# Reach 4B, Eastside Bypass, and Mariposa Bypass Channel and Structural Improvements Project

## Initial Alternatives Technical Memorandum

SAN JOAQUIN RIVER
RESTORATION PROGRAM

October 2011

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# List of Abbreviations and Acronyms

| | |
|---|---|
| CEQA | California Environmental Quality Act |
| cfs | cubic foot per second |
| CNDDB | California Natural Diversity Database |
| CNPS | California Native Plant Society |
| CVRWQCB | Central Valley Regional Water Quality Control Board |
| DDT | dichlorodiphenyltrichloroethane |
| Delta | Sacramento and San Joaquin River Delta |
| DFG | California Department of Fish and Game |
| DWR | Department of Water Resources |
| EIS/R | Environmental Impact Statement/Environmental Impact Report |
| ESA | Endangered Species Act |
| Flood Control Project | Lower San Joaquin River Flood Control Project |
| FMP | Fisheries Management Plan |
| FMWG | Fisheries Management Work Group |
| FWA | Friant Water Authority |
| LSJLD | Lower San Joaquin Levee District |
| LWD | large woody debris |
| mg/L | milligrams per liter |
| NEPA | National Environmental Policy Act |
| NRDC | Natural Resources Defense Council |
| NMFS | National Marine Fisheries Service |
| pvc | poly-vinyl chloride |
| RA | Restoration Administrator |
| Reach 4B Project | Reach 4B, Eastside Bypass, and Mariposa Bypass Channel and Structural Improvements Project |
| Reclamation | United States Department of the Interior, Bureau of Reclamation |
| RM | River Mile |
| RMC | San Joaquin River Resource Management Coalition |
| Settlement | Stipulation of Settlement in *NRDC et al. v. Kirk Rodgers et al.* |
| SJVDP | San Joaquin Valley Drainage Program |

| | |
|---|---|
| SJRRP | San Joaquin River Restoration Program |
| TAC | Technical Advisory Committee |
| TDS | Total Dissolved Solids |
| TM | Technical Memorandum |
| TMDL | Total Maximum Daily Load |
| USACE | United States Army Corps of Engineers |
| USEPA | United States Environmental Protection Agency |
| USFWS | United States Fish and Wildlife Service |

***Note to Reviewers:***

*This Technical Memorandum was prepared by the San Joaquin River Restoration Program Team in support of preparing an Environmental Impact Statement/Report for the Reach 4B, Eastside Bypass, and Mariposa Bypass Channel and Structural Improvements Project. The purpose of circulating this document at this time is to facilitate early coordination regarding the alternatives under consideration by the San Joaquin River Restoration Program Team with the Settling Parties, Third Parties, regulatory agencies, stakeholders, and interested members of the public. Therefore, the content of this document may not necessarily be included in the Project Environmental Impact Statement/Report. While the San Joaquin River Restoration Project Team is not requesting formal comments on this document, comments received will be considered to the extent possible.*

# 1.0 Introduction

This Initial Alternatives Technical Memorandum (TM) documents the process for formulating preliminary alternatives to implement the Reach 4B, Eastside Bypass, and Mariposa Bypass Channel and Structural Improvements Project (Reach 4B Project), a component of the San Joaquin River Restoration Program (SJRRP). The SJRRP was established in late 2006 to implement the Stipulation of Settlement (Settlement) in *Natural Resources Defense Council, et al., v. Kirk Rodgers, et al*. Initial alternatives presented in this TM are at a conceptual level of design; alternatives will be refined and evaluated as the alternatives formulation process moves forward. This TM presents a collection of conceptual alternatives to encourage comments before the evaluation of the alternatives.

## 1.1 Purpose of This Technical Memorandum

The purposes of this TM include:

1. Document the alternatives formulation process for the Reach 4B Project
2. Examine a wide range of initial alternatives that could meet the San Joaquin River Settlement goals for the Reach 4B Project
3. Obtain input and feedback from the Implementing Agencies[1], Technical Work Groups, Settling Parties[2], Third Parties[3], landowners, and other stakeholders involved in the Reach 4B Project to help refine initial alternatives
4. Establish a process to evaluate alternatives to determine which alternatives should be analyzed in the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) documentation for the Reach 4B Project

This Initial Alternatives TM presents the initial Reach 4B Project alternatives as a starting point to formulate a range of approaches that achieve the Settlement goals for the Reach 4B Project. Technical work and continued coordination with the Implementing Agencies, Technical Work Groups, Settling Parties, Third Parties, landowners, and other stakeholders over the next several months will increase the understanding of how the initial alternatives may be refined, evaluated, and carried forward for analysis in the

[1] Implementing Agencies refer to the agencies responsible for managing and implementing the SJRRP: the United States Department of the Interior, Bureau of Reclamation, United States Fish and Wildlife Service, National Marine Fisheries Service, California Department of Water Resources, and California Department of Fish and Game.

[2] The Settling Parties include the Natural Resources Defense Council, Friant Water Authority, and the United States Departments of the Interior and Commerce.

[3] Third Parties refer to persons or entities diverting or receiving water pursuant to applicable State and Federal laws and includes Central Valley Project contractors outside of the Friant Division of the Central Valley Project and the State Water Project.

upcoming Reach 4B Project Environmental Impact Statement/Environmental Impact Report (EIS/R).

## 1.2 Background

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC) filed a lawsuit, known as *NRDC, et al., v. Kirk Rodgers, et al.*, challenging the renewal of long-term water service contracts between the United States and the Central Valley Project Friant Division contractors. On September 13, 2006, after more than 18 years of litigation, the Settling Parties, including NRDC, Friant Water Authority (FWA), and the United States Departments of the Interior and Commerce, agreed on the terms and conditions of a Settlement subsequently approved by the United States Eastern District Court of California on October 23, 2006. The San Joaquin River Restoration Settlement Act, included in Public Law 111-11 and signed into law on March 30, 2009, authorizes and directs the Secretary of the Interior to implement the Settlement. The Settlement establishes two primary goals:

- **Restoration Goal –** To restore and maintain fish populations in "good condition" in the main stem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.

- **Water Management Goal –** To reduce or avoid adverse water supply impacts on all of the Friant Division long-term contractors that may result from the Interim and Restoration flows provided for in the Settlement.

To achieve the Restoration Goal, the Settlement calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River (referred to as Interim and Restoration flows), and reintroduction of Chinook salmon. To achieve the Water Management Goal, the Settlement calls for downstream recapture of Interim and Restoration flows from the San Joaquin River and the Sacramento and San Joaquin River Delta (Delta) and recirculation of that water to replace reductions in water supplies to Friant Division long-term contractors resulting from the release of Interim and Restoration flows. In addition, the Settlement establishes a Recovered Water Account and allows the delivery of surplus water supplies to Friant Division long-term contractors during wet hydrologic conditions.

The SJRRP will implement the Settlement consistent with the San Joaquin River Restoration Settlement Act. Implementing Agencies responsible for managing and implementing the SJRRP are the Reclamation, United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Water Resources (DWR), and California Department of Fish and Game (DFG). The Settlement identifies the roles and responsibilities of the Restoration Administrator (RA) which is supported by the Technical Advisory Committee (TAC). The RA is jointly selected by NRDC and the FWA and provides recommendations to the Secretary of the Interior and the Governor of California regarding specific elements of the Settlement related the SJRRP's Restoration Goal. The Settlement includes a detailed timeline for developing and implementing SJRRP actions.

### 1.2.1 Reach 4B, Eastside Bypass, and Mariposa Bypass Channel and Structural Improvements Project

The Reach 4B Project is a high-priority SJRRP project with key elements in Paragraph 11(a) and 11(b) of the Settlement. Phase 1 improvements refer to the improvements specified in Paragraph 11(a) of the Settlement, while Phase 2 improvements refer to the improvements specified in Paragraph 11(b). Specifically, Paragraph 11(a) of the Settlement stipulates:

- Modifications in San Joaquin River channel capacity to the extent necessary to ensure conveyance of at least 475 cubic feet per second (cfs) through Reach 4B
- Modifications at the Reach 4B Headgate on the San Joaquin River channel to ensure fish passage and enable flow routing of between 500 cfs and 4,500 cfs into Reach 4B, consistent with any determination made in Paragraph 11(b)(1)
- Modifications to the Sand Slough Control Structure to ensure fish passage
- Modifications to structures in the Eastside and Mariposa bypass channels, to the extent needed to provide anadromous fish passage on an interim basis until completion of the Phase 2 improvements[4]
- Modifications in the Eastside and Mariposa bypass channels to establish a suitable low-flow channel, if the Secretary of the Interior in consultation with the RA determines such modifications are necessary to support anadromous fish migration through these channels

Paragraph 11(b)(1) of the Settlement includes additional language on long-term flows in Reach 4B of the San Joaquin River:

- Modifications in the San Joaquin River channel capacity (incorporating new floodplain and related riparian habitat) to ensure conveyance of at least 4,500 cfs through Reach 4B, unless the Secretary of the Interior, in consultation with the RA and with the concurrence of NMFS and USFWS, determines that such modifications would not substantially enhance achievement of the Restoration Goal

The San Joaquin River Settlement Act contains the following language requiring a report on the long-term flows in Section 10009(f)(2):

[4] Phase 1 improvements refer to the improvements specified in Paragraph 11(a) of the Settlement, while Phase 2 improvements refer to the improvements specified in Paragraph 11(b).

- Secretary of the Interior shall submit a report to Congress on whether to expand the channel conveyance to 4,500 cfs in Reach 4B of the San Joaquin River, or use an alternative route for pulse flows
- Secretary of the Interior shall make the high-flow routing determination prior to undertaking “any substantial construction work” to increase capacity in Reach 4B of the San Joaquin River

The Reach 4B Project will address Paragraph 11(a) requirements of at least 475 cfs capacity in the San Joaquin River. It may also meet the requirements in Paragraph 11(b)(1) of the Settlement. As stipulated in the San Joaquin River Restoration Settlement Act, no substantial construction work can occur to increase capacity in Reach 4B of the San Joaquin River until the high-flow routing determination is made, which includes the Secretary of the Interior’s report to Congress regarding the high-flow routing determination.

## 1.3 Study Area

The Reach 4B Project study area includes Reach 4B of the San Joaquin River, Reaches 2 and 3 of the Eastside Bypass, and the Mariposa Bypass in Merced County, California (See Figure 1-1).

The Reach 4B Project study area includes a 32.5-mile stretch of the San Joaquin River in Merced County, California. Reach 4B of the San Joaquin River begins at the Sand Slough Control Structure (River Mile [RM] 168.5) and extends to the confluence of the Eastside Bypass and San Joaquin River (RM 136) (see Figure 1-2). Reach 4B has been further divided into two subreaches; Reach 4B1 from the Sand Slough Control Structure to the Mariposa Bypass, and Reach 4B2 from the Mariposa Bypass to the confluence of the Eastside Bypass and the San Joaquin River.

Currently, Reach 4A, the section of river directly upstream of Reach 4B, is dry in most months because all flows in the San Joaquin River are diverted at Sack Dam to the Arroyo Canal. Any flows reaching the Sand Slough Control Structure are diverted to the Eastside Bypass via the Sand Slough Control Structure, leaving Reach 4B1 dry, with the exception of agricultural tailwater recovery.

The study area for the Reach 4B Project also includes the Eastside and Mariposa bypasses. The Eastside and Mariposa bypasses are flood control channels that convey flood flows and reduce flooding to surrounding lands. The portions of the Eastside Bypass within the Reach 4B Project study area include Reach 2, which begins at the Sand Slough Control Structure and ends at Eastside Bypass Control Structure, and Reach 3, which begins at the Eastside Bypass Control Structure and ends at the confluence with the San Joaquin River. The Mariposa Bypass conveys flows from the end of the Eastside Bypass Reach 2 to the San Joaquin River Reach 4B2.


**Figure 1-1.**
**Reach 4B Project Regional Area**

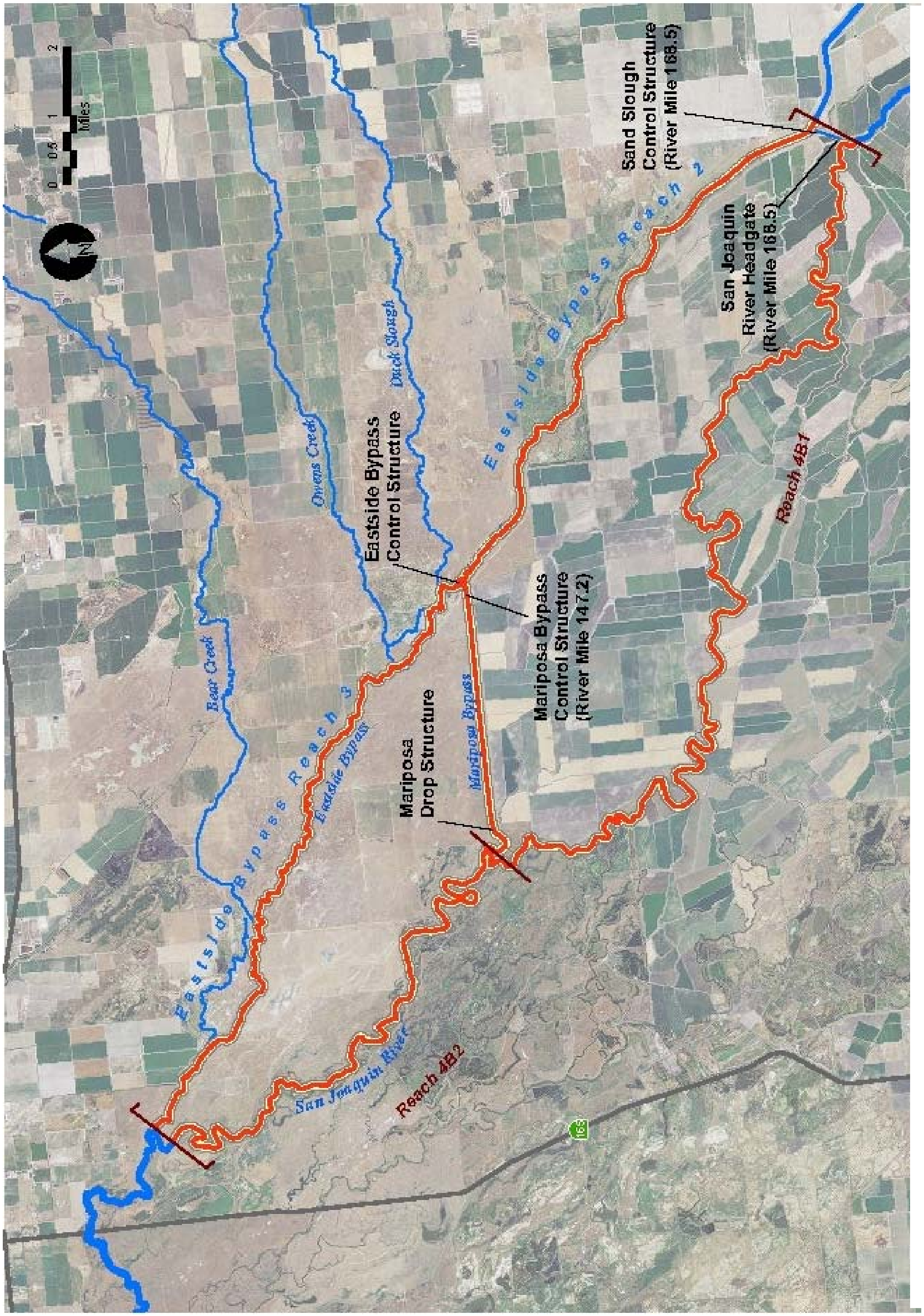


**Figure 1-2.**
**Reach 4B Study Area**

With the exception of some ponding in low-lying areas, the bypasses generally remain dry until they are required to convey higher flows during the flood season. The flood season for the Lower San Joaquin Levee District (LSJLD) typically lasts from November 15 to June 15 of each water year, with rainfall contributing to higher flows during the early part of the flood season, and snow melt contributing to flows at the later part of the flood season.

Key flood control structures within the study area include the Reach 4B Headgate on the San Joaquin River at the beginning of Reach 4B1, the Sand Slough Control Structure at beginning of the Eastside Bypass Reach 2, the Eastside and Mariposa bypass control structures where the Eastside Bypass transitions from Reach 2 to Reach 3, and the Mariposa Drop Structure at the end of the Mariposa Bypass near the confluence with the San Joaquin River Reach 4B2.

## 1.4 Related Documents

The SJRRP produced numerous documents that were considered during the development of this TM. Several of the key documents are described below.

### 1.4.1 SJRRP Program EIS/R

When an individual project is a necessary precedent for action on a larger project, or where a project is going to be implemented in phases, and the results of these projects or phases would have potentially significant environmental effects, NEPA and CEQA require a Program EIS/R be completed to ensure the total effects of the entire project are considered and disclosed to the public. A Program EIS/R helps to establish a framework for tiered or project-level environmental documents that are prepared in accordance with the overall program. The Program EIS/R analyzes the entire program, but at a more general level of detail. Project proponents must also complete project-level environmental documentation that analyzes each component of the program at a more detailed level before determining whether to proceed with the component.

In April 2011, the SJRRP released a Draft Program EIS/R to provide program-level NEPA and CEQA analysis of the overall SJRRP with a general or programmatic evaluation of the channel and structural modifications required for each river reach. The Program EIS/R also includes a more detailed “project-specific” analysis of actions related to reoperating Friant Dam for the release of Interim and Restoration flows and recapture of water.

The alternatives considered in the Program EIS/R identify actions that would be implemented over the next several years, as specified in the Settlement, to achieve the Restoration and Water Management goals. These actions include the reoperation of Friant Dam to release Interim and Restoration flows, channel modifications in the San Joaquin River and the bypass system, fish reintroduction to support the Restoration Goal, and several operational and structural actions to support both the Restoration Goal and the Water Management Goal. The Program EIS/R addresses the Reach 4B Project at a programmatic (general) level. A project-level EIS/R is required for the Reach 4B Project to provide additional site-specific environmental analysis.

### 1.4.2 Fisheries Management Plan

The Fisheries Management Work Group (FMWG), composed of representatives from Reclamation, USFWS, NMFS, DFG, DWR, and consultants, developed the SJRRP Fisheries Management Plan (FMP) (SJRRP 2010). The FMP provides the overarching population and habitat goals necessary to restore fish populations and appropriate habitat in the San Joaquin River between Friant Dam and the confluence with the Merced River (Restoration Area). The FMP goals were used to form specific objectives, which are intended to be realistic and measurable so the process will have a quantitative means of evaluating program success.

The habitat goals established for the Restoration Area focus on improved streamflow conditions and the establishment of suitable habitat. The following habitat goals focus on Chinook salmon and other native fishes:

- Restore a flow regime that (1) maximizes the duration and downstream extent of suitable rearing and outmigration temperatures for Chinook salmon and other native fishes, and (2) provides year-round river habitat connectivity throughout the Restoration Area
- Provide adequate flows and necessary structural modifications to ensure adult and juvenile passage during the migration periods of both spring-run and fall-run Chinook salmon
- Provide a balanced, integrated, native vegetation community in the riparian corridor that supports channel stability and buttressing, reduces bank erosion, filters sediment and contaminants, buffers stream temperatures, supports nutrient cycling, and provides food resources and unique microclimates for the fishery
- Provide suitable habitat for Chinook salmon holding, rearing, and outmigration during a variety of water-year types, enabling an expression of a variety of life history strategies. Suitable habitat will encompass appropriate holding habitat, spawning areas, and seasonal rearing habitat
- Provide water-quality conditions suitable for Chinook salmon and other native fishes that allow for the successful completion of life cycles
- Reduce predation losses in all reaches by reducing the extent and suitability of habitat for non-native predatory fish
- Restore habitat complexity, functional floodplains, and diverse riparian forests that provide habitat for spawning and rearing by native resident species, including salmon, during winter and spring

The FMP serves as an adaptive planning and procedural tool for managers and technical specialists of the SJRRP. It lays out a structured approach to adaptively manage the reintroduction of Chinook salmon and the reestablishment of other fishes. While not intended to be an implementation plan, it provides a roadmap to adaptively manage efforts to restore and maintain naturally reproducing and self-sustaining populations of Chinook salmon and other fish. It addresses the SJRRP on a program-level and refers to how the Settlement will be implemented from a fisheries perspective.

To help define problems limiting the reestablishment Chinook salmon and other fishes in the San Joaquin River, the FMP also summarizes known information about existing conditions, including habitat, water quality, recreational use, fish populations, and climate change.

The FMP serves as guidance for developing alternatives for the Reach 4B Project. The Reach 4B Project will be developed in accordance with the FMP and will contribute to the habitat goals outlined above.

## 1.5 Overview of Fishery Needs

Paragraph 14 of the Settlement addresses the restoration of salmon and other native fishes to the San Joaquin River. To successfully implement the Settlement, reach modifications need to consider the different life stages of salmon and the habitat requirements for these stages. The Reach 4B Project must provide upstream migration habitat, including holding or refuge habitat, for adult salmon to allow them to move upstream without expending large amounts of energy. Additionally, the Reach 4B Project must provide juvenile salmon with downstream migration habitat, including feeding and holding habitat to support rearing of downstream migrants (transient rearing) and floodplain habitat. Spawning is anticipated to occur in upstream reaches and would not occur in the Reach 4B Project study area due to a lack of suitable gravels. The following sections present an overview of the Central Valley Chinook salmon life cycle. This information helps to inform the development of alternatives for the Reach 4B Project.

### 1.5.1 Central Valley Chinook Salmon

Chinook salmon are the largest of the Pacific salmon, typically ranging from 30 to 32 inches long (19 to 22 pounds) with lengths in excess of 55 inches (100 pounds) (Moyle 2002). Chinook salmon spend most of their life cycle as top predators in the coastal waters of the Pacific United States; however, they must return to freshwater to reproduce (see Figure 1-3). This is known as anadromy.

Chinook salmon can be divided into two life-history strategies: stream and ocean. Stream-type Chinook have adults that run up streams before they reach full maturity, in spring or summer, and juveniles that spend a long time (usually greater than 1 year) in fresh water. Spring and late fall-run Chinook typically fall into this category. Ocean-type Chinook salmon have adults that spawn soon after entering fresh water, in summer and fall, and juveniles that spend a relatively short time (3 to 12 months) rearing in fresh water. Fall-run Chinook typically fall into this category.

#### *1.5.1.1 Ocean Distribution*

Chinook salmon may spend 1 to 5 years in the ocean, though 2 to 4 years is typical. While most Central Valley Chinook salmon remain primarily in coastal California waters, California salmon have been found in waters from Baja California to the Russian Kamchatka Peninsula. Along the California coast, adult Chinook salmon are key predators (Adams 2001). Their diets often consist of Pacific herring, anchovies, shrimp, crab larvae, and juvenile rockfish.

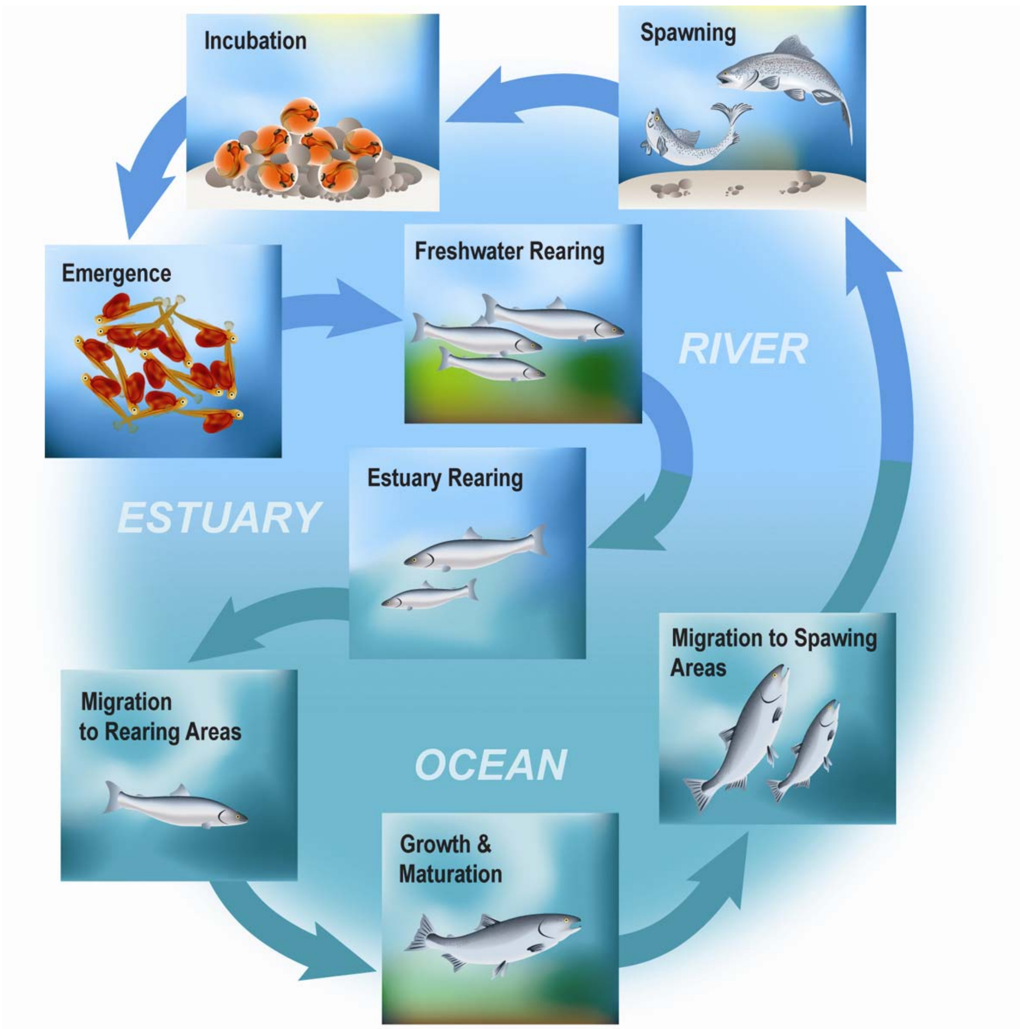


**Figure 1-3.**
**Salmon Life Cycle**

#### *1.5.1.2 Adult Migration*

Specific cues triggering adult Chinook salmon to return to their spawning grounds from the Pacific Ocean are not well understood. During upward migration (immigration), adults stop feeding, causing them to live increasingly on body fat reserves. Spring-run Chinook salmon are not well documented in the San Joaquin River System and what is currently known about them is from the Sacramento River and its tributaries. Adults typically migrate upstream from March through June, and hold in deep pools until they are ready to spawn. Adult fall-run Chinook salmon that utilize lower tributaries of the San Joaquin River typically migrate into fresh water between September and December.

The ability for Chinook to find their way back to their home stream to spawn is mainly related to the long-term olfaction (smell, taste) memory of the salmon, but is also aided by their vision (Healey 1991) and may be stimulated by higher streamflow and changes in water turbidity, temperature, and oxygen content (Allen and Hassler 1986). Migratory routes must be free of barriers that can impede or prevent movement upstream and downstream. Numerous issues, such as predation and water quality, can affect the ability of adults to reach spawning areas and complete successful spawning (Goniea et al. 2006; Beamsdorfer 2000; Hillemeier 1999). These are further affected by anthropogenic (human-caused) effects, such water diversion, channel modification, and water quality.

#### *1.5.1.3 Spawning*

Chinook salmon select gravel and cobble areas of cool, flowing streams for spawning. In general, salmon can spawn in gravels with a median diameter up to about 10 percent of their body length (0.5 to 10 inches) (Kondolf and Wolman 1993). Sand and silt can suffocate eggs and embryos and affect temperatures within the gravel.

Central Valley fall-run Chinook salmon typically spawn within a few days or weeks of arriving at their spawning grounds. Spring-run may wait several months (Moyle 2002). Spawning for spring-run Chinook salmon takes place between August and October, while spawning for fall-run Chinook salmon takes place between October and December.

#### *1.5.1.4 Embryo Development*

The incubation life stage for spring and fall-run Chinook salmon generally extends from September through April. The intragravel residence period of incubating eggs and alevins (yolk-sac fry) and egg incubation survival rates and times are highly dependent on water temperature and dissolved oxygen (Merz et al. 2006). Alevins remain in the gravel for 2 to 3 weeks after hatching, receiving nutrients and energy from their yolk sac before emerging from the gravels into the water column from November to March (Fisher 1994; Ward and McReynolds 2001).

#### *1.5.1.5 Fry and Juvenile Rearing and Emigration*

The length of time spent rearing in freshwater varies greatly among juvenile Central Valley spring-run Chinook salmon. Spring-run Chinook salmon may disperse downstream as fry (young salmon that have absorbed their yolk sacks) soon after emergence, or early in their first summer, in the fall as flows increase, or as yearlings after overwintering in freshwater (Healey 1991). Central Valley fall-run Chinook salmon fry typically disperse downstream from early January through mid-March, whereas smolts (young salmon that have undergone the physiological transformation to allow them to survive in a saltwater environment) primarily migrate between late March and mid-June in the Central Valley (Brandes and McLain 2001). Central Valley late fall-run Chinook salmon juveniles typically rear in the stream through the summer before beginning their emigration in the fall or winter (Fisher 1994). Juvenile Chinook salmon and steelhead may rear on seasonally inundated floodplains when available. Juvenile Chinook salmon that have had access to floodplain rearing habitat have been shown to grow more rapidly and larger body size may increase chances of survival upon emigration (Sommers et al. 2001; Jeffres et al. 2008). Habitat complexity, such as woody debris, overhanging vegetation, boulders, and seasonal backwater areas provide hiding, resting, and feeding areas for growing Chinook salmon, and increase their ability to grow, mature, and survive their emigration.

Juvenile Chinook salmon diets often vary by habitat type. Midges, mayflies, caddisflies, and larval fish and eggs are important prey for juvenile Chinook salmon upstream of the Delta (Sasaki 1966; Merz and Vanicek 1996; Moore 1997; Sommer et al. 2001), whereas crustaceans may be more important in the western Delta (Sasaki 1966; Kjelson et al. 1982). At times, floodplains may provide better rearing opportunities for juvenile salmon because they create an environment richer in prey items away from predators and high flows.

Typically, juvenile Chinook salmon do not move into brackish water (mildly salty water) until they have undergone smoltification (the process that allows them to survive in saltwater), after which they move quickly to the ocean (Healey 1991). Within the Central Valley, there is extensive variation in emigrant size within the ocean-type life history. For example, juvenile Chinook salmon emigrate as fry (<55 mm FL), parr (<75 mm FL), or smolts (>75 mm FL) (Brandes & McLain 2001, Williams 2001). Fry and parr generally emigrate from river systems in February-March whereas smolt emigration occurs in April-May (Brandes & McLain 2001). While several researchers have questioned if fry migrants make a significant contribution to adult populations (Brandes & McLain 2001, Williams 2001), Miller et al. (2010) have demonstrated that fry-sized emigrants in Central Valley are a viable life history strategy.

