4		353.1	0.000363	6.8	21249	787.1	0.20
Sacramento River	2	7380	Q50	123515	311.5	350.8		351.4	0.000382	6.8	19955	752.5	0.20
Sacramento River	2	7380	FOR 1-24-1970	111714	311.5	348.6		349.2	0.000396	6.6	18335	718.1	0.20
Sacramento River	2	6020.*	Q100	131161	309.4	351.9		352.6	0.000370	6.9	21249	869.3	0.20
Sacramento River	2	6020.*	Q50	123515	309.4	350.2		350.9	0.000386	6.8	19870	775.4	0.20
Sacramento River	2	6020.*	FOR 1-24-1970	111714	309.4	348.0		348.7	0.000400	6.6	18203	724.7	0.21
Sacramento River	2	4660	Q100	131161	307.4	351.4		352.1	0.000413	7.0	20094	697.1	0.21
Sacramento River	2	4660	Q50	123515	307.4	349.6		350.3	0.000442	7.0	18881	694.6	0.22
Sacramento River	2	4660	FOR 1-24-1970	111714	307.4	347.3		348.1	0.000468	6.9	17311	691.3	0.22
Sacramento River	1	4480	Q100	170535	307.8	351.1		351.8	0.000402	7.9	30015	1243.0	0.23
Sacramento River	1	4480	Q50	158097	307.8	349.3		350.1	0.000429	7.9	27822	1238.8	0.23
Sacramento River	1	4480	FOR 1-24-1970	142105	307.8	347.0		347.8	0.000471	7.9	24948	1233.3	0.24
Sacramento River	1	4400	Q100	170535	307.9	351.0		351.8	0.000447	8.4	28289	1214.1	0.24
Sacramento River	1	4400	Q50	158097	307.9	349.2		350.0	0.000478	8.4	26132	1211.7	0.25
Sacramento River	1	4400	FOR 1-24-1970	142105	307.9	346.8		347.7	0.000528	8.4	23298	1208.5	0.25
Sacramento River	1	4305	Q100	170535	307.9	350.7	332.6	351.7	0.000524	9.0	23485	838.5	0.26
Sacramento River	1	4305	Q50	158097	307.9	348.9	330.9	349.9	0.000542	8.9	22031	834.5	0.26
Sacramento River	1	4305	FOR 1-24-1970	142105	307.9	346.6	329.9	347.6	0.000570	8.7	20132	830.0	0.27
Sacramento River	1	4285		Bridge									
Sacramento River	1	4240	Q100	170535	307.4	350.3		351.5	0.000578	9.5	22341	812.5	0.27
Sacramento River	1	4240	Q50	158097	307.4	348.6		349.7	0.000600	9.3	20938	809.9	0.27
Sacramento River	1	4240	FOR 1-24-1970	142105	307.4	346.3		347.4	0.000631	9.2	19104	806.4	0.28
Sacramento River	1	4000	Q100	170535	305.9	350.0		351.3	0.000609	9.8	20864	749.0	0.28
Sacramento River	1	4000	Q50	158097	305.9	348.2		349.5	0.000625	9.7	19584	741.5	0.28
Sacramento River	1	4000	FOR 1-24-1970	142105	305.9	346.0		347.2	0.000644	9.4	17930	730.9	0.28
Sacramento River	1	3500	Q100	190228	305.4	349.7		350.9	0.000603	9.8	28154	1550.1	0.28
Sacramento River	1	3500	Q50	171934	305.4	348.0		349.2	0.000622	9.7	25460	1528.1	0.28
Sacramento River	1	3500	FOR 1-24-1970	149447	305.4	345.7		346.9	0.000647	9.5	21991	1497.4	0.28
Sacramento River	1	2900	Q100	190228	308.6	349.4		350.6	0.000607	9.3	26829	1408.8	0.27
Sacramento River	1	2900	Q50	171934	308.6	347.7		348.8	0.000617	9.1	24413	1373.0	0.27
Sacramento River	1	2900	FOR 1-24-1970	149447	308.6	345.4		346.5	0.000631	8.8	21338	1330.9	0.27
Sacramento River	1	1530	Q100	190228	305.5	348.6		349.7	0.000569	9.2	27288	1255.0	0.27
Sacramento River	1	1530	Q50	171934	305.5	346.9		348.0	0.000565	8.9	25194	1193.7	0.27
Sacramento River	1	1530	FOR 1-24-1970	149447	305.5	344.7		345.6	0.000566	8.5	22544	1145.3	0.26
Sacramento River	1	0	Q100	190228	300.1	347.9	330.5	348.9	0.000500	9.1	29582	1232.2	0.26
Sacramento River	1	0	Q50	171934	300.1	346.2	329.1	347.1	0.000500	8.8	27465	1214.8	0.25
Sacramento River	1	0	FOR 1-24-1970	149447	300.1	343.9	327.2	344.8	0.000501	8.5	24725	1189.8	0.25
North Overflow	6	4.89	Q100	1	341.0	352.8		352.8	0.000000	0.0	6591	1190.5	0.00
North Overflow	6	4.89	Q50	1	341.0	351.2		351.2	0.000000	0.0	4888	911.3	0.00
North Overflow	6	4.89	FOR 1-24-1970	1	341.0	349.2		349.2	0.000000	0.0	3419	628.9	0.00

HEC-RAS Plan: Existing 8-2013 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
North Overflow	6	4.88	Q100	14773	341.0	352.7		352.8	0.000245	2.5	6468	1171.7	0.15
North Overflow	6	4.88	Q50	11067	341.0	351.1		351.2	0.000287	2.4	4800	895.3	0.15
North Overflow	6	4.88	FOR 1-24-1970	7554	341.0	349.1		349.2	0.000384	2.2	3364	625.0	0.17
North Overflow	6	4.79	Q100	14773	339.0	352.7		352.8	0.000223	2.5	6603	1186.8	0.14
North Overflow	6	4.79	Q50	11067	339.0	351.1		351.2	0.000253	2.3	4905	886.6	0.15
North Overflow	6	4.79	FOR 1-24-1970	7554	339.0	349.1		349.2	0.000313	2.1	3518	599.6	0.16
North Overflow	6	4.7	Q100	14773	339.0	352.7		352.8	0.000207	2.5	6744	1231.7	0.14
North Overflow	6	4.7	Q50	11067	339.0	351.0		351.1	0.000228	2.3	5019	857.7	0.14
North Overflow	6	4.7	FOR 1-24-1970	7554	339.0	349.1		349.1	0.000271	2.1	3645	602.1	0.15
North Overflow	6	4.6	Q100	14773	338.6	352.5		352.6	0.000334	3.2	5159	866.9	0.18
North Overflow	6	4.6	Q50	11067	338.6	350.8		351.0	0.000353	3.0	3918	668.0	0.18
North Overflow	6	4.6	FOR 1-24-1970	7554	338.6	348.9		349.0	0.000349	2.6	2886	408.1	0.17
North Overflow	6	4.56666*	Q100	14773	338.0	352.3		352.5	0.000421	3.5	4593	785.6	0.20
North Overflow	6	4.56666*	Q50	11067	338.0	350.7		350.9	0.000416	3.2	3553	532.0	0.19
North Overflow	6	4.56666*	FOR 1-24-1970	7554	338.0	348.7		348.9	0.000409	2.8	2683	368.6	0.18
North Overflow	6	4.53333*	Q100	14773	336.8	352.1		352.3	0.000443	3.6	4402	665.3	0.20
North Overflow	6	4.53333*	Q50	11067	336.8	350.5		350.7	0.000435	3.3	3470	512.5	0.20
North Overflow	6	4.53333*	FOR 1-24-1970	7554	336.8	348.5		348.7	0.000426	2.9	2605	352.6	0.19
North Overflow	6	4.5	Q100	14773	335.6	351.9	344.3	352.1	0.000501	3.8	4188	632.0	0.21
North Overflow	6	4.5	Q50	11067	335.6	350.2	343.5	350.4	0.000500	3.5	3296	503.3	0.21
North Overflow	6	4.5	FOR 1-24-1970	7554	335.6	348.3	342.6	348.4	0.000500	3.1	2436	335.7	0.20
Main Overflow US	4	10.01	Q100	47456	338.1	358.5		358.7	0.000651	3.6	17227	2234.2	0.17
Main Overflow US	4	10.01	Q50	39488	338.1	357.3		357.5	0.000725	3.6	14480	2221.6	0.18
Main Overflow US	4	10.01	FOR 1-24-1970	31538	338.1	355.9		356.1	0.000831	3.6	11484	2207.7	0.19
Main Overflow US	4	10.0	Q100	47456	338.1	358.5		358.7	0.000653	3.6	17212	2234.2	0.17
Main Overflow US	4	10.0	Q50	39488	338.1	357.3		357.4	0.000728	3.6	14463	2221.5	0.18
Main Overflow US	4	10.0	FOR 1-24-1970	31538	338.1	355.9		356.1	0.000835	3.6	11464	2207.6	0.19
Main Overflow US	4	9.0	Q100	47456	336.6	358.0		358.2	0.000866	4.0	13141	1528.1	0.20
Main Overflow US	4	9.0	Q50	39488	336.6	356.8		357.0	0.000936	3.9	11220	1519.9	0.20
Main Overflow US	4	9.0	FOR 1-24-1970	31538	336.6	355.4		355.6	0.000991	3.7	9191	1341.5	0.20
Main Overflow US	4	8.0	Q100	47456	336.2	357.3		357.6	0.000767	4.6	11627	1379.2	0.24
Main Overflow US	4	8.0	Q50	39488	336.2	356.0		356.3	0.000870	4.5	9797	1369.0	0.25
Main Overflow US	4	8.0	FOR 1-24-1970	31538	336.2	354.5		354.8	0.001019	4.3	7832	1277.8	0.26
Main Overflow US	4	7.0	Q100	47456	335.3	356.0		356.6	0.001204	6.2	7946	952.1	0.31
Main Overflow US	4	7.0	Q50	39488	335.3	354.7		355.2	0.001217	5.8	6937	682.3	0.30
Main Overflow US	4	7.0	FOR 1-24-1970	31538	335.3	353.2		353.6	0.001259	5.3	5934	651.2	0.30
Main Overflow US	4	6.0	Q100	47456	331.0	354.4		355.1	0.002426	6.9	6949	782.1	0.38
Main Overflow US	4	6.0	Q50	39488	331.0	353.0		353.7	0.002668	6.7	5912	674.1	0.39
Main Overflow US	4	6.0	FOR 1-24-1970	31538	331.0	351.3		352.0	0.002957	6.5	4875	599.7	0.40
Main Overflow US	4	5.0	Q100	47456	332.6	353.1		353.5	0.000957	5.0	9900	1159.0	0.25
Main Overflow US	4	5.0	Q50	39488	332.6	351.6		351.9	0.001045	4.7	8370	833.1	0.25
Main Overflow US	4	5.0	FOR 1-24-1970	31538	332.6	349.7		350.0	0.001245	4.6	6889	750.9	0.27
Main Overflow US	4	4.99		Lat Struct									
Main Overflow US	4	4.0	Q100	32684	332.9	352.5		352.8	0.000502	4.4	7689	665.0	0.20
Main Overflow US	4	4.0	Q50	28422	332.9	350.8		351.1	0.000577	4.4	6655	588.1	0.21
Main Overflow US	4	4.0	FOR 1-24-1970	23985	332.9	348.7		349.0	0.000749	4.4	5470	540.0	0.24
Main Overflow US	4	3.0	Q100	32684	329.9	352.3		352.6	0.000405	4.6	8410	693.0	0.19
Main Overflow US	4	3.0	Q50	28422	329.9	350.6		350.9	0.000445	4.5	7278	633.7	0.19
Main Overflow US	4	3.0	FOR 1-24-1970	23985	329.9	348.4		348.7	0.000530	4.5	5985	553.4	0.21
Main Overflow DS	3	2.0	Q100	59067	331.0	352.0		352.3	0.000512	5.0	14818	1199.4	0.21
Main Overflow DS	3	2.0	Q50	48419	331.0	350.3		350.6	0.000510	4.7	12845	1131.8	0.21
Main Overflow DS	3	2.0	FOR 1-24-1970	37733	331.0	348.2		348.4	0.000563	4.5	10443	1080.6	0.21
Main Overflow DS	3	1.99		Lat Struct									
Main Overflow DS	3	1.0	Q100	39374	328.9	351.6	341.0	351.9	0.000545	5.2	8497	877.6	0.22
Main Overflow DS	3	1.0	Q50	34582	328.9	349.8	340.4	350.2	0.000627	5.2	7452	867.1	0.23
Main Overflow DS	3	1.0	FOR 1-24-1970	30391	328.9	347.4	339.9	347.9	0.000903	5.6	6053	864.4	0.27

