3.4.2.2 CM2 Yolo Bypass Fishery Enhancement

The purpose of this conservation measure is to improve upstream and downstream fish passage, reduce straying and stranding of native fish, increase availability of floodplain fish rearing and spawning habitat, and stimulate the food web in the Yolo Bypass and to investigate the potential for food web export from the Yolo Bypass to the Delta. The conservation measure requires the preparation and implementation of a Yolo Bypass Fishery Enhancement Plan (YBFEP) that details the specific actions to be implemented to achieve the biological objectives of this measure. Key benefits to covered fish species include reduced migratory delays and loss of salmon, steelhead, and sturgeon at Fremont Weir and other structures; enhanced rearing habitat for Sacramento River Basin salmonids; enhanced spawning and rearing habitat for splittail; and potential improvement of food sources of Delta smelt in habitat downstream of the Bypass. The YBFEP will:

- evaluate alternative actions to restore passage and reduce stranding, including, but not limited to, physical modifications to the Fremont Weir and Yolo Bypass to manage the timing, frequency, and duration of inundation of the Yolo Bypass (Figure 3.4) with gravity flow from the Sacramento River, and to improve upstream fish passage past barriers including Fremont and Lisbon Weirs;
- based on the evaluation, identify the actions, including, but not limited to, the physical modifications to the Fremont Weir and the Yolo Bypass, that will be implemented;
- describe the YBFEP's biological objectives, performance goals, and monitoring metrics in detail;
- ensure compatibility with the flood control functions of the Yolo Bypass;
- identify specific funding sources from the BDCP funding commitments;
- discuss regulatory and legal constraints and how the constraints will be addressed; and
- provide an implementation schedule with milestones for key actions.

The BDCP Implementing Entity will consult with the U.S. Army Corps of Engineers, DWR, DFG, NMFS, and USFWS in development of the YBFEP and will coordinate with Yolo and Solano counties, affected reclamation districts, other flood control entities, and the Yolo Bypass Working Group on a wide range of issues during preparation of the YBFEP. During implementation of this conservation measure, the BDCP Implementing Entity will coordinate with the U.S. Army Corps of Engineers, DWR, reclamation districts, and other flood control entities, as appropriate, to ensure that fish passage improvements, bypass improvements, and Fremont Weir improvements and operations are constructed in accordance with the YBFEP and particularly the compatibility with the flood control functions of the Yolo Bypass.

The YBFEP analysis of alternative actions will focus on the construction of physical improvements and modifications from Fremont Weir downstream to the Lisbon Weir to (1) reduce migratory delays and loss of salmonids and sturgeon at Fremont Weir; and (2) enhance seasonal floodplain habitats for salmonids, splittail, and other covered aquatic species. The YBFEP will also evaluate the need for actions that may be necessary to optimize the number of juvenile salmonids entering the bypass when the water is being diverted through the modified

Fremont Weir. In addition, a gated channel that could provide flows from the Sacramento River, Colusa Basin Drain, Knights Landing Ridge Cut, or other sources into the Yolo Bypass along the west side will be evaluated.

All of the actions identified below will be evaluated in the YBFEP. If supported by the evaluation (i.e., would achieve the biological objectives of this conservation measure), all of these actions will be further developed in the YBFEP and implemented. If the YBFEP evaluation does not support implementation of one or more of the actions--because the action would not be effective, is not needed because of the effectiveness of other actions, would have unacceptable effects on flood control, or for other reasons--the action will not be implemented. However, the YBFEP will identify for implementation specific actions that together are sufficient to achieve the biological objectives identified in the YBFEP.

Actions to Reduce Migratory Delays and Loss of Salmonids and Sturgeon at Fremont Weir

1. Fremont Weir Fish Ladder Replacement. The existing Fremont Weir Denil fish ladder will be removed and replaced with new salmonid passage facilities designed to allow for the effective passage of adult salmonids and sturgeon from the Yolo Bypass past the Fremont Weir and into the Sacramento River when the river overtops the weir. Specific design criteria of the ladder have not yet been determined. This facility will incorporate monitoring technologies to allow for collection of information to evaluate its efficacy at passing adult fishes.