### 1.5.2 Native Fishes

One of the goals identified in the FMP is to establish a balanced, integrated, adaptive community of fishes having a species composition and functional organization similar to what would be expected in the Sacramento-San Joaquin Province.

Within the Reach 4B Project study area, this goal would be met by designing the channels to accommodate Pacific lamprey, white and green sturgeon, Central Valley steelhead, Sacramento pikeminnow, hardhead, hitch, Sacramento splittail, and Sacramento sucker. In addition, the following are considered species of interest that will benefit from the project but for which channel design criteria are not explicitly considered: Sacramento blackfish, Kern brook lamprey, California roach, tule perch, prickly and riffle sculpin and three-spined stickleback.

In Chapter 5 of this TM, the initial alternative descriptions emphasize passage and habitat requirements for Chinook salmon, but it is recognized that in developing habitat and passage conditions for salmon, conditions will be created that benefit the other species and support connectivity that not only benefits all of the reaches but the long term health of the Sacramento-San Joaquin System. As the Reach 4B Project alternatives are further developed, consultation with the FMWG and wildlife agencies will help determine what additional features or passage requirements are needed for the native fish species identified above. The final Reach 4B Project alternatives will incorporate fish passage and habitat conditions for native species to support the Restoration Goal of maintaining fish populations in "good condition."

## 1.6 Organization of this Document

This TM is organized as follows:

- **Section 1 Introduction –** Describes the purpose of this TM and background on the SJRRP and Reach 4B Project.
- **Section 2 Purpose and Need/Project Objectives, Challenges, Opportunities, and Constraints –** Identifies the purpose and need/project objectives, challenges, opportunities, and constraints associated with the Reach 4B Project.
- **Section 3 Existing and Future Without Project Conditions –** Describes the existing conditions for environmental resource areas and the future conditions if the Reach 4B Project is not implemented.
- **Section 4 Alternative Formulation –** Describes the process to identify and formulate initial alternatives.
- **Section 5 Initial Alternatives –** Provides information on the range of initial alternatives for the Reach 4B Project.
- **Section 6 Summary and Next Steps –** Summarizes the content of the TM and identifies next steps.
- **Section 7 References –** Contains a list of all references cited in this TM.

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# 2.0 Purpose and Need/Project Objectives, Challenges, Opportunities, and Constraints

This chapter describes the overall purpose and need/project objectives of the Reach 4B Project, challenges that must be addressed during implementation, opportunities that may result from project implementation and constraints that limit the formulation process and the range of alternatives considered.

## 2.1 Purpose and Need/Project Objectives

The purpose and need/project objectives explain the reason for implementing a project and what the project is intended to accomplish. Under NEPA, the purpose and need establishes the intention of the project and why the federal agency is undertaking the project. This statement sets the overall direction of the NEPA process and serves as the criterion for identifying a range of reasonable alternatives that will be evaluated in detail in an EIS. The project objectives serve a similar function under CEQA. All alternatives examined in detail in the EIS/R must meet most of the purpose and need/project objectives.

### 2.1.1 Reach 4B Project Purpose and Need/Project Objectives

The purpose of the Reach 4B Project is to implement channel and structural improvements for Reach 4B of the San Joaquin River and the Eastside and Mariposa bypasses, as required by the Settlement of *NRDC, et al., v. Kirk Rodgers, et al.*, approved by the United States Eastern District Court of California on October 23, 2006 and authorized by Public Law 111-11, the San Joaquin River Restoration Settlement Act. These improvements are needed to ensure flows and fish passage through Reach 4B of the San Joaquin River, the Sand Slough Control Structure, the Reach 4B Headgate, and the Eastside and Mariposa bypasses.

Specifically, the Settlement's objectives for Reach 4B Project are:

- Modifications in San Joaquin River channel capacity necessary to ensure conveyance of at least 475 cfs through Reach 4B

- Modifications at the Reach 4B Headgate on the San Joaquin River channel to ensure fish passage and enable flow routing of between 500 cfs and 4,500 cfs into Reach 4B, consistent with any determination made in Paragraph 11(b)(1)

- Modifications to the Sand Slough Control Structure to ensure fish passage

- Modifications to structures in the Eastside and Mariposa bypass channels to the extent needed to provide anadromous fish passage on an interim basis until completion of the Phase 2 improvements

- Modifications in the Eastside and Mariposa bypass channels to establish a suitable low-flow channel if the Secretary of the Interior in consultation with the RA determines such modifications are necessary to support anadromous fish migration through these channels

- Modifications in the San Joaquin River channel capacity (incorporating new floodplain and related riparian habitat) to ensure conveyance of at least 4,500 cfs through Reach 4B, unless the Secretary of the Interior, in consultation with the RA and with the concurrence of NMFS and USFWS, determines that such modifications would not substantially enhance achievement of the Restoration Goal

The Reach 4B Project, in conjunction with other site-specific projects in the SJRRP, must also contribute to meeting long-term fisheries population goals and the SJRRP Restoration Goal:

- To restore and maintain fish populations in “good condition” in the main stem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish

## 2.2 Challenges

The Settlement requires the Implementing Agencies to provide fish passage, fish habitat, and conveyance of flows through Reach 4B of the San Joaquin River and the Eastside and Mariposa bypasses.

Fish passage is a challenge in the Reach 4B Project area. Passage is a general term used to represent all types of fish migration including localized movements within a given habitat type to large scale movements over hundreds of miles. Such movements are necessary to complete a fish’s lifecycle and may include trophic (movements to rearing habitats), reproductive (spawning), or refuge (escape harmful environmental conditions) migrations. Fish passage requires adequate flows, velocities, and gradients to allow fish to move through a waterway. The success of migration, whether upstream, downstream, or laterally (to floodplain and off channel habitat) is also limited by the presence of barriers that can impede fish passage. According to NMFS (2008), a passage impediment is defined as any artificial structural feature or project operation that causes adult or juvenile fish to be injured, killed, blocked, or delayed in their migration to a greater degree than in a natural river setting. However, water quality such as temperature, dissolved oxygen, water source and chemical/biological constituents (e.g. nutrients, contaminants, pathogens) can also create passage barriers.

Altering fish passage can result in habitat fragmentation, loss of genetic diversity, population declines, species replacement or even extirpation. There are also situations where restricting fish passage is required to achieve management objectives. Examples include preventing fish from entering water diversions, dead end channels or streams void of appropriate habitat that may impeded, delay or halt migration.

Direct and indirect impacts related to fish passage issues include:

- **Blockage –** Both complete and partial
- **Fatigue –** Cannot complete immediate passage or reduced ability to complete migration or life strategy
- **Vulnerability –** Predation and disease
- **Injury –** Impact, scrapes, and abrasions
- **Desiccation –** Tissue damage or reduction in gill function due to being out of water for prolonged periods
- **Disorientation –** Fish cannot find pathways or access to passage, impeding or reducing migration success (this includes increased delays or straying)
- **Behavioral –** Fish may avoid darkened corridors, dense predator concentrations or certain water quality

Velocity, depth, and elevation changes (hydraulic drops) can block or impede fish movement. Whether a channel feature (structural or non-structural) is a barrier to fish movement depends on the physical and hydraulic elements of the feature and the physiology and behavior of the fish. This can change with fish species, size and developmental stage. Barriers may create velocity, depth, and slope conditions that fish cannot physically overcome. They may also disorient fish, and fish may avoid such conditions for all or some of these reasons. In addition, turbulence, depth, and fall can injure or otherwise incapacitate fish, increasing their vulnerability to predation, disease, or fatigue. Structures that may divert fish from a safe pathway with no ability to return are also considered barriers. Multiple barriers along a migratory path may tire fish as they migrate upstream or downstream, and the cumulative effect of these barriers may decrease the physical abilities of individual fish to migrate or successfully complete their life history (FWA and NRDC 2001; Gallagher 1999).

In regulated streams, higher water discharge from tributaries and engineered flow returns can attract migrating fish and can delay or hinder passage. Juvenile fish that use one pathway may be attracted to the same pathway as returning adults, complicating successful migration in highly managed streams (Thorstad et al. 2008).

Water quality such as temperature, dissolved oxygen, turbidity, salinity and anthropogenically sourced chemicals (e.g. fertilizers, pesticides) can also create barriers for fish migration. These situations can arise for numerous reasons including poor water quality from off channel returns, increased water residence time caused by over-extending floodplains and secondary channels beyond water availability, or increased roughness caused by overgrowth of aquatic nuisance vegetation. Vegetation can provide both positive and negative effects on water quality. Riparian vegetation can make shade available, reducing solar inputs and decreasing water temperature. This, in turn, can increase water carrying capacity for dissolved oxygen, benefiting target aquatic organisms. Invasive aquatic vegetation (i.e. macrophytes) may increase water temperature, create swings in dissolved oxygen concentrations (via respiration, photosynthesis, decay), affect turbidity, alter water chemistry and even harbor invasive predatory fish; all having effects on successful migration of target fish species (Brooker et al. 1977; Brown and Michniuk 2007).

To effectively implement the Settlement requirements, several challenges will need to be addressed related to fish passage for the Reach 4B Project:

1. **San Joaquin River –** Reach 4B1 of the San Joaquin River has been hydraulically disconnected from other river reaches for approximately 40 years, is poorly defined, contains dense vegetation, and, in some segments, is filled with sediment and other debris. The current channel capacity of Reach 4B1 is unknown and could be zero in some locations. There is no available floodplain rearing habitat. Several agricultural diversions and returns occur throughout this reach that may entrain or create water quality issues for fish.

2. **Eastside and Mariposa Bypasses –** The bypasses were designed to carry flood flows from the San Joaquin River and Kings River basins. The bypasses were not designed to facilitate fish migration, and they include several structures that impede fish passage. Additionally, they do not provide fish rearing habitat and may not provide a suitable low-flow channel for fish migration. Because of a lack of riparian vegetation and an extremely wide primary channel, water temperatures during some periods of the year may be unsuitable for fish. Lack of riparian vegetation or structural cover could also increase risk of avian predation of juvenile fishes. Several agricultural diversions and returns occur throughout this reach that may entrain or create water quality issues for fish.

3. **Reach 4B Headgate (RM 168.5) –** The Reach 4B Headgates remain closed under current operations and have not been operated for several decades. They were designed to convey 1,500 cfs into the San Joaquin River channel. When the gates are closed, this structure is a complete barrier to flow and fish. Downstream of the gates is a concrete energy dissipation structure with an elevation gradient that would be an impediment to upstream and downstream migration. Energy dissipation would create a potential pool in conjunction with the concrete basin, providing holding areas for potential predators of small fish moving downstream. Depending on velocities, fish might impact concrete energy dissipation structures, creating injury or disorientation.

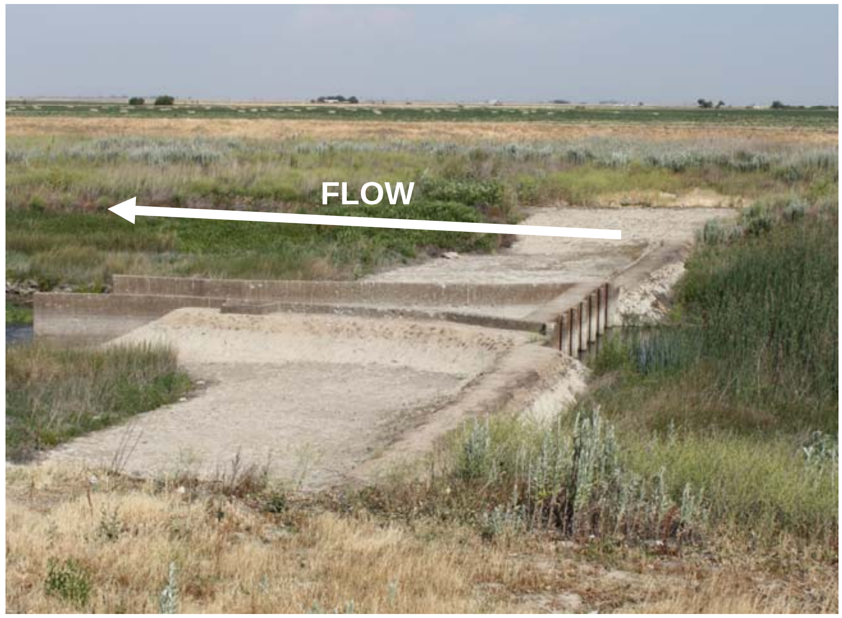



**Figure 2-1.**
**Sand Slough Control Structure**

4. **Sand Slough Control Structure (RM 168.5) –** The Sand Slough Control Structure regulates flow in Reach 4B of the San Joaquin River and the Eastside Bypass (see Figure 2-1). The gateless structure includes bays that could potentially have stop logs but are currently open. Depending on flow, the long concrete apron could be a depth and velocity impediment to both adult and juvenile fish. The scour pools above and below the concrete structure could provide potential predator holding areas as well as hydraulic drops that could impede the movement of some fish. At higher flows, however, the structure would be completely inundated and would likely not create significant fish passage issues.

5. **Mariposa Bypass Control Structure –** The concrete structure has 14 bays (six open in the middle and four gated on either side). This structure, in cooperation with the Eastside Bypass Control Structure, directs flows into the Mariposa or Eastside bypasses downstream of the connection. The structure would most likely create hydraulic drops that could potentially injure and disorient downstream moving fish. A deep pool has developed downstream of the structure, which would greatly dissipate velocities, creating an energy sink for juvenile fish and potentially disorienting fish searching for upstream and downstream passage as well as harbor potential fish predators. Deep scour holes may also develop water quality issues at certain flow and time periods.

6. **Mariposa Bypass Drop Structure –** This structure dissipates energy from flows before they enter the main stem San Joaquin River channel near RM 147.6. The structure consists of a concrete wall spanning the channel and two concrete walls framing the downstream channel banks. The channel-spanning wall is over six feet tall on the upstream side and well over 15 feet on the downstream side. The drop height and downstream pool depths will not allow upstream fish passage. The concrete basin on the downstream side concentrates high flows, creating a scour pool. At lower flows, this pool would greatly dissipate velocities, creating an energy sink for down-migrating juvenile fish and could potentially disorient fish searching for upstream and downstream passage as well as harbor potential

fish predators. Deep scour holes may also develop water quality issues at certain flow and time periods.

7. **Eastside Bypass Control Structure –** The six-gated Eastside Bypass Control Structure directs flows to either the Eastside Bypass Reach 3 or the Mariposa Bypass. The structure will impede fish passage. Each of the bays has concrete energy dissipation structures that would create upstream fish barriers under a variety of flows. Structures would most likely create hydraulic drops that could potentially injure and disorient downstream moving fish. At lower flows, the lower pool on the downstream side of the structure would greatly dissipate velocities, creating energetically demanding hydrologic conditions for juvenile fish and potentially disorienting fish searching for upstream and downstream passage as well as harbor potential fish predators. Deep scour holes may also develop water quality issues at certain flow and time periods.

8. **Bridges/Road Crossings –**There are multiple road crossings and several bridges in Reach 4B of the San Joaquin River and in the bypasses. There are three main roads that cross the San Joaquin River channel: Turner Island Road, Indiana Avenue, and Washington Road. These roads (and three additional unnamed crossings) may act as fish barriers and may be inundated during higher flows. Bridges constructed with concrete aprons may create depth and velocity barriers at low flows or scour holes downstream of the structures that could block fish movement or harbor predators. The culverts associated with some of the road crossings are significantly undersized for the channel and would not be able to carry the range of flows expected for the Reach 4B Project. Upstream migrating fish would not be able to negotiate these culverts.

9. **Tributaries –**There are three main tributaries to the Eastside Bypass in the Reach 4B Project study area (see Figure 1-2). During high flows, the tributaries could attract adult migrating fish away from the main channel, which could create potential delays or false migration pathways that prevent adults from reaching appropriate spawning habitat. Juveniles might also traverse these tributaries.

10. **Wildlife Refuge Weirs –** Within the Eastside Bypass, two low-head structures (weirs) control water elevation and flow in the Merced National Wildlife Refuge. Both structures appear to create upstream and downstream barriers to fish due to hydraulic drops. Passage would be further impeded due to high debris loading across both structures from plant production, human refuse and beaver activity. Predation could also be enhanced because of low velocities in and around these constricted passage areas. At certain flows and times of year, water quality within the highly-vegetated, slow flow, may create passage issues.

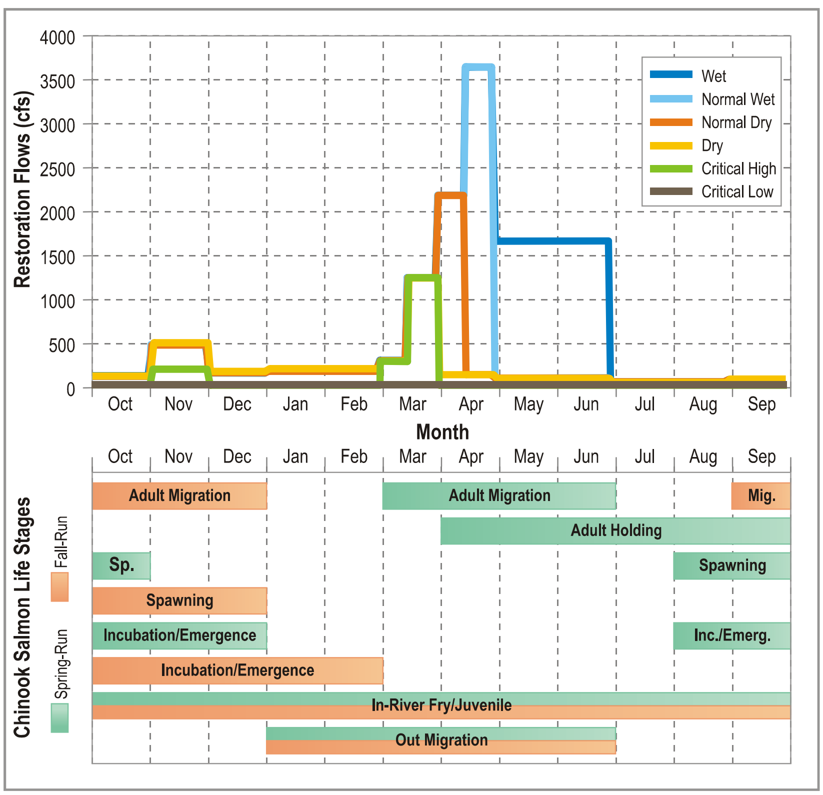
11. **Water District Facilities –** Several water districts have conveyance canals or facilities near or adjacent to the Reach 4B channel. If channel restoration includes relocation of banks or setback levees, these facilities would need to be relocated.

## 2.3 Opportunities

Implementation of the Reach 4B Project presents the opportunities described below. Opportunities can include direct opportunities associated with the Reach 4B Project, secondary benefits of the project, or an opening for other entities to complete actions that may not have otherwise occurred without the Reach 4B Project.

### 2.3.1 Habitat Improvement

The Reach 4B Project has the opportunity to improve floodplain and channel rearing habitat within the San Joaquin River channel and the bypasses. Reach 4B1 of the San Joaquin River has a dense corridor of riparian vegetation that could provide habitat, but this section of the river has multiple passage issues that prevent fish from entering. The Eastside and Mariposa bypasses have barriers to fish passage and little vegetation. The San Joaquin River and the Eastside and Mariposa bypasses need to provide passage for adult and juvenile spring-run and fall-run Chinook salmon and rearing habitat for juveniles. Figure 2-2 presents the hypothetical timing of the different salmon life stages along with the SJRRP flows through the Reach 4B Project study area at those times (SJRRP 2010). This flow pattern is an example from the Settlement, but could vary according to Settlement stipulations, such as RA recommendations.




Source: SJRRP 2009

**Figure 2-2.**
**Reach 4 Restoration Flows and Chinook Salmon Life Stages**

As described in Section 1.5, each life stage has different requirements. Adult salmon are migrating upstream, and do not consume food during their migration. Therefore, their primary need is unobstructed passage through the reach to conserve energy. Juvenile salmon do require caloric intake to fuel their movement through the reach and would benefit from opportunities for rearing habitat in the area. The Reach 4B Project could remove passage obstacles and provide rearing habitat. These features could improve habitat for fish and other vegetation and wildlife.

### 2.3.2 Water Quality

Currently, the San Joaquin River channel in Reach 4B primarily contains agricultural runoff. Increasing flows in the channel under various hydrologic conditions could possibly improve local water quality.

### 2.3.3 Recreation

Release of Restoration Flows to the San Joaquin River would provide opportunities to develop new and enhanced recreation opportunities on and along the San Joaquin River. These potential opportunities include fishing, hunting, boating, and other water-related activities. It is likely that any new and/or enhanced recreational opportunities would be a result of actions by other agencies and programs, and not part of the SJRRP or Reach 4B Project. These opportunities would also need to consider the predominantly agricultural use of this area.

## 2.4 Constraints

Constraints are defined as restrictions that limit the extent of the planning process or possible limitations on the scope of the Reach 4B Project itself, and will need to be considered when planning the project. Constraints include the following:

- **Legal Constraints –** Existing laws, regulations, and policies.
- **Project-specific Constraints –** Unique constraints identified by project proponents.
- **Flood Conveyance Capacity Constraints –** Constraints associated with flood protection.

### 2.4.1 Legal Constraints

The Reach 4B Project is constrained by the Settlement, which stipulates specific modifications for Reach 4B of the San Joaquin River and the Eastside and Mariposa bypasses, as well as a schedule for the completion of these modifications. With the exception of the creation of a low-flow channel in the Eastside and Mariposa bypasses, these specific modifications are not optional, although the methods to implement the modifications may vary.

The Reach 4B Project must also comply with many federal, state, and local laws, regulations, executive orders, and policies. The alternatives developed for the Reach 4B Project must demonstrate compliance with applicable regulatory requirements as part of the NEPA/CEQA process. Additionally, regulatory compliance is necessary to obtain many of the permits and approvals that will be required prior to construction. Many of the laws and regulations, such as the Clean Air and Clean Water acts, set thresholds or standards for the types of impacts a project may cause. Consideration of these permitting and approval actions early in the alternatives development process is important to avoid adverse environmental effects, project delays, and costly mitigation. Table 2-1 presents a brief list of applicable laws, regulations, executive orders, and policies that the Reach 4B Project will need to comply with. These regulatory requirements will be considered throughout the alternatives development process and will be updated as the alternatives are refined.

**Table 2-1.**
**Laws, Regulations, Executive Orders, and Policies**

| **Federal** | **State** |
|---|---|
| Archaeological Resources Protection Act | California Clean Air Act |
| Antiquities Act | California Environmental Quality Act |
| Bald and Golden Eagle Protection Act | California Endangered Species Act |
| Clean Air Act | California Fish and Game Code Section 1602 Lake and Streambed Alteration Agreement |
| Clean Water Act Sections 401, 402, 404 | California Land Conservation Act (Williamson Act) |
| Endangered Species Act Section 7 | California Native American Graves Protection and Repatriation Act |
| Executive Order 12898, Environmental Justice | California Public Resources Code 5097.94, 5097.98, 5097.99 (Native American Artifacts and Remains) |
| Executive Order 13112, Invasive Species | California Public Resources Code 21083.2 (Unique Archaeological Resources) |
| Executive Order 11988, Floodplain Management | Environmental Justice Public Resources Code 65040.12(e) |
| Executive Order 11990, Protection of Wetlands | Native Plant Protection Act |
| Farmland Protection Policy Act | Porter-Cologne Water Quality Control Act |
| Fish and Wildlife Coordination Act | California Public Resources Code 6501- 6509 (Lease of Public Lands under State Lands Commission) |
| General Bridge Act | Surface Mining and Reclamation Act |
| Indian Trust Assets (United States Department of the Interior Departmental Manual Part 512) | 23 California Code of Regulations 6 (Reclamation Board Organization, Powers and Standards) |
| National Environmental Policy Act | **Local** |
| Native American Graves Protection and Repatriation Act | Merced County Code Section 13.30.101 – Encroachment Permit |
| National Historic Preservation Act Section 106 | San Joaquin Valley Air Pollution Control District Rule 2010 – Authority to Construct/Permit to Operate |
| Magnuson-Stevens Fishery Conservation and Management Act | San Joaquin Valley Air Pollution Control District Regulation VIII – Fugitive $PM_{10}$ Prohibition |
| Migratory Bird Treaty Act | |
| Paleontological Resources Preservation | |
| River and Harbors Act Sections 9, 10, and 14 | |

### 2.4.2 Project-Specific Constraints

Reclamation and DWR, as the Lead NEPA and CEQA Agencies for the Reach 4B Project, have identified several project-specific constraints:

- **Minimize Land Use Impacts** – the land surrounding the San Joaquin River channel is developed for agricultural and residential purposes, and much of the area in the bypasses is used as grazing land. Any changes to these areas have the potential to affect land owners and uses of land, and the Lead Agencies are committed to minimizing these impacts where possible.

- **Minimize Seepage Impacts –** increasing flows in the San Joaquin River channel or the bypasses has the potential to increase groundwater seepage into the adjacent agricultural lands. Seepage could affect adjacent crops and the long-term productivity of adjacent agricultural lands. The Lead Agencies are committed to addressing any material adverse impacts to third parties from groundwater seepage.

- **Maintain Current Flood Operations and Conveyance Capacity of the System** – the Eastside and Mariposa bypasses are central features of the Flood Control Project that provides flood protection for the majority of the Reach 4B Project study area. The Lead Agencies are committed to avoiding or minimizing actions that would reduce the conveyance capacity of the Flood Control Project.

- **Coordination with the Overall SJRRP –** alternatives that meet the Settlement requirements related to the Reach 4B Project must also fit within the overall restoration framework for the SJRRP. Consideration must be given to modifications that have the potential to affect upstream and downstream reaches and tributaries. The Reach 4B Project modifications must be coordinated with the overall program to make sure they help meet the SJRRP goals.

- **Minimize Channel Operation and Maintenance** – Alternatives that require a substantial amount of long-term operations and maintenance have the potential to increase costs and result in long-term, continual disturbance to the system and adjacent landowners. The Lead Agencies are committed to designing alternatives that minimize channel operations and maintenance whenever applicable. Additionally, minimizing operations and maintenance also promotes the design of systems that have a more natural geomorphology and stream function.

### 2.4.3 Flood Conveyance Capacity

As discussed in the constraints section above, the Reach 4B Project cannot reduce the capacity of the Flood Control Project. Some alternatives, however, may need to include some modifications to the flood control system that have the potential to change the capacity. These changes must be completed in cooperation with the LSJLD and the United States Army Corps of Engineers (USACE), as well as other local and regional flood control entities. The Lead Agencies are working with these entities to determine how a change in capacity could be mitigated, such as:

- Increasing conveyance capacity in the San Joaquin River channel to offset reductions in the Flood Control Project
- Increasing the width of the bypasses in select areas to allow some changes within the bypasses, such as creating vegetated areas, without a reduction in conveyance capacity
- Changing the slope in the bypasses by lowering the downstream elevation (by removing the Mariposa Bypass Drop Structure) to offset reductions associated with increasing vegetation

If an initial alternative is carried forward for the Reach 4B Project, and it could result in a reduction in the flood conveyance capacity of the Flood Control Project, then the Lead Agencies will work in cooperation with the local and regional flood control entities to determine suitable mitigation measures.

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# 3.0 Existing and Future Without Project Conditions

The existing conditions are the conditions within the Reach 4B Project 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 Reach 4B Project.

The information in this chapter is presented at a general level of detail for the purpose of providing background information and aiding in initial alternatives development. This information will be further developed as the alternatives are refined and the environmental process moves forward[5].

## 3.1 Existing Conditions

### 3.1.1 Biological Resources

#### *3.1.1.1 San Joaquin River*

The river channel in Reach 4B meanders through cultivated fields in the upper segment and wildlife refuges south of the Mariposa Bypass. This reach has relatively high water table levels in comparison to other reaches and therefore supports a greater diversity of natural vegetation. Grasslands and pasture are the most extensive vegetation type, but willow riparian forest and emergent wetlands are also relatively abundant (DWR 2002). Limited stands of non-native trees occur but stands of giant reed have not been observed (DWR 2002). Invasive species noted in the reach include salt cedar (*Tamarix spp.*), castor bean (*Ricinus communis*), and perennial pepperweed (*Lepidium latifolium*) (DWR 2002; SJRRP 2008).

Reach 4B1 no longer conveys active flow. As a result, the channel is not strongly defined and is commonly obstructed by patches of dense vegetation and sediment. The reach is confined by adjacent agricultural use and natural vegetation is primarily limited to the river channel and a narrow floodplain. A nearly unbroken, dense corridor of willow scrub and young mixed riparian vegetation extends the majority of its length. Some areas also support mature stands of oaks, willows, and cottonwoods and expanses of open, ponded water.

[5] Note: The existing conditions and future without project conditions described in this TM are not meant to address NEPA and CEQA requirements; they are provided for informational purposes only. The Reach 4B Project EIS/R will describe existing and future without project conditions according to the requirements of NEPA and CEQA. The EIS/R will describe additional resources that are not presented in this TM.

Reach 4B2 supports extensive natural vegetation compared with upstream reaches because it has a wider floodplain and available groundwater. This reach is characterized by open grasslands and mature riparian forest of willow, cottonwood, and oak growing along the river and in the floodplain. Tules (*Scirpus spp.*) and cattails (*Typha spp.*) are present along the main channel and side channels (DWR 2002; SJRRP Team 2008)

Reach 4B1 of the San Joaquin River has almost no flow with the exception of ponded areas created for tailwater recovery and areas with high groundwater levels. The Reach 4B Headgate is a fish barrier and impedes fish passage from Reach 4A into Reach 4B.

Based upon a search of the USFWS species lists for applicable quadrangles (USFWS 2011), the California Natural Diversity Data Base (CNDDB) (CDFG 2011), and the California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants (CNPS 2011), several special-status species may occur within or adjacent to Reach 4B. In addition, several species are known to occur in the area based on the Program EIS/R (Reclamation and DWR 2011). The summary table below (Table 3-1) lists those special-status species that are either known to or have potential to occur within the Reach 4B Project study area.