HEC-RAS Plan: Existing 8-2013 Backwater Model Summary Output, Existing Condition With Drift

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Sacramento River	2	20410	Q100	205000	324.9	357.3		358.5	0.001023	9.9	26758	1465.1	0.32
Sacramento River	2	20410	Q50	183000	324.9	355.9		356.9	0.000984	9.4	24646	1450.7	0.31
Sacramento River	2	20410	FOR 1-24-1970	157000	324.9	353.9		354.9	0.000999	9.1	21902	1413.1	0.31
Sacramento River	2	18850	Q100	157544	323.7	356.7		357.2	0.000419	6.3	32162	1668.7	0.21
Sacramento River	2	18850	Q50	143512	323.7	355.3		355.7	0.000423	6.1	29691	1664.6	0.21
Sacramento River	2	18850	FOR 1-24-1970	125462	323.7	353.3		353.7	0.000446	6.0	26426	1626.4	0.21
Sacramento River	2	16600	Q100	157544	322.2	356.1		356.4	0.000320	5.5	35871	1659.2	0.18
Sacramento River	2	16600	Q50	143512	322.2	354.5		354.9	0.000331	5.4	33366	1657.5	0.18
Sacramento River	2	16600	FOR 1-24-1970	125462	322.2	352.5		352.8	0.000349	5.3	30002	1655.2	0.18
Sacramento River	2	14880	Q100	157544	315.7	355.3		355.8	0.000344	6.2	30819	1324.2	0.19
Sacramento River	2	14880	Q50	143512	315.7	353.8		354.3	0.000347	6.0	28818	1322.8	0.19
Sacramento River	2	14880	FOR 1-24-1970	125462	315.7	351.8		352.2	0.000352	5.8	26131	1320.9	0.19
Sacramento River	2	13630.*	Q100	157544	314.4	354.9		355.4	0.000332	6.1	32237	1469.8	0.19
Sacramento River	2	13630.*	Q50	143512	314.4	353.4		353.9	0.000338	6.0	30003	1465.6	0.19
Sacramento River	2	13630.*	FOR 1-24-1970	125462	314.4	351.4		351.8	0.000347	5.8	27007	1461.9	0.19
Sacramento River	2	12380.*	Q100	157544	313.1	354.5		355.0	0.000353	6.2	32607	1609.6	0.19
Sacramento River	2	12380.*	Q50	143512	313.1	353.0		353.4	0.000365	6.1	30127	1607.2	0.20
Sacramento River	2	12380.*	FOR 1-24-1970	125462	313.1	350.9		351.3	0.000382	6.0	26801	1593.1	0.20
Sacramento River	2	11130	Q100	131161	311.8	354.2		354.5	0.000281	5.4	32178	1747.2	0.17
Sacramento River	2	11130	Q50	123515	311.8	352.6		353.0	0.000319	5.5	29388	1743.8	0.18
Sacramento River	2	11130	FOR 1-24-1970	111714	311.8	350.4		350.9	0.000371	5.7	25673	1726.1	0.19
Sacramento River	2	9880.*	Q100	131161	311.7	353.5		354.1	0.000383	6.5	25188	1514.5	0.20
Sacramento River	2	9880.*	Q50	123515	311.7	351.9		352.5	0.000420	6.5	22772	1375.7	0.21
Sacramento River	2	9880.*	FOR 1-24-1970	111714	311.7	349.7		350.3	0.000470	6.6	19834	1307.2	0.22
Sacramento River	2	8630.*	Q100	131161	311.6	352.9		353.6	0.000402	6.9	21528	1042.3	0.21
Sacramento River	2	8630.*	Q50	123515	311.6	351.3		352.0	0.000428	6.9	19879	944.5	0.21
Sacramento River	2	8630.*	FOR 1-24-1970	111714	311.6	349.1		349.7	0.000451	6.7	18018	790.6	0.22
Sacramento River	2	7380	Q100	131161	311.5	352.5		353.1	0.000362	6.8	21263	787.4	0.20
Sacramento River	2	7380	Q50	123515	311.5	350.8		351.5	0.000381	6.8	19969	752.9	0.20
Sacramento River	2	7380	FOR 1-24-1970	111714	311.5	348.6		349.2	0.000395	6.6	18345	718.3	0.20
Sacramento River	2	6020.*	Q100	131161	309.4	351.9		352.6	0.000369	6.9	21266	869.3	0.20
Sacramento River	2	6020.*	Q50	123515	309.4	350.2		350.9	0.000386	6.8	19885	776.1	0.20
Sacramento River	2	6020.*	FOR 1-24-1970	111714	309.4	348.0		348.7	0.000400	6.6	18214	725.0	0.21
Sacramento River	2	4660	Q100	131161	307.4	351.4		352.1	0.000412	7.0	20109	697.1	0.21
Sacramento River	2	4660	Q50	123515	307.4	349.6		350.4	0.000441	7.0	18896	694.6	0.22
Sacramento River	2	4660	FOR 1-24-1970	111714	307.4	347.4		348.1	0.000467	6.9	17322	691.3	0.22
Sacramento River	1	4480	Q100	170467	307.8	351.1		351.8	0.000401	7.9	30042	1243.1	0.23
Sacramento River	1	4480	Q50	157990	307.8	349.4		350.1	0.000428	7.9	27851	1238.9	0.23
Sacramento River	1	4480	FOR 1-24-1970	142056	307.8	347.0		347.8	0.000469	7.9	24969	1233.3	0.24
Sacramento River	1	4400	Q100	170467	307.9	351.0		351.8	0.000445	8.3	28317	1214.1	0.24
Sacramento River	1	4400	Q50	157990	307.9	349.2		350.0	0.000476	8.4	26161	1211.7	0.24
Sacramento River	1	4400	FOR 1-24-1970	142056	307.9	346.9		347.7	0.000526	8.4	23320	1208.5	0.25
Sacramento River	1	4305	Q100	170467	307.9	350.7	332.6	351.7	0.000522	9.0	23504	838.6	0.26
Sacramento River	1	4305	Q50	157990	307.9	349.0	330.9	350.0	0.000540	8.9	22052	834.5	0.26
Sacramento River	1	4305	FOR 1-24-1970	142056	307.9	346.7	329.9	347.7	0.000568	8.7	20147	830.0	0.26
Sacramento River	1	4285		Bridge									
Sacramento River	1	4240	Q100	170467	307.4	350.3		351.5	0.000578	9.4	22340	812.5	0.27
Sacramento River	1	4240	Q50	157990	307.4	348.6		349.7	0.000599	9.3	20935	809.9	0.27
Sacramento River	1	4240	FOR 1-24-1970	142056	307.4	346.3		347.4	0.000630	9.2	19103	806.4	0.28
Sacramento River	1	4000	Q100	170467	305.9	350.0		351.3	0.000609	9.8	20863	749.0	0.28
Sacramento River	1	4000	Q50	157990	305.9	348.2		349.5	0.000624	9.6	19582	741.5	0.28
Sacramento River	1	4000	FOR 1-24-1970	142056	305.9	346.0		347.2	0.000644	9.4	17929	730.9	0.28
Sacramento River	1	3500	Q100	190207	305.4	349.7		350.9	0.000603	9.8	28151	1550.1	0.28
Sacramento River	1	3500	Q50	171896	305.4	348.0		349.2	0.000622	9.7	25454	1528.1	0.28
Sacramento River	1	3500	FOR 1-24-1970	149436	305.4	345.7		346.9	0.000647	9.5	21989	1497.4	0.28
Sacramento River	1	2900	Q100	190207	308.6	349.4		350.6	0.000607	9.3	26826	1408.7	0.27
Sacramento River	1	2900	Q50	171896	308.6	347.7		348.8	0.000617	9.1	24408	1373.0	0.27
Sacramento River	1	2900	FOR 1-24-1970	149436	308.6	345.4		346.5	0.000631	8.8	21336	1330.9	0.27
Sacramento River	1	1530	Q100	190207	305.5	348.6		349.7	0.000569	9.2	27286	1254.9	0.27
Sacramento River	1	1530	Q50	171896	305.5	346.9		347.9	0.000565	8.9	25190	1193.7	0.27
Sacramento River	1	1530	FOR 1-24-1970	149436	305.5	344.7		345.6	0.000566	8.5	22543	1145.3	0.26
Sacramento River	1	0	Q100	190207	300.1	347.9	330.5	348.9	0.000500	9.1	29579	1232.2	0.26
Sacramento River	1	0	Q50	171896	300.1	346.2	329.1	347.1	0.000500	8.8	27461	1214.7	0.25
Sacramento River	1	0	FOR 1-24-1970	149436	300.1	343.9	327.2	344.8	0.000501	8.5	24724	1189.8	0.25
North Overflow	6	4.89	Q100	1	341.0	352.8		352.8	0.000000	0.0	6601	1192.0	0.00
North Overflow	6	4.89	Q50	1	341.0	351.2		351.2	0.000000	0.0	4905	914.3	0.00
North Overflow	6	4.89	FOR 1-24-1970	1	341.0	349.2		349.2	0.000000	0.0	3424	629.2	0.00

