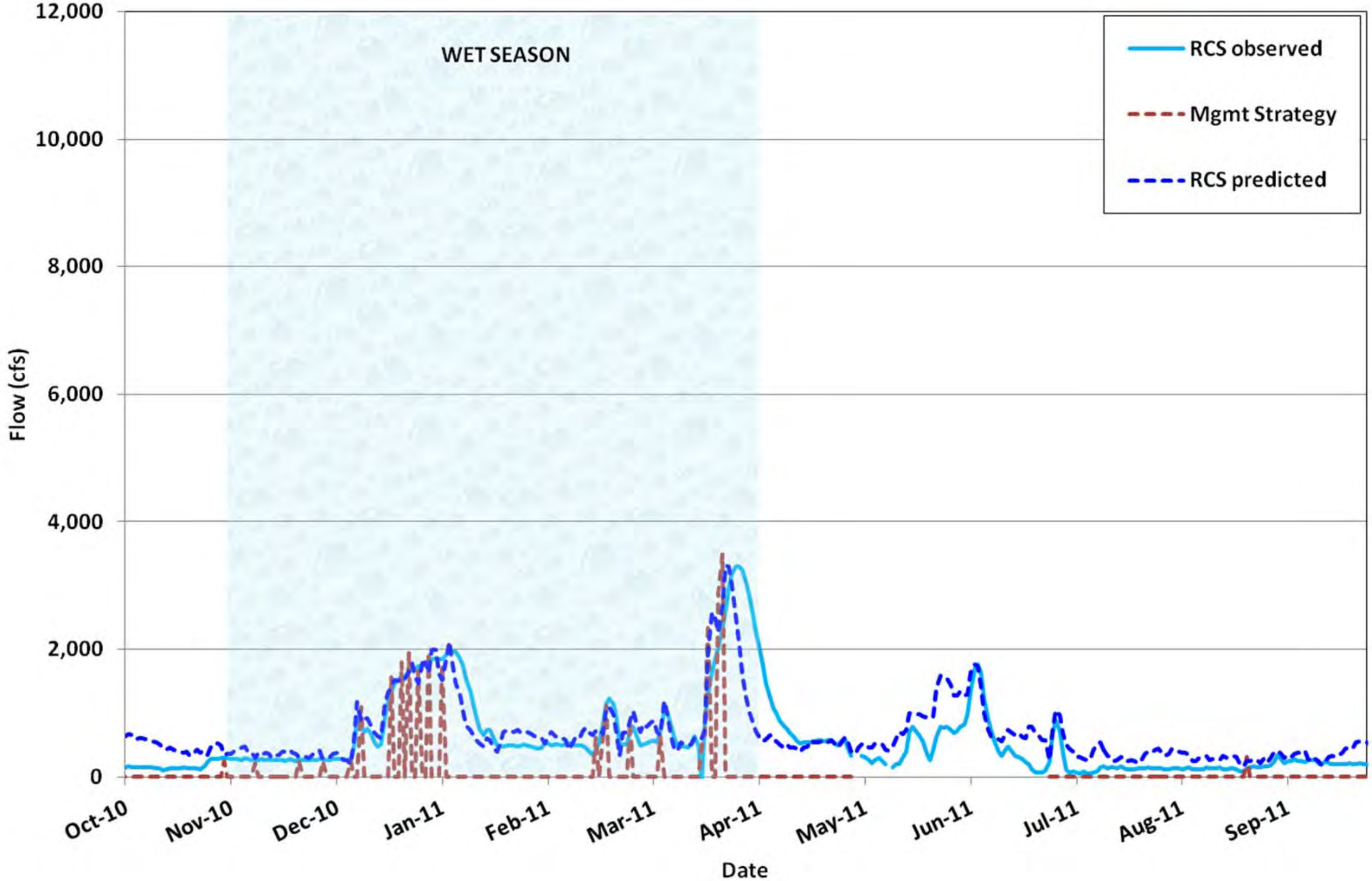
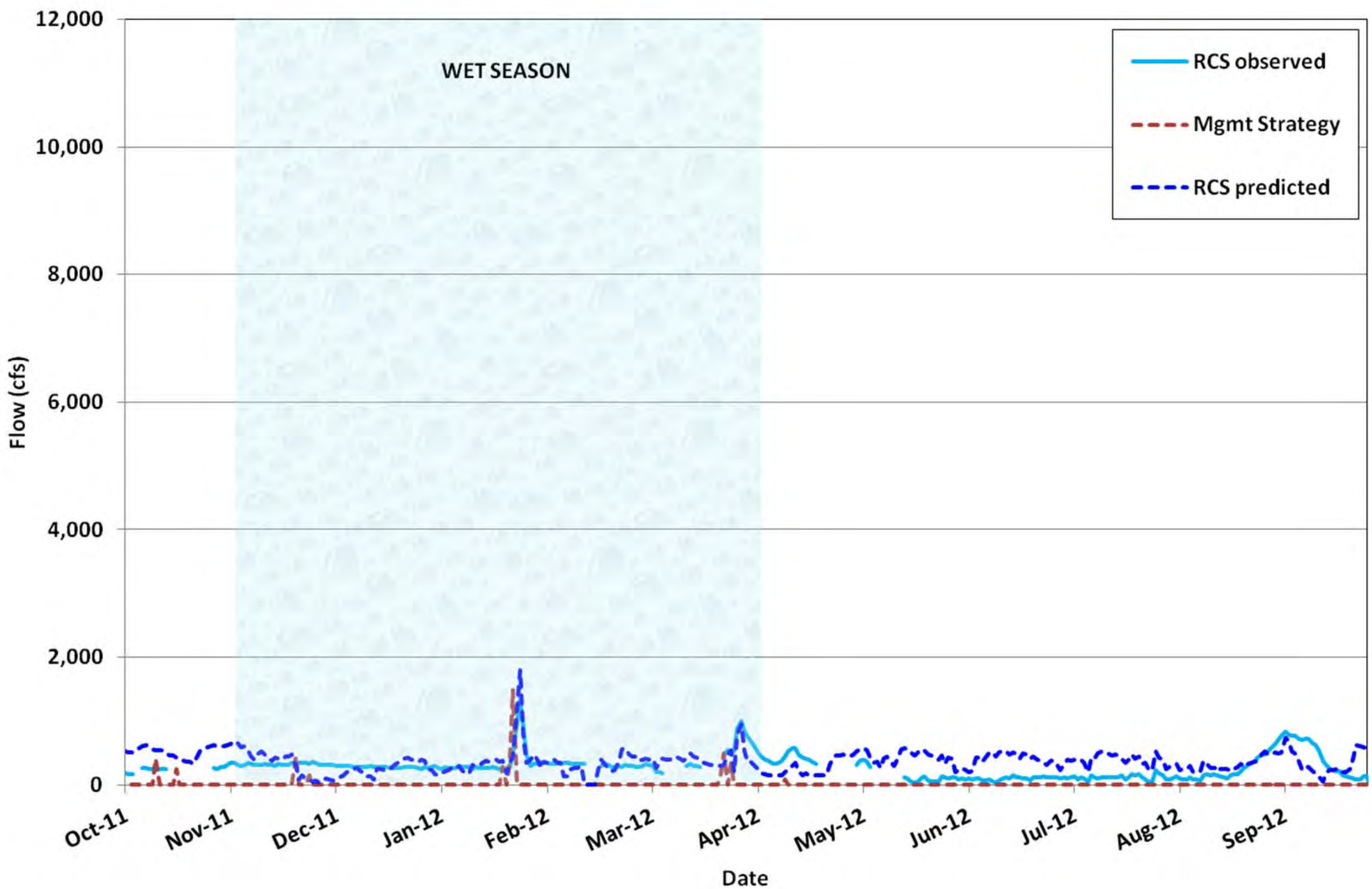


Notes:	HDR cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **KLRC Inflow Validation – WY2011**		
		Prepared for DWR	Created By: SP	**Figure 4-16**



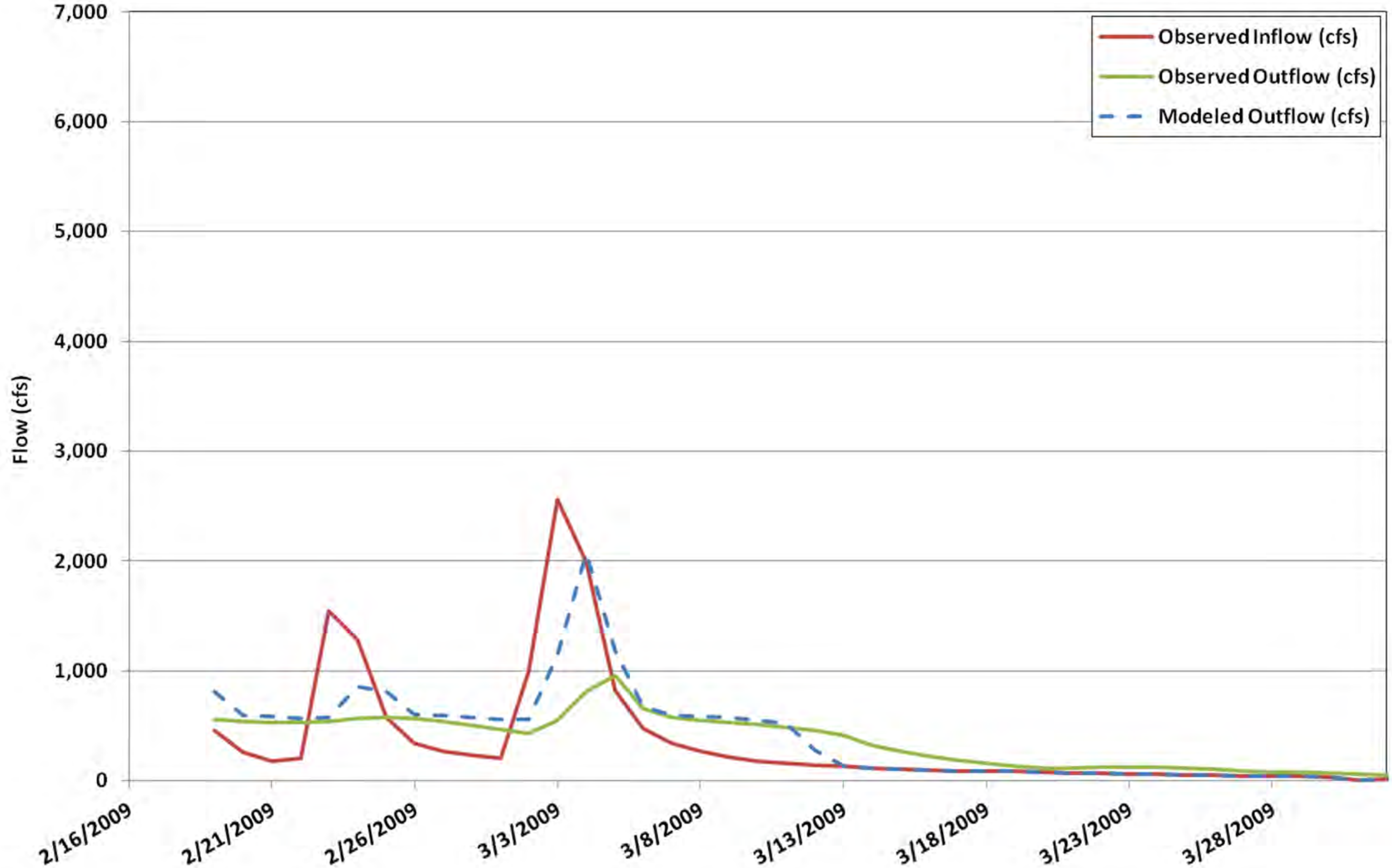
Notes:

HDR cbec eco engineering

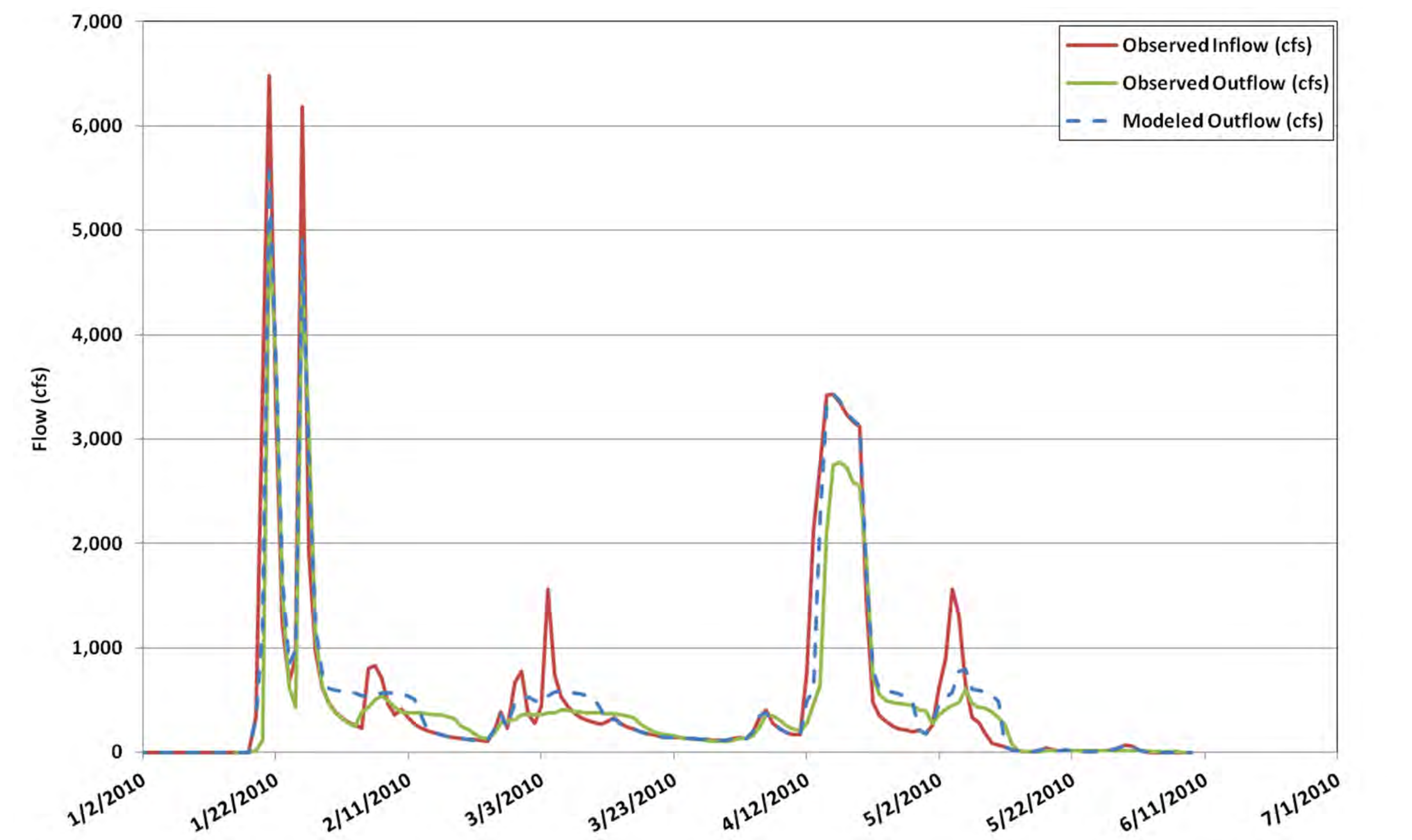
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

