Appendix A
Plan Formulation Report

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RECLAMATION

Managing Water in the West

Yolo Bypass Salmonid Habitat and Fish Restoration Project

Plan Formulation Report

U.S. Department of the Interior
Bureau of Reclamation

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List of Abbreviations and Acronyms

A	ampere
AF	acre-feet
AQMD	Air Quality Management District
ARCF	American River Common Features
BMP	best management practice
BO	biological opinion
BPM	Bypass Production Model
CAA	Clean Air Act
CAAQS	California Ambient Air Quality Standard
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife (after January 1, 2013)
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	cubic foot per second
CGS	California Geological Survey
CO	carbon monoxide
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPP	Central Valley Flood Protection Plan
CVP	Central Valley Project
CWA	Clean Water Act
CY	cubic yards
Delta	Sacramento-San Joaquin Delta
DPS	distinct population segment
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELAM	Eulerian-Lagrangian Agent Method
ESA	Endangered Species Act
FL	fork length
FWWA	Fremont Weir Wildlife Area
GHG	greenhouse gas
HEC-RAS	Hydrologic Engineering Center River Analysis System
hp	horsepower
I	Interstate
IMPLAN	Impact Planning and Analysis
ITA	Indian Trust Asset
JEET	Juvenile Entrainment Evaluation Tool
KLRC	Knights Landing Ridge Cut
kVA	kilovolt-amps
kW	kilowatt
LIER	Liberty Island Ecological Reserve

mm	millimeter
NAAQS	National Ambient Air Quality Standard
NAVD 88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NGO	non-governmental organization
NMFS	National Oceanic and Atmospheric Administration National Marine Fisheries Service
O&M	operations and maintenance
O_3	ozone
PR&G	2013 Principles, Requirements and Guidelines for Water and Related Land Resources Implementation Studies
PLC	programmable logic controller
$PM_{2.5}$	fine particulate matter, particles up to 2.5 microns
PM_{10}	coarse particulate matter, particles up to 10 microns
Project	Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
Reclamation	United States Department of the Interior, Bureau of Reclamation
RM	river mile
RPA	reasonable and prudent alternative
SBM	Salmon Benefits Model
SBWA	Sacramento Bypass Wildlife Area
SPFC	State Plan of Flood Control
SRBPP	Sacramento River Bank Protection Project
SRFCP	Sacramento River Flood Control Project
State	State of California
SVAB	Sacramento Valley Air Basin
SWP	State Water Project
TCP	traditional cultural property
TN	ton
TUFLOW	two-dimensional unsteady flow
UCCE	University of California Cooperative Extension
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VAC	volts alternating current
WTP	willingness to pay
YBWA	Yolo Bypass Wildlife Area

1 Introduction

This Plan Formulation Report describes the plan formulation process for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project). The purpose of the Project is to improve fish passage in the Yolo Bypass and increase floodplain fisheries rearing habitat in Yolo Bypass and/or the lower Sacramento River basin. The Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR) (collectively referred to as the Lead Agencies) are working to identify and evaluate alternatives for implementing this Project.

1.1 Background

Substantial modifications have been made to the historical floodplain of California's Central Valley for water supply and flood damage reduction purposes. The resulting losses of rearing habitat, migration corridors, and food web production for fish have adversely affected native fish species that rely on floodplain habitat during part or all of their life history.

DWR is responsible for operating and maintaining the State Water Project (SWP), and Reclamation is responsible for managing the Central Valley Project (CVP). The SWP and CVP deliver water to agricultural, municipal, and industrial contractors throughout California. On June 4, 2009, the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) biological opinion (BO) concluded that, if left unchanged, CVP and SWP operations are likely to jeopardize the continued existence of four anadromous species listed under the Federal Endangered Species Act (ESA): Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and southern distinct population segment (DPS) North American green sturgeon. The NMFS BO sets forth Reasonable and Prudent Alternative (RPA) actions that allow CVP and SWP operations to remain in compliance with the ESA.

RPA actions I.6.1 and I.7 identify fish passage and habitat restoration actions in the lower Sacramento River basin, including the Yolo Bypass. The Yolo Bypass, which currently experiences at least some flooding in approximately 70 percent of years, retains many characteristics of the historical floodplain habitat that are favorable to various fish species. Implementation of the RPA actions would enhance existing floodplain benefits in the lower Sacramento River basin and improve fish passage in Yolo Bypass. The primary function of the Yolo Bypass is flood damage reduction, with most of the bypass also managed as agricultural land. Major California restoration planning efforts (e.g., CALFED Bay-Delta Program, the Bay Delta Conservation Plan, and California EcoRestore) have (or are) focused on the Yolo Bypass as a prime area of the Sacramento Valley for enhancement of seasonal floodplain fisheries rearing habitat.

The two RPA actions that form the basis for alternatives considered in this report include:

- RPA Action I.6.1: Restore floodplain rearing habitat for juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead through increased acreage of seasonal floodplain inundation within the lower Sacramento River basin
- RPA Action I.7: Reduce migratory delays and loss of salmon, steelhead, and sturgeon at Fremont Weir and other structures in Yolo Bypass (NMFS 2009)

In addition to the species included in the NMFS BO, two other species listed under the California Endangered Species Act (CESA) as fisheries Species of Special Concern may benefit from increased floodplain rearing habitat: Sacramento splittail and Sacramento River fall-run Chinook salmon.

1.2 Study Area Location and Description

The study area includes the lower Sacramento River basin, including Yolo Bypass, in Sacramento, Solano, Sutter, and Yolo counties, California. Major water bodies and infrastructure located within the study area include the Sacramento River; Fremont, Sacramento, and Lisbon weirs; Knights Landing Ridge Cut (KLRC) and Wallace Weir; Cache and Putah creeks; Willow Slough Bypass; Tule Canal; and the Toe Drain. Figure 1-1 shows the study area location.

Yolo Bypass is a flood bypass along the Sacramento River located in Yolo, Solano, and Sutter counties. The bypass separates the California cities of Sacramento and Davis. Flood inflow to the bypass primarily occurs through the Fremont Weir. Fremont Weir is one of five weirs along the Sacramento River. The weir overflows into Yolo Bypass at an elevation of 32 feet (crest elevation). Sacramento Weir can also be opened into the bypass to divert additional flood flows to protect Sacramento and West Sacramento. The bypass ends a few miles north of Rio Vista in the Liberty Farms area where it joins first Prospect Slough and then Cache Slough adjacent to the connection of the Sacramento Deep Water Ship Channel. Cache Slough then reconnects with the Sacramento River just north of Rio Vista. The Yolo Bypass has a maximum design flow capacity of 600,000 cubic feet per second (cfs) and covers an area of approximately 59,000 acres (DWR 2010). The Yolo Bypass experiences at least some flooding in approximately 80 percent of the years. The floods of 1986 and 1997 inundated the Yolo Bypass to maximum design capacity.

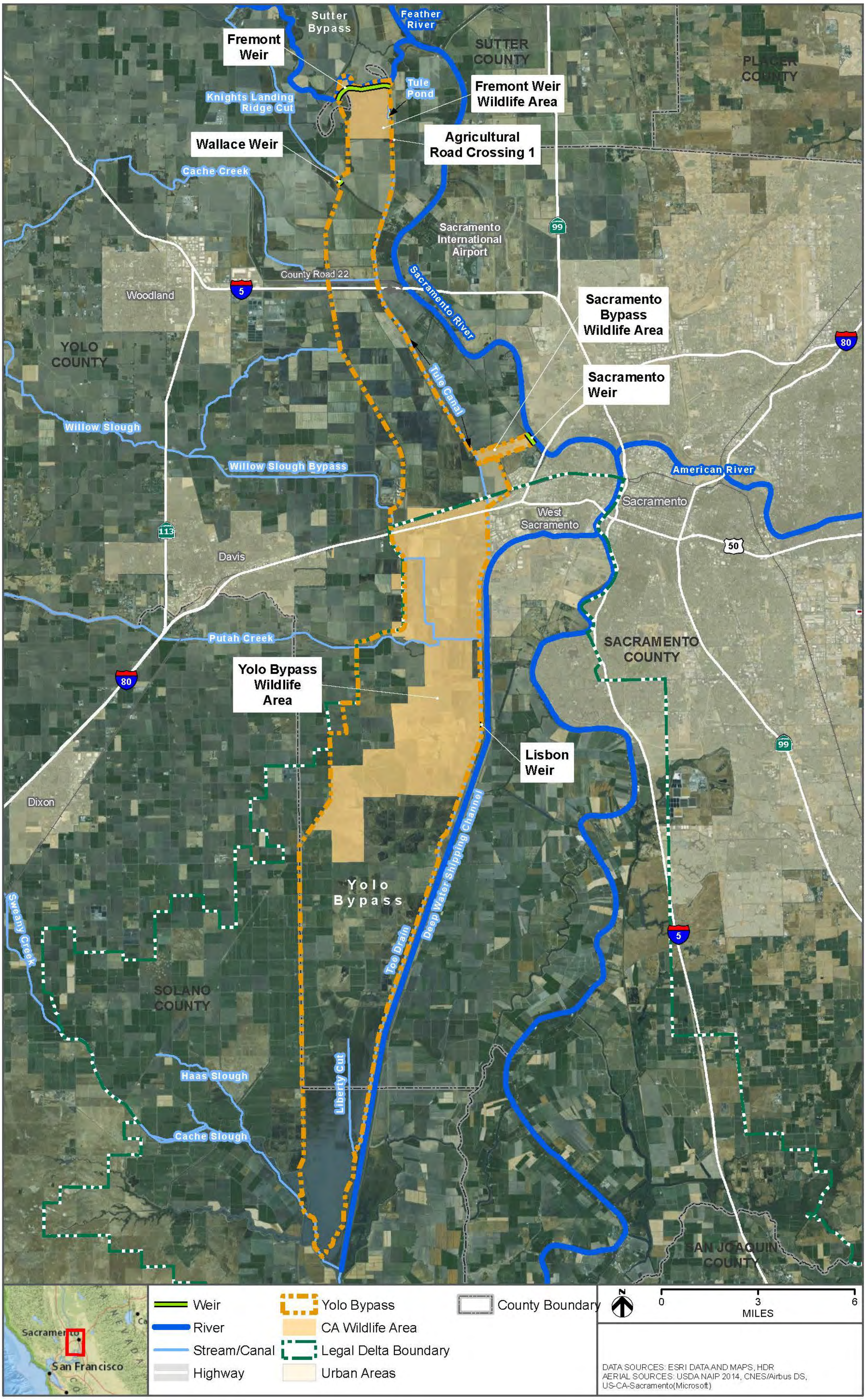

Figure 1-1. Project Area

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Major infrastructure in Yolo Bypass relevant to the Project includes:

- Fremont Weir – Fremont Weir allows relief from the Sacramento River in times of high flood stage to divert water around the City of Sacramento within Yolo Bypass.
- Sacramento Weir – Sacramento Weir is located along the right bank of the Sacramento River approximately two miles upstream from the mouth of the American River. Its primary purpose is to protect the City of Sacramento from excessive flood stages in the Sacramento River channel downstream of the American River.
- Agricultural Road Crossing 1 – Agricultural Road Crossing 1, which is the northernmost agricultural road crossing in Tule Canal at the southeastern corner of the Fremont Weir Wildlife Area (FWWA), serves as a vehicular crossing and a water delivery feature.
- Tule Pond – Tule Pond is an approximately 15-acre perennial pond in Yolo Bypass located about 13 miles north of Interstate (I) 80. It is likely the pond is sustained by multiple sources, including impounded floodwater, leakage from an agricultural canal at its southern end, and groundwater.
- Tule Canal – Tule Canal is a channel along the east side of Yolo Bypass, which begins south of Tule Pond. Tule Canal receives water from westside tributaries and agricultural diversions almost year-round. Tule Canal also drains the initial flows from the Sacramento River when the river rises above the crest of Fremont Weir.
- Toe Drain – Tule Canal becomes the Toe Drain south of the I-80 Yolo Causeway. The perennially wetted Toe Drain extends south approximately 20 miles and becomes increasingly tidal as it connects with Cache Slough, past Lower Yolo Bypass.
- Lisbon Weir – Lisbon Weir is the southernmost water-control structure that crosses the Toe Drain. Lisbon Weir provides higher and more stable water levels to water users north of the weir.

1.3 Authorization

Authority for combined Federal and State of California (State) documents is provided in Title 40, Code of Federal Regulations (CFR), Sections 1502.25, 1506.2, and 1506.4 (Council on Environmental Quality's Regulations for Implementing the National Environmental Policy Act [NEPA]) and California Code of Regulations (CCR) Title 14, Division 6, Chapter 3 (California Environmental Quality Act [CEQA] Guidelines), Section 15222 (Preparation of Joint Documents). This document also was prepared consistent with United States Department of the Interior regulations specified in 43 CFR, Part 46 (United States Department of the Interior Implementation of NEPA, Final Rule).

1.4 Problems, Opportunities, Constraints, and Objectives

The problems, opportunities, constraints, and objectives describe why Reclamation and DWR are considering the Project.

1.4.1 Problems

Populations of the four fish species in the NMFS BO have declined substantially from their historical numbers, primarily due to habitat degradation. The following paragraphs further describe the recent decline of fish populations for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and southern DPS green sturgeon as well as Sacramento River fall-run Chinook salmon and Sacramento splittail, two species of special concern under CESA. This section concludes with a discussion of the problems within the Yolo Bypass that are preventing it from providing rearing habitat and fish passage. Historical fish data and fish problems within the Yolo Bypass are summarized from NMFS 2009 unless otherwise noted.

Sacramento River winter-run Chinook Salmon – Historical Sacramento River winter-run Chinook salmon population estimates were as high as over 230,000 adults in 1969 but declined to under 200 fish in the 1990s. From 2006 to 2008, population estimates were fewer than 3,000 fish. The development of upstream facilities, such as Shasta Dam and Reservoir, blocked much of the winter-run Chinook salmon historical spawning and rearing habitat. Approximately 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run Chinook salmon. The remaining spawning and rearing habitat is severely degraded, and continued threats include impaired water temperatures, impaired water quality from agricultural runoff, degradation of freshwater rearing habitat from levee protection and disconnected rivers from the floodplains, and new water diversion sites.

Central Valley spring-run Chinook Salmon – Historically, spring-run Chinook salmon occupied the upper and middle reaches of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud, and Pit rivers. There were 19 independent populations of spring-run Chinook salmon; now only 3 populations remain. The current spatial distribution for spring-run Chinook has been reduced to Butte, Mill, and Deer creeks. The Feather River also has a significant number of returning spring-run Chinook salmon; however, the hatchery at times spawns spring-run and fall-run together. This practice has compromised the genetic integrity of the Feather River spring-run and fall-run Chinook salmon stocks. Central Valley spring-run Chinook salmon have declined substantially from their historical numbers. These fish were once the second most abundant salmon species in the Central Valley, estimated at 600,000 between 1880 and 1940. A drastic decline in the spring-run Chinook population was experienced in the mid to late 1980s although it stabilized at low levels in the early to mid-1990s. In 2008, the population size was estimated at 10,000. Factors influencing the decline include the development of low elevation dams that have cut off spring-run Chinook salmon from most of their historical upstream spawning grounds. The remaining spawning and rearing habitat are also degraded and do not provide conservation value necessary for the recovery of the species. Other factors include interbreeding with fall-run Chinook salmon due to mismanagement of runs, poor ocean and in-river water quality, and over summering flows with increased water temperatures contributing to disease.

Central Valley Steelhead – Over the past 30 years, the steelhead population has steadily declined from 20,540 in the 1960s to 10,000 in 1993, which was when the last Central Valley steelhead population census was conducted. As such, data for steelhead populations is largely deficient. Historically, there were 81 independent populations of steelhead throughout the Central Valley. The development of upstream dams has contributed to 80 percent of the historical steelhead habitat being impassable or degraded, with 38 percent of the steelhead habitat permanently lost. Small populations of steelhead are still most commonly found in the Sacramento River and most of its tributaries and some tributaries of the San Joaquin River. The remaining habitat conditions are fragmented and degraded and provide little conservation value. Steelhead diversity has also declined due to hatchery-origin fish, which compromise the natural spawning run and threaten natural populations.

Southern DPS of North American Green Sturgeon – Little population data are available for green sturgeon, and some experts disagree on existing estimates due to their small sample sizes. Existing estimates conclude that in 1993 the green sturgeon population was as low as 175; however, after emphasis on improving the viability of the species, in 2001, the population estimate increased to 8,421, with an average increase of 1,509 fish per year. Historical spawning habitat for green sturgeon was widespread throughout the Sacramento River system. Green sturgeon spawning grounds were believed to stretch north past the current locations of Shasta Dam and up into the Pit and McCloud rivers. Today, the spatial distribution for green sturgeon has been relegated to a single spawning area, between the Keswick Dam and Hamilton City, outside of their historic spawning area. Additional factors of decline include loss of juvenile green sturgeon due to entrainment, alteration of food resources due to changes to Sacramento River and Sacramento-San Joaquin Delta (Delta) habitats, and exposure to various sources of contaminants throughout the basin. Reduced population and spatial structure has also led to a reduction in diversity of green sturgeon. Green sturgeon have been reduced to one population variation, which places the species at risk for long-term persistence.

Sacramento splittail – Sacramento splittail is a State Species of Special Concern and was delisted as a threatened species by the United States Fish and Wildlife Service (USFWS) in 2003. In October 2010, USFWS reviewed the status of finding for the Sacramento splittail and concluded it did not warrant protection under the ESA but will continue to monitor the population range (USFWS 2012). While there has been loss of habitat over the years, splittail populations can tolerate a wide variety of environmental conditions. A key to their long-term conservation is providing adequate spawning and rearing habitat and preventing excessive mortality on upstream migrating adults and downstream migrating juveniles (Moyle et al. 2004). Splittail typically spawn in April and May in seasonally inundated floodplains with cooler water temperatures and flowing water.

Sacramento River fall-run Chinook Salmon – Sacramento River fall-run Chinook salmon is a State Species of Special Concern and an NMFS Species of Concern. General factors for decline for fall-run Chinook salmon include habitat loss due to dams and other barriers, water development projects, pollution, hatchery fish interactions, and introduced species (NMFS 2010). Recently, the abundance of fall-run Chinook salmon has become increasingly variable. Increasing the diversity among populations of fall-run Chinook salmon by changing hatchery operations, restoring habitat, and managing for natural production could reduce variability (Lindley et al. 2009).

Yolo Bypass Passage and Habitat Concerns – The Yolo Bypass and Fremont Weir can cause migratory delays or loss of adult fish of the species described above. The Fremont Weir is not passable, and the fish ladder is not adequate under most operations. Other structures, such as the Lisbon Weir, Toe Drain, and agricultural road crossings, also cause delays or prevent passage. Additionally, juveniles can become stranded in scoured areas behind the weir and in other ponds in the bypass.

The Yolo Bypass currently provides rearing habitat for juvenile fish; however, the opportunities for habitat are limited by the frequency and duration of inundation, which is driven by flood management. Changing the inundation frequency and duration could provide additional rearing opportunities.

1.4.2 Opportunities

The Yolo Bypass has been identified as a potential opportunity for habitat restoration to address the problems facing native fish species described in Section 1.4.1. There is growing recognition that naturally functioning floodplains can provide benefits for many fish species by providing an abundant food supply and habitat diversity. The Yolo Bypass, which currently experiences at least some flooding in approximately 80 percent of years, still retains many characteristics of the historical floodplain habitat that are favorable to native fish species.

Inundated floodplains provide important rearing habitat for winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. Floodplain habitat could provide these fish species with physical habitat conditions that support juvenile growth and mobility, water quality, and the forage necessary to support juvenile development (Reclamation and DWR 2012).

Fish passage improvements through the Yolo Bypass could reduce migratory delays and potential stranding and poaching, reducing loss of adult and juvenile winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon. Currently, during flood events, salmon and sturgeon become stranded in isolated areas throughout the bypass where they are exposed to increased risk of mortality. Improving connectivity throughout the bypass is expected to increase rates of survival (Reclamation and DWR 2012).

The Yolo Bypass can also be high quality spawning grounds for splittail by providing sufficient inundation to attract spawning fish and remaining flooded long enough to allow for spawning and rearing of larvae and small juveniles. Restoration of the bypass could produce moderate to strong year classes of splittail that can survive downstream migration (Moyle et al. 2004).

1.4.2.1 Fish Use of the Bypass

The complete set of species benefitting from increasing inundation frequency and duration in the Yolo Bypass is still unclear. However, the species utilizing the bypass generally spawn or reside in the Sacramento River and its tributaries or the Delta. It is likely that most anadromous salmonid species potentially benefitting from the Yolo Bypass when it is inundated spawn in the Sacramento, Feather, and Yuba rivers, and Deer, Mill, Butte, and Clear creeks. However, during some conditions, American River anadromous salmonids could also utilize the Yolo Bypass. Studies have shown as many as 42 species (Sommer et al. 2001) and as few as 29 species (Feyrer et al. 2006a) have been found in the bypass during flooded periods. Feyrer et al. (2006b) found Chinook salmon (*Oncorhynchus tshawytscha*) and splittail (*Pogonichthys macrolepidotus*) made up 79 percent of the total catch in screw traps at the Yolo and Sutter bypasses. Additional native species found in the bypass include lamprey (*Entosphenus spp.*), hitch (*Lavinia exilicauda*), Sacramento blackfish (*Orthodon microlepidotus*), Sacramento pikeminnow (*Ptychochelius grandis*), Sacramento sucker (*Catostomus occidentalis*), prickly sculpin (*Cottus asper*), delta smelt (*Hypomesus transpacificus*), green sturgeon (*Acipenser medirostrus*), and white sturgeon (*Acipenser transmontanus*). A total of 15 native species have been documented in the Yolo Bypass. Much like the rest of the Delta, native species' diversity is less than that of introduced species (Sommer et al. 2003). The most common introduced species include American shad (*Alosa sapidissima*), common carp (*Cyprinus carpoi*), three species of black bass (*Micropterus spp*.), and striped bass (*Morone saxitilis*) (Sommer et al. 2003).

For anadromous species, primarily Chinook salmon and green and white sturgeon, the bypass is an alternate migration route up the Sacramento River. It is thought that anadromous species utilize floodplains as alternate migration routes as a life history strategy to minimize potential population-level effects of potential environmental perturbations in mainstem rivers. Currently, this life history strategy would allow migrating adults to avoid recreational anglers and other anthropogenic disturbances (e.g., water treatment plant outflow, diversion structures). Both Chinook salmon and striped bass showed migration peaks independent of flow in winter (November through December) and spring (March through April), according to Harrell and Sommer (2003). Similarly, American shad and white sturgeon also migrated in the greatest numbers in the spring.

Spawning habitat is potentially the most significant benefit of the Yolo Bypass for some fish species. Harrell and Sommer (2003) showed evidence that 12 of 19 species migrating to the bypass as adults were captured as age-0 fish in screw traps later in the flood season. Splittail are the most numerous native cyprinid in the Yolo Bypass when it is inundated. For most of the year, adult splittail are residents of the lower Delta and San Francisco estuary, moving up the delta to Sacramento River tributaries in the early winter and spring to forage and spawn (Sommer et al. 2003). Spawning typically occurs in shallow, vegetated areas, which historically have been inundated floodplains (Moyle 2002). However, due to the construction of levees in the Sacramento River system, splittail spawning habitat availability has become limited, which in turn results in reduced spawning success, initial year class strength, and low splittail populations, relative to historical conditions (Sommer et al 1997; USFWS 1995). Specifically, Feyrer et al. (2006b) stated that the amount of inundated floodplain available between January and June was the single most important factor in explaining annual production of juvenile splittail.

Generally, food production in floodplain habitats is substantially higher than in mainstem rivers and tributary streams, allowing for increased growth. Sommer et al. (2001) showed significantly higher levels of diptera versus zooplankton in the gut contents of juvenile Chinook salmon raised in the bypass relative to the Sacramento River. Jeffres et al. (2008) observed higher diversity of prey items in the gut contents of age-0 Chinook raised in floodplain ponds on the Cosumnes River versus main channel margins. Both studies also reported increased growth in fish reared on floodplain habitat as compared to the adjacent riverine habitats. Duration of inundation also appears to play a role in benefits to rearing fish. Juvenile Chinook salmon that foraged in the bypass for an annual mean of 30 to 56 days were significantly larger upon emigration out of the bypass according to Sommer et al. (2005). Logic would indicate that larger, more robust fish are of better overall condition and have an increased ability to withstand environmental stresses. However, Sommer et al. (2001) did not show a significant benefit to survival for juvenile Chinook in the bypass.

In addition to increased feeding and growth opportunities, floodplain habitat provides greater area for rearing. Sommer et al. (2002) observed splittail in the range of 15- to 20-millimeter (mm) fork length (FL), using the lower part of the water column in edge habitat of an experimental floodplain. Larger fish (28- to 4 mm FL) showed stronger tendencies toward open water. By 30 to 40 mm FL, age-0 splittail routinely emigrate off the floodplain (Feyrer et al. 2006b). The same report hypothesized that increased foraging opportunities in floodplain habitat would reduce the period required for age-0 splittail to reach lengths required to move into open water.

In addition to rearing native fishes, non-native predatory adult striped bass and black bass migrate onto the floodplain in search of spawning and foraging opportunities. However, the predation success of these fish likely is low. Moyle et al. (2004) suggests that expanded habitat from increased water levels has an inverse relationship to predator density, lowering these encounters for age-0 splittail. However, if water temperatures are suitable, spawning success could be high, potentially resulting in higher predator concentrations in the Toe Drain and Cache Slough complex after floodplain inundation.

1.4.3 Planning Constraints

Constraints provide limits on the planning process based on institutional, legal, and physical restrictions, among others. Alternatives for the Project must adhere to the following constraints:

- Regulations and Authorities: The Project must follow all relevant Federal, State, and local laws and regulations, including NEPA, CEQA, the Fish and Wildlife Coordination Action, Clean Air Act (CAA), Clean Water Act (CWA), ESA and CESA, Magnuson Stevens Act, and the CVP and SWP authorities.
- Flood Protection Limitations: The Yolo Bypass is included as a part of the Central Valley Flood Protection Plan (CVFPP) and the Sacramento Valley Flood Control Project and currently provides flood protection for much of the Sacramento Valley; thus, the level of flood protection in the area cannot be reduced.
- Physical Limitations: The NMFS BO specifies that the seasonal floodplain rearing habitat must be in the lower Sacramento River basin, including the Yolo Bypass. Actions in other locations were considered separately and would not be able to satisfy this requirement.

1.4.4 Planning Objectives

The planning objectives are described in the purpose and need statements and objectives, which describe the underlying need for and purpose of a proposed project. The purpose statement is a critical part of the environmental review process because it helps to set the overall direction of an Environmental Impact Statement (EIS)/ Environmental Impact Report (EIR), identify the range of reasonable alternatives, and focus the scope of analysis.

1.4.4.1 Purpose and Need

The need for action is decreased habitat quality and an inadequate ability to access that habitat, which has led to a decline in abundance, spatial distribution, and life history diversity associated with native ESA-listed and CESA-listed fish species. The purpose of the action is to enhance floodplain rearing habitat and fish passage in Yolo Bypass and/or other suitable areas of the lower Sacramento River by implementing RPA actions I.6.1 and I.7, as described in the NMFS BO, to benefit Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead.

1.4.4.2 Project Objectives

The objective of RPA action I.6.1 is to increase the availability of floodplain fisheries rearing habitat for juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. This action can also improve conditions for splittail and Central Valley fall-run Chinook salmon under CESA. Specific biological objectives include:

- Improve access to seasonal habitat through volitional entry
- Increase access to and acreage of seasonal floodplain fisheries rearing habitat
- Reduce stranding and presence of migration barriers
- Increase aquatic primary and secondary biotic production to provide food through an ecosystem approach

The objective of RPA action I.7 is to reduce migratory delays and loss of fish at Fremont Weir and other structures in Yolo Bypass. Specific biological objectives include:

- Improve connectivity within Yolo Bypass for passage of salmonids and green sturgeon
- Improve connectivity between the Sacramento River and Yolo Bypass to provide safe and timely passage for:
  - Adult Sacramento River winter-run Chinook salmon between mid-November and May when elevations in the Sacramento River are amenable to fish passage
  - Adult Central Valley spring-run Chinook salmon between January and May when elevations in the Sacramento River are amenable to fish passage
  - Adult California Central Valley steelhead in the event their presence overlaps with the defined seasonal window for other target species when elevations in the Sacramento River are amenable to fish passage
  - Adult southern DPS green sturgeon between February and May when elevations in the Sacramento River are amenable to fish passage

1.5 Related Studies, Projects, and Programs

This section describes studies, projects, and programs conducted by various Federal, State, and local agencies that are directly or indirectly related to the Project.

1.5.1 Central Valley Flood Protection Plan

The CVFPP sets forth a comprehensive framework for system wide sustainable flood management and investment to improve flood risk management along the Sacramento and San Joaquin River basins. The CVFPP proposes three preliminary approaches for sustainable, integrated flood management in areas currently protected by facilities of the State Plan of Flood Control (SPFC).

1. The first approach would improve existing SPFC facilities to convey design flows.

2. The second approach evaluates improvements to levees to protect life safety and property for high risk population centers, including urban and small communities.
3. The last approach would provide enhanced flood system storage and conveyance capacity to protect high risk communities. This approach combines features of the first and second approach and allows flood conveyance channels to lower flood stages, with additional features and functions for ecosystem restoration and enhancements.

The Enhance Flood System Storage approach of the CVFPP recommends increasing the capacity of the existing bypass system, including the Sutter and Yolo bypasses. The approach includes: 1) widening the Sutter Bypass by up to 1,000 feet to increase its capacity by 50,000 cfs, 2) widening the Colusa Weir and Bypass and the Tisdale Weir and Bypass by up to 1,000 feet, 3) widening the Fremont Weir by about 1 mile and widening portions of the Yolo Bypass to increase its capacity by 40,000 cfs, and 4) widening the Sacramento Weir and Bypass by about 1,000 feet (DWR 2011).

1.5.2 American River Common Features General Reevaluation Report

The American River Common Features (ARCF) Reevaluation Report proposes measures in addition to current and other planned measures to reduce the risk of flooding in the Sacramento and American rivers watersheds.

The tentatively selected plan in the ARCF includes: 1) construction of nine miles of slurry cutoff walls to address levee seepage and stability issues along the Sacramento River, 10 miles of rock bank protection to address erosion problems along the Sacramento River east levee, 2.5 miles of geotextile stabilized slope and two miles of slope flattening to address levee stability and less than one mile of levee raise; 2) construction of rock bank protection and launchable rock trenches to address erosion problems along four miles of the right (north) bank and seven miles of the left (south) bank of the American River; 3) construction of four miles of slurry cutoff walls to address levee seepage and stability problems and 7.5 miles of levee raises to address potential overtopping of floodwaters along the Natomas East Main Drain Canal, Arcade Creek, and Dry Creek levees; and 4) widening of the Sacramento Weir and Bypass by 1,500 feet to reduce the water surface elevation in the Sacramento River and allow more water to flow into the Bypass system.

1.5.3 Sacramento River Bank Protection Project General Reevaluation Report

The Sacramento River Bank Protection Project (SRBPP) provides protection to the existing levee and flood control facilities of the Sacramento River Flood Control Project (SRFCP). Phase III of the SRBPP will be executed through a SRBPP General Reevaluation Report and includes the following: 1) comprehensive sediment stud, 2) thorough economic analysis, 3) continued biological studies and monitoring, 4) comprehensive cultural resources survey, 5) detailed real estate plan, and 6) updated mitigation site inventory and needs assessment (DWR and United States Army Corps of Engineers [USACE] 2009).

1.5.4 California EcoRestore

The California EcoRestore initiative accelerates the implementation of a comprehensive suite of habitat restoration actions to support the long-term health of the Delta's native fish and wildlife species. The project will coordinate and advance at least 30,000 acres of critical habitat restoration (25,000 acres associated with existing mandates for habitat restoration, pursuant to Federal BOs, and 5,000 acres of habitat enhancements). Several projects are being implemented in the Yolo Bypass:

1. Wallace Weir Fish Rescue Facility: Improvements to Wallace Weir to block fish passage into KLRC and construction of a new fish rescue facility
2. Fremont Weir Adult Fish Passage Modification Project: Modifications to the existing fish passage facility in Fremont Weir and improvements at two agricultural road crossings over the Tule Canal to provide fish passage
3. Lisbon Weir Fish Passage Modification Project: Modifications to Lisbon Weir to improve fish passage (without affecting water supplies)
4. Lower Putah Creek Realignment: Improvements to conditions in Putah Creek and realignment of the channel to connect to the Toe Drain downstream of Lisbon Weir

These projects are also RPA actions: Wallace Weir improvements and Fremont Weir Adult Fish Passage Modification Project are part of RPA action I.7, Lisbon Weir improvements are under RPA action I.6.4, and Lower Putah Creek Realignment is under RPA action I.6.3.

1.5.5 Experimental Agricultural Floodplain Habitat Investigation at Knaggs Ranch on Yolo Bypass

This experimental agricultural floodplain habitat investigation was developed to better understand how management of rice fields may affect water quality, invertebrate assemblages and abundance, juvenile salmon growth, survival, and behavior. Three concurrent studies were conducted in the northern portion of the Yolo Bypass on the Knaggs Ranch: 1) food web and salmon responses to agricultural management, 2) behavior of salmon in different agricultural habitat types, and 3) a pilot study evaluating the feasibility of extending inundation duration after natural flood events to prolong salmon rearing in floodplain habitats.

The experimental study was completed in 2013. It concluded that winter inundation of rice fields creates high-quality growth opportunities for juvenile Chinook salmon and agricultural landscapes can function as habitats for Chinook salmon populations using existing agricultural infrastructure (CalTrout et al. 2013).

1.5.6 Lower Sacramento/Delta North Regional Flood Management Plan

The Lower Sacramento/Delta North Regional Flood Management Plan establishes a flood management vision and a prioritized list of flood risk reductions within the study area, i.e., portions of Yolo, Solano, Sacramento and Sutter counties. The study will include expansions of both the Fremont and Sacramento weirs and widening of the Yolo and Sacramento bypasses. These modifications, in concert with improvements to Folsom Dam, will lower flood stages in the Sacramento River downstream of the Fremont Weir; the tributary channels around the Natomas Basin, the American River, Feather River, and Sutter Bypass channels upstream of the

Fremont Weir; and the Yolo Bypass itself. The regional partners believe these actions would also provide new regularly inundated floodplain that could be managed to improve fish rearing and passage as part of an overall framework that includes agricultural sustainability and other objectives (USACE 2015).

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2 Existing and Future Conditions

The existing conditions are the conditions within the Yolo Bypass study area that exist today. The future without project conditions are the future conditions expected to occur if the Project is not implemented. Existing and future without project conditions are defined to provide a better understanding of the challenges and potential opportunities for the Project effort.