HEC-RAS Plan: Existing 8-2013 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
North Overflow	6	4.88	Q100	14794	341.0	352.7		352.8	0.000245	2.5	6477	1173.2	0.15
North Overflow	6	4.88	Q50	11105	341.0	351.1		351.2	0.000286	2.4	4817	898.4	0.15
North Overflow	6	4.88	FOR 1-24-1970	7565	341.0	349.1		349.2	0.000383	2.2	3369	625.4	0.17
North Overflow	6	4.79	Q100	14794	339.0	352.7		352.8	0.000223	2.5	6613	1188.1	0.14
North Overflow	6	4.79	Q50	11105	339.0	351.1		351.2	0.000252	2.3	4921	890.5	0.15
North Overflow	6	4.79	FOR 1-24-1970	7565	339.0	349.1		349.2	0.000313	2.1	3523	599.9	0.16
North Overflow	6	4.7	Q100	14794	339.0	352.7		352.8	0.000207	2.5	6754	1233.1	0.14
North Overflow	6	4.7	Q50	11105	339.0	351.1		351.1	0.000228	2.3	5035	862.7	0.14
North Overflow	6	4.7	FOR 1-24-1970	7565	339.0	349.1		349.1	0.000271	2.1	3650	602.4	0.15
North Overflow	6	4.6	Q100	14794	338.6	352.5		352.6	0.000334	3.2	5166	868.0	0.18
North Overflow	6	4.6	Q50	11105	338.6	350.9		351.0	0.000353	3.0	3930	670.4	0.18
North Overflow	6	4.6	FOR 1-24-1970	7565	338.6	348.9		349.0	0.000349	2.6	2889	408.5	0.17
North Overflow	6	4.56666*	Q100	14794	338.0	352.3		352.5	0.000420	3.5	4600	786.9	0.20
North Overflow	6	4.56666*	Q50	11105	338.0	350.7		350.9	0.000416	3.2	3563	534.3	0.19
North Overflow	6	4.56666*	FOR 1-24-1970	7565	338.0	348.7		348.9	0.000409	2.8	2686	368.7	0.18
North Overflow	6	4.53333*	Q100	14794	336.8	352.1		352.3	0.000443	3.6	4408	666.6	0.20
North Overflow	6	4.53333*	Q50	11105	336.8	350.5		350.7	0.000435	3.3	3479	513.7	0.20
North Overflow	6	4.53333*	FOR 1-24-1970	7565	336.8	348.5		348.7	0.000426	2.9	2608	352.7	0.19
North Overflow	6	4.5	Q100	14794	335.6	351.9	344.4	352.1	0.000501	3.8	4193	633.9	0.21
North Overflow	6	4.5	Q50	11105	335.6	350.3	343.5	350.5	0.000500	3.5	3305	504.3	0.21
North Overflow	6	4.5	FOR 1-24-1970	7565	335.6	348.3	342.6	348.4	0.000500	3.1	2438	335.9	0.20
Main Overflow US	4	10.01	Q100	47456	338.1	358.5		358.7	0.000651	3.6	17232	2234.3	0.17
Main Overflow US	4	10.01	Q50	39488	338.1	357.3		357.5	0.000725	3.6	14483	2221.6	0.18
Main Overflow US	4	10.01	FOR 1-24-1970	31538	338.1	355.9		356.1	0.000831	3.6	11485	2207.7	0.19
Main Overflow US	4	10.0	Q100	47456	338.1	358.5		358.7	0.000652	3.6	17217	2234.2	0.17
Main Overflow US	4	10.0	Q50	39488	338.1	357.3		357.4	0.000727	3.6	14466	2221.5	0.18
Main Overflow US	4	10.0	FOR 1-24-1970	31538	338.1	355.9		356.1	0.000834	3.6	11465	2207.6	0.19
Main Overflow US	4	9.0	Q100	47456	336.6	358.0		358.3	0.000866	4.0	13145	1528.1	0.20
Main Overflow US	4	9.0	Q50	39488	336.6	356.8		357.0	0.000935	3.9	11223	1519.9	0.20
Main Overflow US	4	9.0	FOR 1-24-1970	31538	336.6	355.4		355.6	0.000990	3.7	9192	1341.6	0.20
Main Overflow US	4	8.0	Q100	47456	336.2	357.3		357.6	0.000766	4.6	11631	1379.3	0.24
Main Overflow US	4	8.0	Q50	39488	336.2	356.0		356.3	0.000869	4.5	9800	1369.0	0.25
Main Overflow US	4	8.0	FOR 1-24-1970	31538	336.2	354.5		354.8	0.001018	4.3	7834	1278.0	0.26
Main Overflow US	4	7.0	Q100	47456	335.3	356.0		356.6	0.001202	6.2	7950	953.4	0.31
Main Overflow US	4	7.0	Q50	39488	335.3	354.7		355.2	0.001215	5.8	6939	682.4	0.30
Main Overflow US	4	7.0	FOR 1-24-1970	31538	335.3	353.2		353.7	0.001258	5.3	5935	651.3	0.30
Main Overflow US	4	6.0	Q100	47456	331.0	354.4		355.1	0.002419	6.9	6956	782.8	0.38
Main Overflow US	4	6.0	Q50	39488	331.0	353.0		353.7	0.002662	6.7	5917	674.3	0.39
Main Overflow US	4	6.0	FOR 1-24-1970	31538	331.0	351.3		352.0	0.002954	6.5	4877	599.9	0.40
Main Overflow US	4	5.0	Q100	47456	332.6	353.2		353.5	0.000954	5.0	9915	1165.5	0.25
Main Overflow US	4	5.0	Q50	39488	332.6	351.6		351.9	0.001042	4.7	8379	833.8	0.25
Main Overflow US	4	5.0	FOR 1-24-1970	31538	332.6	349.7		350.0	0.001242	4.6	6894	750.9	0.27
Main Overflow US	4	4.99		Lat Struct									
Main Overflow US	4	4.0	Q100	32663	332.9	352.5		352.8	0.000499	4.4	7700	666.3	0.20
Main Overflow US	4	4.0	Q50	28384	332.9	350.8		351.1	0.000574	4.4	6664	588.4	0.21
Main Overflow US	4	4.0	FOR 1-24-1970	23974	332.9	348.7		349.0	0.000746	4.4	5476	540.2	0.24
Main Overflow US	4	3.0	Q100	32663	329.9	352.3		352.6	0.000403	4.6	8422	693.0	0.19
Main Overflow US	4	3.0	Q50	28384	329.9	350.6		350.9	0.000442	4.5	7288	634.1	0.19
Main Overflow US	4	3.0	FOR 1-24-1970	23974	329.9	348.5		348.8	0.000528	4.4	5991	553.8	0.21
Main Overflow DS	3	2.0	Q100	59046	331.0	352.0		352.3	0.000509	5.0	14840	1199.4	0.21
Main Overflow DS	3	2.0	Q50	48381	331.0	350.3		350.6	0.000507	4.7	12865	1132.5	0.21
Main Overflow DS	3	2.0	FOR 1-24-1970	37722	331.0	348.2		348.4	0.000561	4.5	10457	1080.8	0.21
Main Overflow DS	3	1.99		Lat Struct									
Main Overflow DS	3	1.0	Q100	39306	328.9	351.6	341.0	351.9	0.000541	5.2	8511	877.7	0.22
Main Overflow DS	3	1.0	Q50	34475	328.9	349.8	340.4	350.2	0.000620	5.2	7466	867.1	0.23
Main Overflow DS	3	1.0	FOR 1-24-1970	30342	328.9	347.4	339.8	347.9	0.000895	5.6	6064	864.4	0.27

HEC-RAS Plan: 12-2013_GP Backwater Model Summary Output, Preferred Project, No Drift

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Sacramento River	2	20410	Q100	205000	324.9	357.2		358.3	0.001046	10.0	26556	1464.8	0.33
Sacramento River	2	20410	Q50	183000	324.9	355.7		356.8	0.001008	9.5	24428	1447.9	0.32
Sacramento River	2	20410	FOR 1-24-1970	157000	324.9	353.8		354.8	0.001022	9.1	21717	1366.6	0.32
Sacramento River	2	18850	Q100	158002	323.7	356.6		357.1	0.000432	6.4	31896	1668.4	0.21
Sacramento River	2	18850	Q50	143735	323.7	355.1		355.6	0.000436	6.2	29406	1661.4	0.21
Sacramento River	2	18850	FOR 1-24-1970	125588	323.7	353.1		353.6	0.000459	6.0	26178	1623.3	0.21
Sacramento River	2	16600	Q100	158002	322.2	355.9		356.2	0.000330	5.6	35569	1659.0	0.18
Sacramento River	2	16600	Q50	143735	322.2	354.3		354.7	0.000342	5.5	33042	1657.3	0.19
Sacramento River	2	16600	FOR 1-24-1970	125588	322.2	352.3		352.7	0.000361	5.3	29708	1655.0	0.19
Sacramento River	2	14880	Q100	158002	315.7	355.1		355.6	0.000355	6.3	30548	1324.0	0.20
Sacramento River	2	14880	Q50	143735	315.7	353.6		354.1	0.000359	6.1	28529	1322.6	0.19
Sacramento River	2	14880	FOR 1-24-1970	125588	315.7	351.6		352.0	0.000363	5.9	25867	1320.7	0.19
Sacramento River	2	13630.*	Q100	158002	314.4	354.7		355.2	0.000344	6.2	31915	1469.2	0.19
Sacramento River	2	13630.*	Q50	143735	314.4	353.2		353.6	0.000350	6.1	29660	1465.0	0.19
Sacramento River	2	13630.*	FOR 1-24-1970	125588	314.4	351.1		351.6	0.000359	5.9	26693	1461.7	0.19
Sacramento River	2	12380.*	Q100	158002	313.1	354.3		354.8	0.000367	6.3	32226	1609.3	0.20
Sacramento River	2	12380.*	Q50	143735	313.1	352.7		353.2	0.000381	6.2	29719	1606.8	0.20
Sacramento River	2	12380.*	FOR 1-24-1970	125588	313.1	350.6		351.1	0.000398	6.1	26426	1591.7	0.20
Sacramento River	2	11130	Q100	132406	311.8	353.9		354.3	0.000297	5.5	31727	1745.1	0.18
Sacramento River	2	11130	Q50	124182	311.8	352.3		352.7	0.000336	5.6	28911	1730.9	0.18
Sacramento River	2	11130	FOR 1-24-1970	112172	311.8	350.2		350.6	0.000391	5.8	25223	1725.4	0.20
Sacramento River	2	9880.*	Q100	132406	311.7	353.2		353.9	0.000407	6.6	24737	1513.5	0.21
Sacramento River	2	9880.*	Q50	124182	311.7	351.6		352.2	0.000443	6.7	22348	1357.4	0.21
Sacramento River	2	9880.*	FOR 1-24-1970	112172	311.7	349.4		350.1	0.000496	6.7	19446	1302.9	0.22
Sacramento River	2	8630.*	Q100	132406	311.6	352.6		353.3	0.000424	7.0	21191	1022.4	0.21
Sacramento River	2	8630.*	Q50	124182	311.6	350.9		351.7	0.000449	7.0	19570	891.9	0.22
Sacramento River	2	8630.*	FOR 1-24-1970	112172	311.6	348.7		349.4	0.000473	6.8	17764	783.2	0.22
Sacramento River	2	7380	Q100	132406	311.5	352.1		352.8	0.000383	6.9	20988	780.2	0.21
Sacramento River	2	7380	Q50	124182	311.5	350.4		351.1	0.000400	6.9	19700	745.5	0.21
Sacramento River	2	7380	FOR 1-24-1970	112172	311.5	348.2		348.9	0.000414	6.7	18097	713.9	0.21
Sacramento River	2	6020.*	Q100	132406	309.4	351.6		352.3	0.000389	7.0	20942	839.3	0.21
Sacramento River	2	6020.*	Q50	124182	309.4	349.9		350.6	0.000405	6.9	19587	763.1	0.21
Sacramento River	2	6020.*	FOR 1-24-1970	112172	309.4	347.6		348.3	0.000420	6.7	17944	717.3	0.21
Sacramento River	2	4660	Q100	132406	307.4	351.0	328.0	351.7	0.000439	7.2	19817	696.5	0.22
Sacramento River	2	4660	Q50	124182	307.4	349.2	327.3	350.0	0.000467	7.2	18600	694.0	0.22
Sacramento River	2	4660	FOR 1-24-1970	112172	307.4	347.0	326.3	347.7	0.000494	7.0	17036	690.7	0.23
Sacramento River	1	4480	Q100	189773	307.8	350.7	335.6	351.6	0.000522	8.9	29525	1242.1	0.26
Sacramento River	1	4480	Q50	171519	307.8	349.0	333.8	349.9	0.000528	8.7	27393	1238.0	0.26
Sacramento River	1	4480	FOR 1-24-1970	149139	307.8	346.8	330.8	347.6	0.000538	8.4	24621	1232.7	0.26
Sacramento River	1	4460		Bridge									
Sacramento River	1	4400	Q100	189773	307.9	350.5		351.5	0.000587	9.5	27685	1213.4	0.27
Sacramento River	1	4400	Q50	171519	307.9	348.7		349.8	0.000596	9.3	25600	1211.1	0.27
Sacramento River	1	4400	FOR 1-24-1970	149139	307.9	346.5		347.5	0.000610	9.0	22880	1208.0	0.27
Sacramento River	1	4305	Q100	189773	307.9	350.4		351.5	0.000593	9.5	27370	1237.6	0.28
Sacramento River	1	4305	Q50	171519	307.9	348.6		349.7	0.000602	9.3	25243	1233.9	0.28
Sacramento River	1	4305	FOR 1-24-1970	149139	307.9	346.4		347.4	0.000615	9.0	22473	1229.5	0.28
Sacramento River	1	4240	Q100	189773	307.4	350.2		351.4	0.000649	10.0	26114	1212.3	0.29
Sacramento River	1	4240	Q50	171519	307.4	348.5		349.6	0.000659	9.8	24027	1209.7	0.29
Sacramento River	1	4240	FOR 1-24-1970	149139	307.4	346.2		347.4	0.000675	9.5	21309	1206.3	0.29
Sacramento River	1	4000	Q100	189773	305.9	349.9		351.2	0.000650	10.1	25207	1149.0	0.29
Sacramento River	1	4000	Q50	171519	305.9	348.2		349.5	0.000652	9.9	23249	1141.4	0.28
Sacramento River	1	4000	FOR 1-24-1970	149139	305.9	346.0		347.2	0.000655	9.5	20718	1130.9	0.28
Sacramento River	1	3500	Q100	189773	305.4	349.7		350.9	0.000604	9.8	28087	1549.7	0.28
Sacramento River	1	3500	Q50	171519	305.4	348.0		349.1	0.000622	9.7	25398	1527.6	0.28
Sacramento River	1	3500	FOR 1-24-1970	149139	305.4	345.7		346.9	0.000646	9.5	21957	1497.1	0.28
Sacramento River	1	2900	Q100	189773	308.6	349.4		350.5	0.000607	9.3	26769	1407.8	0.27
Sacramento River	1	2900	Q50	171519	308.6	347.6		348.8	0.000617	9.1	24358	1372.3	0.27
Sacramento River	1	2900	FOR 1-24-1970	149139	308.6	345.4		346.5	0.000630	8.7	21308	1330.5	0.27
Sacramento River	1	1530	Q100	189773	305.5	348.6		349.7	0.000568	9.2	27236	1252.8	0.27
Sacramento River	1	1530	Q50	171519	305.5	346.9		347.9	0.000565	8.9	25146	1192.9	0.27
Sacramento River	1	1530	FOR 1-24-1970	149139	305.5	344.6		345.6	0.000565	8.5	22520	1144.9	0.26
Sacramento River	1	0	Q100	189773	300.1	347.9	330.4	348.8	0.000500	9.1	29529	1231.8	0.26
Sacramento River	1	0	Q50	171519	300.1	346.2	328.8	347.1	0.000500	8.8	27416	1214.4	0.25
Sacramento River	1	0	FOR 1-24-1970	149139	300.1	343.9	327.2	344.8	0.000500	8.4	24701	1189.5	0.25
North Overflow	6	4.89	Q100	1	338.5	353.0	338.7	353.0	0.000000	0.0	7132	1218.5	0.00
North Overflow	6	4.89	Q50	1	338.5	351.3	338.7	351.3	0.000000	0.0	6111	943.1	0.00
North Overflow	6	4.89	FOR 1-24-1970	1	338.5	349.3	338.7	349.3	0.000000	0.0	4856	662.0	0.00