KLRC Inflow Validation – WY 2012

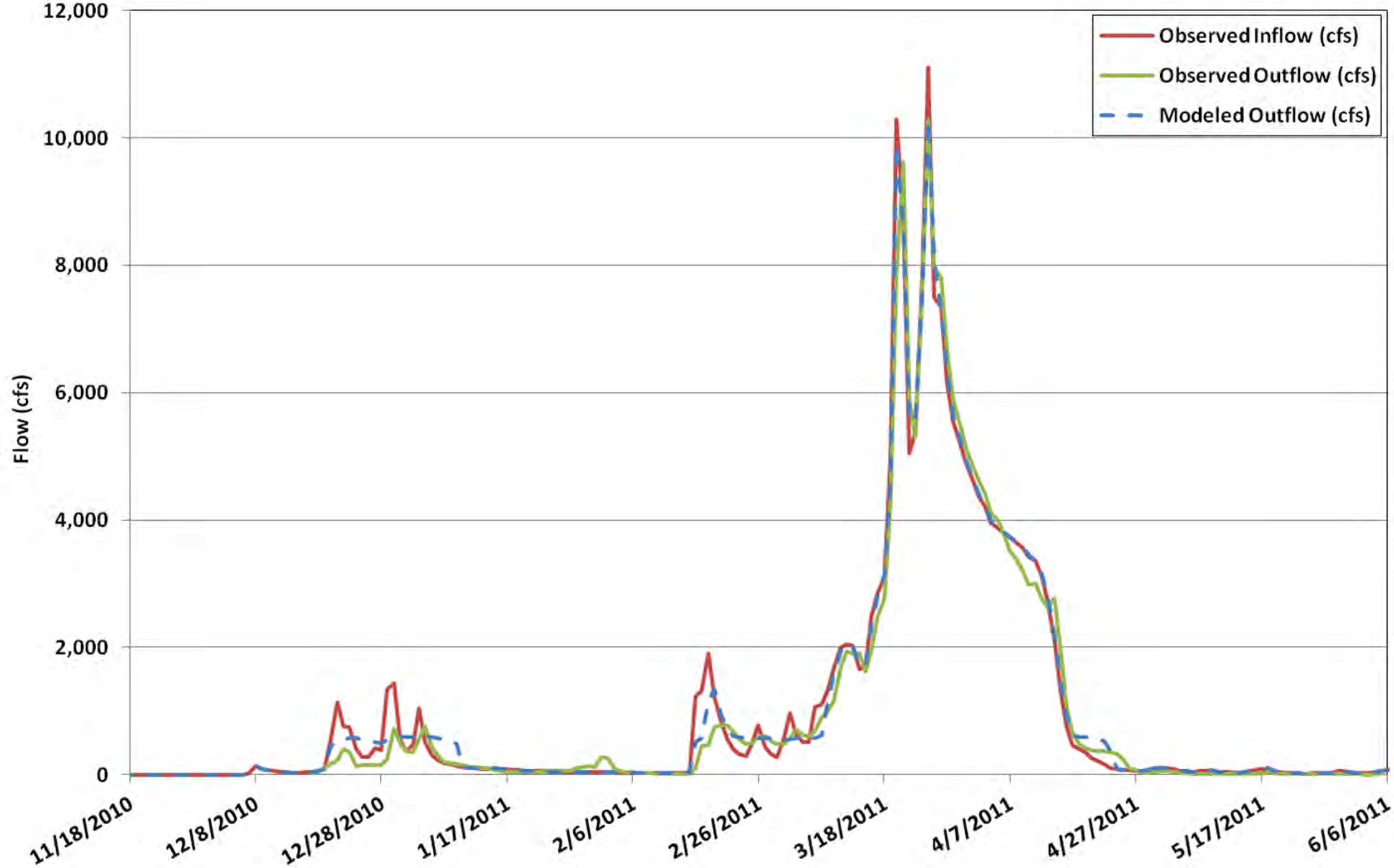
Prepared for DWR	Created By: SP	**Figure 4-17**



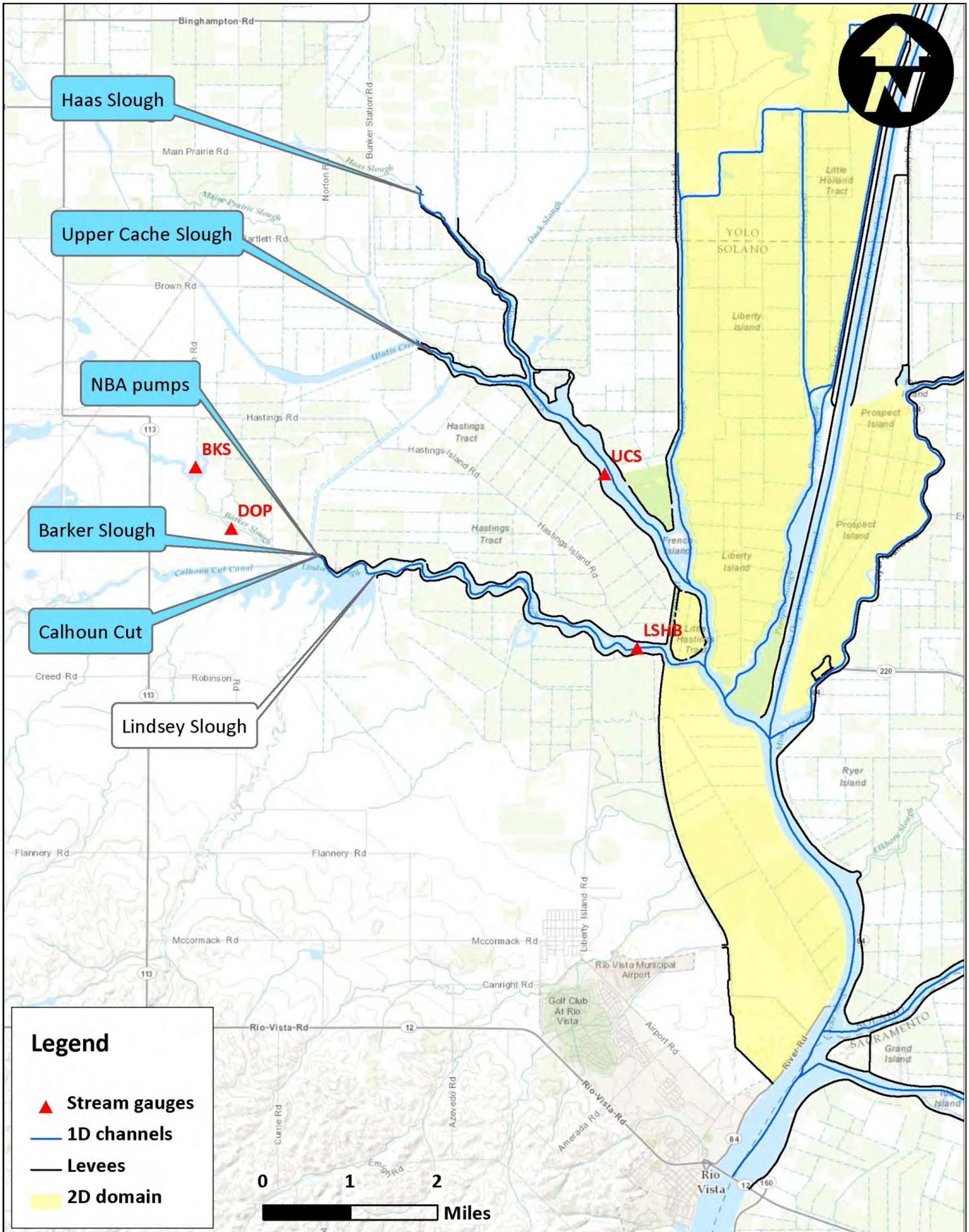
Notes:	HDR cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **Cache Creek Settling Basin Outflows – 2009 Rainfall Events**		
		Prepared for DWR	Created By: SP	**Figure 4-18**



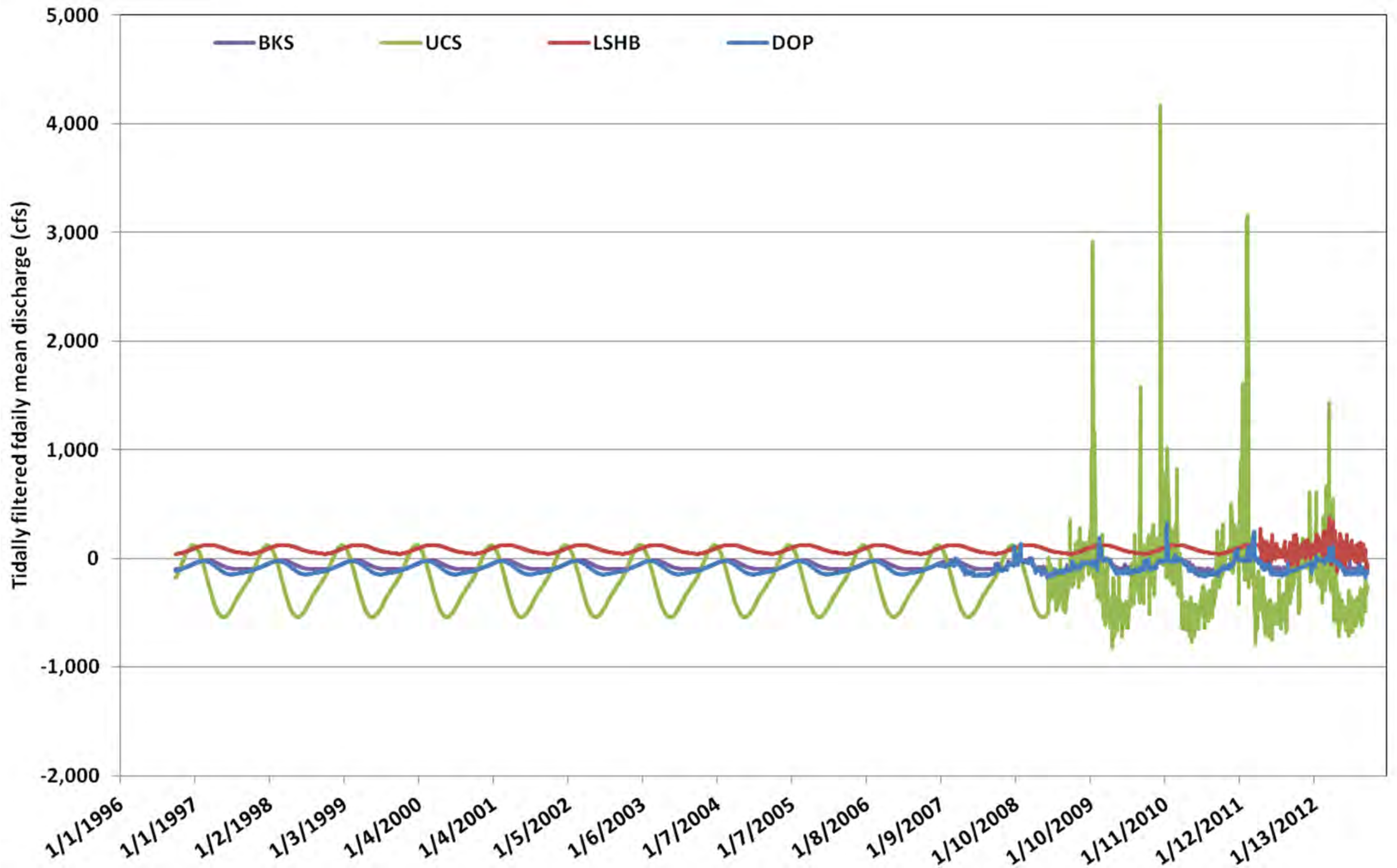
Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **Cache Creek Settling Basin Outflows – 2010 Rainfall Events**		
		Prepared for DWR	Created By: SP	**Figure 4-19**



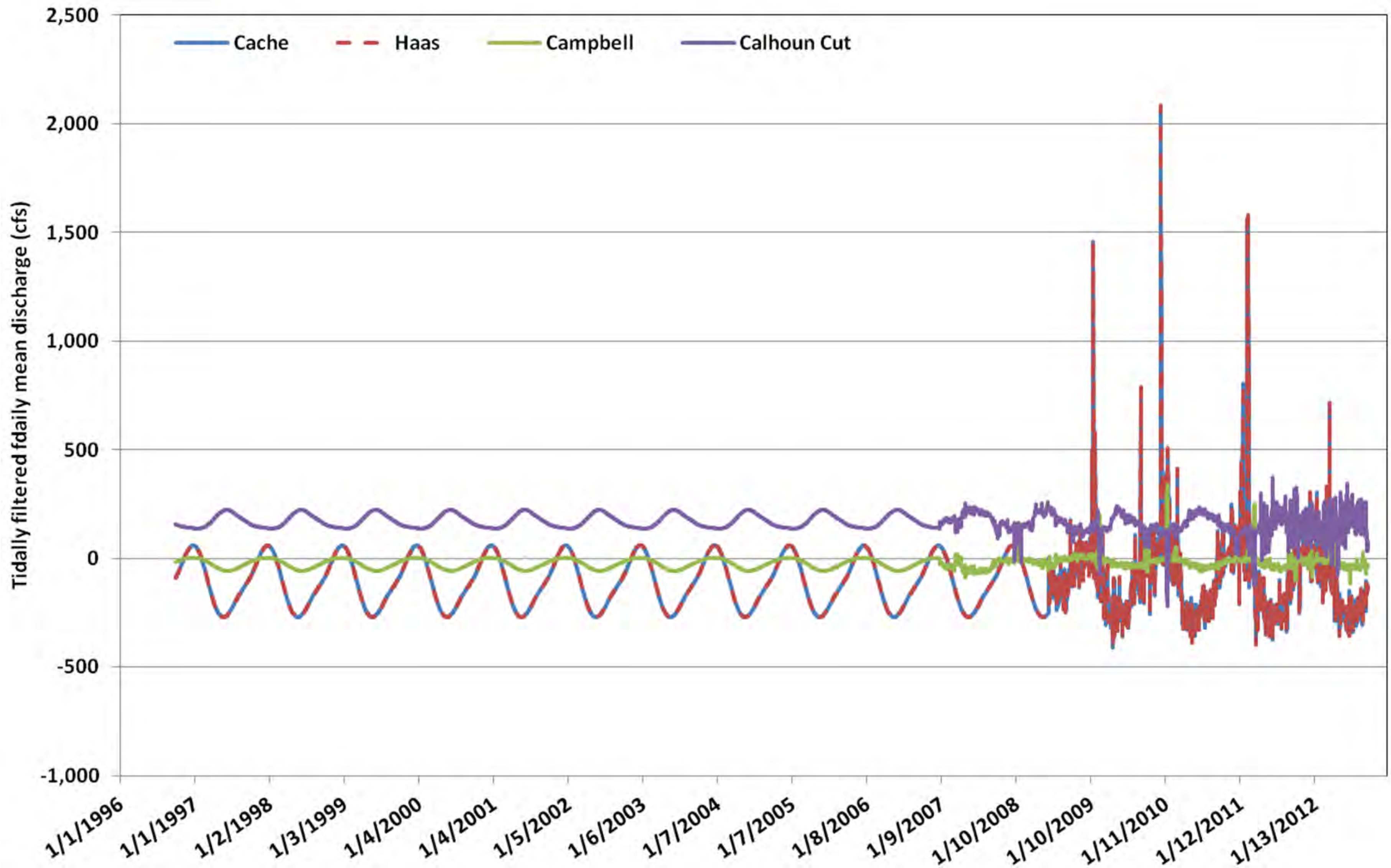
Notes:	HDR cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **Cache Creek Settling Basin Outflows – 2011 Rainfall Events**		
		Prepared for DWR	Created By: SP	**Figure 4-20**



Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **Delta Sloughs Inflows and Gauges**		
		Prepared for DWR	Created By: SP	**Figure 4-21**



Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **Sinusoidal Curve Fitting for Delta Slough Gauges**		
		Prepared for DWR	Created By: SP	**Figure 4-22**

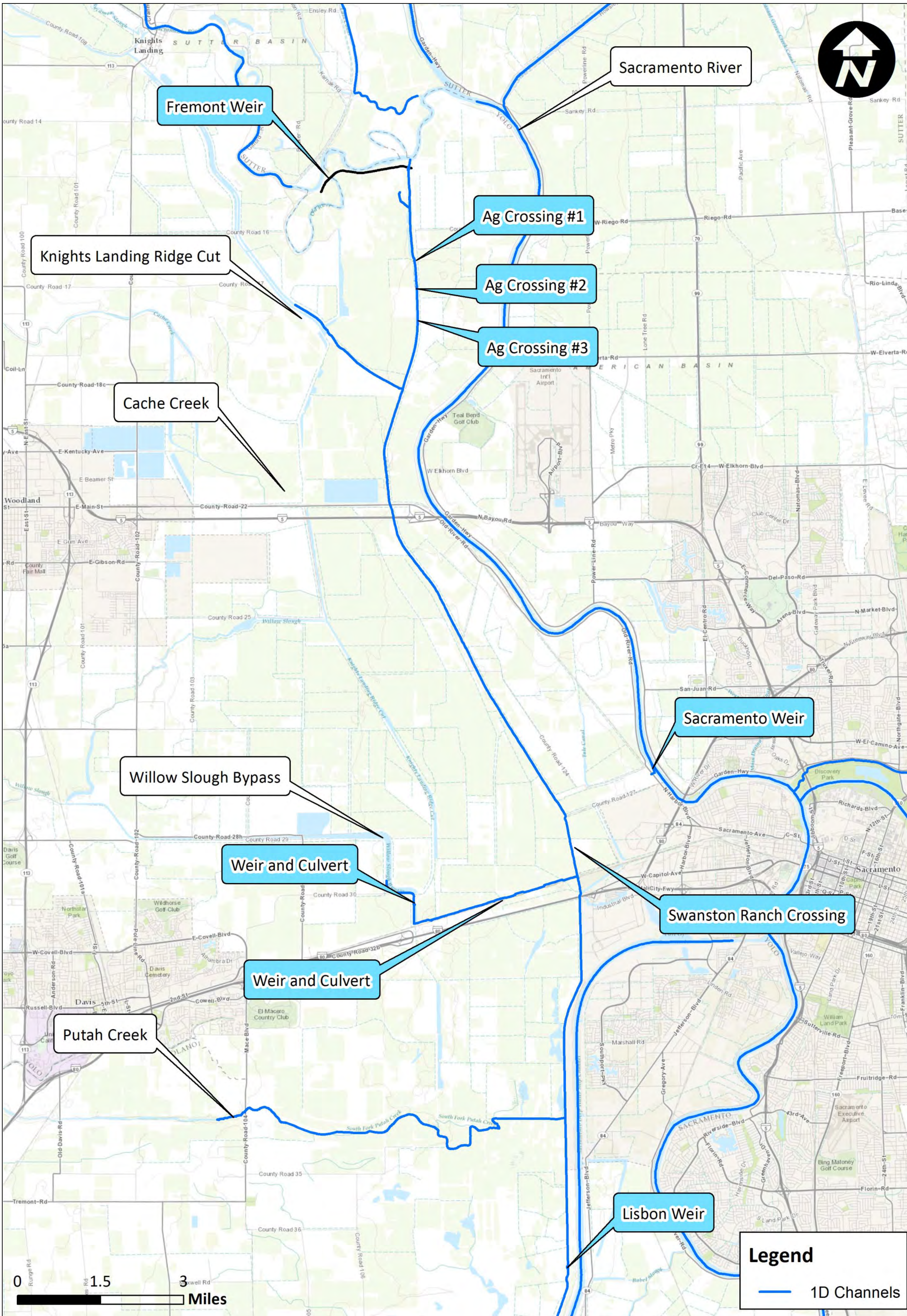


Notes:

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Estimated Delta Slough Daily Flows

Prepared for DWR	Created By: SP	**Figure 4-23**

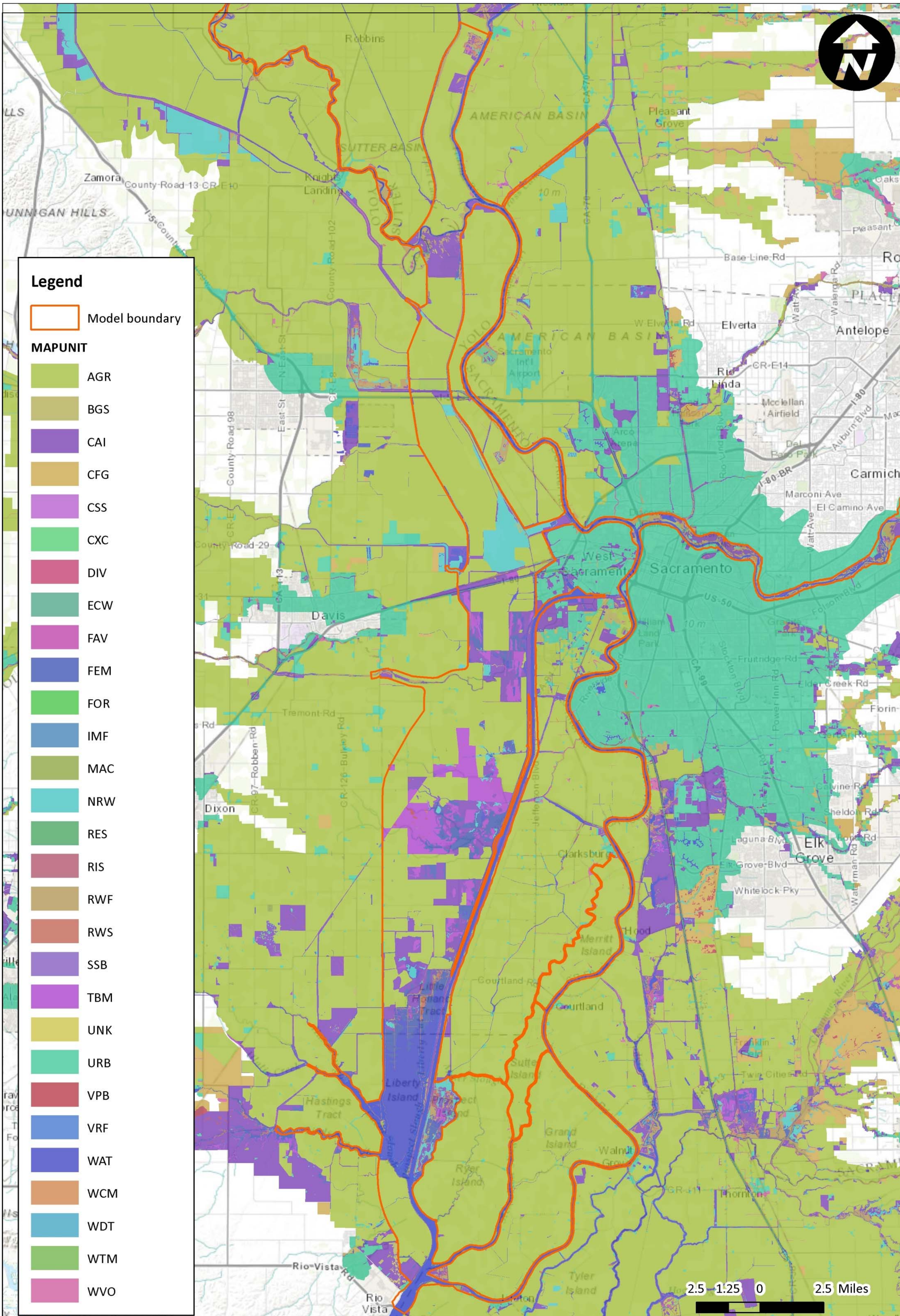


Notes:

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Hydraulic Structures within the Yolo Bypass

Prepared for DWR | Created By: RDJ | **Figure 4-24**



Notes:

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Central Valley Medium Scale Riparian Mapping

Prepared for DWR	Created By: SP	**Figure 4-25**

5.0 Model Calibration

5.1 Overview of Model Calibration

TUFLOW model calibration was performed for three hydrologic conditions in the Bypass to cover the range of flow conditions modeled during the 16 water years. To support model calibration, model data was prepared to include a combination of boundary conditions, measured and gauged flows and stages, surveyed high water marks (HWMs), and gate/weir operations for the following three conditions:

- **1997 Flood** – high flow calibration of the TUFLOW model to HWMs in the Bypass, gauge data (i.e., stage and flow) in the Bypass and the Sacramento River, and the Fremont Weir flow split using gauge data and boundary conditions from the CVFED HEC-RAS model.

- **Low Flow** – calibration to flow within the Tule Canal/Toe Drain channel capacity. Flows and water surface elevations (WSEs) along the Tule Canal/Toe Drain were measured by cbec during February 2010.

- **Flood Recession** – calibration to Yolo Bypass shallow flooding during recession of the March/April 2011 Fremont Weir overtopping event. In addition to readily available gauge data, a series of aerial photographs, HWMs, and limited flow measurements were collected or acquired by cbec.

Calibration of the model was largely focused on river conditions when Fremont Weir spills during system-wide flooding (i.e., January 1997 flood) and localized inundation within the Yolo Bypass (i.e., February 2010 low flow, March/April 2011 flood recession). For conditions when Fremont Weir was not spilling, between elevations 14 to 33 feet NAVD88 when the proposed gated notch could be activated, calibration was not performed. However, the long-term time series plots in Section 6 (i.e., Figures 6-1 to 6-6) provide validation for how the existing conditions model is performing in the Sacramento River when Fremont Weir is not overtopping.

The 2D portion of the model and the 1D channels within the Yolo Bypass (i.e., four Westside tributaries and Tule Canal / Toe Drain) were given initial Manning's n assignments based on medium scale vegetation mapping provided in Table 4-5 in the Report (see tables) as derived from previous studies. The Westside tributaries initial Manning's n assignments never changed as the Westside tributaries were not individually calibrated. The Tule Canal / Toe Drain was individually calibrated and the reach roughness multipliers from the initial values specified in Table 4-5 are provided in Table 5-4 of the Report (see tables). Calibration of the 2D portion of the model by vegetation type occurred by applying global adjustments to the initial Manning's n assignments as provided in Table 4-5 to arrive at the calibrated values. For the 1D-channels outside the Yolo Bypass, in addition to adding energy losses, modifications were made to the CVFED RAS model derived cross section Manning's n values.

The 1997 flood calibration used the full model whereas the other two calibration periods used truncated model domains specific to each calibration period.. The truncated models were used to calibrate specific portions of the Yolo Bypass without having to run the full model. In this way, the team had tighter control over the boundary conditions and the benefit of reduced run times in arriving at solutions quickly. The truncated calibrations focused on refinements to the Tule Canal / Toe Drain channel capacity and relevant hydraulic structures, 1D/2D interface, reinforcement of features in the DEM affecting inundation (i.e., berms and gullies), model stability and coupling across the 1D/2D interface, and modifications to Manning's n assignments. The modifications made to the truncated models were then evaluated in the full model for the 1997 flood calibration, and if further modifications were made to the full model, they were passed back to the truncated models and re-evaluated until the model calibration was satisfactory among all three calibration models. The satisfactory calibration was then verified by the long-term time series plots provided in Section 6.

5.2 High Flow – 1997 Calibration Period

5.2.1 Model Setup

The 1997 event (December 29, 1996 through January 4, 1997) delivered the largest observed discharges into the Bypass over the 16 year period of interest. The observed WSE at the gauge for the Sacramento River on the west side of the Fremont Weir peaked on January 2, 1997 with a stage of 41.4 feet NAVD88. The peak observed flow over the Fremont Weir was 318,000 cfs. For these reasons, the 1997 event was used to calibrate the model for higher flows, with particular attention given to hydrograph timing, peak flows and WSE.

The hydrodynamic model was calibrated to HWMs in the Yolo Bypass, gauge data (i.e., stage and flow) in the Bypass and the Sacramento River, and the Fremont Weir flow split using sub-daily (i.e., 15-minute and hourly) boundary conditions that were generated following the same methods described in Section 4.4. Figure 5-1 shows the boundary conditions, gauges with recorded stage and flow, and surveyed HWMs compiled for the 1997 calibration event. The observed stage and flow data and HWMs were acquired from the CVFED HEC-RAS model. Table 5-1 summarizes the boundary conditions and recorded stage and flow locations that were used for calibration. The Delta Cross Channel gates remained closed during the flood event and diverted no flows out of the Sacramento River.

It should be noted that the gauged Fremont Weir spills for the 1997 flood event consist of a reconstructed hydrograph developed from flow measurements taken downstream of the Fremont Weir during the 1997 flood event (USACE 2007). Based on the measurements taken, DWR discovered that the rating curve was over predicting flows at higher stages and believed that to be caused by sediment buildup causing backwater conditions.

The TUFLOW model was calibrated with:

- Extensive HWMs in the Yolo Bypass and Sacramento River
- Observed stage and flow at multiple gauge locations
- The flow split between Fremont Weir and the Sacramento River

Table 5-1. Boundary conditions and gauge data information for the 1997 calibration event

Boundary Location	Data Source	Stage Gauges	Data Source
Sacramento River			
Sacramento River inflow below Wilkins Slough near Grimes (WLK)	USGS 11390500	Sacramento River at Knights Landing (KNL)	DWR's Water Data Library (A02200)
Knights Landing Outfall Gates (KLOG)	DWR's Water Data Library (A02945)	Sacramento River at Fremont Weir (FRE), West end	DWR's Water Data Library (A02170)
Feather River and Sutter Bypass (FEA+SUT)	Estimated using methods developed in this study[1,2]	Fremont Weir Spill	DWR's Water Data Library A02930
Natomas Cross Canal (NCC)	Estimated using methods developed in this study[1,3]	Sacramento River at Fremont Weir, East end	DWR's Water Data Library (A02160)
		Sacramento River at Verona (VON)	USGS 11425500
American River (AFO)	USGS 11446500	Sacramento River above Sacramento Weir (SBP)	DWR's Water Data Library (A02108)
Steelhead Creek	Estimated using methods developed in this study[1,4]	Sacramento Weir Spill	DWR operations data
Delta Cross Channel(DLC)	Closed during the flood event, no flow	Sacramento River at I Street Bridge (IST)	DWR's Water Data Library (A02100)
Georgiana Slough (GSS)	Estimated using methods developed in this study[1,5]	Sacramento River near Freeport Bridge (FPT)	USGS 11447650
		Sacramento River at Walnut Grove (SDC)	DWR's Water Data Library (B91650)

Boundary Location	Data Source	Stage Gauges	Data Source
Yolo Bypass			
Knights Landing Ridge Cut (KLRC)	Estimated using methods developed in this study[1]	Yolo Bypass near Woodland (YBY)	USGS 11453000
Cache Creek Settling Basin	Estimated using methods developed in this study[1]	Yolo Bypass at Lisbon (LIS)	DWR's Water Data Library (B91560)
Putah Creek	Estimated using methods developed in this study[1]		
Willow Slough Bypass	Estimated using methods developed in this study[1]		
Downstream Boundary			
Sacramento River at Rio Vista (RVB)	DWR's Water Data Library (B91212)[6]		

Notes:
[1] Developed following the methods outlined in Section 4.4
[2] Estimated using a mass balance relationship: (FEA + SUT) = (VON + FRE) - (WLK + KLOG + NCC); flows split was based on ratio of (GRL+MRY+BRW) and (BSL+TIS)
[3] Estimated as 1.43 x Steelhead Creek flow
[4] Estimated using the computed stage along the Steelhead Creek near the West El Camino Avenue bridge and stage-discharge curve previously developed by DWR (2008a) and extended by cbec as a part of this study
[5] Daily flows provided by DWR's Dayflow program converted to hourly flows
[6] The stage data is in USED datum and the gauge height correction (NAVD88 = USED - 0.6 ft) has not been applied

5.2.1 Results Summary

Modeled maximum WSEs were compared at 43 HWMs within the Bypass and 21 in the Sutter Bypass and along the Feather River. Additionally, gauge records at 11 stream gauges (8 outside the Bypass, 3 within) were compared to model results. Reasonable changes within engineering judgment were made in the model, mainly modifications to the Manning roughness coefficients and adding energy losses to calibrate the model to these data. The model was considered calibrated when modeled peak WSE demonstrated good agreement with the majority of HWMs and gauge stage records and predicted hydrographs at flow gauge locations compared favorably with discharge records.

Additional energy losses were used to improve calibration in areas where 1D losses due to turbulence may have been underestimated such as the confluence of a river or where increasing the Manning roughness coefficients impaired the low flow calibration as shown in Figure 5-2. Energy losses are applied as a function of the velocity head so they have a very small impact at low flows.

A comparison of the peak computed WSEs to collected HWMs is shown in Figure 5-33. The computed WSE within the Yolo Bypass are typically high (average error 0.2 feet) and those in the Sutter Bypass are typically low (average error -0.2 feet). The root-mean-square error (RMSE) for the Sutter Bypass is 1.1 feet. The RMSE for the higher priority HWMs within the Yolo Bypass is 0.8 feet. The RMSE for all of the HWMs is 0.9 feet.

The flow split between the Fremont Weir and Verona are of particular concern for modeling of the Yolo Bypass. Figure 5-4 shows a comparison of the computed and observed relationship between flows into the Bypass and flows down the Sacramento River, indicating that the model is reasonably predicting the flow split.

Outside of the Bypass, calibrated model results were compared at 8 gauges (3 gauges included discharge). Comparison plots are shown in Figure 5-5 through Figure 5-18. Generally, the shape of the predicted stage hydrographs match reasonably well to observed stages. In several instances, although the general shape and magnitude of the predicted WSEs compare well to the gauge records, the full magnitude of peaks and dips observed at gauges are not reproduced in the model. Potential inaccuracies in the assumed Sacramento Weir gate operations and/or boundary conditions may hamper the ability of the model to capture peak stages. At discharge gauges, flow hydrographs from the model reproduce the shape and magnitude of hydrographs well. The WSEs in the Sacramento River at Walnut Grove Stage shown in Figure 5-15 are consistently high but the tidal signal timing matches well.

5.3 Low Flow– February 2010 Calibration Period

5.3.1 Model Setup

The TUFLOW model was calibrated to the capacity of Tule Canal/Toe Drain during low flows in February 2010. Flows and WSEs along the Tule Canal/Toe Drain were measured by cbec (2010) on February 19, 2010 at 19 locations from the northerly extent of the Tule Canal (south of Tule Pond) to just downstream of Lisbon Weir near the DWR Lisbon Weir gauge. Flow in the channel was measured with an Acoustic Doppler Current Profiler (ADCP). WSEs were collected using Real Time Kinematic (RTK) Global Positioning System (GPS) survey equipment and referenced to NAVD88. Figure 5-19 shows the locations of flow and stage measurements. Table 5-2 provides a summary of the flow and stage measurements. The benefit of obtaining these measurements in February 2010 was that the flows in the Tule Canal/Toe Drain were at a point where in most places they were just passing onto the floodplain, or just below the top of bank, thus providing a relatively reasonable estimate of the flow capacity of the Tule Canal/Toe Drain.

