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

Project Description Technical Memorandum
Appendix A – Initial Alternatives Evaluation

SAN JOAQUIN RIVER RESTORATION PROGRAM

July 2015

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List of Abbreviations and Acronyms

°F	degrees Fahrenheit
AASHTO	American Association of State Highway Transportation Officials
CDFW	California Department of Fish and Wildlife (after January 1, 2013)
CEQA	California Environmental Quality Act
cfs	cubic foot per second
DFG	California Department of Fish and Game (prior to January 1, 2013)
DO	dissolved oxygen
DWR	California Department of Water Resources
EIS/R	Environmental Impact Statement/Environmental Impact Report
Flood Control Project	Lower San Joaquin River Flood Control Project
FWA	Friant Water Authority
GIS	geographic information systems
HIS	habitat suitability index
LSJLD	Lower San Joaquin Levee District
LWD	large woody debris
m	meters
mg/L	milligrams per liter
NEPA	National Environmental Policy Act
NRDC	Natural Resources Defense Council
NMFS	National Marine Fisheries Service
NWR	National Wildlife Refuge
O&M	operation and maintenance
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
Settlement	Stipulation of Settlement in NRDC et al. v. Kirk Rodgers et al.
SJRRP	San Joaquin River Restoration Program

TM	Technical Memorandum
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

Note to Reviewers:

This document 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 Program Team is not requesting formal comments on this document, all comments received will be considered to the extent possible when developing the Environmental Impact Statement/Report.

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1.0 Introduction

This Initial Alternatives Evaluation documents the process for evaluating a broad range of initial alternatives and selecting a reasonable range of alternatives to move forward for more detailed analysis in the Reach 4B, Eastside Bypass, and Mariposa Bypass Channel and Structural Improvements Project (Reach 4B Project) Environmental Impact Statement/Environmental Impact Report (EIS/R). The Reach 4B Project is a component of the overall 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 (NRDC), et al., v. Kirk Rodgers, et al*.

The United States Department of the Interior, Bureau of Reclamation, as the Federal lead agency under the National Environmental Policy Act (NEPA), and the California Department of Water Resources (DWR), as the State lead agency under the California Environmental Quality Act (CEQA), have prepared this document as an initial step in preparation of an EIS/R for the Reach 4B Project. Federal authorization for implementing the Settlement is provided in the San Joaquin River Restoration Settlement Act (Public Law 111-11).

1.1 Purpose of this Document

This Initial Alternatives Evaluation document is intended to:

- Describe the alternatives formulation and evaluation process for the Reach 4B Project consistent with NEPA and CEQA requirements
- Present the results of the alternatives evaluation process for the Reach 4B Project
- Recommend a reasonable range of potential alternatives to move forward for more detailed analysis in the forthcoming Reach 4B Project EIS/R
- 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.

[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 groups that are not party to a lawsuit or agreement, but are implicated in such lawsuits or agreements and includes landowners and agencies that have a vested interest in implementing the SJRRP.

1.2 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 1-1). 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.

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.

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.

While the Reach 4B Project alternatives development process incorporated potential actions throughout this study area, the alternatives documented within this TM do not include actions in the entire study area. The alternatives only include actions in Reach 4B1 of the San Joaquin River, the Eastside Bypass Reach 2, and the Mariposa Bypass. These areas constitute the “impact area” that has the potential for environmental effects. The impact area will be evaluated in the EIS/R.