HEC-RAS Plan: 12-2013_GP (Continued)

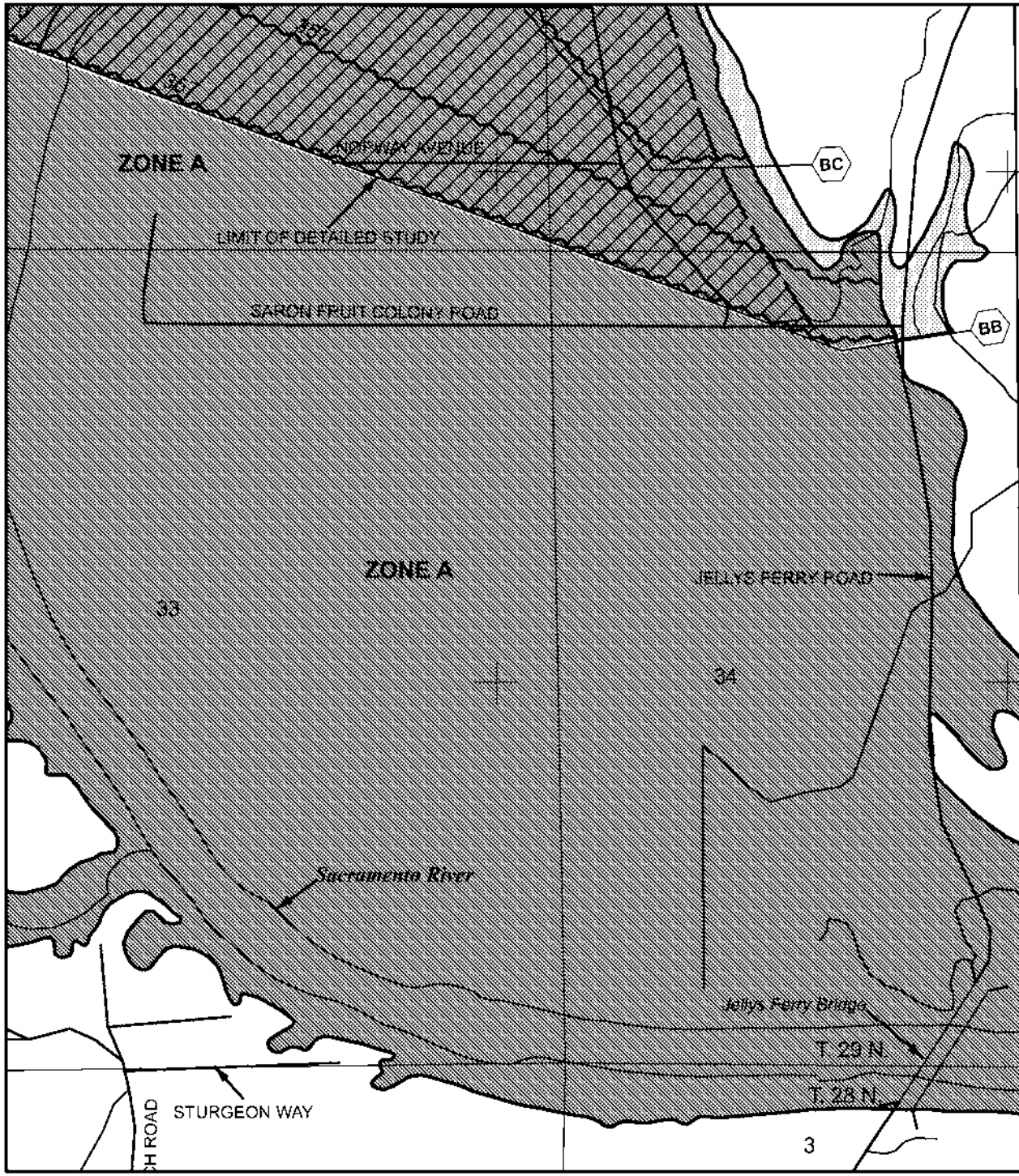
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
North Overflow	6	4.88	Q100	15228	338.5	352.9	343.1	353.0	0.000125	2.2	7081	1204.2	0.11
North Overflow	6	4.88	Q50	11482	338.5	351.3	342.5	351.3	0.000116	1.9	6072	933.0	0.10
North Overflow	6	4.88	FOR 1-24-1970	7862	338.5	349.3	341.9	349.3	0.000112	1.7	4827	660.8	0.10
North Overflow	6	4.79	Q100	15228	338.5	352.9	343.1	352.9	0.000134	2.3	6747	1213.9	0.11
North Overflow	6	4.79	Q50	11482	338.5	351.3	342.6	351.3	0.000123	2.0	5828	932.8	0.11
North Overflow	6	4.79	FOR 1-24-1970	7862	338.5	349.3	341.9	349.3	0.000116	1.7	4692	626.7	0.10
North Overflow	6	4.76		Bridge									
North Overflow	6	4.7	Q100	15228	338.5	352.8	343.0	352.9	0.000134	2.3	6672	1255.1	0.12
North Overflow	6	4.7	Q50	11482	338.5	351.2	342.5	351.3	0.000122	2.0	5790	892.2	0.11
North Overflow	6	4.7	FOR 1-24-1970	7862	338.5	349.2	341.9	349.3	0.000114	1.7	4697	598.9	0.10
North Overflow	6	4.6	Q100	15228	338.6	352.6		352.8	0.000331	3.2	5314	890.9	0.18
North Overflow	6	4.6	Q50	11482	338.6	351.0		351.2	0.000353	3.0	4052	692.7	0.18
North Overflow	6	4.6	FOR 1-24-1970	7862	338.6	349.1		349.2	0.000349	2.7	2970	420.1	0.17
North Overflow	6	4.56666*	Q100	15228	338.0	352.5		352.7	0.000417	3.5	4735	815.9	0.20
North Overflow	6	4.56666*	Q50	11482	338.0	350.9		351.1	0.000418	3.2	3659	556.2	0.19
North Overflow	6	4.56666*	FOR 1-24-1970	7862	338.0	348.9		349.1	0.000409	2.9	2758	371.9	0.18
North Overflow	6	4.53333*	Q100	15228	336.8	352.3		352.5	0.000445	3.6	4522	694.7	0.20
North Overflow	6	4.53333*	Q50	11482	336.8	350.7		350.9	0.000437	3.3	3570	527.0	0.20
North Overflow	6	4.53333*	FOR 1-24-1970	7862	336.8	348.7		348.9	0.000427	2.9	2677	355.8	0.19
North Overflow	6	4.5	Q100	15228	335.6	352.0	344.4	352.3	0.000501	3.8	4302	672.9	0.21
North Overflow	6	4.5	Q50	11482	335.6	350.4	343.6	350.6	0.000501	3.5	3394	513.7	0.21
North Overflow	6	4.5	FOR 1-24-1970	7862	335.6	348.5	342.6	348.6	0.000500	3.1	2506	363.3	0.20
Main Overflow US	4	10.01	Q100	46998	338.1	358.5		358.6	0.000647	3.6	17148	2233.9	0.17
Main Overflow US	4	10.01	Q50	39265	338.1	357.3		357.4	0.000723	3.6	14441	2221.4	0.18
Main Overflow US	4	10.01	FOR 1-24-1970	31412	338.1	355.9		356.1	0.000830	3.6	11452	2207.5	0.19
Main Overflow US	4	10.0	Q100	46998	338.1	358.5		358.6	0.000649	3.6	17133	2233.8	0.17
Main Overflow US	4	10.0	Q50	39265	338.1	357.3		357.4	0.000725	3.6	14423	2221.3	0.18
Main Overflow US	4	10.0	FOR 1-24-1970	31412	338.1	355.9		356.1	0.000833	3.6	11432	2207.4	0.19
Main Overflow US	4	9.0	Q100	46998	336.6	358.0		358.2	0.000858	4.0	13095	1527.9	0.20
Main Overflow US	4	9.0	Q50	39265	336.6	356.7		357.0	0.000930	3.9	11198	1519.8	0.20
Main Overflow US	4	9.0	FOR 1-24-1970	31412	336.6	355.4		355.6	0.000987	3.7	9174	1340.1	0.20
Main Overflow US	4	8.0	Q100	46998	336.2	357.3		357.6	0.000758	4.5	11597	1379.1	0.24
Main Overflow US	4	8.0	Q50	39265	336.2	356.0		356.2	0.000863	4.5	9785	1368.9	0.25
Main Overflow US	4	8.0	FOR 1-24-1970	31412	336.2	354.5		354.8	0.001015	4.3	7821	1276.8	0.26
Main Overflow US	4	7.0	Q100	46998	335.3	356.0		356.6	0.001181	6.1	7946	952.1	0.30
Main Overflow US	4	7.0	Q50	39265	335.3	354.7		355.2	0.001201	5.7	6941	682.4	0.30
Main Overflow US	4	7.0	FOR 1-24-1970	31412	335.3	353.2		353.6	0.001249	5.3	5934	651.2	0.30
Main Overflow US	4	6.0	Q100	46998	331.0	354.4		355.2	0.002344	6.8	6987	786.1	0.37
Main Overflow US	4	6.0	Q50	39265	331.0	353.0		353.7	0.002601	6.6	5941	676.0	0.38
Main Overflow US	4	6.0	FOR 1-24-1970	31412	331.0	351.4		352.0	0.002914	6.4	4889	601.2	0.40
Main Overflow US	4	5.0	Q100	46998	332.6	353.2		353.6	0.000912	4.9	10027	1211.5	0.24
Main Overflow US	4	5.0	Q50	39265	332.6	351.7		352.0	0.001004	4.7	8450	839.1	0.25
Main Overflow US	4	5.0	FOR 1-24-1970	31412	332.6	349.7		350.0	0.001204	4.5	6943	751.2	0.26
Main Overflow US	4	4.99		Lat Struct									
Main Overflow US	4	4.0	Q100	31771	332.9	352.7		352.9	0.000456	4.2	7796	678.5	0.19
Main Overflow US	4	4.0	Q50	27784	332.9	351.0		351.2	0.000531	4.2	6742	591.6	0.21
Main Overflow US	4	4.0	FOR 1-24-1970	23551	332.9	348.8		349.1	0.000695	4.3	5539	542.3	0.23
Main Overflow US	4	3.0	Q100	31771	329.9	352.5		352.8	0.000368	4.4	8533	693.0	0.18
Main Overflow US	4	3.0	Q50	27784	329.9	350.8		351.0	0.000409	4.3	7383	637.1	0.19
Main Overflow US	4	3.0	FOR 1-24-1970	23551	329.9	348.6		348.9	0.000492	4.3	6067	558.9	0.20
Main Overflow DS	3	2.0	Q100	57367	331.0	352.2		352.5	0.000461	4.8	15065	1199.4	0.20
Main Overflow DS	3	2.0	Q50	47337	331.0	350.5		350.8	0.000467	4.6	13058	1139.4	0.20
Main Overflow DS	3	2.0	FOR 1-24-1970	36967	331.0	348.3		348.6	0.000515	4.4	10629	1084.1	0.20
Main Overflow DS	3	1.99		Lat Struct									
Main Overflow DS	3	1.0	Q100	57367	328.9	351.5		352.0	0.000823	6.4	10991	877.4	0.27
Main Overflow DS	3	1.0	Q50	47337	328.9	349.8		350.3	0.000866	6.1	9496	867.1	0.27
Main Overflow DS	3	1.0	FOR 1-24-1970	36967	328.9	347.5		348.0	0.001036	6.1	7521	864.5	0.29