For the low flow calibration of the Tule Canal/Toe Drain, the TUFLOW model was truncated to the 1D channel between Tule Pond and Little Holland Tract. The 2D domain was also truncated to these general extents. The flows in Tule Canal/Toe Drain were based on measured flows, as shown in Table 5-2, with incremental flows added or subtracted from the channel. There were minimal spills over the Fremont Weir (less than 3,000 cfs) and no spills over

Sacramento Weir during this low flow event. Flows from the Westside tributaries are included within the measured flows, so inflows from these tributaries are accounted for in the incremental flows. The tidal boundary at Little Holland Tract was based on recorded elevations collected by cbec (unpublished) in support of the Lower Yolo Restoration Project at Metropolitan Water District Gauge 7 (MWD7).

Table 5-2. Summary of flow and stage measurements taken in the Toe Drain/Tule Canal

Location	Elevation (ft NAVD88)	Measured Flow (cfs)[1]
ADCP1	17.08	---
ADCP2	17.26	151
ADCP3	16.86	920
ADCP4	16.37	1072
ADCP5	16.10	1344
ADCP6	15.71	1281
ADCP7	15.60	1443
ADCP8	15.15	1408
ADCP9	14.90	1539
ADCP10	14.46	1541
ADCP11	13.56	1644
ADCP12	11.52	2154
ADCP13	11.12	2307
ADCP14	11.00	2278
ADCP15	10.59	2526
ADCP16	10.28	2622
ADCP17	10.30	2692
ADCP18	9.79	2609
ADCP19	8.58	2805

Notes:
[1] Flow measurements recorded in the Toe Drain/Tule Canal were validated with flow measurements observed at Lisbon Weir. Flow measurements taken by cbec near Lisbon Weir were within 3.0% of those at Lisbon Weir.

5.3.2 Results Summary

Low flow calibration of the Tule Canal/Toe Drain north of Lisbon Weir was achieved by adjusting the hydraulic roughness coefficients (see Table 5-4 for 1D channel multipliers on the 1D channel base values provided by Table 4-6) and implementing energy losses to account for woody debris, hydraulic structures (e.g., piers), and flow transitions (e.g., scour holes downstream of hydraulic structures). These adjustments were made to minimize the RMSE between the measured and modeled values in the water surface profile. At this flow condition, there was minimal flow interaction between the 1D channel and 2D grid, as flows were largely contained to the channel. As shown by Figure 5-20, the RMSE for the WSEs was within 0.3 feet, with the largest errors occurring in the vicinity of hydraulic constrictions (i.e., upstream of KLRC confluence, at Swanston Ranch check dam, and upstream of Lisbon Weir).

5.4 Flood Recession– March/April 2011 Calibration Period

5.4.1 Model Setup

The TUFLOW model was calibrated for shallow flooding on the Bypass during the receding limb of the March/April 2011 Fremont Weir overtopping event. The flows as measured at Yolo Bypass near Woodland per USGS gauge 11423000 show that the overtopping event peaked around March 27 and receded thereafter. The TUFLOW model 1D channel and 2D floodplain was truncated between Fremont Weir in the north and Little Holland Tract in the south. Figure 5-21 shows the model extents, boundary conditions, gauges with recorded stage and flow, and surveyed WSEs compiled for the 2011 calibration event. Table 5-3 summarizes the boundary conditions and recorded stage and flow locations that were used for calibration. Sub daily boundary condition data was largely based on gauged data and estimated where gauged data was not available following the methods outlined in Section 4.4. The Sacramento Weir gates remained closed during the flood event and diverted no flows out of the Sacramento River into Yolo Bypass.

In addition to readily available gauge data, a series of aerial photographs, WSEs, and limited flow measurements were collected or acquired by cbec (unpublished). The aerial photographs were collected on April 9, 2011 around 4 pm (see Figure 5-22) and on April 12, 2011 around 1:45 pm (see Figure 5-23), and were subsequently georeferenced using flight crosses. WSEs along the Tule Canal/Toe Drain were collected on the same days as the aerial photographs using RTK GPS survey equipment. The WSE data collected on April 9, 2011 extended from Fremont Weir to Lisbon Weir. The WSE data collected on April 12, 2011 extended from Tule Pond to Yolo Flyway Farms.

In addition to the WSEs, an ADCP was used to measure flow in the Tule Canal just downstream of the USGS Yolo Bypass at Woodland gauge from the County Road 22 bridge over the Tule Canal. This location includes flows from Fremont Weir, KLRC, Cache Creek Settling Basin, and floodplain drainage north of County Road 22. The measured discharges on April 9, 2011 at 12:30 pm and on April 12, 2011 at 2:25 pm were 7,290 cfs and 4,250 cfs respectively, while the flows reported at the Yolo Bypass at Woodland gauge were 5,750 cfs and 3,460 cfs. Potential discrepancies between USGS published and measured values could be due to an older USGS rating curve or local conditions at the time of the measurements (e.g., presence of aquatic vegetation or debris loading on the railroad track trestle bents).

The TUFLOW model was generally calibrated with:

- Measured WSEs in the Tule Canal/Toe Drain
- Limited measured flows at County Road 22
- Georeferenced aerial photographs showing floodplain inundation

Table 5-3. Boundary conditions and gauge data information for the 2011 calibration event

Boundary Location	Data Source	Gauge Data	Data Source
Yolo Bypass			
Fremont Weir spill into Yolo Bypass	CDEC (FRE)		
Knights Landing Ridge Cut	DWR's Water Data Library (A02939)		
Cache Creek Settling Basin	USGS 11452800 and USGS 11452900	Yolo Bypass near Woodland (YBY)	USGS 11453000
Putah Creek	Estimated using methods developed in this study[1]		
Willow Slough Bypass	Estimated using methods developed in this study[1]	Yolo Bypass at Lisbon (LIS)	DWR's Water Data Library (B91560)
Downstream Boundary			
Little Holland Tract	Westland Water District gauge (WWD6)[2]		
Notes: [1] *Long-term Boundary Conditions Development* technical memorandum (cbec 2014) [2] See cbec (2011)			

5.4.2 Results Summary

During the 2011 flood recession calibration, the wetting and draining of Yolo Bypass was evaluated by modifying the berm density, adding drainage features, and analyzing the elevations along the 1D/2D interface for the Tule Canal/Toe Drain, as previously described in Section 4.3.4. It was determined that adding berms and drainage features to the 2D grid was necessary, but modifying the elevations along the 1D/2D interface was not necessary. Energy losses were also implemented at specific locations to account for woody debris, hydraulic structures, and flow transitions, same as the 2010 low flow calibration.

Infiltration losses were also added to the 2D grid to accommodate 1) sub grid scale field drainage not captured by the drainage features described in Section 4.3.4 and 2) to remove isolated ponding so as not to affect the LDW calculations. The infiltration or loss rate was set to 0.05 inches/hour (in/hr), which corresponds to a typical value for the saturated hydraulic conductivity of the limiting layer for the silty clay to clay soils underlying the Bypass. At this loss rate, 1 foot of ponded water would take approximately 10 days to be infiltrated. It should be noted that infiltrated water is lost from the model and does not reenter the Tule Canal/Toe Drain.

In addition to these changes, the Fremont Weir inflows to the Yolo Bypass were modified specific to this model calibration. Because the Fremont Weir inflows are derived from a rating curve established for a 1.8-mile-long weir, the estimated inflows are sensitive to small changes in stage. After reviewing the April 9, 2011 aerial photograph (see Figure 5-22), it was determined that there was a relatively small amount of flow through the fish ladder as well as very shallow overtopping over a 100-ft segment of the weir immediately to the east of the fish ladder. However, the published inflow would suggest that there was approximately 5000 to 10000 cfs over the weir, which is incorrect based on the aerial photograph. As such, the Fremont Weir inflows were manually modified given uncertainty in the Fremont Weir gauge data so the modeled flows at County Road 22 would reasonably match the measured flows on April 9 and 12, 2011 (see Section 5.4.1). This was also done to provide the best fit with the measured water surface profiles and inundation extents while keeping Manning roughness coefficients within reasonable limits. In doing so, the Westside tributary flows were left unchanged. The final inflows are a slight modification to the Fremont Weir inflows (see Figure 5-24). However, it should be noted that the long-term simulation for water year 2011 used the full model whereby inflow over Fremont Weir was computed by the model per the long-term hydrologic boundary conditions.

The adjustments described above were made to minimize the RMSE between the measured and modeled values in the water surface profiles as well as minimize the difference in flooded extents between observed and modeled. Figure 5-25 and Figure 5-26 show the modeled water surface profile and wetted extents, respectively, compared to observations made on April 9, 2011. The RMSE for the WSEs was within 0.3 feet, with the largest increases in the profile occurring north of County Road 22. The modeled wetted extents north of I-80 were 3.6 percent (or a net 400 acres) higher than observed, with the largest deviations occurring north of County Road 22. The increases in stage and wetted extents north of County Road 22 are closely linked to the modeled flows being 1,110 cfs higher than measured on April 9, 2011.

Figure 5-27 shows the water surface profile on April 12th. Figure 5-28 and Figure 5-29 show the wetted extents north and south of I-80, respectively, on April 12, 2011. The RMSE for the WSEs was within 0.5 feet, but generally under predicting the measured profile. The modeled wetted extents for the entire model domain were 10 percent (or a net 2800 acres) lower than observed, with the largest deviations occurring along Conaway Ranch and south of Lisbon Weir. The decreases in stage and wetted extents could be linked to the modeled flows being 775 cfs lower than measured on April 12, 2011 and a simplified drainage network that is perhaps too efficient at draining the Yolo Bypass.

Given the uncertainties in the modeled inflows over Fremont Weir and contributions from major drainage features not represented by the Westside tributaries (such as the City of Davis and RD 2068), along with simplified representation of field berms and drainage features, the 2010 low flow and 2011 flood recession calibration results are presumed to be satisfactory and to provide a relatively reasonable description of the inundation patterns within the Yolo Bypass during frequent events.

Table 5-4 shows the resultant Tule Canal/Toe Drain subreach multipliers that were applied to the composite Manning roughness coefficients assigned from the medium scale vegetation mapping.

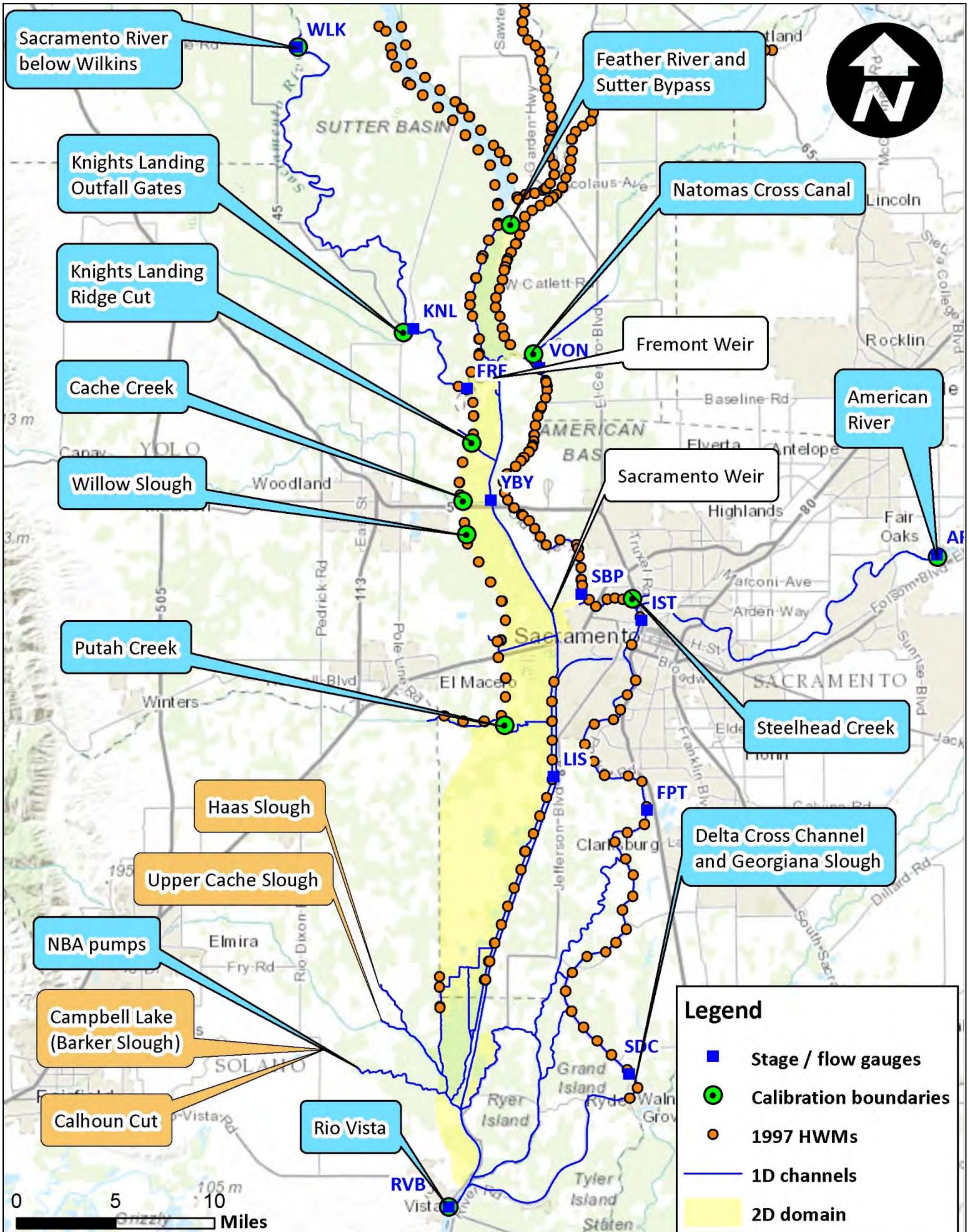
Table 5-4. Tule Canal/Toe Drain 1D low flow roughness multipliers

Subreach Stationing (feet)	Manning Roughness Coefficients Multiplier	Subreach Stationing (feet)	Manning Roughness Coefficients Multiplier
2500 - 69227	1.5	84226 - 91726	0.95
70606 - 75726	1.25	93226 - 98226	1.1875
77226 - 80726	1.1	99726 - 108470	1.25
81226 - 82726	1.045	108727 - 157227	0.95

5.5 Results Summary

Three calibration events were used to optimize model parameters and demonstrate that the model performs as expected. Both low flow and high flow scenarios were conducted to ensure the model handles the range of expected flow rates. The RMSE for the WSEs for the low and high flow calibration events were 0.3 ft and 0.9 ft, respectively, providing good fit between observed and modeled results. The 2011 flood recession calibration included aerial photos which provided the ability to compare modeled and observed inundations extents. The RMSE for the WSEs for April 12, 2011 were within 0.5 ft and the area of inundation was within 10% as shown in the aerial photographs. The results of the three calibration events provide assurance that the model represents well the flooding and draining processes in the bypass. The 2010 and 2011 calibrations also provide verification that the flow estimation techniques for the Westside tributaries (see Section 4.4.8) are reasonably accurate given the low RMSE for the WSEs despite the uncertainty in the inflows from major drainage features.

We recognize that the USGS has a comprehensive network of gauges recording stage and flow in the slough system south of the Stair Step and Courtland that can be used to calibrate the flow splits within the Cache Slough Complex. Model calibration was not performed in great detail within the Cache Slough Complex during the 2010 and 2011 calibrations as those calibrations were focused on the Yolo Bypass north of Liberty Island. However, the long-term stage verification at Liberty Island (see Figure 6-6) and downstream boundary sensitivity (see Figure 6-7 and Figure 6-8) demonstrate that the model reasonably predicts WSEs south of the Stair Step and that small deviations in stage do not affect the model results within the area of interest (i.e., Yolo Bypass bounded by Fremont Weir and the Stair Step).