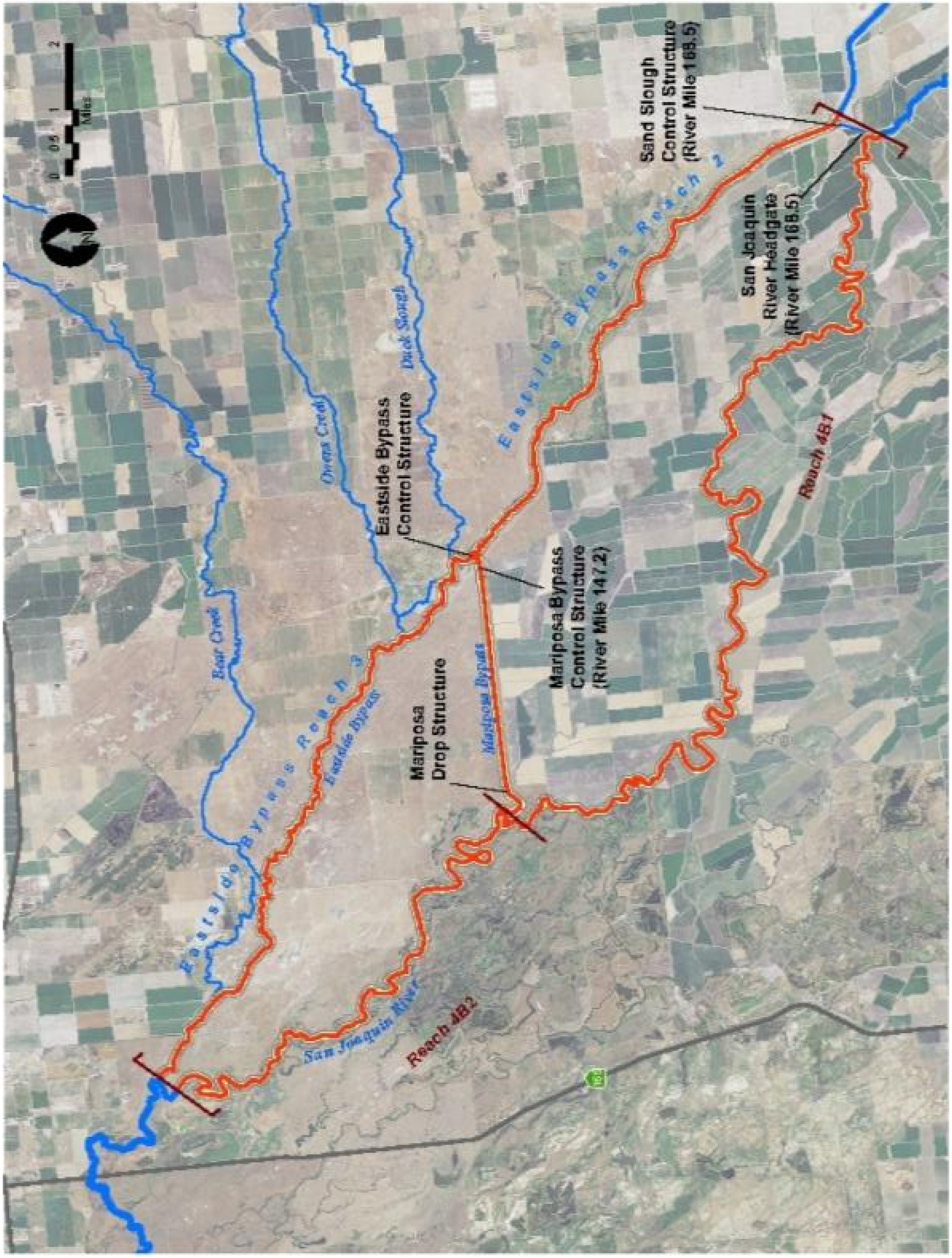

Figure 1-1.
Reach 4B Project Study Area

1.3 Key Reach 4B Project Features

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 the National Marine Fisheries Service (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 (DO), 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 (Friant Water Authority (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, DO, 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 moderating water temperature. This, in turn, can increase water carrying capacity for DO, benefiting target aquatic organisms. Invasive aquatic vegetation (i.e. macrophytes) may increase water temperature, create swings in DO 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).

In order to effectively implement the Settlement requirements, several elements 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 cubic feet per second (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.

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 1-2). 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.

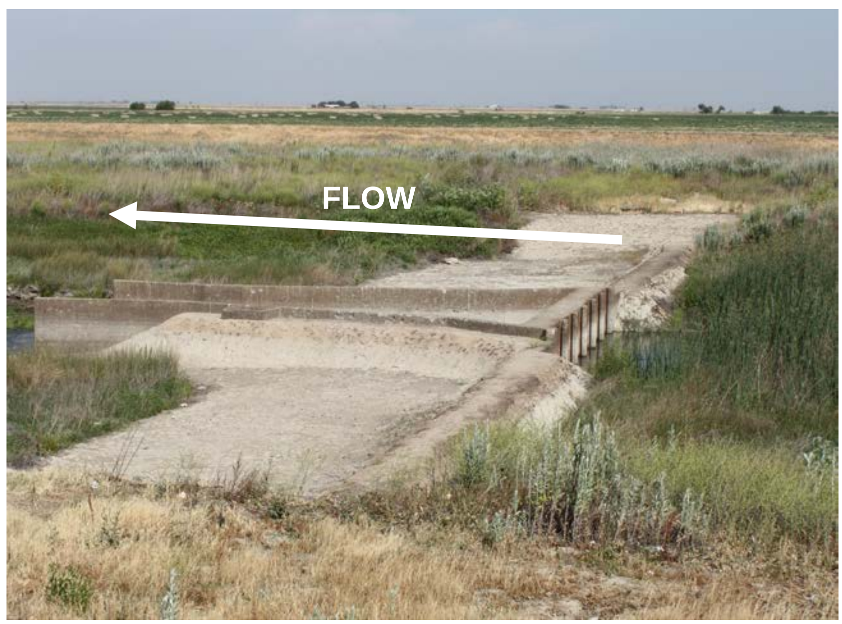

Figure 1-2.
Sand Slough Control Structure

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[4] 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 would 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 would impede fish passage. Each of the bays has concrete energy dissipation structures[5] that would create upstream fish barriers under a variety of flows. The 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

[4] This structure would be a partial velocity and drop barrier, depending on fish size, swimming ability, and flow.
[5] Although some of these energy dissipation structures could be navigated, it would depend on the flow and time of year. These features would regularly collect debris, and therefore would impair passage and potentially impact downstream-migrating fish.

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. **Wildlife Refuge Weirs –** Within the Eastside Bypass, two low-head structures (weirs) control water elevation and flow in the Merced National Wildlife Refuge (NWR). 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.

10. **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.

1.4 Relationship to Initial Alternatives Technical Memorandum (TM)

The Reach 4B, Eastside Bypass, and Mariposa Bypass Channel and Structural Improvements Project Initial Alternatives Technical Memorandum (October 2011) documents the first step in initial alternatives formulation for the Reach 4B Project. The TM presents the Purpose and Need/Project Objectives for the Reach 4B Project, the opportunities and constraints, the existing conditions in the Reach 4B Project study area, the process used to formulate initial alternatives and the description of the initial alternatives for the Reach 4B Project. The Initial Alternatives TM was used to gain feedback from the Implementing Agencies, Technical Work Groups, Settling Parties, Third Parties, landowners, and other stakeholders involved in the Reach 4B Project, and to refine the initial alternatives.

This Initial Alternatives Evaluation document builds upon the initial alternatives described in the Initial Alternatives TM by comparing and evaluating the initial alternatives using the evaluation criteria presented in Section 4.0 and recommending a reasonable range of alternatives to be carried forward for analysis in the Reach 4B Project EIS/R (Section 6.0).

1.5 Organization of this Document

This document is organized as follows:

- **Section 1.0 Introduction –** Describes the purpose of this document, an overview of the alternatives formulation and evaluation process, and the relationship of this document to the Initial Alternatives TM.