Occurrences of Swainson's hawk (*Buteo swainsoni*) are recorded throughout Reach 4B1. This species has been documented foraging in the adjacent grassland and agricultural areas and nesting in the riparian forest along the river. Large expanses of wildlife refuge lands, including the San Luis National Wildlife Refuge and Grasslands Wildlife Management Area, support many species of wildlife, including those associated with vernal pool habitats. These refuge lands are managed to preserve and maintain existing marsh and emergent wetlands, native grasslands, alkali sink, riparian forests, and vernal pool habitats. The Grasslands Wildlife Management Area supports the largest remaining block of contiguous wetlands in the Central Valley. Numerous occurrences of special-status species affiliated with these habitats have been documented throughout Reach 4B of the San Joaquin River including: Swainson's hawk, California tiger salamander (*Ambystoma californiense*), Conservancy fairy shrimp (*Branchinecta conservatio*), Delta button-celery (*Eryngium racemosum*), northern harrier (*Circus cyaneus*), San Joaquin kit fox (*Vulpes macrotis mutica*), vernal pool fairy shrimp (*Branchinecta lynchi*), Conservancy fairy shrimp (*Branchinecta conservatio*), longhorn fairy shrimp (*Branchinecta longiantenna*), vernal pool tadpole shrimp (*Lepidurus packardi*), California linderiella (*Linderiella occidentalis*), western pond turtle (*Emys marmorata*), and western spadefoot toad (*Spea hammondii*). Species recorded from the surrounding area include American badger (*Taxidea taxus*) and giant garter snake (*Thamnophis gigas*).

In addition to recorded occurrences in and near the Reach 4B Project study area, the USFWS has designated critical habitat for Hoover's spurge (*Chamaesyce hooveri*), Colusa grass (*Neostapfia colusana*), vernal pool tadpole shrimp, vernal pool fairy shrimp, longhorn fairy shrimp, and Conservancy fairy shrimp within and adjacent to Reach 4B2.

#### ***3.1.1.2 Eastside Bypass***

The Eastside Bypass is maintained for flood control purposes, and riparian vegetation along the channel is limited. Scattered trees occur do occur, but denser riparian forest and scrub habitat is mostly absent. The lower 10 miles of the Eastside Bypass is characterized by grassland and ruderal vegetation (non-native herbaceous species associated with disturbance). The segment between the Sand Slough Control Structure and Merced National Wildlife Refuge (approximately 4.5 miles) supports a number of large duck ponds. The next 2.2 miles of the Eastside Bypass are located directly adjacent to the Merced National Wildlife Refuge, which encompasses over 10,000 acres of wetlands, native grasslands, vernal pools, and riparian habitat, and hosts the largest documented wintering populations of lesser sandhill cranes (*Grus canadensis canadensis*) and Ross's geese (*Chen rossii*) in the Pacific Flyway. Farther downstream, the Eastside Bypass flows through the Grasslands Wildlife Management Area, an area of private lands protected by conservation easements held by the USFWS, and the East Bear Creek Unit of the San Luis National Wildlife Refuge Complex. Patchy riparian trees and shrubs occur along the banks of the Eastside Bypass in these areas.

Side channels and sloughs present along the Eastside Bypass including Duck, Deep, and Bravel sloughs, which support remnant patches of riparian vegetation. Invasive plant species recorded in the Eastside Bypass in 2008 include two occurrences of perennial pepperweed and three occurrences of red sesbania (*Sesbania punicea*). Fish species observed at the Merced National Wildlife Refuge include common carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), mosquito fish (*Gambusia affinis*), green sunfish (*Lopomis cyanellus),* and blugill (*Lopomis macrochiru*) (Woolington 2011). Several documented occurrences of special-status species are associated with the wetland and grassland habitats in the wildlife refuges and management areas that surround the Eastside Bypass. These species include Conservancy fairy shrimp, San Joaquin kit fox, Swainson's hawk, tricolored blackbird (*Agelaius tricolor*), vernal pool fairy shrimp, vernal pool tadpole shrimp, Delta button-celery, and Wright's trichocoronis (*Trichocoronis wrightii*). The Merced National Wildlife Refuge also supports habitat for Colusa grass and wintering lesser sandhill crane. Other special-status species, including American badger, brittlescale (*Atriplex depressa*), heartscale (*Atriplex cordulata*), Sanford's arrowhead (*Sagittaria sanfordii*), and vernal pool smallscale (*Atriplex persistens*), are documented in the vicinity but outside the Reach 4B Project study area. In addition to recorded occurrences in and near the Reach 4B Project study area, the USFWS has designated critical habitat for Hoover's spurge, Colusa grass, vernal pool tadpole shrimp, vernal pool fairy shrimp, and Conservancy fairy shrimp along the Eastside Bypass.

**Table 3-1**
**Special-Status Species with**
**Potential to Occur in the Study Area**

| Species | Fed/State/CNPS Status |
|---|---|
| **Invertebrates** | |
| *Branchinecta conservatio*<br>Conservancy fairy shrimp | FE/--/-- |
| *Branchinecta longiantenna*<br>longhorn fairy shrimp | FE/--/-- |
| *Branchinecta lynchi*<br>vernal pool fairy shrimp | FT/--/-- |
| *Desmocerus californicus dimorphus*<br>valley elderberry longhorn beetle | FT/--/-- |
| *Lepidurus packardi*<br>vernal pool tadpole shrimp | FE/--/-- |
| *Linderiella occidentalis*<br>California linderiella | --/--/-- |
| **Fish** | |
| *Hypomesus transpacificus*<br>Delta smelt | FT/ST/-- |
| *Mylopharodon conocephalus*<br>hardhead | --/CSC/-- |
| *Oncorhynchus mykiss*<br>Steelhead - Central Valley ESU | FT/--/-- |
| *Oncorhynchus tshawytscha*<br>Central Valley spring-run chinook salmon | FT/CT/-- |
| *Oncorhynchus tshawytscha*<br>Winter run chinook salmon,<br>Sacramento River | FE/--/-- |
| *Oncorhynchus tshawytscha*<br>Central Valley fall-/late fall- run chinook salmon | FSC/CSC/-- |

**Table 3-1**
**Special-Status Species with**
**Potential to Occur in the Study Area**

| Species | Fed/State/CNPS Status |
|---|---|
| **Amphibians** | |
| *Ambystoma californiense*<br>California tiger salamander (central population) | FT/CT/-- |
| *Spea (=Scaphiopus) hammondii*<br>Western spadefoot | --/CSC/-- |
| **Reptiles** | |
| *Anniella pulchra pulchra*<br>*silvery legless lizard* | --/CSC/-- |
| *Emys marmorata*<br>western pond turtle | --/CSC/-- |
| *Gambelia sila*<br>blunt-nosed leopard lizard | FE/CE;CFP/-- |
| *Masticophis flagellum ruddocki*<br>San Joaquin whipsnake | --/CSC/-- |
| *Phrynosoma coronatum*<br>coast (California) horned lizard | --/CSC/-- |
| *Thamnophis gigas*<br>giant garter snake | FT/CT/-- |
| **Birds** | |
| *Agelaius tricolor*<br>tricolored blackbird | --/CSC/-- |
| *Ardea alba*<br>great egret | --/--/-- |
| *Ardea herodias*<br>great blue heron | --/--/-- |
| *Athene cunicularia*<br>burrowing owl | --/CSC/-- |

**Table 3-1**
**Special-Status Species with**
**Potential to Occur in the Study Area**

| Species | Fed/State/CNPS Status |
|---|---|
| *Buteo swainsonii*<br>Swainson's hawk | --/CT/-- |
| *Circus cyaneus*<br>northern harrier | --/CSC/-- |
| *Elanus leucurus*<br>white-tailed kite | --/CFP/-- |
| *Grus candensis tabida*<br>greater sandhill crane | --/CFP; CT/-- |
| *Lanius ludovicianus*<br>loggerhead shrike | --/CSC/-- |
| **Mammals** | |
| *Antrozous pallidus*<br>pallid bat | --/CSC/-- |
| *Bassariscus astutus*<br>ringtail cat | --/CFP/-- |
| *Corynorhinus townsendii*<br>Townsend's big-eared bat | --/CSC/-- |
| *Dipodomys nitradoides exilis*<br>Fresno kangaroo rat | FE/CE/-- |
| *Euderma maculatum*<br>spotted bat | --/CSC/-- |
| *Eumops perotis californicus*<br>Western mastiff bat | --/CSC/-- |
| *Lasiurus blossevillii*<br>Western red bat | --/CSC/-- |
| *Neotoma fuscipes riparia*<br>riparian woodrat | FE/CSC/-- |
| *Sylvilagus bachmani riparius*<br>riparian brush rabbit | FE/CE/-- |
| *Taxidea taxus*<br>American badger | --/CSC/-- |
| *Vulpes macrotis mutica*<br>San Joaquin kit fox | FE/CT/-- |

**Table 3-1**
**Special-Status Species with**
**Potential to Occur in the Study Area**

| Species | Fed/State/CNPS Status |
|---|---|
| **Plants** | |
| *Astragalus tener* var. *tener*<br>Alkali milk-vetch | --/--1B.2 |
| *Atriplex cordulata*<br>heartscale | --/--/1B.2 |
| *Atriplex depressa*<br>brittlescale | --/--/1B.2 |
| *Atriplex joaquiniana*<br>San Joaquin spearscale | --/--/1B.2 |
| *Atriplex minuscula*<br>lesser saltscale | --/--/1B.1 |
| *Atriplex persistens*<br>vernal pool smallscale | --/--/1B.2 |
| *Atriplex subtilis*<br>sublte orache | --/--/1B.2 |
| *Chamaesyce hooveri*<br>Hoover's spurge | FT/--/1B.2 |
| *Chloropyron molle (=Cordylanthus mollis) ssp. hispidus*<br>hispid bird's beak | --/--/1B.1 |
| *Delphinium recurvatum*<br>recurved larkspur | --/--/1B.2 |
| *Eryngium racemosum*<br>delta button-celery | --/CE/1B.1 |
| *Lasthenia glabrata* ssp. *coulteri*<br>Coulter's goldfields | --/--/1B.2 |
| *Lepidium latipes* var. *heckardii*<br>Heckard's pepper-grass | --/--/1B.2 |
| *Myosurus minimus ssp. apus*<br>little mousetail | --/--/3.1 |
| *Navarretia prostrata*<br>prostrate vernal pool navarretia | --/--/1B.1 |

**Table 3-1**
**Special-Status Species with**
**Potential to Occur in the Study Area**

| Species | Fed/State/CNPS Status |
|---|---|
| *Neostapfia colusana*<br>Colusa grass | FT/CE/1B.1 |
| *Sagittaria sanfordii*<br>Sanford's arrowhead | --/--/1B.2 |
| *Trichocoronis wrightii* var. *wrightii*<br>Wright's trichocoronis | --/--/2.1 |

**STATUS CODES**:

**Federal**
FE = Endangered
FT = Threatened
FC = Candidate
FSC = Species of Concern

**State**
CE = Endangered
CT = Threatened
CFP = Fully Protected
CSC = (CA) DFG Special Concern species

**California Native Plant Society**
List 1B = Plants rare, threatened, or endangered in California and elsewhere
List 2 = Plants rare, threatened, or endangered in California, but more common elsewhere
List 3 = Plants about which we need more information--a review list
List 4 = Plants of limited distribution--a watch list

0.1 = Seriously endangered in California
0.2 = Fairly endangered in California
0.3 = Not very endangered in California

Source: USFWS 2011; CDFG 2011; CNPS 2011; Federal Register 1993 & 2005.

### 3.1.2 Cultural Resources

Very little information is available for cultural resources in the Reach 4B Project study area. Some cultural resources information was developed as part of the SJRRP Program EIS/R for Reach 4 of the San Joaquin River and the Eastside Bypass; however, additional cultural resources surveys and data collection will occur in the future as part of development of the Reach 4B Project EIS/R. The cultural resources information presented below was gathered largely from the Central California and San Joaquin Valley Information Centers.

Within Reach 4 of the San Joaquin River, 9.7 percent of the total 43,821 acres have been surveyed for archeological resources. Spanning a total of 12,750 acres, 11.7 percent of the Eastside Bypass has been surveyed for cultural resources. Table 3-2 summarizes the cultural resources found in Reach 4, including Reach 4A and Reach 4B of the San Joaquin River.

**Table 3-2.**
**Summary of Cultural Resources in Reach 4 and the Eastside Bypass**

| Cultural Resource | San Joaquin River Reach 4 | Eastside Bypass | Total |
|---|---|---|---|
| Acreage | 43,821 | 12,750 | 56,571 |
| Archeological Survey (%) | 9.7 | 11.7 | 21.4 |
| **Recorded Archaeological Sites (Resources with trinomials)** | | | |
| Historic | 2 | 0 | 2 |
| Prehistoric | 12 | 5 | 17 |
| Prehistoric/Historic | 2 | 0 | 2 |
| **TOTAL** | **16** | **5** | **21** |
| **Recorded Historic Architecture** | | | |
| Primary Number Only | 1 | 0 | 1 |
| Caltrans Bridge Inventory | 0 | 0 | 0 |
| Partially Documented | 0 | 0 | 0 |
| Archaeological Sites with Architecture[1] | 2 | 0 | 2 |
| **TOTAL** | **3** | **0** | **3** |
| **Potential Prehistoric Surface Site Distribution[2]** | | | |
| Using Survey Results by Reach | 82 | 17 | 99 |
| **Buried Prehistoric Site Potential** | | | |
| Very Low-Low (%) | 41 | 73 | 114 |
| Moderate (%) | 20 | 22 | 42 |
| High-Very High (%) | 37 | 3 | 40 |

**Table 3-2.**
**Summary of Cultural Resources in Reach 4 and the Eastside Bypass**

| Cultural Resource | San Joaquin River Reach 4 | Eastside Bypass | Total |
|---|---|---|---|
| **Potentially Sensitive Historic-Era Archaeological Sites** | | | |
| Number | 26 | 0 | 26 |
| Percent | 12.1 | 0 | 12.1 |
| **Potential Historic-Era Architectural Resources** | | | |
| Number | 94 | 14 | 108 |
| By Weighted Value | 138 | 13 | 151 |

Source: SJRRP 2011
Notes:
[1] Also counted in archaeological site numbers
[2] Conservative estimate – higher densities indicated by landform age data

### 3.1.3 Geology and Soils

The upstream portion of Reach 4 of the San Joaquin River contains a meandering, sand-bedded channel with a gradient that decreases relative to Reach 3. River morphology in the upstream portion of Reach 4 once included extensive flood basin that continued through Reach 5. Because of the flat slope in Reach 4B of the San Joaquin River, channel migration was probably slow and infrequent. Flood flows likely spilled out into the flood plain, reducing stream energy (San Joaquin River Resource Management Coalition [RMC] 2003). Much of the natural floodplain has been cut off by construction of levees and the development of the land for agricultural production. Several sloughs originate within Reach 4 that convey agricultural return flows and runoff. Sand Slough, located near the Sand Slough Control Structure, once likely carried winter and summer base flows.

Prior to dam construction, Reach 4 was likely subject to sediment deprivation relative to the upstream reaches (RMC 2003). Since construction of the Chowchilla Bypass, sediment deprivation has increased. In Reach 4B1 of the San Joaquin River, the Sand Slough Control Structure diverts all flows into the Eastside Bypass, preventing sediment from moving downstream into the Reach 4B1 channel. The Mariposa Bypass downstream of Sand Slough Control Structure diverts flows from the Eastside Bypass Reach 2 through the Mariposa Bypass to Reach 4B2 of the San Joaquin River channel. Flows from the Chowchilla and Eastside bypasses and agricultural return flows contribute additional sediment to Reach 4B.

Soils in Reach 4A of the San Joaquin River are generally characterized as sandy loam, with loam, clay loam, and clay found downstream. Soils in Reach 4B of the San Joaquin River are characterized as clay loam, clay, and some loam, with minor amounts of sandier soils. The absence of flows through this reach has prevented channel scour from removing the fine sediments. Overall, soils in Reach 4 of the San Joaquin River have moderate soil erosion potential (Reclamation and DWR 2011).

The bypass system contains man-made channels and converted sloughs. Throughout most of the bypass system there is a channel that is best defined in the Mariposa Bypass. Sand scoured from the Eastside Bypass Reach 1 is deposited in the Eastside Bypass Reach 3. Soils in the bypass system are characterized as loam, clay loam, and clay, with some sandy loam and sand. Soils in the bypass system have a moderate erosion potential (Reclamation and DWR 2011).

Structures in Reach 4B of the San Joaquin River, including the Sand Slough Control Structure, the Reach 4B Headgates, the Eastside and Mariposa bypass control structures, and the Mariposa Drop Structure, have affected geomorphic processes, including the disruption of local incision and deposition patterns due to backwater effects, and the rerouting of sediment load.

#### *3.1.3.1 Subsidence*

Reach 4B falls within the portion of the San Joaquin Valley with high levels of historical subsidence. The primary cause of this subsidence is groundwater pumping. Most of the subsidence observed in the study area occurred by the late 1970s, but subsidence processes in the valley have continued and are expected to continue into the future. Approximately 1 to 6 feet of subsidence has been observed along the Flood Control Project, and the zone of greatest subsidence has occurred just upstream of the Reach 4B Project study area (USACE 2002).

The effects of subsidence on the profile of the river channel may be a significant contributing factor to the deposition challenges within the bypasses. Upstream of Reach 4B, subsidence appears to have steepened the slope of the San Joaquin River channel and Flood Control Project facilities. The steeper slope creates more erosion, which increases sediment loads into the Reach 4B Project study area. At the same time, less subsidence within the Reach 4B Project study area has resulted in a more gradual slope. Flows slow down when they enter the Reach 4B Project study area, which increases deposition of sediment.

### 3.1.4 Groundwater

The San Joaquin Valley Groundwater Basin makes up the southern two-thirds of the 400-mile-long, northwest-trending asymmetric trough of the Central Valley regional aquifer system in the southern extent of the Great Valley Geomorphic Province (DWR 1975).

The San Joaquin Valley Groundwater Basin comprises the San Joaquin River Hydrologic Region and Tulare Lake Hydrologic Region. The San Joaquin Valley Hydrologic Region is composed of nine subbasins (DWR 2003). Reach 4B of the San Joaquin River forms the divide between the Delta-Mendota and the Merced subbasins.

The San Joaquin River Hydrologic Region is heavily groundwater-reliant, with groundwater making up approximately 30 percent of the annual supply for agricultural and urban uses (DWR 2003). Groundwater use is greatest in the Merced Subbasin, and both agricultural and domestic supplies are almost entirely dependent on groundwater (DWR 2003).

Groundwater in the greater San Joaquin River Hydrologic Region historically flowed from the edges to the center of the valley during predevelopment conditions, discharging to the river system and then flowing north toward the Delta as surface water. Significant development of groundwater has lowered groundwater levels, and today flow primarily occurs from areas of recharge toward areas of lower groundwater levels (Bertoldi et at.1991).

The average water level in the Delta-Mendota Subbasin has increased by 2.2 feet from 1970 to 2000. From 1970 to 1985, water levels increased; however, there was a general decrease in water levels from 1985 to 1994. Groundwater levels increased in 1995 to about 2.2 feet above the 1970 groundwater level and fluctuated around this value until 2000 (DWR 2006). In the southern portion of the Delta-Mendota Subbasin, land subsidence up to 16 feet has occurred from artesian head decline (Ireland 1964, as cited in DWR 2006).

On average, the water level in the Merced Subbasin has declined almost 30 feet from 1970 to 2000 (DWR 2004). Water level declines have been greater in the eastern portion of the subbasin.

#### *3.1.4.1 Groundwater Monitoring*

There are five SJRRP groundwater monitoring wells along or near Reach 4B of the San Joaquin River. Three wells (MW-90, MW-94, and MW-95) are monitored manually each week. These wells are located along the Eastside Bypass from RM 168 to 166.7. There are also two monitoring wells (MW-10-92 and MW-11-142) that are monitored continuously. Well MW-10-92 is actually in Reach 4A; however, the well is just upstream of the Sand Slough Control Structure, the start of Reach 4B. Well MW-10-142 is located along the Eastside Bypass upstream of the Mariposa Bypass. Table 3-3 summarizes the locations, periods of data, and depths to water for these five groundwater monitoring wells.

The depth to water at these five wells ranges from 0.8 to 8.7 ft below ground surface. The average depth to water ranges from 1.6 to 6.2 ft below ground surface.

#### *3.1.4.2 Groundwater Quality*

Groundwater quality in the San Joaquin Valley Groundwater Basin varies considerably. In general, groundwater quality is suitable for most urban and agricultural uses (DWR 2003). Primary constituents of concern include total dissolved solids (TDS), chloride, and nitrates, which are discussed in this section.

**TDS.** TDS concentrations vary considerably throughout this hydrologic region but, in general, concentrations are highest along the west side of the San Joaquin River Hydrologic Region. These higher concentrations are a result of recharged streamflow originating from marine deposits in the west, and the concentration of salt due to evaporation and poor drainage in the center (DWR 2003). On the west side of the valley, TDS concentrations generally exceed 500 milligrams per liter (mg/L), and are in excess of 2,000 mg/L along portions of the western margin of the valley (Bertoldi et al. 1991). In Reach 4B of the San Joaquin River, which defines the eastern margin of the Delta-Mendota Subbasin, average TDS concentrations of 770mg/L in DWR monitoring wells are close to the highest for nine subbasins in the Hydrologic Region (DWR 2003).

**Table 3-3. SJRRP Groundwater Monitoring Data**

| Well ID | Location | Start of Data Record | Recording Method, Frequency | Minimum Depth to Water (ft) | Maximum Depth to Water (ft) | Average Depth to Water (ft) |
|---|---|---|---|---|---|---|
| MW-90 | Reach 4B; Eastside Bypass, RM 168.0 | 2/10/11 | Manual, Weekly | 0.8 | 3.6 | 1.6 |
| MW-94 | Reach 4B; Eastside Bypass, RM 166.7 | 2/10/11 | Manual, Weekly | 4.2 | 5.6 | 5.4 |
| MW-95 | Reach 4B; Eastside Bypass, RM 166.7 | 2/10/11 | Manual, Weekly | 2.1 | 4.5 | 3.2 |
| MW-10-92 | Reach 4A; Just upstream of San Slough Control Structure; RM 168.9 | 5/10/10 | Automatic; Hourly | 2.7 | 8.7 | 6.2 |
| MW-10-142 | Reach 4B; Upstream of Mariposa Bypass | 6-16-11 | Automatic; Hourly | 3.8 | 4.9 | 4.4 |

**Chloride.** Chloride concentrations can be toxic to crops, typically at concentrations higher than 700 mg/L. However, salinity usually is the primary toxin to plants before chloride alone reaches toxic levels. In the northwestern and north central part of the San Joaquin River Hydrologic Region, along the course of the San Joaquin River and adjacent low lands, chloride concentrations are typically highest. High chloride in shallow groundwater is predominantly caused by the upward flow of saline-concentrated groundwater (Bertoldi et al. 1991). DWR reported that areas of elevated chloride concentrations have been identified in localized areas of the Merced Subbasin, containing the majority of the Reach 4B Project study area (DWR 2003).

**Nitrates.** Nitrates are typically prevalent in shallow, younger groundwater throughout the San Joaquin River Hydrologic Region as a result of disposal of human and animal waste products and fertilizers. The recommended maximum concentration in drinking water for nitrate (as nitrogen) is 10 mg/L. Nitrate concentrations have been reported above the maximum contaminant level of 10 mg/L in the Merced Subbasin (Landon and Belitz 2008).

#### *3.1.4.3 Agriculture Subsurface Drainage*

Inadequate drainage and accumulating salts have been persistent challenges for irrigated agriculture along the west side and in parts of the east side of the San Joaquin River Hydrologic Region for more than a century. The most extensive drainage challenges exist on the west side of the San Joaquin River. The drainage problem developed as a result of imported water from manmade infrastructures, naturally occurring saline soils, and distinctive geology that prevents natural drainage.

Subsurface drainage challenges extend along the western side of the San Joaquin River. In some portions of this hydrologic region, natural drainage conditions are inadequate to remove the quantities of deep percolation that accrue to the water table where the upper, semiconfined aquifer is shallow. Therefore, groundwater levels often encroach on the root zone of agricultural crops, and subsurface drainage must be supplemented by constructed facilities (tile drains) for irrigation to be sustained. Present problem areas were defined in the San Joaquin Valley Drainage Program (SJVDP) (DWR 2005) as locations where the water table is within 5 feet of the ground surface at any time during the year. Potential problem areas were defined in the SJVDP at locations where the water table is between 5 and 20 feet below the ground surface (DWR 2005).

Trace elements that are toxic or potentially toxic to terrestrial and aquatic species exist in some soil and shallow groundwater on the western side of the San Joaquin River hydrologic region. These trace elements greatly complicate the disposal of subsurface drainage waters. Elements of primary concern are selenium, boron, molybdenum, and arsenic. Selenium is of greatest concern because of the wide distribution and selenium's known toxicity to aquatic animals and waterfowl.

#### *3.1.4.4 Seepage and Water Logging*

Groundwater in the San Joaquin River Hydrologic Region historically flowed from the edges to the center of the valley discharging to the San Joaquin River system. A river reach that experiences groundwater accretion is termed a "gaining stream." Conversely, where groundwater levels are deeper than a stream's bottom, and seepage from the stream occurs, the stream is a "losing stream." Because of long-term groundwater development, the San Joaquin River has shifted over time from a primarily gaining stream to a losing stream, although there are isolated areas of the river that still exhibit gaining conditions.

While the magnitude of flow losses and gains is not well known, portions of Reach 4B and Reach 5 are the only reaches along the San Joaquin River that have been reported to have gaining conditions (RMC 2005).

Gaining and losing river conditions are important to understand as the addition of new water to a river system can alter the dynamics of groundwater, leading to seepage and water logging of crops if water levels encroach upon the crop root zone. Additionally, gaining reaches would introduce additional water into the river system that may affect the water quality and suitability of the river for biological resources. Losing reaches would result in decreased flows that could affect biological resources.

The *San Joaquin River Preliminary Underseepage Limiting Capacity Analysis, Draft Technical Memorandum* has started the analysis of potential effects of Restoration Flows on levee underseepage for Reach 4B2 of the San Joaquin River and the Eastside Bypass (Tetra Tech 2011). The study compared modeled water surface elevations to the land elevations adjacent to the levees to identify areas where seepage under levees could cause concerns. The SJRRP is monitoring Interim Flows to provide additional seepage data to augment this analytical work. The report identified some areas that could be improved to avoid seepage, and the SJRRP is going to use the monitoring data to determine the need for additional work in Reach 4B2 to prevent seepage-related impacts. This work would be separate from the Reach 4B Project.

### 3.1.5 Hydrology and Flood Control

Hydrology and flood control conditions in the Reach 4B Project study area are controlled by multiple facilities. The sections below describe the facilities and discuss facility operations.

#### *3.1.5.1 Lower San Joaquin River Flood Control Project*

The Flood Control Project was authorized by Congress and the California legislature in 1946 and constructed from 1959 to 1966 (DWR 1969 in RMC 2003). The Flood Control Project consists of a network of bypasses, levees, and structures that provide flood protection from Gravelly Ford to the Merced River confluence (RMC 2003). Flood Control Project facilities within the Reach 4B Project study area include:

- San Joaquin River channel
- Eastside Bypass
- Mariposa Bypass
- Levees that extend along the Eastside Bypass, Mariposa Bypass, and Reach 4B2 of the San Joaquin River (these levees are referred to as Project levees)
- Flood control structures, including the Reach 4B Headgate, Sand Slough Control Structure, Eastside Bypass Control Structure, Mariposa Bypass Control Structure, and Mariposa Drop Structure

The LSJLD was created in 1955 by a special act of the Legislature to operate, maintain and repair levees, bypasses and other facilities built for the Flood Control Project. In 1958, the LSJLD formally agreed to become responsible for the operation and maintenance of the Flood Control Project after it was completed. According to the agreement with the State Reclamation Board (now called the Central Valley Flood Protection Board), LSJLD is required to maintain the bypass channels and the San Joaquin River channel in a condition where the channels will carry flood flows in accordance with the maximum benefits for flood protection (RMC 2003). An Operation and Maintenance Manual developed by the State Reclamation Board in 1967 and amended in 1978 outlines the operating rules and procedures for the Flood Control Project facilities.

DWR designed the Flood Control Project levees on the San Joaquin River channels (in Reach 4B2) and the bypass channels to provide protection from the 50-year flood event, according to the definition of the event at the time of design in the 1950s (DWR 1969 in RMC 2003). The San Joaquin River channel levees were constructed to have 3 feet of freeboard above the maximum design water surface elevation and the bypass channel levees were designed with a freeboard of 4 feet (Reclamation Board 1967). The San Joaquin River Reach 4B1 is lined with private levees with a published design capacity of 1,500 cfs from the Sand Slough Control Structure to the Mariposa Bypass (RMC 2003). Aggradations of the channel bed, subsidence, and vegetation encroachment have reduced the capacity of the San Joaquin River channel to convey the published design flows (RMC 2003). Additionally, the Reach 4B Headgate at the upstream end of Reach 4B1 has not been operated in several decades and it is not known if the gates are still functioning.

#### *3.1.5.2 San Joaquin River Reach 4B*

Reach 4B of the San Joaquin River stretches from RM 168.5 to RM 136, beginning at the Reach 4B Headgate and ending where the Eastside Bypass rejoins the San Joaquin River. Reach 4B1 of the San Joaquin River channel does not receive river flows; water in this reach is from high groundwater levels, agricultural tailwater, and seepage from canals, and is often pumped and reused for irrigation. Reach 4B2 does receive water regularly.

**Reach 4B Headgate.** The Reach 4B Headgate controls the amount of flow from Reach 4A of the San Joaquin River into Reach 4B. Operating rules for the Reach 4B Headgate state that the gates should be opened when there is 10,000 cfs in the Sand Slough area. During receding flows that drop below 10,000 cfs, the gates can either be closed or left open during the entire recession of flow (Reclamation Board 1967). The Reach 4B Headgate creates a barrier to fish migration. Currently, the Reach 4B Headgate is not operated and remains closed to prevent flow from entering the San Joaquin River channel.

**Sand Slough Control Structure.** The Sand Slough Control Structure is between the San Joaquin River at RM 168.5 and the Eastside Bypass. It is an uncontrolled weir and flume that controls the flow split between the main stem San Joaquin River and the Eastside Bypass. The Sand Slough Control Structure conveys all flows from the San Joaquin River to the Eastside Bypass.

**San Joaquin River Reach 4B1.** Reach 4B1 extends from the Reach 4B Headgate (RM 168.5) to the confluence with the Mariposa Bypass (RM 147.2). The design capacity of the channel in Reach 4B1 is 1,500 cfs, as shown in Table 3-4; however, the actual capacity is substantially less, and may even be zero in some areas. Reach 4B1 of the San Joaquin River channel is part of the Flood Control Project; however, most of the channel is bordered by private levees constructed by local landowners.