The information in this chapter is presented at a general level of detail to provide background information and aid in initial alternatives development. This information will be further developed as the alternatives are refined and the environmental process moves forward.

2.1 Existing Conditions

2.1.1 Water Resources

2.1.1.1 Hydrology, Hydraulics, and Flood Management

The area of analysis for hydrology and hydraulics consists of the Sacramento River from Fremont Weir to Rio Vista and the southern end of the Yolo Bypass. The major features of the flood management system in and surrounding the area of analysis include reservoirs, levees, weirs, and bypasses. Flows within the Project area are regulated by Shasta, Oroville, and Folsom reservoirs. Each of these features is described below.

Sacramento River – The portion of the Sacramento River within the study area begins at Fremont Weir and extends to just upstream of Rio Vista near River Mile (RM) 12 (see Figure 2-1). Flood management facilities along Sacramento River and in the Delta include the levees, weirs, and bypasses of upper and lower Butte basin, Sacramento River between Colusa and Verona, and Sacramento River between Verona and Collinsville. When Sacramento River system flood flows are the highest, a portion of the flow is diverted from the Sacramento River through the Sacramento Bypass to Yolo Bypass. At the downstream end, Yolo Bypass flows reenter Sacramento River near Rio Vista.

Yolo Bypass – Yolo Bypass is a leveed floodway through the natural overflow Yolo Basin on the west side of Sacramento River between Verona and Rio Vista near Suisun Bay. The bypass flows generally north to south and extends from Fremont Weir (RM 83) downstream to Liberty Island (RM 14) in the Delta.

During high flows in the Sacramento River, water enters Yolo Bypass from the north over Fremont Weir and from the east via the Sacramento Weir and bypass. Flows are then conveyed south around the City of West Sacramento. During periods of high stage in the Sacramento River, flows from Colusa Basin are discharged through KLRC to Yolo Bypass. Additional flows enter the bypass from the west-side tributaries, including Cache Creek, Putah Creek, and Willow Slough Bypass. Flood waters reenter Sacramento River through Cache Slough, upstream from Rio Vista. Liberty Island is the southern outlet of Yolo Bypass.

Flood management facilities along Yolo Bypass include Fremont Weir at the northern end of the bypass, levees on either side of the bypass, and the bypass itself, which conveys floodwaters from the Sacramento, American, and Feather rivers away from West Sacramento. Yolo Bypass floods approximately once every three years, generally during the winter months of December, January, and February. However, in 1998, water entered the bypass in June. During the irrigation season, non-flood waters exit the bypass primarily through the east levee Toe Drain, a riparian channel running along the eastern edge of the bypass.

Shasta Reservoir – Maximum seasonal flood management storage space in Shasta Reservoir is 1.3 million acre-feet (AF). Releases from Shasta Dam can be made through the power plant, over the spillway, or through the river outlets. Releases from Shasta Dam are often made for flood management. Releases for flood management either occur after a storm event to maintain the prescribed vacant flood space in the reservoir or in the fall, beginning in early October, to reach the prescribed vacant flood space. During a storm event, releases for flood management occur either over the spillway during large events or through river outlets for smaller events.

Oroville Reservoir – The primary flood management feature of Feather River Basin is Oroville Reservoir, with a flood management reservation volume of 750,000 AF. Oroville Reservoir releases are used to help meet the objective flow on Feather River of 150,000 cfs and, in conjunction with New Bullards Bar Reservoir on the Yuba River, to meet an objective flow below the Yuba River confluence of 300,000 cfs. Levees line Feather River from its confluence with Sacramento River to the City of Oroville (RM 63).

Folsom Reservoir –The Folsom Reservoir flood management reservation volume is variable, ranging from 400,000 to 670,000 AF. The target maximum release on the American River is 115,000 cfs due to leveed capacity along the lower American River. The American River is leveed from its confluence with the Sacramento River to near Carmichael Bluffs on the north bank and to near Sunrise Boulevard Bridge on the south bank (RM 19).

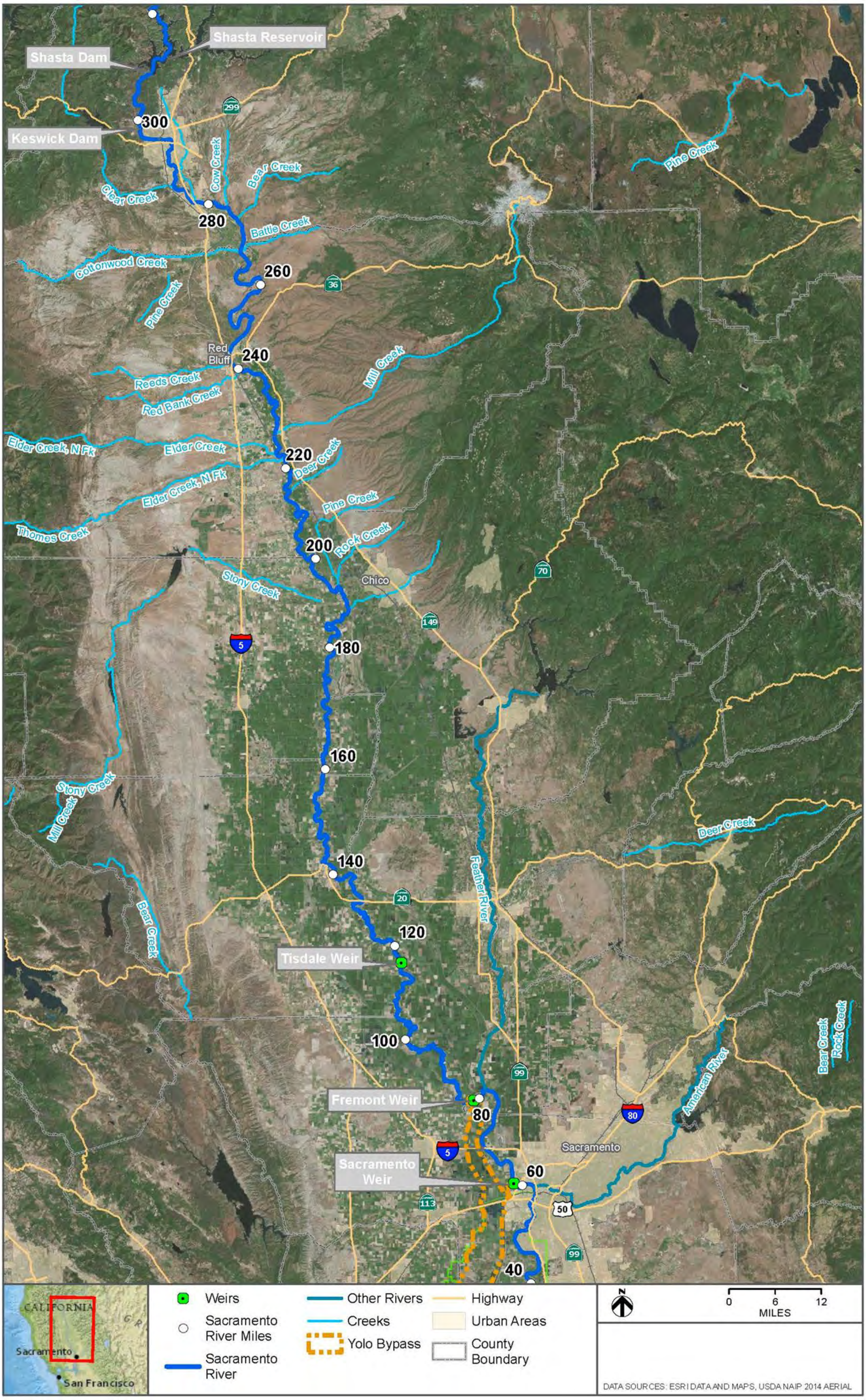

Figure 2-1. Sacramento River and Tributaries

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2.1.1.2 *Groundwater*

The area of analysis for groundwater resources is limited to the area around the Yolo Bypass and includes portions of the Colusa, Yolo, and Sutter subbasins as defined in Bulletin 118 (DWR 2003). Limited data exist to estimate groundwater pumping in these subbasins. Bulletin 118 states that an estimated 310,000 AF of groundwater was pumped for agricultural purposes in the Colusa subbasin. Municipal, industrial, and environmental/wetland pumping is estimated at 14,000 and 22,000 AF, respectively (DWR 2003). In the Sutter subbasin, DWR estimates pumping for agricultural uses at 171,400 AF and urban use at 3,900 AF (DWR 2003). DWR does not provide a groundwater pumping estimate for the Yolo subbasin in Bulletin 118.

Groundwater is recharged by deep percolation from rainfall infiltration, leakage from streambeds, lateral inflow along the basin boundaries, and other surface processes such as irrigation. Groundwater discharges primarily include evapotranspiration and discharge to streams or other surface features such as marshes. The estimated recharge to the Colusa subbasin due to deep percolation of applied water is 64,000 AF based on studies conducted in 1993, 1994, and 1999 (DWR 2003). In the Sutter subbasin, DWR estimates natural recharge to be 40,000 AF and applied water recharge to be 22,100 AF based on studies conducted in 1990. DWR does not provide groundwater recharge estimates for Yolo subbasin.

Land Subsidence: Groundwater-related land subsidence is a process that causes the elevation of the ground surface to lower in response to groundwater pumping occurring. This process, which is typically not reversible, occurs when groundwater extraction lowers groundwater levels below the historical level seen in that area. The reduction in water level causes the loss of pore pressure within the soil matrix. This loss in pore pressure can result in collapse (i.e., consolidation, compaction) of soils that may be susceptible to subsidence. Clays are typically the soils most susceptible to subsidence.

Historically, land subsidence occurred in the eastern portion of Yolo County and the southern portion of Colusa County because of extensive groundwater pumping in areas that have soils that are susceptible to subsidence (DWR 2014). As much as four feet of land subsidence has been measured east of Zamora over the last several decades. The area between Zamora, KLRC, and Woodland has been most affected (Yolo County 2009). DWR extensometer 09N03E08C004M near the Yolo Bypass, has recorded approximately 0.9 foot of subsidence from 1991 to the present (DWR 2016). Extensometer 11N01E24Q008M, near the Yolo-Zamora area has recorded approximately 1.1 feet decline from 1992 to the present (DWR 2016). DWR has prioritized the Colusa and Yolo subbasins as having a high potential for subsidence (DWR 2014).

Groundwater Quality: Groundwater quality in the area of analysis is generally good and of sufficient quality for municipal, agricultural, domestic, and industrial uses. In the Yolo, Colusa and Sutter subbasins, groundwater is generally hard (high in mineral content) and high in salt content. Groundwater in the Colusa and Yolo subbasins is characterized as sodium magnesium, calcium magnesium, or magnesium bicarbonate type. There are also some localized groundwater quality issues in all three subbasins. Localized areas of high electrical conductivity, total dissolved solids, adjusted sodium adsorption ratio, nitrate, and magnesium occur within the Project area. Elevated levels of boron as high as two to four milligrams per liter have been recorded along Cache Creek. Elevated selenium and nitrate concentrations have occurred in groundwater near the City of Davis (DWR 2003).

2.1.2 Land Use and Agricultural Resources

The area of analysis for land use and agricultural resources includes areas within Yolo, Sutter, and Solano counties where construction and operations would take place and could result in land use and/or agricultural resource effects. The Yolo Bypass is predominantly in Yolo County, with small areas of the bypass in Sutter and Solano counties. Construction activities would take place in Yolo and Sutter counties, in and between the FWWA and Tule Pond and the Tule Canal, near agricultural road crossings along Tule Canal, and in the adjacent Elkhorn Area. These lands are designated Agriculture and Public and Open Space by Sutter County and Agriculture by Yolo County (Yolo County 2009; Sutter County 2011). There are no established communities within the area of analysis. Although a small portion of southern Yolo Bypass is in Solano County, impacts to land use and agriculture are assumed to be minimal, and the county is not included in the area of analysis.

The Yolo Bypass is approximately 69,000 acres and is in the Yolo Basin of the Sacramento Valley, near the cities of Davis and West Sacramento in Yolo County. The bypass stretches north to the Fremont Weir and south to the City of Rio Vista and follows the west side of the Sacramento River. Physical infrastructure within the bypass includes the Fremont, Sacramento, and Lisbon weirs. Table 2-1 presents the land designations within the Yolo Bypass. The majority of the Yolo Bypass is designated as unique farmland. Unique farmland refers to lands, other than prime farmland, that are used for producing specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, and other fruits and vegetables, and is often located in special microclimates. Prime farmland is land that has the best combination of physical and chemical properties desired to produce food, feed, forage, fiber, and oilseed crops. Farmland of statewide or local importance are generally lands that nearly meet the requirements for prime or unique farmlands that are used to produce food, feed, fiber, forage, and oilseed crop. Figure 2-2 presents the prime farmland, unique farmland, and the farmland of statewide importance within the Yolo Bypass.

Table 2-1. Summary Land Use Category in the Yolo Bypass

Land Use Category	Acres
Prime Farmland	6,108
Farmland of Statewide Importance	2
Unique Farmland	18,429
Farmland of Local Importance	169
Important Farmland Subtotal	24,708
Grazing Land	17,389
Farmland of Local Potential	1,301
Agricultural Land Subtotal	43,398
Other Land	13,686
Water Area	584

Sources: Farmland Mapping and Monitoring Program 2014

As discussed above, most lands in Yolo and Sutter counties are designated as Agriculture. In both counties, a large portion of the lands are designated as Prime or Unique Farmland or Farmland of Statewide Importance. Table 2-2 presents the land use categories in the two counties for 2014.

Table 2-2. Summary Land Use Category in Yolo and Sutter Counties

Land Use Category	Yolo County (Acres)	Sutter County (Acres)
Prime Farmland	250,345	161,019
Farmland of Statewide Importance	18,861	104,003
Unique Farmland	44,604	16,087
Farmland of Local Importance	51,725	0
Important Farmland Subtotal	365,535	281,109
Grazing Land	166,367	54,327
Agricultural Land Subtotal	531,902	335,436
Urban and Built-up Land	31,049	13,607
Other Land	82,694	38,386
Water Area	7,804	1,883
Total Area Inventoried	653,449	389,312

Sources: California Department of Conservation 2016

Notes:

[1] Based on 2012 to 2014 Land Use Conversion Data.

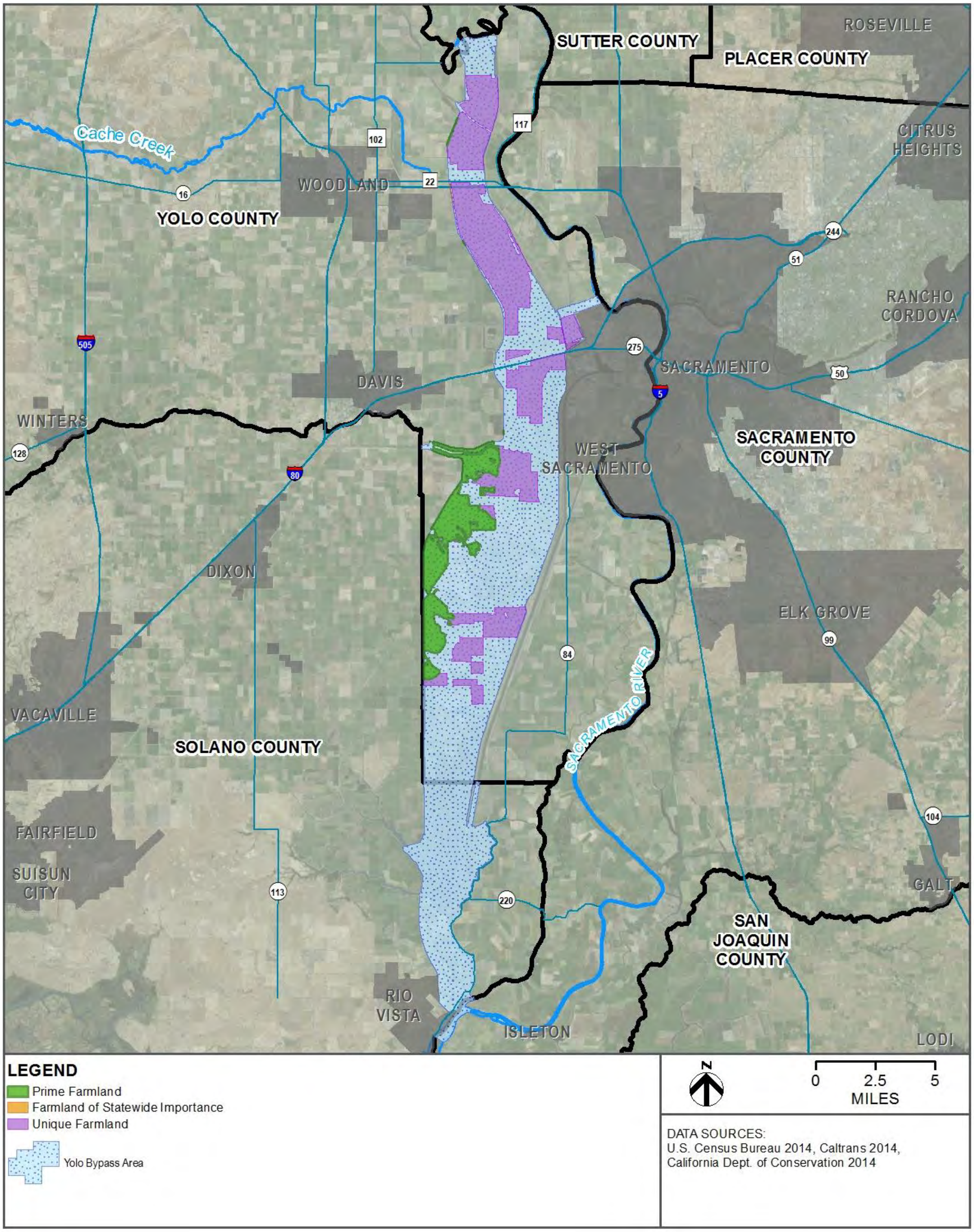

Figure 2-2. Land Use Classifications

2.1.3 Socioeconomics

The area of analysis for socioeconomics includes counties (Yolo and Sutter) that could be affected by the development of the Project alternatives. However, employment and spending associated with construction actions could also affect regional economies in the neighboring counties of Solano and Sacramento.

Table 2-3 presents employment, labor income, and output by industry for the combined regional economies of Yolo, Sutter, Solano, and Sacramento counties in 2014. In 2014, services provided the most jobs (601,176 jobs) in the area, followed by government (248,817 jobs), and trade (139,870 jobs). Services also had the highest output ($78.6 billion) of all industries in the region, followed by government ($32.4 billion), and manufacturing ($28.4 billion). Services and government were the top industries in terms of labor income in 2014.

Table 2-3. Summary of 2014 Regional Economy in Yolo, Sutter, Solano, and Sacramento Counties

Industry	Employment (Jobs)	Output (Million $)	Labor Income (Million $)
Agriculture	18,596	2,490.4	561.6
Mining	1,830	640.3	74.9
Construction	60,132	10,653.5	2,577.1
Manufacturing	43,261	28,417.0	4,153.9
Transportation, Information, Power, and Utilities	50,940	13,448.3	2,568.6
Trade	139,870	16,741.9	5,257.9
Service	601,176	78,598.7	25,355.7
Government	248,817	32,398.4	25,216.7
Total	1,164,624	183,388.5	65,766.4

Source: Minnesota IMPLAN Group 2016

[a] Employment is measured in number of jobs.

[b] Income is the dollar value of total payroll for each industry plus income received by self-employed individuals.

[c] Output represents the dollar value of industry production.

Nine major crop types were identified in Yolo Bypass, including corn, rice, wild rice, safflower, sunflower, processing tomatoes, vines (melons), irrigated pasture, and non-irrigated pasture. Table 2-4 provides labor and cost data to produce the identified crops from available University of California Cooperative Extension (UCCE) Agricultural Issues Center cost and return studies. The costs and returns presented in Table 2-4 represent costs in various years because UCCE crop studies are prepared and updated in different years for different crops.

Table 2-4. Crop Cost and Return in Yolo, Sutter, Solano, and Sacramento Counties

Crop Category	Crop Sub Category	Direct Labor Hours/Acre (hours/acre)	Gross Revenue/Acre ($/acre)	Operating Costs/Acre ($/acre)	Year Studied
Corn	Field Corn	2.83	$1,260	$1,117	2015
Rice	Rice Only Rotation, Medium Grain	4.52	$1,760	$1,225	2016
Safflower	Irrigated-Bed Planted, Dryland-Flat Planted	2.02	$363	$206	2011
Sunflower	For Seed	4.13	$1,360	$447	2011
Tomato, processing	Sub-surface, Drip Irrigated	24.96	$3,520	$2,733	2014
	Furrow Irrigated	22.38	$3,040	$2,859	2014

Source: UCCE 2011a, 2011b, 2014a, 2014b, 2015a, 2015b

Figure 2-3 presents the unemployment rate trends for Yolo, Sutter, Solano, and Sacramento counties between 2005 and 2016. The unemployment rate in all four counties increased from 2006 through 2010 and decreased from 2011 through 2016.

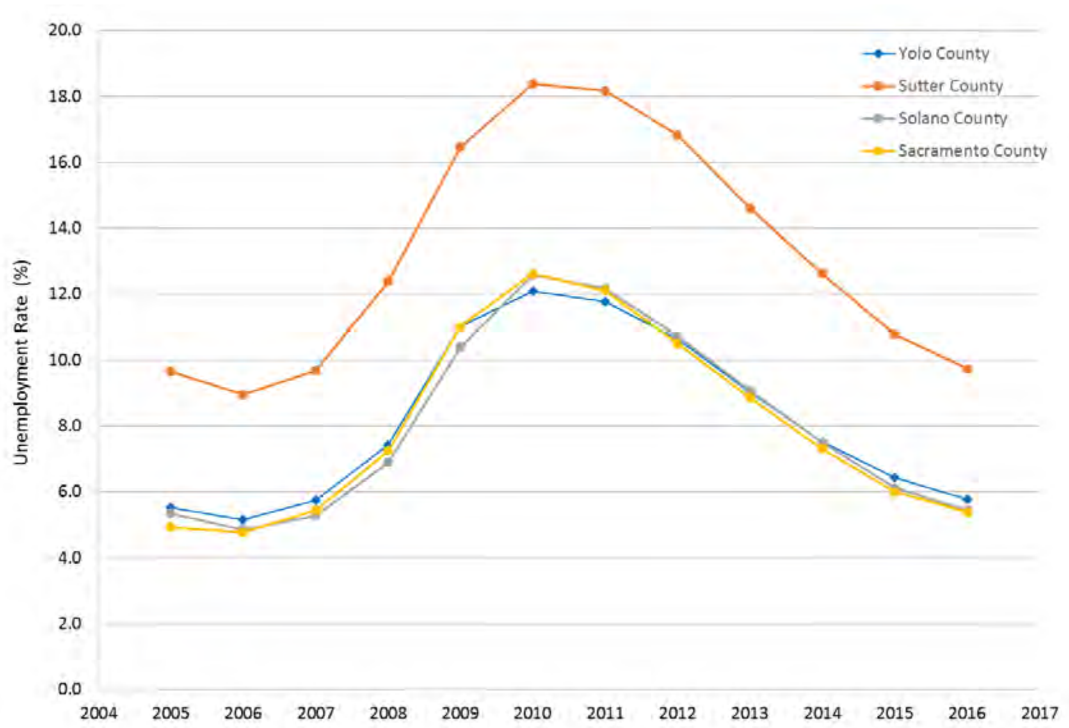

Figure 2-3. Unemployment Rate Profile for Yolo, Sutter, Solano, and Sacramento Counties

Table 2-5 presents household income and per capita income in Yolo, Sutter, Solano, and Sacramento counties relative to California. Yolo County had a median income approximately $7,000 less than the median household income in the State. Sutter County had a median income approximately $10,000 less than the median household income in the State. Solano County had a median income approximately $5,000 greater than the median household income in the State. Sacramento County had a median income approximately $6,000 less than the median household income in the State.

Table 2-5. 2011 through 2015 Household income by County

Income	Yolo County	Sutter County	Solano County	Sacramento County	California
Median Household Income	$54,989	$52,017	$66,828	$55,987	$61,818
Mean Household Income	$78,450	$69,238	$83,446	$74,159	$87,877
Per Capita Income	$28,116	$23,689	$29,185	$27,315	$30,318

Source: United States Census Bureau 2011 through 2015

2.1.4 Environmental Justice

Environmental justice refers to the equitable rights to healthy environmental conditions for minority and low-income populations relative to other populations. The area of analysis for environmental justice included areas where associated project construction would occur or construction traffic would increase, potentially causing an adverse and disproportionately high effect on neighboring minority and low-income populations, or where agriculturally productive land would be taken out of production. The regional level analysis includes Yolo and Sutter counties. Specific to construction-related employment, the environmental justice area of analysis expands to include Solano and Sacramento counties because it is assumed workers from these counties could commute in for construction-related work. A small portion of Yolo Bypass (the southern point) is in Solano County. Almost all of this area is water (Prospect Slough) and would have no environmental justice effects except when specific to construction-related employment impacts. The local level analysis includes Census Tracts 101.02, 112.06, 114, and 509. Construction would not occur in census tracts in the remainder of Yolo Bypass; therefore, they are not included in this analysis.

In 2015, both Yolo and Sutter counties exhibited a total minority proportion exceeding 50 percent at 52.5 and 52.9 percent, respectively, which indicates the presence of an environmental justice population. Solano and Sacramento counties also exhibited a total minority proportion that exceeded 50 percent. The total minority population percentage across all four counties is lower than that of the State (62.2 percent). Table 2-6 presents the racial and ethnic composition of Yolo County, and the median household income, the mean household income, and the percent of the population below the poverty threshold. As shown, Yolo and Solano counties have a smaller proportion of residents living below the poverty threshold than that for the State (8.8 and 9.6 percent compared to 11.3 percent), whereas the low-income residents in Sutter and Sacramento counties exceed that of the State at 16.9 and 12.6 percent, respectively. Yolo and Sutter counties have a median household income and mean household income lower than the State average; however, neither county falls below the United States Census Bureau's defined poverty thresholds for a four-person family unit (two adults and two children) or an individual ($24,339 and $12,486, respectively [United States Census Bureau 2016]). Similarly, Solano and Sacramento counties do not fall below the defined poverty thresholds for a four-person family unit or an individual.

Table 2-6. Regional-Level Environmental Justice Existing Conditions

		California	Yolo County	Sutter County	Solano County	Sacramento County
Ethnicity[1]	Hispanic or Latino	38.8%	31.5%	30.3%	26.0%	27.0%
Race[2]	White	60.9%	65.9%	70.5%	53.5%	59.8%
	African American	5.8%	2.7%	1.1%	14.1%	9.8%
	American Indian	0.7%	0.4%	1.0%	0.5%	0.6%
	Asian	14.2%	13.9%	15.7%	15.4%	15.6%
	Pacific Islander	0.4%	0.3%	0.4%	0.8%	1.1%
	Total Minority[3]	**62.2%**	**52.5%**	**52.9%**	**61.2%**	**54.2%**
Median Household Income [4,5]		$64,500	$58,966	$52,277	$67,443	$58,942
Mean Household Income		$91,757	$81,995	$67,427	$84,403	$76,613
Percent of Population Below Poverty Threshold [6]		11.3%	8.8%	16.9%	9.6%	12.6%

Source: United States Census Bureau 2015a and 2015b.

[1] The term "Hispanic" is an ethnic category and can apply to members of any race, including respondents who self-identified as "White." The total numbers of Hispanic residents for each geographic region are tabulated separately from the racial distribution by the United States Census Bureau.

[2] A minority is defined as a member of the following population groups: American Indian/Alaskan Native, Asian or Pacific Islander, Black (non-Hispanic), or Hispanic.

[3] "Total Minority" is the aggregation of all non-white racial groups with the addition of all Hispanics, regardless of race, with the total for "White Alone, Not Hispanic" subtracted from the total population.

[4] Household income is defined by the United States Census Bureau as "the sum of money income received in the calendar year by all household members 15 years old and over" (United States Census Bureau Undated).

[5] In 2015 inflation-adjusted dollars.

[6] Percentage of families and people whose income in the past 12 months was below the poverty level. The census classifies families and persons as below poverty "if their total family income or unrelated individual income was less than the poverty threshold" as defined for all parts of the country by the Federal government (United States Census Bureau Undated). For 2015, the preliminary Federal weighted average poverty level threshold for an individual was $12,486 and $24,339 for a four-person family unit (two adults and two children) (United States Census Bureau 2016).

Census tracts are defined as "small, relatively permanent statistical subdivisions of a county delineated by local participants as part of the United States Census Bureau's Participant Statistical Areas Program" (United States Census Bureau Undated). Table 2-7 presents the racial and ethnic composition and economic characteristics of the census tracts that could be affected by Project actions. Most of the census tracts have total minority proportions greater than 50 percent. Census Tracts 101.02, 114, and 509 have a higher proportion of residents living below the poverty threshold than the State and county in which it is located. All but one of the census tracts (Census Tract 112.06) have median and mean household incomes lower than the State and county average; however, these census tracts do not fall below the United States Census Bureau's defined poverty thresholds for a four-person family unit (two adults and two children) or an individual.

Table 2-7. 2015 Local-Level Environmental Justice Existing Conditions

		California	CT 101.02	CT 112.06	CT 114	CT 509
Ethnicity[1]	Hispanic or Latino	38.4%	35.1%	30.4%	50.1%	35.7%
Race[2]	White	61.8%	57.9%	69.4%	72.4%	80.4%
	African American	5.9%	5.8%	1.2%	1.9%	1.9%
	American Indian	0.7%	0.1%	3.9%	2.6%	1.4%
	Asian	13.7%	9.2%	13.7%	5.2%	0.0%
	Pacific Islander	0.4%	1.9%	0.3%	0.0%	1.2%
	Total Minority[3]	**61.3%**	**52.5%**	**52.9%**	**61.2%**	**54.2%**
Median Household Income [4,5]		$64,500	$58,966	$52,277	$67,443	$58,942
Mean Household Income		$91,757	$81,995	$67,427	$84,403	$76,613
Percent of Population Below Poverty Threshold [6]		11.3%	8.8%	16.9%	9.6%	12.6%

Source: United States Census Bureau 2011-2015a and 2011-2015b.

[1] The term "Hispanic" is an ethnic category and can apply to members of any race, including respondents who self-identified as "White." The total numbers of Hispanic residents for each geographic region are tabulated separately from the racial distribution by the United States Census Bureau.

[2] A minority is defined as a member of the following population groups: American Indian/Alaskan Native, Asian or Pacific Islander, Black (non-Hispanic), or Hispanic.

[3] "Total Minority" is the aggregation of all non-white racial groups with the addition of all Hispanics, regardless of race, with the total for "White Alone, Not Hispanic" subtracted from the total population.

[4] Household income is defined by the United States Census Bureau as "the sum of money income received in the calendar year by all household members 15 years old and over" (United States Census Bureau Undated).

[5] In 2015 inflation-adjusted dollars.

[6] Percentage of families and people whose income in the past 12 months was below the poverty level. The census classifies families and persons as below poverty "if their total family income or unrelated individual income was less than the poverty threshold" as defined for all parts of the country by the Federal government (United States Census Bureau Undated). For 2015, the preliminary Federal weighted average poverty level threshold for an individual was $12,486 and $24,339 for a four-person family unit (two adults and two children) (United States Census Bureau 2016).

The Project could affect agricultural employment by reducing the amount of agriculturally productive land within the study area. This could potentially reduce the need for farm labor, which is typically classified as minority and low-income, and the number of agricultural jobs available in the study area. Farm operators in Yolo and Sutter counties are predominately White, their laborers and helpers are predominately Hispanic, and several agricultural worker groups receive annual wages below the United States Census Bureau's poverty level threshold for a family of four composed of two adults and two children (United States Department of Agriculture 2014). The race and ethnic composition of this sector suggests that laborers and helpers, as an employment sector, are generally of minority status, with Hispanics comprising the largest proportion of laborers and helpers in both Yolo and Sutter counties (68.3 and 75.5 percent, respectively [United States Census Bureau 2006-2010]). While the 2016 First Quarter Mean Annual Wages data (California Employment Development Department 2016) does not demonstrate as clearly as the United States Census data the proportion of residents living below the poverty threshold, the information provided therein does suggest that mean incomes in the farming industry are generally lower than the mean income for all industries, with less skilled workers (agricultural equipment operators and farmworkers) generally earning less than 50 percent of the mean wage for all industries.

2.1.5 Biological Resources

2.1.5.1 *Fisheries*

The area of analysis for fisheries includes Yolo Bypass, Sacramento River from the vicinity of Fremont Weir (near RM 83) to about Rio Vista (near RM 12), and the Delta (see Figure 2-4). Although Yolo Bypass is the primary region expected to be affected by the Project, changes in the frequency, duration, and volume of water spilling into Yolo Bypass from the Sacramento River could affect aquatic resources and fisheries in the river downstream of Fremont Weir and in the Delta.

Yolo Bypass – Yolo Bypass is California's largest contiguous floodplain and provides valuable habitat for a wide variety of aquatic and terrestrial species (Sommer et al. 2001). Yolo Bypass is inundated to some extent during about 70 percent of all years when total flow in the Sacramento River exceeds about 56,270 cfs (California Data Exchange Center 2017). When flooded, Yolo Bypass provides up to about 59,300 acres of shallow floodplain habitat. The bypass ranges from 1.2 to six miles wide over its about 40-mile length and has a typical mean depth (when flooded) of 6.5 feet or less (Sommer et al. 2008).

The Yolo Bypass provides aquatic habitat, including floodplain habitat, during seasonal flood events, and permanent wetlands, essential for fish spawning, rearing, and migratory passage. During flood pulses, the Yolo Bypass provides fish in the Sacramento River an alternative migration corridor. This seasonal floodplain habitat has been studied as a beneficial resource, providing fish better rearing conditions than that of the Sacramento River channel. This seasonal habitat provides fish an increased habitat and food supply (California Department of Fish and Game [CDFG] 2008).

Various native and non-native fish species occur in the Yolo Bypass, including nine special status species. Appendix A includes a preliminary list of the identified fish species, including special status species, commonly found in the Yolo Bypass and adjacent aquatic habitats in the Yolo Basin.

Sacramento River – The Sacramento River is California's largest river, with an average annual runoff of 22,000,000 AF. The segment of the Sacramento River located within the study area extends from Fremont Weir (about RM 83) downstream to just above Rio Vista near RM 12. The Sacramento River within the study area is predominantly channelized and leveed. It is bordered by agricultural land and the City of Sacramento and surrounding areas. This segment of the Sacramento River is characterized primarily by slow-water glides and pools, is depositional in nature, and has lower water clarity and habitat diversity relative to the upper portion of the river.