- **Section 2.0 Alternatives Evaluation Process –** Describes the alternatives evaluation process.
- **Section 3.0 Initial Alternatives Descriptions –** Presents a description of the initial alternatives that are evaluated in this document.
- **Section 4.0 Initial Alternatives Evaluation Criteria –** Describes the criteria used to evaluate the initial alternatives.
- **Section 5.0 Initial Alternatives Evaluation Results –** Presents the results of the initial alternatives evaluation.
- **Section 6.0 Conclusions and Recommendations –** Summarizes the evaluation results and recommends the final alternatives for evaluation in the Reach 4B Project EIS/R.
- **Section 7.0 References –** Contains a list of all references cited in this document.

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2.0 Alternative Evaluation Process

This section describes the overall alternative evaluation process for the Reach 4B Project, including the goals, objectives, opportunities and constraints, the evaluation criteria, how they are applied, and the final selection of alternatives.

2.1 Goals and Objectives, Opportunities, and Constraints

Alternatives developed for the Reach 4B Project must meet certain goals and objectives.

2.1.1 Goals and 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 cornerstone 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.

Reach 4B 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 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 Restoration Administrator (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, in consultation with the RA and with the concurrence of NMFS and the United States Fish and Wildlife Service (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

2.1.2 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.

Habitat Improvement

The Reach 4B Project has the opportunity to improve 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. Reach 4B of 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.

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.

Water Quality

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.

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.

2.1.3 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.

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	

Project-Specific Constraints

Reclamation and DWR, as the Lead Agencies under NEPA and CEQA, respectively, 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 Lower San Joaquin River Flood Control Project (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. Coordination with the overall SJRRP also includes implementation of all aspects of the SJRRP Conservation Strategy identified in the PEIS/R

- **Minimize Channel Operation and Maintenance (O&M)**. Alternatives that require a substantial amount of long-term O&M 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 O&M whenever applicable. Additionally, minimizing O&M also promotes the design of systems that have a more natural geomorphology and stream function.

Flood Conveyance Capacity

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 establishing 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, in coordination with analysis of sediment transport and geomorphology

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.

2.2 Alternatives Identification Process

This TM documents the evaluation of alternatives that were initially identified in the Initial Alternatives TM. These alternatives have undergone further screening and refinements, based on comments received on the TM, preliminary engineering designs, and feedback from the Implementing Agencies, the landowners, the Technical Work Groups, the Settling Parties, and the Third Parties. This section summarizes the process to reach a set of alternatives for evaluation.

2.2.1 Initial Concept Development

The first step in identifying alternatives was the development of initial concepts. Initial concepts consist of individual components (potential physical modifications) that could be combined together to achieve the overall Reach 4B Project purpose and need/project objectives. The Reach 4B Project 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 California Department of Fish and Wildlife (CDFW) guidance documents pertaining to river restoration and fish passage.
- Technical expertise of the Implementing Agencies.

Screening Initial Concepts

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

- 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.

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. Establishing 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 locations.

- 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.

2.2.2 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 the Reach 4B Project Initial Alternatives 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 were used as a starting point to obtain feedback to refine existing alternatives.

2.2.3 Expand Initial Alternatives

After developing the initial alternatives, the initial alternatives have been expanded to create multiple sub-alternatives that explore multiple proposed levee alignments and floodplain habitat configurations.

2.3 Initial Alternatives Evaluation Methods

The next step in alternatives development includes evaluating the expanded list of alternatives. Evaluation criteria have been developed (presented in Section 4) to determine how well the alternatives meet the overall purpose and need/objectives of the Reach 4B Project. The evaluation criteria also provide a means to compare similar alternatives. 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. The following steps outline the evaluation process.

Step 1: Develop Evaluation Criteria

- Identify a set of criteria that indicate how well the alternatives meet the goals and objectives of the Reach 4B Project and the overall SJRRP.
- Develop performance measures (quantitative or qualitative) for each criterion that measure how well an alternative meets the criterion.
- Determine methods to analyze alternatives related to each performance measure.

Step 2: Complete Alternative Pre-Design

- Develop pre-design information for each Initial Alternative (and sub-alternative).
- Run hydraulic and hydrologic models to understand how alternatives would function.
- Design structures and features (at a preliminary level) to develop a complete alternative.

Step 3: Evaluate Initial Alternatives

- Identify data needed to evaluate the alternatives based on the evaluation criteria developed in Step 1.

- Use current level of design, existing data, and appropriate assumptions to determine how well each alternative meets the performance measures.

Step 4: Compare Alternatives

- Review overall information contained in completed evaluation criteria.

- Recommend alternatives to move forward that represent a broad range of how to accomplish the Reach 4B Project purpose and need/project objectives. The alternatives that move forward may be different than the alternatives described in this evaluation document because of changes made based on evaluation results and feedback.

2.3.1 Evaluation Criteria Development

To develop evaluation criteria for the Reach 4B Project initial alternatives, the Reach 4B Team reviewed scoping comments, comments on the Initial Alternatives TM, the purpose and need/project objectives, the opportunities and constraints identified for the project, and spring-run and fall-run Chinook salmon requirements. A set of evaluation criteria was then developed and presented to the Implementing Agencies and Technical Work Groups for review and feedback. The criteria were then revised based on this feedback. The bullets below outline the general steps for developing the evaluation criteria:

1. Identify primary evaluation criteria categories to help determine the performance of the alternatives. An example of a primary criterion is Fisheries.

2. Under each primary criterion, identify secondary criteria to be evaluated. Examples of secondary criteria under Fisheries are “Passage,” and “Habitat Complexity.”

3. Determine the performance measures, that is, how each primary or secondary evaluation criterion will be measured (qualitative or quantitative), and the unit type, if necessary. For example, the “passage” criterion includes the number of hydraulic jumps/vertical barriers and velocities as two of the performance measures.