**Table 3-4.**
**San Joaquin River Reach 4B Design Capacity**

| Channel Description | River Mile | Subreach | Design Capacity |
|---|---|---|---|
| Sand Slough to Mariposa Bypass Confluence | 168.5 – 147.2 | 4B1 | 1,500 cfs |
| Mariposa Bypass Confluence to Eastside Bypass Confluence | 147.2 – 135.8 | 4B2 | 10,000 cfs |

Source: Reclamation Board 1967
Key: cfs = cubic feet per second

**San Joaquin River Reach 4B2.** Reach 4B2 extends from the confluence with the Mariposa Bypass (RM 147.2) to the confluence with the Eastside Bypass (RM 135.8). The design channel capacity of Reach 4B2 is 10,000 cfs (see Table 3-4). The levees that bound Reach 4B2 are part of the Flood Control Project. The Reach 4B2 channel receives tributary and flood flows from the Mariposa Bypass. With an existing conveyance capacity of 10,000 cfs, Reach 4B2 meets the Settlement requirements of conveying at least 475 cfs. No modifications are proposed for Reach 4B2 under the Reach 4B Project.

#### *3.1.5.3 Eastside Bypass*

The Eastside Bypass extends from the confluence of the Fresno River and the Chowchilla Bypass to its confluence with the San Joaquin River at the downstream end of Reach 4 (see Figure 3-1). The Eastside Bypass carries flood flows from the San Joaquin River (at the Chowchilla Bifurcation Structure) and the eastside tributaries to the main stem San Joaquin River upstream of the Merced River confluence.

The Eastside Bypass is divided into three reaches with varying capacities and waterways that contribute flows. Reaches 2 and 3 of the Eastside Bypass are within the Reach 4B Project study area. The design capacity of Reach 2 is 16,500 cfs, while the design capacity of Reach 3 is 12,000 cfs at the Eastside Bypass Control Structure, increasing to 18,500 cfs at the confluence with Bear Creek. Table 3-5 provides the design capacity and tributaries for each reach of the Eastside Bypass. DWR has started a process to examine the current capacity in these reaches to determine if any changes have occurred over time.

**Table 3-5.**
**Eastside Bypass Design Capacity**

| Reach | Extent | Design Capacity[1] | Waterways Entering Eastside Bypass |
|---|---|---|---|
| 1 | From Fresno River to Sand Slough | Increases from 10,000 cfs at Fresno River to 17,500 cfs at Ash Slough | Berenda Slough<br>Ash Slough |
| 2 | From Sand Slough to Eastside Bypass Control Structure | 16,500 cfs | None |
| 3 | From Eastside Bypass Control Structure to where it rejoin with San Joaquin River | 12,000 cfs at Eastside Bypass Control Structure increases to 18,500 cfs at confluence with Bear Creek | Bear Creek<br>Owens Creek<br>Duck Slough |

Source: Reclamation Board 1967; DWR 2010
Notes:
[1] The channel capacities are design capacities; current capacities may be reduced due to subsidence of levees and other operational and maintenance factors.

**Eastside Bypass Control Structure.** The Eastside Bypass Control Structure is approximately 1,100 feet downstream of the Mariposa Bypass Control Structure in Reach 3 of the Eastside Bypass. The reinforced concrete structure contains six gated bays and works in conjunction with the Mariposa Bypass Control Structure to convey flows down the Mariposa Bypass or Reach 3 of the Eastside Bypass.

The operating rule for the bypasses is to allow the first 8,500 cfs of flow through the Mariposa Bypass Control Structure and down the Mariposa Bypass with all gates remaining closed on the Eastside Bypass Control Structure. The radial gates of the Mariposa Bypass Control Structure can be closed to ensure additional flows that exceed 8,500 cfs are diverted to the Eastside Bypass Control Structure (Reclamation Board 1967). Table 3-6 presents an overview of the normal operations for the bypasses.

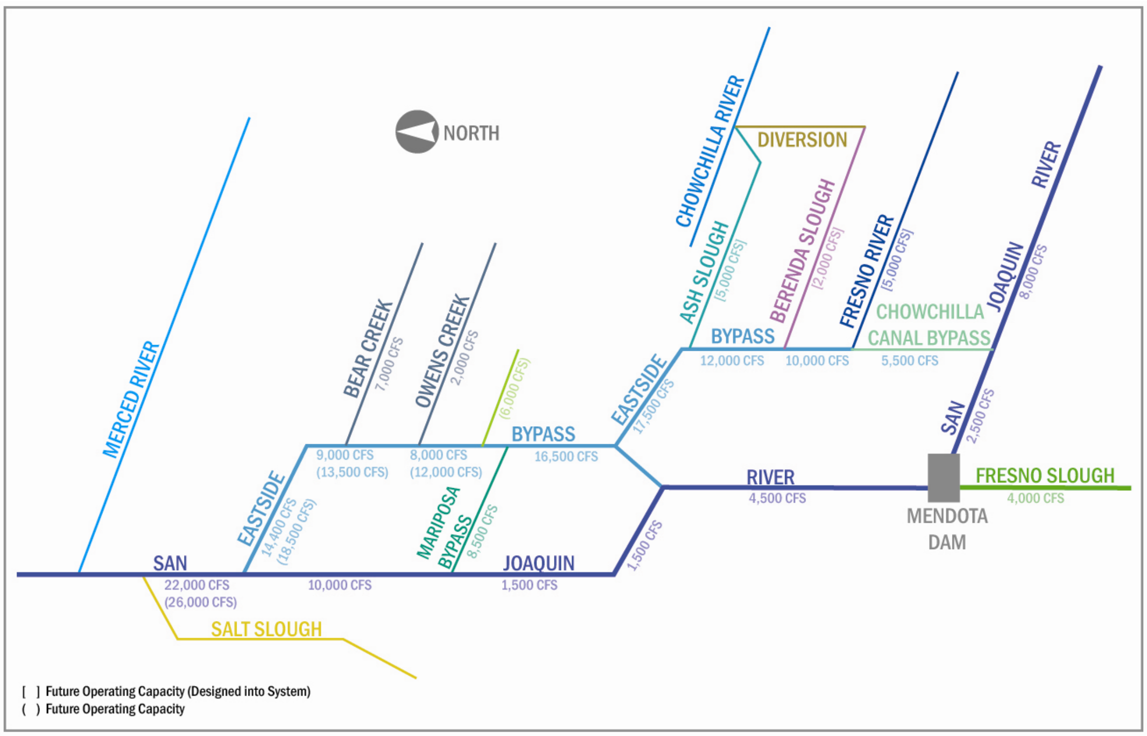
**Table 3-6.**
**Eastside and Mariposa Bypasses Normal Operations**

| Eastside Bypass (Upstream Flow) | Eastside Bypass Control Structure | Mariposa Bypass Control Structure |
|---|---|---|
| 0 to 8,500 cfs | 0 cfs<br>Gates closed | 0 to 8,500 cfs<br>Gates open |
| 8,500 to 16,500 cfs | 0 to 8,500 cfs<br>Open gates as required to pass excess flow and maintain constant pool elevation | 8,500 cfs<br>Close gates as required to maintain constant 8,500 cfs flow |

Source: Reclamation Board 1967

#### *3.1.5.4 Mariposa Bypass*

The Mariposa Bypass conveys flows from Reach 2 of the Eastside Bypass to Reach 4B2 of the San Joaquin River (see Figure 3-1). Two main structures are associated with this bypass: the Mariposa Bypass Control Structure in Reach 2 of the Eastside Bypass and the Mariposa Drop Structure near Reach 4B2 of the San Joaquin River.




Source: Reclamation Board 1967

**Figure 3-1.**
**San Joaquin River Flood Control Project Facilities and Design Capacities**

The operating rule for the Mariposa Bypass is to divert all flows through the Mariposa Bypass to the San Joaquin River when flows in the Eastside Bypass are less than 8,500 cfs. Any flows above 8,500 cfs remain in the Eastside Bypass and are eventually discharged into the end of Reach 4B2 of the San Joaquin River (Reclamation Board 1967). Historical operations deviate from this rule because of the elevation difference between the Eastside Bypass Control Structure and the Mariposa Bypass Control Structure. The Mariposa Bypass Control Structure is approximately six feet higher than the Eastside Bypass Control Structure (Hill 2010, personal communication). To move water into the Mariposa Bypass when flows are relatively low, the LSJLD must close the Eastside Bypass Control Structure and back water up into a sizeable pool to raise the elevation. Rather than raising the elevation, the LSJLD typically allows low flows to continue into the Eastside Bypass (Hill 2010, personal communication).

**Mariposa Bypass Control Structure.** The Mariposa Bypass Control Structure is at the head of the Mariposa Bypass where Reach 2 of the Eastside Bypass transitions to Reach 3. The Mariposa Bypass Control Structure allows flood flows to continue through the Eastside Bypass or be diverted through the Mariposa Bypass to Reach 4B of the San Joaquin River. The concrete structure has 14 bays, with four gated bays on either end and six open bays in the middle.

**Mariposa Drop Structure.** The Mariposa Drop Structure is used to control the hydraulic grade in the Mariposa Bypass. The drop structure reduces the velocity of high flows and the consequent scour potential in the bypass that could erode channel levees. The drop structure dissipates the energy by passing the water over the concrete structure to a concrete apron.

#### *3.1.5.5 Flows from 1950 to Present*

Flows from 1950 to present in Reach 4B of the San Joaquin River and the Eastside and Mariposa bypasses are summarized in Table 3-7. Flows from Reach 4A enter this reach at the Reach 4B Headgate and Sand Slough Control Structure, which route flow between the San Joaquin River Reach 4B1 and the Eastside Bypass Reach 2. However, current operations keep the gates to the San Joaquin River Reach 4B1 closed, diverting all flow to the Eastside Bypass. Reach 4B1 only receives very small flows from runoff and agricultural discharge.

**Table 3-7.**
**Flows from 1950[1] to Present**

| Location | Gage Location | Average streamflow (cfs) | Maximum daily average streamflow (cfs) | Period of Record |
|---|---|---|---|---|
| San Joaquin River Reach 4A | San Joaquin near Dos Palos | 478 | 8,170 | 1950 – 1954, 1974 – 1987, 1995[1] |
| San Joaquin River Reach 4B | San Joaquin River near El Nido[3] (at Sand Slough) | 705 | 3,700 | 1939 – 1949[2] |
| Mariposa Bypass | Mariposa Bypass near Crane Ranch | 456 | 9,960 | 1980 – 1994 |
| Eastside Bypass Reach 2 | Eastside Bypass near El Nido[3] | 840 | 20,400 | 1980 – 2007 |
| Eastside Bypass Reach 3 | Eastside Bypass below Mariposa Bypass | 257 | 11,400 | 1980 – 2007 |

Source: United States Geologic Survey 2009
Notes:
[1] Period of record coincides with start of diversions from Friant Dam (1950).
[2] Period of record predates completion of Friant Dam diversion facilities.
[3] El Nido is located at Latitude 37.133056, Longitude -120.566944.

Flows from Reach 2 of the Eastside Bypass are split between the Mariposa Bypass and the Eastside Bypass Reach 3. Flows from the Mariposa Bypass re-enter the San Joaquin

River at the upstream end of Reach 4B2. Flows from the Eastside Bypass Reach 3 re-enter the San Joaquin River at the downstream end of Reach 4B2.

### 3.1.6 Land Use and Agriculture

Land use within the Reach 4B Project study area consists mainly of agriculture and open space. Most of the land throughout this reach is privately owned. Agricultural crops grown within the Reach 4B Project study area include field crops, truck, nursery and berry crops, pasture, and grain and hay. Many of the agricultural lands within this reach had Williamson Act Contracts in 2008 (Merced County 2008). The Eastside and Mariposa bypasses are typically used for rangeland or cattle grazing during non-flood periods.

Federally owned lands in the Reach 4B Project study area include the San Luis National Wildlife Refuge, the Grasslands Wildlife Management Area, and the Merced National Wildlife Refuge, all managed by USFWS.

At approximately RM 156, there is one house within the immediate floodplain of the Reach 4B1 channel.

### 3.1.7 Transportation and Infrastructure

There are several roads within the Reach 4B Project study area. The primary heavy-traffic roads in the vicinity are State Route 33 (Reach 4A) and State Route 152 (Reach 4B). Because there are no urbanized areas in this reach and agriculture is the main industry, traffic levels on arterials, collectors, local roads, and private roads are likely to be moderate, with local agricultural trucks and commuters. With the exception of the State Route 152 Bridge, river crossings are arterials, collectors, or local roads under the jurisdiction of Merced County.

A number of crossings in the study area may be barriers to fish passage or may become unusable during low and high flow conditions, including Washington/Indiana Road, Turner Island Road, and four unnamed crossings in Reach 4B1, one unnamed crossing in Reach 4B2, West El Nido Road and Dan McNamara Road in the Eastside Bypass, and one unnamed crossing in the Mariposa Bypass. Table 3-8 presents a list of existing roads and identifies those that may be barriers to fish passage or flows.

Pacific Gas and Electric owns two overhead electrical transmission lines and 59 overhead electrical distribution lines that cross the San Joaquin River channel in the vicinity of the Reach 4B Project study area. The extent of utilities in the bypass system is unknown at this time.

**Table 3-8.**
**Road Crossings in the Reach 4B Project Study Area**

| Name | River Reach | Potential Issue for Fish Passage or Flows? | Name | Bypass Reach | Potential Issue for Fish Passage or Flows? |
|---|---|---|---|---|---|
| Washington Road (Bridge) | Sand Slough | No | West El Nido Road | Eastside Bypass 2 | Yes |
| Washington/ Indiana Road (Bridge) | 4B1 | Yes | Chamberlain Road (Bridge) | Eastside Bypass 2 | No |
| Unnamed Crossing with Culvert | 4B1 | Yes | Sandy Mush Road (Bridge) | Eastside Bypass 2 | No |
| Turner Island Road (Bridge) | 4B1 | Yes | Dan McNamara Road | Eastside Bypass 2 | Yes |
| Unnamed Crossing | 4B1 | Yes | Green House Road (Bridge) | Eastside Bypass 3 | No |
| Unnamed Crossing with Culvert | 4B1 | Yes | Unnamed Crossing (Bridge) | Eastside Bypass 3 | No |
| Unnamed Crossing with Culvert | 4B1 | Yes | Unnamed Crossing (Bridge) | Eastside Bypass 3 | No |
| Unnamed Refuge Crossing | 4B2 | Yes | Unnamed Crossing | Mariposa Bypass | Yes |

Source: DWR 2011

### 3.1.8 Water Quality

While there is little historic water quality data available, surface water quality in the Reach 4B Project study area is believed to be influenced primarily by discharges from agriculture lands. As noted in the previous sections, flows have not been conveyed into Reach 4B1 of the San Joaquin River in several decades and standing water in the San Joaquin River channel is mainly associated with tailwater recovery. The SJRRP has initiated water quality monitoring efforts to provide additional data within the study area and the results are reported annually in the technical reports (http://www.restoresjr.net/flows/atr.html).

To comply with federal and state water quality laws to protect water resources, water quality control plans or Basin Plans are prepared and adopted for specific regions in the State of California. The Basin Plans describe beneficial uses and water quality standards to meet state and federal requirements for water quality. The Central Valley Regional Water Quality Control Board (CVRWQCB) is the entity responsible for protecting surface water quality in the Reach 4B Project study area. The CVRWQCB Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (CVRWQCB Basin Plan) is the Basin Plan in effect in the study area.

The CVRWQCB Basin Plan defines the following as existing beneficial uses for the San Joaquin River from Sack Dam to the mouth of the Merced River:

- Agricultural supply, including irrigation and stock water
- Water contact recreation
- Non-contact recreation
- Warm freshwater habitat
- Migration of aquatic organisms
- Warm spawning, reproduction, and early development habitat
- Wildlife habitat

Section 303(d) of the Federal Clean Water Act requires states to develop a list of water quality-impaired segments of waterways. The list includes waters that do not meet the water quality standards necessary to support the designated beneficial uses. States must establish priority rankings for waterways on the lists and develop action plans, called Total Maximum Daily Loads (TMDLs), to improve water quality (United States Environmental Protection Agency [USEPA] 2006). Water quality criteria applicable to some beneficial uses are not currently met within the Reach 4B Project study area. The draft 303(d) listings for Reaches 3 and 4 of the San Joaquin River include boron, chlorpyrifos, diazinon, dichlorodiphenyltrichloroethane (DDT), electrical conductivity, Group A pesticides, and unknown toxicity (CVRWQCB 2009). For the constituents listed above, the CVRWQCB has approved TMDLs drafted as Basin Plan Amendments for diazinon and chlorpyrifos (CVRWQCB 2006). Implementation of the Reach 4B Project must be consistent with the Basin Plan water quality standards and TMDLs established for Reach 4B of the San Joaquin River.

## 3.2 Future Without Project Conditions

The future without project conditions are the conditions that would be expected to occur if the Reach 4B Project is not implemented. Under this condition, the Reach 4B Project would not be implemented; however, other components of the Settlement would be assumed to be implemented. This includes the Settlement components analyzed at a project level in the SJRRP Program EIS/R (increases in release from Friant Dam and related management, monitoring, and mitigation actions) and other reasonably foreseeable actions expected to occur in the study area.

In the future, if the Reach 4B Project is not implemented, Interim and Restoration flows would continue to be released from Friant Dam. Most of these flows would make their way into the Eastside Bypass, but some could also be conveyed into Reach 4B1 of the San Joaquin River. The amount conveyed into Reach 4B1 is unknown at this time, but would not exceed the channel capacity of the Reach 4B1 channel. Additional survey and field work is necessary to determine the channel capacity in the reach. Limited fish passage would occur through Reach 4B1, as the Reach 4B Headgate would continue to impede fish passage. Fish passage would also be limited through the Eastside or

Mariposa bypasses under most flow conditions because several structures in the bypasses do not meet NMFS criteria for fish passage under most flow conditions. Under these conditions, Reclamation would not meet the Paragraph 11(a) Settlement requirements related to Reach 4B of the San Joaquin River and the Eastside and Mariposa bypasses, and may not achieve the Settlement's Restoration Goal without suitable fish passage in Reach 4B of the San Joaquin River and the bypass system.

### 3.2.1 Biological Resources

Under the future without project conditions, there could be changes to biological resources. Interim and Restoration flows would increase the timing and frequency of flows through the Eastside Bypass. The flows would have the potential to decrease some vegetation as it becomes inundated, and expand other areas of riparian vegetation as more water becomes available. Some existing habitat in the Eastside Bypass may be inundated under the increased flows. However, the flows may also provide new aquatic and riparian habitat. Fish passage would be impeded through Reach 4B of the San Joaquin River or through the Eastside Bypass because the upstream-migrating fish would have difficulty passing the Reach 4B Headgate and the Eastside and Mariposa bypass control structures. Interim and Restoration flows may attract fish to swim upstream towards the study area, but they would have difficulty passing upstream into Reach 4A or Eastside Bypass Reach 1.

### 3.2.2 Cultural Resources

Under the future without project conditions, the Reach 4B Project would not cause any construction activities. There would be no change to cultural resources.

### 3.2.3 Groundwater

There may be some changes to groundwater under the future without project conditions. Because Interim and Restoration flows would be released from Friant Dam, these flows would travel through the Eastside and Mariposa bypasses when those facilities are currently dry. The increased flows would have the potential to increase groundwater levels in the area.

### 3.2.4 Geology and Soils

There could be some changes to geology and soils in Reach 4B of the San Joaquin River in the future, if Interim or Restoration flows are conveyed into Reach 4B1. Any changes to geology and soils would depend on the quantity of flows conveyed through this reach. There would also be some changes to geology and soils in the Eastside and Mariposa bypasses in the future. Because Interim and Restoration flows would be released from Friant Dam, these flows would travel through the Eastside and Mariposa bypasses when those facilities are currently dry. The increased flows would have the potential to affect sediment erosion and deposition and may change the geomorphic processes currently occurring in the bypass system.

### 3.2.5 Hydrology and Flood Control

Under the future without project conditions, the Interim and Restoration flows would continue to be released from Friant Dam. Most of the flows would be diverted into the Eastside Bypass, but some could also be conveyed into Reach 4B1 of the San Joaquin

River. The Reach 4B Project channel modifications to the San Joaquin River channel and the Eastside or Mariposa bypasses would not occur. Overall, average flows through Reach 4B of the San Joaquin River, the Eastside Bypass, and the Mariposa Bypass may increase.

### 3.2.6 Land Use and Agriculture

Under the future without project conditions, flows would inundate the Eastside and Mariposa bypasses for longer periods than during the existing conditions. Some of these lands are currently used for grazing, but the grazing opportunities may change in the future with the new flow pattern. Channel improvements to Reach 4B of the San Joaquin River would not occur; therefore, there would be no land use changes along Reach 4B1. Agriculture would continue to remain the primary land use in the area.

### 3.2.7 Transportation and Infrastructure

Transportation and infrastructure in Reach 4B of the San Joaquin River would likely remain unchanged under the future without project conditions. Reach 4B1 would not experience changes to road crossings or utilities because no construction would occur. Because most Interim and Restoration flows would likely be sent down the Eastside Bypass, some road crossings through the Eastside Bypass may experience more flooding than under existing conditions. If any flows are conveyed down Reach 4B1 of the San Joaquin River, some low crossings may experience more flooding.

### 3.2.8 Water Quality

The future without project conditions could allow some flow into Reach 4B1 of the San Joaquin River. This flow could provide some dilution to the existing water in the reach, which is primarily composed of agricultural drainage water. In the bypasses, Interim and Restoration flows would change the flow patterns. Increased flows during parts of the year are likely to increase water quality, and decreased flows at other times of the year are likely to decrease water quality, but both changes are expected to be small. Increased flows through the bypasses could also increase bank erosion and sedimentation.

# 4.0 Alternatives Formulation

This chapter describes the process to develop alternatives for the Reach 4B Project, including formulating initial concepts, combining concepts into initial alternatives, refining and evaluating initial alternatives, and creating a final set of alternatives for inclusion in the EIS/R. This chapter also describes stakeholder involvement in the alternatives formulation process.

## 4.1 Alternative Development Process

This TM is the first step in the larger process of developing project alternatives for the Reach 4B Project. The following sections describe primary steps in the process.

### 4.1.1 Initial Concept Development

Initial concepts represent individual components (potential physical modifications) that are combined together to achieve the overall Reach 4B Project purpose and need/project objectives. For discussion purposes, initial concepts were separated into two categories:

- **Channel Modifications –** The channel modifications include modifications to the San Joaquin River to create a channel that would pass at least 475 cfs, and modifications to the Eastside and Mariposa bypasses that would create, at a minimum, a low-flow channel that allows for fish passage.

- **Structural Modifications –** The structural modifications include modifications to existing structures to provide fish passage and convey flows as well as new barriers on existing waterways to prevent fish migration into undesirable areas.

#### *4.1.1.1 Formulating Initial Concepts*

The Study Team developed a list of initial channel and structural modification concepts for inclusion in the initial alternatives. This list was compiled from multiple sources:

- Public scoping comments
- SJRRP documents, including the Draft Program EIS/R, the Initial Program Alternatives Report, and the Plan Formulation TM (an appendix to the Program EIS/R)
- Pre-Settlement documents, such as the Draft Restoration Strategies for the San Joaquin River (Stillwater Sciences 2003)
- NMFS and DFG guidance documents pertaining to river restoration and fish passage
- Technical expertise of the Implementing Agencies

#### *4.1.1.2 Screening Initial Concepts*

To eliminate infeasible concepts, basic screening criteria were developed. The criteria for initial concept inclusion include:

- **Consistency with the Settlement –** the Implementing Agencies are committed to fulfilling the terms of the Settlement. All concepts must contribute to meeting the requirements for Reach 4B of the San Joaquin River and the Eastside and Mariposa bypasses stipulated in the Settlement.

- **Technical Viability –** some concepts identified are not technically viable for the Reach 4B Project and were screened out from further consideration.

Any concepts deemed not technically viable or outside the range of the Settlement requirements have not been carried forward for further consideration.

#### *4.1.1.3 Concepts Eliminated from Further Consideration*

The following concepts were eliminated from further consideration because they do not meet the screening criteria:

- **Spawning habitat in Reach 4B of the San Joaquin River or the bypasses –** this concept was screened out for technical viability. Creating spawning habitat is not feasible because of existing gradient and soil conditions.

- **Velocity barriers to prevent fish migration into tributaries –** this concept was screened out for technical viability. Velocity barriers would not work with the range of flows that would occur in these applications.

- **Behavioral barriers to prevent fish migration into tributaries –** this concept was screened out for technical viability. These barriers have inconsistent results and limited applications (NMFS 2008).

- **Upward sloping fixed plate screens, downward sloping fixed plate screens, drum screens, or traveling screens –** these concepts were screened out for technical viability. They would not be viable in an application where the flows going through the screen could be much greater than the flows passing the screen (that would contain fish).

- **Bottomless culverts –** the bed material in the San Joaquin River and the Eastside Bypass consists mainly of sand. Bottomless culverts are not feasible in sand.

- **Flooding the San Joaquin River channel to remove vegetation –** Non-mechanized channel clearing of the San Joaquin River channel has been screened out. The concept of non-mechanized clearing of the San Joaquin River Channel would involve releasing water through Reach 4B1 to scour out the channel, with no mechanical excavation. This method would likely not result in acceptable flows in the channel to meet the requirement in the Settlement of creating 475 cfs of capacity within an acceptable timeframe, and may result in substantial impacts to adjacent agricultural lands.

### 4.1.2 Formulate Initial Alternatives

The remaining structural and channel modification concepts were combined to create a set of five initial alternatives presented in Chapter 5 of this TM. The five initial alternatives are intended to cover a broad range of potential environmental impacts for the purposes of analysis as required by NEPA and CEQA. These alternatives represent the range of potential routes for fish and flows, and include the flexibility to expand or modify as alternative development moves forward. These initial alternatives will be used as a starting point to obtain feedback to refine existing alternatives.

### 4.1.3 Expand Initial Alternatives

After developing initial alternatives, the initial alternatives will be expanded to create multiple sub-alternatives that explore multiple ways of accomplishing the alternatives' main features. The sub-alternatives could include varying facility layouts, levee setbacks, habitat design, or channel grading. Figure 4-1 shows how the alternatives will expand and then narrow during the next evaluate step.

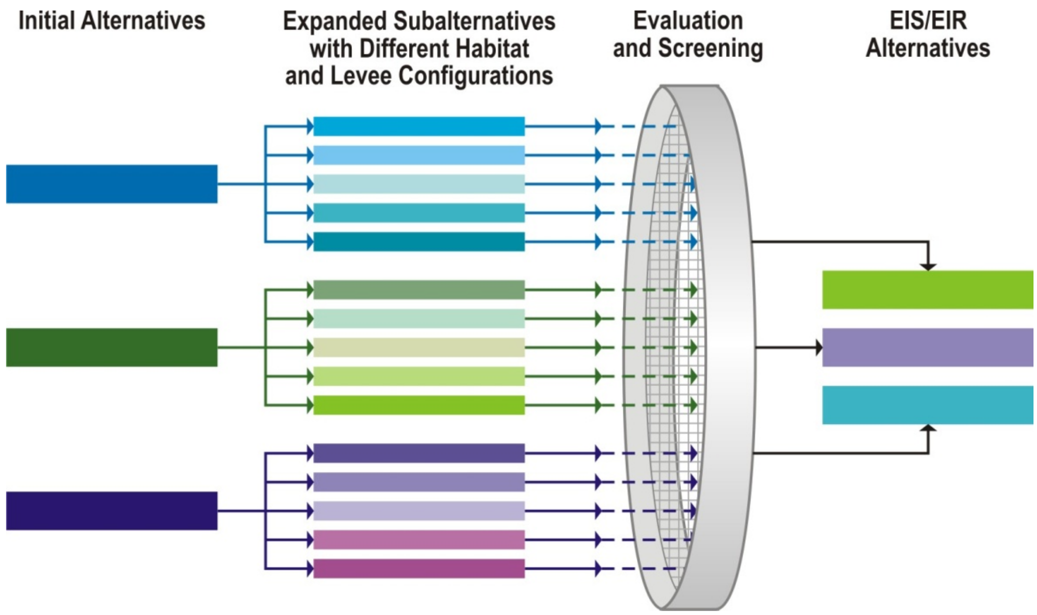



**Figure 4-1.**
**Alternatives Evaluation**

### 4.1.4 Evaluate Initial Alternatives

The next step in alternatives development includes evaluating the longer list of alternatives. Evaluation criteria will be developed to determine how well the alternatives meet the overall purpose and need/objectives of the Reach 4B Project. The evaluation criteria will also provide a means to compare similar alternatives.

Determining how well the alternatives meet the evaluation criteria will involve developing preliminary engineering design, preliminary cost estimates, and completing hydraulic, sediment, and water temperature modeling, as necessary. The alternatives will then be compared and evaluated to determine how well they meet the purpose and need/project objectives of the Reach 4B Project. A range of alternatives that represent different approaches that could best meet the purpose and need/project objectives but could result in varying environmental effects will move forward into the EIS/R for further evaluation.

### 4.1.5 Final Alternatives

Using information obtained through alternatives evaluation and refinement, the final set of alternatives will be developed. The alternatives will then be refined to form the basis for the EIS/R project description. The draft project description will be documented in a Project Description TM. The final project description will be presented in the EIS/R and the final alternatives will be evaluated as required by NEPA and CEQA.

## 4.2 Stakeholder Involvement

The alternatives development process provides opportunities for stakeholder involvement and input. Primary stakeholders for the Reach 4B Project include federal, state, and local agencies, landowners, and the public. This section describes how each stakeholder group fits into the alternatives development process and the opportunities they have to provide input and comments on the project concepts and alternatives. In addition to these groups, the RA participates in regular coordination meetings with Reclamation and DWR staff and reports information to the Settling Party representatives and the TAC.

### 4.2.1 Agency Involvement

Federal and State Implementing Agencies involved in the SJRRP have representatives in the Technical Work Groups and Sub-Groups that provide support for the development, evaluation, and refinement of alternatives. Four agency Technical Work Groups have been formed to help with specific project tasks, the Water Management Work Group, Engineering and Design Work Group, FMWG, and Environmental Compliance and Permitting Work Group all have been and will continue to be invited to participate in alternatives development for the Reach 4B Project. The Fisheries Agencies will provide input on development of structural modification concepts to ensure they are consistent with fisheries needs, in coordination with the FMWG. The Reach 4B Project Design Team will provide engineering and design for alternatives, in coordination with the Engineering and Design Work Group. The Environmental Compliance and Permitting Work Group will coordinate environmental compliance requirements and potential regulatory constraints to alternative formulation.