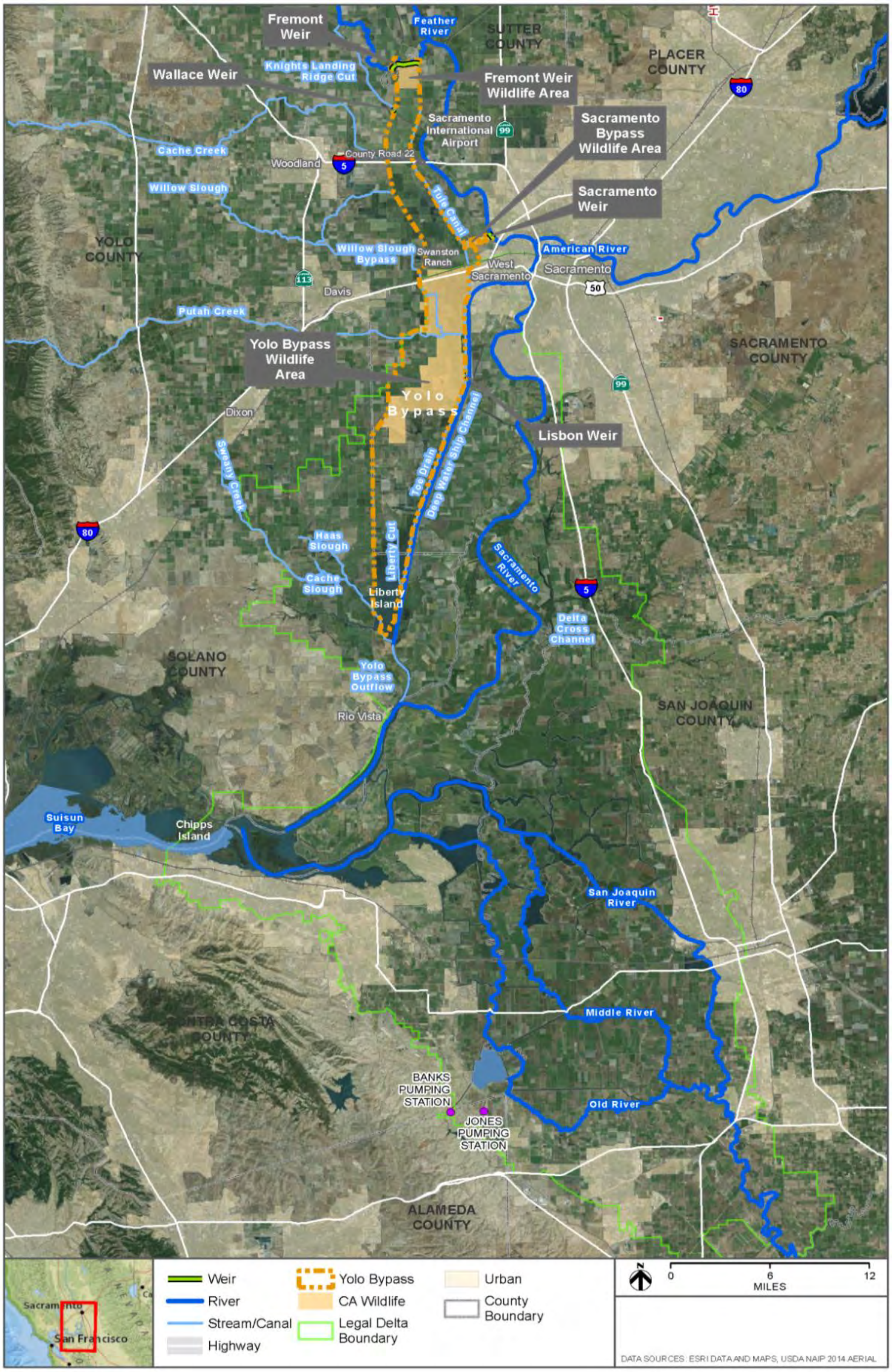

Figure 2-4. Overview of the Aquatic Resources and Fisheries Study Area

Over 30 fish species are known to occur within the Sacramento River. Many of these are anadromous, including both native and introduced species. Anadromous species include Chinook salmon (winter-run, spring-run, fall-run, and late fall-run), steelhead, green and white sturgeon, Pacific lamprey, river lamprey, American shad, and striped bass.

Most anadromous salmonid spawning occurs upstream of the study area between Keswick Dam and Red Bluff Diversion Dam (RM 243) (NMFS 2009 as cited in Reclamation 2015). Downstream from the City of Red Bluff, the Sacramento River provides a migration corridor and rearing habitat for salmonids as well as spawning and rearing habitat for a variety of other native fish species such as Sacramento stickleback and Sacramento pikeminnow.

Delta – The San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Estuary) is the largest intact estuary on the west coast of the United States (United States Environmental Protection Agency [USEPA] 2003). The portion of the Delta in the study area consists primarily of the Sacramento River and associated waters located downstream of the Yolo Bypass outlet near Rio Vista. Estuarine fishes occurring in this area include delta smelt and longfin smelt, which might use these areas depending on seasonal and diel (i.e., daily) salinity gradients. Additionally, many non-native warm water fish species are common in this area and use it for spawning and rearing purposes, whereas anadromous fish use this area primarily for migration and rearing.

Ecological processes in the Project area include floodplain ecology and distribution, Yolo Bypass hydrology, and Sacramento River hydrology. Floodplains are a valuable component of riverine ecosystems and provide important habitat for a variety of aquatic and terrestrial species (Junk et al. 1989; Tockner and Stanford 2002). Within California’s Central Valley, including the Sacramento River system, floodplain habitat is generally considered one of the most important seasonal habitats for anadromous salmonids. Many California fish species have evolved life history strategies to take advantage of high-quality rearing habitat provided by predictable seasonal floodplain inundation (Katz et al. 2013 and references therein). Yolo Bypass’ typical period of inundation is between January and March. However, it can flood as early as October and remain flooded as late as June. Typically, Yolo Bypass remains inundated between one and 68 days (Katz et al. 2013; Schemel et al. 2004; Sommer et al. 2008). Seasonal inundation of Yolo Bypass leads to an increase in phytoplankton and other food resources that support fish species residing in the floodplain and provides a source of these food resources to downstream habitats.

Stressors in the Project area include inundation in the Yolo Bypass, water quality, migration barriers and stranding, and various qualities and changes in the Sacramento River and Delta. During overtopping events at Fremont Weir, increased flows into the Cache Slough area can attract migrating anadromous species. Although fish are attracted to Yolo Bypass during these flood events, the bypass can cause migratory delays and increased mortality of adults relative to the Sacramento River migration corridor. The existing fish passage structure at Fremont Weir is inadequate to allow normal fish passage at most flows (NMFS 2009). As a result, adult salmonids and sturgeon migrating upstream through Yolo Bypass are unable to reach upstream spawning habitat in the Sacramento River and its tributaries when there is insufficient flow through Fremont Weir (Harrell and Sommer 2003). However, longer inundation duration can increase primary and secondary production, which can benefit fish species in the immediate area and contribute to food web systems in the Delta.

2.1.5.2 Vegetation and Wildlife

The area of analysis for vegetation and wildlife includes areas in Yolo Bypass that have been identified for ground disturbance. Most of the direct impacts associated with ground disturbance would occur in the northern portion of Yolo Bypass in the FWWA. The study area includes the area of temporary and permanent impacts plus a 100-foot buffer and the entirety of the Yolo Bypass.

Those portions of Yolo Bypass that are flooded in winter and early spring also function as a migration route and spawning and rearing habitat for many sensitive special-status fish species endemic to the region (as defined by the ESA and the CESA). This migration connection occurs when floodwaters are spilling over Fremont and Sacramento weirs, creating an upstream hydrologic connection between Yolo Bypass and Sacramento River. As the floodwaters inundate and then recede, Yolo Bypass also provides habitat for shorebirds, waterfowl, and terrestrial species (Jones and Stokes 2001). Large areas in the bypass are currently managed for wildlife habitat areas, including Yolo Bypass Wildlife Area (YBWA), Conaway Ranch, and private duck club lands in the southern section of the bypass (Jones and Stokes 2001)

Vegetation communities identified in the biological resources area of analysis include the following:

- Agriculture – Cropland consisting of major crops and cover types in agricultural production, including rice, corn, milo, sorghum, millet, safflower, tomatoes, and irrigated pastures. Non-cropland includes agricultural areas used for cattle grazing, small roads, and ditches and non-planted areas associated with cultivated lands (DWR 2013).
- Annual and Perennial Grassland – California annual herb/grassland (which includes native herbaceous plants although non-native grasses might still be dominant) and California naturalized annual and perennial grassland (which is dominated by non-native grass species with very little or no presence of native herbaceous plants).
- Open Water and Freshwater Aquatic Vegetation – Parts of the study area are covered by floating mats of vegetation dominated by mosquito fern (*Azolla* sp.) and water primrose (*Ludwigia* spp.) wetlands. There are also many native submerged aquatic species, including pondweeds such as sago pondweed (*Stuckenia pectinata*) and stoneworts (*Charales* spp., green algae structurally similar to vascular plants).
- Freshwater Emergent Marshes and Seeps – California and hardstem bulrush marsh, dominated by California bulrush (*Schoenoplectus californicus*) and hardstem bulrush (*Schoenoplectus acutus*); Douglas's mugwort patches, dominated by mugwort (*Artemisia douglasiana*); and managed annual wetland vegetation, which is managed to provide wildlife habitat.
- Riparian Forest/Woodland – Black willow thickets, box elder forest, Fremont cottonwood forest, mixed hardwood forest, and valley oak woodland
- Riparian Scrub – Non-native Himalayan blackberry brambles and sandbar willow thickets

Special-status species are defined as species that are legally protected or that are otherwise considered sensitive by Federal, State, or local resource agencies. Appendix B includes a list of the special-status plant and wildlife species that were identified during database queries, including 15 that are known from the study area and 41 that have the potential to occur in the study area because of the presence of suitable soils and habitat (freshwater marsh and alkaline grassland).

Wildlife movement corridors, also called dispersal corridors or landscape linkages, are linear features whose primary wildlife function is to connect at least two habitat areas (Beier and Loe 1992). The study area is adjacent to a natural waterway (Sacramento River) that is likely used by resident and migratory birds as a wildlife corridor. In addition, Yolo Bypass serves as a regional connection that provides connectivity for resident and migratory wildlife throughout this region. Federally listed species that might use this movement corridor include valley elderberry longhorn beetle, giant garter snake, western yellow-billed cuckoo, and anadromous fish.

Sensitive habitat types include those that are of special concern to California Department of Fish and Wildlife (CDFW) or that are afforded specific consideration through CEQA, Section 1602 of the California Fish and Game Code, the Porter-Cologne Water Quality Control Act, and/or Section 404 of the CWA, as discussed in Section 9.2, *Regulatory Setting*. The following vegetation communities in the study area are considered sensitive habitats:

- Black willow thickets
- Blue elderberry forest
- California and hardstem bulrush marsh
- Fremont cottonwood forest
- Mixed hardwood forest
- Sandbar willow thickets
- Valley oak woodland

The following vegetation communities are considered waters of the United States subject to regulation by USACE and the Regional Water Quality Control Board under Sections 404 and 401 of the CWA, respectively, because they are hydrologically connected to the Sacramento River. These vegetation communities are also considered waters of the state subject to regulation by Regional Water Quality Control Board under the Porter-Cologne Water Quality Control Act and by CDFW under Section 1600 of the California Fish and Game Code:

- California and hardstem bulrush marsh
- Managed annual wetland vegetation
- Temperate freshwater floating mat
- Open water
- Water primrose wetlands

2.1.6 Cultural Resources

Cultural resources are defined as prehistoric and historic archaeological resources, architectural/built-environment resources, places important to Native Americans and other ethnic groups, and human remains. The Project area is in the Sacramento Valley.

Early inhabitants of the Yolo Basin used the various habitats found throughout the valley, including those previously detailed. They created a sophisticated material culture and established a trade system involving a wide range of manufactured goods from distant and neighboring regions, and their population and villages prospered in the centuries prior to historic contact (Rosenthal et al. 2007). Many surface sites in the Sacramento Valley have been disturbed, buried, or destroyed by agricultural development, levee construction, and river processes. Untrained individuals and professionals with rudimentary methods performed many excavations of Sacramento Valley and Sacramento-San Joaquin Delta (Delta) sites in the early twentieth century. They focused on excavating burials and artifacts that could be arranged into chronological and stylistic groups and paid little attention to other artifacts such as tool stone manufacturing debris, dietary remains, and cooking features; thus, hampering modern attempts at reanalysis. Early professional efforts emphasized culture history rather than processes that drive culture change. There are three basic periods include Paleo-Indian, Archaic, and Emergent/Historic (1973, 1974). The discussion that follows is based on these divisions.

- **Paleo-Indian**: The earliest accepted evidence of human occupation in the Central Valley during the Paleo-Indian Period (11,550 to 8500 BC) comes from the discovery of basally thinned and fluted projectile points at three separate locations in the southern portion of the basin (Rosenthal et al. 2007).
- **Archaic**: The Archaic Period (5550–1100AD) includes a change to settlement subsistence in the early part of the period, followed by what appears to be increasingly sedentary lifestyle, Cultural resources identified includes refined and specialized tool assemblages and features, a wide range of non-utilitarian artifacts, abundant trade objects, and plant and animal remains indicative of year round occupation (Moratto 1984; Ragir 1972; White 2003a, 2003b). Further changes were noted in later as new technologies were developed during this period, including new types of bone tools and bone implements, and widespread manufactured goods such as ornaments and ceremonial blades (Bennyhoff and Fredrickson 1969; Fredrickson 1974; Moratto 1984) large quantities of habitation debris and features (such as fire-cracked rock heaps, shallow hearths, house floors, and flexed burials) that reflected long-term residential occupation.
- **Emergent**: The archaeological record for the Emergent/Historic Period (AD 1000) is more substantial and comprehensive than those of earlier periods in the Central Valley, and the artifact assemblages are the most diverse (Fredrickson 1974; Kowta 1988; Sundahl 1992).

According to ethnographer Alfred Krober (1932), the Project area falls between ethnographically reported Patwin and Nisenan areas. Heizer and Hester (1970) present information naming the Patwin village of Yo’doi at Knights Landing and the Nisenan village of Hol’lo-wi near the historic town of Fremont. The NAHC however has previously assigned the Patwin as Most Likely Descendants (MLDs) for the Project area. Both the Yocha Dehe Wintun Nation (Patwin) and the United Auburn Indian Community of the Auburn Rancheria (Nisenan and Miwok) claim cultural and traditional affiliation with the Project area.

- **Nisenan**: Nisenan villages, which ranged from “tribelets” of small extended families consisting of 15 to 25 individuals to larger communities with more than 100 people, have been documented as being along the western bank of the Sacramento River. Wilson and Towne (1978) defined three main subgroups within the Nisenan tribe: Northern Hill Nisenan, Southern Hill Nisenan, and Valley Nisenan. The traditional Valley Nisenan lived on both sides of the Feather River from above Marysville to the confluence of the Sacramento and Feather rivers, then down both sides of the Sacramento River past the city of Sacramento (Wilson and Towne 1978; Kroeber 1932).

- **Patwin**: The Patwin were a series of linguistically and culturally related tribelets that occupied a portion of the lower Sacramento Valley west of the Sacramento River and north of Suisun Bay. Today, the Patwin descendants affiliated with the Project area are the Yocha Dehe Wintun Nation. The Project area's historic-era environment is largely the product of agricultural and residential development as well as fishing, canning, and other industrialized produce processing. These were facilitated by land reclamation and by transportation development, the latter of which initially depended on Delta waterways but eventually surmounted those waterways. The Project area's environment has also been shaped by large-scale flood control and water management efforts as well as recreational activities such as fishing and boating.

Previous studies near the Project area provide reasonable expectations of the range of historic archaeological property types relevant to the study area. These property types are classified here in terms of function. Intensive historic-era use of waterways within the Project area coincides with the discovery of gold in 1848. The sudden influx of fortune seekers resulted in heavy use of waterways within the Project area for transportation of individuals and supplies. To accommodate the surge, cities and towns were established along the rivers. Both small- and large-scale mining endeavors were carried out in the Project area vicinity along the Feather, Sacramento, and American rivers. Agricultural endeavors followed quickly, and overland transportation routes were developed that often paralleled waterways in the Project area. Historic archaeological resources within the Project area are mostly related to these events. Six categories of historical archaeological property types have been identified within the Project area: building foundations, refuse scatters/dumps, transportation-related features, water conveyance systems, historic isolates, and maritime/riverine property types.

The paleontological setting in the area is defined by the two geologic deposits that characterize the Lower Sacramento River region: Holocene river deposits and Holocene flood-basin deposits. Pliocene and Holocene continental rocks and deposits are mixed into flood-basin deposits in the Sacramento Valley (Page 1986). The fossil-bearing Pleistocene Modesto formation may be present within the Lower Sacramento River floodplain. The Modesto formation consists of alluvial terraces and fans dating between 9,000 and 75,000 years ago (Page 1986). Fossil discovery within Sacramento and Yolo counties largely occurs within quarries and along river banks.

The Sacramento River and its tributaries have been heavily affected by anthropogenic processes. The natural flooding and meandering have been confined to manmade earthen structures with no course deviation. Agricultural irrigation is the most significant anthropogenic impact within and around the Project area, including a major canal (Tule Canal) intersecting with the Project area. Anthropogenic impacts to regional riverine landscapes contribute to disturbance and rearrangement of native surficial soils. The probability of paleontological resource discovery within the project area is unlikely without considerable excavation.

2.1.7 Water Quality

The Yolo Bypass region is primarily influenced by inputs from the Sacramento and Feather rivers as well as western stream inputs, including KLRC, Cache Creek, Willow Slough Bypass, and Putah Creek. The basin drains to the lower Delta through the Toe Drain channel along the Sacramento River. There are several high priority pollutants of concern identified in the YBWA Management Plan (CDFG 2008). These include mercury, toxic chemicals, salinity, bacteria, selenium, and boron. Several of these have been identified in the contributing waterbodies to the bypass as part of the 303(d) program.

Mercury. Mercury is a toxic pollutant that readily transports through the environment and accumulates within fish in both contaminated and seemingly pristine aquatic ecosystems (Cabana et al. 1994). Human and wildlife exposure to methylmercury, for organic form of the metal that accumulates in the food web, is a potent neurotoxin that can impair reproduction and fetal development (Ratcliffe et al. 1996). Mercury released during gold mining operations in the Sierra Nevada and mercury mining along the eastern edge of the Central Valley from south of Paso Robles to north of the Bay Area are primary sources of Hg to rivers and lakes, including the Sacramento River and Yolo Bypass. Many of the more than 500 mercury mines in California have not been remediated and many continue to release mercury to the environment (CDFG 2017). Yolo Bypass is essentially a seasonal wetland, with periodic flows of shallow slow-moving water over vegetated soils. In an analysis of a suite of wetlands managed for either agriculture or wildlife, the presence of shallow slow-moving water, flooding and drying cycles, and presence of plant matter overall enhance the production of methylmercury (Windham-Myers et al. 2014).

Toxic Chemicals. Toxic chemicals, including pesticides, are included as 303(d) listed constituents of concern primarily in the Sacramento River. Due to agricultural land uses, pesticides are found throughout the waters and sediments of the bypass (CDFG 2008). The major pesticides that have been used on rice in this region are molinate, thiobencarb, and carbofuran. Molinate and thiocarb are applied to control aquatic grasses and weeds on flooded rice fields while carbofuran is applied to control insects. These chemicals have been shown in the past to be acutely toxic to fish and were attributed to objectionable taste issues in drinking water in the City of Sacramento (Domagalski et al. 2000).

Salinity. High salt content is a concern for the entire bypass area (City of Woodland 2005). Salinity can reduce the productivity of the bypass agricultural fields and may create problems for seasonal wetlands, including stress on microorganisms, plants, and animals.

2.1.8 Air Quality

2.1.8.1 Criteria Pollutants

The study area is within the boundaries of Sacramento Valley Air Basin (SVAB). SVAB is bounded by North Coast Ranges on the west and Northern Sierra Nevada Mountains on the east, and the intervening terrain is relatively flat. The mountains surrounding SVAB create a barrier to airflow, which can trap air pollutants under certain meteorological conditions. Hot dry summers and mild rainy winters characterize the Mediterranean climate of SVAB (California Air Resources Board undated).

The USEPA regulates ambient concentrations of seven common pollutants: carbon monoxide (CO), lead, nitrogen dioxide, O_3, particulate matter (PM_{10} and $PM_{2.5}$), and sulfur dioxide. The Federal CAA requires states to classify air basins (or portions thereof) as either “attainment” or “nonattainment,” with respect to criteria air pollutants, based on whether the national ambient air quality standards (NAAQS) have been achieved. California also has its own ambient air quality standards (CAAQS) and has designated the air basins within the State based on whether the CAAQS are attained.

The project area is designated severe nonattainment for the O_3 NAAQS, nonattainment for the O_3 CAAQS (except Sutter County, which is designated nonattainment-transitional), nonattainment for the $PM_{2.5}$ NAAQS, nonattainment for the PM_{10} CAAQS, and maintenance for the CO and PM_{10} NAAQS. The area is designated attainment for all other pollutants.

2.1.8.2 Climate Change and Greenhouse Gases

The projected changes in climate conditions are expected to result in a wide variety of impacts in Yolo County and the Sacramento River area. In general, estimated future climate conditions include changes to: 1) average daily temperature, 2) extreme heat, 3) precipitation, 4) sea level and storm surge, and 5) snowpack and streamflow.

Global climate model data exhibit warming across California under multiple scenarios with a steady, linear increase over the 21st century. Temperatures in the study area are expected to be between 5.1 and 9.3°F higher than the historic average (1961 to 1990) by the end of the 21st century. The climate model results also consistently show increases in frequency, magnitude, and duration of heat waves when compared to historical averages (Cayan at al. 2012).

For Sacramento, several model simulations indicate a drying trend (i.e., less precipitation) when compared to the historical average. Under the low emissions scenario, the 30-year mean precipitation is projected to be more than five percent drier by mid-21st century and 10 percent drier by late-21st century (Cayan et al. 2012).

Streamflow amounts are projected to shift to more runoff in the winter and less in the spring months. This projected shift occurs because higher temperatures during winter cause more precipitation to occur as rainfall, which increases runoff and reduces snowpack (Reclamation 2014). The frequency of reduced cold water pool in Shasta Reservoir is expected to increase on average by five percent overall during the 21st century (Reclamation 2014).

Sea level rise is expected to increase water levels in the Delta. Additionally, the increase in water levels in the Delta will also increase salinity at the confluence of the Sacramento River and the Delta.

2.1.9 Soils, Geology, and Mineral Resources

The area of analysis includes the Yolo Bypass and surrounding areas within Yolo and Sutter counties. The southern point of the Yolo Bypass, in Solano County, is not considered because no project actions would occur there. Yolo and Sutter counties are in the southern part of Sacramento Valley. Sacramento Valley is bordered by the Coast Range to the west, the Sierra Nevada to the east, and San Joaquin Valley to the south. Yolo Basin is bounded to the north and east by the natural levees of the Sacramento River, to the west by the coalesced alluvial fans of Putah Creek and Cache Creek, and to the south by the tidal marshes of the Delta.

Yolo Bypass is in the Great Valley geomorphic province of California. The Great Valley is an alluvial plain that acts as a trough where sediment has been continuously deposited. Geologic units in the Great Valley Province generally consist of Quaternary alluvium and the Quaternary Modesto and Riverbank formations, both of which consist of somewhat older alluvium and make up the alluvial fan deposits.

The linear extensibility of the soils in the Project area indicate the presence of shrink-swell potentials, ranging from small to high. Soils near Fremont Weir indicate a low risk of damage due to shrinking or swelling. Soils near some of the agricultural road crossings indicate moderate to high shrink-swell potential. In Yolo County, most of the soils are defined by low erodibility and low to high shrink-swell potentials. There are some areas in Yolo County with mid-range erodibility and high erosion potentials. Soils with high to very high shrink-swell potentials, like most the soil in Yolo County, have the potential to cause damage to infrastructure such as buildings, roads, and bridges. Soils with high to very high shrink-swell potential also have high to very high linear extensibility percentages (six percent or higher), which can also lead to infrastructure damage. Soils in Sutter County have low to mid-range erodibility and low to high shrink-swell potentials.

The Project area is not within range of known active faults and experiences less frequent seismic activity than the rest of California (California Geologic Survey [CGS] 2008). The Project area is not located in an Alquist-Priolo Earthquake Fault Zone, and no active faults have been identified in the area; therefore, the risk for surface fault rupture in the Project area is low (CGS 2015 and 2010). The active fault closest to the Project area is the Hunting Creek fault, in the northwest portion of Yolo County, and the closest inactive fault is the Dunnigan Hills fault (CGS 2010). Although the potential for liquefaction in the area is assumed to be moderate, the potential for liquefaction is greater when there is a seismic event. Therefore, it is assumed that because the potential for seismic events is low, there is little to no concern for liquefaction.

2.1.10 Visual, Scenic, or Aesthetic Resources

The Project would take place in Sutter County, Yolo County, within the FWWA, near agricultural road crossings along Tule Canal, and in the adjacent Elkhorn Area. The wildlife area is a 1,461-acre riparian area surrounding part of the Sacramento River. It consists of a wide assortment of vegetation, ranging from large trees and shrubs to smaller shrubs and grasses and riparian areas. This wildlife area is publicly accessible year-round during daylight hours for fishing, wildlife viewing, bird watching, and seasonal hunting. The surrounding area is flat agricultural land and open fields. Agricultural fields are usually contained by small levees or berms, separated by ditches and canals that carry water from the major aqueducts to the fields. There are no residences within the Project area and very few residences and no neighborhoods or other concentrations of housing in the vicinity.

Existing features in the Project area include Tule Pond and Agricultural Road Crossing 1, situated along local scenic, County Road (CR) 16, Fremont Weir located in the northern portion of the wildlife area, and the existing fish ladder located near the eastern end of the Fremont Weir. These areas are intended for public use. The area is rural, with limited urban elements and has various visual elements such as ponds, trees and vegetation, and other various habitats, offering contrast that provides a pleasant visual experience, though there are distinct differences between the heavily vegetated wildlife area and the stark open concrete and dirt foundations of the weir.

2.1.11 Indian Trust Assets

Indian Trust Assets (ITAs) are defined as legal interests in property held in trust by the United States government for Indian tribes or individuals or property protected under United States law for federally recognized Indian tribes or individuals. ITAs can include land, minerals, Federally reserved hunting and fishing rights, Federally reserved water rights, and in-stream flows associated with a reservation or Rancheria. ITAs cannot be sold, leased, or otherwise encumbered without approval of the United States.

Figure 2-5 includes a map of ITAs within the southern Sacramento Valley. These ITAs are not within the vicinity of the Project area; therefore, there is no additional discussion of ITAs because of the geographical distance.

2.1.12 Recreation

The area of analysis for recreation is the Yolo Bypass in Yolo, Sutter, and Solano counties, as shown on Figure 2-6. Public lands in Yolo Bypass are limited and predominantly designated and managed by the CDFW as wildlife areas or ecological reserves. These public lands include FWWA, Sacramento Bypass Wildlife Area (SBWA), YBWA, and Liberty Island Ecological Reserve (LIER). Public access to these CDFW-managed areas typically occurs in the spring and summer when Yolo Bypass is not used as a floodplain for the Sacramento River. When Yolo Bypass is inundated, public access is restricted; thus, recreational use is severely limited. Each of these areas managed by CDFW for recreational uses, agricultural uses, wildlife habitat, and wetlands is described below from north to south. In addition, private recreation areas and sites are dispersed throughout the Project area.

FWWA – The FWWA is along the northern boundary of Yolo Bypass in Sutter and Yolo counties, northeast of the Town of Woodland on the south side of the Sacramento River, with Fremont Weir situated along the northern edge of FWWA. The area consists of 1,461 acres of wetland habitat, including weedy vegetation, brush, valley oaks, willows, and cottonwood trees (CDFW 2016a). FWWA is managed as a Type C wildlife area, with hunting opportunities for pheasant, waterfowl, quail, turkey, mourning dove, cottontail, jackrabbit, and deer (CDFW 2016a). CDFW defines Type C wildlife areas as areas that are generally open daily for hunting for all legal species and do not require the purchase of a hunting pass for entry (CDFW 2016b). Hunting is allowed during spring turkey season and daily from July 1 through January 31. Public access and recreation is allowed at the wildlife area, except when river waters are present.

SBWA – SBWA is adjacent to and east of Tule Canal in the central portion of Yolo Bypass in Yolo County. SBWA is managed as a Type C wildlife area. This 360-acre state wildlife area is an important cover and feeding area for wildlife during late fall, winter, and early spring. SBWA provides recreational opportunities for fishing (in Tule Canal), wildlife viewing, bird watching, and seasonal hunting (September 1 to January 31) (CDFW 2016c).

Figure 2-5. Yolo Bypass Proximity to ITAs in the Sacramento Valley

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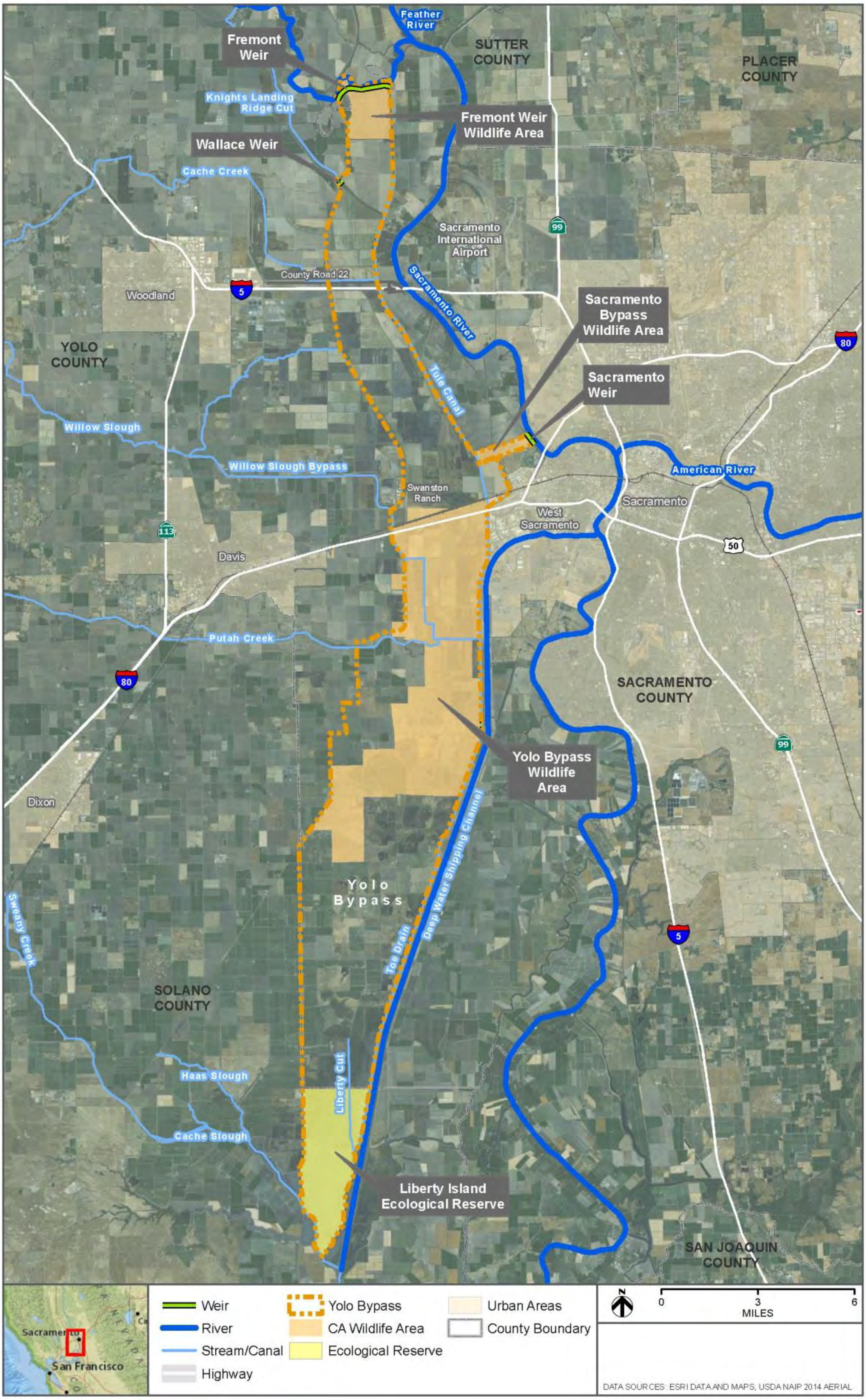

Figure 2-6. Recreation Resources in the Project Area and Region

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YBWA – YBWA is in the central portion of Yolo Bypass in Yolo County between the cities of Davis and West Sacramento. YBWA consists of 17 separate management units on about 16,770 acres of CDFW-managed wildlife habitat and agricultural land. CDFW manages YBWA as a Type A wildlife area, including hunting opportunities for waterfowl and upland game species (CDFW 2016d). CDFW defines a Type A wildlife area as an area with restricted hunter access during waterfowl season and requires a hunting pass to be purchased in advance and exchanged for an entry permit at the wildlife area. YBWA is open year-round from sunrise to sunset except for Christmas Day. Recreational uses for YBWA include hunting, fishing, walking, hiking, wildlife viewing, nature exploration and photography, and environmental education activities for students and the public (CDFW 2016d). Hunting historically has been a popular seasonal use of YBWA, with about 5,000 acres open for hunting. The hunting season runs from the opening of dove season (September) through January, but the most popular hunting season is for waterfowl from late October through January (about 100 days).

In addition, CDFW has partnered with Yolo Basin Foundation to provide educational programs and outreach. Facilities supporting the recreational and education uses include trails, gravel roads, parking areas, and hunting blinds. Yolo Bypass Foundation estimates that more than 4,000 students, teachers, and parents visit the area annually to participate in the Discover the Flyway program implemented in partnership with CDFW (Yolo Basin Foundation 2016).

YBWA is open to the public except during certain Yolo Bypass flooding occurrences. Currently, YBWA public-access policy is to close the entire area soon after water overtops Fremont Weir. Much of YBWA is closed to all non-hunting purposes from two weeks before waterfowl season to one week after waterfowl season though areas designated for wildlife viewing purposes are open on most days throughout the year (CDFG 2008). Significant flooding during the 100-day hunting season (mid-October to mid-January) requires CDFW to discontinue access to these areas, resulting in lost hunting time and other public uses (CDFG 2008). Under existing conditions, inundation results in wildlife area closures lasting for up to two weeks (14 days) out of the 100-day hunting season (Petrik et al 2012).