4. Determine the source of information needed to complete the evaluation for each criterion. For instance, to determine the total number of hydraulic jumps, the preliminary engineering designs will be used.

2.3.2 Evaluation Criteria Application

After the evaluation criteria were developed and revised based on feedback from the Implementing Agencies and Technical Work Groups, the next step involved gathering the information necessary to complete the evaluation and developing a ranking system to allow comparison between the initial alternatives.

2.4 Final Alternative Selection

The results of the alternatives evaluation will be reviewed, and a reasonable range of final alternatives will be recommended for analysis in the Reach 4B Project EIS/R that:

1. Meet most of the Purpose and Need/Project Objectives; and,
2. Can avoid or substantially lessen one or more of the significant effects.

The alternatives selected to for analysis in the Reach 4B Project EIS/R may not be the alternatives that score the highest for all evaluation criteria. Instead, the alternatives that move forward may represent trade-offs between different evaluation criteria to allow the best-performing alternative for different sets of criteria to move forward.

The alternatives selected may be the alternatives presented in Section 3, or could represent modifications made as a result of the evaluation findings. A preferred alternative will be identified in the Final EIS/R. After the Final EIS/R is published, Reclamation will prepare and adopt a Record of Decision, and DWR will prepare and adopt a Notice of Determination, to implement a preferred alternative.

3.0 Initial Alternatives Descriptions

This section describes pre-evaluation screening that occurred before the initial alternatives were evaluated and presents detailed descriptions of the remaining alternatives.

3.1 Pre-Evaluation Screening

Before evaluating the alternatives, pre-design efforts indicated several issues with the viability of Initial Alternative 5 from the Initial Alternatives TM. For Alternative 5, Split Flow and Fish Enhancements in River, flows would be split between the San Joaquin River and the bypass system. Base and fall pulse flows, and some spring pulse flows, would be diverted into the San Joaquin River; the Flood Flows and the remaining Restoration Flows above the Reach 4B capacity diverted to the Eastside Bypass (see Figure 3-1). Flows would be split, but fish enhancements would be focused in the San Joaquin River and fish screens and barriers would direct fish to this channel.

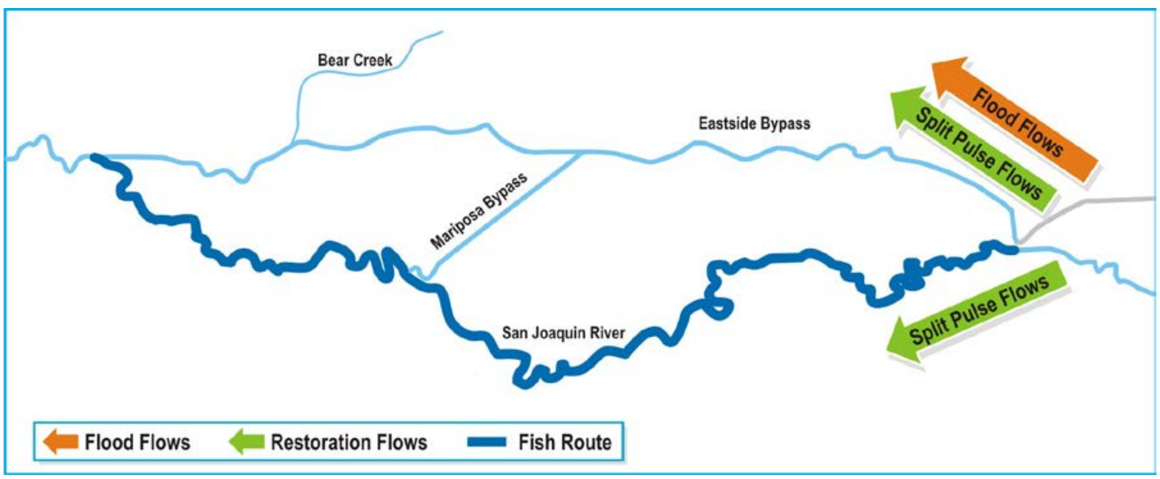

Figure 3-1.
Alternative 5 – Split Flow, Fish Enhancements Focused in River

Under this initial concept for this alternative, juvenile fish would be screened out of the Eastside Bypass by a fish screen at the Sand Slough Control Structure. This screening location assumed that fish would enter the Reach 4B Project study area from Reach 4A of the San Joaquin River. Further evaluation of this alternative indicated that this assumption would not be valid in all years.

Daily modeling of the San Joaquin River system indicated that flow would enter the Chowchilla Bypass at the Chowchilla Bifurcation Structure in approximately 20 years. These flows would continue down the Chowchilla Bypass into the Eastside Bypass. If fish would enter from the Eastside Bypass Reach 1, those fish would not pass the fish screen and would enter the Eastside Bypass Reach 2. Fish in the Eastside Bypass could not enter the San Joaquin River. To capture these fish, the screen would have to be moved out of the Sand Slough area and into Reach 2 of the Eastside Bypass. The fish screen site in the Eastside Bypass would be in an area approximately one to two miles wide, an extremely long length for a fish screen. Additionally, the range of flows that could potentially come down the Eastside Bypass (up to 16,500 cfs) would make the screen prohibitively long. The fish screen would divert fish into a bypass pipe that would route fish into Reach 4B1 of the San Joaquin River; however, this bypass pipe would be ½ to ¾ mile long. This is a much longer bypass pipe than in typical fish screen designs.

Because of the prohibitively large size of the screen and the length of the bypass pipe, screening fish out of the bypass system would not be preferable for fish. This alternative was therefore removed from further consideration based on technical feasibility. A similar alternative that modifies the Eastside Bypass to allow fish passage rather than screening all fish into the San Joaquin River is still being carried forward for consideration (Alternative 4, Split Flow, Fish Friendly Bypass).