The Reach 4B Alternatives Formulation Sub-Group includes representatives from the Implementing Agencies that wish to be involved in the detailed development of alternatives. During the alternatives formulation process, the Alternative Formulation Sub-Group will meet on a monthly or as-needed basis to provide substantive input to alternatives development. The Alternatives Formulation Sub-Group will identify issues that can be resolved through the Technical Work Groups, or require Project Management

Team and Settling Parties interaction. The Alternatives Formulation Sub-Group will also indentify questions for the TAC and the RA.

### 4.2.2 Landowner Involvement

During the alternatives development process, the Implementing Agencies will hold monthly or periodic landowner meetings to inform landowners of project progress and collect input on alternatives development. The Implementing Agencies will include representatives of the LSJLD, San Joaquin River Exchange Contractors Water Authority, and RMC in these meetings.

### 4.2.3 Public Involvement

Reclamation and DWR held two public scoping meetings in September of 2009, and an additional scoping meeting in December 2010 regarding the preparation of an EIS/R for the Reach 4B Project. During the scoping meetings and throughout the public scoping comment period, Reclamation and DWR accepted comments to help determine the range of alternatives, the environmental effects, and the mitigation measures to be considered in the upcoming EIS/R. Suggestions regarding alternatives were documented in two Scoping Reports and have been considered in this Initial Alternatives TM.

The public will have an opportunity to review and comment on the Reach 4B Project Draft and Final EIS/R documents when these documents are released for public review. The initial alternatives will be presented for comment at a public Restoration Goals Technical Feedback Meeting. The public will also have the opportunity to attend public meetings on the Reach 4B Project EIS/R.

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# 5.0 Initial Alternatives

This section presents the initial alternatives identified to meet the purpose and need/project objectives for the Reach 4B Project.

## 5.1 Overview

This section describes five initial alternatives that represent a range of potential actions within the river and bypass channels. The initial alternatives include a description of the channel modifications and identification of the structural modifications. Table 5-1 shows a summary of the five initial alternatives and the measures included in each initial alternative. These alternatives include two “bookend” alternatives that bracket the range of potential modifications in the river channel and bypass (Alternatives 1 and 2) with three additional alternatives in between the bookends. The initial alternatives and associated structural modification concepts presented in this chapter are at a conceptual level of detail and require further development. Coordination with the Implementing Agencies, Settling Parties, and stakeholders will help to refine these initial alternatives.

**Table 5-1.**
**Summary of Initial Alternatives**

| Alternative Number | Alternative Name | Description | Page Number |
|---|---|---|---|
| 1 | Primary Restored Channel in San Joaquin River | All fish and flows from Reach 4A would go into Reach 4B, which would have capacity of 4,500 cfs and rearing habitat | 5-5 |
| 2 | Primary Restored Channel in Bypass | Eastside and Mariposa bypasses would be the primary channel for flow and fish; Reach 4B channel would provide offset for changes in flood conveyance capacity | 5-9 |
| 3 | Flows of at least 475 cfs in San Joaquin River with Eastside Bypass as High Flow Floodplain | Reach 4B channel would be the primary low-flow channel for flows less than 475 cfs; the surplus of flows above this capacity would pass down the Eastside Bypass, which would provide floodplain habitat | 5-15 |
| 4 | Split Flow, Fish-Friendly Bypass | Reach 4B channel would be the primary channel for base and fall pulse flows; spring pulse flow would be split between river and bypasses | 5-19 |
| 5 | Split Flow, Fish Enhancements Focused in River | Reach 4B channel would be the primary channel for fish; fish would be screened out of the bypasses | 5-22 |

Many of the structural modifications are included in more than one initial alternative; therefore, Section 5.3 presents these concepts. Table 5-2 includes a list of these structural modifications that may be included in multiple initial alternatives and the page numbers where they are described.

**Table 5-2.
Structural Modifications**

| Concept ID | Description | Page Number |
|---|---|---|
| ***Structural Modification Concepts: Modify Head Gates for Fish Passage and Flows*** | | |
| **HG-1** | Radial Gates | 5-26 |
| **HG-2** | Hinged Crest Gates | 5-27 |
| **HG-3** | Roller Gates | 5-28 |
| **HG-4** | Inflatable Dams | 5-28 |
| ***Structural Modification Concepts: Fish Screens*** | | |
| **FS-1** | Vertical Fixed Plate Screens | 5-29 |
| ***Structural Modification Concepts: Fish Ladders or Bypasses*** | | |
| **LAD-1** | Culvert and Step-pool Bypass Structure | 5-31 |
| **LAD-2** | Culvert and Roughened Channel Fishway | 5-33 |
| **LAD-3** | Fish Ladder | 5-34 |
| **NOT-1** | Spillway Crest Notching | 5-36 |
| ***Structural Modification Concepts: Road Crossings*** | | |
| **RD-1** | Round Culverts | 5-37 |
| **RD-2** | Corrugated Steel Partially Buried Pipe Arch Culverts | 5-38 |
| **RD-3** | Partially Buried Concrete Box Culverts | 5-38 |
| **RD-4** | Bridges | 5-39 |
| ***Refuge Modification Concepts: Modify Weirs for Fish Passage and Flows*** | | |
| **REM-1** | Weir Removal or Reoperation | 5-41 |
| ***Structural Modification Concepts: Barriers to Upstream Fish Migration*** | | |
| **BAR-1** | Fixed Bar Screens | 5-42 |
| **BAR-2** | Hinged Floating Picket Weirs | 5-43 |
| **BAR-3** | Vertical Drop Structure | 5-43 |

Key:
HG = Hydraulic control gates
FS = Fish Screens
LAD = Fish Ladders
NOT = Notches
RD = Road crossings
BAR = Fish barriers
REM = Weir Removal or Reoperation

## 5.2 Initial Alternatives

For the entire SJRRP to be successful, the San Joaquin River must provide suitable habitats for spawning, feeding and rearing, refugia for different life stages, and successful movement (migration) among and between the reaches to allow target species of fish to successfully complete their life history. The initial alternatives for the Reach 4B Project are primarily focused on the goal of providing for the feeding and rearing, refugia, and migration of native fishes, emphasizing spring-run and fall-run Chinook salmon. Fish passage is the upstream or downstream movement of fish beyond an instream impediment to migration; it typically involves a discrete obstacle that requires a short (though metabolically demanding, stressful, and potentially risky) burst of effort. Impediments can also make fish more vulnerable to predation (e.g., in scour pools at the foot of vertical steps in the river profile and by concentrating fish through “bottlenecks” where predators gather). Examples of such obstacles include culverts, shallow riffles, vertical barriers or obstacles, and irrigation diversions.

Providing for passage requires considerations of fish behavior, physiology, and bio-mechanics, in addition to physical habitat conditions (hydraulics, velocity, depth, height, distance) and needs of target species and life stages (NMFS 2008). Migrations are movements involving regular cyclic alternation between different habitats used for spawning and feeding, or to avoid harsh environmental conditions. Migrations take place over much longer distances than passage, and so exposure to risks and stressors is much more prolonged, though usually less intense. Migration must provide ambient conditions over a long distance that support healthy fish, including resting, shelter, and (for juvenile emigrants) feeding opportunities.

In addition, refuge from predators and high flows are required. In the case of juvenile salmonids, migration to the marine environment overlaps with the rearing stage of the fish’s life cycle. Therefore, these juveniles not only need sustenance to carry out their emigration, but also use the emigration period to feed, gain weight, and undergo physical adaptations for adult life in the ocean. Thus, meeting migration goals for juvenile fish requires provision for rearing during migration. Suitable habitat for the migration of juvenile Chinook salmon, including rearing, may be provided through the Reach 4B Project study area either by modifications to the San Joaquin River channel or modifications to the bypass system. In either case, the methods and desired results of modifications would be similar, though the opportunities and constraints in the channel and bypass system differ.

The Reach 4B Project would develop an artery of waterways that activate and deactivate depending on quantity and quality of water and time of year appropriate for target fish requirements. Complexity of waterways would include primary and secondary channels as well as floodplains that function in unison with the developed hydrograph, providing fish habitat (e.g. passage, rearing, foraging) for the appropriate time and duration while reducing the possibility of fish stranding often associated with a receding hydrograph or off channel diversions. Management of nuisance aquatic vegetation would continue to be a problem in Reach 4B and would require maintenance to minimize potential water quality, predator and physical barriers to fish movement. Developing channels that would minimize habitats conducive to nuisance aquatic vegetation will be emphasized during the design phase of the project. Furthermore, barriers would be used, when appropriate, guide fish away from false channels and diversions that are deemed detrimental to successful fish passage and the overall success of long term management goals associated with the Reach 4B Project.

Five initial alternatives have been developed for the San Joaquin River Channel and the bypasses. Alternatives 1 to 5 focus on different fish routes, and accommodating different flow levels. Alternatives 1 and 2 bookend the potential modifications to the river and bypass channels. Alternative 1 focuses on using the San Joaquin River to convey all Restoration Flows and fish. Alternative 2 focuses on using the San Joaquin River channel as a flood bypass to offset reductions in flood conveyance in the Eastside and Mariposa bypasses. This allows modifications to be made in the bypasses to enhance their suitability for fish migration, such as increases in channel roughness due to vegetation. Alternatives 3, 4, and 5 represent alternatives that split flows between the river and bypass system. Some alternatives route flows through the Mariposa Bypass and Reach 4B2 of the San Joaquin River, while other alternatives route flows through Eastside Bypass Reach 3. At this point in the evaluation, no information exists to determine which route would be more suitable for fish. Alternatives include different routes to allow a comparison as the alternative development process further analyzes these alternatives.

In Reach 4B1 of the San Joaquin River, restoring flows and cleaning excess sediment and non-aquatic vegetation out of the channel where needed should provide conditions that support some migration and in-channel rearing. In-channel rearing habitat may be provided by channel complexity (in the form of meanders, pools, bankside vegetation, and root masses) through the production of invertebrate prey items on the natural substrate and the input of terrestrial prey items from the surrounding vegetation.

All initial alternatives create opportunities to enhance migration, refugia, and feeding for salmonids. This is achieved by adding channel complexity features, such as large woody debris (LWD) and by adding inset floodplain benches or providing sufficient flow to activate existing potential floodplain areas.

LWD and other in-stream complexity and habitat structures can be used to support fish rearing and migration both directly and indirectly. Complexity structures, such as root wads and rock clusters, create flow convergence and divergence, which leads to pool scour and sediment sorting. These geomorphic processes sustain the different ecological functions needed by fish, such as:

- Providing feeding opportunities for fish by creating flow separations that concentrate food in the water column by stimulating bed sediment deposition, sorting that provides substrate for invertebrates, and supplying decaying wood that feeds invertebrates

- Providing shelter from high flows, predators, or high air temperatures by creating scour pools, undercut banks, and direct shelter in the structure itself

There are potential trade-offs between the benefits of LWD and the detrimental effects, which include:

- Additional costs
- The risk of LWD structures breaking free during flood events and causing damage downstream
- The potential for LWD scour pools to harbor predators to salmonids

Vegetated floodplain benches create additional feeding and shelter opportunities:

- When flooded they initially supply a source of terrestrial invertebrates that are a food source for juvenile salmonids
- When flooded for at least two weeks, they allow a food chain to build up, starting with phytoplankton that in turn supply zooplankton that are themselves a source of food for juvenile salmonids
- During high flows, floodplains provide lower-velocity water flows, allowing adult immigrating salmonids to move upstream with less energy expenditure (or to await slower flows after the peak has passed) and allowing juvenile emigrants to move downstream more slowly

The potential negative effects associated with floodplain areas include:

- Increased retention and exposure of water to the sun and to warmer ambient air, leading to heating and thermal stress to fish in the channel downstream
- Increased cost associated with construction

Because of these potential trade-offs, the different channel modifications presented under the alternatives provide different degrees of channel modification, feeding or rearing opportunities, in-channel structures, river-floodplain connectivity, and floodplain structural elements. Some alternatives would require relocated or expanded levees, but that information has not yet been developed. This TM has not attempted to fully develop each of the initial alternatives at this stage, but rather bracket a wide range of options for discussion purposes, and provide a base template on which conceptual designs can be fully developed.

### 5.2.1 Alternative 1 – Primary Restored Channel in San Joaquin River

Under this alternative, Restoration Flows up to 4,500 cfs would be routed down Reach 4B of the San Joaquin River. All flows greater than 4,500 cfs would be routed down the bypass system. A Reach 4B1 capacity of 4,500 cfs would allow all flow from Reach 4A to be routed into Reach 4B1. Under this alternative, for flows up to 4,500 cfs, adult salmon would migrate upstream and juvenile salmon downstream along the San Joaquin River. The river would provide both in-channel habitat and access to wide, frequently inundated floodplains. During Flood Flows greater than 4,500 cfs, fish could be washed into the bypass, or could migrate up into the bypass. Due to the infrequency of such events, no effort would be made to prevent Chinook salmon and other target fish species from entering the bypass system during such flows. Figure 5-1 presents the flow routing for Alternative 1.

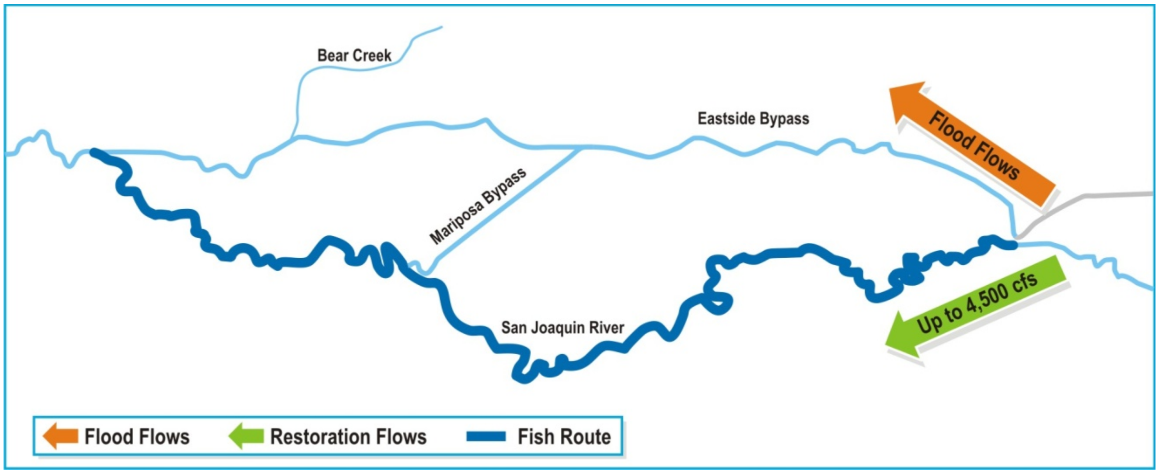



**Figure 5-1.**
**Alternative 1 – Primary Restored Channel in San Joaquin River**

#### *5.2.1.1 San Joaquin River Channel*

The San Joaquin River channel does not have capacity to convey 4,500 cfs in Reach 4B1 under current conditions. Under Alternative 1, the San Joaquin River levees would be set back and engineered to contain 4,500 cfs within the channel and floodplain.

**Headgates and Sand Slough Area**

The Headgates at the upstream end of Reach 4B of the San Joaquin River would be removed to allow all flows from Reach 4A to enter Reach 4B. Design capacity at the downstream end of Reach 4A is 4,500 cfs; therefore, all flow should be able to enter Reach 4B. Gates would be constructed in place of the current Sand Slough Control Structure to prevent water from traveling between the river channel and bypasses during normal operations. These gates could be opened during flood events to increase operational flexibility.

**Habitat Modifications in Reach 4B**

The addition of setback levees under this alternative allows for an expanded range of habitat features, including more riparian vegetation and floodplain rearing areas. Under Alternative 1, in-channel vegetation would be left in place except for any major flow or fish impediments, which would be cleared. Over time, the presence of flows would kill non-riparian vegetation and support a transition to riparian species. Native riparian vegetation along the channel banks and between the banks and the levees would be preserved and enhanced. Between the setback levees and the river channel the floodplain would be regraded to eliminate fish stranding areas and to encourage gentle drainage towards the river. Secondary channels and lower floodplain areas would be cut to create areas that inundated at different flow rates. These features would be designed to inundate at flows corresponding to species needs and water availability (based on the Restoration Flow schedule). Figure 5-2 shows a schematic of river channel habitat modification.

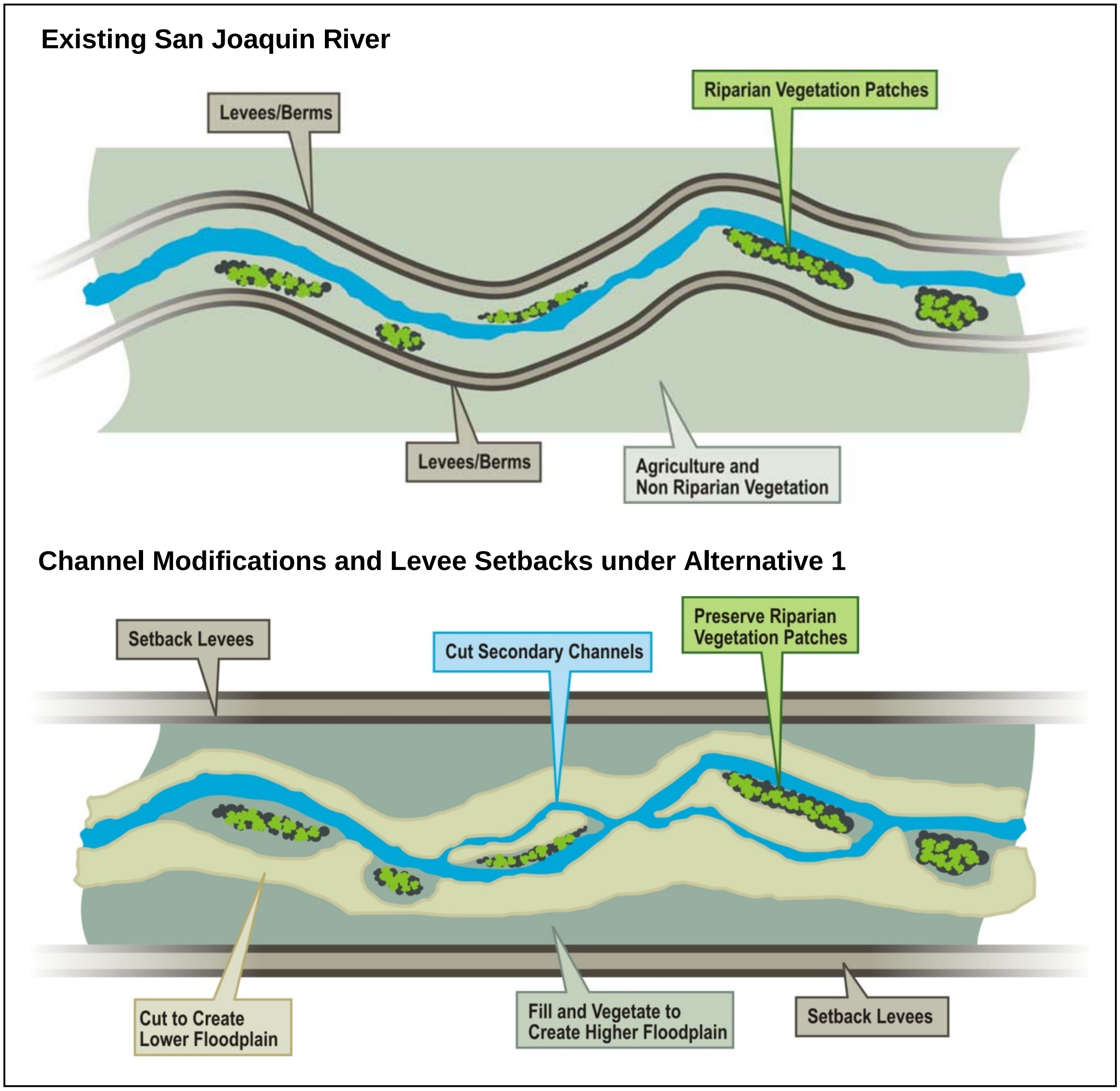



**Figure 5-2.**
**Alternative 1 - Example of Channel Modifications and Levee Setbacks**

**Channel Modifications in Reach 4B**

Vegetation clearing would involve limited mechanical grubbing (cutting down selected vegetation in the San Joaquin River channel alignment (between the banks) and scraping the surface to remove any organic soil). The setback levees would provide increased flood capacity; therefore, this alternative would include minimal vegetation clearance. The newly exposed channel banks would be treated for erosion control (typically by covering them in biodegradable coir fabric) and seeded with native grasses, shrubs, and trees to establish a new bank cover. Construction would be carried out with typical grading equipment during the dry season. Figures 5-2 and 5-3 present an example of setback levees under Alternative 1.

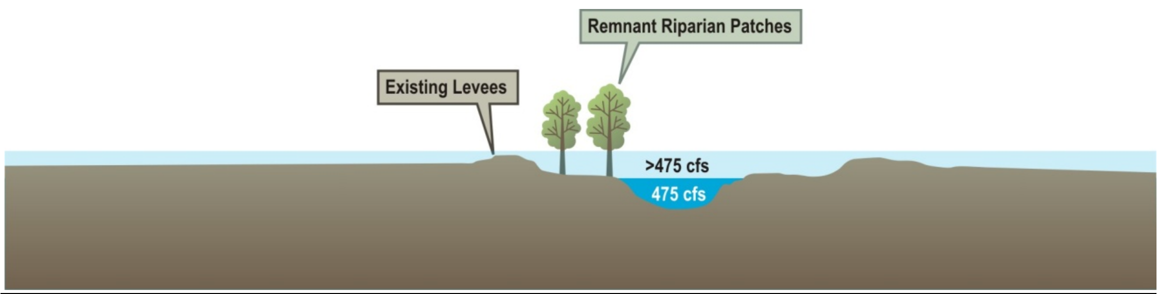



**Figure 5-3.
Alternative 1 - Example Cross Section of Channel Modifications and Levee Setbacks**

**Crossings in Reach 4B**

Road bridges at Washington/Indiana Road and Turner Island Road, as well as three road crossings and associated culverts would need to be replaced to allow 4,500 cfs to flow through the channel and to allow both upstream and downstream fish passage. A fourth unnamed road crossing currently connects the southern levee road to a privately owned park in the center area of the San Joaquin River channel. With the flows in this alternative, the park would become inundated and therefore the preliminary assumption is that this crossing would no longer be required. Consequently, there are no improvements planned for this crossing. Section 5.3.5 describes potential concepts for road crossing improvements.  Reach 4B2 may have potential barriers to fish passage; these barriers will be evaluated as the Reach 4B Project progresses.

#### *5.2.1.2 Eastside Bypass and Mariposa Bypass*

Under this concept, flows greater than 4,500 cfs would be routed through the bypass system. Because such flows would happen less frequently, Alternative 1 includes no provision of rearing habitat or modifications to allow fish passage within the bypasses. As described above, headgates would be added to Sand Slough that, when opened, would allow Flood Flows to pass down the Eastside Bypass. Potential gate concepts are described in Sections 5.3.1.1 through 5.3.1.4.

### 5.2.2 Alternative 2 – Primary Restored Channel in Bypass

Under this alternative, all Restoration Flows and up to 16,000 cfs of Flood Flows would be routed down the Eastside Bypass, through the Mariposa Bypass, and into Reach 4B2 of the San Joaquin River. Adult salmon migrating upstream would enter the San Joaquin River at Reach 4B2, would be directed up the Mariposa Bypass over modified structures that allow fish passage, and would pass up Reach 2 of the Eastside Bypass before rejoining the San Joaquin River channel at the junction of Reach 4B1 and Reach 4A. Juvenile salmon migrating downstream would follow the same path in reverse. This pathway would be restored to provide rearing habitat and barriers to migration would be removed or modified. Adult salmon would be barred from migrating into the Eastside Bypass Reach 3 by a barrier at the downstream end. Some juveniles would be washed into the Eastside Bypass Reach 3 and the San Joaquin River Reach 4B1 during rare flood events, though a portion of these would likely be able to pass down the flooded reaches and rejoin the river downstream.

Reach 4B1 of the San Joaquin River would be modified to convey at least 475 cfs of flood relief for the Eastside Bypass and to compensate for increases in roughness in the Eastside Bypass due to habitat restoration. It is likely that this would not, on its own, provide enough flood relief to allow for habitat in the Eastside Bypass, in which case levee setbacks or channel improvements would still be needed in the bypass. Figure 5-4 presents the flow and fish routing for Alternative 2.

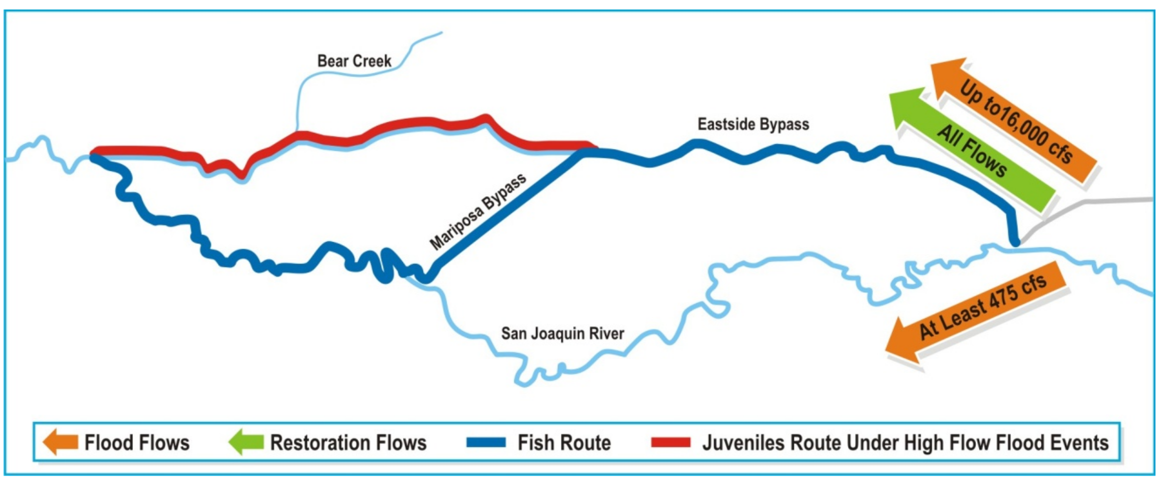



**Figure 5-4.**
**Alternative 2 – Primary Restored Channel in Bypass**

#### *5.2.2.1 San Joaquin River Channel*

The San Joaquin River channel does not have capacity to convey 475 cfs in Reach 4B1 under current conditions. Under Alternative 2, in-channel vegetation would be removed from an estimated 8.5 miles of channel to bring it up to capacity, and a combination of vegetation and sediment removal would be carried out over an estimated additional 3.5 miles of channel that are more constricted (See Figure 5-5). DWR's preliminary HEC-RAS modeling demonstrated that these actions would allow Reach 4B1 to convey 475 cfs without overflowing the existing levees or banks.


**Figure 5-5.**
**Alternative 2 – Example of Channel Excavation and Vegetation Clearing in the San Joaquin River**

**<u>Headgates and Sand Slough Area</u>**

A new headgate would be constructed at the upstream end of Reach 4B to divert all Restoration Flows into the Eastside Bypass but allow limited flow during very large floods. Section 5.3.1 describes the potential concepts for gates. The Sand Slough Control Structure would be removed.

**<u>Habitat Modifications in Reach 4B</u>**

Under Alternative 2, in-channel vegetation would be removed from an estimated 8.5 miles of the Reach 4B1 channel, and a combination of vegetation and sediment removal would be carried out over an estimated additional 3.5 miles of channel that are more constricted. The remaining habitat would be preserved. This disturbance would be limited to the extent required to provide 475 cfs of conveyance capacity and would be conducted so as to preserve existing habitat value to the extent possible. Because fish would rarely be present in this reach, no additional habitat modifications would occur.

**<u>Channel Modifications in Reach 4B</u>**

Vegetation clearing would involve mechanical grubbing, including cutting down all vegetation in the San Joaquin River channel alignment (between the banks) and scraping the surface to remove any organic soil. Vegetation along the edge of the channel (trees and understory) would be preserved wherever possible to provide a riparian corridor. The newly exposed channel banks would be treated for erosion control (typically by covering them in biodegradable coir fabric) and seeded with native grasses, shrubs, and trees to establish a new bank cover. Construction would be carried out with typical grading equipment during the dry season.

**Crossings in Reach 4B**

Four unnamed dirt road crossings in Reach 4B1 would need to be replaced by structures that do not create a hydraulic impediment. This would likely involve improving the crossings by clearing out existing culverts or replacing the crossings. Section 5.3.5 describes a variety of concepts for road crossings, including different types of culverts. The existing bridges in this reach would not require improvements. Reach 4B2 may have potential barriers to fish passage; these barriers will be evaluated as the Reach 4B Project progresses.

#### *5.2.2.2 Eastside Bypass and Mariposa Bypass*

Under this concept, all flows up to 16,000 cfs would be routed through the Eastside and Mariposa bypasses. Thus, under this alternative, all necessary features for all life stages of Chinook salmon and other target species supported by the Restoration Flows must be provided within the bypass system. Because the provision of a 475 cfs flood capacity increase using the Reach 4B river channel does not by itself allow for much habitat creation in the Eastside and Mariposa bypasses, additional structural modifications to the bypasses (such as additional channel and levee improvements) would be included in this alternative to allow for additional habitat while maintaining flood conveyance capacity and operational flexibility.

**Habitat Modifications in the Bypasses**

The existing channel in the Eastside Bypass upstream of the Mariposa Bypass would be enhanced to provide a channel suitable for both fish passage and rearing of Chinook salmon and other target fish species. A narrow, deep channel would be excavated within the existing wide, shallow channel, leaving the remaining channel as a secondary higher flow area that would either be actively revegetated or allowed to passively revegetate with tules and other vegetation over time. Additional secondary channels would be graded into the floodplain to provide a diversity of depth and velocities across a range of flow levels. Vegetation management practices would be modified to allow vegetation that is beneficial to habitat to persist while maintaining the conveyance capacity of the bypass system to the extent not offset by new San Joaquin River conveyance.

Channel enhancement actions may include creating a riparian corridor around the channel to provide shade, cover, and inputs of nutrients and woody debris. Establishing a riparian corridor in the bypasses would take some time (10-15 years to provide significant shade along the channel) and would be challenging due to the highly-erodible, sandy soils. LWD habitat elements could be introduced into the channel to improve rearing and shelter for target fish species. LWD would need to be anchored or keyed into the banks to minimize wood movement during Flood Flows. Parts of the bypass floodplain area would be locally regraded to create lower floodplain areas and secondary channels that inundated more frequently, thereby providing floodplain rearing areas and high water refugia at certain flow rates. Surplus material graded from the lower areas would be disposed of within the bypasses to form topographic heterogeneity, beneficial to supporting in-channel heterogeneity, and shallow depth refugia at high flows. Any excess material would be placed so as to avoid impacts to existing flood control facilities and conveyance capacity.