LIER – LIER is located along the southern boundary of Yolo Bypass in Solano County, southeast of the Town of Dixon. LIER consists of 4,450 acres of mostly inundated tidal marsh habitat in the southern portion of Liberty Island between Prospect Slough and Shag Slough (CDFW 2016e). Recreational uses include wildlife viewing, shoreline fishing, boat fishing, and waterfowl hunting. Hunting for waterfowl in the ecological reserve is allowed seven days per week during the regular waterfowl season, and specific regulations allow the use of temporary floating blinds that must be removed daily (CDFW 2016e).

Private Recreation Areas and Sites – The majority of private recreational use and opportunities occurs on the expansive private lands throughout the Yolo Bypass area where private landowners and their personnel and guests have access to private recreational opportunities, many of which occur without formal recreational facilities. Most of these opportunities are in Yolo County where 17 private hunting clubs, three marinas, and one yacht club are located (DWR 2013). The private hunting clubs are south of YBWA and north of LIER. Sutter County has a minor amount of private recreational opportunities (two marinas and boat clubs) adjacent to the Project area (DWR 2013). Solano County also has limited private recreational facilities, including two marinas, one yacht club, and one hunting club (DWR 2013).

2.2 Future Without Project Conditions

Future without project conditions represent the reasonably foreseeable future conditions in the study area in the absence of the Project. Yolo Bypass would continue to be inundated during overtopping events at Fremont Weir. Juvenile fish would enter the bypass with these flood flows, and the fish would benefit from the rearing opportunities in Yolo Bypass. Additional flow and fish would not pass through Fremont Weir when the Sacramento River is below Fremont Weir.

Adult fish may move upstream in Tule Canal when flows over Fremont Weir or from the westside tributaries provide attraction. As under existing conditions, fish would either pass over Fremont Weir, pass through the fish passage structure at Fremont Weir, become stranded at Fremont Weir, or move to the fish rescue facility at Wallace Weir.

The resources discussed in Section 2.1 are expected to remain largely the same into the future within the Yolo Bypass.

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3 Alternative Formulation Process

The purpose of the alternative formulation process is to identify a reasonable range of alternatives for inclusion in the EIS/EIR.

3.1 Process Overview

The alternatives development process involved input and review from resource agencies, local agencies, landowners, non-governmental organizations (NGOs), and stakeholders. Resource agencies and local agencies were involved at a detailed level, including participation in technical teams (such as the Fisheries and Engineering Technical Team). The process began in 2012 with the development of the *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan* (Implementation Plan) (Reclamation and DWR 2012). In the Implementation Plan, Reclamation and DWR identified their overall plan to develop, refine, and implement projects to satisfy RPA actions I.6.1 and I.7.

The alternatives development process included public scoping conducted in March 2013. Public scoping allowed the Lead Agencies to provide preliminary information on the purpose and need for the project. This step also allowed the Lead Agencies to solicit ideas for achieving the Project's purpose and need and learn of potential impacts. The purpose and need for the project includes:

> The need for action is to address decreased habitat quality and an inadequate ability to access that habitat, which has led to a decline in abundance, spatial distribution, and life history diversity for native ESA-listed and CESA-listed fish species. The purpose of the action is to enhance floodplain rearing habitat and fish passage in the Yolo Bypass and/or other suitable areas of the lower Sacramento River basin by implementing RPA actions I.6.1 and I.7, as described in the NMFS BO, to benefit Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and southern DPS North American green sturgeon

Alternative development focused on providing fish passage and juvenile floodplain rearing habitat. Key considerations for adult and juvenile fish movement included:

- Adult fish passage: Passage must consider both salmonids and green sturgeon, but sturgeon passage requirements are generally more stringent. As benthic swimmers, sturgeon generate speed through body curvature, which can limit passage if a channel has submerged obstacles, orifices, or jumps (DWR 2017). Sturgeon avoid turbulent flow conditions, so passage must be provided by non-turbulent, open channel flow structures (DWR 2017). Both salmonids and sturgeon need to pass on their own volition, eliminating trap and haul as a primary means for fish passage (DWR 2017).
- Juvenile migration: Structures must be designed so that fish are not disoriented as they pass through the gates. Juvenile salmonids migrate down the river in the top third of the water

column. Functional design concepts must avoid impingement[1] and the creation of eddies[2] that can increase predation. Juvenile fish should enter the Yolo Bypass on their own volition with the redirected flow from the Sacramento River; trapping fish in the Sacramento River and relocating them to the Yolo Bypass would not satisfy the requirement for volitional passage (DWR 2017).

The Lead Agencies developed fish passage criteria to comply with during design of structures so that adult salmonids and sturgeon would be able to pass. The criteria are presented in Table 3-1. Appendix C includes the basis for development of these criteria.

Table 3-1. Summary of Fish Passage Criteria for Federally-Listed Species within the Yolo Bypass and Sacramento River

Species	Adult Migration Time	Minimum Depth of Flow (Short Distance)	Minimum Depth of Flow (Long Distance)	Minimum Channel Width	Maximum Velocity (Short Distance)	Maximum Velocity (Long Distance)
Adult Sturgeon	Jan-May	3 feet	5 feet	10 feet	6 feet/ second*	4 feet/ second
Adult Salmonids	Nov-May	1 feet	3 feet	4 feet		

Source: DWR 2017

* Short distance velocity is for a maximum length of 60 feet

Juvenile salmonids out-migrate past Fremont Weir at different times of the year, depending on hydrologic conditions. The majority of juvenile winter-run Chinook salmon migrate through this area from December through January and continue to migrate through mid-April to early May (Reclamation and DWR 2012). The early pulse of out-migration is strongly correlated with the first flushing flow of over 15,000 cfs in the Sacramento River at the Wilkins Slough gage (Reclamation and DWR 2012). The majority of juvenile Central Valley spring-run Chinook salmon pass through this area in late-November through December, with out-migration continuing through mid-May (but primarily complete in mid-April) (Reclamation and DWR 2012). Diverting fish into the Yolo Bypass (or "entrainment") would need to occur at times when fish are present in the river near Fremont Weir.

The alternatives development process was outlined in the Planning Framework Technical Memorandum (Reclamation and DWR 2013). This document identified the steps to formulate alternatives, including the screening process and initial criteria. Figure 3-1 shows a summary of the alternatives formulation process.

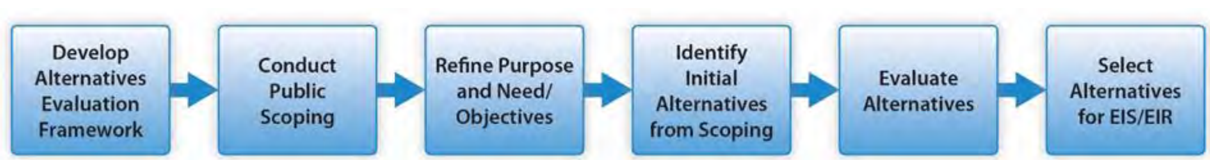

Figure 3-1. Alternatives Formulation Process

[1] Impingement occurs when fish are held against a structure.
[2] Eddies are circular flow patterns that can delay fish.

3.2 Initial Alternatives

3.2.1 Identification

After the public scoping process, the Lead Agencies collected initial components that could help achieve the purpose and need of the project. A component is a project or plan that could contribute to meeting the purpose and need but may not be able to fully accomplish it independently. The Bay Delta Conservation Plan included a planning effort to identify actions that could expand rearing habitat and improve fish passage in the Yolo Bypass. The materials developed in that effort provided initial components for consideration. These components were augmented with suggestions from the Lead Agencies' technical experts and comments during the public scoping process. The Bay Delta Conservation Plan also formed a stakeholder group, the Yolo Bypass Fisheries Enhancement Planning Team, which included resource agencies, landowners, and NGOs, to help develop a plan for the Yolo Bypass. The Lead Agencies solicited additional suggestions from the planning team.

The Lead Agencies performed an initial screening of the components that came out of this process. Components were not considered further if they would not contribute toward accomplishing the purpose and need or if they were deemed technically infeasible. Several options that were screened out are discussed below.

3.2.1.1 Switchbacks

Initial components included structures that had multiple connections from the Sacramento River through Fremont Weir into the FWWA. Each of these connections would have a canal system with switchbacks between the multiple connections. The team did not continue to consider components with switchbacks because they are not conducive to reliable sturgeon passage.

3.2.1.2 Create a Habitat "Shelf" Along the Tule Canal/Toe Drain

To expand floodplain area, this component considered developing a terrace on a portion of the land along the Tule Canal/Toe Drain to create a habitat "shelf" that inundates more frequently. This effort would have land use concerns because it would remove land from agricultural production or wetland use that is adjacent to the Tule Canal/Toe Drain, and the earthwork would be costly. Therefore, it was not retained for further consideration.

3.2.1.3 Create Berms along the Tule Canal/Toe Drain

This component considered creating berms along a portion of the land along the Tule Canal/Toe Drain to help keep water that gets onto the floodplain out of the channel for a certain distance. This component was not retained because it would impede fish passage, which must be improved as part of the Project.

3.2.1.4 Create Setback Levees along the Lower Sacramento River

This component considered creating rearing habitat along the lower Sacramento River system by setting back the Sacramento River levees (or levees on tributaries or adjacent waterways) and creating floodplain habitat. The Lead Agencies considered areas along the Sacramento River system where levees could be set back without encountering engineering constraints or causing substantial land use impacts. The Lead Agencies identified that this could be possible within the Elkhorn Area, which moved forward for more analysis. But the remaining areas within the lower Sacramento River system were not conducive to major setback levee projects. The levee setbacks would not result in enough floodplain habitat acreage to satisfy the requirements in the RPA, and the Lead Agencies would have had to construct in multiple places because construction in the Yolo Bypass would have been required to address adult fish passage concerns.

3.2.2 Formulation

After screening the initial components, the remaining components were combined into initial alternatives in 2014. These six alternatives had several variations, which are described below. The alternative numbering used here does not correspond to the final alternatives (identified in Section 3.3 and discussed in the later sections of this document). For this initial evaluation, the alternatives that increased inundation used the same date for the end of the inundation operations (either March 30 or April 30).

3.2.2.1 Common Elements

At this point in alternatives development, most alternatives included a set of common elements. These common elements included upstream adult fish passage, stranding reduction, agricultural road crossing modifications, Lisbon Weir improvements, Wallace Weir improvements, research and monitoring, and support and maintenance facilities. Several of these elements were later separated into stand-alone projects with independent utility and advanced for implementation outside of this Project, as described in Section 3.3.

3.2.2.2 Initial Alternative 1: No Action and No Project Alternative

The No Action and No Project Alternative describes conditions if no actions are taken as part of this Project to accomplish the project objectives. This alternative is required under NEPA and CEQA. This alternative is called the No Action alternative under NEPA and the No Project alternative under CEQA and is referred to in the remainder of the document as the “No Action Alternative.” Under the No Action Alternative, the Yolo Bypass would continue to be inundated during overtopping events at Fremont Weir. Juvenile fish would enter the bypass with these flood flows, and the fish would benefit from the rearing opportunities in the Yolo Bypass. Additional flow and fish would not pass through Fremont Weir when the Sacramento River stage is below the crest of Fremont Weir.

Adult fish may move upstream in Tule Canal when flows over Fremont Weir or from the westside tributaries attract fish. As under existing conditions, fish would either pass over Fremont Weir, pass through the existing fish passage structure at Fremont Weir, become stranded at Fremont Weir, or move to the fish rescue facility at Wallace Weir.

3.2.2.3 Initial Alternative 2: Fremont Weir Notch Alternative

The Fremont Weir Notch alternative would construct a new gated notch in Fremont Weir to function as the primary adult fish passage mechanism and allow flow and juvenile fish to enter the Yolo Bypass before the Sacramento River rises above the Fremont Weir crest. This alternative included variations with notches of different size and location. Some of these variations also considered developing a new gate structure in the Sacramento River levee near the Yolo Bypass with a transport channel through the Yolo Bypass levee into the bypass system. Figure 3-2 shows the potential locations for different variations. All notches would allow flows up to 6,000 cfs to enter the Yolo Bypass from the Sacramento River.

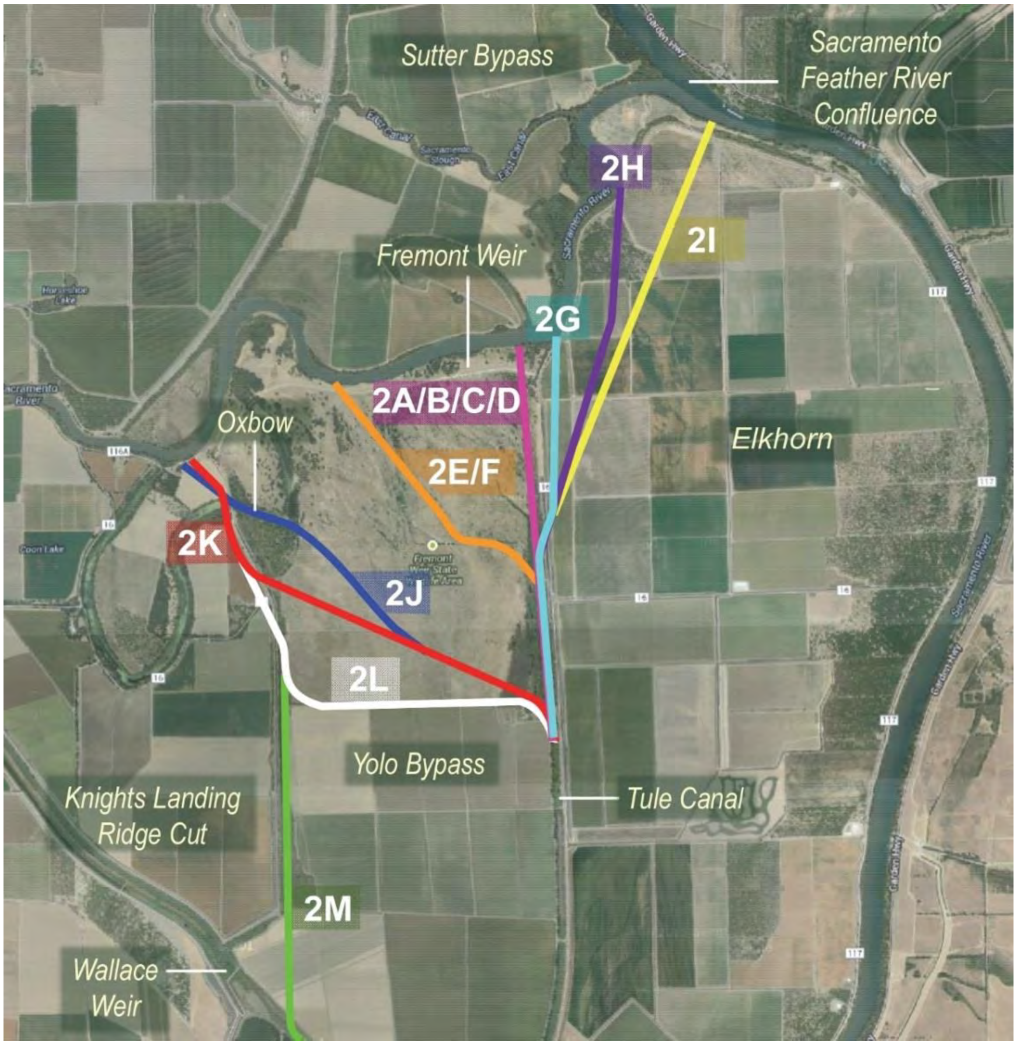

Figure 3-2. Variations for Initial Alternative 2: Fremont Weir Gated Notch

In addition to the different locations, the variations included different sizes of notches. Table 3-2 shows the different variations for this alternative, including the invert elevation (the elevation of the bottom of the gated channel) and the bottom width at this location. Each notch would be trapezoidal in shape and include gates for hydraulic control.

Table 3-2. Fremont Weir Gated Notch Initial Alternatives

Alternative Variation	Invert Elevation	Bottom Width	Notch Location	Connection Point to Tule Canal	Other Features
2a: Small east-side notch	14’	20’	East	Tule Pond	
2b: Medium east-side notch	17.5’	225’	East	Tule Pond	
2c: Medium east-side notch with supplemental flows	17.5’	225’	East	Tule Pond	Supplemental Flows from KLRC
2d: Large east-side notch	14’	225’	East	Tule Pond	
2e: Large central notch	14’	225’	Central	Tule Pond	
2f: Medium central notch	17.5’	225’	Central	Tule Pond	
2g: East of Fremont Weir	17.5’	225’	East of Fremont Weir	Tule Pond	
2h: Elkhorn notch	17.5’	225’	East of Fremont Weir and Alt 2G	Tule Pond	
2i: Eastern Elkhorn notch	17.5’	225’	Downstream of Feather River confluence	Tule Pond	
2j: West notch through oxbow	17.5’	225’	West	South end of FWWA	Canal alignment through oxbow
2k: West notch along levee	17.5’	225’	West	South end of FWWA	Canal alignment around oxbow
2l: West notch with canal connection	17.5’	225’	West	South end of FWWA	Canal alignment uses existing irrigation canals
2m: West notch with connection to KLRC	17.5’	225’	West	KLRC	Canal heads south along levee to connect to KLRC

Notes: FWWA = Fremont Weir Wildlife Area; KLRC = Knights Landing Ridge Cut

Previous efforts had focused on a “medium” notch with an invert elevation of 17.5 feet and a bottom width of 225 feet in the east location. The initial alternative analysis considered multiple notch sizes at this location and then considered multiple other locations with the medium notch size. These comparisons helped identify the benefits and drawbacks of different notch sizes and locations.

3.2.2.4 Initial Alternative 3: Westside Alternative

Alternative 3 would allow additional flow entering the bypass through the KLRC (west of Yolo Bypass). Under Alternative 3a, fish rearing would be accomplished through aquaculture, and upstream fish passage would be accomplished through fish rescue. Water from KLRC would be used for fish rearing. No new fish passage structures would be constructed at the Fremont Weir; fish passage would be accomplished by capturing adult fish on the downstream side of Fremont Weir and transporting them to the Sacramento River in trucks. Figure 3-3 shows the key features of Alternative 3a.

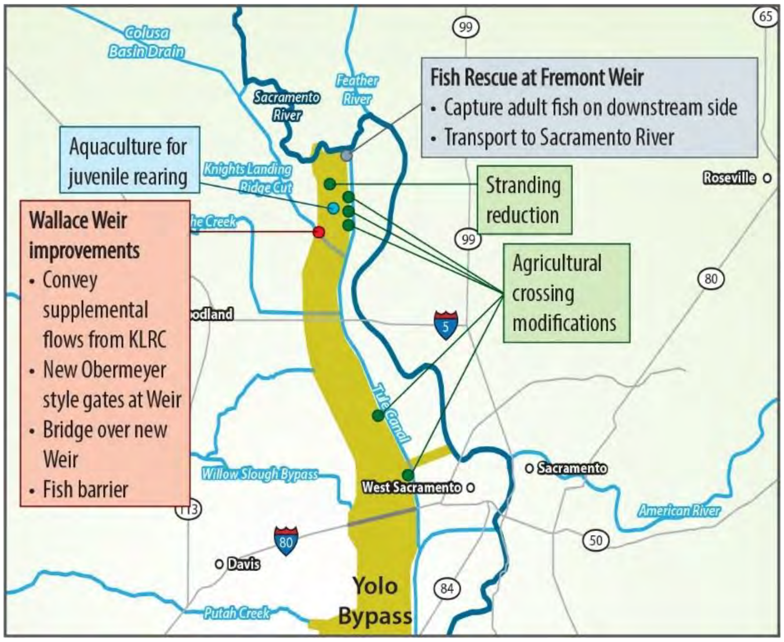

Figure 3-3. Initial Alternative 3a: Westside Alternative

Alternative 3 could have a different variation, which would work to allow volitional fish passage while retaining some concepts of Alternative 3. Alternative 3b would have Sacramento River water enter the KLRC at the Knights Landing Outfall Gates (upstream of the Fremont Weir near Knights Landing). Juvenile fish would enter the Yolo Bypass through the KLRC, and adult fish would have volitional passage upstream through the KLRC into the Sacramento River (through the Knights Landing Outfall Gates). Figure 3-4 shows the key features of Alternative 3b.

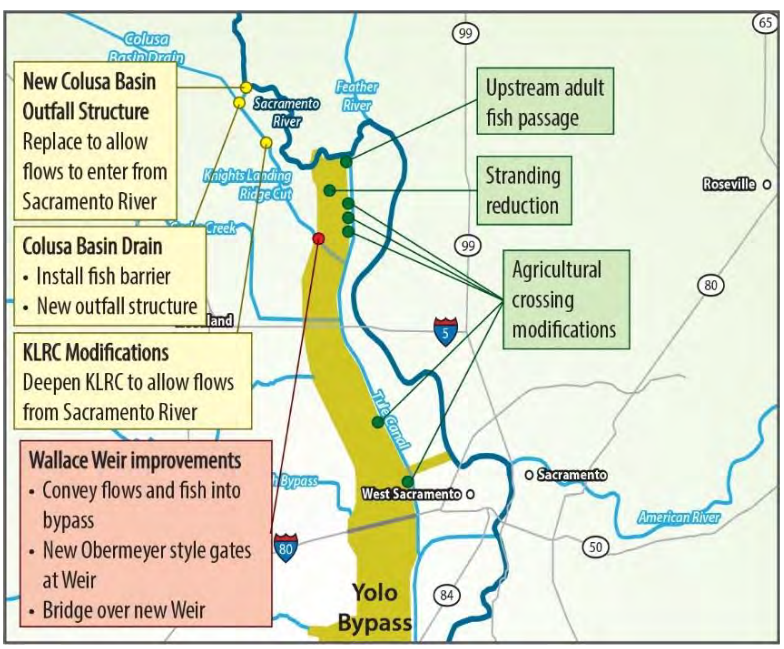

Figure 3-4. Initial Alternative 3b: Westside Alternative with Volitional Passage

Under current operations, the Colusa Basin Drain collects and conveys flood and irrigation return flows from the Colusa Basin watershed and agricultural lands and discharges them into the Sacramento River. When the river is at a higher elevation, the water flows into the KLRC and then into the Yolo Bypass. This alternative would have flows be diverted from the Sacramento River into the Colusa Basin Drain and into the KLRC to support volitional fish passage.

This alternative would require a new Colusa Basin Outfall structure to replace the Knights Landing Outfall Gates that would allow volitional fish passage but close during flood events. The portion of the Colusa Basin Drain from the Sacramento River to the KLRC would need to be regraded so flow would move toward the KLRC. The alternative would also require an outfall structure and fish barrier at the Colusa Basin Drain to control water flow and prevent fish from moving upstream into the drain. KLRC would require modifications to deepen the channel to allow flows from the Sacramento River into the bypass system. Additionally, fish passage structures would be required in the Tule Canal and at Fremont Weir to provide upstream fish passage after Fremont Weir overtopping events.

3.2.2.5 Initial Alternative 4: Elkhorn Alternative

Alternative 4 would include several options to develop floodplain rearing habitat within the Elkhorn Area, which is to the east of the upper Yolo Bypass (between the Yolo Bypass and the Sacramento River, bounded on the south by the Sacramento Bypass). Figure 3-5 shows four of the options (4a-4d), which included varying amounts of new floodplain in the Elkhorn area.

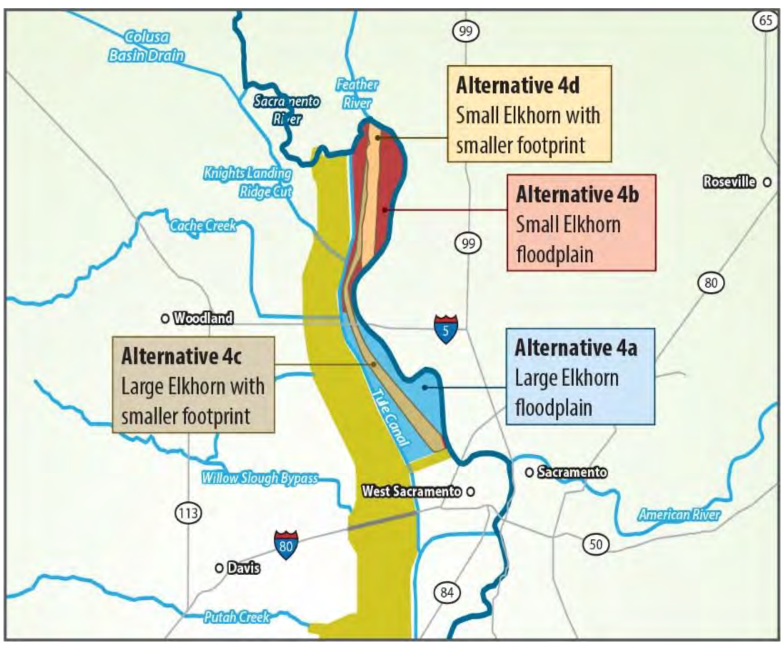

Figure 3-5. Initial Alternatives 4a-4d: Elkhorn Alternative

Alternatives 4a and 4b would expand Sacramento River floodplain into the Elkhorn Area. Alternative 4a would inundate the Elkhorn area to create new floodplain habitat and migratory passage. The levee between the Elkhorn area and the Sacramento River would be removed to allow flows into the Elkhorn area. Alternative 4b would be similar except it would only remove the levee for the northern portion of the Elkhorn area and would not alter the southern portion. The land surface of the Elkhorn area would need to be lowered to allow inundation and create new floodplain habitat. The northern portion and much of the area along the existing levee would be excavated to an average elevation of 18.5 feet. The outside part of the eastern bypass levee would need to be reinforced because it would be wet under this alternative. Alternative 4a would have about 12,400 acres of additional floodplain habitat, and Alternative 4b would have about 6,400 acres of new floodplain habitat.

Alternatives 4c and 4d are similar to Alternatives 4a and 4b but include less earthwork. Alternative 4c would allow inundation of the Elkhorn area but would only remove portions of the Sacramento River levee and excavate a channel between those portions. The areas outside the channel would inundate less frequently than under Alternative 4a. Alternative 4d would similarly inundate only the northern Elkhorn area and would remove portions of the northern Sacramento River levee and develop a channel between those portions. These alternatives would have a secondary channel and floodplain system in the Elkhorn area, but most of the Sacramento River levee would remain in place and some areas would rarely (if ever) be inundated. These alternatives would include ring levees to protect structures from flooding.

Alternative 4e would expand the Yolo Bypass into the Elkhorn area by moving the eastern bypass levee. Water would be diverted from a new notch in the Sacramento River levee. Figure 3-6 shows elements of Alternative 4e. The brown shaded area depicts the Elkhorn expansion. A portion of the bypass levee along the Tule Canal would be removed, and a new levee would be constructed to include the Elkhorn area. The southern area would be graded to a lower elevation to create new floodplain habitat. The expanded area would add about 5,000 acres of inundated floodplain habitat. Juvenile salmonids would be able to use the existing Yolo Bypass and the new Elkhorn area for rearing.

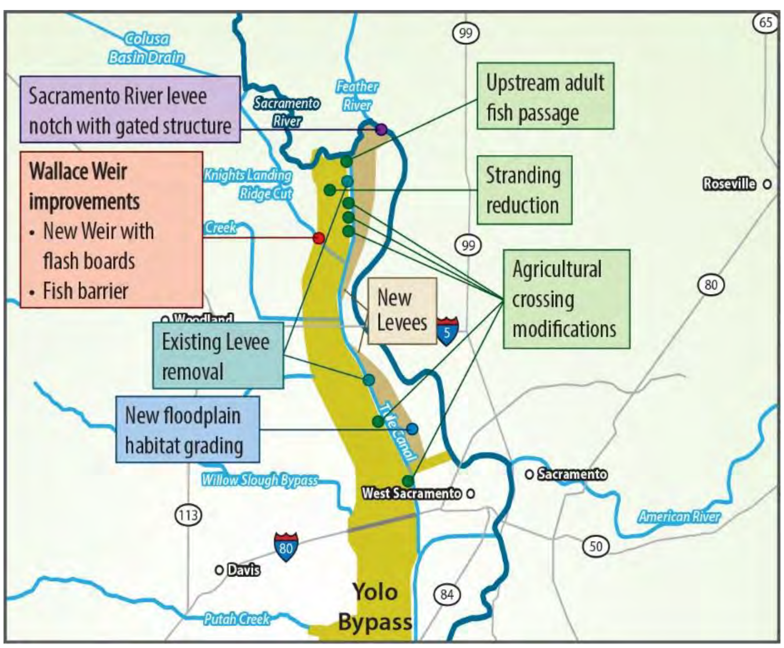

Figure 3-6. Initial Alternative 4e: Yolo Bypass Expansion

3.2.2.6 Initial Alternative 5: Sacramento Weir Notch Alternative

Alternative 5 would construct a new gated notch in the Sacramento Weir to function as the primary adult fish passage mechanism and allow flow and juvenile fish to enter Yolo Bypass through the Sacramento Bypass before the Sacramento River rises above the Sacramento Weir crest. Figure 3-7 shows Alternative 5a (a small notch) and Alternative 5b (a large notch).

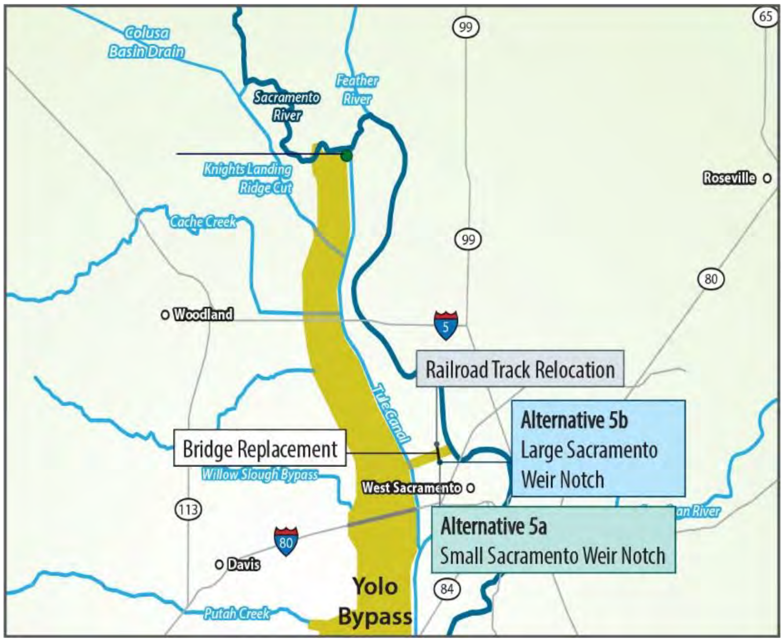

Figure 3-7. Initial Alternative 5: Sacramento Weir Notch

Alternative 5a included a small notch in the Sacramento Weir to allow for floodplain inundation and provide fish passage. The notch would have an invert elevation of two feet and a bottom width of 20 feet. The Sacramento Weir is connected to the southern portion of the Yolo Bypass by a one-mile channel; therefore, only the southern portion of the bypass would be inundated and provide additional rearing habitat. Migrating adult salmonids could swim past the channel to the Sacramento Weir to Fremont Weir. This alternative would also include a fish passage facility at Fremont Weir so that fish upstream of the Sacramento Bypass could pass into the Sacramento River.

Old River Road runs adjacent to the Sacramento Weir and a railroad track runs also along top of Sacramento Weir. Installation of a notch in the weir would destabilize these structures. The existing bridge would need to be strengthened. The railroad track over the weir would need to be relocated because there cannot be any interruptions in rail traffic during the construction period. Because railroad tracks cannot have sharp turns, a longer portion of the track would need to be realigned to accommodate the relocation.

Alternative 5b would include a larger notch in the Sacramento Weir with an invert elevation at two feet and a bottom width of 225 feet. Similar to Alternative 5a, the bridge would need to be strengthened and the railroad track would need to be relocated. Additionally, Alternative 5b would include a fish passage structure at Fremont Weir.

3.2.2.7 Initial Alternative 6: Sutter Bypass Alternative

Alternative 6 would include actions to increase floodplain rearing habitat in the Sutter Bypass, a flood bypass to the north of the Yolo Bypass. Tisdale Weir, north of Knights Landing, diverts flood water from the Sacramento River into the Sutter Bypass, which flows south into the Sacramento River near Fremont Weir. Multiple variations of Alternative 6 would include different actions within Sutter Bypass that could improve floodplain rearing habitat. Alternative 6 also includes fish passage actions in the Yolo Bypass to satisfy RPA action I.7. Figure 3-8 shows Alternatives 6a through 6f:

- Alternative 6a would create a gated notch in Tisdale Weir to allow flow and fish to enter and leave the Sutter Bypass at lower Sacramento River elevations. This alternative would also include a low-flow channel in the Tisdale Bypass to connect to the Sutter Bypass.
- Alternative 6b would set back the southern Tisdale Bypass levee by 1,000 feet to allow increased flow and fish rearing in this area.
- Alternative 6c would set back the west Sutter Bypass levee (south of the Tisdale Bypass) to provide increased floodplain rearing habitat.
- Alternative 6d would set back the east Sutter Bypass levee (south of the Tisdale Bypass) to provide increased floodplain and expand the Feather River floodplain in the southern portion of the bypass.
- Alternative 6e would create 800 acres of a habitat shelf in the Sutter Bypass that would be inundated seasonally from the Sacramento River to the south.
- Alternative 6f would connect several existing gravel pits to reduce predation and potentially provide habitat.