2. Experimental Sturgeon Ramps. An experimental ramp(s) will be constructed at the Fremont Weir to allow for the effective passage of adult sturgeon and lamprey from the Yolo Bypass over the Fremont Weir and into the Sacramento River at flows when the new Fremont Weir Fish Ladder will also be operated when the river overtops the weir by approximately 3 feet (Figure 3.__). Specific design criteria of ramps have not yet been determined. This facility will incorporate monitoring technologies to allow for collection of information to evaluate its efficacy at passing adult fishes.

3. Deep Fish Passage Gates and Channel. To enhance adult fish passage through the Fremont Weir, as part of modifications to the Fremont Weir (see action #8, below), a deep fish passage notch will be cut through a much smaller section of the Fremont Weir to an elevation of 11.5 feet (NAVD88) (Figure 3.__). This notch will be fitted with operable “fish passage gates” that will allow controlled flow into the Yolo Bypass when the Sacramento River stage is between 11.5 and 17.5 feet (NAVD88). A “fish passage channel” will be excavated to convey water from the Sacramento River to the new fish passage gates, and from the fish passage gates to the Tule Canal to convey water from the Sacramento River, through the gates, and to the Tule Canal and Toe Drain.

4. Stilling Basin Modification. Modifications will be made to the existing Fremont Weir stilling basin to ensure that the basin drains sufficiently into the deep fish passage channel. Effective drainage of the stilling basin will prevent stranding of juvenile and adult fish that are attracted to pooled water in the stilling basin during drainage of the floodplain.

5. Sacramento Weir Improvements. Modifications will be made to reduce leakage at the Sacramento Weir and therefore reduce attraction of fish from the Yolo Bypass to the weir where they are blocked and could become stranded. For comparative analysis purposes, the plan will review the benefits and necessity of constructing fish passage facilities at the Sacramento Weir to reduce juvenile fish stranding and improve upstream adult fish passage. This action may require excavation of a channel to convey water from the Sacramento River to the Sacramento Weir and from the Sacramento Weir to the Toe Drain, construction of new gates at a portion of the weir, and minor modifications to the stilling basin of the weir to ensure proper basin drainage. Specific design criteria of ramps would need to be determined.

6. Tule Canal/Toe Drain and Lisbon Weir Improvements. The YBFEP will include physical modifications to passage impediments, including road crossings and agricultural impoundments in the Tule Canal/Toe Drain to improve fish passage and survival. The plan will evaluate the benefits of replacing three existing structures at the northern end of the Tule Canal with bridges or other structures to allow adult fish passage. Lisbon Weir will be redesigned to improve fish passage while maintaining or improving water capture efficiency for irrigation.

7. Lower Putah Creek Improvements. The YBFEP will include a realignment of Lower Putah Creek. The YBFEP will include a realignment sufficient to improve upstream and downstream passage of Chinook salmon and steelhead in Putah Creek and floodplain habitat restoration to provide benefits for multiple species on existing public lands. This action will be designed so that it will not create stranding or migration barriers for juvenile salmon.

Actions to Increase Seasonal Floodplain Habitats for Salmonids, Splittail, and other Covered Aquatic Species

8. Fremont Weir Modification. The YBFEP will include engineering designs to physically modify the Fremont Weir to manage the timing, frequency, and duration of inundation of the Yolo Bypass (Figure 3.4) with Sacramento River flows. The plan will support the physical and biological attributes described in Section 3.4.2.1, *Physical Habitat Conservation Concepts*. In the BDCP Effects Analysis, it was assumed a section of the Fremont Weir will be lowered to 17.5 feet (NAVD88) (lower elevations may be considered if necessary to satisfy inundation targets or fish passage needs) and fitted with operable gates that will allow for controlled flow into the Yolo Bypass when the Sacramento River stage at the weir exceeds 17.5 feet. Separate operable gates will be designed and operated to provide for the efficient upstream and downstream passage of sturgeon and salmonids to and from the Yolo Bypass into the Sacramento River (as described in action #3 above). The YBFEP will explain how this modification will provide significantly increased acreage of seasonal floodplain rearing habitat with biologically appropriate durations and magnitudes on a return rate of one to three years, depending on water year type.