HEC-RAS Plan: 12-2013_GP Backwater Model Summary Output, Preferred Project With Drift

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Sacramento River	2	20410	Q100	205000	324.9	357.2		358.3	0.001046	10.0	26558	1464.8	0.33
Sacramento River	2	20410	Q50	183000	324.9	355.7		356.8	0.001008	9.5	24431	1447.9	0.32
Sacramento River	2	20410	FOR 1-24-1970	157000	324.9	353.8		354.8	0.001022	9.1	21719	1367.0	0.32
Sacramento River	2	18850	Q100	158002	323.7	356.6		357.1	0.000432	6.4	31900	1668.4	0.21
Sacramento River	2	18850	Q50	143735	323.7	355.1		355.6	0.000436	6.2	29409	1661.4	0.21
Sacramento River	2	18850	FOR 1-24-1970	125588	323.7	353.1		353.6	0.000459	6.0	26180	1623.4	0.21
Sacramento River	2	16600	Q100	158002	322.2	355.9		356.2	0.000330	5.6	35573	1659.0	0.18
Sacramento River	2	16600	Q50	143735	322.2	354.3		354.7	0.000342	5.5	33045	1657.3	0.19
Sacramento River	2	16600	FOR 1-24-1970	125588	322.2	352.3		352.7	0.000361	5.3	29711	1655.0	0.19
Sacramento River	2	14880	Q100	158002	315.7	355.1		355.6	0.000355	6.3	30552	1324.0	0.20
Sacramento River	2	14880	Q50	143735	315.7	353.6		354.1	0.000359	6.1	28532	1322.6	0.19
Sacramento River	2	14880	FOR 1-24-1970	125588	315.7	351.6		352.0	0.000362	5.9	25870	1320.7	0.19
Sacramento River	2	13630.*	Q100	158002	314.4	354.7		355.2	0.000344	6.2	31919	1469.2	0.19
Sacramento River	2	13630.*	Q50	143735	314.4	353.2		353.6	0.000350	6.1	29664	1465.0	0.19
Sacramento River	2	13630.*	FOR 1-24-1970	125588	314.4	351.1		351.6	0.000359	5.9	26696	1461.7	0.19
Sacramento River	2	12380.*	Q100	158002	313.1	354.3		354.8	0.000367	6.3	32230	1609.3	0.20
Sacramento River	2	12380.*	Q50	143735	313.1	352.7		353.2	0.000380	6.2	29723	1606.8	0.20
Sacramento River	2	12380.*	FOR 1-24-1970	125588	313.1	350.6		351.1	0.000398	6.1	26430	1591.7	0.20
Sacramento River	2	11130	Q100	132406	311.8	353.9		354.3	0.000297	5.5	31732	1745.1	0.18
Sacramento River	2	11130	Q50	124182	311.8	352.3		352.7	0.000335	5.6	28916	1730.9	0.18
Sacramento River	2	11130	FOR 1-24-1970	112172	311.8	350.2		350.6	0.000391	5.8	25227	1725.4	0.20
Sacramento River	2	9880.*	Q100	132406	311.7	353.2		353.9	0.000406	6.6	24742	1513.5	0.21
Sacramento River	2	9880.*	Q50	124182	311.7	351.6		352.2	0.000443	6.7	22352	1357.5	0.21
Sacramento River	2	9880.*	FOR 1-24-1970	112172	311.7	349.4		350.1	0.000496	6.7	19449	1303.0	0.22
Sacramento River	2	8630.*	Q100	132406	311.6	352.6		353.3	0.000424	7.0	21195	1022.6	0.21
Sacramento River	2	8630.*	Q50	124182	311.6	350.9		351.7	0.000449	7.0	19573	892.3	0.22
Sacramento River	2	8630.*	FOR 1-24-1970	112172	311.6	348.8		349.4	0.000472	6.8	17767	783.2	0.22
Sacramento River	2	7380	Q100	132406	311.5	352.1		352.8	0.000382	6.9	20991	780.3	0.21
Sacramento River	2	7380	Q50	124182	311.5	350.4		351.1	0.000400	6.9	19702	745.6	0.21
Sacramento River	2	7380	FOR 1-24-1970	112172	311.5	348.2		348.9	0.000414	6.7	18099	714.0	0.21
Sacramento River	2	6020.*	Q100	132406	309.4	351.6		352.3	0.000389	7.0	20945	839.6	0.21
Sacramento River	2	6020.*	Q50	124182	309.4	349.9		350.6	0.000405	6.9	19590	763.2	0.21
Sacramento River	2	6020.*	FOR 1-24-1970	112172	309.4	347.6		348.3	0.000420	6.7	17946	717.4	0.21
Sacramento River	2	4660	Q100	132406	307.4	351.0	328.0	351.7	0.000439	7.2	19820	696.5	0.22
Sacramento River	2	4660	Q50	124182	307.4	349.2	327.3	350.0	0.000467	7.2	18603	694.0	0.22
Sacramento River	2	4660	FOR 1-24-1970	112172	307.4	347.0	326.3	347.7	0.000494	7.0	17039	690.7	0.23
Sacramento River	1	4480	Q100	189783	307.8	350.7	335.6	351.6	0.000522	8.9	29530	1242.1	0.26
Sacramento River	1	4480	Q50	171529	307.8	349.0	333.8	349.9	0.000528	8.7	27399	1238.0	0.26
Sacramento River	1	4480	FOR 1-24-1970	149141	307.8	346.8	330.8	347.6	0.000537	8.4	24625	1232.7	0.26
Sacramento River	1	4460		Bridge									
Sacramento River	1	4400	Q100	189783	307.9	350.5		351.5	0.000587	9.5	27687	1213.4	0.27
Sacramento River	1	4400	Q50	171529	307.9	348.7		349.8	0.000596	9.3	25601	1211.1	0.27
Sacramento River	1	4400	FOR 1-24-1970	149141	307.9	346.5		347.5	0.000610	9.0	22880	1208.0	0.27
Sacramento River	1	4305	Q100	189783	307.9	350.4		351.5	0.000593	9.5	27371	1237.6	0.28
Sacramento River	1	4305	Q50	171529	307.9	348.6		349.7	0.000602	9.3	25244	1233.9	0.28
Sacramento River	1	4305	FOR 1-24-1970	149141	307.9	346.4		347.4	0.000615	9.0	22473	1229.5	0.28
Sacramento River	1	4240	Q100	189783	307.4	350.2		351.4	0.000649	10.0	26115	1212.3	0.29
Sacramento River	1	4240	Q50	171529	307.4	348.5		349.6	0.000659	9.8	24028	1209.7	0.29
Sacramento River	1	4240	FOR 1-24-1970	149141	307.4	346.2		347.4	0.000675	9.5	21310	1206.3	0.29
Sacramento River	1	4000	Q100	189783	305.9	349.9		351.2	0.000650	10.1	25208	1149.0	0.29
Sacramento River	1	4000	Q50	171529	305.9	348.2		349.5	0.000652	9.9	23250	1141.4	0.28
Sacramento River	1	4000	FOR 1-24-1970	149141	305.9	346.0		347.2	0.000655	9.5	20718	1130.9	0.28
Sacramento River	1	3500	Q100	189783	305.4	349.7		350.9	0.000604	9.8	28089	1549.7	0.28
Sacramento River	1	3500	Q50	171529	305.4	348.0		349.1	0.000622	9.7	25400	1527.6	0.28
Sacramento River	1	3500	FOR 1-24-1970	149141	305.4	345.7		346.9	0.000646	9.5	21957	1497.1	0.28
Sacramento River	1	2900	Q100	189783	308.6	349.4		350.5	0.000607	9.3	26770	1407.8	0.27
Sacramento River	1	2900	Q50	171529	308.6	347.6		348.8	0.000617	9.1	24360	1372.3	0.27
Sacramento River	1	2900	FOR 1-24-1970	149141	308.6	345.4		346.5	0.000630	8.7	21309	1330.5	0.27
Sacramento River	1	1530	Q100	189783	305.5	348.6		349.7	0.000568	9.2	27237	1252.9	0.27
Sacramento River	1	1530	Q50	171529	305.5	346.9		347.9	0.000565	8.9	25148	1192.9	0.27
Sacramento River	1	1530	FOR 1-24-1970	149141	305.5	344.6		345.6	0.000565	8.5	22520	1144.9	0.26
Sacramento River	1	0	Q100	189783	300.1	347.9	330.4	348.8	0.000500	9.1	29531	1231.8	0.26
Sacramento River	1	0	Q50	171529	300.1	346.2	328.7	347.1	0.000500	8.8	27418	1214.4	0.25
Sacramento River	1	0	FOR 1-24-1970	149141	300.1	343.9	327.2	344.8	0.000500	8.4	24702	1189.5	0.25
North Overflow	6	4.89	Q100	1	338.5	353.0	338.7	353.0	0.000000	0.0	7135	1219.1	0.00
North Overflow	6	4.89	Q50	1	338.5	351.3	338.7	351.3	0.000000	0.0	6112	943.4	0.00
North Overflow	6	4.89	FOR 1-24-1970	1	338.5	349.3	338.7	349.3	0.000000	0.0	4858	662.1	0.00