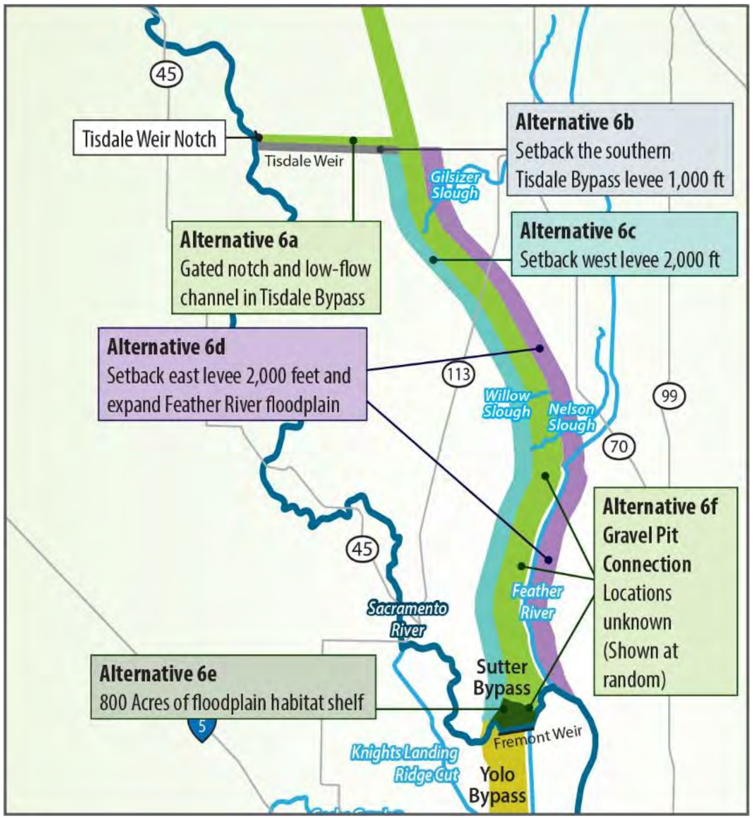

Figure 3-8. Initial Alternative 6a through 6f in the Sutter Bypass

Figure 3-9 shows two additional alternatives in the Sutter Bypass. Alternative 6g would modify the Nelson Rock Weir in the Sutter Bypass to increase inundation. It would not increase access for fish to habitat but would increase the length of inundation for fish in the Sutter Bypass. Alternative 6h would modify Weir 1 in the Sutter Bypass to increase inundation in the Sutter National Wildlife Refuge to the north of Tisdale Bypass.

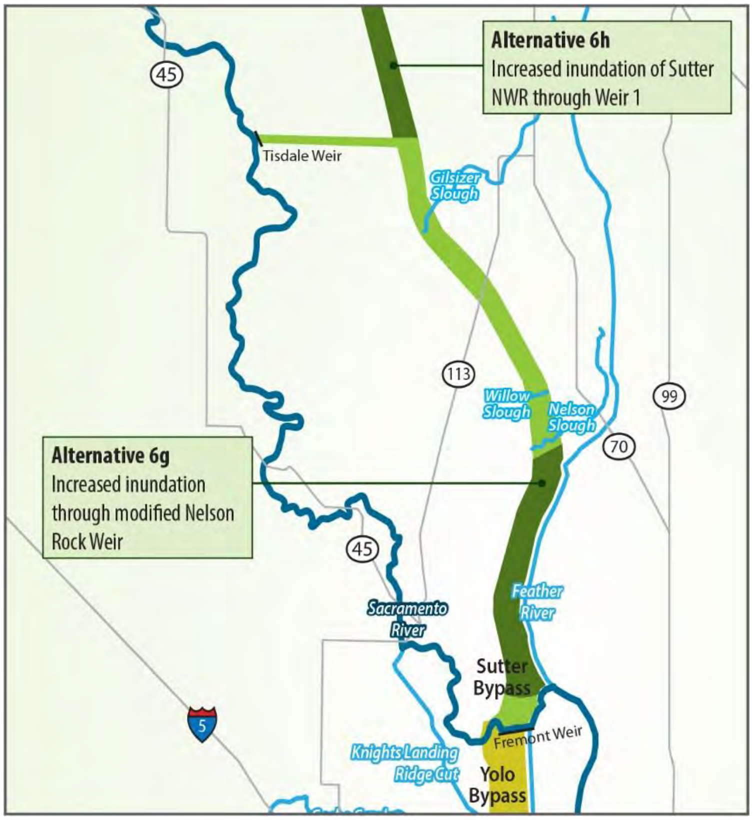

Figure 3-9. Initial Alternatives 6g and 6h in the Sutter Bypass

3.2.3 Alternative Screening

The Lead Agencies completed an initial evaluation of these alternatives based on the Federal planning criteria included in the 2013 Principles, Requirements and Guidelines for Water and Related Land Resources Implementation Studies (PR&Gs). The evaluation considered:

- Effectiveness: How well an alternative plan would achieve rearing habitat and fish passage objectives.
- Completeness: Whether an alternative plan would provide improvements for all four focus fish.
- Acceptability: Whether an alternative plan would be compatible with other efforts in the bypass and minimize effects to agriculture, waterfowl, education, and biological resources.
- Efficiency: How well an alternative plan would deliver economic benefits relative to project costs.

The Lead Agencies further defined these Federal planning criteria related to this project and developed a set of evaluation factors. The evaluation factors identify how well an alternative meets each Federal planning criterion. For initial alternative screening, most of the evaluation was at a qualitative level. Table 3-3 shows the planning criteria and evaluation factors.

Table 3-3. Federal Planning Criteria and Evaluation Factors

Federal Planning Criterion	Category	Evaluation Factors
Effectiveness: How well an alternative would alleviate problems and achieve opportunities	Increase access to floodplain habitat	Measure connectivity and potential to entrain winter-run Chinook onto floodplain
		Measure connectivity and potential to entrain spring-run Chinook onto floodplain
	Increase area of floodplain habitat	Inundation area (area inundated at least 14 days in 50 percent of years)
	Increase food production as part of ecosystem approach	Increase in food production
	Adult fish passage	Percent of season that meets adult fish passage criteria
	Juvenile fish passage	Potential for juvenile stranding or predation risk
Completeness: Whether an alternative would account for all investments or other actions necessary to realize the planned efforts	Provide complete fish benefits	Addresses all four focus fish
Acceptability: The viability of an alternative with respect to acceptance by other Federal, State, and local entities and compatibility with existing laws	Agricultural impacts	Inundation effects on agricultural production
	Waterfowl impacts	Available foraging habitat
		Inundation of areas that reduce waterfowl food production
		Impacts to access or increased inundation of recreation areas
	Education impacts	Inundation of areas used for educational outreach
	Biological impacts	Impacts from construction (benefits addressed under “effectiveness” criterion)
	Compatibility with other related efforts	Potential to affect future options or costs for other flood and restoration planning efforts
Efficiency: How well an alternative would deliver economic benefits relative to project costs	Cost-effectiveness	Relative benefits and costs

3.2.3.1 Effectiveness

The effectiveness planning criterion considers how well the alternatives would meet the purpose and need and project objectives. For this project, the evaluation factors consider the quantity and quality of floodplain rearing habitat, access to that habitat, and fish passage through the Yolo Bypass. The sections below describe how the alternatives perform compared to each evaluation factor, and the results are summarized in Table 3-4.

Table 3-4. Effectiveness Evaluation Results

Alternative	Winter-Run Entrainment	Spring-Run Entrainment	Inundation Area	Food Production	Adult Fish Passage	Juvenile Fish Passage
Alt 2a, Small East Notch						
Alt 2b, Medium East Notch						
Alt 2c, Medium East Notch with Supplemental Flows						
Alt 2d, Large East Notch						
Alt 2e, Large Central Notch						
Alt 2f, Medium Central Notch						
Alt 2g, East of Fremont Weir						
Alt 2h, Elkhorn Notch						
Alt 2i, Eastern Elkhorn Notch						
Alt 2j, West Notch through Oxbow						
Alt 2k, West Notch along Levee						
Alt 2l, West Notch with Canal Connection						
Alt 2m, West Notch with KLRC Connection						
Alt 3a, Westside						
Alt 3b, Westside with Volitional Passage						
Alt 4a, Large Elkhorn Floodplain						
Alt 4b, Small Elkhorn Floodplain						
Alt 4c, Large Elkhorn with Smaller Footprint						

Alternative	Winter-Run Entrainment	Spring-Run Entrainment	Inundation Area	Food Production	Adult Fish Passage	Juvenile Fish Passage
Alt 4d, Small Elkhorn with Smaller Footprint	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	High Performance	High Performance
Alt 4e, Yolo Bypass Expansion	Neutral Performance or Minor Benefits	Medium Performance	Medium Performance	Medium Performance	High Performance	Medium Performance
Alt 5a, Small Sacramento Weir Notch	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Poor Performance	Poor Performance	High Performance	Medium Performance
Alt 5b, Large Sacramento Weir Notch	Medium Performance	Medium Performance	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	High Performance	Medium Performance
Alt 6a, Tisdale Weir Notch	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	High Performance	Medium Performance
Alt 6b, Tisdale Bypass Setback	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	High Performance	Medium Performance
Alt 6c, West Sutter Bypass Setback	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	High Performance	Medium Performance
Alt 6d, East Sutter Bypass Setback	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	High Performance	Medium Performance
Alt 6e, Sutter Bypass Habitat Shelf	Neutral Performance or Minor Benefits	Poor Performance	Poor Performance	Poor Performance	High Performance	Medium Performance
Alt 6f, Gravel Pit Connection	Poor Performance	Poor Performance	Poor Performance	Poor Performance	High Performance	Medium Performance
Alt 6g, Nelson Rock Weir Modification	Poor Performance	Poor Performance	Poor Performance	Poor Performance	High Performance	Medium Performance
Alt 6h, Weir 1 Modifications	Poor Performance	Poor Performance	Poor Performance	Poor Performance	High Performance	Medium Performance

Legend

High Performance	Medium Performance	Neutral Performance or Minor Benefits	Poor Performance

3.2.3.1.1 Winter-Run Chinook Salmon Entrainment

Large numbers of juvenile winter-run Chinook salmon typically move downstream on the Sacramento River during the first wet event of the year. The type of event that causes fish to move downstream results in flows of about 15,000 cfs at Wilkins Slough; these flow events have Sacramento River elevations at Fremont Weir of about 18 feet. Alternative 2 with larger notches would better capture river flows at these lower elevations, but none of the facilities would capture a substantial amount of flow. Alternative 3a would not entrain juvenile salmonids, and Alternative 3b would have minimal flow at lower river elevations. Alternatives 4a through 4d would have grading with an average floodplain elevation of 18.5 feet. While some lower areas may be inundated to provide floodplain habitat at lower river elevations, most of the area would be above water and would not entrain fish. Alternative 5 would entrain more fish with a large notch than a small notch. Alternative 6 has some variations that would not have fish entering from the Sacramento River, and these variations would perform poorly.

3.2.3.1.2 Spring-Run Chinook Salmon Entrainment

Juvenile spring-run Chinook salmon migrate down the Sacramento River in the fall and winter after their birth. Generally, alternatives that allow more flow to quickly enter the Bypass are the alternatives that entrain the most spring-run salmon. In the Sutter Bypass, the Tisdale Weir overtops at lower river elevations than the Fremont Weir. Notching the Tisdale Weir would have a smaller increase compared to existing conditions for spring-run salmon than the alternatives in the Yolo Bypass. Additionally, alternatives that are upstream of Tisdale Weir or look at features without a Tisdale Weir notch would have poor performance related to spring-run salmon entrainment.

3.2.3.1.3 Inundation Area

The area of inundation is an indicator for the amount of floodplain rearing habitat provided by an alternative. For Alternative 2, the inundated area is driven by the size of the gated notch because larger notches would increase flows more quickly as the Sacramento River rises, resulting in larger inundated areas. Alternative 3 would include managed floodplain areas that have smaller areas than the other alternatives. The Alternative 4 inundated area is larger for the alternatives that include larger portions of the Elkhorn area and more grading to allow inundation on the land. Alternative 5 would have flows entering the Yolo Bypass through the Sacramento Weir, which would result in limited inundation north of the Sacramento Bypass. Alternative 6 would inundate portions of the Sutter Bypass, but the Sutter Bypass has less area available for inundation than the Yolo Bypass.

3.2.3.1.4 Food Production

Food production, as part of an ecosystem approach, is driven by larger areas that are inundated for longer periods. The food that is produced must then be moved through the system with flows moving through the Yolo Bypass. Alternatives perform better when they have a larger area of inundation that is inundated for a longer period.

3.2.3.1.5 Adult Volitional Fish Passage

Providing volitional passage for adults through the Yolo Bypass into the Sacramento River is a part of the purpose and need. While all alternatives may require some fish rescue operations at times, alternatives performed better for this criterion if they allow volitional fish passage at most times. Alternative 2c did not perform as well as other alternatives because the supplemental flows from KLRC could confuse fish compared to the other alternatives. Alternative 3a does not include volitional fish passage and performs poorly for this criterion. Alternative 3b has a convoluted route for fish to travel to reach the Sacramento River, which would increase the likelihood that fish require rescue.

Alternatives 2d and 2e include a large gated notch in the Fremont Weir. To limit the flows into the Yolo Bypass to 6,000 cfs or less, this gated notch requires operations to close gates as Sacramento River flows increase. The gate operations result in conditions that do not meet fish passage criteria as river levels approach Fremont Weir elevations (32 feet), so these alternatives did not perform as well for fish passage.

3.2.3.1.6 Juvenile Fish Passage

This evaluation factor considers if alternatives provide conditions for fish to enter and exit the floodplain in a safe and timely manner. Alternatives 4a through 4d perform the best for this factor because fish could move on and off the floodplain as Sacramento River water levels rise and fall without water control structures. Alternative 3a would require fish transport to move juveniles onto the floodplain, so it performs poorly related to this factor. Alternative 3b includes the ability for juveniles to move onto the Yolo Bypass through the KLRC without fish transport, but it requires the juveniles to travel through about eight miles of the KLRC before entering the Yolo Bypass. This passage route is not as timely as the remaining alternatives.

3.2.3.2 Completeness

All the alternatives include improvements for the four focus fish species; therefore, they all perform well for this evaluation factor.

3.2.3.3 Acceptability

Acceptability considers other factors that may make an alternative more or less acceptable to other Federal, State, and local entities. The sections below describe how the alternatives perform compared to each evaluation factor, and the results are summarized in Table 3-5.

Table 3-5. Acceptability Evaluation Results

Alternative	Agriculture: Late Spring Inundation	Waterfowl: Available Foraging Area	Waterfowl: Food Production	Waterfowl: Inundation of Recreation	Education	Biological Impacts from Construction	Compatibility with other Programs
Alt 2a, Small East Notch							
Alt 2b, Medium East Notch							
Alt 2c, Medium East Notch with Supplemental Flows							
Alt 2d, Large East Notch							
Alt 2e, Large Central Notch							
Alt 2f, Medium Central Notch							
Alt 2g, East of Fremont Weir							
Alt 2h, Elkhorn Notch							
Alt 2i, Eastern Elkhorn Notch							

Alternative	Agriculture: Late Spring Inundation	Waterfowl: Available Foraging Area	Waterfowl: Food Production	Waterfowl: Inundation of Recreation	Education	Biological Impacts from Construction	Compatibility with other Programs
Alt 2j, West Notch through Oxbow							
Alt 2k, West Notch along Levee							
Alt 2l, West Notch with Canal Connection							
Alt 2m, West Notch with KLRC Connection							
Alt 3a, Westside							
Alt 3b, Westside with Volitional Passage							
Alt 4a, Large Elkhorn Floodplain							
Alt 4b, Small Elkhorn Floodplain							
Alt 4c, Large Elkhorn with Smaller Footprint							
Alt 4d, Small Elkhorn with Smaller Footprint							
Alt 4e, Yolo Bypass Expansion							
Alt 5a, Small Sacramento Weir Notch							
Alt 5b, Large Sacramento Weir Notch							
Alt 6a, Tisdale Weir Notch							

Alternative	Agriculture: Late Spring Inundation	Waterfowl: Available Foraging Area	Waterfowl: Food Production	Waterfowl: Inundation of Recreation	Education	Biological Impacts from Construction	Compatibility with other Programs
Alt 6b, Tisdale Bypass Setback	Medium Performance	Neutral Performance or Minor Benefits	Medium Performance	Medium Performance	High Performance	Medium Performance	Medium Performance
Alt 6c, West Sutter Bypass Setback	Medium Performance	Neutral Performance or Minor Benefits	Medium Performance	Medium Performance	High Performance	Medium Performance	Medium Performance
Alt 6d, East Sutter Bypass Setback	Medium Performance	Neutral Performance or Minor Benefits	Medium Performance	Medium Performance	High Performance	Medium Performance	Medium Performance
Alt 6e, Sutter Bypass Habitat Shelf	High Performance	Medium Performance	Medium Performance	Medium Performance	High Performance	Medium Performance	Medium Performance
Alt 6f, Gravel Pit Connection	High Performance	Medium Performance	Medium Performance	Medium Performance	High Performance	High Performance	Medium Performance
Alt 6g, Nelson Rock Weir Modification	Medium Performance	Medium Performance	Medium Performance	Medium Performance	High Performance	Medium Performance	Medium Performance
Alt 6h, Weir 1 Modifications	High Performance	Medium Performance	Neutral Performance or Minor Benefits	Neutral Performance or Minor Benefits	High Performance	High Performance	Medium Performance

Legend

High Performance	Medium Performance	Neutral Performance or Minor Benefits	Poor Performance

3.2.3.3.1 Agricultural Impacts from Inundation

Agricultural production in the Yolo Bypass would be affected if fields are inundated in the spring when growers need to start field preparation and planting. For these types of impacts, the key driver in the potential for impacts is the closure date for the gated notch. All alternatives incorporate the same closure dates (either March 30 or April 30); thus, the key performance indicator is the size of the facility that allows water into the Yolo or Sutter bypasses. Larger notches allow more water to enter the bypass at lower Sacramento River flows, which could extend the inundation period on some parcels.

Agricultural uses could also be affected if alternatives change land use on specific parcels. Alternatives 4a through 4d would convert land uses for all (or part) of the Elkhorn area. While agricultural land uses may continue within the floodplain in the future, the extensive grading required would have a substantial effect on existing land uses in the Elkhorn area. Alternative 4e would involve less grading on existing land uses because the areas that would be incorporated within the Yolo Bypass are already at lower elevation. (The higher ground in the Elkhorn area tends to be closer to the river, caused by historical alluvial sediment deposition.)

3.2.3.3.2 Waterfowl Impacts to Available Foraging Habitat

Changes in water depth could affect the usefulness of an area for waterfowl foraging. Waterfowl need water shallower than 18 inches and prefer water shallower than 10 inches (Petrik et al. 2012). Depths over 18 inches are not used for foraging. Larger gated notch facilities would have greater depths of inundation at lower Sacramento River elevations, but the depths at higher river elevations would be consistent across alternatives because the alternatives have a peak notch flow of 6,000 cfs.

Alternatives 4a through 4d could have beneficial effects by providing new areas of inundation for waterfowl foraging that are currently not available. The remaining alternatives would have some new foraging areas but would lose some existing areas and likely have a small overall decrease in foraging area.

3.2.3.3.3 Waterfowl Impacts to Food Production

Swamp timothy (*Crypsis schoenoides*) is the primary food source on the seasonal wetlands in the Yolo Bypass, and it requires careful management of water levels starting at the beginning of March (Petrik et al. 2012). Increased inundation after this date could affect available food for waterfowl. The end dates for inundation are the same for all alternatives (March 30 or April 30), and these dates would influence the growth of swamp timothy for the alternatives that inundate refuge areas in the Yolo or Sutter bypasses. Facilities with larger notches that inundate more area at lower Sacramento River flows would inundate the refuge areas more frequently and have a greater potential to affect food production. Alternatives 3 and 4a through 4d would not increase inundation of the refuges in the Yolo or Sutter bypasses; therefore, these alternatives perform the best for this factor.

3.2.3.3.4 Waterfowl Impacts for Recreation Areas

Increased inundation could close waterfowl viewing and hunting areas more often. Longer periods of inundation would have greater effects, and these effects are more likely for the larger notches that would inundate more area with lower Sacramento River flows. Alternatives 3 and 4a through 4d would not increase inundation in areas used for recreational waterfowl viewing and hunting in the Yolo or Sutter bypasses; thus, these alternatives perform the best for this factor.

3.2.3.3.5 Educational Impacts

Inundating areas that are used for educational outreach could reduce the ability to conduct educational field trips. Inundating a small amount of land (or no land) used for educational outreach would be preferable to inundating more area. The YBWA (near Highway 80) is the main area that is used for educational activities, and larger notches would inundate this area for more of the winter. Alternatives 3, 4a through 4d, and 6 would not increase inundation in this area and perform the best for this factor.

3.2.3.3.6 Biological Impacts from Construction

The biological impacts of construction are related to how much construction is likely to occur and whether that construction occurs in sensitive areas. Generally, the only area where construction activities may be more sensitive is in the oxbow area in the western part of the

FWWA, which provides habitat area for multiple species. This area is affected in Alternative 2j. For remaining alternatives, the areas for construction are not more sensitive for some of the alternatives than others; thus, the key factor is the magnitude of construction. Larger notches generally perform less well than smaller notches because they require additional construction and could affect more biological resources. Alternatives 3b and 4 would require a substantial amount of earthwork that would also have increased potential for effects to biological resources.

3.2.3.3.7 Compatibility with Other Programs

The Yolo Bypass has multiple functions, and alternatives are more acceptable if they are compatible with other ongoing or new programs. A key consideration is that DWR and USACE flood-planning efforts are considering an expansion to the Yolo Bypass. The effort would expand Fremont Weir to the east into the Elkhorn Area and set back the east Yolo Bypass levee into the Elkhorn Area. It would also consider other efforts in the central and southern bypass to expand capacity and improve habitat. Alternatives that would have key construction elements in the Elkhorn Area may be less compatible with these flood-related plans, and the alternatives would have to be re-constructed when this project moves forward. These alternatives include Alternatives 2g through 2i and 4a through 4d. Alternative 4e has a similar alignment as the flood setback and would be more compatible than the other alternatives. The remaining alternatives would not conflict with the flood efforts and may provide some opportunities for collaboration.

3.2.3.4 Efficiency

Efficiency compares costs and benefits of each alternative, with the highest ranking for alternatives that have the highest benefits relative to costs. At this point in the process, detailed cost estimates were not yet available. A preliminary cost estimate (not including the common elements) was developed for each alternative using cost estimates from other, similar projects or comparing to other alternatives. These costs have changed as the alternatives have moved forward through the design process. Cost estimates in subsequent chapters reflect a higher level of design and cost estimate accuracy. However, these preliminary cost ranges helped to compare costs and benefits of the different initial alternatives.

The cost estimates found that a key driver in the alternative cost is the amount of earthwork. Alternatives that include substantial earthwork, including Alternatives 3b and 4a through 4e, have much higher costs than the alternatives with less earthwork.

These costs were compared to the benefits of each alternative, based on an average of the factors from the effectiveness table. For Alternative 2, the small notch produces smaller benefits for fish regarding floodplain inundation but has low costs relative to the other alternatives, which results in a cost-effective alternative. Alternative 3a has poor benefits that drive the poor cost-effectiveness rating. All Alternative 4 variations have poor cost-effectiveness because the construction costs associated with the earthwork are much higher than the other alternatives. Alternative 5 has similar costs for similarly sized facilities as Alternative 2 (with some added costs for additional fish passage facilities at Fremont Weir), but the benefits are decreased because the inundated area would generally be south of the Sacramento Bypass. The Sutter Bypass options in Alternative 6 generally require more construction (including levee setbacks or channel work) than Alternative 2 and produce fewer benefits because the area inundates less frequently. Table 3-6 summarizes the results of the efficiency analysis.

Table 3-6. Efficiency Evaluation Results

Alternative	Potential Cost Range	Benefits	Cost-Effectiveness
Alt 2a, Small East Notch	$0-50 million		
Alt 2b, Medium East Notch	$50-100 million		
Alt 2c, Medium East Notch with Supplemental Flows	$50-100 million		
Alt 2d, Large East Notch	$50-100 million		
Alt 2e, Large Central Notch	$50-100 million		
Alt 2f, Medium Central Notch	$50-100 million		
Alt 2g, East of Fremont Weir	$100-150 million		
Alt 2h, Elkhorn Notch	$100-150 million		
Alt 2i, Eastern Elkhorn Notch	$100-150 million		
Alt 2j, West Notch through Oxbow	$50-100 million		
Alt 2k, West Notch along Levee	$50-100 million		
Alt 2l, West Notch with Canal Connection	$50-100 million		
Alt 2m, West Notch with KLRC Connection	$50-100 million		
Alt 3a, Westside	$50-100 million		
Alt 3b, Westside with Volitional Passage	$550-$600 million		
Alt 4a, Large Elkhorn Floodplain	Greater than $700 million		
Alt 4b, Small Elkhorn Floodplain	$600-$700 million		
Alt 4c, Large Elkhorn with Smaller Footprint	$600-$700 million		
Alt 4d, Small Elkhorn with Smaller Footprint	$600-$700 million		
Alt 4e, Yolo Bypass Expansion	$500-$600 million		
Alt 5a, Small Sacramento Weir Notch	$50-100 million		
Alt 5b, Large Sacramento Weir Notch	$50-100 million		
Alt 6a, Tisdale Weir Notch	$50-100 million		
Alt 6b, Tisdale Bypass Setback	Greater than $500 million		
Alt 6c, West Sutter Bypass Setback	Greater than $500 million		
Alt 6d, East Sutter Bypass Setback	Greater than $500 million		
Alt 6e, Sutter Bypass Habitat Shelf	Greater than $100 million		

Alternative	Potential Cost Range	Benefits	Cost-Effectiveness
Alt 6f, Gravel Pit Connection	$50-100 million		
Alt 6g, Nelson Rock Weir Modification	$50-100 million		
Alt 6h, Weir 1 Modifications	$50-100 million		

Legend

High Performance	Medium Performance	Neutral Performance or Minor Benefits	Poor Performance

3.2.4 Screening Results

The preliminary screening effort resulted in a reduced range of alternatives for further evaluation in the EIS/EIR. The No Action Alternative moved forward for additional consideration in the EIS/EIR because it is a requirement of NEPA and CEQA. For Alternative 2 (Fremont Weir Gated Notch), the Lead Agencies identified that the smaller notch (in Alternative 2a) provided good fish passage, is cost-effective, and has higher acceptability compared to the other Fremont Weir notch alternatives. The benefits from increased inundation are not as high as the other Alternative 2 variations, but this notch design would provide benefits to juvenile fish. The Lead Agencies decided to move forward with this small notch because of the fish passage effectiveness, acceptability, and efficiency. This notch configuration will be considered in the east, central, and west location.

Alternative 3a (Westside Alternative) does not provide volitional fish passage, which is a key concern when considering the effectiveness of this alternative. The Lead Agencies decided not to carry this alternative forward for additional analysis because of the poor performance related to effectiveness. Alternative 3b (Westside Alternative with Volitional Passage) included options to provide volitional fish passage, but the increased construction effort led to higher potential for environmental impacts and higher costs. Alternative 3b had only a small improvement in effectiveness but had concerns for acceptability and efficiency, so this alternative did not move forward for additional evaluation in the EIS/EIR.

The Alternative 4 variations (Elkhorn Alternatives) all involved substantial earthwork, which resulted in the increased potential for environmental effects and high costs. Additionally, this alternative resulted in acceptability concerns because it would affect land uses and some existing structures in the Elkhorn area. For these reasons, the Lead Agencies decided not to carry forward the Alternative 4 variations for additional analysis in the EIS/EIR.

Alternative 5 (Sacramento Weir Gated Notch) would inundate a smaller area than Alternative 2, which would reduce the benefits of increased inundation for fish. The costs would be similar to Alternative 2 but higher because Alternative 5 includes separate fish passage facilities at Fremont Weir to allow fish passage after Fremont Weir overtopping events. The Lead Agencies decided not to carry forward Alternative 5 for additional analysis in the EIS/EIR because of the reduced benefits and increased costs.

Alternative 6 (Sutter Bypass) generally produced fewer benefits than Alternative 2. The Sutter Bypass is inundated more frequently than the Yolo Bypass under existing conditions because the Tisdale Weir is at a lower elevation. A new gated notch in Tisdale Weir would be used less frequently, and the area available for inundation is smaller. The Lead Agencies initially recommended removing Alternatives 6a through 6f from further consideration for these reasons but continued to consider incorporating Alternatives 6g and 6h as features in other alternatives. As the alternatives formulation process progressed, however, these features added costs and environmental impacts to other alternatives without increasing fishery benefits. These elements were not incorporated in the range of alternatives considered in the EIS/EIR.

3.2.5 Value Planning

Value Planning is part of the Federal process in planning projects. The purpose of value planning is to take a big-picture look at project alternatives and see if there is a better way to achieve the greatest value. Reclamation conducted a value planning study in August 2014. The value planning effort included agency representatives, landowners, NGOs, and other stakeholders and was designed to focus on those that have not been key participants in the alternatives formulation process. The value planning team concluded that more focus should be placed on integrating flood projects with restoration efforts and recommended including water control structures to help increase inundation on the Yolo Bypass. This effort led to a closer working relationship with this stakeholder group and alternative refinement (discussed in Section 3.3).

3.3 Alternative Refinement

The Lead Agencies continued to refine the initial alternatives after the screening effort. In 2015, the State started the EcoRestore program with a goal to advance restoration of at least 30,000 acres of habitat by 2020. Several of the common elements in the alternatives have independent utility as restoration projects and were separated from this effort to be a part of the EcoRestore program. These projects include Wallace Weir improvements, modifications to existing fish passage at Fremont Weir, removal and replacement of three agricultural road crossings in the Tule Canal, and modification of Lisbon Weir. These projects are now underway as separate efforts.

Key alternative refinements were developed from working closely with the Yolo Bypass Biological Opinion Working Group. This group includes Federal, State, and local agencies, landowners, land managers, water suppliers, and NGOs. A key consideration from this group is that an earlier inundation end date (initially suggested as March 15) would reduce impacts to agricultural users and wetlands. The Lead Agencies analyzed whether this change would result in a substantive decrease in benefits to the focus fish species and found little change in benefits. The end date was changed for all alternatives to March 15. Subsequent discussion with landowners identified potential benefits from an earlier closure date of March 7, and this date was incorporated into one of the alternatives as a variation. The stakeholder group also worked to update the evaluation criteria to incorporate other evaluation factors that could characterize an alternative’s effectiveness and acceptability; these updated factors are included in Chapter 5.

The Working Group expressed interest in a broader range of alternatives, and discussions resulted in several additional alternatives:

- Smaller inundation structure with water control structures: This alternative would have a smaller flow from the Sacramento River into the Yolo Bypass (3,000 cfs) and would incorporate water control structures in the Tule Canal to slow water and increase inundation on parcels with willing landowners.

- Multiple gated notches: This alternative would include four sets of gates to maximize capture of Sacramento River water (and juvenile fish) at lower river elevations but have a lower maximum flow of 3,400 cfs. This alternative initially included an excavated floodplain within the FWWA, but this feature was later removed because of concerns about biological, wetland, and air quality impacts of construction.
- Large gated notch: The initial evaluation limited flows from the Sacramento River to a maximum of 6,000 cfs based on previous studies. The larger notch variations considered for the Fremont Weir included gate operations to limit this flow that resulted in fish passage concerns. This alternative would include a larger notch in Fremont Weir that would allow flows up to 12,000 cfs to enter the Yolo Bypass.

The Lead Agencies compared these alternatives to the evaluation factors and identified that these three alternatives would be beneficial to include in the Draft EIS/EIR for further evaluation in addition to the three alternatives identified in the process described in Section 3.2. The details of these six alternatives are included in Chapter 4.

3.4 References

DWR (California Department of Water Resources). 2017. *Adult fish passage criteria for federally listed species within the Yolo Bypass and Sacramento River*. Technical memorandum for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project. Sacramento, California.

Petrik, K., Petrie, M., Will, A., and J. McCreary. 2012. Waterfowl Impacts of the Proposed Conservation Measure 2 for the Yolo Bypass – An effects analysis tool. Accessed on: July 19, 2017. Available at: http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/YBFE_Planning_Team_-_Waterfowl_Impacts_of_the_Proposed_CM_2_-Report-_7-16-12.sflb.ashx

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———. 2013. Yolo Bypass Salmonid Habitat Restoration and Fish Passage Planning and Environmental Compliance, Planning Framework Technical Memorandum.

4 Features of Alternatives

4.1 Analysis Methodology

4.1.1 Hydraulic Modeling

The evaluation of impacts on flood control, hydraulics, and hydrology considers the potential for increased frequency or severity of damaging flood flows. This section describes the models used to evaluate effects of the Project alternatives.

4.1.1.1 HEC-RAS

The one-dimensional Central Valley Floodplain Evaluation and Delineation (CVFED) Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic model of the SRFCP was used to evaluate changes in peak water surface elevation throughout the bypass and Sacramento River.

The CVFED HEC-RAS geometry was modified to represent assumed future hydraulic features for each of the alternatives. Hydrology was scaled down from the Central Valley Hydrology Study's 1997 storm pattern to represent a storm with a peak flow at Fremont Weir close to 343,000 cfs, the capacity of Yolo Bypass. The resulting hydrograph was routed through the HEC-RAS model to find peak water surface elevations. Resulting peak water surface elevations from the alternatives were compared against the resulting peak water surface elevations from existing geometry.

The main limitation of the CVFED HEC-RAS model is the level of detail of its geometry, particularly at low flows. Results are averaged across cross-sections and represent the floodplain in coarser spatial detail than the two-dimensional unsteady flow (TUFLOW) model, discussed in Section 4.4.1.1.2. The HEC-RAS model is calibrated to represent peak water surface elevations during flood flows and is not calibrated to represent low flows.

4.1.1.1.1 TUFLOW

TUFLOW is a two-dimensional hydrodynamic modeling engine used to simulate the hydraulics within the Yolo Bypass. The two-dimensional capabilities of the engine allow for the comparison of the spatial distribution of flow, velocity, and depth, with or without assumed future hydraulic features. The TUFLOW model extends along the Sacramento River from RM 118 to RM 12 near Rio Vista and includes the entire Yolo Bypass. Historical flows from the year 1997 to 2012 were simulated for several channel and weir configurations on a 5- to 10-second time step as a part of the alternatives evaluation.

The two-dimensional TUFLOW model is more spatially detailed than the HEC-RAS model and calibrated for low and high flows.

4.1.1.1.2 CalSim II

CalSim II is the application of the Water Resources Integrated Modeling System software to the CVP and SWP. This application was jointly developed by Reclamation and DWR for planning studies relating to CVP/SWP operations. The primary purpose of CalSim II is to evaluate the water supply reliability of the CVP and SWP at current and/or future levels of development (e.g., 2005, 2030), with and without various assumed future facilities, and with different modes of facility operations. Geographically, the model covers the drainage basin of the Delta and CVP/SWP exports to the San Francisco Bay Area, San Joaquin Valley, Central Coast, and Southern California.

CalSim II typically simulates system operations for an 82-year period using a monthly time step. The model assumes that facilities, land use, water supply contracts, and regulatory requirements are constant over this period, representing a fixed level of development (e.g., 2005, 2030). The historical flow record of October 1921 to September 2003, adjusted for the influences of land use changes and upstream flow regulation, is used to represent the possible range of water supply conditions. Major Central Valley rivers, reservoirs, and CVP/SWP facilities are represented by a network of arcs and nodes. CalSim II uses a mass balance approach to route water through this network. Simulated flows are mean flows for the month; reservoir storage volumes correspond to end-of-month storage.