9. Yolo Bypass Modification. Grading, removal of existing berms, levees, and water control structures, construction of berms or levees, re-working of agricultural delivery channels, and earthwork or construction of structures to reduce Tule Canal/Toe Drain channel capacities will be conducted to the extent necessary to improve the distribution (e.g., wetted area) and hydrodynamic characteristics (e.g., residence

times, flow ramping, and recession) of water moving through the Yolo Bypass. The YBFEP will include modifications that will allow water to inundate in certain areas of the bypass to maximize biological benefits and keep water away from other areas to reduce stranding of covered fish species in isolated ponds, minimize impacts to terrestrial covered species, including giant garter snake, and accommodate other existing land uses (e.g., wildlife, public, and agricultural use areas). If necessary, lands will be acquired, in fee-title and through conservation or flood easements.

10. Westside Channel. The YBFEP will include a feasibility study and evaluation of a gated channel to provide flows into Yolo Bypass along the west side. Potential flow sources are the Sacramento River, Colusa Basin Drain or Sacramento River flows through Knights Landing Ridge Cut, or augmentation of other western tributaries. Some modification of the existing configuration of the discontinuous channels along the western edge of the Yolo Bypass may also be required. If effective at meeting biological objectives, this option could be included in the implementation of the conservation measure.

Operational Criteria and Adaptive Limits

The YBFEP will include operational criteria as well as a strategy for adaptive management. The YBFEP will describe how a modified Fremont Weir will be operated to manage the timing and increase the frequency and duration of inundation of a portion of the Yolo Bypass with Sacramento River flows via the Fremont Weir to achieve the biological goals and objectives. The YBFEP will take into account both Weir and tributary inflows.

In the Effects Analysis, inundation timing, frequency, and duration in the Yolo Bypass within the period of December 1 through March 31 (with occasional extension to May 15, depending on hydrologic conditions and measures to minimize land use and ecological conflicts) at the reduced weir elevation of 17.5 feet was considered. In evaluating this scenario, target flows into the bypass were between 3,000 and 6,000 cfs. In the Effects Analysis, flow through modified Fremont Weir gates was limited to maximum spills of 6,000 cfs when the Sacramento River was not spilling over the 33 foot crest of the weir. For the Effects Analysis, no management of the gates was assumed to limit lower flows (e.g., <3,000 cfs). The YBFEP will further refine these operational criteria to provide the specific biological objectives, restoration actions, and locations necessary to meet performance goals including habitat attributes, juvenile and adult metrics, and inundation depth and duration criteria. The YBFEP will include criteria for rare situations to limit flooding when, as determined by the BDCP Implementing Entity, inundation could cause more harm than benefit to covered species. Gates will remain closed in such situations

Under existing conditions the Fremont Weir is overtopped and spills into the Yolo Bypass in about 70 percent of years. The proposed notch and gates could increase that frequency to about 75-95 percent of years with a modified weir height of 17.5 feet (NAVD88) compared to the existing weir height of 33 feet (NAVD88). The frequency of Fremont Weir spills of at least 30 days at 3,000 cfs between 1984 and 2007 would double with a modified weir height of 17.5 feet compared to the existing weir height of 33 feet (Table 3.##). Once the targeted duration of inundation is achieved and the river is below the top of the Fremont Weir, the weir gates could be operated to reduce diversion of flow from the Sacramento River to allow for drainage of the Bypass while still allowing for fish passage. The basic flood control functions of the Fremont Weir will not be changed; at flood stage, the weir will overtop as it does currently.

Table 3.##. Number of events (number of water years[1] in which events took place in parentheses) with consecutive spills producing[2] at least 3,000 cfs over the Fremont Weir under current (elevation = 33 ft NAVD88) and weir with proposed elevational change (elevation 17.5 ft NAVD88) conditions.