The channel would be designed to maximize sediment transport over the expected flow regime within the constraints of fish passage geometry demands, including both Restoration and Flood flows. Channel geometry would also be designed to reduce potential temperature increases, concentrate lower flows to facilitate drainage, and support fish passage during flow ramp-down periods.

This concept would support immigration of adult Chinook salmon and other target species. It would also support emigration of juvenile Chinook salmon as it would provide juvenile rearing habitat, including in-channel habitat. For migration through a reach as long as the bypass system, rearing habitat would be required by juvenile Chinook salmon for successful emigration.

**Channel Modifications in the Bypasses**

Under existing conditions, the Mariposa Bypass Control Structure is six feet higher than the Eastside Bypass Control Structure, requiring a backwater at the Eastside Bypass before water can be forced into the Mariposa Bypass. Furthermore, the Mariposa Bypass has a very flat gradient culminating in a vertical eight foot drop at the downstream end. These two features create a flat gradient upstream in the Eastside Bypass that reduces flow conveyance and creates fish passage barriers. Major elements of Alternative 2 include the removal of the Mariposa Bypass Drop Structure for fish passage and sediment transport, and the notching of the Mariposa Bypass Control Structure. These actions would allow the channel through the bypass to be regraded to gradually lose elevation over the length of the bypass. The resulting channel would be deeper and somewhat more defined than the existing channel, which is very flat and shallow. It would create some additional flood conveyance through the Mariposa and Eastside bypasses, allowing for more habitat restoration. However, some levee modifications may still be necessary to achieve the required level of habitat needed to meet fish needs. This alternative might also require levee strengthening in the Mariposa Bypass to accommodate higher Flood Flow velocities.

Alternative 2 includes a two stage primary channel through the bypass system capable of containing at least 475 cfs, the approximate magnitude of the Dry Year fall attraction flow, so that the attraction flow would be concentrated in a channel suitable for immigration of adult Chinook salmon and other target species. In addition to supporting the immigration of adult fall and spring-run Chinook salmon through the primary channel, breakout flows into elevated side channels or the bed of the bypass must occur at flows between 475 cfs and 1,225 cfs (the magnitude of the smallest spring pulse flows included in the Restoration Flows). Connectivity to shallow water habitats at this flow range would provide lower-velocity areas suitable for rearing habitat for juvenile Chinook salmon under spring pulse Restoration Flows in most years in such side channels or the bed of the bypass, which would function as floodplain to the primary channel. The floodplain portion of the bypass would be graded towards the channel to prevent fish stranding when flows receded. In addition, numerous ponds and borrow areas would be filled to prevent fish stranding.

Grade breaks or terraces within the primary channel cross section would be provided to contain the anticipated range of Restoration Flows at appropriate depths and velocities for the life stages of fish present at those flows. For example, a channel terrace at the 175 cfs level would keep flows below that level well confined to facilitate the migration and passage of adult Chinook salmon following a potential "pulse flow" to attract Fall Run in drier than average years, and throughout the migration period in wetter years when Restoration Flows are available. An additional increment of confined primary channel such that the channel is capable of conveying at least 475 cfs would also be included, associated with pulse flows in Normal Dry and Dry years. A second in-channel terrace may be included at the stage associated with 475 cfs to contain any Restoration or Flood flows greater than 475 cfs but less than the maximum capacity of the channel. The primary channel width required is estimated to be greater than 100 feet wide to carry the anticipated range of Restoration Flows within the primary channel, at desirable depths and velocities for adult Chinook salmon immigration. Figure 5-6 presents an overview of Alternative 2 in the Eastside Bypass. Figures 5-7 and 5-8 show the existing cross section the Eastside Bypass and potential modifications included in Alternative 2.

Construction of the primary channel would generate fill material that may be retained within the bypass, though conveyance capacity must be maintained.

**<u>Crossings in the Bypasses</u>**

Low flow crossings in the bypasses would be evaluated taking into account likely flow scenarios, including inflows from Bear Creek, and those that are likely to be fish passage barriers or that have uses that would be affected by flooding would be improved. The crossings currently assumed to require improvements are West El Nido Road, Dan McNamara Road, and an unnamed crossing in the Mariposa Bypass; however, additional analysis will be undertaken to verify this. Section 5.3.5 describes potential concepts for road crossings.

**<u>Mariposa Bypass Control Structure</u>**

The two center bays of the Mariposa Bypass Control Structure would be notched by approximately six feet and the existing plunge pool on the downstream side of the structure filled to eliminate potential fish predator habitat under Alternative 2. This, with channel regrading on either side, would bring them to the same elevation as the existing channel, allowing fish and sediment passage. See Section 5.3.4.3 for more detail on the concept for notching.


**Figure 5-6.**
**Alternative 2 – Example of Channel Excavation in the Eastside Bypass**

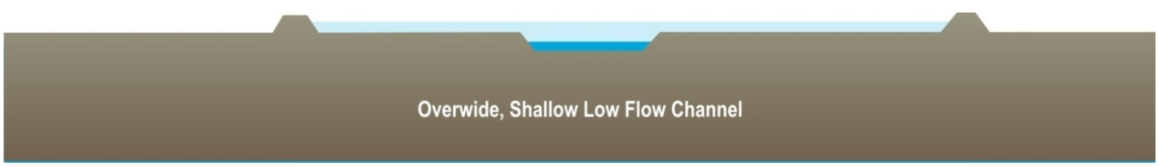



**Figure 5-7.**
**Existing Channel in Eastside Bypass**

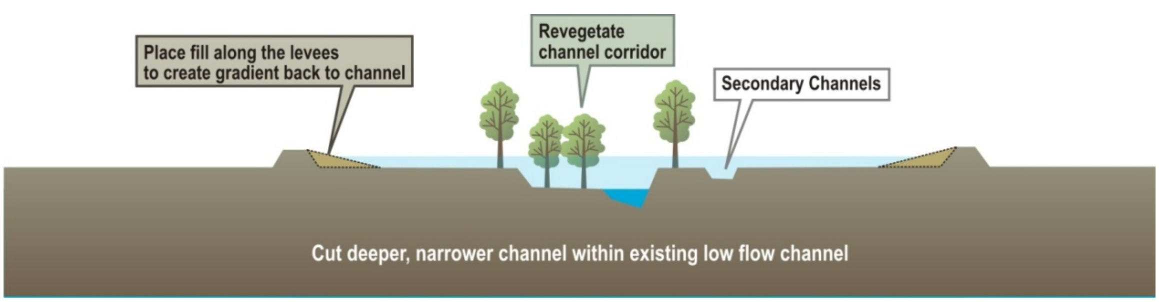



**Figure 5-8.**
**Cross-section of Eastside Bypass Channel Modifications under Alternative 2**

**Mariposa Bypass Drop Structure**

The Mariposa Bypass Drop Structure would be removed under Alternative 2 and the plunge pool downstream filled to eliminate potential fish predator habitat.

**Eastside Bypass Control Structure**

No changes would be made to the Eastside Bypass Control Structure.

**Confluence of Eastside Bypass Reach 3 and San Joaquin River Reach 5**

Currently there is no structure in this location. A drop structure or other barrier (see Section 5.3.7) may be needed to prevent adult anadromous fish from migrating up into the Eastside Bypass and is included. The barrier could also be constructed at the confluence of Bear Creek and Eastside Bypass Reach 3.

### 5.2.3 Alternative 3 – Flows of at least 475 cfs in San Joaquin River with Eastside Bypass as High Flow Floodplain

Under this alternative, the San Joaquin River would have the capacity to convey Restoration Flows of at least 475 cfs. Restoration Flows greater than 475 cfs and all Flood Flows would be routed down the Eastside Bypass Reaches 2 and 3. No Restoration Flows would be routed down the Mariposa Bypass. Under this alternative, during flows up to 475 cfs, adult salmon would migrate up the San Joaquin River channel while juveniles would migrate down the same channel. The river channel would provide in-channel rearing and migration needs but would not have significant areas of inundated floodplain. For flows greater than 475 cfs, adults migrating upstream and juveniles migrating downstream could split and pass down either channel. The Eastside Bypass channel would function as a floodplain (comparable to the Yolo Bypass during flood years on the Sacramento River) though a channel would be cut to prevent fish stranding and facilitate migration. Some fish could pass down the Mariposa Bypass during rare flood events. Fish would not be able to enter the Mariposa Bypass in the upstream direction because of the Mariposa Drop Structure. Fish passage barriers would be removed from both the San Joaquin River channel and the Eastside Bypass. Flood Flows would be routed down the Eastside Bypass. Figure 5-9 presents the flow and fish routing for Alternative 3.

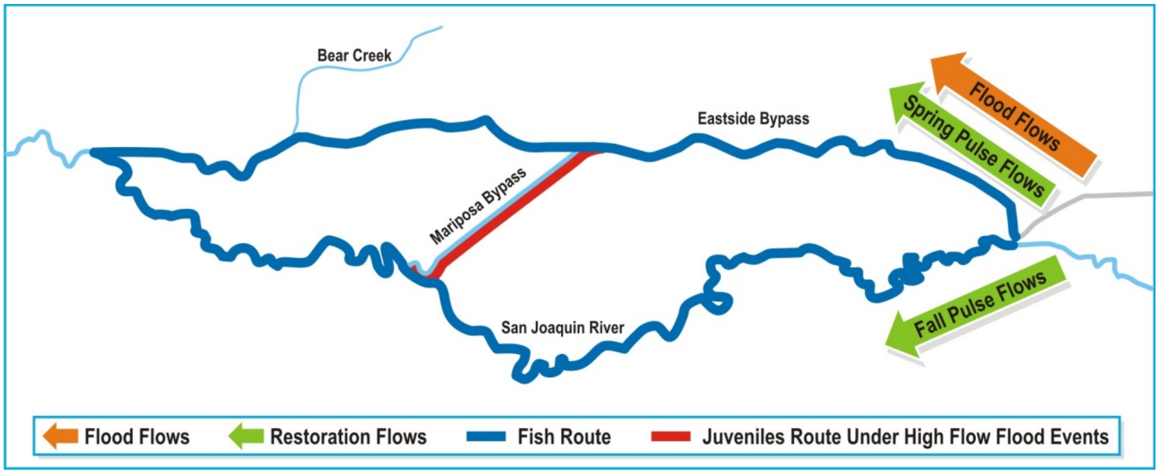



**Figure 5-9.**
**Alternative 3 – Flows of at least 475 cfs in San Joaquin River with Eastside Bypass as High Flow Floodplain**

#### *5.2.3.1 San Joaquin River Channel*

Under Alternative 3, in-channel vegetation would be removed from an estimated 8.5 miles of channel to bring it up to capacity, and a combination of vegetation and sediment removal would be carried out over an estimated additional 3.5 miles of channel that are more constricted (see example in Figure 5-5). DWR's preliminary HEC-RAS modeling demonstrated that these actions would allow Reach 4B1 to convey 475 cfs without overflowing the existing levees or banks.

**Headgates and Sand Slough Area**

The 4B Headgate at the upstream end of Reach 4B of the San Joaquin River would be reconstructed with new gates to allow flows of up to 475 cfs to pass through them. Section 5.3.1 describes several concepts for the proposed gates. Because of the wide range of flows entering Reach 4B from Reach 4A, the headgates and associated fish passage structures would be complex. A fish ladder with multi-level fish entrances would be constructed to allow upstream and downstream fish migration for the target species. Flashboards would be added to the Sand Slough Control Structure to direct water into Reach 4B1, or a gated structure would be added between the Headgate and the Sand Slough Control Structure to allow water to be backed up and diverted through Reach 4B1.

**Habitat Modifications in Reach 4B**

Under Alternative 3, as for Alternative 2, in-channel vegetation (between the banks) would be removed from an estimated 8.5 miles of channel, and a combination of vegetation and sediment removal would be carried out over an estimated additional 3.5 miles of channel that are more constricted. For Alternative 3, however, additional habitat enhancement would be undertaken. Native riparian vegetation along the channel banks and between the banks and the levees would be preserved and enhanced. In reaches where channel capacity allows, additional riparian vegetation would be planted to provide shade and a riparian corridor. LWD habitat elements would be added to the channel where appropriate, to provide additional cover and complexity. Where used, LWD structures would be anchored or keyed into the banks. Given the limited flows that would be conveyed through this reach, enhancement of floodplain habitat along the channel would not be undertaken. The San Joaquin River channel would provide in-channel rearing and refugia habitat but little floodplain rearing habitat so as to avoid significant out-of-bank flows under this alternative.

**Channel Modifications in Reach 4B**

Vegetation clearing would involve mechanical grubbing (cutting down all vegetation in the San Joaquin River channel alignment (between the banks) and scraping the surface to remove any organic soil). Vegetation along the edge of the channel (trees and understory) would be preserved wherever possible to provide a riparian corridor. The newly exposed channel banks would be treated for erosion control (typically by covering them in biodegradable coir fabric) and seeded with native grasses, shrubs, and trees to establish a new bank cover. Construction would be carried out with typical grading equipment during the dry season.

**Crossings in Reach 4B**

Four unnamed road crossings and culverts in Reach 4B1 would need to be improved or replaced by structures that allow 475 cfs to flow through the channel. Additionally, these new structures would need to be designed to allow fish passage for adults and juveniles in both directions. Section 5.3.5 describes concepts for improving road crossings. The existing bridges in this reach would not require improvements. Reach 4B2 may have potential barriers to fish passage; these barriers will be evaluated as the Reach 4B Project progresses.

#### *5.2.3.2 Eastside Bypass and Mariposa Bypass*

Under Alternative 3, Restoration Flows greater than 475 cfs and all Flood Flows would be routed through the Eastside Bypass. Unlike Alternative 2, the bypasses would be designed to function more like a floodplain than as the main channel for fish migration and rearing. Fish and Restoration Flows would not be routed down the Mariposa Bypass under this alternative. The 475 cfs flood capacity increase in the Reach 4B river channel may not, by itself, accommodate changes in capacity because of habitat creation in the Eastside and Mariposa bypasses. If needed, additional structural modifications to the bypasses (i.e., additional channel and levee improvements) would be included in this alternative to allow for additional habitat while maintaining flood conveyance capacity and operational flexibility.

**Habitat Modifications in the Bypasses**

Under Alternative 3, the Eastside Bypass would provide a functioning floodplain but would still require an improved channel due to its length, the low velocity at moderate flows, and to provide an escape path for fish when flows in the Eastside Bypass recede following inundation. As with Alternative 2, a narrower, deeper channel would be cut within the existing channel in the Eastside Bypass to concentrate flow and provide a narrow, inner floodplain for flows that did not completely inundate the bypass.

Vegetation would be actively planted or allowed to naturally recruit along the channel to provide shade, cover and inputs of nutrients.

This alternative would support immigration of adult Chinook salmon and other target species. It would also support emigration of juvenile Chinook salmon, as it would provide juvenile rearing habitat. For migration through a reach as long as the Eastside Bypass, rearing habitat would be required by juvenile Chinook salmon for successful emigration.

**<u>Channel Modifications in the Bypasses</u>**

Alternative 3 would involve construction of a two stage primary channel through the Eastside Bypass system. The floodplain portion of the bypass would be graded towards the channel to prevent fish stranding when flows receded. In addition numerous ponds and borrow areas would be filled to prevent fish stranding.

Inundation of the bed of the bypass would be triggered at flows greater than the maximum capacity of the primary channel. The channel would be sized to take advantage of this characteristic, triggering activation by out-of-bank flows of suitable rearing habitat for juvenile Chinook salmon under spring pulse Restoration Flows in most years. Figure 5-8 shows an example of modifications in the Eastside Bypass. Construction of the primary channel would generate fill material that may be retained within the bypass without reducing its conveyance capacity.

**<u>Crossings in the Bypasses</u>**

Low flow crossings in the bypasses would be evaluated and those that are likely to be fish passage barriers or that have uses that would be impacted by flooding would be improved. The preliminary analysis has identified West El Nido Road and Dan McNamara Road as requiring improvements; however, additional analysis will be completed to verify this. Section 5.3.5 describes concepts for improving road crossings, such as different types of culverts or bridges.

**<u>Mariposa Bypass Control Structure</u>**

No fish or Restoration Flows would be routed down the Mariposa Bypass; therefore no changes would be made. Some juvenile fish would pass down the Mariposa Bypass during rare flood events when flows exceed the capacity of the Eastside Bypass Reach 3. Fish would not be able to enter the Mariposa Bypass in the upstream direction because of the Mariposa Drop Structure.

**<u>Mariposa Bypass Drop Structure</u>**

Fish would generally not be in the Mariposa Bypass; therefore no changes would be made.

**<u>Eastside Bypass Control Structure</u>**

The Eastside Bypass Control Structure would be modified with the addition of a fish passage facility to allow fish migration. Section 5.3.4 describes potential concepts that could be implemented to allow fish migration, such as fish ladders.

### 5.2.4 Alternative 4 – Split Flow, Fish-Friendly Bypass

Under this alternative, Restoration Flows would be split between the San Joaquin River and the bypass system. The capacity for Reach 4B is not yet determined, but it would convey the base flows, fall pulse, and part of the spring pulse flows. As Restoration Flows exceed the Reach 4B capacity, the surplus Restoration Flows would be routed down the Eastside Bypass Reach 2, returning to Reach 4B2 via the Mariposa Bypass. Under this alternative, adult salmon migrating upstream would travel up the San Joaquin River during lower flows but would also have access to the Eastside and Mariposa bypasses during higher flows. Juveniles migrating downstream would have the same options. The San Joaquin River route would have setback levees to create more capacity and to allow floodplain to be inundated next to the river channel. The Eastside and Mariposa Bypasses would also function as floodplains when flows inundated them, but would have channels constructed to prevent fish stranding and to concentrate low flows as flows rise and fall. Figure 5-10 presents the flow and fish routing for Alternative 4.

#### *5.2.4.1 San Joaquin River Channel*

The San Joaquin River channel has a constrained capacity in Reach 4B1 under current conditions in all areas, and would require engineered setback levees to allow for floodplain rearing habitat.

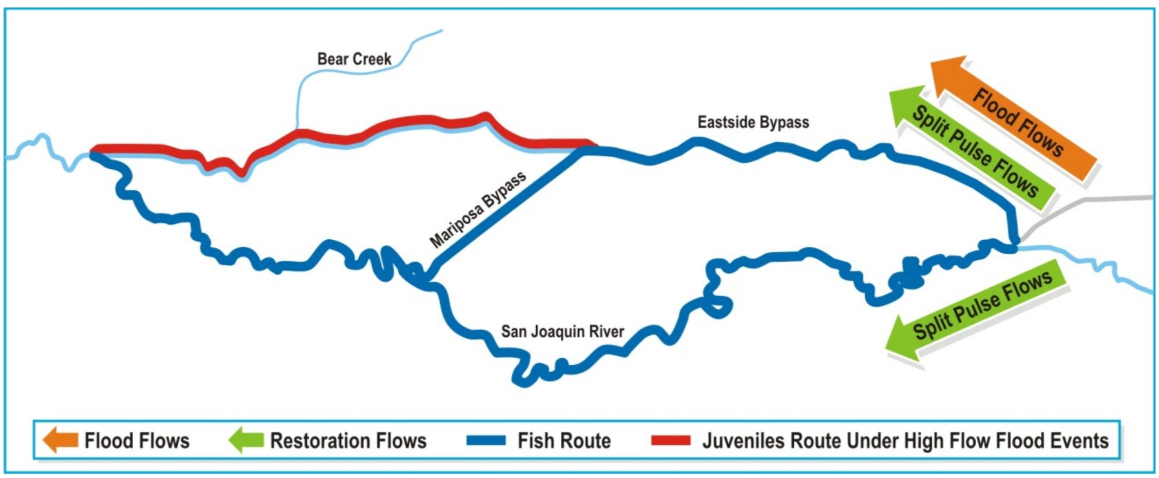



**Figure 5-10.**
**Alternative 4 – Split Flow, Fish-Friendly Bypass**

**<u>Headgates and Sand Slough Area</u>**

Similar to Alternative 3, the Reach 4B Headgates at the upstream end of Reach 4B of the San Joaquin River would be replaced by new gates under Alternative 4. These would be designed to direct base flows, fall pulse flows, and some of the spring pulse flows into the San Joaquin River channel. A fish ladder would be constructed with multi-level fish entrances to allow upstream and downstream fish migration for the species of concern. Design and operation of this feature would be complex because of the wide range of flows and water surface elevations that would have to be accommodated. No changes would be made to the Sand Slough Control Structure. A new gated structure would be required in the current location of the Sand Slough Control Structure to allow water to be backed up and diverted through Reach 4B1.

**Habitat Modifications in Reach 4B**

The addition of setback levees under this alternative allows for an expanded range of habitat features, including more riparian vegetation and floodplain rearing areas. Under Alternative 4, more in-channel vegetation would be left in place compared with Alternative 3, except for any major flow impediments, which would be cleared. Over time, the presence of flows would kill non-riparian vegetation and support a transition to riparian species. Native riparian vegetation along the channel banks and between the banks and the levees would be preserved and enhanced. Between the setback levees and the channel, the floodplain would be regraded to eliminate fish stranding areas and to encourage gentle drainage towards the river. Secondary channels and lower floodplain areas would be cut to create areas that inundated at different flow rates. These features would be designed to inundate at flows corresponding to species needs and water availability (based on the Restoration Flow schedule). For example, side channels would be designed to provide off-channel rearing habitat during spring releases in most years, with more extensive and prolonged floodplain inundation in the spring in wetter years. These modification concepts are similar to those in Alternative 1 (see Figures 5-2 and 5-3).

**Channel Modifications in Reach 4B**

Vegetation clearing would involve limited mechanical grubbing (cutting down selected vegetation in the San Joaquin River channel alignment (between the banks) and scraping the surface to remove any organic soil). As with Alternatives 2 and 3, vegetation along the edge of the channel (trees and understory) would be preserved and enhanced to provide a riparian corridor. Because of the greater flow capacity due to the setback levees, less aggressive channel clearing would be needed for Alternatives 1, 4, and 5 compared with Alternatives 2 and 3. More riparian vegetation would be preserved, and areas of in-channel vegetation that did not pose a hydraulic constraint would be left intact and allowed to die over time due to inundation. The newly exposed channel banks would be treated to control erosion (typically by covering them in biodegradable coir fabric) and seeded with native grasses, shrubs, and trees to establish a new bank cover. Construction would be carried out with typical grading equipment during the dry season.

**Crossings in Reach 4B**

Four unnamed road crossings and culverts in Reach 4B1 would be replaced or improved to improve channel conveyance and allow fish migration. These new structures would need to be designed to allow fish passage for adults and juveniles in both directions. Section 5.3.5 describes concepts for improving road crossings. The existing bridges in this reach would not require improvements. Reach 4B2 may have potential barriers to fish passage; these barriers will be evaluated as the Reach 4B Project progresses.

#### *5.2.4.2 Eastside Bypass and Mariposa Bypass*

Under Alternative 4, flows greater than the capacity of Reach 4B1 would be routed through the Eastside Bypass Reach 2 and the Mariposa Bypass into Reach 4B2. Although the bypass would receive less frequent flows under Alternative 4 than Alternatives 2 and 3, it would still need to provide passage and rearing habitat for Chinook salmon and other species of interest, including measures to prevent stranding during receding flows.

**Habitat Modifications in the Bypasses**

Under Alternative 4, the Eastside Bypass would be active only when Restoration Flows exceed the capacity of Reach 4B1. Thus, as for Alternative 3, it would function as an occasional floodplain but would still need to provide an escape path for fish when flows in the bypass receded following inundation. As with Alternatives 2 and 3, a narrower, deeper channel would be cut within the existing channel in the Eastside Bypass to concentrate flow and provide a narrow inner floodplain for flows that did not completely inundate the bypass. The bed of the bypass would be graded towards the channel to prevent fish stranding when flows receded. In addition numerous ponds and borrow areas would be filled to prevent fish stranding. Habitat modifications may involve vegetation plantings or natural recruitment in the bypasses to provide shade, cover and inputs of nutrients.

This alternative would support immigration of adult Chinook salmon and other target species. It would also support emigration of juvenile Chinook salmon, as it would provide some degree of juvenile rearing habitat, including in-channel habitat. For migration through a reach as long as the Eastside Bypass, rearing habitat would be required by juvenile Chinook salmon for successful emigration.

**Channel Modifications in the Bypasses**

Major elements of Alternative 4 would include the modification of the Mariposa Bypass Drop Structure to allow for fish passage and the notching of the Mariposa Bypass Control Structure. By notching the Control Structure some parts of the Eastside Bypass channel upstream of the Control Structure would be steepened, offsetting the reduction in flood conveyance due to the increase in roughness.

Like Alternative 2, Alternative 4 would include a two stage primary channel through the upper Eastside and Mariposa bypasses. Grade breaks or terraces within the channel cross section would be provided to contain the anticipated range of Restoration Flows at appropriate depths and velocities for the life stages of Chinook salmon and other target fish species present at those flows.

Inundation of the bed of the bypass would be triggered at flows greater than the maximum capacity of the primary channel. The channel must be sized to take advantage of this characteristic, triggering activation by out-of-bank flows of suitable rearing habitat for juvenile Chinook salmon under spring pulse Restoration Flows in most years. These modifications are conceptually similar to those in Alternative 2 (see Figure 5-8). Construction of the primary channel would generate fill material that may be retained within the bypass without reducing its conveyance capacity.

**Crossings in the Bypasses**

Several low flow crossings in the bypasses would be assessed to determine the need for improvements to prevent them from being fish migration barriers and to maintain uses under the modified hydrologic regime. However, as the bypass would be inundated less frequently under Alternative 4 than under Alternative 3, it is anticipated that fewer structures would need improvements under this alternative. The preliminary analysis identified West El Nido Road Dan McNamara Road, and an unnamed crossing in the Mariposa Bypass as requiring improvements for this alternative. Additional analysis will be undertaken to verify this. Section 5.3.5 describes several concepts for road crossing improvements, such as different types of culverts or bridges.

**Mariposa Bypass Control Structure**

The center bays of the Mariposa Bypass Control Structure would be notched by approximately 6 feet under Alternative 4. This, with channel regrading on either side, would bring them to the same elevation as the existing channel, allowing fish and sediment passage. In addition, the plunge pool downstream of the structure would be filled to reduce the risk of fish predation. Section 5.3.4 provides additional details on the concept of notching.

**Mariposa Bypass Drop Structure**

The Mariposa Bypass Drop Structure would be modified under Alternative 4 to allow for fish passage, and the plunge pool downstream filled to eliminate potential fish predator habitat. Section 5.3.3 provides concepts for modifying the structure to provide fish passage.

**Eastside Bypass Control Structure**

Fish would not be intentionally routed down Reach 3 of the Eastside Bypass; therefore no modifications would be made to the Eastside Bypass Control Structure. Some flows may enter Reach 3 of the Eastside Bypass and carry juvenile fish during rare flood events that exceed the capacity of the Mariposa Bypass.

**Confluence of Eastside Bypass Reach 3 and San Joaquin River Reach 5**

Currently there is no structure in this location. As with Alternative 2, a drop structure or other barrier (see Section 5.3.7) would be needed to prevent adult anadromous fish from migrating from Reach 5 of the San Joaquin River upstream into Reach 3 of the Eastside Bypass. The barrier could also be sited at the confluence of Bear Creek and the Eastside Bypass Reach 3.

### 5.2.5 Alternative 5 – Split Flow, Fish Enhancements Focused in River

Under this alternative, Restoration Flows would be split between the San Joaquin River and the bypass system. The capacity for Reach 4B is not yet determined, but it would convey the base flows, fall pulse, and part of the spring pulse flows. As Restoration Flows exceed the Reach 4B capacity, the surplus would be routed down the bypass system. Adult salmon would migrate upstream and juveniles would migrate downstream along the San Joaquin River, which would provide both in-channel rearing habitat and access to inundated floodplains. Fish would be prevented from entering the bypasses in both upstream and downstream directions (to the extent possible), with the San Joaquin River acting as the fish route. Fish enhancements would be focused in the Reach 4B channel; however, some fish passage actions may be necessary in the bypasses if fish cannot be completely excluded from the bypass system. Figure 5-11 presents the flow routing for Alternative 5.

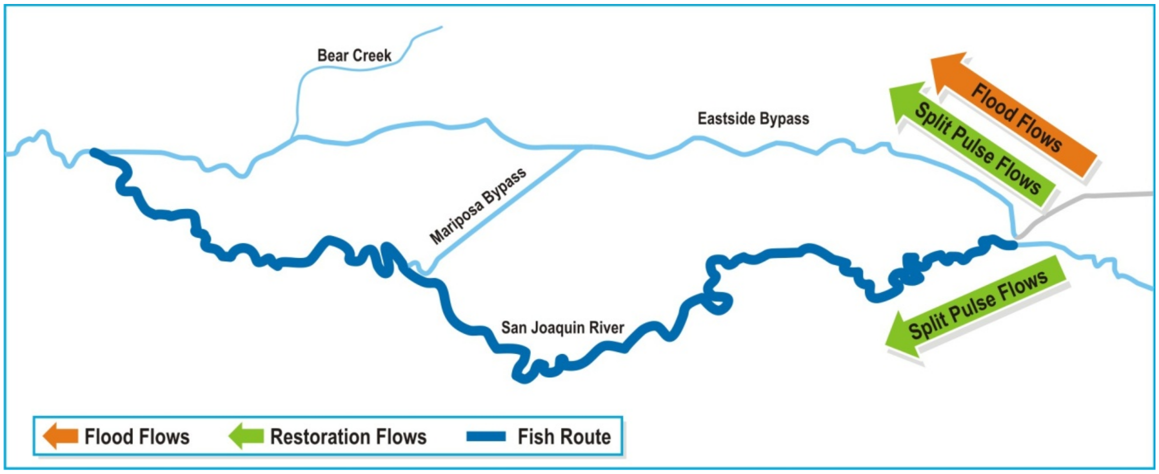



**Figure 5-11.**
**Alternative 5 – Split Flow, Fish Enhancements Focused in River**

#### *5.2.5.1 San Joaquin River Channel*

Modifications to the San Joaquin River channel would be similar to Alternative 4.