3.2 Elements Common to all the Initial Alternatives

This section describes elements and assumptions that are common to the initial alternatives. These elements are common to most alternatives, although some elements may vary slightly between alternatives.

3.2.1 Proposed Levee Alignments

Four proposed levee alignments have been developed for Reach 4B1 (see Figure 3-2). These alignments were developed to help estimate costs, environmental impacts, and benefits for a variety of levee setback alternatives. All levees would be at least 250 feet apart, constructed with three feet of freeboard above the maximum design flow, and with 3:1 horizontal to vertical side slopes. The levees would have a seepage berm to improve levee stability, where necessary. These proposed levee alignments are preliminary; the final alignments that are selected for analysis in the EIS/R will be modified to incorporate results of further analysis, including topography, canal realignments, land acquisition constraints, and habitat value.

Option A: **Existing Levee Alignment** This option would use the existing levee alignment in Reach 4B1 with improvements to contain the design flow. The maximum flow capacity with this alignment is 1,500 cfs, which is the original design capacity of Reach 4B1. This levee alignment would also be applicable for alternatives that would convey lower flows (such as 475 cfs) through Reach 4B1. Existing levees would be removed and replaced because the existing levees are not continuous and several road crossings would have to be reconstructed to pass flow. The levees would typically be 250 to 400 feet apart in this option, but there are several sections where the levee width is wider.

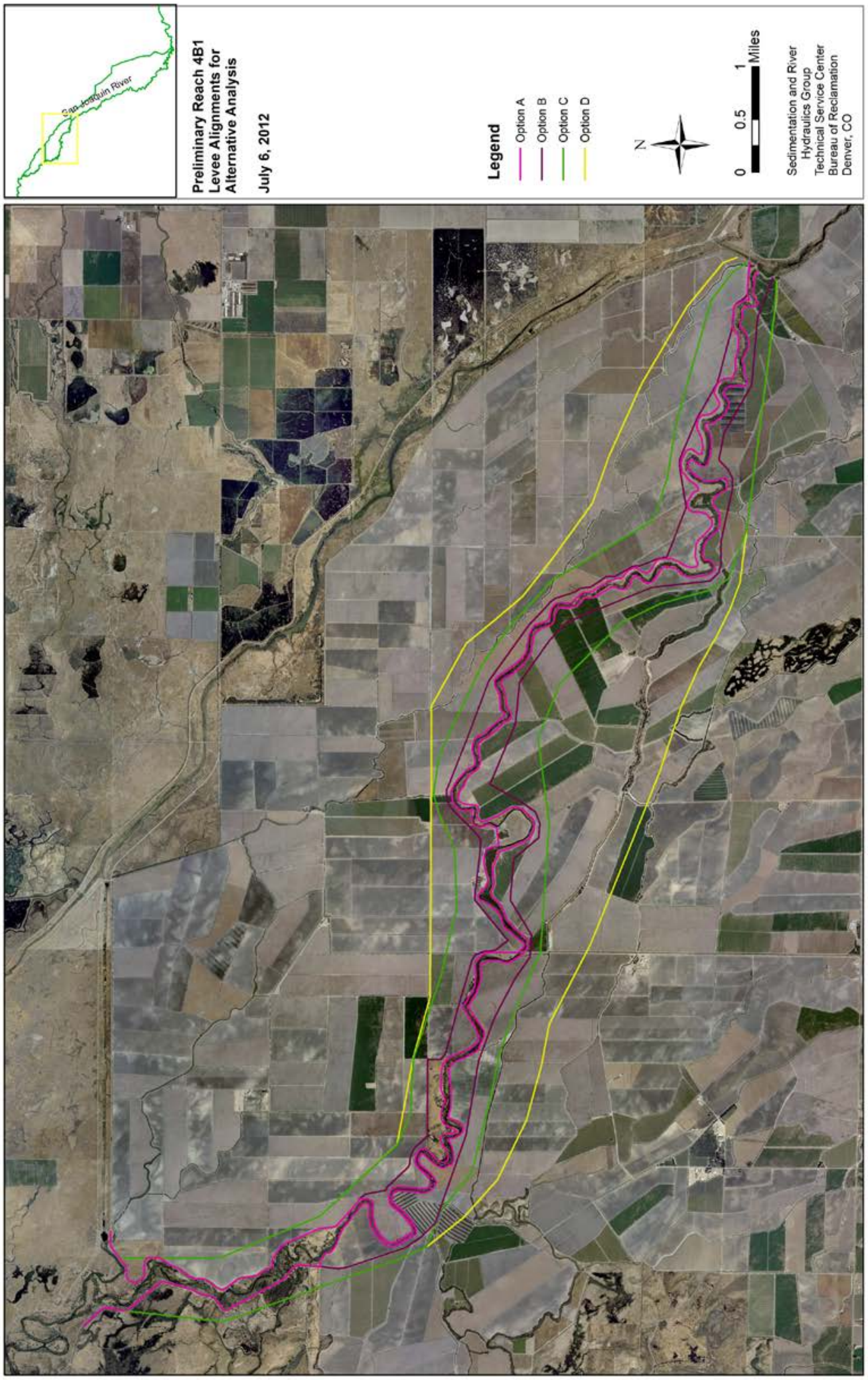

Figure 3-2.
Four Proposed Levee Alignment Options for Reach 4B1

Option B: **Minimal Levee Setback** This option is considered the minimum levee setback necessary to convey 4,500 cfs and maintain a minimum level of riparian habitat. It incorporates approximately one channel width (about 250 feet) of riparian vegetation on each side of the channel. One channel width is considered the minimum acceptable levee setback to allow for riparian shading, allow natural bank erosion processes, and minimize levee maintenance. Some side channels would be constructed, but on a limited basis. The channel would be intended to be primarily a single thread channel. The levees would typically be 1,300 to 2,000 feet apart under this option. Where existing levees exist, they would be removed and the material used to help construct the new levees.