HEC-RAS Plan: 12-2013_GP (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
North Overflow	6	4.88	Q100	15218	338.5	352.9	343.1	353.0	0.000125	2.2	7084	1204.8	0.11
North Overflow	6	4.88	Q50	11472	338.5	351.3	342.5	351.3	0.000116	1.9	6073	933.3	0.10
North Overflow	6	4.88	FOR 1-24-1970	7860	338.5	349.3	341.9	349.3	0.000112	1.7	4829	660.9	0.10
North Overflow	6	4.79	Q100	15218	338.5	352.9	343.1	352.9	0.000133	2.3	6749	1214.4	0.11
North Overflow	6	4.79	Q50	11472	338.5	351.3	342.5	351.3	0.000122	2.0	5829	933.2	0.11
North Overflow	6	4.79	FOR 1-24-1970	7860	338.5	349.3	341.9	349.3	0.000116	1.7	4694	626.8	0.10
North Overflow	6	4.76		Bridge									
North Overflow	6	4.7	Q100	15218	338.5	352.8	343.0	352.9	0.000134	2.3	6670	1254.7	0.12
North Overflow	6	4.7	Q50	11472	338.5	351.2	342.5	351.3	0.000122	2.0	5787	890.9	0.11
North Overflow	6	4.7	FOR 1-24-1970	7860	338.5	349.2	341.9	349.3	0.000114	1.7	4696	598.9	0.10
North Overflow	6	4.6	Q100	15218	338.6	352.6		352.8	0.000331	3.2	5311	890.4	0.18
North Overflow	6	4.6	Q50	11472	338.6	351.0		351.2	0.000353	3.0	4048	692.1	0.18
North Overflow	6	4.6	FOR 1-24-1970	7860	338.6	349.1		349.2	0.000349	2.7	2970	420.0	0.17
North Overflow	6	4.56666*	Q100	15218	338.0	352.5		352.7	0.000417	3.5	4732	815.2	0.20
North Overflow	6	4.56666*	Q50	11472	338.0	350.9		351.1	0.000418	3.2	3657	555.6	0.19
North Overflow	6	4.56666*	FOR 1-24-1970	7860	338.0	348.9		349.1	0.000409	2.9	2758	371.9	0.18
North Overflow	6	4.53333*	Q100	15218	336.8	352.3		352.5	0.000445	3.6	4519	694.1	0.20
North Overflow	6	4.53333*	Q50	11472	336.8	350.7		350.9	0.000437	3.3	3568	526.6	0.20
North Overflow	6	4.53333*	FOR 1-24-1970	7860	336.8	348.7		348.9	0.000427	2.9	2677	355.7	0.19
North Overflow	6	4.5	Q100	15218	335.6	352.0	344.4	352.3	0.000501	3.8	4300	672.0	0.21
North Overflow	6	4.5	Q50	11472	335.6	350.4	343.6	350.6	0.000501	3.5	3392	513.5	0.21
North Overflow	6	4.5	FOR 1-24-1970	7860	335.6	348.5	342.6	348.6	0.000500	3.1	2505	363.0	0.20
Main Overflow US	4	10.01	Q100	46998	338.1	358.5		358.6	0.000647	3.6	17150	2233.9	0.17
Main Overflow US	4	10.01	Q50	39265	338.1	357.3		357.4	0.000722	3.6	14442	2221.4	0.18
Main Overflow US	4	10.01	FOR 1-24-1970	31412	338.1	355.9		356.1	0.000830	3.6	11453	2207.5	0.19
Main Overflow US	4	10.0	Q100	46998	338.1	358.5		358.6	0.000649	3.6	17134	2233.8	0.17
Main Overflow US	4	10.0	Q50	39265	338.1	357.3		357.4	0.000725	3.6	14424	2221.3	0.18
Main Overflow US	4	10.0	FOR 1-24-1970	31412	338.1	355.9		356.1	0.000833	3.6	11433	2207.4	0.19
Main Overflow US	4	9.0	Q100	46998	336.6	358.0		358.2	0.000858	4.0	13096	1527.9	0.20
Main Overflow US	4	9.0	Q50	39265	336.6	356.7		357.0	0.000930	3.9	11199	1519.8	0.20
Main Overflow US	4	9.0	FOR 1-24-1970	31412	336.6	355.4		355.6	0.000987	3.7	9175	1340.2	0.20
Main Overflow US	4	8.0	Q100	46998	336.2	357.3		357.6	0.000757	4.5	11598	1379.1	0.24
Main Overflow US	4	8.0	Q50	39265	336.2	356.0		356.2	0.000862	4.5	9786	1368.9	0.25
Main Overflow US	4	8.0	FOR 1-24-1970	31412	336.2	354.5		354.8	0.001014	4.3	7822	1276.8	0.26
Main Overflow US	4	7.0	Q100	46998	335.3	356.0		356.6	0.001180	6.1	7947	952.5	0.30
Main Overflow US	4	7.0	Q50	39265	335.3	354.7		355.2	0.001200	5.7	6942	682.4	0.30
Main Overflow US	4	7.0	FOR 1-24-1970	31412	335.3	353.2		353.6	0.001249	5.3	5934	651.2	0.30
Main Overflow US	4	6.0	Q100	46998	331.0	354.4		355.2	0.002342	6.8	6989	786.3	0.37
Main Overflow US	4	6.0	Q50	39265	331.0	353.0		353.7	0.002599	6.6	5943	676.1	0.38
Main Overflow US	4	6.0	FOR 1-24-1970	31412	331.0	351.4		352.0	0.002914	6.4	4890	601.2	0.40
Main Overflow US	4	5.0	Q100	46998	332.6	353.3		353.6	0.000911	4.9	10031	1213.1	0.24
Main Overflow US	4	5.0	Q50	39265	332.6	351.7		352.0	0.001003	4.7	8453	839.3	0.25
Main Overflow US	4	5.0	FOR 1-24-1970	31412	332.6	349.7		350.1	0.001203	4.5	6944	751.2	0.26
Main Overflow US	4	4.99		Lat Struct									
Main Overflow US	4	4.0	Q100	31781	332.9	352.7		352.9	0.000456	4.2	7799	678.8	0.19
Main Overflow US	4	4.0	Q50	27794	332.9	351.0		351.2	0.000531	4.2	6744	591.6	0.21
Main Overflow US	4	4.0	FOR 1-24-1970	23553	332.9	348.9		349.1	0.000694	4.3	5540	542.4	0.23
Main Overflow US	4	3.0	Q100	31781	329.9	352.5		352.8	0.000368	4.4	8536	693.0	0.18
Main Overflow US	4	3.0	Q50	27794	329.9	350.8		351.0	0.000409	4.3	7385	637.1	0.19
Main Overflow US	4	3.0	FOR 1-24-1970	23553	329.9	348.6		348.9	0.000492	4.3	6068	559.0	0.20
Main Overflow DS	3	2.0	Q100	57377	331.0	352.2		352.5	0.000460	4.8	15069	1199.4	0.20
Main Overflow DS	3	2.0	Q50	47347	331.0	350.5		350.8	0.000467	4.6	13062	1139.5	0.20
Main Overflow DS	3	2.0	FOR 1-24-1970	36969	331.0	348.3		348.6	0.000515	4.4	10633	1084.1	0.20
Main Overflow DS	3	1.99		Lat Struct									
Main Overflow DS	3	1.0	Q100	57377	328.9	351.5		352.0	0.000823	6.4	10994	877.5	0.27
Main Overflow DS	3	1.0	Q50	47347	328.9	349.8		350.3	0.000866	6.1	9499	867.1	0.27
Main Overflow DS	3	1.0	FOR 1-24-1970	36969	328.9	347.5		348.0	0.001034	6.1	7524	864.5	0.29



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0430H

FIRM

FLOOD INSURANCE RATE MAP

TEHAMA COUNTY, CALIFORNIA

AND INCORPORATED AREAS

PANEL 430 OF 1775

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
TEHAMA COUNTY	065064	0430	H

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
06103C0430H

EFFECTIVE DATE
SEPTEMBER 29, 2011

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

APPENDIX C

Scour Calculations

Potential Pier Scour Using CSU Equation, 100 - Year flood
Jellys Ferry Road over Sacramento River Piers 2 & 3, January 2, 2014

Ys = Depth of potential scour, Ft.

K1 = 1.0 Nose shape coefficient, round

Theta = 0 Angle between direction of flow and pier, degrees

Length of pier = 9.0 Ft

K2 = 1.00 Angle coefficient

K3 = 1.1 Bed condition coefficient

a = Pier Width, assume 9.0 Ft

Y1 = 43.5 Ft, Maximum depth expected in front of pier, 100 - Year flood.

V1 = 9.5 FPS, Maximum velocity in front of pier, 100 - Year flood.

Fr1 = Froude Number in front of pier

Fr1 = V1/[(g x Y1)^(1/2)] = 0.254

Ys/Y1 = 2.0 x K1 x K2 x K3 x [(a/Y1)^0.65] x Fr1^0.43 = 0.44

Ys = Y1 x (Ys/Y1) = 19.1 Ft.

Potential Pier Scour Using CSU Equation, 100 - Year flood
Jellys Ferry Road over Sacramento River Piers 4, 5, & 6, January 2, 2014

Ys = Depth of potential scour, Ft.

K1 = 1.0 Nose shape coefficient, round

Theta = 0 Angle between direction of flow and pier, degrees

Length of pier = 6.0 Ft

K2 = 1.00 Angle coefficient

K3 = 1.1 Bed condition coefficient

a = Pier Width, assume 6.0 Ft

Y1 = 43.5 Ft, Maximum depth expected in front of pier, 100 - Year flood.

V1 = 9.5 FPS, Maximum velocity in front of pier, 100 - Year flood.