**Headgates and Sand Slough Area**

As with Alternative 4, under Alternative 5 the Headgates at the upstream end of Reach 4B would be replaced by new gates to allow flow and fish to pass through them. Section 5.3.1 presents a variety of potential concepts for new gates. A fish ladder would be constructed with multi-level fish entrances to allow upstream and downstream fish migration for the species of concern (See Section 5.3.3.3 for description of a fish ladder). The Sand Slough Control Structure would be modified with a fish screen to prevent fish traveling down into the Eastside Bypass from the San Joaquin River (See Section 5.3.2 for a description of fish screens). The screen would run down the center of the San Joaquin River just upstream of Reach 4B1, parallel with the flow. Maintaining the screen free of debris would be a maintenance challenge though similar facilities have been successful elsewhere. A gated structure would be constructed in place of the Sand Slough Control Structure to cause water to backup for diversion into Reach 4B.

**Habitat Modifications in Reach 4B**

Habitat modifications in the San Joaquin River channel for Alternative 5 would be the same as for Alternative 4, though the width of the floodplain may vary between alternatives. Most in-channel vegetation would be left in place except for any major flow impediments, which would be cleared. Over time, the presence of flows would kill non-riparian vegetation and support a transition to riparian species. Native riparian vegetation along the channel banks and between the banks and the levees would be preserved and enhanced. Between the setback levees and the river channel, the floodplain would be regraded to eliminate fish stranding areas and to encourage gentle drainage towards the river. Secondary channels and lower floodplain areas would be cut to create areas that inundated at different flow rates. These features would be designed to inundate at flows corresponding to species needs and water availability (based on the Restoration Flow schedule).

**Channel Modifications in Reach 4B**

Channel modifications for Alternative 5 would be the same as for Alternative 4. Because of the increased flow capacity provided by the setback levees, less aggressive vegetation removal would be needed under Alternatives 4 and 5 than under Alternatives 2 and 3. Figures 5-2 and 5-3 present an example of a floodplain and setback levee configuration under Alternative 5.

**Crossings in Reach 4B**

Road crossing improvements would be the same as described for Alternative 4. Section 5.3.5 describes several concepts for road crossing improvements.

#### *5.2.5.2 Eastside Bypass and Mariposa Bypass*

Under this concept, flows exceeding the Reach 4B capacity would be routed through the bypass system, but Chinook salmon and other target fish species would be prevented from entering the bypasses. Thus, under this alternative, there would not be a need for rearing habitat or modifications for fish passage within the bypasses. Like Alternative 4, the bypass would receive less frequent flows under Alternative 5 than Alternatives 2 and 3. Unlike Alternative 4, the bypass system would not be enhanced for fish habitat.

Further evaluation of this initial alternative may find that screens and barriers are not effective in preventing fish from accessing the bypasses. In this case, passage improvements at the structures and crossings may be necessary to allow passage at higher flows.

**Habitat Modifications in the Bypasses**

There would be no modifications for habitat. Fish would be prevented from entering the bypasses in both upstream and downstream directions (to the extent possible), with the San Joaquin River acting as the fish route. Fish enhancements would be focused in the Reach 4B channel; however, some fish passage actions may be necessary in the bypasses if fish cannot be completely excluded from the bypass system.

**Channel Modifications in the Bypasses**

There would be no modifications to the channel.

**Crossings in the Bypasses**

Several low flow crossings in the bypasses would be assessed to determine whether they might need to be improved to increase flow capacity. However, since flows would be routed down the bypasses less frequently under Alternatives 4 and 5 than Alternatives 2 and 3, fewer crossings may need modification. The preliminary analysis identified West El Nido Road, Dan McNamara Road, and an unnamed crossing in the Mariposa Bypass as potentially requiring improvements. Additional analysis will be undertaken to verify this. Section 5.3.5 describes concepts for road crossing improvements, such as different types of culverts and bridges.

**Mariposa Bypass Control Structure**

No changes would be made to the Mariposa Bypass Control Structure.

**Mariposa Bypass Drop Structure**

No changes would be made to the Mariposa Bypass Drop Structure.

**Eastside Bypass Control Structure**

No changes would be made to the Eastside Bypass Control Structure.

**Confluence of Eastside Bypass and San Joaquin River**

Currently there is no structure in this location. A drop structure or other barrier (see Section 5.3.7) would be needed to prevent adult anadromous fish from migrating up into the Eastside Bypass. The barrier could also be sited at the confluence of Bear Creek and the Eastside Bypass Reach 3.

## 5.3 Structural Modification Concepts

Several different structures in the Reach 4B Project study area may require modifications to pass fish and convey flows, depending on the scenario, project alternative and on-going studies to assess the alternatives. These concepts could be included in multiple alternatives; therefore, they are described at one time by type of structural modifications. The Reach 4B Project structures that may require modifications under some alternatives include:

- Reach 4B Headgate to enable fish passage and flow routing
- Sand Slough Control Structure to allow fish passage
- Mariposa and Eastside Bypass Control Structures to allow fish passage
- Mariposa Bypass Drop Structure to provide fish passage
- Road crossings to allow passage of fish and flows
- National Wildlife Refuge weirs to allow passage of fish and flows

In addition to the structural modifications, new barriers may need to be constructed in the Eastside Bypass to prevent upstream migration of fish.

The sections below describe the purpose of each modification and identify several different concepts for the modification. Alternatives would not include all of these concepts; several concepts are mutually exclusive. Many of these concepts could apply in more than one location. The structural modification concepts were developed with input from the Design Team and experts from the Implementing Agencies. They represent a wide range of options that may or may not apply to the alternatives.

The structural modification concepts are numbered to help track measures that are related and identify which measures are included in which alternative.

### 5.3.1 Modify Reach 4B Headgate for Fish and Flow Passage

The existing Reach 4B Headgate was designed to allow 1,500 cfs to pass into Reach 4B of the San Joaquin River (see Figure 5-12). The gates have not been operated for several decades. The velocities through the gates and the energy dissipation structure may make the structure impassable for fish and could require replacement of the existing gates. Presented below are concepts to modify the Reach 4B Headgate to allow flow and fish passage. These concepts would apply to Alternatives 1 through 4. Under alternatives 2, 3, and 4, these concepts would likely need to be combined with measures to allow fish passage, such as culverts (RD-1 through RD-3), step pools (LAD-1 and LAD-2), or fish ladders (LAD-3). Under Alternative 5, all Restoration Flows and fish would utilize the San Joaquin River; therefore the Reach 4B Headgate could simply be removed.

**Figure 5-12.**
**Reach 4B Headgate**

#### *5.3.1.1 HG-1 – Radial Gates*

Radial gates are composed of a curved plate that pivots about a fixed point. The flow through the radial gate is controlled by the size of the area between the bottom of the gate and the channel bottom. As the radial gate pivots downward, the area through which water can flow decreases, allowing less water to flow through the structure. Radial gates can either be fully submerged or can extend up above the surface of the water.

Radial gates are typically constructed of carbon steel, stainless steel, aluminum, or cast iron and installed onto concrete frames and supports. Because radial gates close (stop flow) by rotating downwards, they are subject to blockage, since debris can get stuck between the bottom of the gate and the canal bottom.

Because radial gates close (stop flow) by rotating downwards, water can flow under the structure, which would be conducive to passage of fish under the appropriate hydraulic conditions. Depending on the design and flow, radial gates can pose two major issues for fish. During periods where the gates are partially closed, they can create high velocities that would be impassable for fish and can also create sediment issues. Additionally, partial closure can cause fish impingement (when fish are trapped against the outer surface). A fish passage facility (like a fish ladder) could be used to reduce the concerns about fish passage with radial gates.

### *5.3.1.2 HG-2 – Hinged Crest Gates*

A hinged crest gate is composed of a flat plate that rotates from the horizontal position to the vertical position. A typical hinged crest gate is shown in Figure 5-13. These structures control flow by adjusting the flow height behind the gate. As the gate rotates toward the vertical position, the water surface behind the gate increases, allowing less water to flow downstream.

**Figure 5-13.**
**Hinged Crest Gate**

Hinged crest gates are typically constructed of carbon steel, stainless steel, aluminum, or cast iron and installed onto concrete frames and supports. They are installed in open channels spanning the entire width of the channel. Because hinged gates close (stop flow) by rotating upwards, they are not as prone to blockage as radial gates.

Because hinged gates close by rotating upwards, water must flow over the top of the structure, creating a drop on the downstream side of the structure. The ability of fish to pass safely downstream would depend on the height of the fall on the downstream side of the structure. This concept could require additional fish passage measures (such as a fish ladder) as described in Sections 5.3.3 and 5.3.4.

#### *5.3.1.3 HG-3 – Roller Gates*

Roller gates are composed of a metal plate that slides on rollers inside of a vertical track. The flow through the roller gate is controlled by the size of the area between the bottom of the gate and the channel bottom. As the roller slides downward, the area through which water can flow decreases, allowing less water to flow through the structure. The existing Reach 4B Headgate is a manually operated roller gate.

Rollers gates are typically constructed of carbon steel, stainless steel, aluminum, or cast iron, and installed onto concrete frames and supports. They are installed in open channels and span the entire width of the channel. Because roller gates close (stop flow) by advancing downward, they are subject to blockage, since debris can get stuck beneath the bottom of the gate.

Because roller gates close by rotating downwards, water can flow under the structure, which would be conducive to passage of fish. Roller gates have similar fish suitability issues as radial gates (Concept HG-1) and may also require fish passage facilities.

#### *5.3.1.4 HG-4 – Inflatable Dams*

Inflatable dams are composed of a rubber bladder that spans the width of a channel. The bladder can be inflated or deflated by adjusting the amount of compressed air in the bladder. These structures control flow by adjusting the flow height behind the dam. As the dam inflates, the water surface behind the dam increases, reducing the amount of water that can flow downstream. Inflatable dams are ideal for low head, long linear applications, such as along a dam spillway or weir where a fixed water elevation is needed. They have been used commonly where flash boards have been used.

Inflatable dams are typically constructed of a rubber bladder installed onto concrete and/or steel frames and supports. These structures are installed in open channels spanning the entire width of the channel or along spillway crests or weirs. Because inflatable dams close (stop flow) by extending upward, they are not as prone to blockage from trapped debris. Inflatable dams are vulnerable to vandalism from gunfire if located in a remote area. They also have longer response time to control flow due to the filling of the bladder. Inflatable dams are generally used to control the upstream pool conditions and are generally not a good structure to moderate or control downstream flow conditions without other control structures.

Because inflatable dams close (stop flow) by elevating upward, water must flow over the top of the structure, creating a drop on the downstream side of the structure. The ability of fish to pass safely downstream would depend on the height of the fall on the downstream side of the structure. This concept may require additional fish passage measures (such as a fish ladder) as described in Sections 5.3.3 and 5.3.4.

### 5.3.2 Modify Sand Slough Control Structure to Allow Fish Passage

The Sand Slough Control Structure currently includes a Parshall flume as water flows into the Eastside Bypass that may not be passable to fish under low flows (see Figure 5-14).

**Figure 5-14.**
**Sand Slough Control Structure**

Modifications to this structure would vary depending on decisions on how to route fish:

- If all Restoration Flows and fish pass into the bypasses (Alternative 1), then the flume would be removed
- If Restoration Flows and fish are routed down the San Joaquin River and bypass (Alternatives 2 and 3) replacement of the structure with a gate system may be necessary to create a water surface elevation high enough to move flow into the Reach 4B channel
- If Restoration Flows are split between the San Joaquin River and bypass (Alternative 4), but fish are only allowed in the San Joaquin River, a fish screen would be required (FS-1)
- If all Restoration Flows and fish pass into the San Joaquin River (Alternative 5), then the structure would be modified to include gates (HG-1 through HG-4)

Many types of fish screens are not applicable to this application; Section 4.1.1.3 describes options considered but eliminated. The fish screen retained after the initial screening is presented below.

#### *5.3.2.1 FS-1 – Vertical Fixed Plate Screens*

Vertical fixed plate screens are composed of a vertical flat metal mesh plate with concrete and/or metal frames and supports. The typical design of a vertical fixed plate screen is shown in Figure 5-15. Vertical fixed plate screens are typically used where the screened flow (no fish) is relatively low when compared to the unscreened flow (containing fish). In this application, more water would be moving through the screen than continuing past the screen, which presents a design challenge. With other types of fish screens considered but eliminated (Section 4.1.1.3), this operation is not feasible. For a vertical fixed plate screen, greater flows through the screen create a need for a very long screen to meet sweeping flows for fish. Considering the vast majority of flow would be diverted, the screens would need to be very long and at a steep angle to the flow.

Vertical fixed plate screens are mechanically simple and easy to seal because the mesh is fixed to the structural frame and there are no moving parts between the mesh and the frame. Vertical fixed plate screens are prone to debris accumulation and require a mechanical cleaning system for debris removal. Traveling brush cleaners and backspray systems are commonly used as cleaning systems. The cleaning system is typically operated on a regular time interval, or when the head loss across the screen reaches a certain threshold, triggering cleaning.

Fixed plate screens are commonly used in California and have been found to be effective for screening fish while minimizing harm.

*Source: Reclamation 2006*

**Figure 5-15.**
**Vertical Fixed Flat Plate Screen**

### 5.3.3 Modify the Mariposa Bypass Drop Structure to Allow Fish Passage

The Mariposa Bypass Drop Structure releases energy as water flows from the Mariposa Bypass into the San Joaquin River Channel (see Figure 5-16). The structure is a vertical barrier and is not currently passable for fish.

**Figure 5-16.**
**Mariposa Bypass Drop Structure**

There are several different ways the Mariposa Bypass Drop Structure can be modified to allow passage of fish, including installation of one of the following:

- Remove structure
- Bottomless culvert and step-pool bypass structure (LAD-1)
- Bottomless culvert and roughened channel fishway (LAD-2)
- Fish ladder (LAD-3)

#### ***5.3.3.1 LAD-1 – Bottomless Culvert and Step-pool Bypass Structure***

Under this concept, the Mariposa Bypass Drop Structure would be bypassed by a boulder step-pool channel, conceptually illustrated in Figures 5-17 and 5-18. A large bottomless culvert would be required to allow access to the Mariposa Bypass Drop Structure, with the step-pool channel constructed through the culvert. The steps would be constructed such that the step heights, pool depths, and maximum velocities conform to the Anadromous Salmonid Passage Facility Design Manual (NMFS 2008). This concept is best suited for high barriers (typically greater than six-foot vertical drop) where there is room alongside the existing drop structure to construct a bypass.

Step-pool channels are constructed from large boulders placed on a constructed consolidated gravel foundation. Rock sizing techniques and hydraulic analysis are used to select rocks appropriate to the design flows. During construction, rocks are interlocked and packed with finer sediment to provide stability and to prevent flow and fine sediment from passing through the structures, rather than over them.

Step-pools should require little routine operation and maintenance once they have ‘bedded in’ and sealed following construction. The channel should self-scour fine sediment and debris from the pools. Immediately after construction, it is important to inspect the steps to make sure they have sealed correctly and that sediment is not being eroded between the large rocks. Thereafter, steps need to be inspected after large flows to check for erosion and make sure that key rock members are not being displaced. If key rocks are moved during flood flows such that the step-pool is breaking apart and not slowing flows to velocities suitable for fish passage they should be replaced.

Step-pools are naturally found in California streams that support anadromous salmonids, and are routinely passed by all life stages; however, they are not typically found in slow-low-gradient channels such as the valley portion of the San Joaquin River. They are regarded as more ‘fish friendly’ than fish ladders because they are more hydraulically heterogeneous than concrete structures, allowing more diverse migration paths that suit different life stages. They also typically require less energy for fish to pass through, and do not pose bottle necks to fish that sometimes promote predation at the foot of ladders.

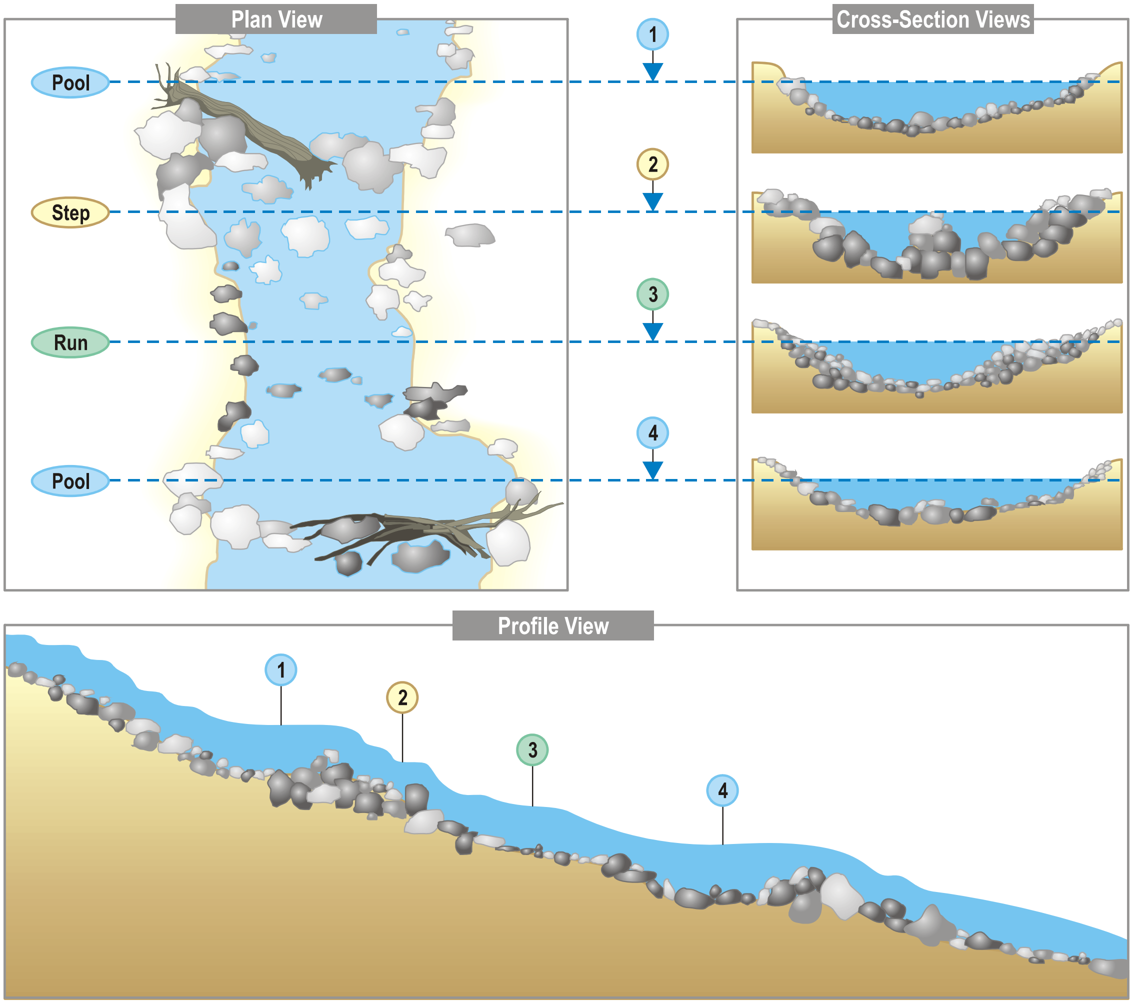



**Figure 5-17.**
**Step-pool Bypass Channel for Fish Passage**

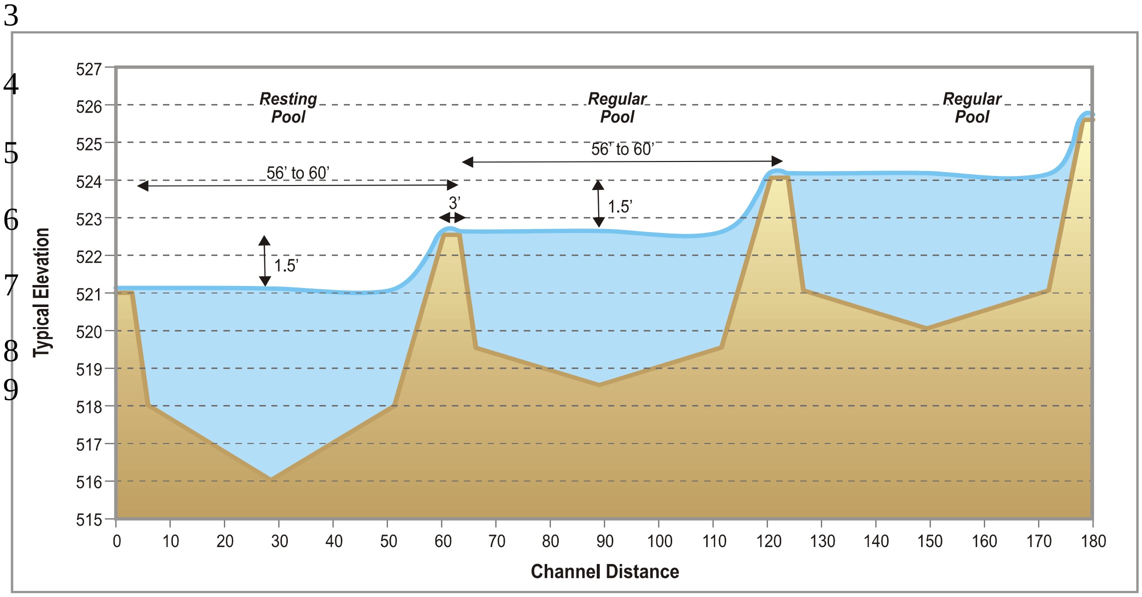



**Figure 5-18.**
**Step Pool Profile**

***5.3.3.2 LAD-2 – Bottomless Culvert and Roughened Channel Fishway***

Under this concept, the Mariposa Bypass Drop Structure would be bypassed by a steep roughened channel composed of boulder and cobble substrate. Figure 5-19 shows a photograph of an exampled roughened channel. A large bottomless culvert would be required to allow access to the Mariposa Bypass Drop Structure, with the roughened channel being constructed through the culvert. The channel would be constructed to conform to the Anadromous Salmonid Passage Facility Design Manual (NMFS 2008). This option is best suited for low barriers (typically less than a six-foot vertical drop) where there is room for a bypass channel around the structure.


**Figure 5-19.**
**Roughened Channel for Fish Passage**

Roughened channels are constructed from medium-sized boulders and cobbles placed on a consolidated gravel foundation. Rock sizing and hydraulic analysis are used to select material appropriate to the design flows. Roughened channels should require little routine operation and maintenance once they have ‘bedded in’ following construction. The channel should self scour fine sediment and debris. After construction and after large-flow events, roughened channels should be inspected to make sure they are not being eroded or outflanked. If erosion occurs, cobbles and boulders should be replaced.

Roughened channels are naturally found in California streams that support anadromous salmonids, and are routinely passed and inhabited by all life stages. They are regarded as more ‘fish friendly’ than fish ladders because they are more hydraulically heterogenous than concrete structures, allowing more diverse migration paths that suit different life stages. They also typically require less energy for fish to pass through, and do not pose bottle necks to fish that sometimes promote predation at the foot of ladders. Roughened channels often provide feeding opportunities for juvenile fish by promoting growth of invertebrates and creating flow separation that concentrates food.

#### *5.3.3.3 LAD-3 – Fish Ladder*

Fish ladders are constructed from concrete either on or around a structure. An example of a fish ladder is shown in Figure 5-20. Under this concept, the Mariposa Bypass Drop Structure would be retrofitted with a concrete structure that breaks the drop into a series of smaller drops that fish can overcome. The ladder would be constructed such that it conforms to the Anadromous Salmonid Passage Facility Design Manual (NMFS 2008). This concept is suited for all sizes of barriers.

**Figure 5-20.**
**Fish Ladder**

Fish ladders can have relatively high operation and maintenance requirements, depending on the design and incoming sediment and debris load. Ladders need to be inspected frequently for signs of blockage, and material must removed when observed to maintain structure performance.

Fish ladders typically impose a high energy requirement on adult migrating fish because of the high velocities of flow through them. They can also lead to fish injuries from scraping and desiccation. Ladders often cause fish to congregate below them, providing potential predation concerns.

### 5.3.4 Modify the Mariposa and Eastside Bypass Control Structures to Allow Fish Passage

The Mariposa Bypass Control Structure (see Figure 5-21) is a concrete dam with 14 bays. Eight bays have radial gates, while six bays always remain open. A concrete spillway underneath an elevated roadway extends across the Mariposa Bypass running parallel to the Eastside Bypass. A concrete slope downstream of the structure creates a pool that is too shallow for fish to jump at low flows (FWA and NRDC 2001). This facility is used to divert water into the Mariposa Bypass during flood conditions.

The gated Eastside Bypass Control Structure (see Figure 5-22) works in coordination with the Mariposa Bypass Control Structure to direct flows to Eastside Bypass Reach 3 or to the Mariposa Bypass. The structure contains six bays with radial gates. Even with the gates open, the structure is a fish barrier at low flow because of energy dissipating blocks and a concrete wall structure directly downstream.

The Mariposa Bypass Control Structure is approximately six feet higher than the Eastside Bypass Control Structure; therefore, the Eastside Bypass Control Structure must restrict flows and create a backwater pool to move water into the Mariposa Bypass.

**Figure 5-21.**
**Mariposa Bypass Control Structure**

**Figure 5-22.**
**Eastside Bypass Control Structure**

There are several different ways the Eastside Bypass Control Structure could be modified to allow passage of fish:

- Bypass structures (LAD-1, LAD-2)
- Fish ladder (LAD-3)
- Spillway crest notching (NOT-1)

The Mariposa Bypass Control Structure could be modified by notching the center bays (See NOT-1 – Spillway Crest Notching in Section 5.3.4.3). Because of the design and function of this structure, no other feasible methods are available to modify the Mariposa Bypass Control Structure for fish passage.

#### *5.3.4.1 Bypass Structures*

Bypass structures, including a bottomless culvert and step-pool bypass structure (LAD-1) or a roughened channel fishway (LAD-2), as described in Section 5.3.3.1 and Section

5.3.3.2 for the Mariposa Bypass Drop Structure could be used in a similar fashion to pass fish around the Eastside Bypass Control Structure. A typical step and pool bypass and roughened channel fishway are depicted in Figures 5-17 and 5-19.

#### *5.3.4.2 Fish Ladder*

The application of a fish ladder to route fish around the Eastside Bypass Control Structure would be similar to the application at the Mariposa Bypass Drop Structure (LAD-3, as described in Section 5.3.3.3). An example of a fish ladder is shown in Figure 5-20.

#### *5.3.4.3 NOT-1 – Spillway Crest Notching*

Under this concept, one or more than one spillway on the Mariposa Bypass Control Structure would be box or ‘V’ notched to provide low-flow passage for down-migrating juveniles and up-migrating adults. An example of spillway notching is shown in Figure 5-23. The box notch would be cut from the existing concrete spillway. The notch would contain baffles to slow the movement of water with baffling configured relative to the slope of the notch. The notch would be configured along the spillway to work with flow channel in the upstream and downstream reach of the bypass. Notching is best suited for barriers lower than 6 feet.

**Figure 5-23.**
**Spillway Notch**

The notch would require a minimum amount of construction by cutting or jackhammering the existing spillway. The surface would be protected with a new concrete surface and baffles to slow the movement of water. The notch would require minimal operation and maintenance. Periodic inspection should be made to ensure large debris is not trapped in the notch. This option should not affect flood control, but hydraulic analysis would be needed to demonstrate that the structure does not increase freeboard in the bypass.

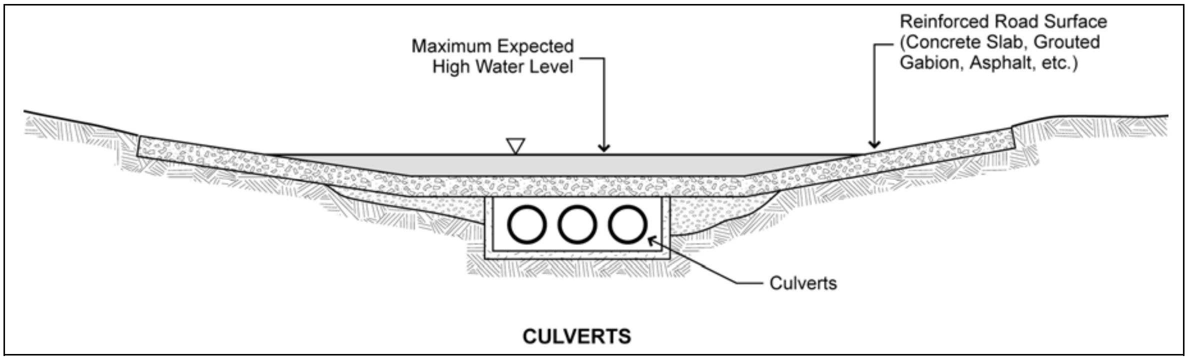
Notches can lead to fish injuries from scraping and desiccation (drying out from exposure to air). The notch could be a high-energy, high-velocity environment depending on its slope. Baffling would help reduce the velocity. The Mariposa Bypass Control Structure has currently created a pool just downstream of the structure that is approximately 30 feet deep. If a notch is used, the pool would need to be filled and the flow patterns would need to be controlled to prevent the pool from re-forming. The pool creates an energy drop that can confuse fish and harbor predators.

### 5.3.5 Road Crossings

The San Joaquin River Reach 4B1 and the Eastside and Mariposa bypasses have several crossings that could impeded flow, be inundated more frequently and at greater depths, and/or would pose a barrier to fish and would require modification. Information regarding the frequency of use of the crossings as well as the frequency of inundation will help to determine which crossings require modifications. Described below are several potential concepts to modify the existing road crossings.

#### *5.3.5.1 RD-1 – Round Culverts*

Round culverts can be constructed of corrugated metal, concrete, or plastic. Construction of culverts would require installation of the culvert topped by a new roadway surface. The typical design of a round culvert is shown in Figure 5-24.




*Source: Knott and McCann 2008*

**Figure 5-24.**
**Round Culvert**

Round culverts are suitable for use where the slope of the bottom of the culverts ranges from 0 to 3 percent. At slopes greater than 3 percent, it is very difficult to maintain natural substrates on the bottom of the structure. Round culverts require regular maintenance to clean out debris, and remove or control beaver activity. The cleanout procedure often involves large forestry equipment that rams a de-limbed section of a tree through the culvert like a plunger to unplug it. Often the culvert is damaged in the process, which impedes function and increases risk of plugging and blow-outs.

When properly installed and embedded, round culverts can be a fish friendly option for road crossings. Incorrect sizing or installation, however can cause damage to aquatic habitats, fish, and other aquatic organisms.

#### *5.3.5.3 RD-2– Corrugated Steel Partially Buried Pipe Arch Culverts*

Corrugated steel pipe-arch culverts are constructed with corrugated pipe and typically require cut-off walls on the upstream and downstream side. A typical corrugated steel pipe-arch arch culvert is shown in Figure 5-25. As with the round culverts (Concept RD-1), construction would require a new roadway surface on top of the pipe arch culvert.