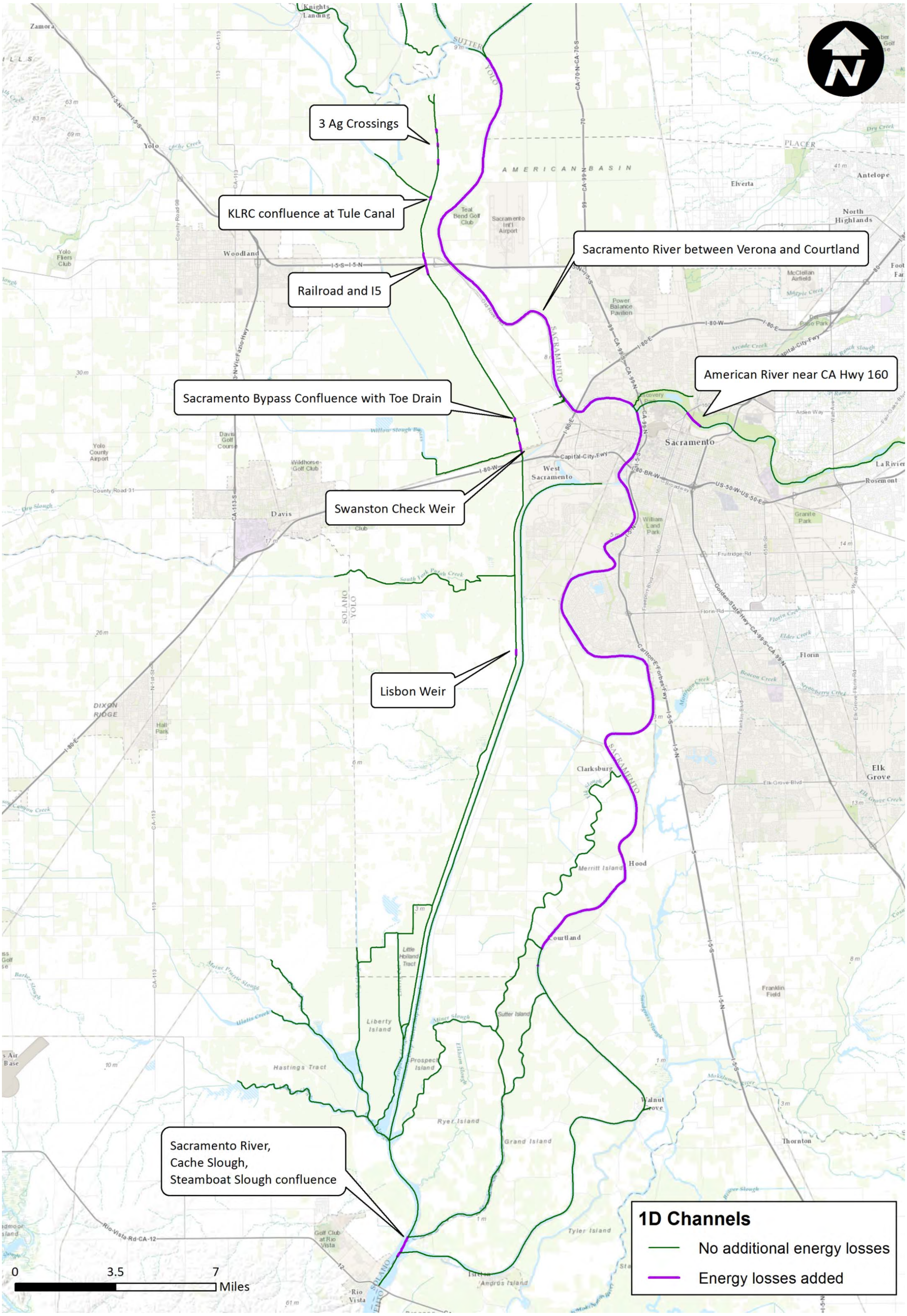


Notes:

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

1997 Flood Calibration Data

Prepared for DWR | Created By: SP | **Figure 5-1**

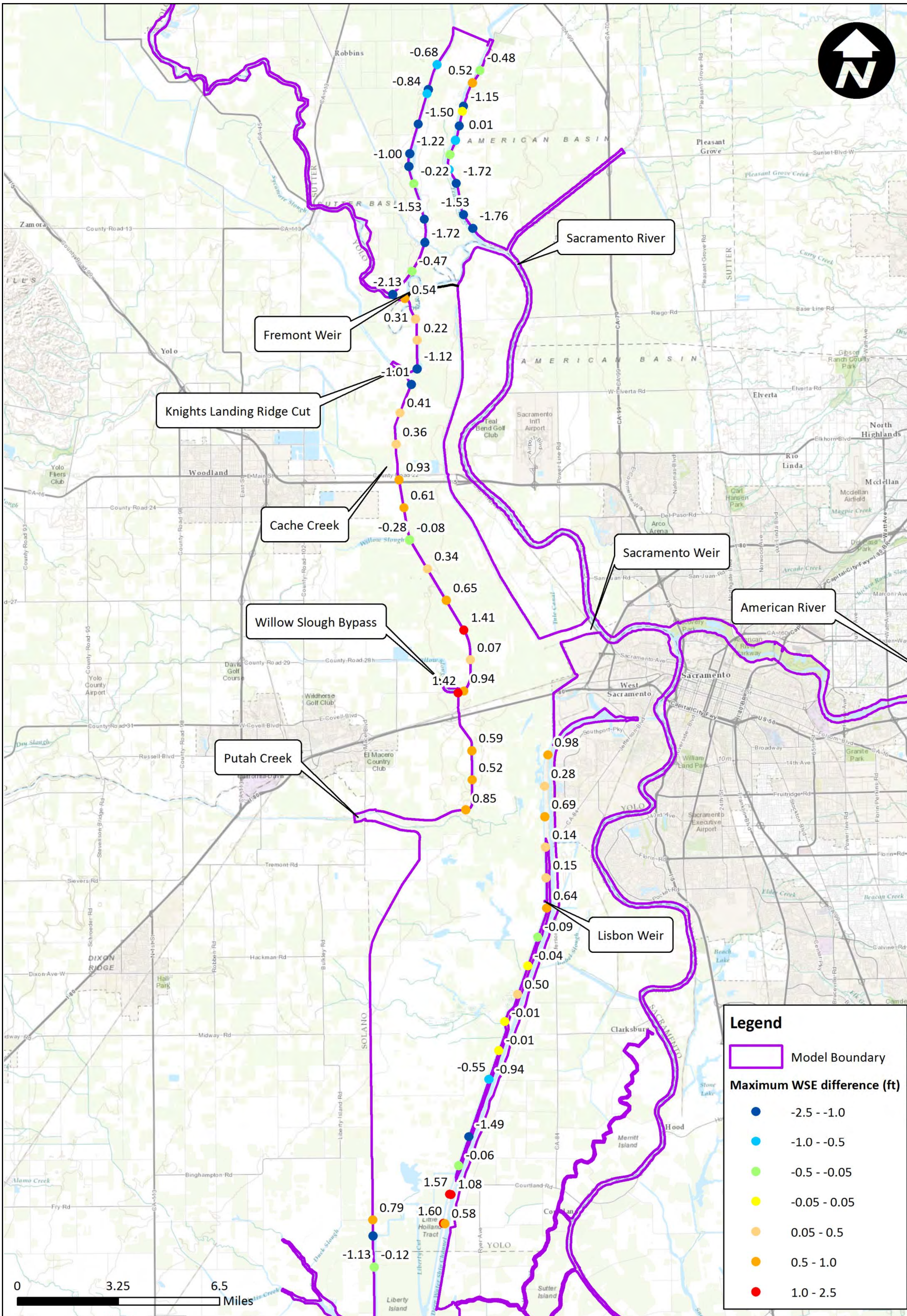


Notes:

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

1D Channels with Additional Energy Losses

Prepared for DWR	Created By: RDJ	**Figure 5-2**

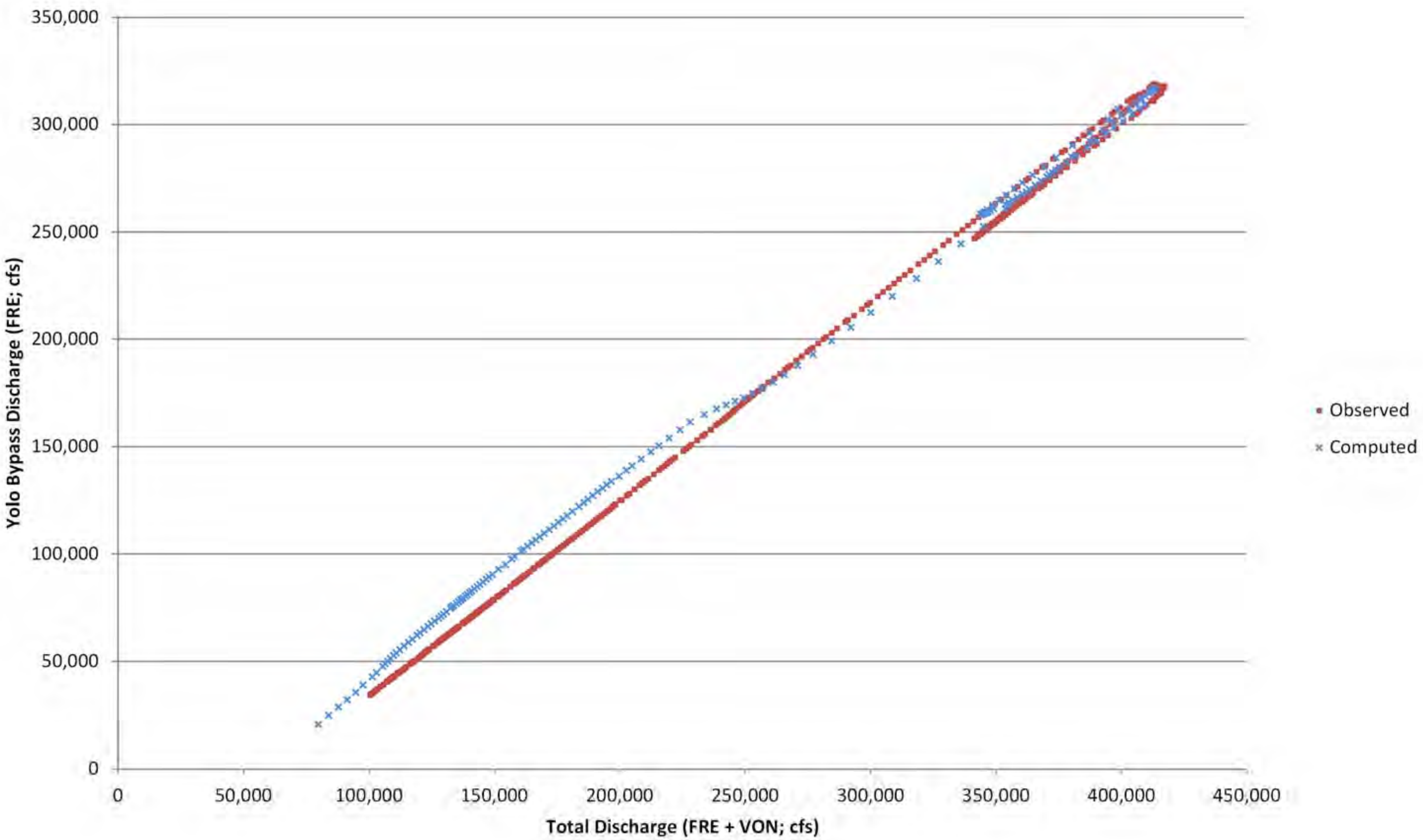


Notes:

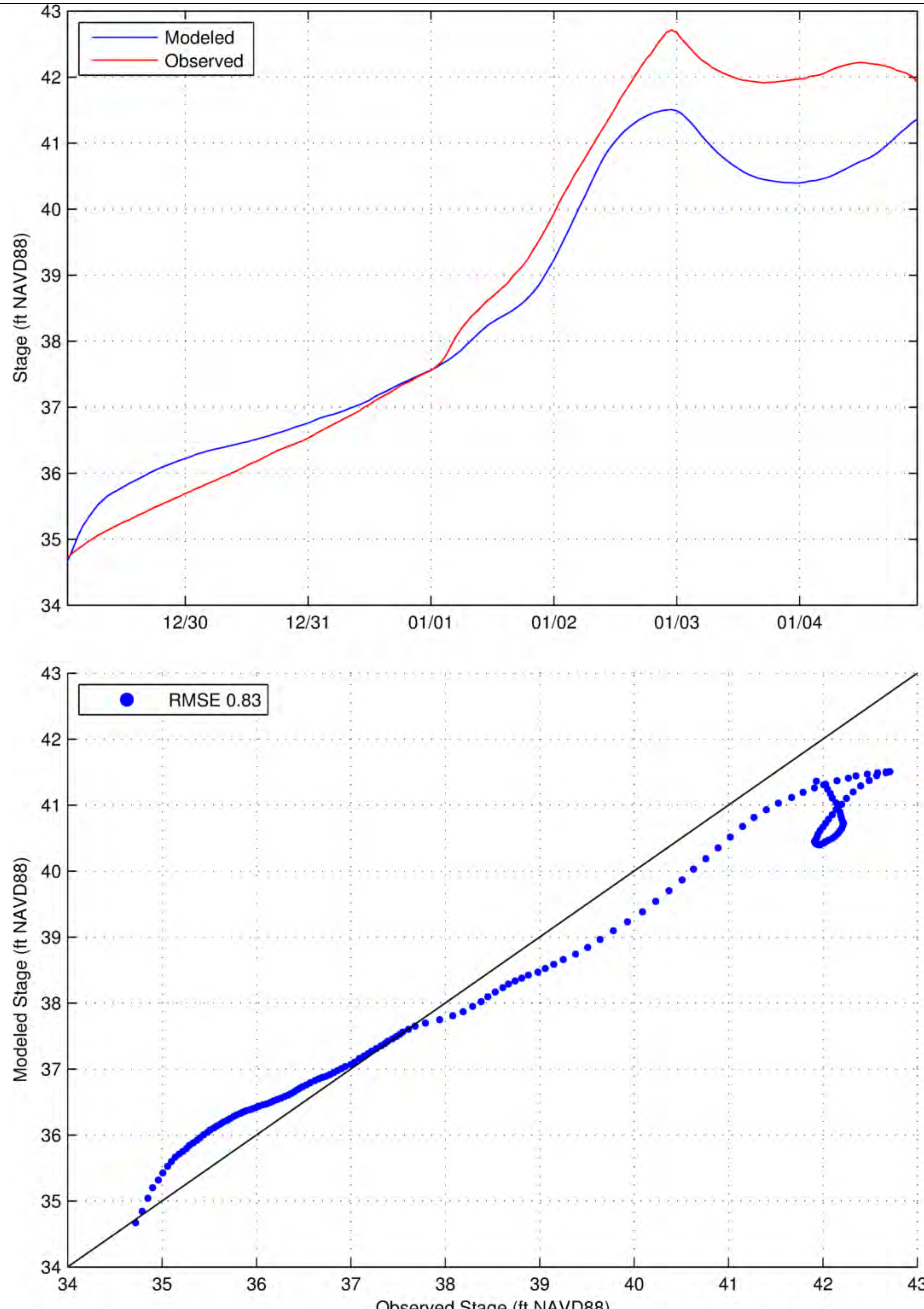
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

1997 Calibration Comparison to High Water Marks

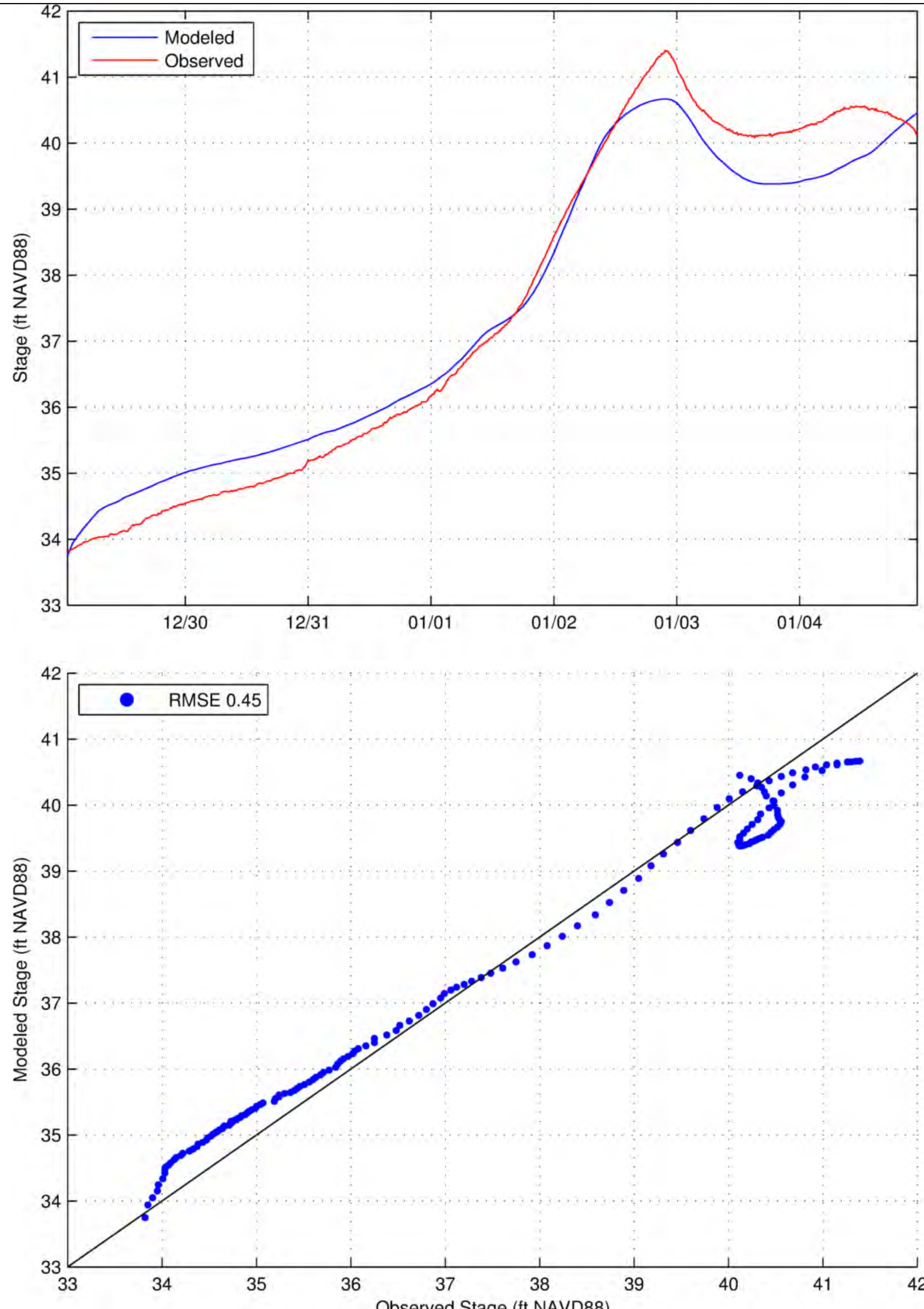
Prepared for DWR	Created By: RDJ	**Figure 5-3**