CalSim II models a complex and extensive set of regulatory standards and operations criteria. The hydrologic analysis conducted used CalSim II models with 2030 and 2070 hydrology from the California Water Commission Climate Change Water Supply Improvement Project modeling to approximate system-wide changes in storage, flow, salinity, and reservoir system reoperation associated with the alternatives. Although CalSim II is the best available tool for simulating system-wide operations, the model also contains simplifying assumptions in its representation of the real system. CalSim II's predictive capability is limited and cannot be readily applied to hourly, daily, or weekly time steps for hydrologic conditions. The model, however, is useful for comparing the relative effects of alternative facilities and operations within the CVP/SWP system on a monthly time step. Reclamation's CalSim II modeling of existing conditions and the existing conditions-level of development alternatives assumes a 2030 hydrology. Future conditions in the CalSim II modeling for the No Action Alternative and future conditions-level of development alternatives assume a 2070 hydrology, including estimates of climate change and sea level rise.

4.1.2 Fish Benefits and Fish Passage Modeling

This section describes the methodologies that the Lead Agencies implemented to evaluate the potential effects of the alternatives on fish species of focused evaluation and their habitats. In addition to generally qualitative methods for assessing potential construction- and maintenance-related impacts, impact assessment methodologies relied on simulated changes in hydrology, water temperature, and fisheries habitat parameters under the alternatives relative to the basis of comparison.

4.1.2.1 YBPASS Tool and HEC-RAS Modeling

To evaluate adult fish passage improvements, DWR and Reclamation formed the interagency Yolo Bypass Fisheries and Engineering Technical Team. Using hydraulic criteria developed by the team, DWR developed the YBPASS (Yolo Bypass Passage for Adult Salmonids and Sturgeon) tool to compare HEC-RAS modeled water depths and velocities in the alternative-specific intake structures and transport channels to compare against adult salmon and sturgeon fish passage criteria.

4.1.2.2 Salmon Benefits Model

The Lead Agencies used simulated daily flows overtopping Fremont Weir and flows through the proposed notches as well as modeled depths and velocities in Yolo Bypass and Sacramento River from TUFLOW as inputs to the Salmon Benefits Model (SBM). The SBM tracks key Chinook salmon life history stages from freshwater emigration in the lower Sacramento River (just upstream of Yolo Bypass) to numbers of returning adults. Specifically, the SBM quantifies effects of changes in flows entering Yolo Bypass on the size distribution of juvenile Chinook salmon emigrating to the ocean and on abundance of returning adults for each year of the simulation period (Hinkelman et al. 2017). The SBM accounts for the timing and duration of inundation of Yolo Bypass as well as modeled depths and velocities with respect to juvenile Chinook salmon habitat suitability criteria. The SBM uses data and assumptions to determine the proportion and abundance of juveniles entrained into the bypass, timing and duration of juvenile rearing, timing and duration of emigration through the bypass, amount of accessible suitable habitat, and growth and survival of juveniles on a daily basis during October through May for each year of the 15-year simulation period (1997 through 2011).

4.1.3 Agricultural Impact Modeling

This analysis used information estimated from multiple models to determine land use impacts resulting from the implementation of the Project alternatives. Models that contributed to this analysis include:

- **TUFLOW** – Used to assess hydraulic impacts, including inundation periods and affected acreages and agricultural impacts, in the Yolo Bypass and surrounding areas. TUFLOW facilitates a comparison of depth, duration, and frequency of flooding between existing and proposed conditions.
- **DAYCENT Model** – Used to estimate crop yields on a subset of fields throughout the Yolo Bypass. The DAYCENT model estimates the yield on any given field considering all production conditions, including climate and date the crop was planted. The model was calibrated against data for corn, rice, safflower, sunflower, processing tomato, alfalfa, and mixed melons.
- **Bypass Production Model (BPM)** – Used to model agriculture in the Yolo Bypass. The BPM relates changes in crop yield and total affected acres to changes in agricultural production and revenues. The BPM incorporates data from TUFLOW as inputs for anticipated overtopping events and other impacts from the proposed actions. Crop yield functions estimated by the DAYCENT model are used along with additional economic data to calibrate the BPM.

- **Impact Planning and Analysis (IMPLAN)** – Used to estimate the effects on employment, labor income, and total value output directly and indirectly associated with construction and reduced crop production. IMPLAN calculates the economic impacts of a change in value of production.

4.1.4 Economic Analysis

The socioeconomic analysis estimates economic effects from construction of the proposed alternatives. The economic analysis uses IMPLAN, an input-output software and data package, which calculates the economic impacts of a change in value of production. IMPLAN is used to estimate the direct effects of construction and reduced crop production as well as the indirect and induced effects in the area of analysis. The direct effects would occur in both the construction and agricultural industries. Indirect effects are caused by expenditures in the region by affected regional industries and include purchases of inputs. Induced effects are caused by expenditure of household income.

IMPLAN estimates effects of various economic measures, including employment, labor income, and total value output. Employment is the number of jobs, including full-time, part-time, and seasonal. Labor income consists of employee compensation and proprietor’s income. Value of output is the dollar value of production.

IMPLAN estimates impacts on an annual basis. If the project effects occurred over a shorter period, economic effects would be less. The 2014 IMPLAN data sets were used for this analysis.

4.2 No Action Alternative

NEPA and CEQA require the evaluation of an alternative that presents the reasonably foreseeable future conditions in the absence of the project. This alternative is called the No Action Alternative under NEPA and the No Project Alternative under CEQA. The No Action or No Project Alternative allows decision makers to compare the impacts of approving the project to the impacts of not approving the project. This alternative is referred to in the remainder of the document as the “No Action Alternative.” Under NEPA, the No Action Alternative also serves as the baseline to which action alternatives are compared to determine potential impacts. This differs from CEQA wherein existing conditions serve as the baseline to determine potential impacts of the alternatives. The No Action Alternative may differ from the existing conditions if other actions that could occur in the Project area in the future do not rely on approval or implementation of the project. The No Action Alternative and the existing conditions will be used as the environmental baseline for identifying project effects.

Under the No Action Alternative, the Yolo Bypass would continue to be inundated from the westside tributaries and overtopping events at Fremont and Sacramento weirs. Juvenile fish would enter the bypass with overtopping flood flows from Fremont and Sacramento weirs, and the fish would benefit from the rearing opportunities in the Yolo Bypass. Additional flow and fish would not pass through Fremont Weir when the Sacramento River elevation is below the crest of Fremont Weir or Sacramento Weir.

Adult fish may move upstream in Tule Canal in response to tidal influence in Cache Slough, flows over Fremont Weir, or when the westside tributaries attract fish. As under existing conditions, fish would either move downstream and migrate back into the Sacramento River, pass over Fremont Weir, pass through the existing fish passage structure at Fremont Weir, become stranded at Fremont Weir, or move to the Wallace Weir Fish Rescue Facility. Other projects in the Yolo Bypass and Sacramento River region would continue to move forward, including California EcoRestore projects, Battle Creek Salmon and Steelhead Restoration project, California WaterFix, Environmental Permitting for Operation and Maintenance of flood facilities, Oroville Facilities Federal Energy Regulatory Commission Relicensing and License Implementation, and Sacramento Regional Wastewater Treatment Plant Upgrade.

4.3 Components Common to Multiple Action Alternatives

This section describes components included in multiple action alternatives. As discussed in Chapter 3, the common elements originally included modifications to Wallace Weir to reduce straying, fish passage improvements in the Fremont Weir, modification of Agricultural Road Crossings 2 and 3 in the Tule Canal, and fish passage improvements to Lisbon Weir. These elements have become separate projects and are being implemented as part of the EcoRestore Program. The common elements that remain in the action alternatives are described below.

4.3.1 Agricultural Road Crossing 1 and Cross-Canal Berms

The northernmost agricultural road crossing in Tule Canal is both a vehicular crossing and water delivery feature (see Figure 1-1 for location). The crossing consists of two earthen berms, with the southern used as the road crossing. Together, the berms create a cross canal that conveys water across the Yolo Bypass from Wallace Weir to two 36-inch culverts that pass through the Yolo Bypass east levee. The culverts deliver water via gravity flow into the Elkhorn area for agricultural use.

The cross-canal berms are flow barriers in Tule Canal and form barriers that maintain water levels in the greater Tule Pond wetland (just upstream). The wetland area north of Agricultural Road Crossing 1 and south of Tule Pond is referred to as the “wooded area” and does not have a defined channel. The top of the berm has an elevation of approximately 21 feet[3] and holds water in the wooded area and Tule Pond (see Figure 4-1) after Fremont Weir overtopping events to cover an area of about 85 acres. During the late winter and early spring, shallow groundwater levels are high enough (HDR, Inc. 2017) that they likely contribute water to the Tule Pond and wooded area. Additionally, the berms leak in some years, which provides water inflow into the wooded area (and allows some outflow when water levels are high during the wet season). The local landowners typically make periodic repairs that decrease the leakage.

[3] Elevations in the EIS/EIR are compared to the North American Vertical Datum of 1988 (NAVD 88).

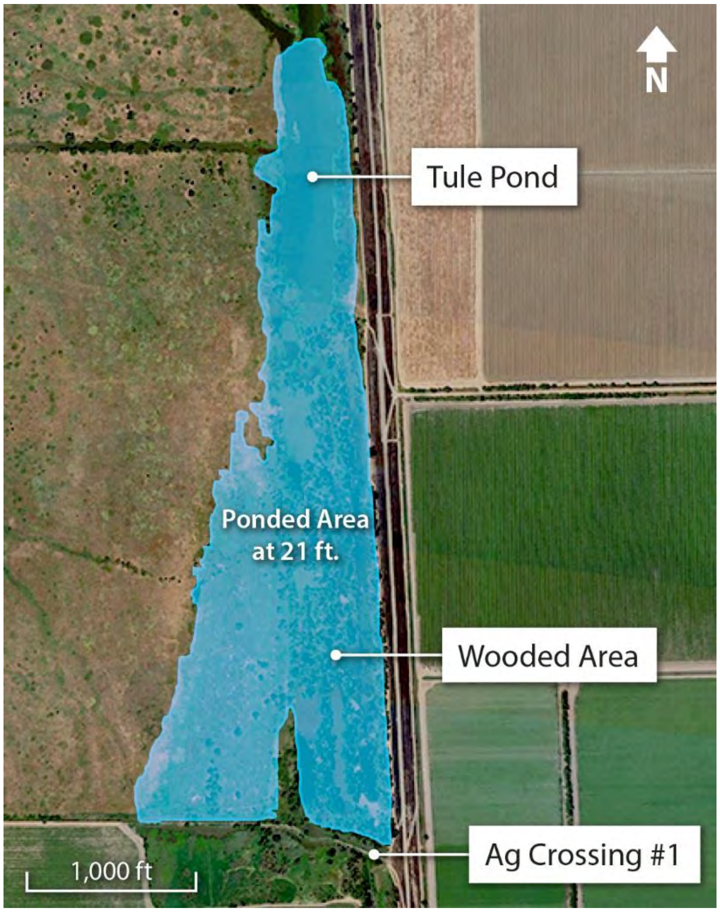


Figure 4-1. Existing Inundation Area North of Agricultural Road Crossing 1

Agricultural Road Crossing 1 improvements would include removal of the cross-canal berms and road crossing that create a fish passage barrier, construction of a bridge for vehicular traffic, and construction of an inverted siphon beneath the new Tule Canal connection to maintain water deliveries to the agricultural water users in the Elkhorn Area. Removing the barriers to fish passage would also remove a flow barrier that retains water in the Tule Pond and wooded area to the north and a source of water for these areas in the cross-canal. The bridge would be 18 feet wide and 80 feet long. It would include concrete abutments on each end to span Tule Canal. Figure 4-2 shows the proposed improvements at Agricultural Road Crossing 1. These improvements are included in all action alternatives.

The cross-canal berm would be removed and the channel regraded to connect proposed upstream channel improvements (described in Section 4.3.2) to Tule Canal. A turnout structure would be constructed on the west side of the new Tule Canal connector channel. Two 36-inch, 270-foot-long pipes would run under the new connection with Tule Canal from the turnout structure and tie into a concrete junction box on the east side of Tule Canal that would feed the supply pipes through the existing levee. An emergency overflow bypass structure would be installed immediately adjacent and northwest of the turnout structure to prevent overtopping the canal embankments into the surrounding fields during non-flood events. Overtopping the embankments could cause erosion; thus, the overflow bypass would reduce operations and maintenance needs on the canal embankments. The overflow bypass structure would discharge high flows south into the existing Tule Canal.

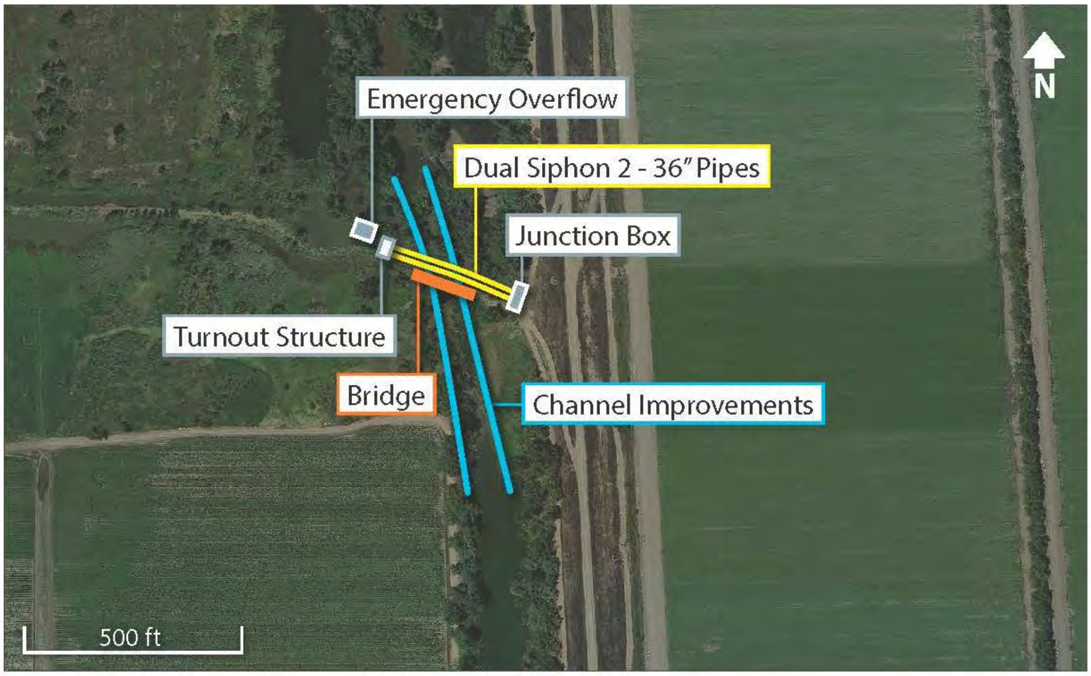


Figure 4-2. Agricultural Road Crossing 1 Improvements

4.3.2 Downstream Channel Improvements

Except for Alternative 5, all proposed alternatives include an engineered, trapezoidal channel that connects a new gated notch in Fremont Weir to Tule Pond. Alternative 5 varies from the other alternatives because it includes a multi-channel complex that connects to Tule Canal south of Tule Pond (near Agricultural Road Crossing 1); the conditions and improvements described in this section do not apply to Alternative 5.

The area just south of Tule Pond is referred to as the "wooded area" on Figure 4-1 and does not have a defined channel. Discussed as part of the Agricultural Road Crossing 1 improvements, water is often ponded in this area, allowing vegetation and tree growth. The area is often wet outside of the winter season and is dominated by tule growth.

The lack of a defined channel within the wooded area makes fish passage more difficult during periods when the entire area is not inundated. Fish do not have a clear path to move between Tule Pond and the wooded area just upstream of Agricultural Road Crossing 1.

Under Alternatives 1 through 4 and 6, improvements would be made to connect isolated pools within the wooded area that extends from the Tule Pond outlet downstream to Agricultural Road Crossing 1 where the Tule Canal begins. Improvements include a trapezoidal channel with constant slope. The improvements would facilitate upstream adult fish passage between the existing Tule Canal and Tule Pond. The engineered, trapezoidal channel would begin downstream of Agricultural Road Crossing 1 and extend north to Tule Pond. The channel would have a 20-foot-bottom width and a 3:1 side slope (horizontal to vertical). The top of channel would be 60 to 70 feet wide, with eight feet of revetment and a 12-foot wide maintenance corridor on either side.

To avoid concerns about levee seepage and stability near the channel improvements, Alternatives 1 through 4 and 6 would include a subsurface cutoff wall in the levee parallel to the channel. A subsurface cutoff wall is a structure that uses a slurry or cement mix to create a "wall" along a levee to prevent seepage under the levee or address other levee stability and seepage concerns. This cutoff wall would be included because the channel construction would cut through an existing clay blanket layer that currently prevents levee underseepage. The cutoff wall would be approximately 3,150 feet long and 30 feet deep. The location is at the toe of the levee, and the cutoff wall would be entirely underground. Figure 4-3 presents a preliminary concept for the channel improvements.

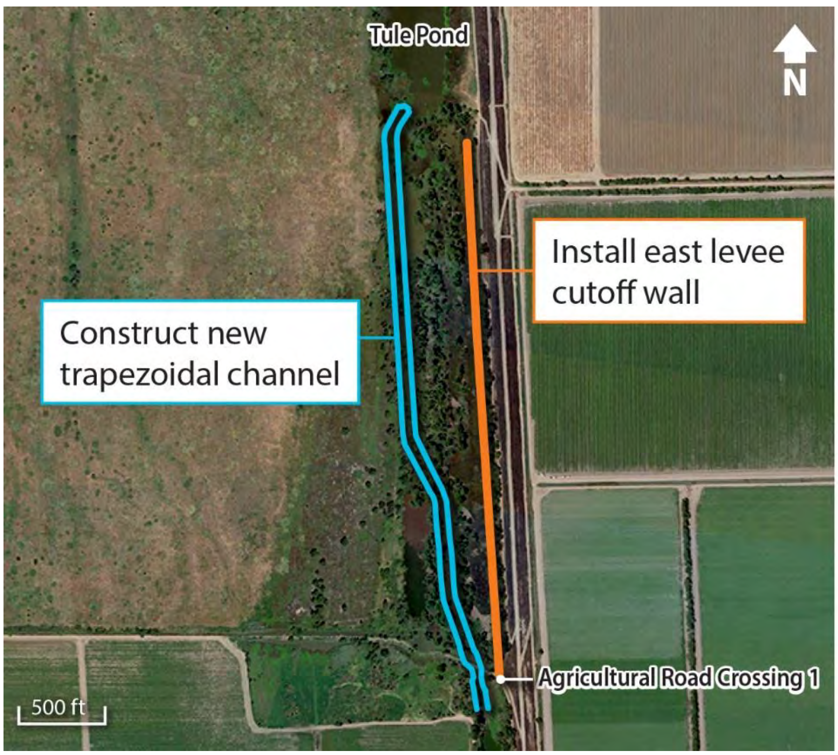


Figure 4-3. Downstream Channel Improvements

4.3.3 Operational Timeframe

All the new gated notch structures have the potential to begin operations on November 1. Juvenile salmonid out-migration typically begins during early storms in November. The gates would open as river elevations rise, which is discussed in more detail in the operations section of each alternative description.

The gated notch structures were originally planned to stay open through April to allow juveniles to enter the Yolo Bypass, but discussions with stakeholders indicated that an earlier inundation end date (originally suggested as March 15) would reduce impacts to agricultural users and wetlands. The Lead Agencies analyzed whether this change would result in a substantive decrease in benefits to the focus fish species and found little change in benefits, so the end date was changed for all alternatives to March 15. Subsequent discussion with landowners identified potential benefits from an earlier closure date of March 7, and this date was incorporated as a variation of Alternative 4.

After March 15 (or March 7 in the Alternative 4 variation), the new gated notch structure could remain partially open to provide fish passage until the end of May. The gated notch would only allow flows up to 1,000 cfs that would not inundate areas outside of Tule Canal. Alternative 6 would not allow operation during this period because the facilities would not provide sufficient depths and velocities for fish passage at flows less than 1,000 cfs.

4.3.4 Best Management Practices

All the alternatives incorporate typical measures to reduce impacts, typically called best management practices (BMPs). All action alternatives incorporate BMPs and have been designed to avoid and minimize impacts to the maximum extent practicable.

4.3.4.1 BMPs for Construction and Maintenance Activities to Reduce Greenhouse Gas (GHG) Emissions

The following measures are considered BMPs for DWR construction and maintenance activities. Implementation of these practices will reduce GHG emissions from construction projects by minimizing fuel usage by construction equipment, reducing fuel consumption for transportation of construction materials, reducing the amount of landfill material, and reducing emissions from the production of cement.

4.3.4.1.1 Pre-Construction and Final Design BMPs

Pre-construction and final design BMPs are designed to ensure that individual projects are evaluated and their unique characteristics taken into consideration when determining if specific equipment, procedures, or material requirements are feasible and efficacious for reducing GHG emissions from the project. While all projects will be evaluated to determine if these BMPs are applicable, not all projects will implement all the BMPs listed below.

- BMP 1. Evaluate project characteristics, including location, project work flow, site conditions, and equipment performance requirements, to determine whether specifications of the use of equipment with repowered engines, electric drive trains, or other high efficiency technologies are appropriate and feasible for the project or specific elements of the project.
- BMP 2. Evaluate the feasibility and efficacy of performing onsite material hauling with trucks equipped with on-road engines.
- BMP 3. Ensure that all feasible avenues have been explored for providing an electrical service drop to the construction site for temporary construction power. When generators must be used, use alternative fuels, such as propane or solar, to power generators to the maximum extent feasible.
- BMP 4. Evaluate the feasibility and efficacy of producing concrete on site and specify that batch plants be set up on site or as close to the site as possible.

- BMP 5. Evaluate the performance requirements for concrete used on the project and specify concrete mix designs that minimize GHG emissions from cement production and curing while preserving all required performance characteristics.
- BMP 6. Limit deliveries of materials and equipment to the site to off peak traffic congestion hours.

4.3.4.1.2 Construction BMPs

Construction BMPs apply to all construction and maintenance projects that DWR completes or for which DWR issues contracts. All projects are expected to implement all construction BMPs unless a variance is granted by the Division of Engineering Chief, Division of Operation and Maintenance Chief, or Division of Flood Management Chief (as applicable) and the variance is approved by the DWR CEQA Climate Change Committee. Variances will be granted when specific project conditions or characteristics make implementation of the BMP infeasible and where omitting the BMP will not be detrimental to the project's consistency with the GHG Emissions Reduction Plan.

- BMP 7. Minimize idling time by requiring that equipment be shut down after five minutes when not in use (as required by the State airborne toxics control measure 13 CCR 2485). Provide clear signage that posts this requirement for workers at the entrances to the site and provide a plan for the enforcement of this requirement.
- BMP 8. Maintain all construction equipment in proper working condition and perform all preventative maintenance. Required maintenance includes compliance with all manufacturer's recommendations, proper upkeep and replacement of filters and mufflers, and maintenance of all engine and emissions systems in proper operating condition. Maintenance schedules shall be detailed in an Air Quality Control Plan prior to commencement of construction.
- BMP 9. Implement a tire inflation program on the jobsite to ensure that equipment tires are correctly inflated. Check tire inflation when equipment arrives on site and every two weeks for equipment that remains on site. Check vehicles used for hauling materials off site weekly for correct tire inflation. Procedures for the tire inflation program shall be documented in an Air Quality Management Plan prior to commencement of construction.
- BMP 10. Develop a project-specific ride share program to encourage carpools, shuttle vans, transit passes, and/or secure bicycle parking for construction worker commutes.
- BMP 11. Reduce electricity use in temporary construction offices by using high efficiency lighting and requiring that heating and cooling units be Energy Star compliant. Require that all contractors develop and implement procedures for turning off computers, lights, air conditioners, heaters, and other equipment each day at close of business.

- BMP 12. For deliveries to project sites where the haul distance exceeds 100 miles and a heavy-duty class 7 or class 8 semi-truck or 53-foot or longer box type trailer is used for hauling, a SmartWay[4] certified truck will be used to the maximum extent feasible.
- BMP 13. Minimize the amount of cement in concrete by specifying higher levels of cementitious material alternatives, larger aggregate, longer final set times, or lower maximum strength where appropriate.
- BMP 14. Develop a project-specific construction debris recycling and diversion program to achieve a documented 50 percent diversion of construction waste.
- BMP 15. Evaluate the feasibility of restricting all material hauling on public roadways to off-peak traffic congestion hours. During construction scheduling and execution, minimize, to the extent possible, uses of public roadways that would increase traffic congestion.

4.3.4.2 Air Quality BMPs

Fugitive dust control measures required by the Sacramento Metropolitan Air Quality Management District (AQMD) will be implemented as environmental commitments for all alternatives. The BMPs required by the Sacramento Metropolitan AQMD (2016) to allow non-zero particulate matter significance thresholds are as follows:

1. Water all exposed surfaces two times daily. Exposed surfaces include but are not limited to soil piles, graded areas, unpaved parking areas, staging areas, and access roads.
2. Cover or maintain at least two feet of freeboard space on haul trucks transporting soil, sand, or other loose material on the site. Any haul trucks that would be traveling along freeways or major roadways should be covered.
3. Use wet power vacuum street sweepers to remove any visible track out mud or dirt onto adjacent public roads at least once a day. Use of dry power sweeping is prohibited.
4. Limit vehicle speeds on unpaved roads to 15 miles per hour.
5. All roadways, driveways, sidewalks, and parking lots to be paved should be completed as soon as possible. In addition, building pads should be laid as soon as possible after grading unless seeding or soil binders are used.
6. Minimize idling time either by shutting equipment off when not in use or reducing the time of idling to five minutes [required by CCR, Title 13, sections 2449(d)(3) and 2485]. Provide clear signage that posts this requirement for workers at the entrances to the site.
7. Maintain all construction equipment in proper working condition according to manufacturer's specifications. The equipment must be checked by a certified mechanic and determined to be running in proper condition before it is operated.

[4] The USEPA has developed the SmartWay truck and trailer certification program to set voluntary standards for trucks and trailers that exhibit the highest fuel efficiency and emissions reductions. These tractors and trailers are outfitted at point of sale or retrofitted with equipment that significantly reduces fuel use and emissions, including idle reduction technologies, improved aerodynamics, automatic tire inflation services, advanced lubricants, advanced powertrain technologies, and low rolling resistance tires.

4.4 Alternative 1: East Side Gated Notch

Alternative 1, East Side Gated Notch, would allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated notch on the east side of Fremont Weir. The gated notch would create an opening in Fremont Weir that is deeper than Fremont Weir, with gates to control water going through the facility into the Yolo Bypass. The invert of the new notch would be at an elevation of 14 feet, which is approximately 18 feet below the existing Fremont Weir crest. Water would be able to flow through the notch during periods when the river elevations are not high enough to go over the crest of Fremont Weir (at an elevation of 32 feet).

Alternative 1 would connect the new gated notch to Tule Pond with a channel that parallels the existing east levee of the Yolo Bypass. Alternative 1 would have the shortest and most direct access to the Tule Canal for migrating fish. Alternative 1 would allow flows up to 6,000 cfs, depending on Sacramento River elevation, through the gated notch to provide open channel flow for adult fish passage, juvenile emigration, and floodplain inundation. This alternative would include a supplemental fish passage facility on the west side of Fremont Weir and improvements to allow fish to pass through Agricultural Road Crossing 1 and the channel north of Agricultural Road Crossing 1, as described in Section 4.3. Figure 4-4 shows key components of the alternative and the common elements described in Section 4.3.

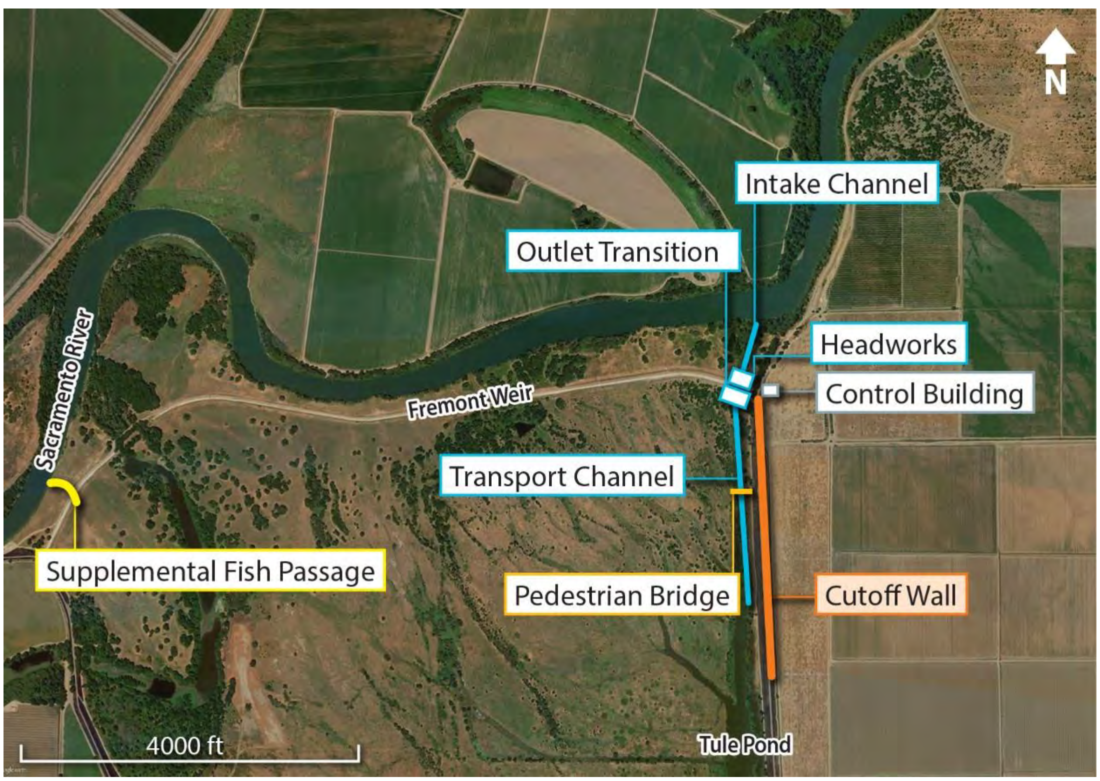


Figure 4-4. Alternative 1 Key Components

The next section includes descriptions of the facilities, construction methods, operations, required maintenance, and environmental commitments associated with this alternative. More detailed construction information is included in Appendix B, *Constructability and Construction Considerations.*

4.4.1 Facilities

4.4.1.1 Intake Channel

The primary purpose of the intake channel is to draw juvenile salmonids and floodplain inundation flows from the Sacramento River to the new headworks structure (described in Section 4.4.1.2) and provide upstream adult fish passage between the headworks structure and the Sacramento River. The intake channel would be constructed with a 98-foot-bottom width with 3:1 side slopes (horizontal to vertical). It would have a gentle slope away from Fremont Weir so that flows would drain toward the river. It would reach the river with an invert elevation of 12 feet (compared to the invert of 14 feet at Fremont Weir). At the downstream end of the intake channel (near the headworks at Fremont Weir), there would be a short transition from the trapezoidal intake channel to the rectangular sides of the headworks structure. To avoid scour, the channel would be lined with angular rock placed along the bank slopes and rounded rock placed along the channel bottom.

4.4.1.2 Headworks Structure

The headworks structure would control the diversion of flow from the Sacramento River to the Yolo Bypass. It would serve as the primary upstream fish passage facility for adult fish and the primary facility for conveying floodplain inundation flows and juvenile salmonids onto the Yolo Bypass.

The headworks structure would be a three-bay, pile-supported, reinforced concrete structure that would bisect the existing Fremont Weir at an eastern location. It was designed to convey 6,000 cfs at a river elevation of 28 feet (14 feet of water depth in the headworks structure) with all gates fully open and to meet the applicable requirements for fish passage and flood control. It would house three operating control gates and include a concrete control structure, an upstream vehicular bridge crossing, and a concrete channel transition, which would transition the rectangular sides of the control structure to the side channel slopes of the outlet channel. It would have a sheet pile cutoff wall on the river side of the structure under the gates and on both sides of the structure to prevent underseepage from the river. The gate structure would be 65 feet (upstream to downstream) by 108 feet, and the sheet piles would add 50 feet on either side of the gate structure.

Stoplogs would be provided at each of the three headworks bays upstream of the control to dewater the gates for maintenance and as a backup closure for the structure. Six stoplogs are required for the larger gate and four for the two smaller gates. Installation of the stoplogs would require a mobile crane capable of lifting approximately 10,000 pounds. Stoplogs would be stored off site and could only be installed or removed when there would be no flow through the headworks structure or when the gates are closed. The stoplogs would be used to prevent groundwater or small amounts of river flow from entering the structure during maintenance activities.

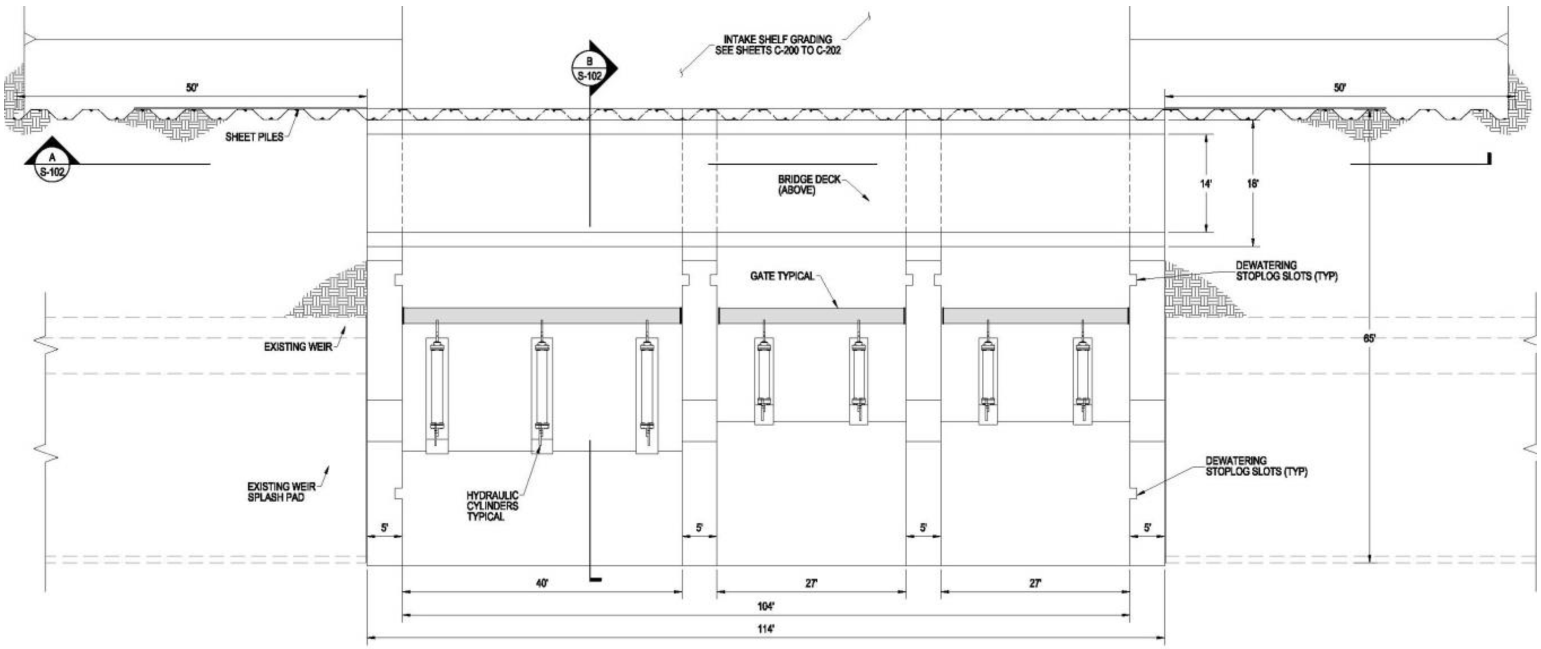
Three hydraulically or pneumatically operated, flush-mounted bottom hinge gates would be used in the headworks structure. These gates would be able to operate under variable river elevations and overtopping events. The top of the gate elevation of 32 feet would be flush with the existing Fremont Weir crest. The upstream face of the control gates would be approximately in-line with the upstream face of the existing Fremont Weir. When open, the gates would be flush with the channel invert. Table 4-1 presents the dimensions, invert elevation, and expected weight of the gates to be installed under Alternative 1.