	Events during Water Years 1984-2008[3]		*Events during Water Years 1929-2008[3]*	
	Current Weir	**Proposed Notch**	**Current Weir**	**Proposed Notch**
Less than 30 days	17 (10)	42 (20)	48 (29)	137 (62)
At least 30 days	9 (9)	18 (14)	11 (10)	70 (52)
At least 45 days	4 (4)	11 (11)	5 (5)	46 (41)

Notes:

1. Water Year is defined as August 1 of the previous year through July 31 of the current year. For example, Water Year 2005 is August 1, 2004 to July 31, 2005.
2. Assumes no more than a 7 day gap in flooding to count as the same event
3. Flows between October 1, 1929 and December 31, 1983 have been reconstructed from the hydrologic record

Problem Statement

The majority of historical floodplain in the Sacramento and San Joaquin River systems have been lost, particularly floodplains that flow directly into the Delta. This loss of floodplains has resulted in a reduction of highly productive rearing habitat for juvenile salmon and spawning and rearing habitat for other native species such as splittail. Loss of floodplain habitat has reduced the seasonal input of organic and inorganic material and food resources into adjoining riverine habitat and the downstream bay and estuary. Inundation of the Yolo Bypass from the Sacramento River is currently limited to times when the Fremont Weir is overtopped, limiting the availability of habitat for covered fish species and inputs to the food web from the Yolo Bypass.

The current configuration of the Yolo Bypass and Fremont Weir creates passage impediments and potential stranding for adult Chinook salmon, steelhead, green and white sturgeon, and river and Pacific lamprey and stranding hazards for juvenile Sacramento splittail, sturgeon, Chinook salmon, and steelhead. First, the Denil fish ladder at the Fremont Weir, designed for adult salmonid passage, is not effective at passing salmon, adult sturgeon and lamprey. Second, the stilling basins immediately downstream of the Sacramento and Fremont weirs have higher stranding rates of juvenile Chinook salmon than do earthen ponds as floodwater recedes (Sommer et al. 2005). Third, there are road crossings and agricultural impoundments in the Tule Canal/Toe Drain that block hydrologic connectivity, and therefore, fish passage. Fourth, the Lisbon Weir, which was built to impound agricultural water in the Toe Drain upstream of the weir, creates a passage impediment for fish at low stage when riprap is exposed or shallowly submerged.

Putah Creek is used for spawning habitat by a small population of Chinook salmon and steelhead. The Los Rios Check Dam, an irrigation impoundment structure, is seasonally removed but remains in place for several months while adult salmon and steelhead are attempting to migrate upstream. The reach of channel downstream of the check dam runs through a straight ditch to the Toe Drain. Putah Creek often breaks through its bank a short distance upstream of the Los Rios Check Dam, requiring periodic road maintenance at the Yolo Bypass Wildlife Area.

Hypothesized Benefits

Modifying the Fremont Weir and its operations and improving fish passage will reduce the adverse effects of stressors related to food availability, habitat availability, passage, harvest, stranding, predation, and entrainment for some of the covered fish species. Specifically, this conservation measure will:

- create additional spawning habitat for Sacramento splittail (Sommer et al. 2001a, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). Because splittail are primarily floodplain spawners, successful spawning is predicted to increase with increased floodplain inundation;

- create additional juvenile rearing habitat for Chinook salmon, Sacramento splittail, and possibly steelhead (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). Growth and survival of larval and juvenile fish is higher in the floodplain compared to those rearing in the mainstem Sacramento River (Sommer et al. 2001b);

- increase downstream juvenile passage of Chinook salmon, Sacramento splittail, river and Pacific lamprey, and possibly steelhead. An inundated Yolo Bypass is used as an alternative to the mainstem Sacramento River for downstream migration of salmonids, splittail, river lamprey, and sturgeon. Sommer et al. (2003, 2004a) found that, other than steelhead and Pacific lamprey, juveniles from all of these species inhabit the Yolo Bypass during periods of inundation. Based on the timing and life history traits of steelhead relative to Chinook salmon, steelhead likely also benefit from inhabiting the Yolo Bypass. Similarly, based on the timing and life history traits of Pacific lamprey relative to river lamprey, Pacific lamprey likely also benefit from inhabiting the Yolo Bypass