Option C: **Intermediate Levee Setback** Option C is considered an intermediate levee setback between Option B and D that would contain 4,500 cfs. The levees would typically be 3,500 to 5,500 ft wide, though the width decreases to about 2,500 feet at the downstream end of the reach. Where existing levees exist, they would be removed and the material used to help construct the new levees.

Option D: **Maximum Levee Setback** Option D is considered a maximum levee setback that would reconnect historical side channels and restore a significant portion of the complex channel network of the San Joaquin River that existed prior to the advent of intensive agricultural production. This proposed levee alignment is also designed to convey 4,500 cfs. This Maximum Levee Setback option was determined through analysis of topography and historical photos. A 1937 aerial photograph of a portion of the San Joaquin, shown in Figure 3-3, was used to help identify historical side channels. The side channels were then overlain with a more recent aerial photograph from 2004 (see Figure 3-4). The levees in this option would typically be 5,000 to 11,000 ft wide, though the width would decrease to about 2,500 ft at the downstream end of the reach. Where existing levees exist, they would be removed and the material used to help construct the new levees.

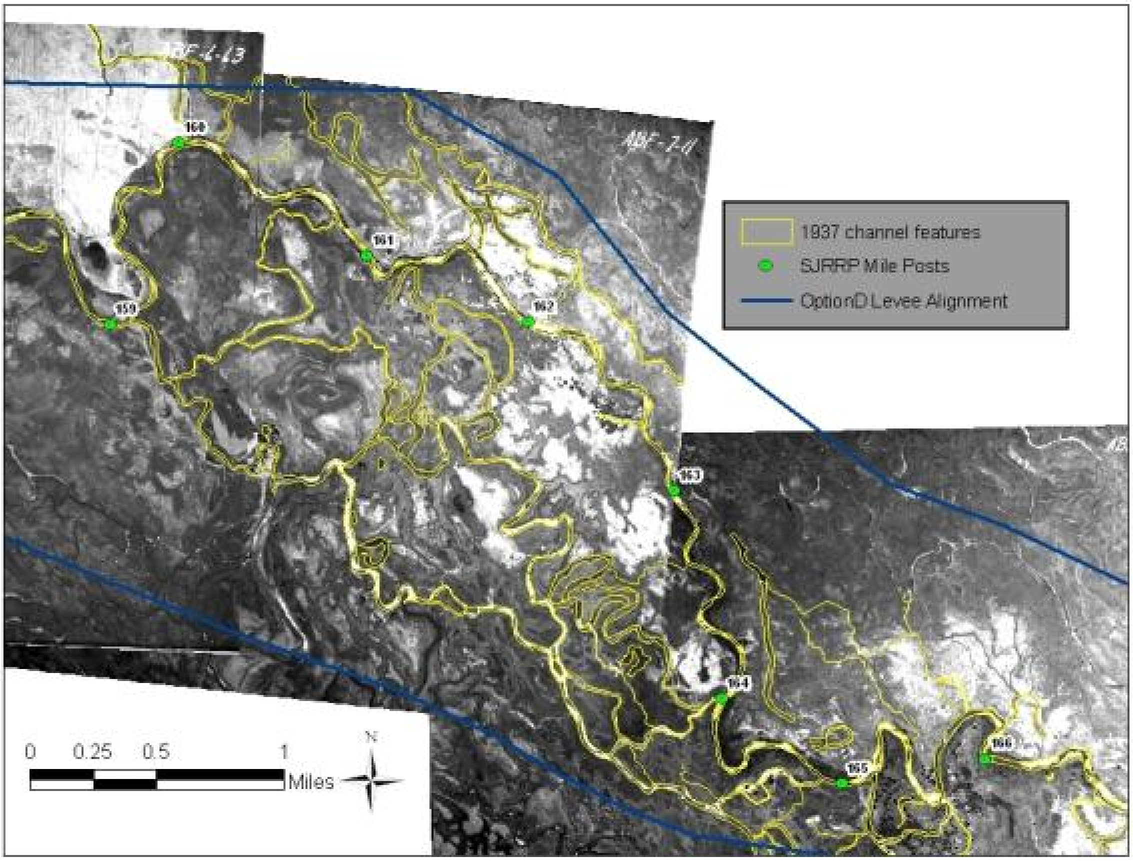

Figure 3-3.
Aerial Photograph of a Portion of Reach 4B1 Taken in 1937

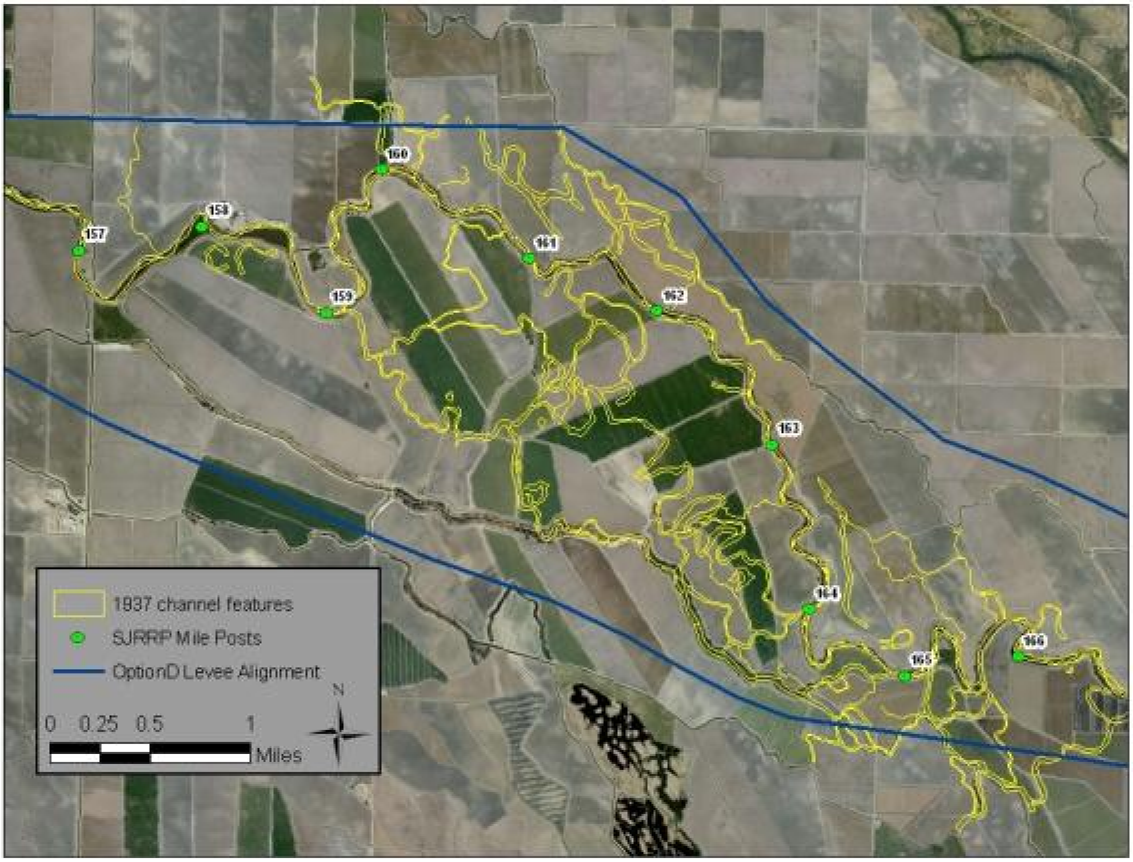

Figure 3-4.
Aerial Photograph of a Portion of Reach 4B1 Taken in 2004

For each proposed levee alignment, a considerable amount of earthwork would be required in Reach 4B1 to restore channel conveyance, floodplain connectivity, and prevent fish stranding. For proposed Levee Alignments B through D, it is assumed that the existing levees would be removed to approximately the surrounding floodplain elevations. The floodplain does not always slope towards the main channel of the San Joaquin River. To prevent stranding of fish in the floodplain, it would be necessary to either grade the floodplain towards the main channel or ensure that a side channel can collect the flow and return it to the main channel.