Fr1 = Froude Number in front of pier

Fr1 = V1/[(g x Y1)^(1/2)] = 0.254

Ys/Y1 = 2.0 x K1 x K2 x K3 x [(a/Y1)^0.65] x Fr1^0.43 = 0.34

Ys = Y1 x (Ys/Y1) = 14.6 Ft.

NOTE: For Fr1 values less than 0.8 the value of Ys/a is not recommended to exceed 2.4.

Ys = 2.4 x a = 14.4 Ft.

Potential Pier Scour Using CSU Equation, 100 - Year flood
Jellys Ferry Road over North Overflow Channel, January 2, 2014

Ys = Depth of potential scour, Ft.

K1 = 1.0 Nose shape coefficient, round

Theta = 0 Angle between direction of flow and pier, degrees

Length of pier = 30.0 Ft

K2 = 1.00 Angle coefficient

K3 = 1.1 Bed condition coefficient

a = Pier Width, assume 4.0 Ft

Y1 = 14.0 Ft, Maximum depth expected in front of pier, 100 - Year flood.

V1 = 3.0 FPS, Maximum velocity in front of pier, 100 - Year flood.

Fr1 = Froude Number in front of pier

Fr1 = V1/[(g x Y1)^(1/2)] = 0.141

Ys/Y1 = 2.0 x K1 x K2 x K3 x [(a/Y1)^0.65] x Fr1^0.43 = 0.42

Ys = Y1 x (Ys/Y1) = 5.9 Ft.

6.3 LIVE-BED CONTRACTION SCOUR JELLYS FERRY RD, SAC R. CHANNEL

A modified version of Laursen's 1960 equation for live-bed scour at a long contraction is recommended to predict the depth of scour in a contracted section (Laursen 1960). The original equation is given in Appendix C. The modification is to eliminate the ratio of Manning n (see the following Note #3). The equation assumes that bed material is being transported from the upstream section.

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1} = 1^{6/7}\left(\frac{500}{450}\right)^{0.59} = 1.064 \quad y_2 = (44)(1.064) = 46.8' \qquad (6.2)$$

$$y_s = 46.8 - 44 = 2.8'$$

$y_s = y_2 - y_o$ = (average contraction scour depth) (6.3)

UPPER LIMIT $= 44\left(\frac{500}{450}\right) - 44 = 4.9' > 2.8 \therefore$ OK

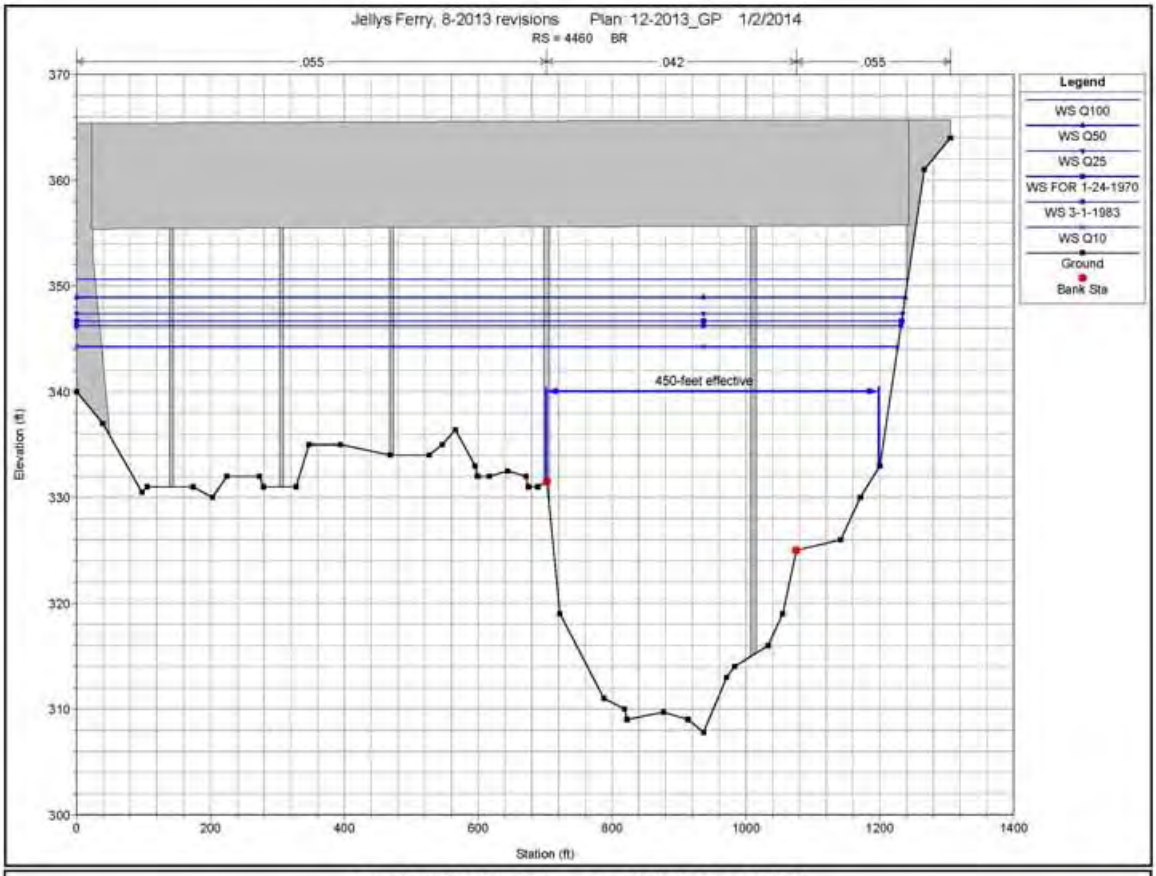
where:

- y_1 = Average depth in the upstream main channel, ft (m) 44'
- y_2 = Average depth in the contracted section, ft (m)
- y_o = Existing depth in the contracted section before scour, ft (m) (see Note 7) 44' *
- Q_1 = Flow in the upstream channel transporting sediment, ft^3/s (m^3/s) 124,500
- Q_2 = Flow in the contracted channel, ft^3/s (m^3/s) 124,500
- W_1 = Bottom width of the upstream main channel that is transporting bed material, ft (m) 500'
- W_2 = Bottom width of main channel in contracted section less pier width(s), ft (m) 450'
- k_1 = Exponent determined below

V_*/ω	k_1	Mode of Bed Material Transport
<0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material discharge
>2.0	0.69	Mostly suspended bed material discharge

- V_* = $(\tau_o/\rho)^{1/2} = (gy_1 S_1)^{1/2}$, shear velocity in the upstream section, ft/s (m/s)
- ω = Fall velocity of bed material based on the D_{50}, m/s (Figure 6.8)
  For fall velocity in English units (ft/s) multiply ω in m/s by 3.28
- g = Acceleration of gravity (32.2 ft/s^2) (9.81 m/s^2)
- S_1 = Slope of energy grade line of main channel, ft/ft (m/m)
- τ_o = Shear stress on the bed, (lb/ft^2) (Pa (N/m^2))
- ρ = Density of water (1.94 $slugs/ft^3$) (1000 kg/m^3)

Notes: * y_1 USED. USE OF EX DEPTH IN "CONTRACTED" CHANNEL MAY DOUBLE ACCOUNT FOR CONTRACTION SCOUR.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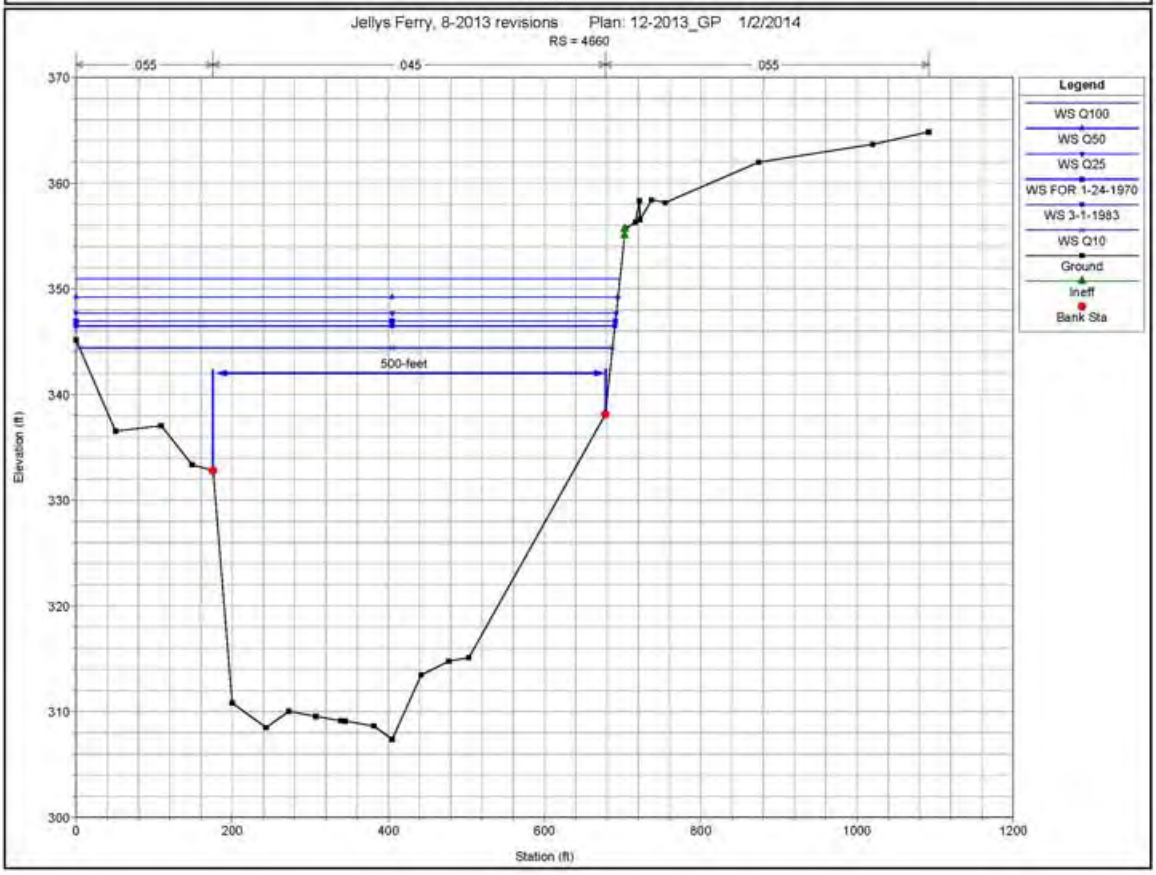
.055
.042
.055
450-feet effective
Legend
WS Q100
WS Q50
WS Q25
WS FOR 1-24-1970
WS 3-1-1983
WS Q10
Ground
Bank Sta
Elevation (ft)
Station (ft)


Jellys Ferry, 8-2013 revisions Plan: 12-2013_GP 1/2/2014
RS = 4660
.055
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.055
500-feet
Legend
WS Q100
WS Q50
WS Q25
WS FOR 1-24-1970
WS 3-1-1983
WS Q10
Ground
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Bank Sta
Elevation (ft)
Station (ft)

6.3 LIVE-BED CONTRACTION SCOUR JELLYS FERRY RD, SAC R. LEFT O.B.

A modified version of Laursen's 1960 equation for live-bed scour at a long contraction is recommended to predict the depth of scour in a contracted section (Laursen 1960). The original equation is given in Appendix C. The modification is to eliminate the ratio of Manning n (see the following Note #3). The equation assumes that bed material is being transported from the upstream section.