- increase adult upstream passage of fall-, late fall-, winter-, and spring-run Chinook salmon, steelhead, green and white sturgeon, and river and Pacific lamprey. It is thought that an inundated Yolo Bypass is used as an alternative route by upstream migrating adults of these species when Fremont Weir is spilling ;

- increase food production for rearing salmonids, splittail, and other covered species on the floodplain (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). During periods when the bypass is flooded, there is relatively high production of zooplankton and macroinvertebrates that serve, in part, as the forage base for many of the covered fish species (Benigno and Sommer 2008);

- increase the availability and production of food in the Delta, Suisun Marsh, and bays downstream of the bypass, including restored habitat in Cache Slough, for delta smelt, longfin smelt, and other covered species by exporting organic material and phytoplankton, zooplankton, and other organisms produced from the inundated floodplain into the Delta (Schemel et al 1996, Jassby and Cloern 2000, Mitsch and Gosselink 2000, Moss 2007, Lehman et al. 2008). The co-occurrence of suitable food supplies (zooplankton) and various life stages of delta smelt (e.g., larval and juvenile life stages) has been assumed to be an important factor affecting delta smelt survival and abundance (Feyrer et al. 2007b, Miller 2007b). The relationship between longfin smelt

abundance and Delta outflow has experienced two step-declines: one after the invasion of *Corbula* and one during the POD years, although the slope of the relationship has not changed, suggesting that longfin smelt are food-limited (Baxter et al. 2008). Hobbs et al. (2006) found evidence of food limitation in early-stage juvenile longfin smelt, although spatially and temporally variable;

- increase the duration that the floodplain is inundated during periods that the Yolo Bypass is receiving water from both the Fremont Weir and the westside tributaries (e.g., Cache and Putah Creeks);

- reduce losses of adult Chinook salmon, sturgeon, and other fish species to stranding and illegal harvest by improving upstream passage at the Fremont Weir. When flows in the Sacramento River recede, the Fremont Weir stops spilling, trapping fish downstream of the weir. Many of these fish remain in the shallow water near the weir, providing easy access to illegal harvesters. Under this conservation measure, the Fremont Weir will be modified to reduce stranding when Sacramento River flows recede;

- reduce the exposure and risk of outmigrating juvenile fish migrating from the Sacramento River into the interior Delta through the Delta Cross Channel and Georgiana Slough, thus decreasing the risk for predation losses (Brandes and McLain 2001);

- reduce the exposure of outmigrating juvenile fish to entrainment or other adverse effects associated with the intakes of the proposed north Delta water diversion facilities by passing juvenile fish into the Yolo Bypass upstream of the proposed intake locations; and

- improve fish passage, and possibly increase and improve seasonal floodplain habitat availability, by retrofitting Los Rios Check Dam with a fish ladder, or creating another, fish-passable route for water from Putah Creek to reach the Toe Drain.

Increasing the frequency and duration of inundation within the Yolo Bypass is the largest opportunity for enhancing seasonally inundated floodplain habitat in the Central Valley . The Yolo Bypass provides the only opportunity for increasing the frequency and duration of inundation of a floodplain in the Planning Area without restoration of historical floodplain surfaces presently in more highly developed, year-round land uses.

Adaptive Management Considerations

Implementation of this conservation measure by the Management Entity will be informed through effectiveness monitoring that will be conducted as described in Section 3.6, *Monitoring and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive Management Program*. Results of both biological and operational monitoring in the Yolo Bypass and the mainstem Sacramento River will be used within the BDCP adaptive management framework to refine and modify project structures and operations and fish passage improvements.

Timeline for Implementation

The Yolo Bypass Fishery Enhancement Plan will be completed within 6 months of approval of BDCP. The Plan shall include: (1) specific biological objectives, restoration actions, and locations; (2) specific operational criteria; (3) a timeline with key milestones, (4) performance goals and associated monitoring, including habitat attributes, juvenile and adult metrics, and inundation depth and duration criteria; (5) specific actions to minimize stranding or migration barriers for juvenile salmon; and (6) identification of regulatory and legal constraints that may delay implementation, and a strategy to address those constraints. Construction of capital improvements identified in the Plan will be completed within five years of completion of the Plan.