Not all proposed levee alignments would work with each of the alternatives because the flows may be too large or small for the levee widths. Table 3-1 below presents the proposed levee alignments that are possible under each alternative.

Table 3-1.
Proposed Levee Alignments

Proposed Levee Alignments	Levee Length Left/Right in feet	Maximum Capacity	Approx. Width Between Levees
A	102,000/ 90,200	1,500 cfs	250-400 ft
B	77,800/ 76,400	4,500 cfs	1,300 to 2,000
C	72,800 / 66,300	4,500 cfs	3,500 to 5,500
D	70,200 / 65,100	4,500 cfs	1-2 miles wide at widest part

3.2.2 Road Crossings

Reach 4B1 and the bypass system have multiple road crossings that could be obstructions to flows or fish (see Figure 3-5). It was assumed that all existing road crossings would be replaced within Reach 4B1, unless it could be shown that a crossing would not be required after the Reach 4B Project's construction. (For example, as described further in Section 3.3, Crossing #0 is not required under Alternative 1 because the public park that it accesses would be inundated by Restoration Flows.) In the bypasses, crossings would be replaced if modeling indicated that they could be an obstruction to fish or flows.

The pre-design process considered whether the crossings would be replaced in-kind or with year-round access capabilities. Many of the existing crossings in the San Joaquin River and the Eastside and Mariposa bypasses become inundated at larger flows. Dan McNamara Road, El Nido Road, and the Mariposa Bypass Crossing are examples of crossings that would become inundated during higher flows. Other crossings, such as the Washington Road/Indiana Road Bridge, would provide for year round access throughout the full range of flows. At this stage of design, no decision was made as to whether these existing low-flow crossings would be replaced with inundated or year-round access crossings. The discussion below documents the assumptions made for the purposes of alternatives development. These assumptions generally describe the largest facility that may be necessary, but smaller low-flow crossings may be identified as feasible in the future. The EIS/R will analyze the environmental impacts of both the larger and smaller crossings.