Table 4-1. Gate Specifications for Alternative 1

Gate	Height x Width (feet)	Invert Elevation (feet)	Expected weight (pounds)
1	18 x 34	14.0	65,000
2 and 3	14 x 27	18.0	40,000 each

The gates would open to allow a maximum flow of 6,000 cfs when the water surface elevation in the river reaches 28 feet. Each gate would be capable of independent operation via submersible hydraulic cylinders or inflatable reinforced bladders located beneath the gate. Mechanical and electrical control components for each gate would be housed in a control building outside of the bypass on the eastern levee. Figure 4-5 and Figure 4-6 show the headworks structure design.

View from top of structure looking down



Cross-section (viewing from bypass side of Fremont Weir)

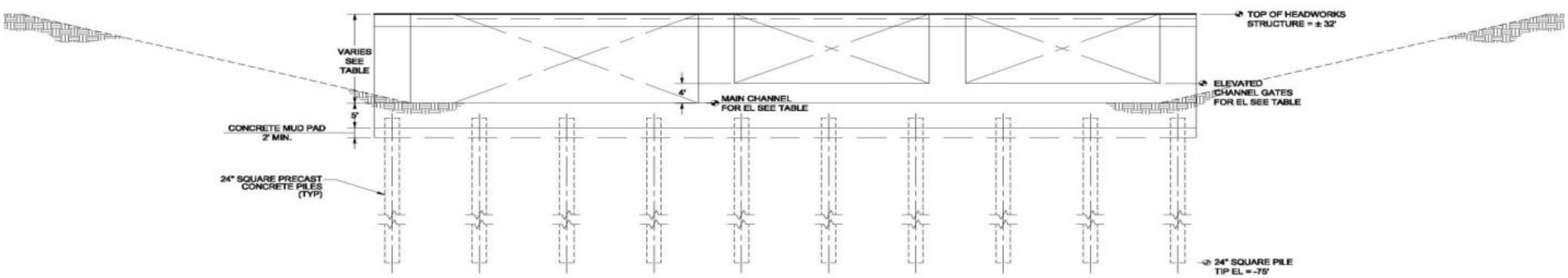


Figure 4-5. Alternative 1 Headworks Cross-Section and Top Views

View from side of structure

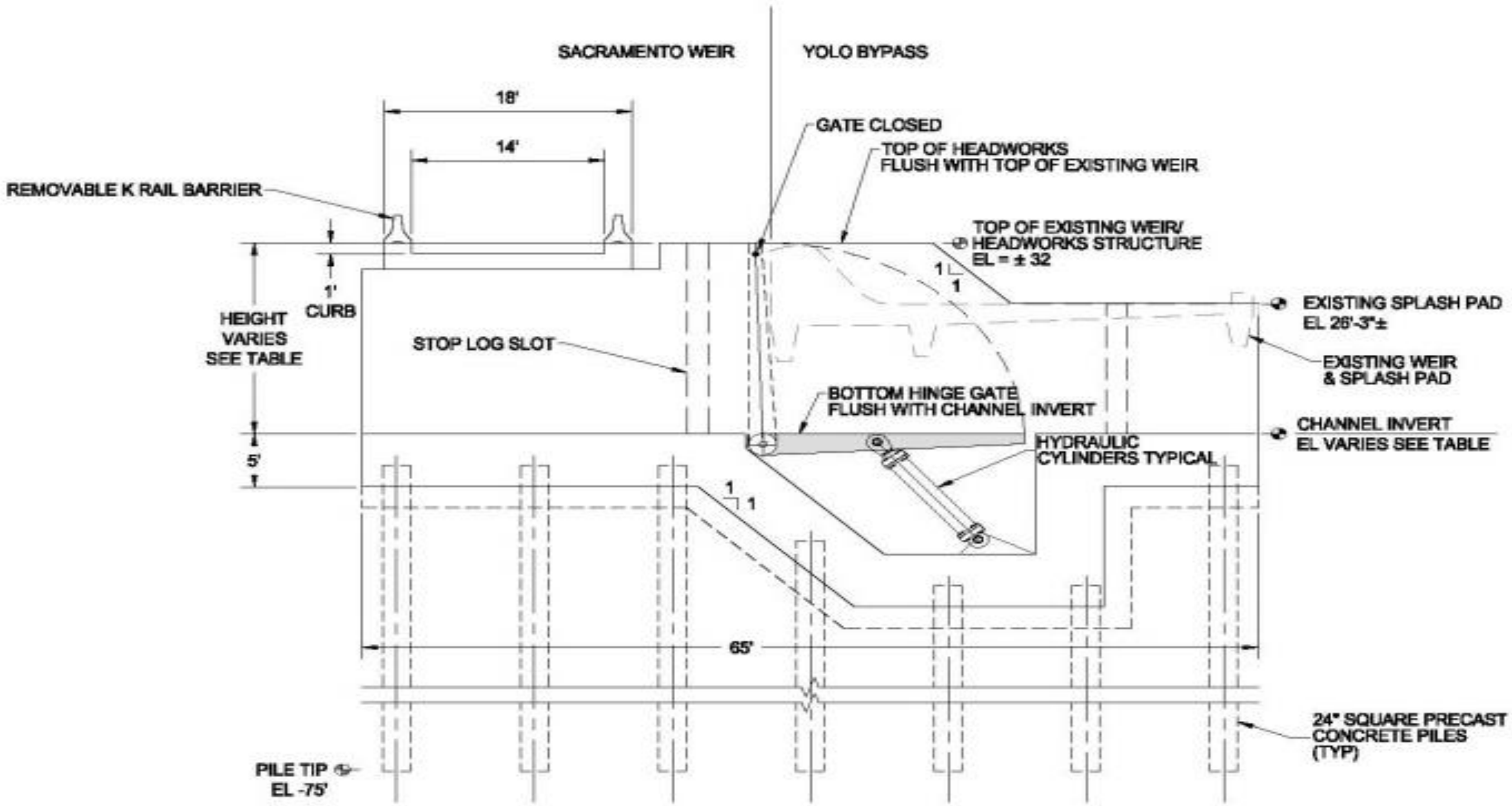


Figure 4-6. Alternative 1 Headworks Side View

Debris is expected within the Sacramento River, and debris accumulation could affect hydraulic performance or fish passage. Debris fins would be installed between gates of the headworks structure (on the river side) to redirect debris to pass through or over the gates rather than become stuck on the gate walls or facilities. Figure 4-7 shows an example of debris fins.

Figure 4-7. Debris Fins Incorporated at Headworks Structure (Example)

4.4.1.3 Control Building

The control building would be a single-story, 18- by 18-foot concrete masonry unit. The building would be located on the eastern levee. It would house, among other equipment, a programmable logic controller (PLC) for the gates, three hydraulic power units, and a motor control center. The electrical service required would be three- phase at approximately 100 amperes (A) and 480 volts alternating current (VAC) (80 kilovolt-amps [kVA]). There would be no backup or standby emergency generator; however, the units would include connections for a portable generator. Active ventilation would be required during the operation of the equipment and would be achieved by installing a roof-mounted fan that vents to the outside of the structure.

4.4.1.4 Access Structures

A reinforced concrete, three-span vehicular headworks bridge would be on the upstream side of Fremont Weir to connect to the existing access road. The bridge would span the channels through the new headworks structure. The bridge would be built at nearly the same alignment and elevation as the existing upstream maintenance road and would allow for continued patrolling and maintenance access along the weir. The bridge would have a roadway width of 14 feet and an overall width of 18 feet. Top curb elevation would be equal to the top of the weir elevation.

Temporary barrier rails (“K rails”) would be installed and removed such that no part of the bridge extends above the top of the weir during an overtopping event.

Table presents the bridge span corresponding to each control gate.

Table 4-2. Bridge Span Specifications for Alternative 1

Gate	Bridge Span (feet)
1	34
2 and 3	27

The headworks bridge would provide a vehicular and pedestrian crossing on the north side of Fremont Weir. However, when water begins to flow through the new notch in Fremont Weir, the channels south of the weir would fill and create a barrier. If recreational users are in the FWWA, they may not be able to cross the channel back to where they accessed the area. For this purpose, Alternative 1 includes a 130-foot-long, eight-foot-wide steel-trussed pedestrian bridge just south of Fremont Weir (and north of Tule Pond), as shown on Figure 4-4.

4.4.1.5 Outlet Transition

The outlet transition would be a 100-foot-long reinforced concrete channel that provides gradual hydraulic transition from the headworks into the graded transport channel. The width varies from 108 feet at the headworks to 196 feet at the transport channel. The cross-section of the headworks includes three rectangular gates (one large gate with an invert elevation of 14 feet and two small gates with an invert elevation of 18 feet, shown on Figure 4-5). The outlet transition would be a structure that transitions from the headworks gates to the trapezoidal downstream transport channel. The transition would be accomplished with reinforced retaining walls that flair out from the headworks abutment piers and a reinforced concrete slab-on-grade bottom, which would gradually transition into the slopes of the trapezoidal transport channel. The outlet transition would have a gentle slope consistent with the downstream transport channel.

4.4.1.6 Transport Channel

The transport (outlet) channel would be a graded trapezoidal channel with an interior inline bench. Figure 4-8 shows the transport channels for Alternatives 1 (east), 2 (central), and 3 and 4 (west). The interior bench would help maintain acceptable velocities for fish passage at higher river elevations. The transport channel would serve as the primary facility for upstream adult fish passage between the existing Tule Pond and the headworks structure. It also would serve as the primary channel for conveying juvenile salmonids and rearing habitat flows from the headworks structure to the existing Tule Pond.

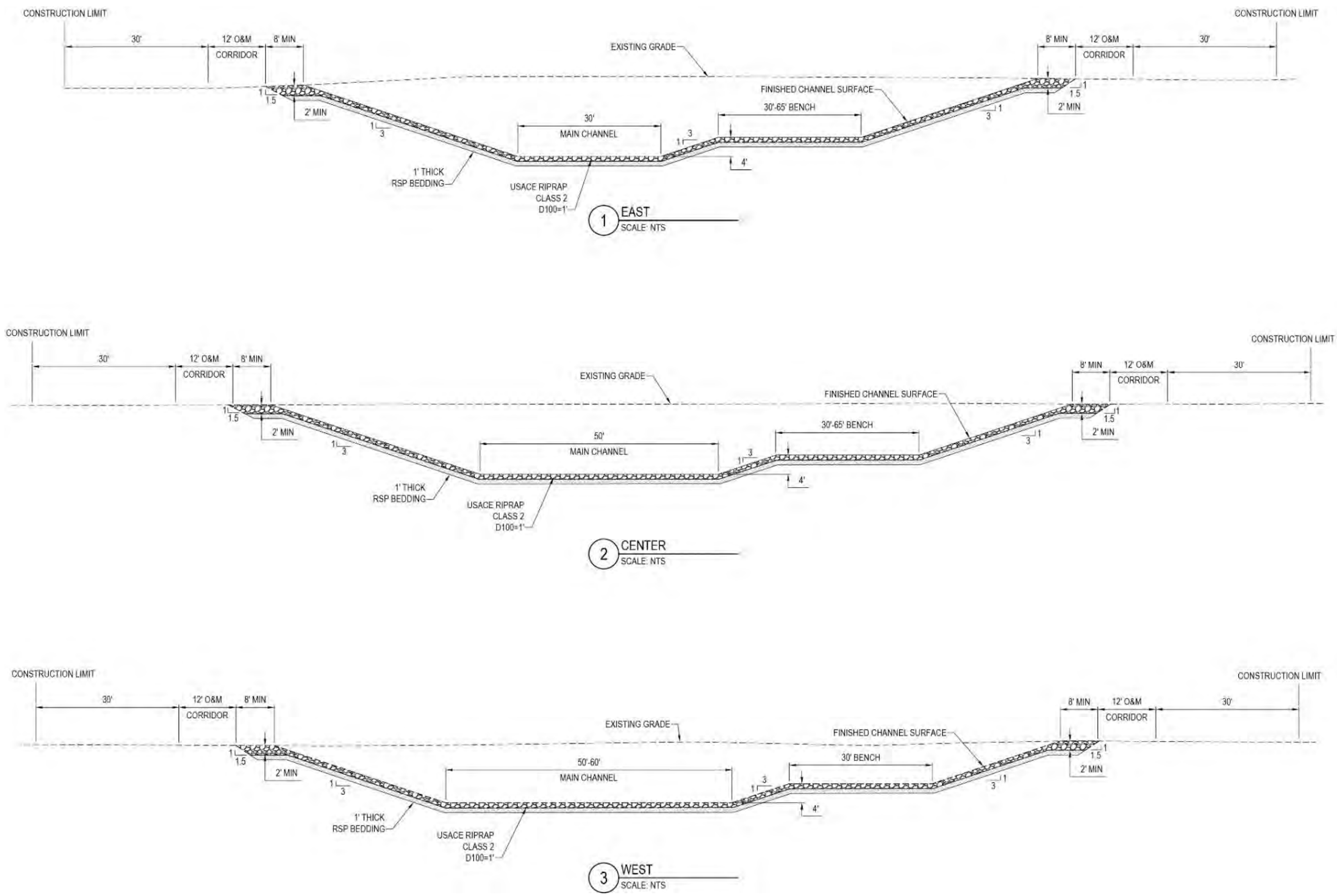


Figure 4-8. Transport Channel Cross-Section

The main channel within the trapezoidal channel would have a bottom width of 30 feet. The bench would be on the east side of the channel and elevated four feet above the main channel. The bench width would vary between 30 and 65 feet. The trapezoidal channel would have 3:1 side slopes (horizontal to vertical). The top of the channel would be approximately 150 feet wide. The channel would be about 2,650 feet long with a gradual downward slope toward Tule Pond (a slope of 0.00075). The entire channel would be lined with rounded rock revetment on the channel bottom and angular rock on the bank slopes. It would be designed to convey up to 6,000 cfs at a river elevation of 28 feet while maintaining velocities that permit fish passage. At the top of each side of the channel, an eight-foot-wide area with rock (a "rock key") would be added to reduce the potential for the channel to head cut the channel banks. The facility also would have a 12-foot-wide maintenance corridor at the top of each side of the channel.

4.4.1.7 Seepage Measures

The transport channel for the new gated notch would be immediately adjacent to the east levee of the Yolo Bypass and would cut through the clay blanket layer at the toe of the levee, which raises concerns about increased levee underseepage. Levee underseepage could cause levee stability concerns. To reduce seepage, a cutoff wall would be constructed at the levee toe from Fremont Weir to the central part of Tule Pond. The cutoff wall would be approximately 2,850 feet long and 30 feet deep, and the wall would be completely underground.

4.4.1.8 Supplemental Fish Passage Facility

The proposed gated notch in Fremont Weir would serve as the primary fish passage facility in Alternative 1. Another project in the Yolo Bypass, the Fremont Weir Adult Fish Passage Modification Project, is constructing an improved fish passage facility at the location of the existing, smaller fish ladder (near the middle of Fremont Weir on the eastern side of Rattlesnake Island) to provide fish passage after an overtopping event. These two facilities would improve fish passage from the Yolo Bypass into the Sacramento River; the proposed gated notch would provide the main passage route, and the improved fish passage structure would pass additional fish on the eastern side of Fremont Weir after overtopping events. However, after an overtopping event, fish on the western side of Fremont Weir would not be able to pass over to the eastern side to access these two fish passage facilities because Rattlesnake Island prevents movement.

An additional fish passage facility would be constructed at a western location along the existing Fremont Weir (Figure 4-9). This facility would provide another opportunity for adult fish to travel from the Yolo Bypass into the Sacramento River. This structure would allow fish that are trapped in the stilling basin (on the bypass side of Fremont Weir) to move back into the Sacramento River after an overtopping event. The facility would have a gentle slope away from Fremont Weir so that flows would drain toward the river. It would reach the river with an invert elevation at 20 feet (compared to the invert of 22 feet at Fremont Weir). The supplemental fish passage channel would have 10-foot-bottom width and 3:1 side slopes, stretch over 350 feet measured from Fremont Weir to Sacramento River, and connect to the fish passage facility through a channel transition. The transition would be 10 feet long and connect the 10-foot wide channel to the 15-foot width of the fish passage structure. The concrete fish passage structure would have an elevation of 22 feet at Fremont Weir and house an approximately 15-foot-wide hinge gate, recessed air bladder, and metal grate. Sheet piles would be installed north of Fremont Weir to prevent underseepage. When open, the gate would allow less than approximately 1,000 cfs to enter the Yolo Bypass. At an elevation of 32 feet, the concrete wall of the fish passage structure would be flush with the top of the existing weir. The structure would have a 16-foot-wide traffic-rated deck to allow vehicular passage.

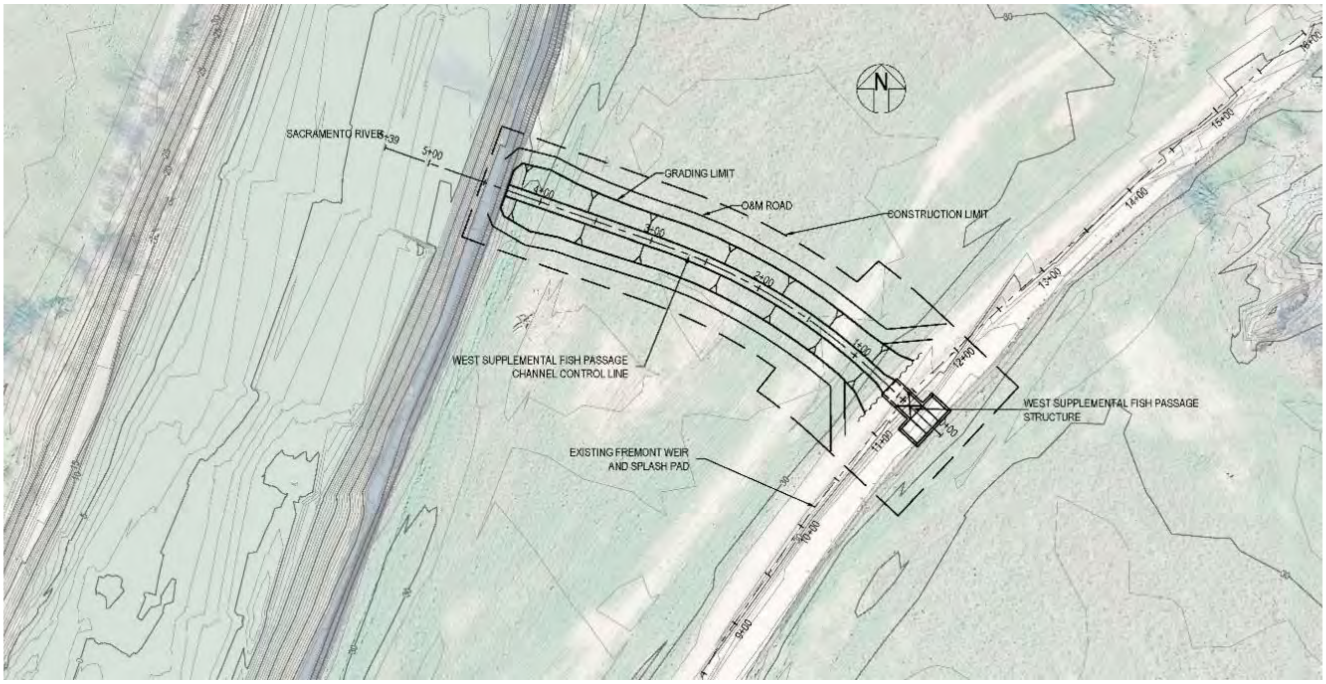


Figure 4-9. Alignment of the Western Supplemental Fish Passage Facility

4.4.2 Construction Methods

Construction of the components of Alternative 1 would begin with the demolition of a portion of the existing concrete Fremont Weir. This step would be completed in about one week. The limits for the weir demolition would extend a minimum of five feet beyond both sides of the headworks footprint to allow for excavation down to an elevation of seven feet and installation of a temporary sheet pile cofferdam.

Construction of the headworks structure, intake channel, and outlet channel would occur concurrently. It would take approximately 25 weeks to construct the headworks structure. Installation and testing of the gates and mechanical equipment would take an additional three to five weeks.

Grading of the transport channel would begin at the downstream outlet (at the northern end of Tule Pond) and progress upstream toward the headworks structure, with grading of the intake channel occurring last. This order would avoid potential interruptions to the headworks construction and allow construction to occur in the less saturated soil first as groundwater levels decrease with increasing distance from the Sacramento River. Groundwater levels are anticipated to be high, especially in the spring months, so dewatering efforts likely would be required to construct the headworks structure, especially where the intake channel meets the Sacramento River. About 60 to 80 percent of the channel excavation could be performed in dry unsaturated soil conditions by scrapers and bulldozers. The remaining portion would be performed in wet, saturated soil conditions by hydraulic excavators and haul trucks.

4.4.2.1 Excavated Material

Alternative 1 would require excavation of the intake channel, transport channel, and downstream facilities. Table 4-3 shows the estimated quantities of excess excavated material that would be generated from each facility and would require removal from the construction area. Depending on the type of material excavated, a portion of the material could be re-used within the project area or for other nearby projects.

Table 4-3. Estimated Excess Excavated Material Quantities for Alternative 1

Component	Estimated Excess Excavated Material (cubic yards)
East Intake Channel	64,150
East Transport Channel	116,600
Headworks	6,150
Downstream Channel	72,520
Supplemental Fish Passage (West)	3,230
Agricultural Road Crossing 1	3,170
TOTAL	*265,820*

Reclamation or DWR would purchase land within two miles of the edge of the Yolo Bypass to receive this excess material. Alternative 1 would require seven to eight acres of land to spoil excess construction-related material. This spoil site would be used for excess excavated soil and green waste. Other construction waste would be hauled to a landfill.

4.4.2.2 Construction Materials

Material imported to the Project site would be obtained from existing permitted commercial sources located within approximately 65 miles of the Project site. The haul routes for these materials would be along public streets, including I-5; State Route 99; and CRs 105, 16, 116A, and 117. Table 4-4 provides potential locations and haul routes for offsite import of materials. The exact source of the materials would be determined by the construction contractor, but these potential sources provide reasonable estimates for distances and haul routes.

Table 4-4. Construction Material Quantities, Sources, and Haul Routes

Material	Quantity	Potential Location	Haul Route	Distance
Aggregate base for road maintenance		Teichert Aggregates	Interstate 5; County Roads 16, 117, and 17; Old River Road	26 miles
Riprap material	66,860 tons	Parks Bar Quarry	County Roads 16 and 117, Old River Road, Interstate 5, State Route 99	66 miles
Rock slope protection bedding	68,618 tons	Parks Bar Quarry	County Roads 16 and 117, Old River Road, Interstate 5, State Route 99	66 miles

Material	Quantity	Potential Location	Haul Route	Distance
Equipment		Construction Contractor Office (likely access from Interstate 5)	County Roads 16 and 117, Old River Road, Interstate 5, Elkhorn Boulevard	20 miles (estimate, varies depending on contractor)

4.4.2.3 Staging Areas and Access

The construction easements for Alternative 1 would encompass staging areas for equipment, mobilization, and spoiling sites. The construction footprints analyzed in this EIS/EIR include space for staging areas. Construction sites would be accessed using I-5 to CR 117 (paved rural road), north to CR 16 (paved and dirt road), west to the Yolo Bypass east levee, and then north on the east levee crown road to access the site. The use of CR 16 for equipment and offsite haul would substantially degrade the quality of the road and require re-grading and gravelling (and potentially repaving) to restore it to pre-project conditions. In addition, portions of the existing levee crown roads would be used for hauling. The levee crown consists of only aggregate surfacing in marginal conditions. It is anticipated that use of the levee crown for hauling would trigger the need to resurface the levee crown to pre-project conditions with six inches of aggregate base material.

The county roads and levee crown roads utilized for site access and haul would be inspected periodically during construction operations. As areas of damage are identified, they would be temporarily repaired to accommodate ongoing operations. At the completion of project construction, all roads that have been temporarily repaired would be repaved as specified by the governing local, county, or State standards.

4.4.2.4 Construction Equipment

A list of the major equipment needs for the construction of both the alternative-specific and common downstream channel improvement actions is provided in Table 4-5. Equipment specifics may vary based on the contractor's capabilities and the availability of equipment. Appendix B, *Constructability and Construction Considerations,* includes information on how many of each type of equipment would be used.

Table 4-5. List of Major Equipment Needed for Construction of Alternative 1

List of Major Equipment	
• 0.8-CY backhoe loaders • 1.5-CY front end loader crawler • 10-TN smooth roller • 100-TN off highway trucks • 100-foot auger track-mounted drill rig • 12-foot blade grader • 165-HP dozer • 2.5-CY hydraulic excavator • 2.5-inch diameter concrete vibrator • 24-TN truck end dump • 3.5-CY hydraulic excavator • 3-axle haul trucks • 30-CY scrapers • 300-kW generator	• 4.5-CY hydraulic excavator • 40-TN truck-mounted hydraulic crane • 4,000-gallon water truck • 450-HP dozer crawler • 6-inch diameter pump engine drive • 75-TN crane crawler pile hammer • Concrete mixer truck • Concrete pump boom, truck-mounted • Extended boom pallet loader • Flatbed truck • Haul truck oversize transport • Hydroseeding truck • Pickup trucks, conventional

Key: CY = cubic yards; HP = horsepower; kW = kilowatt; TN = ton

4.4.2.5 Construction Schedule and Workers

Alternative 1 construction likely would begin in late 2020 or early 2021 and is estimated to last 28 weeks. All project components are expected to be completed in one construction season during times that are outside the flood period (construction from April 15 through November 1). The headworks structure would have the longest construction duration and would start at the beginning of the construction period. Construction of channel improvements would commence the same week as the headworks structure construction activities.

Construction would occur six days per week, 10 hours per day between 7 a.m. and 6 p.m. Construction workers would be divided into multiple crews and would work one shift per day. Maintenance and equipment upkeep crews would work on equipment at night when it is not in use. The peak number of construction workers, which would be needed for one week in July, is estimated to be 202.

4.4.3 Operations

The goal of Alternative 1 operations is to maximize the number of out-migrating juvenile winter-run Chinook salmon that enter the Yolo Bypass. Downstream out-migration is triggered during the first wet season event. Gate operations could begin each year on November 1 and would first open based on river conditions. All gates would be opened when the river elevation reaches 15 feet, which is one foot above the lowest gate invert. At this river elevation, about 130 cfs would enter the gated notch. If the river continues to rise, the gates would stay open until the flow through the gates reaches 6,000 cfs. The flow through the gates would reach 6,000 cfs when the river elevation is about 27.5 feet; at this point, the two smaller gates would be programmed to start closing such that 6,000 cfs would not be exceeded. Gate closures would be controlled so that there is not a sudden reduction in flow. Gate 1, the larger gate, would remain fully open throughout operations.

Once Fremont Weir begins to overtop, the smaller gates would remain in their last position prior to the weir overtopping (generally both would be closed at this point). After the overtopping event is over, the smaller gates would open and close as needed to keep the flow through the gate below, but as close as possible to, 6,000 cfs. All gates would close when the river elevation falls below 14 feet. Gate operations to increase inundation could continue through March 15 of each year, based on hydraulic conditions. The gates may remain partially open after March 15 to provide fish passage. However, flows through the gates after March 15 could not exceed 1,000 cfs (the capacity of Tule Canal) so that these flows do not inundate areas outside of the canal and affect landowners.

The headworks structure would house three operating control gates and include a "dogging" device on each gate to be used when the gates are raised (closed) for long periods of time. The dogging device, when manually engaged, would relieve the hydraulic operating equipment of the need to maintain pressure to keep the gates from lowering.

Each control gate would be capable of independent operation via submersible hydraulic cylinders located beneath the gate. Operation of the gates would occur from an operating control building that would house the service panel board and electrical controls for the gates, including a PLC panel.

4.4.4 Inspection and Maintenance

Maintenance activities would include debris removal, sediment removal, and facility inspections. To prevent corrosion, the gates would be rinsed at the end of the flood season as part of the facility inspections. As the Sacramento River rises, some components would no longer be accessible for maintenance. Bridge guardrails would be removed before the river rises to 28 feet. The installation of dewatering stoplogs could not be performed under any flow conditions but rather could only be installed below a river elevation of 14 feet or when the river elevation is between 14 and 28 feet and the gates are raised. When the river elevation is greater than 28 feet, with the gates open or partially open, there would be no safe access to the headworks or bridges. Table 4-6 provides a list of accessible components at varying river stages.

Table 4-6. Maintenance Accessibility by River Elevation

River Elevation	Areas Accessible for Maintenance
Below 14 feet	All components of the headworks structure, bridges, gates (upstream and downstream), and operating components. Stoplogs could be installed for all gates.
14 to 28 feet (gate closed)	Upstream sides of Gates 2 and 3 (from 14 to 18 feet), downstream components of the headworks structure, bridges, gates, and operating components. Stoplogs could be installed for Gates 2 and 3.
14 to 28 feet (gate open)	Upstream bridge deck.
Above 28 feet (gate open)	All components inaccessible.

4.4.4.1 Sediment Deposition

Estimates indicate that approximately 659,000 cubic yards of sediment enter the bypass annually under existing conditions. A portion of this sediment settles in the Yolo Bypass and must be removed through current maintenance efforts. Alternative 1 would increase sediment entering the bypass to about 743,000 cubic yards annually. Most of the additional sediment (about 45 percent) would settle out in the FWWA, about 25 percent would settle downstream of Agricultural Road Crossing 1, and the remaining 30 percent of sediment would remain in suspension and flow out of the bypass. Most of the sediment that settles out would be removed through flood maintenance in the FWWA, as under existing conditions. The additional deposition would be in areas inundated regularly under Alternative 1 (in and around channels), and sediment removal efforts associated with Alternative 1 would focus on the channel system. Alternative 1 would accumulate an additional 37,800 cubic yards of sediment annually that would be removed every five years.

Reclamation or DWR would purchase land outside the bypass for the sediment removed during maintenance actions. This acquisition would be part of the land acquired for the construction effort, but the acquisition could be phased over time. The maintenance-related sediment removal operation would require 38 to 43 acres for 50 years of operation.

New channel areas that are constructed perpendicular to the direction of flow in the bypass would incur greater sedimentation. The eastern channel alignment included in Alternative 1 likely would have less sedimentation and debris accumulation than the other action alternatives because it is the shortest and most aligned with the direction of flood flows.

4.4.4.2 Headworks Inspection and Debris Removal

The serviceability and proper function of gates, their actuators, controls, hydraulic cylinders, and the recessed areas for stoplogs and gates would be inspected at the beginning and end of the flood season and after overtopping events. Concrete spalling or severe cracking, material corrosion, or identified weakness would be noted and evaluated to determine whether repair or replacement is necessary. Any sediment deposits or accumulated debris would be removed. Debris removal in and around the headworks would be accomplished using an excavator or a crane.

4.4.4.3 Vegetation Removal

Maintenance activities would include removing vegetation and debris from the project channels annually. Grasses and woody vegetation would be allowed to remain in the channels unless it becomes an obstruction to flow within the passage channel.

4.4.5 Monitoring and Adaptive Management

During project implementation, DWR and Reclamation would monitor fish activity to identify if the project objectives are being met. Specifically, the agencies would monitor:

- Fremont Weir splash pad after overtopping events to identify if fish pass into the Sacramento River (through visual inspection)

- Structures within the Tule Canal/Toe Drain to identify fish passage concerns (through visual inspection)
- Stranding within the floodplain areas (through visual inspection and reports from landowners or visitors)
- Juvenile fish entrainment at the Fremont Weir gated notch (through camera footage at the structure)

If DWR and Reclamation identify concerns or areas where performance could improve, they would consider taking an adaptive management action. Appendix C describes the Adaptive Management Framework that would be implemented.

In addition to monitoring for fish, DWR and Reclamation would monitor groundwater levels in the area surrounding the Yolo Bypass during and after periods when the gated notch would be operating. DWR has a groundwater monitoring network in this area, and the wells are checked regularly. DWR and Reclamation would consider groundwater levels each operating season to identify if the gated notch operations could be elevating shallow groundwater levels such that they could affect surrounding lands. If the agencies identify potential effects to surrounding landowners, they would work with landowners to consider a physical solution to the high groundwater elevation, property easements, or consideration of damages.

4.4.6 Alternative 1 Preliminary Costs

Alternative 1 project facilities would be constructed within one year over a 28-week period between April to October. Construction of Alternative 1 project facilities would cost approximately $44.9 million. The operations and maintenance cost for Alternative 1 would be approximately $0.5 million annually.

4.5 Alternative 2: Central Gated Notch

Alternative 2, Central Gated Notch, would provide a new gated notch through Fremont Weir similar to the notch described for Alternative 1. The primary difference between Alternatives 1 and 2 is the location of the notch; Alternative 2 would site the notch near the center of Fremont Weir. This gated notch would be similar in size to Alternative 1 but would have an invert elevation that is higher (14.8 feet) because the river is higher at this upstream location. This location is on an outside bend of the river. Studies have indicated that juvenile fish may be found in greater numbers on the outside edge of river bends (DWR 2017). The new gated notch would allow flow to pass into the Yolo Bypass at lower river elevations than under existing conditions where flows only enter the Yolo Bypass when Fremont Weir overtops.