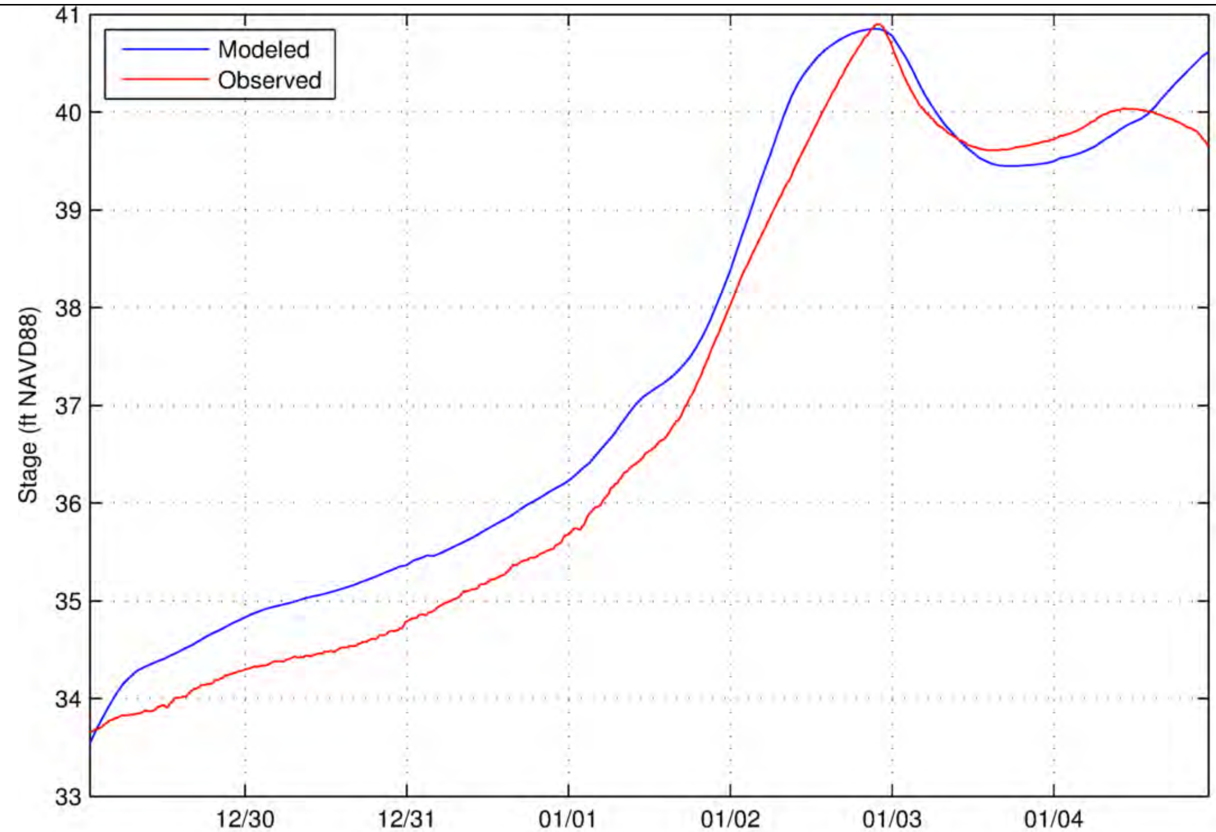
Notes: Comparison of Yolo Bypass discharge vs total discharge for computed and observed data.	HDR cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **1997 Calibration Sacramento River Flow Split**
		Prepared for DWR · Created By: RDJ · **Figure 5-4**

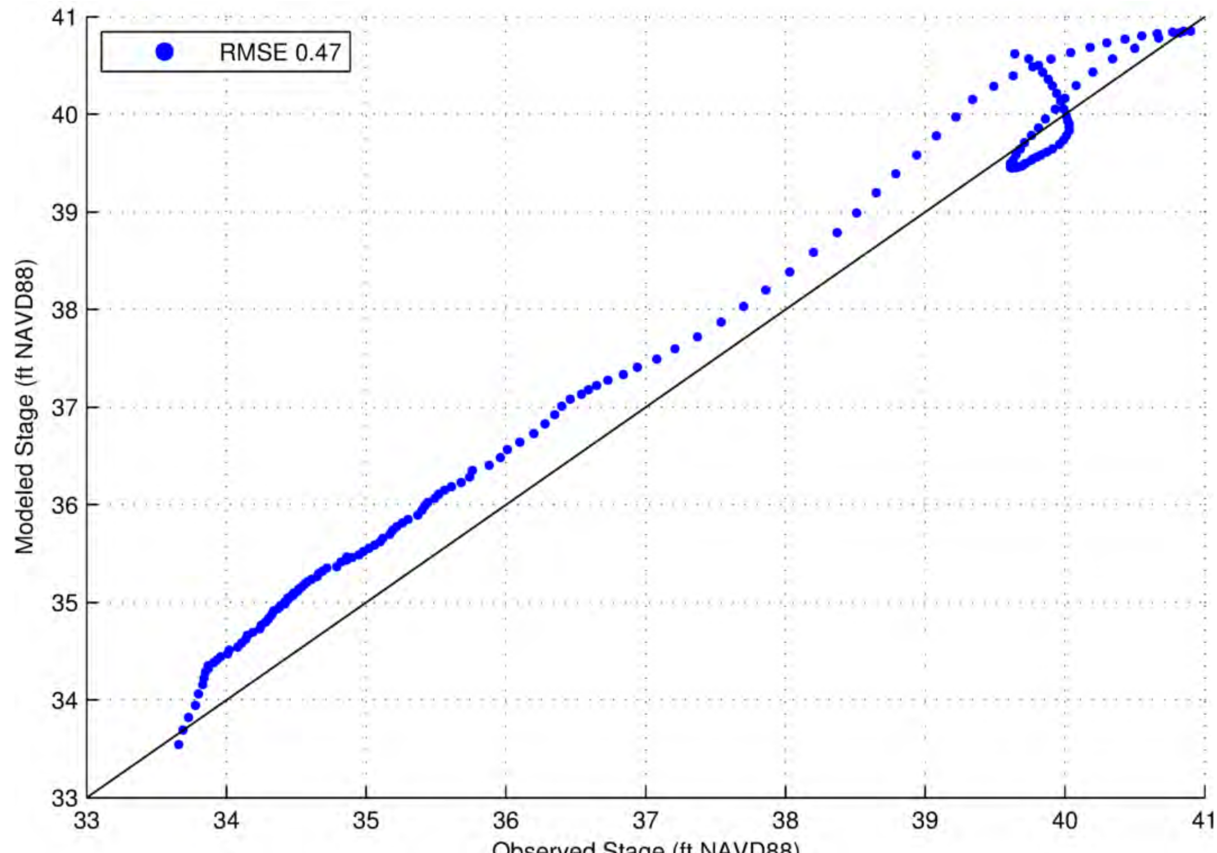


Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **1997 Calibration Sac at Knights L Stage**
		Prepared for DWR | Created By: RDJ | **Figure 5-5**

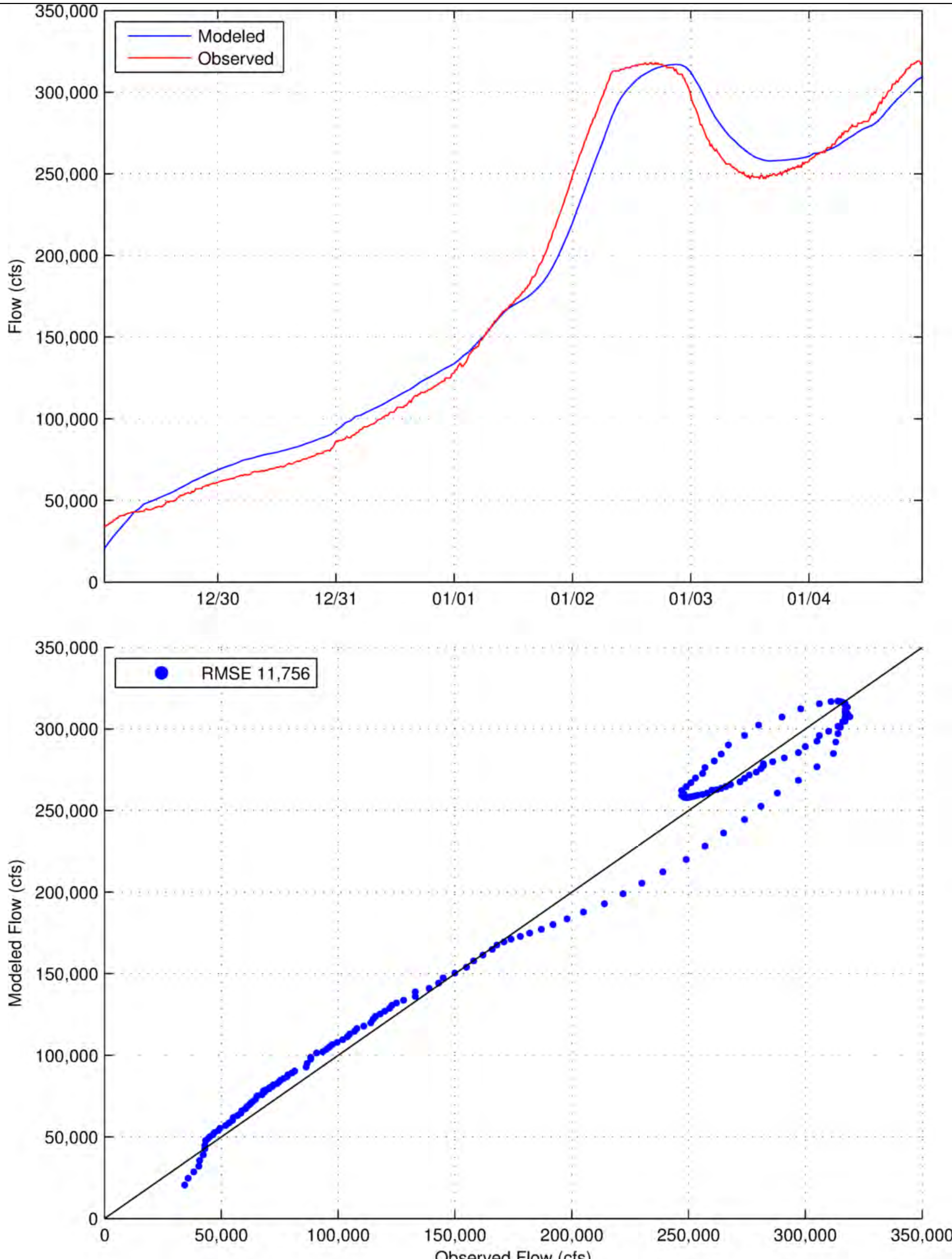


Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage*		
		1997 Calibration Fremont Weir West Stage		
		Prepared for DWR	Created By: RDJ	**Figure 5-6**

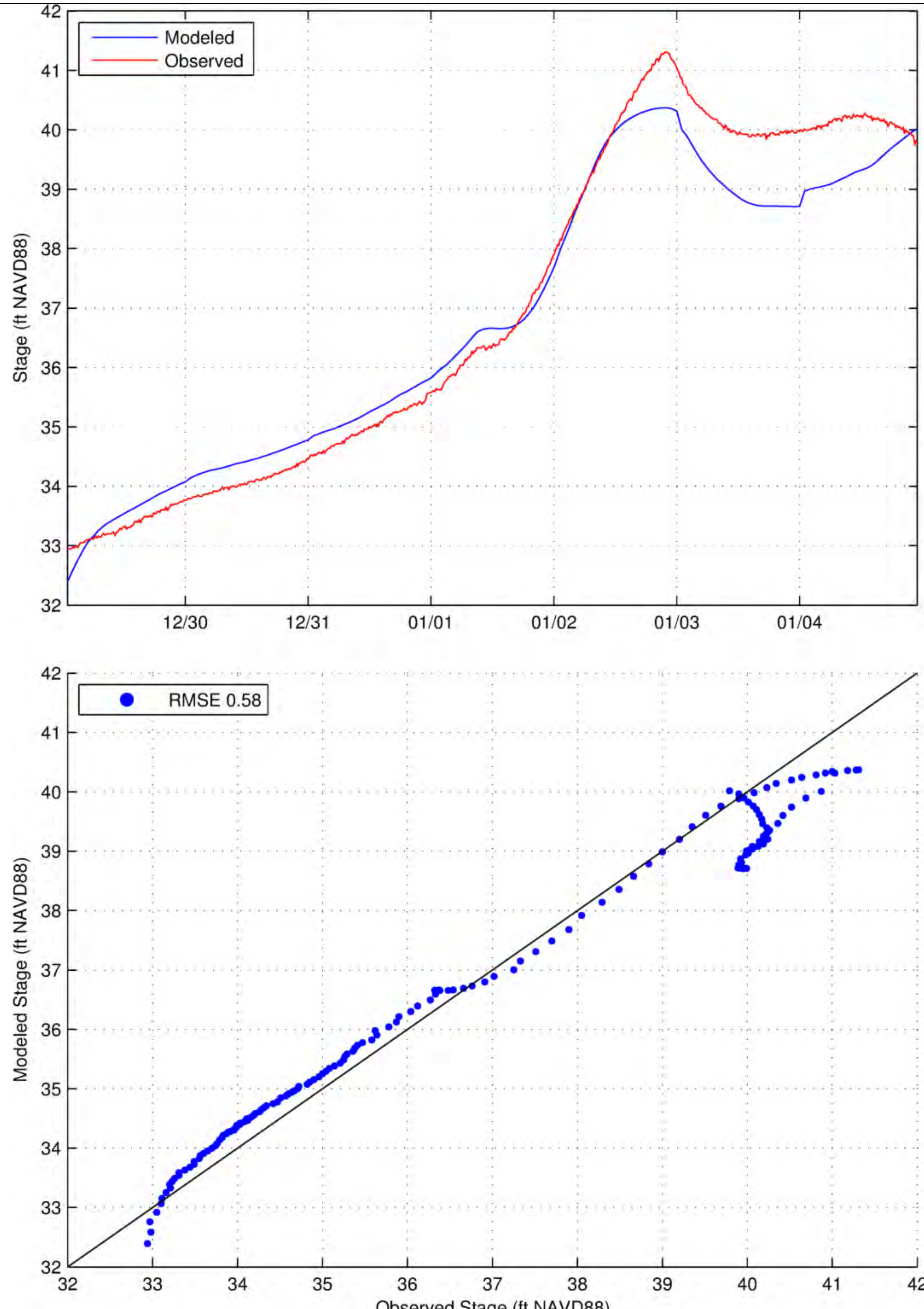




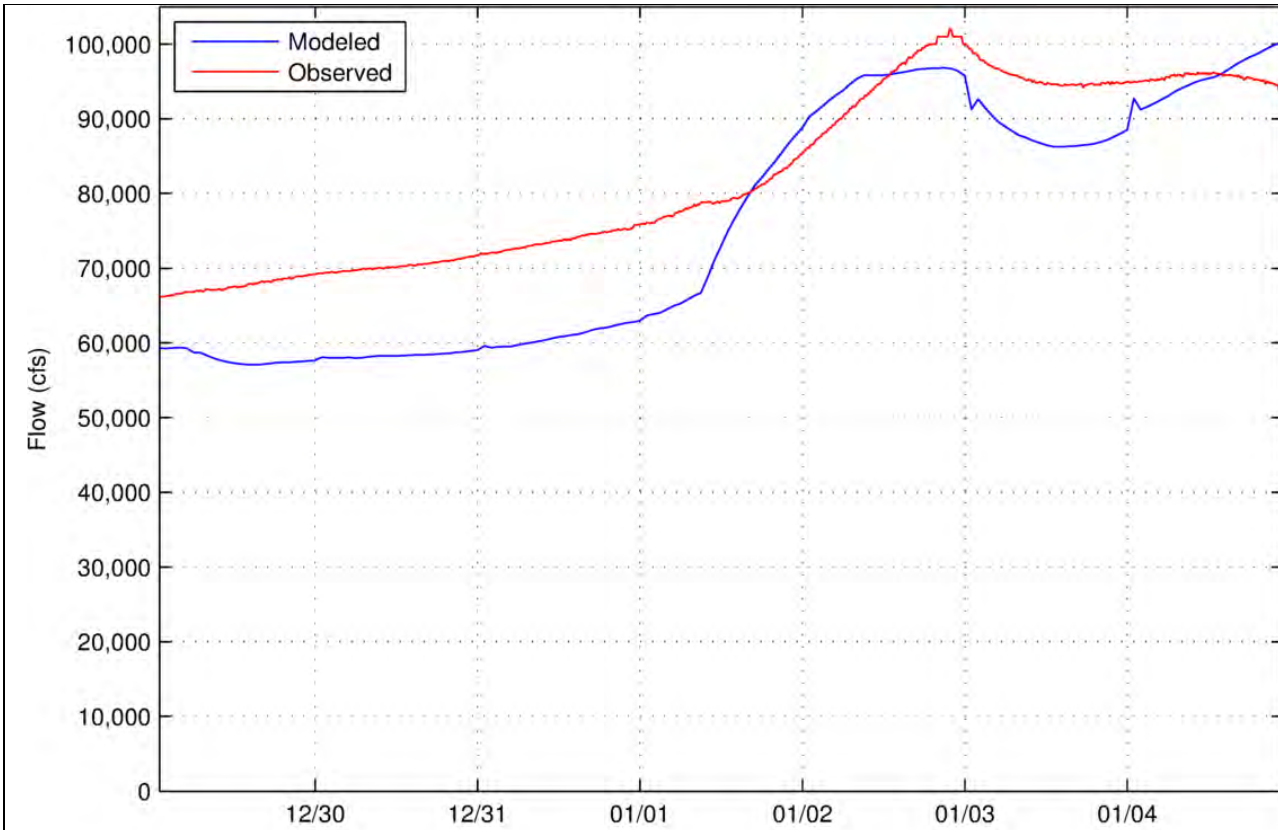
Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **1997 Calibration Fremont Weir East Stage**		
		Prepared for DWR	Created By: RDJ	**Figure 5-7**