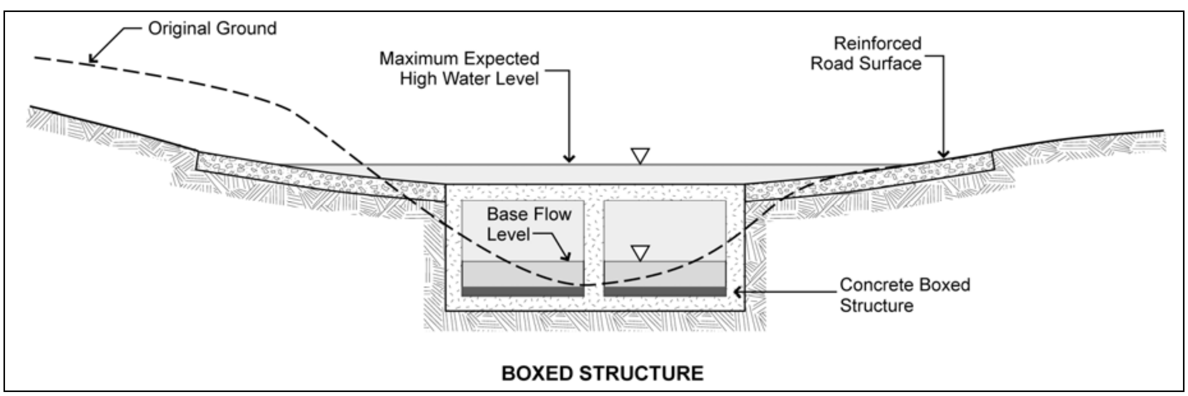
**Figure 5-25.**
**Corrugated Steel Partially Buried Pipe Arch Culvert**

Corrugated steel pipe-arch culverts may be used at sites where the slope of the riverbed is relatively flat with a bed load of fine grained material. Corrugated steel pipe-arch culverts are not as prone to accumulation of debris as round culverts and require little maintenance.

The culvert would be partially buried, allowing natural substrate on the bottom of the culvert. Corrugated steel pipe-arch culverts provide a natural stream channel between the sides of the arch. This allows natural stream channel processes to take place that would maintain favorable habitat and fish passage under the structure.

#### *5.3.5.4 RD-3 – Partially Buried Concrete Box Culverts*

Box culverts are usually made of concrete and may be purchased as pre-fabricated units of various lengths, or fabricated in place. Box culverts are commonly used where traffic loads or higher fill levels place heavy stresses on structure. As with the round culverts (Concept RD-1), construction would require a new roadway surface on top of the concrete box culverts. The typical design of a box culvert is shown in Figure 5-26.




*Source: Knot 2008*

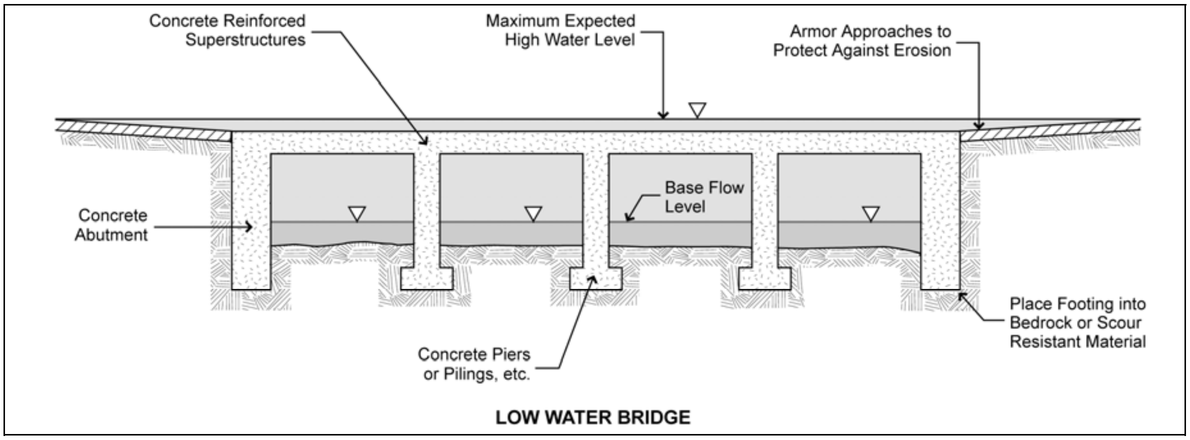
**Figure 5-26.**
**Partially Buried Concrete Box Culvert**

Box culverts are suitable for use where riverbed slopes range from 0 to 3 percent. At slopes greater than 3 percent, it is difficult to maintain natural substrates on the bottom of the culvert. The suggested concrete box culvert would be partially buried to allow a natural bottom on the culvert. Debris can accumulate inside concrete box culverts. Therefore, concrete box culverts need to be cleaned periodically.

Solid culverts can pose several challenges for fish, including a vertical jump at the outlet, water too shallow inside the culvert for fish to swim, and high water velocities inside the culvert that can act as a fish barrier.

#### *5.3.5.5 RD-4 – Bridges*

The typical design of a bridge is shown in Figure 5-27. Two of the crossings in the Reach 4B Project study area, Washington Road (RM168.1) and Turner Island Road (RM157.1), have existing bridges over the river channel. Depending on the alternative selected for implementation, the two crossings could require work to improve or replace the existing bridges.




*Source: Knott and McCann 2008*

**Figure 5-27.**
**Bridge**

Bridges can be constructed of metal or concrete and consist of a span across a stream that is supported by several piers or pilings. The piers or pilings are mounted on footings that extend below the scour line. To construct a bridge, the existing crossing would be removed and replaced with a bridge.

An advantage of bridges is that they provide a greater natural stream channel surface area, because the span between piers or pilings is typically larger than the span between arches. Therefore, the headloss in the channel across the bridge would be less for bridges than for the other road crossing concepts. Bridges are also less prone to accumulation of debris than round culverts or concrete box culverts.

Bridges provide a natural stream channel between the piers or pilings. This allows for natural stream channel processes to take place that would maintain favorable habitat and fish passage under the structure.

### 5.3.6 Modify Merced National Wildlife Refuge Weirs in the Eastside Bypass to Allow Fish Passage

The Merced National Wildlife Refuge operates two check structures (weirs) (see Figures 5-28 and 5-29) in the Eastside Bypass to the south of Sandy Mush Road that allow for the diversion of water into side channels and pools to support winter waterfowl habitat. The system is operated by the placement of flash boards in the center of an earthen embankment structure that create back water to a depth of approximately 24 to 36 inches. The backwater pools are operated from approximately October through March of each year. During the summer months, the refuge goes dry and consequently does not support the continued presence of aquatic predators, such as largemouth bass. The backwater areas of the refuge would provide good habitat for out migrating juvenile fish but the check structures would block the migration of adult fish.

**Figure 5-28. Upper Weir**

**Figure 5-29. Lower Weir**

The options to modify the check structures to allow passage of fish include:

- Bypass structures (LAD-1, LAD-2)
- Fish ladder (LAD-3)
- Removal or reoperation (REM-1)

#### *5.3.6.1 Bypass Structures*

Bypass structures including a bottomless culvert step-pool bypass structure (LAD-1) or a roughened channel fishway (LAD-2) (as described in Section 5.3.3.1 and Section 5.3.3.2, for the Mariposa Bypass Drop Structure), could be used in a similar fashion to pass fish around the check structures. A typical step and pool bypass and roughened channel fishway are depicted in Figures 5-17 and 5-19.

#### *5.3.6.2 Fish Ladder*

The application of a fish ladder to route fish around the check structures would be similar to the application at the Mariposa Bypass Drop Structure (LAD-3, as described in Section 5.3.3.3). An example of a fish ladder is shown in Figure 5-20.

#### *5.3.6.3 REM-1 – Weir Removal or Reoperation*

Under this concept, the weirs would be removed or reoperated so that the channel was not blocked during the fish migratory period. Reoperation or structure removal could adversely affect the productivity of the refuge by reducing or eliminating waterfowl habitat.

Reoperation of the weirs would require more constant attention to the specific dates of fish migration and the corresponding removal of the check structures by refuge staff to allow fish passage. Draining of the refuge backwater areas at the end of the season would require attention to the presence of juveniles to ensure that opportunities for stranding are reduced. This option would not affect flood control; however, the hydraulics of the refuge would be altered and would reduce or eliminate waterfowl habitat.

Removal or reoperation of the structures would be beneficial to the passage of adult fish. The backwater area created by the refuge would provide suitable juvenile rearing and foraging habitat that is currently isolated from the presence of year-round predators.

### 5.3.7 Prevent Upstream Migration into Unsuitable Areas

Barriers may be required to prevent the migration of adult salmon into areas without suitable habitat. However, there may also be some instances where barriers are not necessary (such as the presence of natural barriers). The need for barriers will be analyzed as the alternatives development process moves forward.

The Reach 4B Project is currently examining the need for barriers at several different locations, depending on the alternative:

- **Downstream end of Eastside Bypass Reach 1 (the reach above the confluence of the bypass with Sand Slough) –** a barrier at the downstream end of Reach 1 of the Eastside Bypass would be required to prevent fish from migrating up to Reach 1. This barrier would allow downstream migration of juveniles, but would not allow upstream migration of adults into Reach 1.

- **Tributaries along Reach 3 of the Eastside Bypass –** several alternatives would include Restoration Flows in Reach 3 of the Eastside Bypass, downstream of the confluence with the Mariposa Bypass. This reach has several tributaries that may require barriers to allow out-migration of juveniles but prevent up-migration of adults.

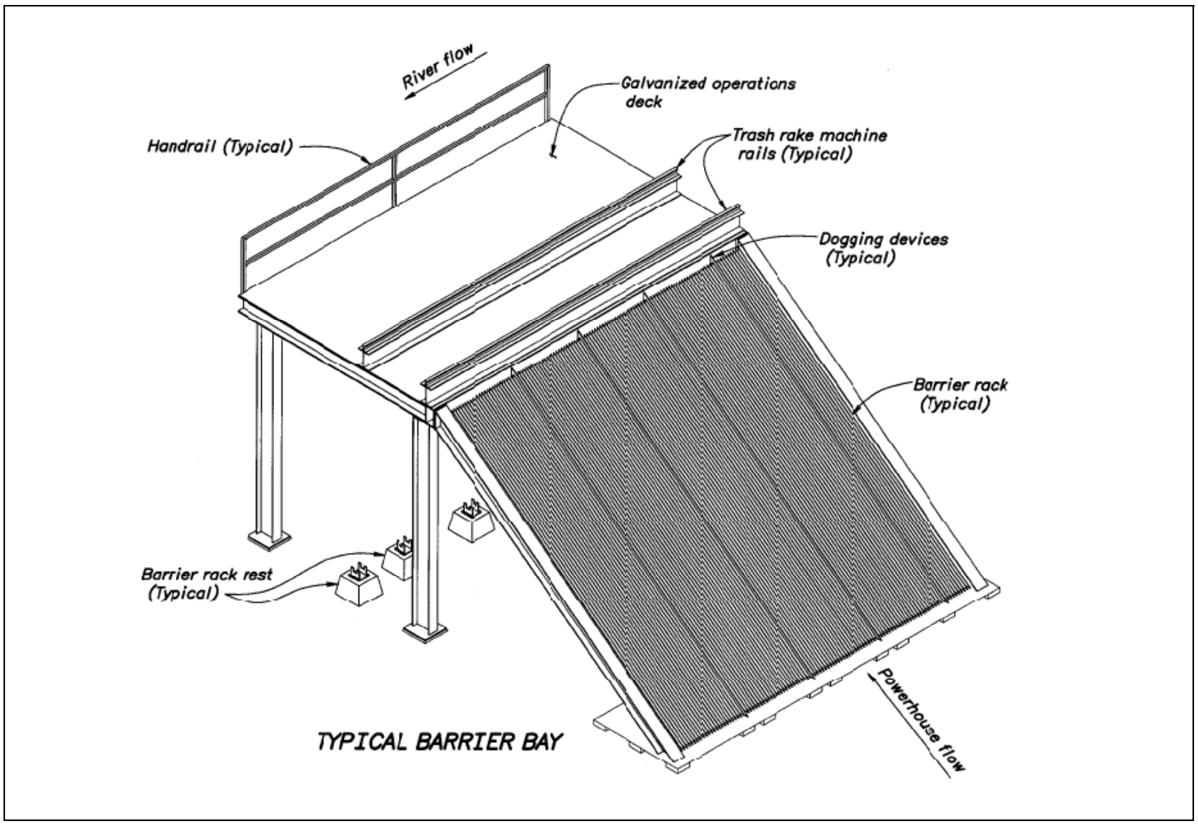
- **Downstream end of Reach 3 of Eastside Bypass –** under one alternative, fish would be routed down the Mariposa Bypass and no fish passage would occur in the Eastside Bypass Reach 3. However, under high flows, there may be adult salmon migrating upstream from Reach 5 that may be attracted to the Eastside

Bypass. A barrier would be needed to prevent fish from migrating up into the Eastside Bypass Reach 3 because the Eastside Bypass Control Structure would not be passable to fish.

There are two main types of fish barriers: positive barriers and behavioral barriers. NMFS has determined that behavioral barriers, including electric and acoustic fields, have very limited applications because of inconsistent results attributed mostly to water quality variations (NMFS 2008). Therefore behavioral barriers are not discussed further in this document. There are three main types of positive barriers: physical (picket) barriers, velocity barriers, and vertical drop structures. Velocity barriers are not a viable concept due to the wide range of flows being considered for this project. Therefore, only physical (picket) barriers and vertical drop structures are discussed in further detail.

#### *5.3.7.1 BAR-1 – Fixed Bar Screens*

The typical design of a fixed bar screen is shown in Figure 5-30. Fixed bar screens consist of a panel of closely spaced metal or poly-vinyl chloride (PVC) bars that span the width of the entire channel in which they are placed and prevent fish from migrating upstream. The bars are typically spaced 1 inch apart or less. The bar screen can be equipped with a deck and raking equipment to clear accumulated debris from the face of the screen. Fixed bar screens are secured to the sides and bottom of a channel and have no moving parts.




*Source: Reclamation 2006*

**Figure 5-30.**
**Fixed Bar Screen**

Fixed bar screens are prone to debris accumulation and require regular maintenance to clear accumulated debris from the face of the screen. Accumulation of debris on the fixed bar screens can reduce the total area available for passage of flow through the screen. This would increase the head differential across the bar screen. The typical maximum head differential across the bar screen is 0.3 feet. Whenever this threshold is exceeded the screen needs to be cleaned.

These types of fish barriers have a high likelihood of impinging fish and therefore cannot be used in waters containing species listed under the ESA, unless certain measures are implemented. These measures may include continual monitoring by on-site personnel and an acceptable plan to remove impinged fish in a timely manner.

#### *5.3.7.2 BAR-2 – Hinged Floating Picket Weirs*

Hinged floating picket weirs consist of a panel of closely spaced bars that span the width of the entire channel in which they are placed. The closely spaced bars prevent fish from migrating upstream. Hinged floating picket weirs are secured at the base to the bottom of the channel and span the entire width of the channel. The top of the hinged floating picket weir extends above the water surface and is allowed to float or sink, rotating about its base, depending on stream conditions. At high flows hinged floating picket weirs rotate downstream and are forced under water, allowing debris to pass.

Hinged floating picket weirs are mechanically simple structures as they have no moving parts. Hinged floating picket weirs are constructed from metal or PVC bars that are typically spaced 1 inch apart or less. The bars are secured at the base to the bottom of the channel and equipped with a resistance board that extends across the width of the bars. The structure floats or sinks depending on stream conditions. Hinged floating picket weirs allow debris to pass at high flows, so they do not require as much maintenance as fixed bar screens. However, the passage of debris downstream may be undesirable.

Similar to the fixed bar screens, the hinged floating picket weirs have a high likelihood of impinging fish and therefore cannot be used in waters containing species listed under the ESA, unless certain measures are implemented.

#### *5.3.7.3 BAR-3 – Vertical Drop Structure*

A vertical drop structure functions by providing a steep vertical drop in water surface elevation in excess of the leaping ability of the target fish species. The drop structure can consist of a concrete structure, a rubber-dam (see Section 5.3.1.4), or a hinged crest gate (see Section 5.3.1.2).

Vertical drop structures can be used to prevent upstream migration of fish with a low potential for fish injury, if the structure is designed correctly. Site conditions, including existing fish species, range of flows, and existing grade are key factors to consider in properly designing vertical drop structures. For the Reach 4B Project, the structure should be designed so that fish attempting to jump over the structure fall in a pool with a minimum depth of five feet.

Vertical drop structures increase the flow depth on the upstream side of the structure. They can also create turbulence on the downstream side. Vertical drop structures are not prone to debris accumulation, since water flows freely over the structure. The structure would need to be inspected periodically to clear accumulated debris and to check for wear.

# 6.0 Next Steps and Summary

This section summarizes the initial alternatives formulation process and provides an overview of the next steps required to carry out the Reach 4B Project.

## 6.1 Summary

The Reach 4B Project includes the improvements to channels and structures in the study area to meet the Settlement requirements. Reach 4B of the San Joaquin River has not received flow since the construction of the Flood Control Project, which diverted all flows into the Eastside and Mariposa bypasses. The Reach 4B Project includes multiple improvements to move fish and flows through these facilities:

- Modifications in San Joaquin River channel to ensure conveyance of at least 475 cfs through Reach 4B of the San Joaquin River
- Modifications at the Reach 4B Headgate on the San Joaquin River channel to ensure fish passage and enable flow routing between 500 cfs and 4,500 cfs into Reach 4B of the San Joaquin River
- Modifications to the Sand Slough Control Structure to ensure fish passage
- Modifications to structures in the Eastside and Mariposa bypass channels to provide fish passage
- Modifications in the Eastside and Mariposa bypass channels to establish a suitable low-flow channel, if the Secretary of the Interior in consultation with the RA determines such modifications are necessary to support anadromous fish migration through these channels
- Modifications in the San Joaquin River channel capacity (incorporating new floodplain and related riparian habitat) to ensure conveyance of at least 4,500 cfs through Reach 4B, unless the Secretary of the Interior, in consultation with the RA and with the concurrence of NMFS and USFWS, determines that such modifications would not substantially enhance achievement of the Restoration Goal

Table 6-1 includes a summary of the initial alternatives identified during development of this TM. The alternatives described in this TM will be used as a starting point to gain feedback from Implementing Agencies, Settling Agencies, other participating agencies, landowners, and the public. It is anticipated that feedback from these entities will increase the number and types of alternatives included for analysis. The feedback may also identify additional benefits and drawbacks of the alternatives that will help during alternatives refinement and evaluation.

**Table 6-1.**
**Initial Alternatives Summary**

| Channels/Structures | | ALTERNATIVE 1<br>Primary Restored Channel in San Joaquin River | ALTERNATIVE 2<br>Primary Restored Channel in Bypass | ALTERNATIVE 3<br>Flows Below 475 cfs in San Joaquin River with Eastside Bypass as High Flow Floodplain | ALTERNATIVE 4<br>Split Flow, Fish Friendly Bypass | ALTERNATIVE 5<br>Split Flow, Fish Enhancements Focused in River |
|---|---|---|---|---|---|---|
| San Joaquin River Capacity | | Up to 4,500 cfs (all Restoration Flows) | At least 475 cfs of Flood Flows | Restoration Flows of at least 475 cfs | Base and fall pulse flows; some spring pulse flows | Base and fall pulse flows; some spring pulse flows |
| Eastside Bypass Reach 2 Flows | | Flood Flows | All Restoration and Flood flows up to capacity | Restoration Flows above 475 cfs and all Flood Flows | Restoration Flows above Reach 4B capacity and Flood Flows | Restoration Flows above Reach 4B capacity and Flood Flows |
| Eastside Bypass Reach 3 Flows | | Flood Flows | Flood Flows greater than capacity of Mariposa Bypass | Restoration Flows above 475 cfs and Flood Flows up to Capacity | Flows greater than capacity of Mariposa Bypass | Restoration Flows above Reach 4B capacity and Flood Flows |
| Mariposa Bypass Flows | | Flood Flows | All Restoration and Flood flows up to capacity | Flood Flows greater than capacity of Eastside Bypass Reach 3 | Restoration Flows above Reach 4B capacity and Flood Flows up to capacity | Restoration Flows above Reach 4B capacity and Flood Flows |
| Fish Routing | SJR | **X** | | **X** | **X** | **X** |
| | Eastside Reach 2 | | **X** | **X** | **X** | |
| | Eastside Reach 3 | | | **X** | | |
| | Mariposa | | **X** | | **X** | |
| Habitat | | SJR | Bypass | SJR and Bypass | SJR and Bypass | SJR |
| Reach 4B Headgates | | Remove Headgate | Simple Gate (HG-1,HG-2,HG-3,HG-4) | Construct gates and ladders with multi-level fish ladder entrances (HG-1,HG-2,HG-3,HG-4, LAD-1,LAD-2,LAD-3) | Construct gates and ladders with multi-level fish ladder entrances (HG-1, HG-2,HG-3,HG-4, LAD-1,LAD-2,LAD-3) | Construct gates and ladders with multi-level fish ladder entrances (HG-1,HG-2,HG-3,HG-4, LAD-1,LAD-2,LAD-3) |
| Sand Slough Control Structure | | Add Gates (HG-1, HG-2, HG-3, HG-4) | Remove Structure | Add Gates (HG-1, HG-2, HG-3, HG-4) | Add Gates (HG-1, HG-2, HG-3, HG-4) | Add Gates (HG-1, HG-2, HG-3, HG-4) and Fish Screen (FS-1) |
| SJR Crossings | | Replace Crossings (RD-1,RD-2,RD-3,RD-4) | Replace culverts (RD-1,RD-2,RD-3,RD-4) | Replace culverts (RD-1,RD-2,RD-3,RD-4) | Improve Crossings (RD-1,RD-2,RD-3,RD-4) | Improve Crossings (RD-1,RD-2,RD-3,RD-4) |
| Bypass Crossings | | None | Improve Crossings (RD-1,RD-2,RD-3,RD-4) | Improve Crossings (RD-1, RD-2,RD-3,RD-4) | Improve Crossings (RD-1,RD-2,RD-3,RD-4) | Improve Crossings (RD-1,RD-2,RD-3,RD-4) |
| Eastside Bypass Control Structure | | No Change | No Change | Fish Passage (LAD-1,LAD-2,LAD-3,NOT-1) | No Change | No Change |
| Mariposa Bypass Control Structure | | No Change | Notch Center Bays (NOT-1) | No Change | Notch Center Bays (NOT-1) | No Change |
| Mariposa Drop Structure | | No Change | Remove Drop Structure | No Change | Fish Passage (LAD-1,LAD-2,LAD-3,NOT-1) | No Change |

**Table 6-1.**
**Initial Alternatives Summary**

| | ALTERNATIVE 1 | ALTERNATIVE 2 | ALTERNATIVE 3 | ALTERNATIVE 4 | ALTERNATIVE 5 |
|---|---|---|---|---|---|
| **Channels/Structures** | **Primary Restored Channel in San Joaquin River** | **Primary Restored Channel in Bypass** | **Flows Below 475 cfs in San Joaquin River with Eastside Bypass as High Flow Floodplain** | **Split Flow, Fish Friendly Bypass** | **Split Flow, Fish Enhancements Focused in River** |
| National Wildlife Refuge Weirs | Removal or Reoperation (REM-1) | Removal or Reoperation (REM-1) | Removal or Reoperation (REM-1) | Removal or Reoperation (REM-1) | Removal or Reoperation (REM-1) |

Key:
SJR = San Joaquin River
cfs = cubic feet per second

Additional information is needed to help develop new alternatives, eliminate alternatives that are not applicable, and refine remaining alternatives. This information includes, but is not limited to:

- Stakeholder feedback, particularly from landowners or others that are very familiar with the local region.
- Site visits to verify the condition of the various structures within Reach 4B of the San Joaquin River and the Eastside and Mariposa bypasses.
- Water temperature modeling to identify potential issues associated with specific target life histories.
- A sediment budget within the reaches to help define sediment parameters for design, including how complex or simple habitat features should be within each reach.
- A better understanding of debris loads within reach 4B of the San Joaquin River and the Eastside and Mariposa bypasses to help define the type of fish ladder needed.
- A better understanding of fish habitat and other requirements through Reach 4B of the San Joaquin River and the Eastside and Mariposa bypasses.
- Hydrologic and hydraulic evaluation of the alternatives to provide information for levee and habitat designs and identify necessary structural modifications.
- An analysis of areas with seepage concerns and evaluate ways to avoid or minimize seepage.
- A better understanding of flood control operations and how potential modifications could be made without affecting flood control capacity, operations, or flexibility.
- Consideration of existing water conveyance canals or facilities near Reach 4B that must be relocated if alternatives move river banks.

## 6.2 Next Steps

This TM represents the first step in development of alternatives and a project description for the Reach 4B Project. Developing the project description is one step in moving towards a project-level EIS/R. The sections below describe how this TM fits in with the rest of the steps to complete the EIS/R and the necessary environmental permits to allow the Reach 4B Project to move forward.

### 6.2.1 Conceptual Design

Once the list of initial alternatives has been finalized, conceptual level designs will be prepared. The conceptual designs will incorporate models and other relevant data to better understand how the alternatives will be implemented and how well they will perform.

### 6.2.2 Environmental Baseline Surveys and Data Collection

Before the EIS/R is developed, environmental baseline surveys and data collection will be needed to gather detailed information on baseline conditions. This will include biological and cultural surveys of the project area, as well as site-specific research to document current conditions. This information will be used to establish the baseline in the EIS/R. The Reach 4B Project alternatives will be compared against this baseline to determine potential environmental effects. The information gathered at this stage will also help to refine the alternatives and provide information for the permitting process.

### 6.2.3 Environmental Permitting

Prior to project implementation, environmental approvals and permits will be required from several different entities. Most of these approvals/permits must be obtained before construction can commence. Preparation of environmental permits/approval applications will be developed concurrent with the project description and EIS/R. This will allow changes to the project description to minimize or avoid environmental impacts and reduce the need for permits and mitigation. Pre-application meetings will likely be scheduled with the permitting entities at this time, to ensure the correct permits are obtained and the necessary information is presented in the applications. When the Draft EIS/R is released to the public, the permit and/or approval applications will be submitted to the appropriate entities.

### 6.2.4 EIS/R

An EIS/R will be prepared for the Reach 4B Project to satisfy NEPA and CEQA. The EIS/R will analyze the potential environmental effects associated with implementation of the project alternatives and will identify potential mitigation measures to reduce or avoid those effects. The Draft EIS/R will be released to the public for review and comment. A Final EIS/R will be prepared that provides responses to the comments received on the Draft EIS/R. From this environmental review process, an alternative will be selected by DWR and Reclamation for implementation. Reclamation’s Record of Decision and DWR’s Statement of Findings will identify the alternative selected for implementation, the environmental effects associated with that alternative, and the mitigation adopted to minimize or avoid the environmental effects. After the environmental review process is complete and all permits/approvals have been obtained, construction of the selected alternative will begin.

## 6.3 Stakeholder Involvement

The Implementing Agencies recognize the importance of stakeholder involvement during alternatives development. They are committed to involving all interested stakeholders in the alternatives development process to provide input on key issues. Stakeholders will have the opportunity to be involved in the alternatives development process by:

- Reviewing this TM and submitting comments
- Attending Reach 4B Project meetings and submitting comments or voicing concerns
- Reviewing the Draft EIS/R document for the Reach 4B Project and submitting comments
- Attending public meetings on the Draft EIS/R document and submitting comments

## 6.4 Schedule

The draft schedule for the Reach 4B Project is provided in Figure 6-1 below. This schedule is preliminary and subject to change.

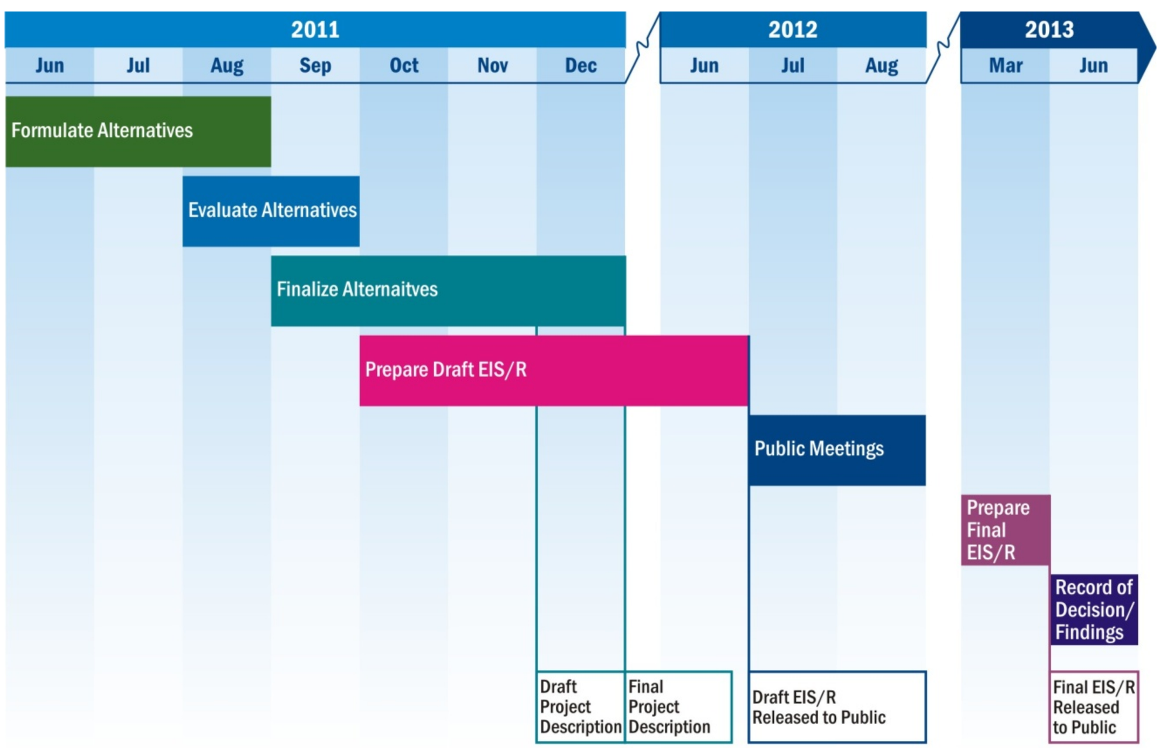



**Figure 6-1.**
**Schedule for the Reach 4B Project EIS/R**

# 7.0 References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