Alternative 2 would include facilities to connect the gated notch to the existing Tule Pond. Alternative 2 would allow flows up to 6,000 cfs, depending on Sacramento River elevation, through the gated notch to provide open channel flow for adult fish passage, juvenile emigration, and floodplain inundation. This alternative would also include a supplemental fish passage facility on the western end of Fremont Weir and improvements downstream of Tule Pond as described in Section 4.3. Figure 4-10 shows the key components of this alternative and the common elements described in Section 4.3.

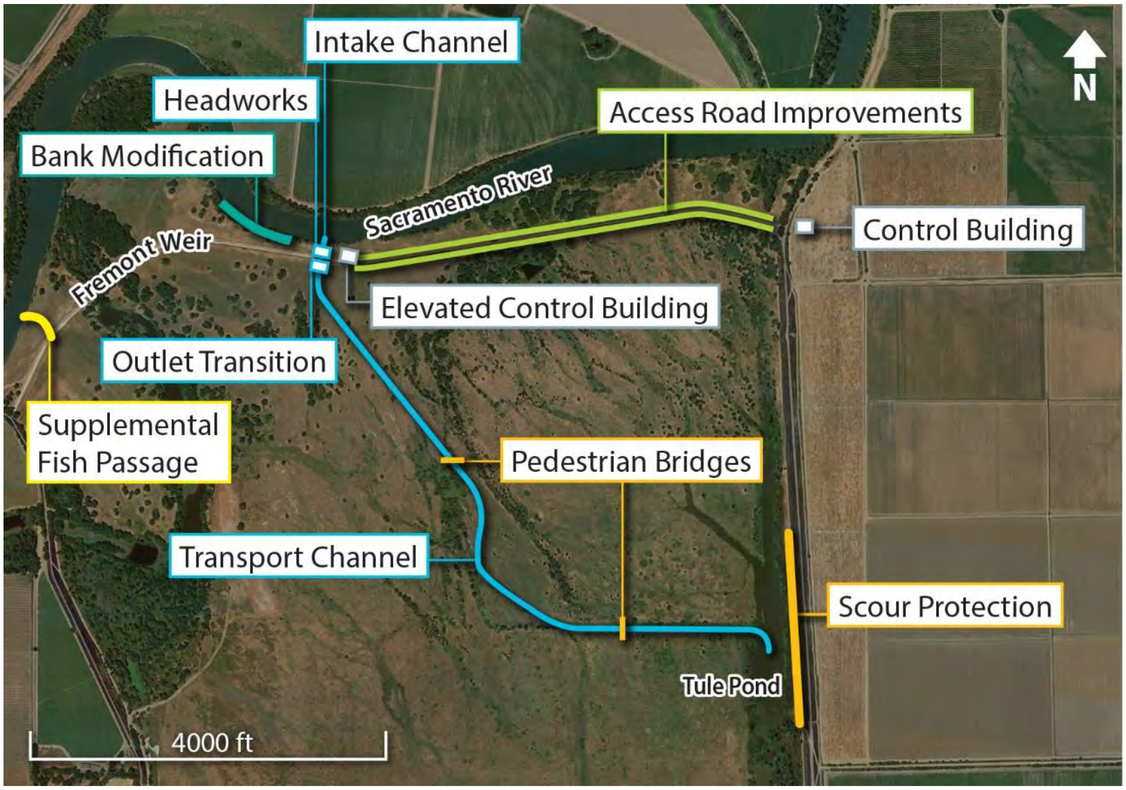


Figure 4-10. Alternative 2 Key Components

The next section includes descriptions of the facilities, construction methods, operations, required maintenance, and environmental commitments associated with this alternative. More detailed construction information is included in Appendix B, *Constructability and Construction Considerations.*

4.5.1 Facilities

4.5.1.1 Intake Channel

Similar to Alternative 1, the primary purpose of the intake channel is to draw juvenile salmonids and floodplain inundation flows from the Sacramento River to the new headworks structure (described in Section 4.5.1.2) and provide upstream adult fish passage between the headworks structure and the Sacramento River. The dimensions and design details would be the same as described for Alternative 1, but the channel would be located in a central location. The Sacramento River bank just upstream and along the intake channel would be modified by removing roughage (existing rock revetment, piles and large wood) in the wetted channel, resloping the bed and embankment contours, and smoothing channel edges along the intake channel.

4.5.1.2 Headworks Structure

Because of the different location, the headworks structure in Alternative 2 would have a slightly different gate configuration than described for Alternative 1. The overall structure and foundation would be the same as described for Alternative 1, but the structure would be a little longer (the gate structure would be 114 feet compared to 108 feet for Alternative 1).

Three hydraulically operated, flush-mounted bottom hinge gates would be used in the headworks structure. These gates would be capable of operating under variable river elevations and overtopping events. The top of the gate elevation would be flush with the existing Fremont Weir crest (32 feet). The upstream face of the control gates would be approximately in-line with the upstream face of the existing Fremont Weir. When open, the gates would be flush with the channel invert. Table 4-7 presents the dimensions, invert elevation, and expected weight of the gates to be installed under this alternative. The layout of the facilities would be the same as described for Alternative 1, shown on Figures 4-5 and 4-6, including debris fins.

Table 4-7. Gate Specifications for Alternative 2

Gate	Height x Width (feet)	Invert Elevation (feet)	Expected weight (pounds)
1	17 x 40	14.8	65,000
2 and 3	13 x 27	18.8	40,000 each

4.5.1.3 Control Buildings

Due to the maximum distance over which hydraulic lines can function, two separate control buildings would be required: an operating control building and an elevated control building for hydraulics. The operating control building would be a concrete masonry unit, measuring approximately 12 by 12 feet, located on the eastern levee. The building would house a PLC for the gates and would require three-phase electrical service at approximately 100 A and 480-VAC (80kVA). There would be no backup or standby emergency generator; however, the units would include connections for a portable generator. Active ventilation would be required during the operation of the equipment and would be achieved by installing a roof-mounted fan that vents to the outside of the structure.

The elevated control building would be located on the river side of the weir near the headworks structure. The building would be of similar size and construction as the operating control structure but would be raised above the probable maximum flood elevation. The foundation of the raised building would consist of H-piles, a reinforced concrete pile cap, and a pair of streamlined reinforced concrete columns on which the building slab would rest.

4.5.1.4 Access Structures

A reinforced concrete, three-span vehicular headworks bridge would be on the upstream side of Fremont Weir to connect to the existing access road. The bridge would span the channels through the new headworks structure. Table 4-8 presents the bridge span corresponding to each control gate. The details of the headworks bridge, other than the span specifications, would be the same as discussed for Alternative 1.

Table 4-8. Bridge Span Specifications for Alternative 2

Gate	Bridge Span (feet)
1	40
2 and 3	27

The headworks bridge would provide a vehicular and pedestrian crossing on the north side of Fremont Weir. As discussed in Alternative 1, the channels south of Fremont Weir could be a barrier to access for recreational users in the FWWA. For this purpose, Alternative 2 includes two 170-foot-long, eight-foot-wide steel-trussed pedestrian bridges south of Fremont Weir (and north of Tule Pond), as shown on Figure 4-10. Alternative 2 includes two bridges (instead of the one bridge in Alternative 1) because of the longer length of the transport channel.

The Sacramento River carries a large amount of debris during high flow events that could accumulate in the new headworks gates. Access immediately after an overtopping event may be necessary to remove debris before a subsequent event, but the existing access roads near Fremont Weir are unpaved and too muddy to travel on for several weeks after overtopping. Alternative 2 would include stabilized access on the north and south sides of Fremont Weir to provide access following overtopping events earlier than under existing conditions. On the north side (closer to the Sacramento River), the 14-foot-wide existing access road would be excavated by two feet. The excavation would be filled with two feet of riprap with rocks less than 12 inches in diameter flush to existing grade. On the south side, the 14-foot-wide access road would be stabilized by placing two feet of riprap on top of the existing access road.

4.5.1.5 Outlet Transition

The outlet transition from the headworks to the transport channel would be the same as described for Alternative 1.

4.5.1.6 Transport Channel

The transport (outlet) channel would be a graded trapezoidal channel with an interior bench. The channel would serve the same function as described for Alternative 1. Figure 4-8 shows the cross-section of the transport channel for Alternative 2 (the central location).

The main channel within the trapezoidal channel would have a bottom width of 50 feet. The bench would be on the east side of the channel and elevated four feet above the main channel. The bench width would vary between 30 and 65 feet. The trapezoidal side slopes would have 3:1 slopes (horizontal to vertical). The top of the channel would be approximately 170 feet wide. The channel would be about 7,570 feet long with a gradual downward slope toward Tule Pond (a slope of 0.00037). The entire channel would be lined with rounded rock revetment on the channel bottom and angular rock revetment on the bank slopes. At the top of each side of the channel, an eight-foot-wide area of rock (a rock key) would be added to reduce the potential for the channel to head cut the channel banks. The facility also would have a 12-foot-wide maintenance corridor at the top of each side of the channel.

4.5.1.7 Scour Protection

The transport channel would enter Tule Pond at an angle, which could cause erosion concerns on the eastern Yolo Bypass levee. Rock revetment would be incorporated on the eastern edge of Tule Pond that is 50 feet wide, 2,500 feet long, and 2.5 feet thick, with 1.5:1 side slopes (horizontal to vertical). Additionally, there are several locations along the proposed transport channel where the channel could interact with existing scour channels. These five areas could experience head cutting as a result of the new facilities. Additional channel revetment would be incorporated at these locations; these improvements are included in the construction quantities.

4.5.1.8 Supplemental Fish Passage Facility

As discussed for Alternative 1, additional fish passage would be needed for the western side of Fremont Weir. Alternative 2 includes a supplemental fish passage facility with the same location and dimensions as described for Alternative 1.

4.5.2 Construction Methods

The construction methods and process would be similar to those described for Alternative 1. Construction would start with demolition of a portion of Fremont Weir and continue with the headworks and channel construction. In addition to the construction activities described for Alternative 1, dewatering would be required for the material removal and regrading at the bank of the Sacramento River near the intake channel.

4.5.2.1 Excavated Material

Alternative 2 would require excavation of the intake channel, transport channel, and downstream facilities. Table 4-9 shows the estimated quantities of excess excavated material that would be generated from each facility and would require removal from the construction area.

Table 4-9. Estimated Excess Excavated Material Quantities for Alternative 2

Component	Estimated Excess Excavated Material (cubic yards)
Central Intake Channel	3,360
Central Transport Channel	457,120
Headworks	6,460
Downstream Channel	72,520
Supplemental Fish Passage (West)	3,230
Agricultural Road Crossing 1	3,170
Sacramento River Bank Modification	44,523
Fremont Weir Access Road Improvements	4,961
TOTAL	*595,336*

Reclamation or DWR would purchase land outside of the bypass within two miles of the edge of the Yolo Bypass to receive this excess material. Alternative 2 would require 12 to 14 acres of land to spoil excess construction-related materials. This spoil site would be used for excess excavated soil and green waste. Other construction waste would be hauled to a landfill.

4.5.2.2 Construction Materials

Material imported to the Project site would be obtained from existing permitted commercial sources located within approximately 65 miles of the Project site. These sites and the associated haul routes would be the same as described for Alternative 1.

4.5.2.3 Staging Areas and Access

The construction easements for Alternative 2 would encompass staging areas for equipment, mobilization, and spoiling sites. The construction footprints analyzed in this EIS/EIR include space for staging areas. Access roads would be the same as described for Alternative 1.

4.5.2.4 Construction Equipment

A list of the major equipment needs for the construction of both the alternative-specific and common downstream channel improvement actions is provided in Table 4-10. Equipment specifics may vary based on the contractor's capabilities and the availability of equipment. Appendix B, *Constructability and Construction Considerations,* includes information on how many of each type of equipment would be used.

4.5.2.5 Construction Schedule and Workers

Construction of Alternative 2 likely would begin in 2020 or 2021 and is estimated to last 28 weeks. The construction schedule is the same as for Alternative 1. The peak number of construction workers, which would be needed during one week in early August, is estimated to be 223.

Table 4-10. List of Major Equipment Needed for Construction of Alternative 2

List of Major Equipment	
• 0.8-CY backhoe loaders	• 4.5-CY hydraulic excavator
• 1.5-CY front end loader crawler	• 40-TN truck-mounted hydraulic crane
• 10-TN smooth roller	• 4,000-gallon water truck
• 100-TN off highway trucks	• 450-HP dozer
• 100-foot auger track-mounted drill rig	• 450-HP dozer crawler
• 12-foot blade grader	• 6-inch diameter pump engine drive
• 165-HP dozer	• 75-TN crane crawler pile hammer
• 2.5-CY hydraulic excavator	• Concrete mixer truck
• 2.5-inch diameter concrete vibrator	• Concrete pump boom, truck mounted
• 24-TN truck end dumps	• Extended boom pallet loader
• 3.5-CY hydraulic excavator	• Flatbed truck
• 3-axle haul trucks	• Haul truck oversize transport
• 30-CY scrapers	• Hydroseeding truck
• 300-kW generator	• Pickup trucks conventional

Key: CY = cubic yards; HP = horsepower; kW = kilowatt; TN = ton

4.5.3 Operations

Alternative 2 operations would be the same as those described for Alternative 1, but the gates would open when the river elevation rises above 15.8 feet (one foot above the gate invert elevation of 14.8 feet).

The headworks operations would be the same as described for Alternative 1. Each gate would have a dogging device to relieve the hydraulic operating equipment of the need to maintain pressure to keep the gates from lowering. Each control gate would be capable of independent operation via submersible hydraulic cylinders located beneath the gate.

4.5.4 Inspection and Maintenance

Maintenance activities associated with Alternative 2 mainly would include debris removal, sediment removal, and facility inspections. Inspection and maintenance would be the same as described for Alternative 1.

4.5.4.1 Sediment Deposition

The amount of sediment entering the Yolo Bypass under Alternative 2 would be the same as described for Alternative 1. The removal frequency, methods, and quantities would be the same as described for Alternative 1.

New areas that are constructed perpendicular to the direction of flow in the bypass would incur greater sedimentation deposition. The central gated notch location, based on its location along the weir and observations of existing debris stranding, likely would experience a higher occurrence of debris accumulation as compared to the west and east alignments. Therefore, debris removal in this area would be required and accomplished using an excavator or a crane.

4.5.4.2 Headworks Inspection and Debris Removal

The serviceability and proper function of gates, their actuators, controls, hydraulic cylinders, and the recessed areas for stoplogs and gates would be inspected at the beginning and end of the flood season and after overtopping events. Concrete spalling or severe cracking, material corrosion, or identified weakness would be noted and evaluated to determine whether repair or replacement is necessary. Sediment deposits or accumulated debris would be removed. Debris removal in and around the headworks would be accomplished using an excavator or a crane.

4.5.4.3 Vegetation Removal

Periodic vegetation and debris removal from project channels would be the same as described for Alternative 1.

4.5.5 Monitoring and Adaptive Management

Monitoring activities and the adaptive management framework would be the same as described for Alternative 1.

4.5.6 Alternative 2 Preliminary Costs

Alternative 2 project facilities would be constructed within one year over a 28-week period between April to October. Construction of Alternative 2 project facilities would cost approximately $53.8 million. The operations and maintenance cost for Alternative 2 would be approximately $0.6 million annually.

4.6 Alternative 3: West Side Gated Notch

Alternative 3, West Side Gated Notch, would provide a new gated notch through Fremont Weir similar to the notch described for Alternative 1. The primary difference between Alternatives 1 and 3 is the location of the notch; Alternative 3 would site the notch on the western side of

Fremont Weir. This gated notch would be similar in size to Alternative 1 but would have an invert elevation that is higher (16.1 feet) because the river is higher at this location. The western location is on the outside of a river bend, similar to Alternative 2, but would be easier to access for operations and maintenance (O&M) than a central location. The new gated notch would allow flow to pass into the Yolo Bypass at lower river elevations than under existing conditions where flows only enter the Yolo Bypass when Fremont Weir overtops.

Alternative 3 would include facilities to connect the gated notch to the existing Tule Pond. Alternative 3 would allow flows up to 6,000 cfs, depending on Sacramento River elevation, through the gated notch to provide open channel flow for adult fish passage, juvenile emigration, and floodplain inundation. This alternative would also include a supplemental fish passage facility on the eastern side of Fremont Weir and improvements downstream of Tule Pond as described in Section 4.3. Figure 4-11 shows the key components of Alternative 3 and the common elements described in Section 4.3.

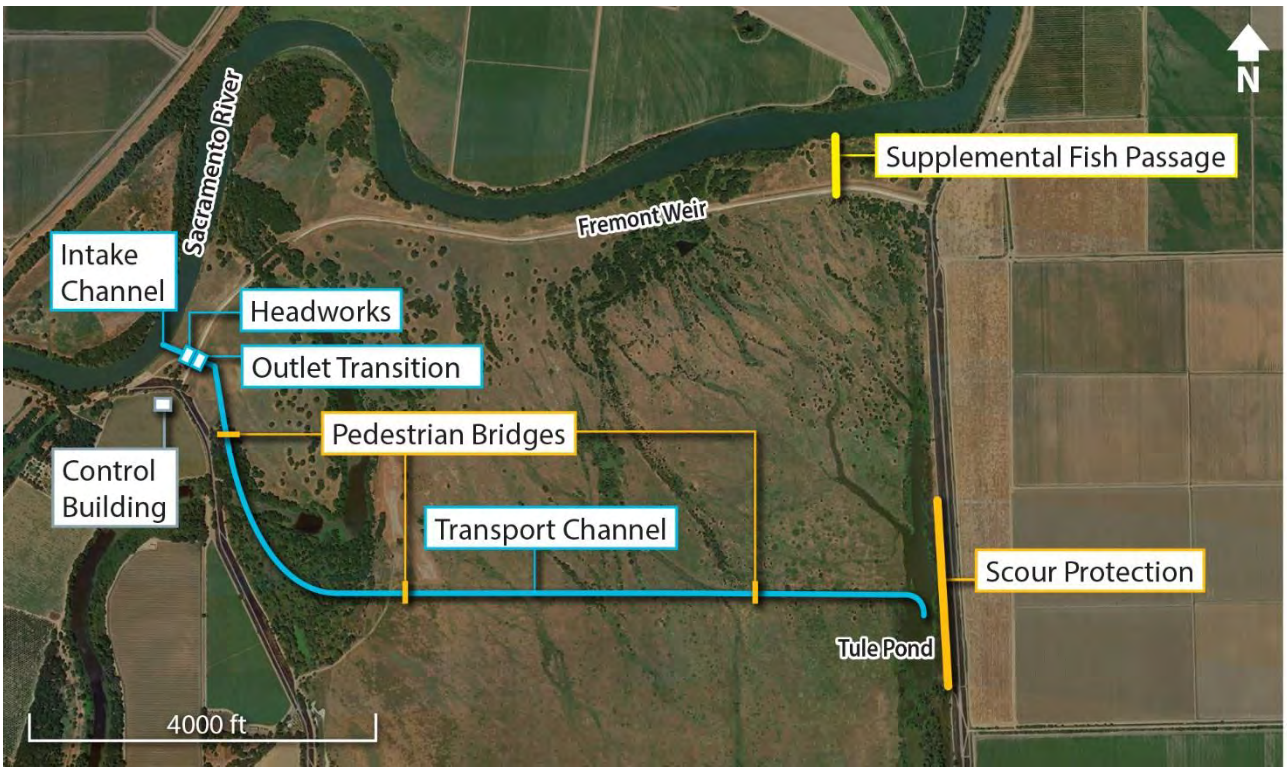


Figure 4-11. Alternative 3 Key Components

The next section includes descriptions of the facilities, construction methods, operations, required maintenance, and environmental commitments associated with this alternative. More detailed construction information is included in Appendix B, *Constructability and Construction Considerations*.

4.6.1 Facilities

4.6.1.1 Intake Channel

Similar to Alternative 1, the primary purpose of the intake channel is to draw juvenile salmonids and floodplain inundation flows from the Sacramento River to the new headworks structure (described in Section 4.6.1.2) and provide upstream adult fish passage between the headworks structure and the Sacramento River. The dimensions and design details would be the same as described for Alternative 1, but the channel would be located in a western location.

4.6.1.2 Headworks Structure

Because of the different location, the headworks structure in Alternative 3 would have a slightly different gate configuration than described for Alternative 1. The overall structure and foundation would be the same as described for Alternative 1, but the structure would be a little longer (the gate structure would be 114 feet compared to 108 feet for Alternative 1).

Three hydraulically operated, flush-mounted bottom hinge gates would be used in the headworks structure. These gates would be capable of operating under variable river elevations and overtopping events. The top of the gate elevation would be flush with the existing Fremont Weir (32 feet). The upstream face of the control gates would be approximately in-line with the upstream face of the existing Fremont Weir. When open, the gates would be flush with the channel invert. Table 4-11 presents the dimensions, invert elevation, and expected weight of the gates to be installed under this alternative. The layout of the facilities would be the same as described for Alternative 1 (Figures 4-5 and 4-6), including debris fins.

Table 4-11. Gate Specifications for Alternative 3

Gate	Height x Width (feet)	Invert Elevation (feet)	Expected weight (pounds)
1	16 x 40	16.1	65,000
2 and 3	12 x 27	20.1	40,000 each

4.6.1.3 Control Building

The control building would be a single-story concrete masonry unit, measuring 18 by 18 feet, located on the western levee. The building would house the same equipment as described for Alternative 1.

4.6.1.4 Access Structures

A reinforced concrete, three-span vehicular headworks bridge would be on the upstream side of Fremont Weir to connect to the existing access road. The bridge would span the channels through the new headworks structure.

Table 4-12 presents the bridge span corresponding to each control gate. The details of the headworks bridge, other than the span specifications, would be the same as discussed for Alternative 1.

Table 4-12. Bridge Span Specifications for Alternative 3

Gate	Bridge Span (feet)
1	40
2 and 3	27

The headworks bridge would provide a vehicular and pedestrian crossing on the north side of Fremont Weir. As discussed in Alternative 1, the channels south of Fremont Weir could be a barrier to access for recreational users in the FWWA. For this purpose, Alternative 3 includes three 185-foot-long, eight-foot-wide steel-trussed pedestrian bridges south of Fremont Weir (and north of Tule Pond), as shown on Figure 4-11.

4.6.1.5 Outlet Transition

The outlet transition from the headworks to the transport channel would be the same as described for Alternative 1.

4.6.1.6 Transport Channel

The transport (outlet) channel would be a graded trapezoidal channel with an interior bench. The channel would serve the same function as described for Alternative 1. Figure 4-8 shows the cross-section of the transport channel for Alternative 3 (the western location). The transport channel would cross the “oxbow” wetland area on the western side of the Yolo Bypass, but the channel would not have a hydraulic connection to the oxbow. A portion of the oxbow near the western Yolo Bypass levee would be filled to approximately existing grade, then the transport channel would be excavated through the filled section.

The main channel within the trapezoidal channel would have a bottom width of 50 to 60 feet. The bench would be on one side of the channel and elevated four feet above the main channel. The bench width would be approximately 30 feet. The trapezoidal side slopes would have 3:1 slopes (horizontal to vertical). The top of the channel would be approximately 180 feet wide. The channel would be about 10,180 feet long with a gradual downward slope toward Tule Pond (a slope of 0.0004). The entire channel would be lined with rounded rock revetment on the channel bottom and angular rock revetment on the bank slopes. At the top of each side of the channel, an eight-foot-wide area of rock (a rock key) would be added to reduce the potential for the channel to head cut the channel banks. The facility also would have a 12-foot-wide maintenance corridor at the top of each side of the channel.

4.6.1.7 Supplemental Fish Passage Facility

Alternative 3 would provide primary fish passage through the new gated notch on the western side of Fremont Weir. The improved fish passage facility at the existing fish ladder would provide passage immediately after an overtopping event near the center of Fremont Weir, but the eastern section of Fremont Weir is very long. To further improve fish passage from the Yolo Bypass into the Sacramento River after an overtopping event, Alternative 3 would include an additional fish passage facility at an eastern location along the existing Fremont Weir (see Figure 4-12). The supplemental fish passage channel would stretch over 500 feet and connect to the fish passage facility through a channel transition. The 10-foot-long channel transition facilitates the transition from the 10-foot width of the channel to the 15-foot width of the fish passage structure.

The concrete fish passage structure would house an approximately 12-foot-wide hinge gate, a recessed air buffer, and a metal grate. The concrete wall of the fish passage structure would be flush with the top of the existing weir (elevation 32 feet).

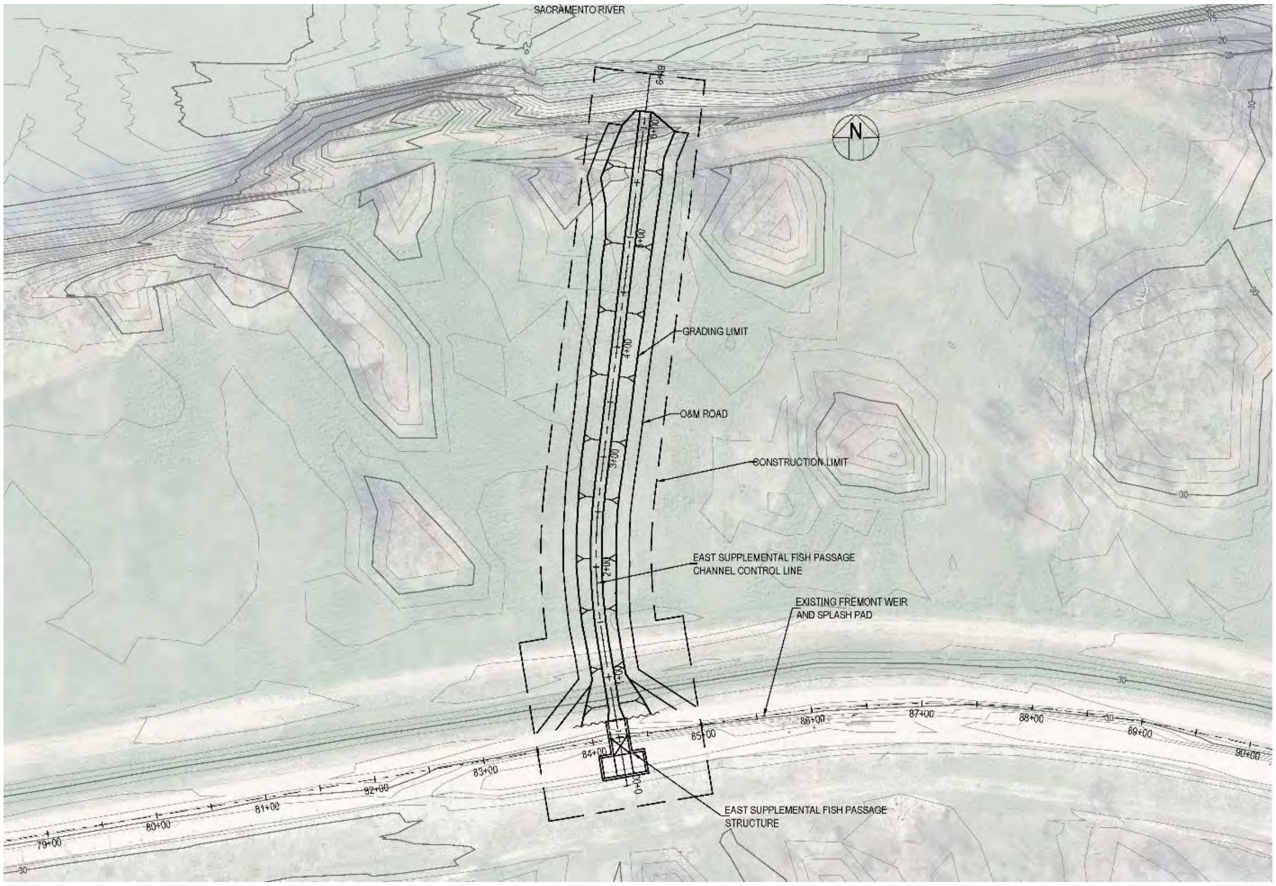


Figure 4-12. Eastern Supplemental Fish Passage

4.6.1.8 Scour Protection

The transport channel would enter Tule Canal at an angle, which could cause erosion on the eastern Yolo Bypass levee. Rock revetment would be placed on the eastern edge of Tule Pond that is 50 feet wide, 2,500 feet long, and 2.5 feet thick, with 1.5:1 side slopes (horizontal to vertical). Additionally, there are several locations along the proposed transport channel where the channel could interact with existing scour channels. These areas could experience head cutting as a result of the new facilities. Additional channel revetment would be incorporated at these locations; these improvements are included in the construction quantities.

4.6.2 Construction Methods

The construction methods and process would be similar to those described for Alternative 1. Construction would start with demolition of Fremont Weir and continue with the headworks and channel construction.

4.6.2.1 Excavated Material

Alternative 3 would require excavation of the intake channel, transport channel, and downstream facilities. Table 4-13 shows the estimated quantities of excess excavated material that would be generated from each facility and would require removal from the construction area.

Table 4-13. Estimated Excess Excavated Material Quantities for Alternative 3

Component	Estimated Excess Excavated Material (cubic yards)
West Intake Channel	32,720
West Transport Channel	687,640
Headworks	6,460
Downstream Channel	72,520
Supplemental Fish Passage (East)	3,540
Agricultural Road Crossing 1	3,170
TOTAL	*806,050*

Reclamation or DWR would purchase land outside of the bypass within two miles of the edge of the Yolo Bypass to receive this excess material. Alternative 3 would require 17 to 20 acres of land to spoil excess construction-related materials.

4.6.2.2 Construction Materials

Material imported to the Project site would be obtained from existing permitted commercial sources located within approximately 65 miles of the Project site. These sites and the associated haul routes would be the same as described for Alternative 1.

4.6.2.3 Staging Areas and Access

The construction easements for Alternative 3 would encompass staging areas for equipment, mobilization, and spoiling sites. The construction footprints analyzed in this EIS/EIR include space for staging areas. Access roads would be the same as described for Alternative 1.

4.6.2.4 Construction Equipment

A list of the major equipment needs for the construction of both the alternative-specific and common downstream channel improvement actions is provided (Table 4-14). Equipment specifics may vary based on the contractor’s capabilities and the availability of equipment. Appendix B, *Constructability and Construction Considerations,* includes information on how many of each type of equipment would be used.

Table 4-14. List of Major Equipment Needed for Construction of Alternative 3

List of Major Equipment	
• 0.8-CY backhoe loaders	• 4.5-CY hydraulic excavator
• 1.5-CY front end loader crawler	• 40-TN truck-mounted hydraulic crane
• 10-TN smooth roller	• 4,000-gallon water truck
• 100-TN off highway trucks	• 450-HP dozer crawler
• 100-foot auger track-mounted drill rig	• 6-inch diameter pump engine drive
• 12-foot blade grader	• 75-TN crane crawler pile hammer
• 165-HP dozer	• Concrete mixer truck
• 2.5-CY hydraulic excavator	• Concrete pump boom, truck mounted
• 2.5-inch diameter concrete vibrator	• Extended boom pallet loader
• 24-TN truck end dump	• Flatbed truck
• 3.5-CY hydraulic excavator	• Haul truck oversize transport
• 3-axle haul trucks	• Hydroseeding truck
• 30-CY scrapers	• Pickup trucks, conventional
• 300-kW generator	

Key: CY = cubic yards; HP = horsepower; kW = kilowatt; TN = ton

4.6.2.5 Construction Schedule and Workers

Construction of Alternative 3 likely would begin in 2020 or 2021 and is estimated to last 28 weeks. The construction schedule is the same as for Alternative 1. The peak number of construction workers, which would be needed during one week in the middle of July, is estimated to be 277.

4.6.3 Operations

Alternative 3 operations would be the same as those described for Alternative 1, but the gates would open when the river elevation rises above 17.1 feet (one foot above the gate invert elevation of 16.1 feet).

The headworks operations would be the same as described for Alternative 1. Each gate would have a dogging device to relieve the hydraulic operating equipment of the need to maintain pressure to keep the gates from lowering. Each control gate would be capable of independent operation via submersible hydraulic cylinders located beneath the gate.

4.6.4 Inspection and Maintenance

Maintenance activities associated with Alternative 3 would mainly include debris removal, sediment removal, and facility inspections. Inspection and maintenance would be the same as described for Alternative 1.

4.6.4.1 Sediment Deposition

The amount of sediment entering the Yolo Bypass under Alternative 3 would be the same as described for Alternative 1. The removal frequency, methods, and quantities would be the same as described for Alternative 1.

New areas that are constructed perpendicular to the direction of flow in the bypass would incur greater sedimentation deposition. This alignment (the western alignment) likely would have the highest amount of sedimentation and debris accumulation because it is the longest and has more changes in direction than the eastern or central alignments. Therefore, debris removal in this area would be required and accomplished using an excavator or a crane.

4.6.4.2 Headworks Inspection and Debris Removal

The serviceability and proper function of gates, their actuators, controls, hydraulic cylinders, and the recessed areas for stoplogs and gates would be inspected at the beginning and end of the flood season and after overtopping events. Concrete spalling or severe cracking, material corrosion, or identified weakness would be noted and evaluated to determine if repair or replacement is necessary. Sediment deposits or accumulated debris would be removed. Debris removal in and around the headworks would be accomplished by excavator or crane.

4.6.4.3 Vegetation Removal

Periodic vegetation and debris removal from project channels would be the same as described for Alternative 1.

4.6.5 Monitoring and Adaptive Management

Monitoring activities and the adaptive management framework would be the same as described for Alternative 1.

4.6.6 Alternative 3 Preliminary Costs

Alternative 3 project facilities would be constructed within one year over a 28-week period between April to October. Construction of Alternative 3 project facilities would cost approximately $61.5 million. The operations and maintenance cost for Alternative 3 would be approximately $0.6 million annually.

4.7 Alternative 4: West Side Gated Notch – Managed Flow

Alternative 4, West Side Gated Notch – Managed Flow, would have a smaller amount of flow entering the Yolo Bypass through the gated notch in Fremont Weir than the other alternatives, but it would incorporate water control structures to maintain inundation in defined areas for longer periods of time within the northern Yolo Bypass. Alternative 4 would include the same gated notch and associated facilities as described for Alternative 3. However, it would be operated to limit the maximum inflow to approximately 3,000 cfs.

Alternative 4 includes two water control structures on Tule Canal to extend periods of inundation locally. A bypass channel would be constructed around each water control structure to provide adult fish passage when the water control structures are controlling flow. This alternative would also provide means for fish passage on the eastern side of Fremont Weir through a supplemental fish passage facility. In addition, improvements to Agricultural Road Crossing 1 and the downstream channel would be implemented under this alternative (see Section 4.3). Figure 4-13 shows the key components of Alternative 4 and the common elements described in Section 4.3.