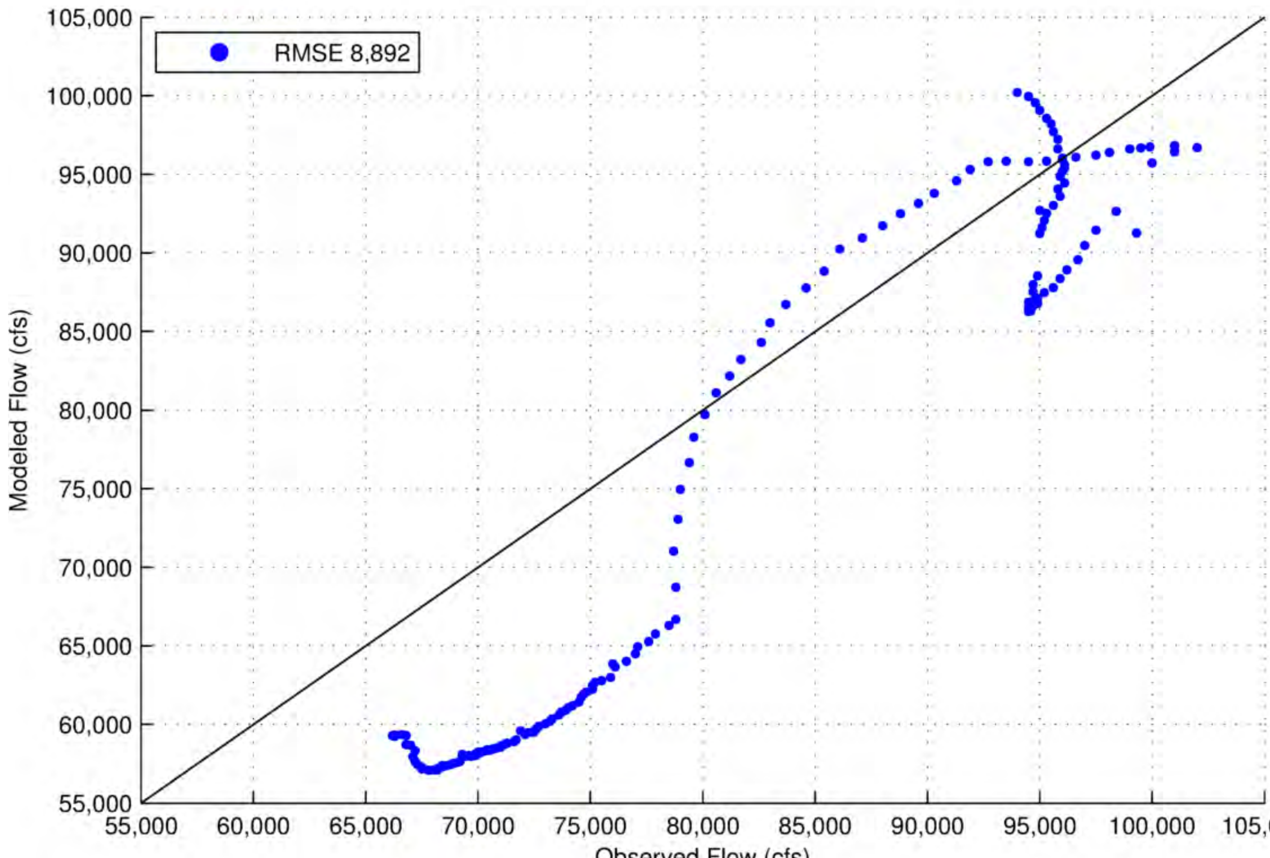


Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage*		
		1997 Calibration Fremont Weir Flow		
		Prepared for DWR	Created By: RDJ	**Figure 5-8**

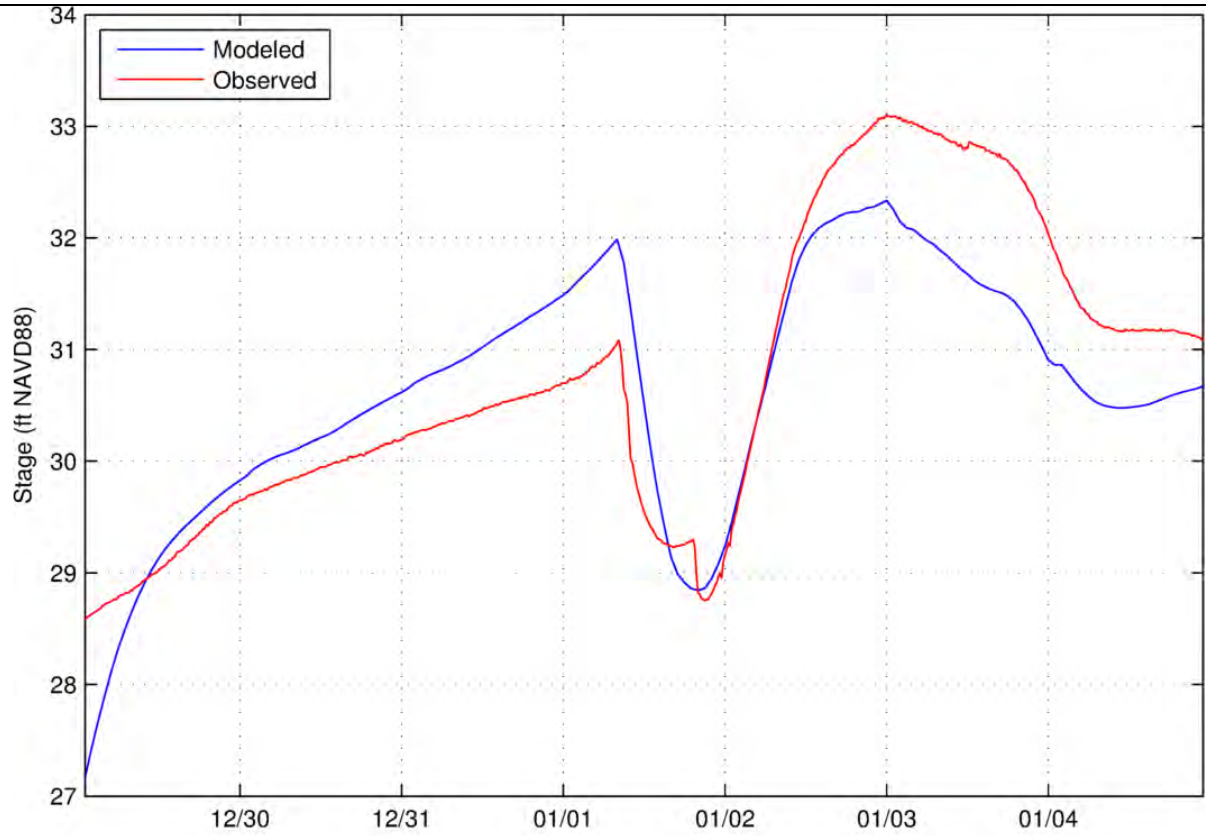


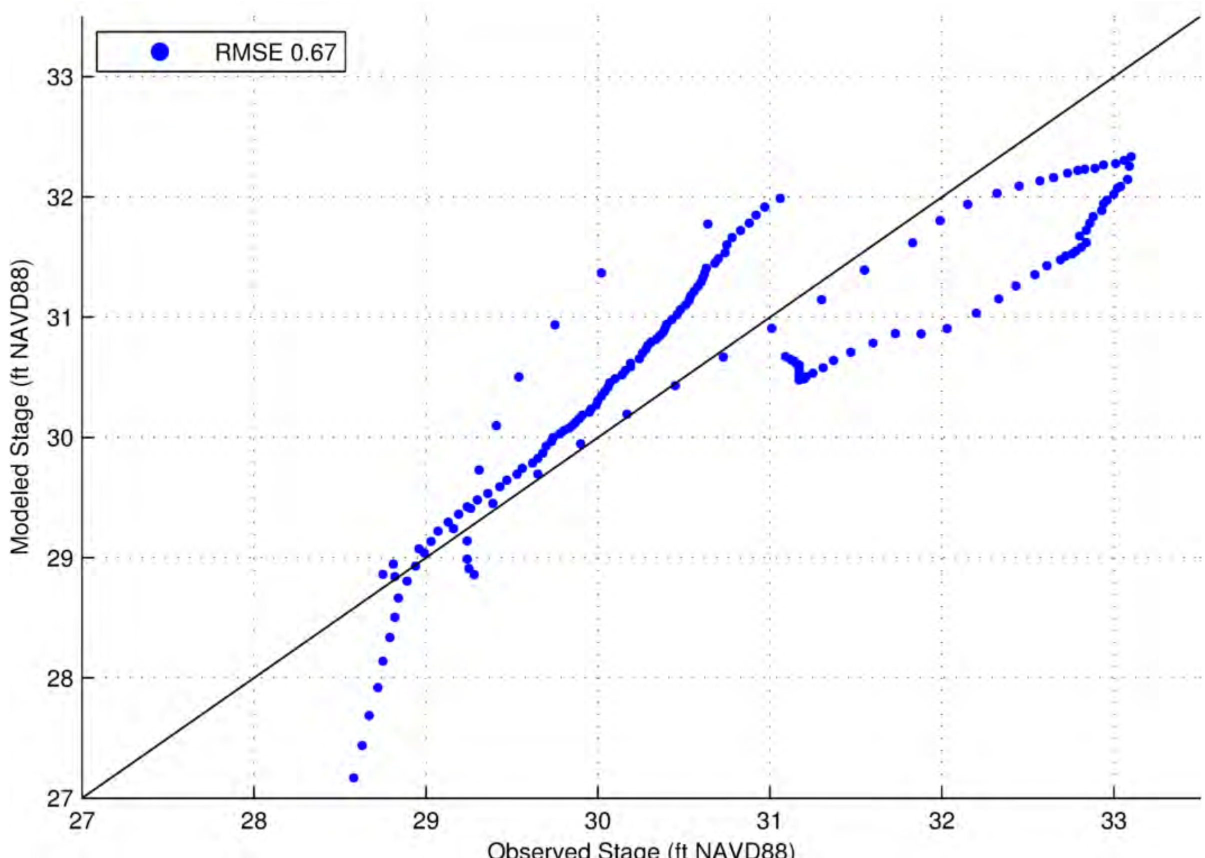
Notes:	HDR cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **1997 Calibration Verona Stage**		
		Prepared for DWR	Created By: RDJ	**Figure 5-9**



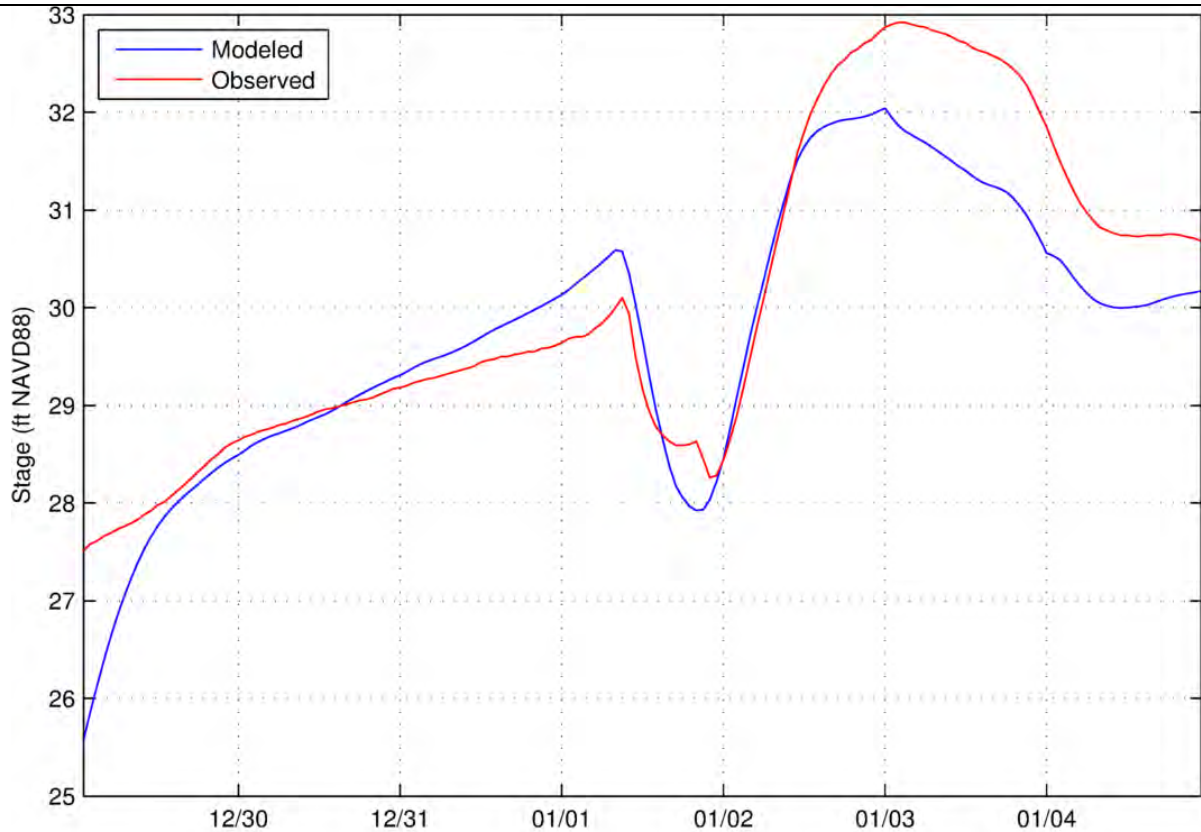


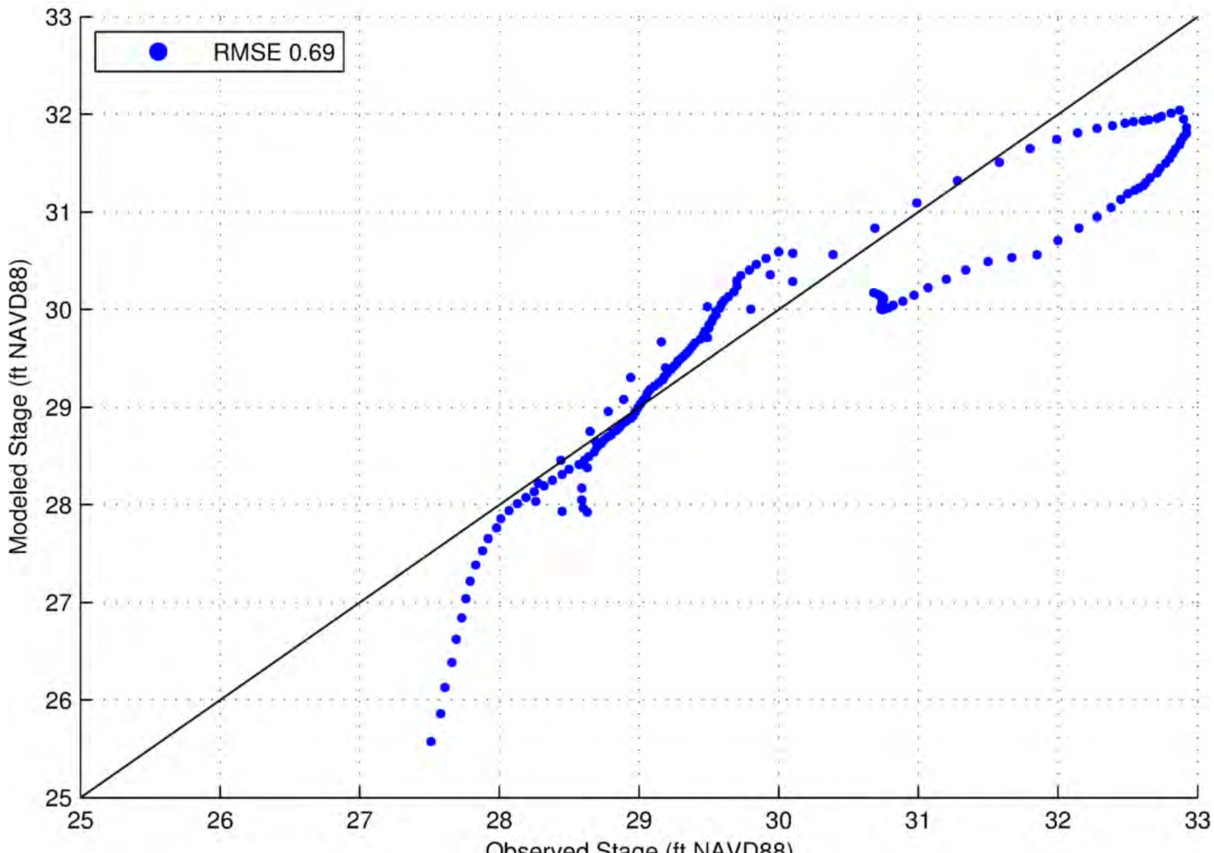
Notes:	HDR cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **1997 Calibration Verona Flow**		
		Prepared for DWR	Created By: RDJ	**Figure 5-10**