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{k_1} = \left(\frac{50900}{49400}\right)^{6/7}\left(\frac{702}{634}\right)^{0.69} = 1.101 \qquad (6.2)$$

$y_2 = (1.101)(17.5) = 19.3'$

$y_s = 19.3 - 17.5 = 1.8'$

$y_s = y_2 - y_o$ = (average contraction scour depth) (6.3)

where: UPPER LIMIT $= 17.5\left(\frac{702}{634}\right) - 17.5 = 1.9' > 1.8 \therefore$ O.K.

- y_1 = Average depth in the upstream main channel, ft (m) 17.5'
- y_2 = Average depth in the contracted section, ft (m)
- y_o = Existing depth in the contracted section before scour, ft (m) (see Note 7) 17.5'
- Q_1 = Flow in the upstream channel transporting sediment, ft³/s (m³/s) 50,900
- Q_2 = Flow in the contracted channel, ft³/s (m³/s) 49,400
- W_1* = Bottom width of the upstream main channel that is transporting bed material, ft (m) 702'
- W_2* = Bottom width of main channel in contracted section less pier width(s), ft (m) 634'
- k_1 = Exponent determined below

V_*/ω	k_1	Mode of Bed Material Transport
<0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material discharge
>2.0	0.69	Mostly suspended bed material discharge

- V_* = $(\tau_o/\rho)^{1/2} = (gy_1 S_1)^{1/2}$, shear velocity in the upstream section, ft/s (m/s)
- ω = Fall velocity of bed material based on the D_{50}, m/s (Figure 6.8)
  For fall velocity in English units (ft/s) multiply ω in m/s by 3.28
- g = Acceleration of gravity (32.2 ft/s²) (9.81 m/s²)
- S_1 = Slope of energy grade line of main channel, ft/ft (m/m)
- τ_o = Shear stress on the bed, (lb/ft²) (Pa (N/m²))
- ρ = Density of water (1.94 slugs/ft³) (1000 kg/m³)

Notes: * FLOW AREA DIVIDED BY HYDRAULIC RADIUS OF LEFT OVERBANK FLOODPLAIN

Plan: 12-2013_GP Sacramento River 1 RS: 4460 BR U Profile: Q100

E.G. Elev (ft)	351.60	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.96	Wt. n-Val.	0.055	0.042	0.055
W.S. Elev (ft)	350.64	Reach Len. (ft)	40.00	40.00	40.00
Crit W.S. (ft)	335.88	Flow Area (sq ft)	11387.42	13488.19	3257.90
E.G. Slope (ft/ft)	0.000732	Area (sq ft)	11387.42	13488.19	3257.90
Q Total (cfs)	189772.90	Flow (cfs)	49451.82	123225.70	17095.38
Top Width (ft)	1176.32	Top Width (ft)	651.90	359.65	164.77
Vel Total (ft/s)	6.75	Avg. Vel. (ft/s)	4.34	9.14	5.25
Max Chl Dpth (ft)	42.84	Hydr. Depth (ft)	17.47	37.50	19.77
Conv. Total (cfs)	7013461.0	Conv. (cfs)	1827597.0	4554069.0	631795.9
Length Wtd. (ft)	40.00	Wetted Per. (ft)	789.01	457.51	169.41
Min Ch El (ft)	307.80	Shear (lb/sq ft)	0.66	1.35	0.88
Alpha	1.35	Stream Power (lb/ft s)	1305.42	0.00	0.00
Frctn Loss (ft)	0.03	Cum Volume (acre-ft)	978.78	1593.40	228.59
C & E Loss (ft)	0.03	Cum SA (acres)	75.69	42.60	15.14

Effective Width = 11387/17.47 = 652'. Less piers, 634'.

Plan: 12-2013_GP Sacramento River 1 RS: 4480 Profile: Q100

E.G. Elev (ft)	351.62	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.91	Wt. n-Val.	0.055	0.042	0.055
W.S. Elev (ft)	350.72	Reach Len. (ft)	20.00	20.00	20.00
Crit W.S. (ft)	335.63	Flow Area (sq ft)	12335.09	13918.42	3271.19
E.G. Slope (ft/ft)	0.000522	Area (sq ft)	12335.09	13918.42	3271.19
Q Total (cfs)	189772.90	Flow (cfs)	50863.95	124451.60	14457.37
Top Width (ft)	1242.07	Top Width (ft)	702.54	372.69	166.84
Vel Total (ft/s)	6.43	Avg. Vel. (ft/s)	4.12	8.94	4.42
Max Chl Dpth (ft)	42.92	Hydr. Depth (ft)	17.56	37.35	19.61
Conv. Total (cfs)	8302307.0	Conv. (cfs)	2225229.0	5444589.0	632490.3
Length Wtd. (ft)	20.00	Wetted Per. (ft)	714.90	378.57	170.86
Min Ch El (ft)	307.80	Shear (lb/sq ft)	0.56	1.20	0.62
Alpha	1.42	Stream Power (lb/ft s)	1305.42	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	984.22	1599.69	230.09
C & E Loss (ft)	0.01	Cum SA (acres)	76.00	42.77	15.22

Effective Width = 12335/17.56 = 702'.

Abutment Scour: EFFECTIVE WIDTH = 12335/17.56 = 702'

$q_1 = 50864/702 = 72.5$ CFS/FT

$q_{2c} = 49452/634 = 78.0$ CFS/FT

$\frac{q_{2c}}{q_1} = \frac{78}{72.5} = 1.076$

$Y_{MAX}/Y_c = 1.55$

$Y_c = 1.8'$ FROM CONTRACTION SCOUR CALC.

$Y_{MAX} = (1.55)(1.8) = 2.8'$

COMPLEX HYDRAULICS AT SITE ∴ DESIGN FOR 5' BELOW ELEVATION OF PROXIMATE FLOODPLAIN & INSPECT ON REGULAR SCHEDULE & AFTER LARGE EVENTS

6.3 LIVE-BED CONTRACTION SCOUR JELLYS FERRY RD, NORTH OVERFLOW

A modified version of Laursen's 1960 equation for live-bed scour at a long contraction is recommended to predict the depth of scour in a contracted section (Laursen 1960). The original equation is given in Appendix C. The modification is to eliminate the ratio of Manning n (see the following Note #3). The equation assumes that bed material is being transported from the upstream section.

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{k_1} = 1^{6/7}\left(\frac{572}{482}\right)^{0.69} = 1.125 \qquad y_2 = 14.4(1.125) = 16.2' \qquad (6.2)$$

$$y_s = 16.2 - 14.4 = 1.8'$$

$y_s = y_2 - y_o$ = (average contraction scour depth) (6.3)

where: UPPER LIMIT $= 14.4\left(\frac{572}{482}\right) - 14.4 = 2.7' > 1.8 \therefore$ O.K.

- y_1 = Average depth in the upstream main channel, ft (m) 14.4'
- y_2 = Average depth in the contracted section, ft (m)
- y_o = Existing depth in the contracted section before scour, ft (m) (see Note 7) 14.4'
- Q_1 = Flow in the upstream channel transporting sediment, ft^3/s (m^3/s) 15,200
- Q_2 = Flow in the contracted channel, ft^3/s (m^3/s) 15,200
- W_1* = Bottom width of the upstream main channel that is transporting bed material, ft (m) 572'
- W_2* = Bottom width of main channel in contracted section less pier width(s), ft (m) 482'
- k_1 = Exponent determined below

V_*/ω	k_1	Mode of Bed Material Transport
<0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material discharge
>2.0	0.69	Mostly suspended bed material discharge

- V_* = $(\tau_o/\rho)^{1/2} = (gy_1 S_1)^{1/2}$, shear velocity in the upstream section, ft/s (m/s)
- ω = Fall velocity of bed material based on the D_{50}, m/s (Figure 6.8)
  For fall velocity in English units (ft/s) multiply ω in m/s by 3.28
- g = Acceleration of gravity (32.2 ft/s^2) (9.81 m/s^2)
- S_1 = Slope of energy grade line of main channel, ft/ft (m/m)
- τ_o = Shear stress on the bed, (lb/ft^2) (Pa (N/m^2))
- ρ = Density of water (1.94 $slugs/ft^3$) (1000 kg/m^3)

Notes: * FLOW AREA DIVIDED BY HYDRAULIC RADIUS/DEPTH

HEC-RAS Plan: 12-2013_GP River: North Overflow Reach: 6 Profile: Q100

Reach	River Sta	Profile	Q Total	Flow Area	Hydr Radius	Vel Total	Top Width	Top Width Act
			(cfs)	(sq ft)	(ft)	(ft/s)	(ft)	(ft)
6	4.89	Q100	1	7132	11.4	0.0	1218	625
6	4.88	Q100	15228	7081	11.3	2.2	1204	625
6	4.79	Q100	15228	6747	11.8	2.3	1214	570
6	4.76		Bridge					
6	4.7	Q100	15228	6672	12.1	2.3	1255	550
6	4.6	Q100	15228	5314	5.9	2.9	891	891
6	4.56666*	Q100	15228	4735	5.8	3.2	816	816
6	4.53333*	Q100	15228	4522	6.5	3.4	695	695
6	4.5	Q100	15228	4302	6.4	3.5	673	673

Effective Width = 6747/11.8 = 572'

Plan: 12-2013_GP North Overflow 6 RS: 4.76 Profile: Q100

E.G. US. (ft)	352.94	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	352.86	E.G. Elev (ft)	352.93	352.92
Q Total (cfs)	15228.06	W.S. Elev (ft)	352.83	352.82
Q Bridge (cfs)	15228.06	Crit W.S. (ft)	343.24	343.15
Q Weir (cfs)		Max Chl Dpth (ft)	14.33	14.32
Weir Sta Lft (ft)		Vel Total (ft/s)	2.57	2.53
Weir Sta Rgt (ft)		Flow Area (sq ft)	5925.79	6008.36
Weir Submerg		Froude # Chl	0.13	0.13
Weir Max Depth (ft)		Specif Force (cu ft)	38765.65	39600.48
Min El Weir Flow (ft)	356.77	Hydr Depth (ft)	12.29	12.46
Min El Prs (ft)	355.07	W.P. Total (ft)	742.46	749.89
Delta EG (ft)	0.04	Conv. Total (cfs)	881595.9	893707.6
Delta WS (ft)	0.04	Top Width (ft)	482.07	482.07
BR Open Area (sq ft)	6930.36	Frctn Loss (ft)	0.02	0.01
BR Open Vel (ft/s)	2.57	C & E Loss (ft)	0.00	0.01
Coef of Q		Shear Total (lb/sq ft)	0.15	0.15
Br Sel Method	Energy only	Power Total (lb/ft s)	-495.00	-495.00

Effective Width = 5926/12.29 = 482'

North Overflow Abutment Scour:

$$q_{2c} = \frac{15228}{482} = 31.6 \text{ CFS/FT}$$

$$q_1 = \frac{15228}{572} = 26.6 \text{ CFS/FT}$$

$$\frac{q_{2c}}{q_1} = \frac{31.6}{26.6} = 1.19$$

$$Y_{MAX}/Y_c = 1.65$$

$Y_c = 1.8'$ FROM CONTRACTION SCOUR CALC.

$$Y_{MAX} = (1.65)(1.8) = 3.0'$$

COMPLEX HYDRAULICS AT SITE ∴ DESIGN FOR 5' BELOW BOTTOM OF CHANNEL & INSPECT ON REGULAR SCHEDULE & AFTER LARGE FLOOD EVENTS

APPENDIX D

References

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APPENDIX E

2D Flow Model Report