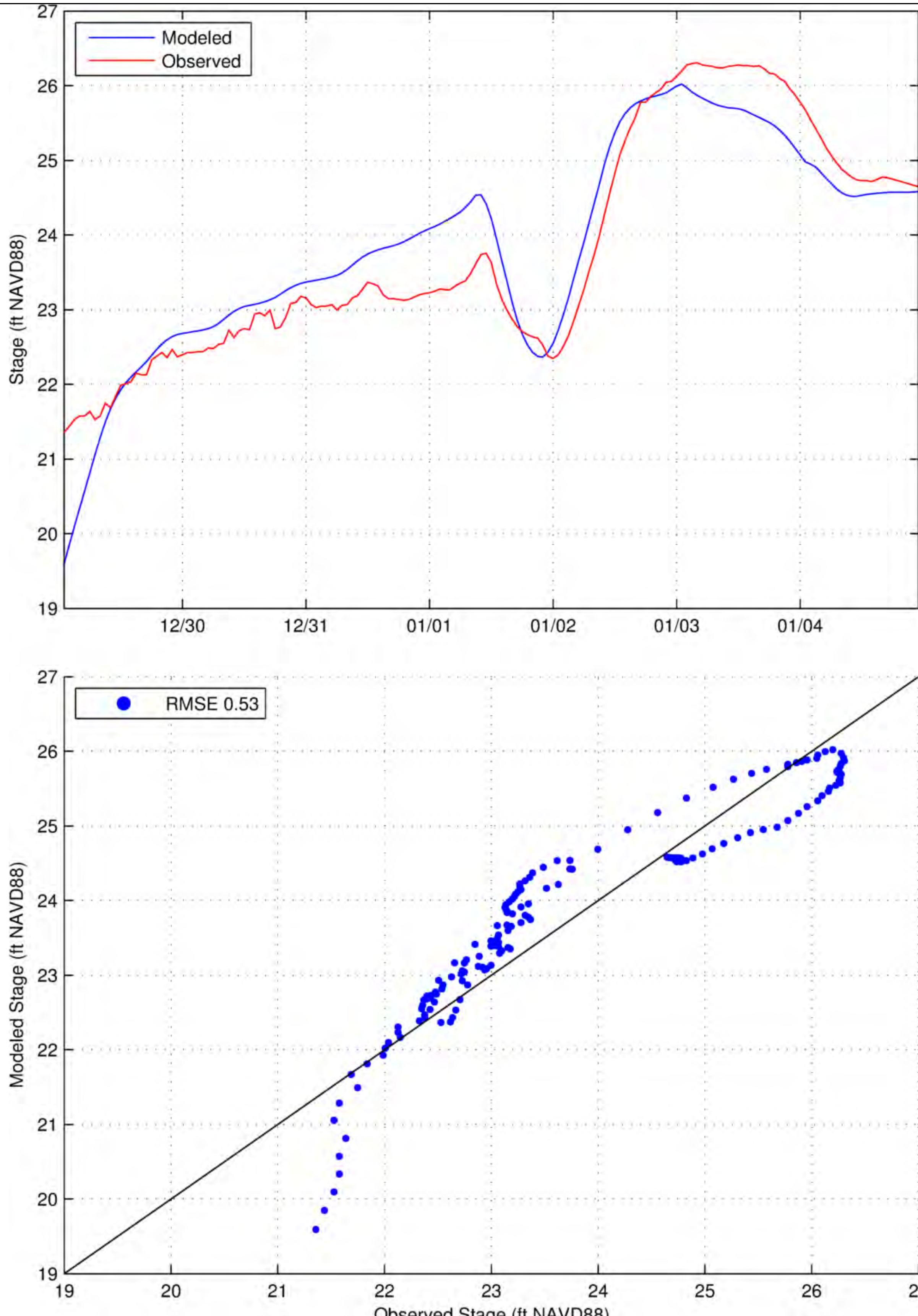


Notes: Upstream of Weir	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **1997 Calibration Sacramento Weir Stage**		
	Prepared for DWR	Created By: RDJ	**Figure 5-11**

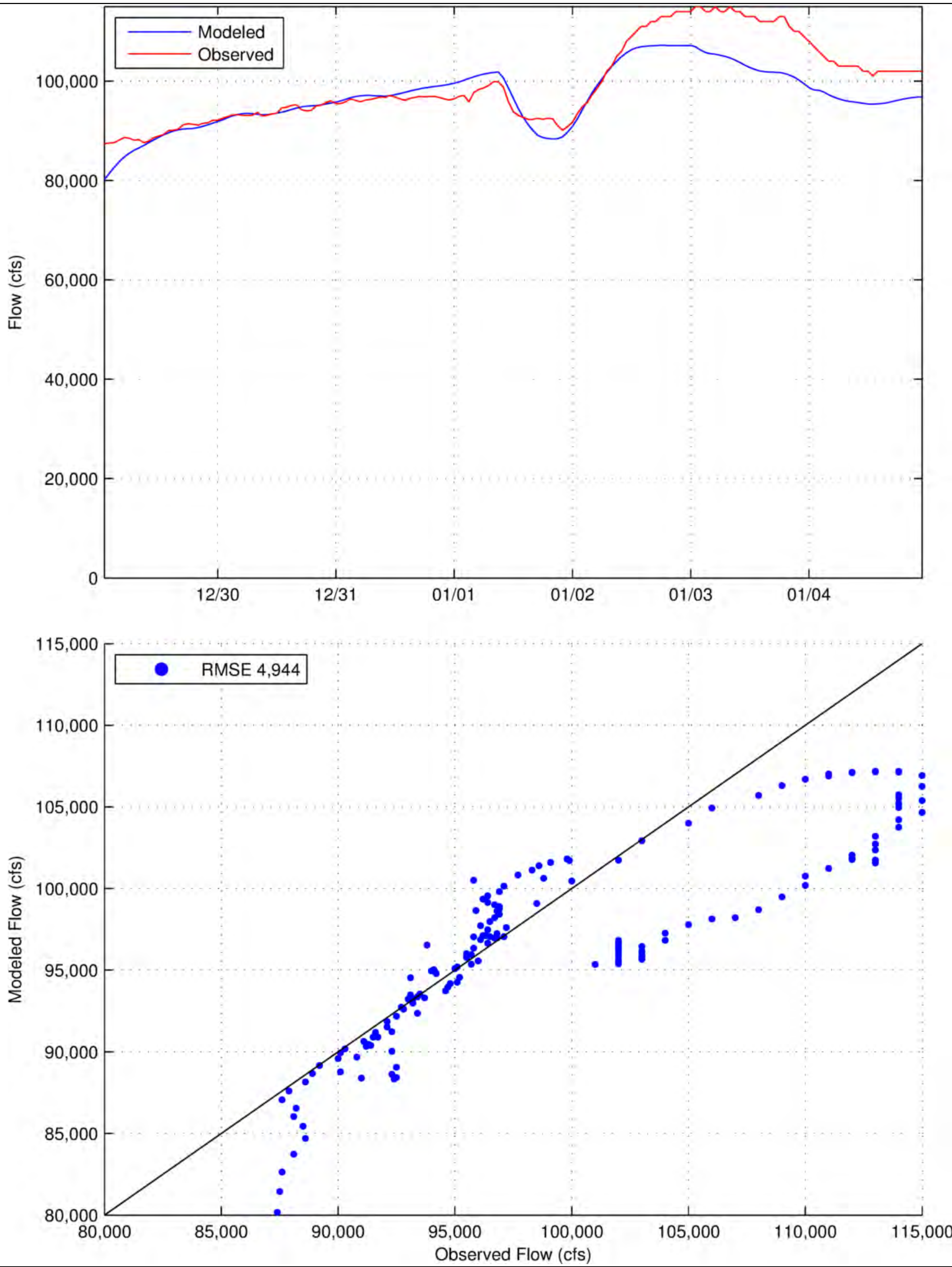




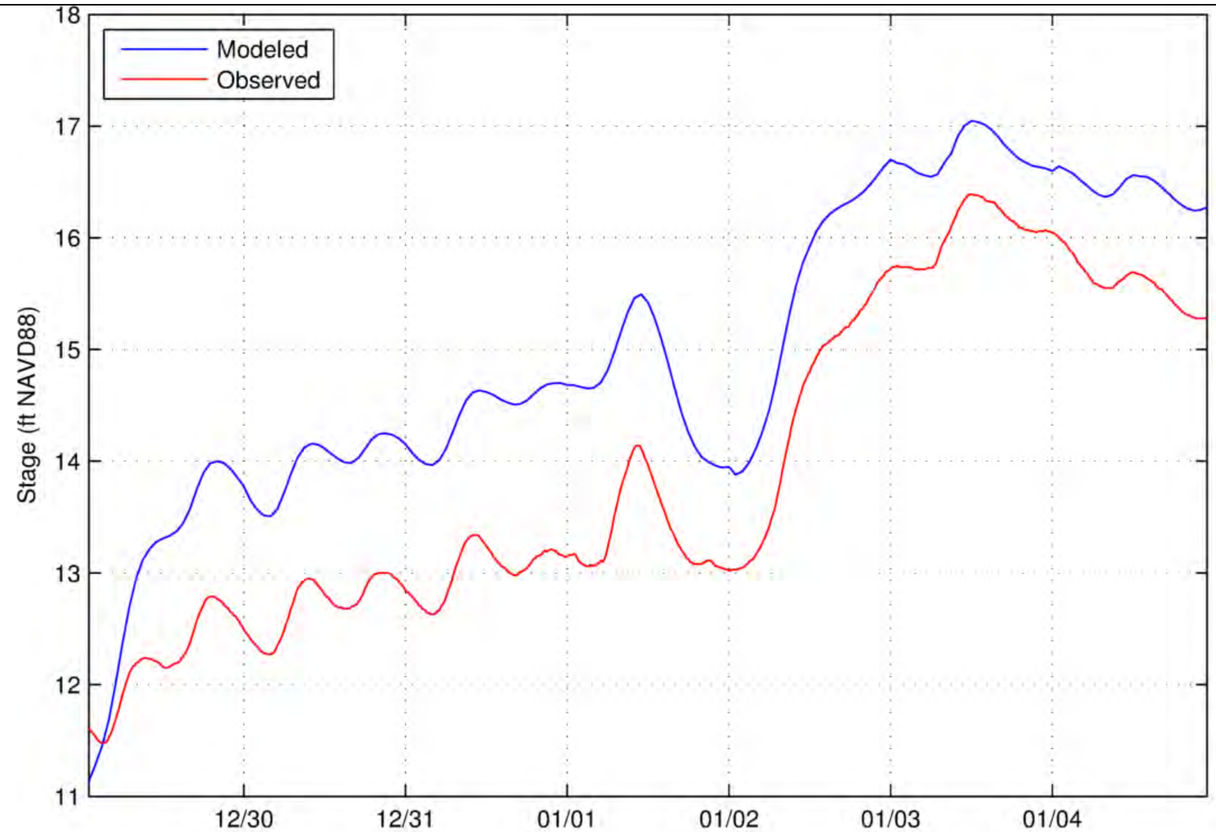
Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage*		
		1997 Calibration Sac U/S Ist Stage		
		Prepared for DWR	Created By: RDJ	**Figure 5-12**

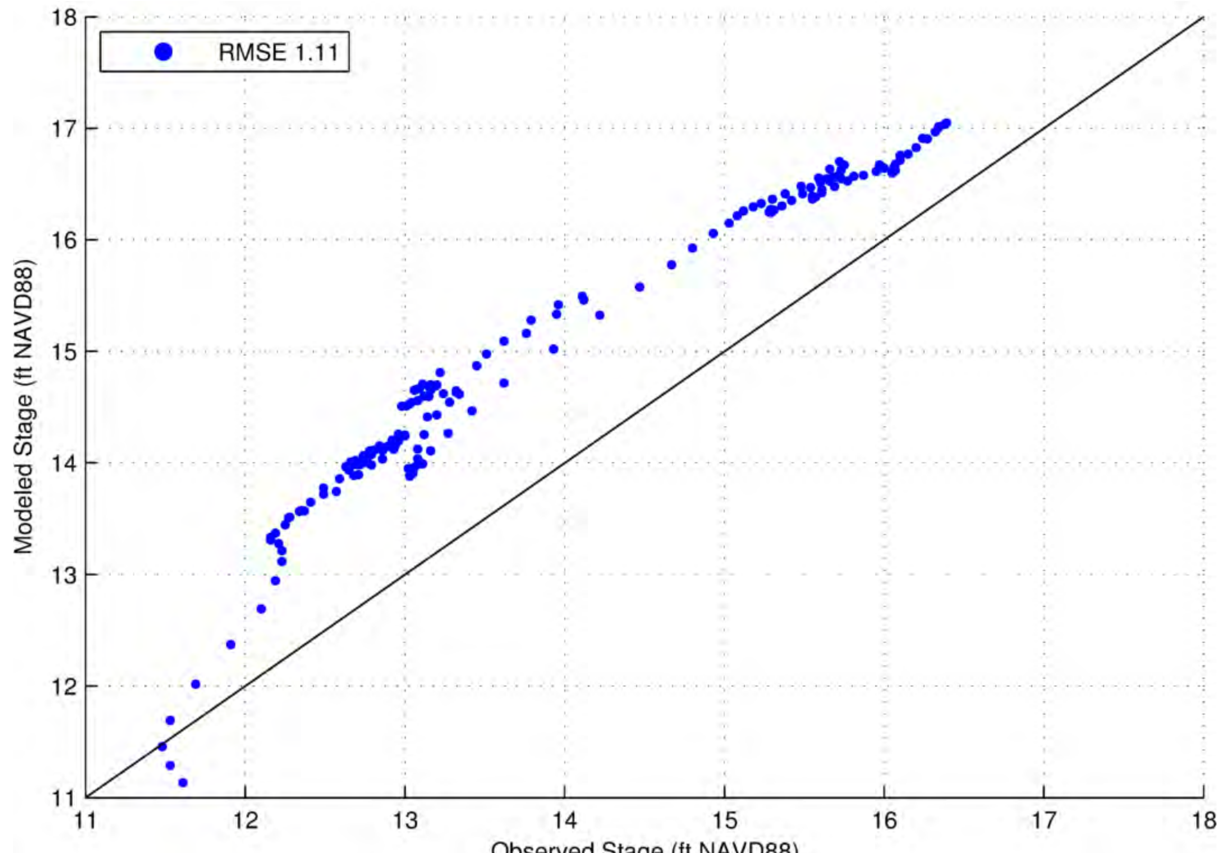


Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage*		
		1997 Calibration Sac at Freeport Stage		
		Prepared for DWR	Created By: RDJ	**Figure 5-13**



Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **1997 Calibration Sac at Freeport Flow**		
		Prepared for DWR	Created By: RDJ	**Figure 5-14**





Notes:		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage*		
		1997 Calibration Sac at Walnut Grove Stage		
		Prepared for DWR	Created By: RDJ	**Figure 5-15**