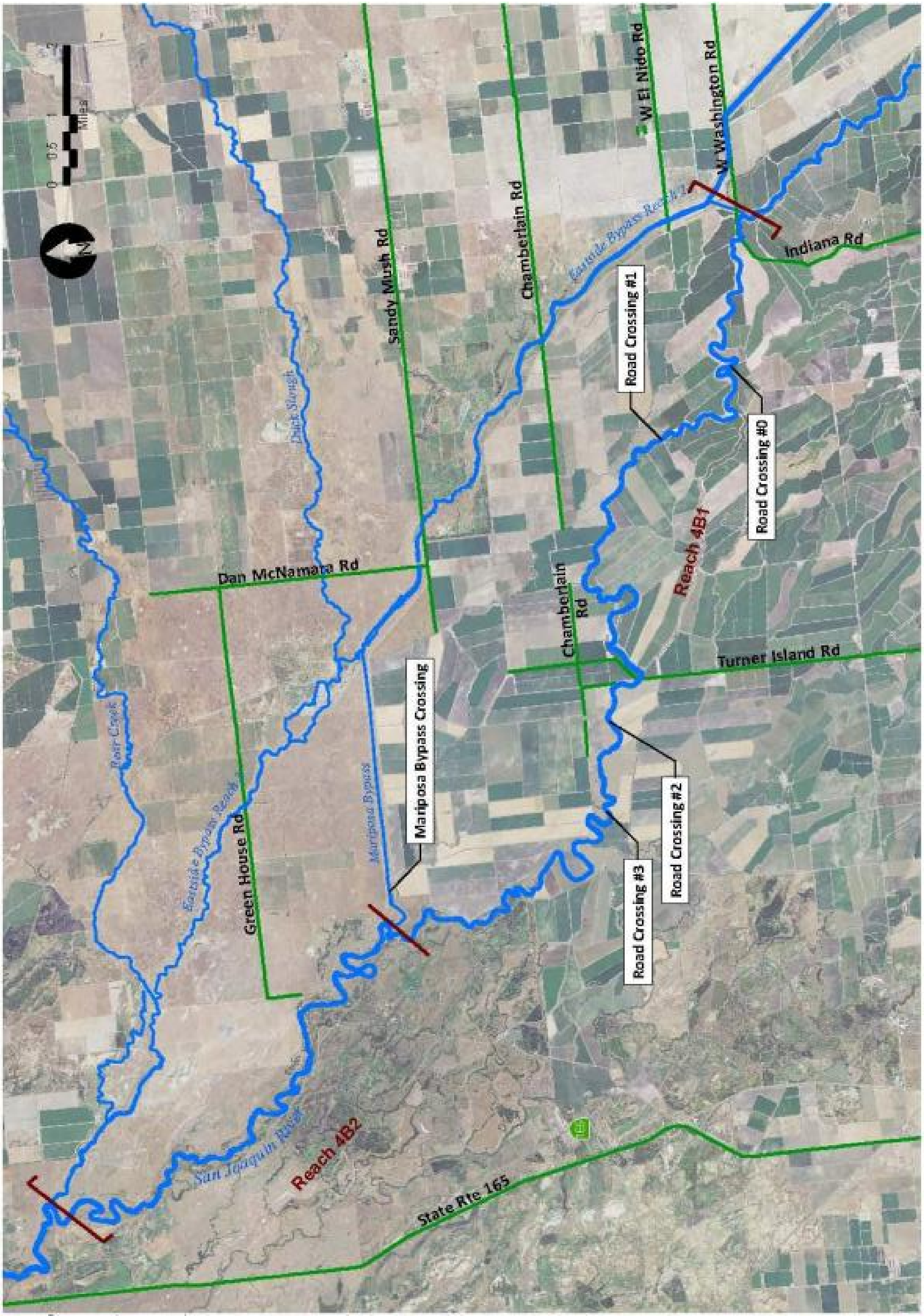

Figure 3-5.
Road Crossings in the Study Area

For river crossings that currently provide year-round access (Washington Road/Indiana Road and Turner Island Road), a new bridge structure would be required for a channel capacity greater than 1,500 cfs. The bridge deck elevation would be set above the modeled water surface with approximately three foot of freeboard, to match the existing levee elevations. The roadway would extend from the levees on either side of the crossing, across the full channel and floodplain. This design was used to provide the maximum available flow area for passing flows, as well as to provide to maximum passage for fish. This design would also be applicable for bypass crossings that need to be replaced because they could obstruct fish or flows.

For low-flow river crossings when the channel capacity is greater than 1,500 cfs, a new bridge would be constructed to span only the active channel width as determined using HEC-RAS modeling and surveying. The bridge deck elevation would be set above the modeled water surface with approximately one foot of freeboard. The roadway would extend from the levee down to the floodplain elevation using a pair of ramps set at a five percent slope to accommodate 40 mile per hour traffic. If required, a pair of ramps would rise from the floodplain elevation to the top of the bridge deck over the active channel and back down to the floodplain on the other side of the bridge. On the floodplains, the roadway would be constructed on a small berm (with culverts for secondary channels). This crossing would remain accessible when flows remain in-channel and for smaller flows that inundate the floodplain, but the portion on the floodplain would be inundated during higher flows. This design was used to provide an economic balance between a full bridge crossing the entire channel and an inundated crossing that would not provide for year-round access. This type of crossing would provide for nearly constant access, only becoming inundated with large flows. These future crossing designs would provide similar access to the existing crossings, but have the added benefit of being passable by fish.

For low-flow river crossings when the channel capacity is less than 1,500 cfs, a series of reinforced concrete box culverts were designed. These box culverts would be set in the active channel, with a road crossing incorporated into the deck of the structure. For these crossings, the roadway would be ramped down from the levee elevations using a pair of ramps built at a five percent slope. This slope was chosen to accommodate 40 mile per hour traffic. The roadway would be constructed on grade across the floodplain, to the culvert structure. The roadway would cross the active channel on the deck of the box culverts, and resume across the floodplain, back up the ramp to the other levee. This design was used to provide for both traffic access and fish passage for lower channel flows.

At a future stage of design, an analysis should be made to determine if the large bridge crossings are required, or if they can be reduced to only meet a specific flow rate for passage. Cost savings could be realized if these bridges and crossings could be reduced in size according to requirements determined by future study. Because of this uncertainty, the environmental impacts of both crossing types will be assessed in the EIS/R.

3.2.3 Fish Passage Design Criteria

The Project team worked in conjunction with the Fisheries Management Workgroup and other experts of the Implementing Agencies to develop criteria for fish passage that were used to design structures and channels. These criteria are used as inputs for the design process; all structures and river channels meet these criteria. The criteria include passage conditions for both salmon and other native fishes.

3.2.4 Canal Relocations

Proposed levee alignments B, C, and D have the potential to affect water delivery canals in the study area. The pre-design process includes an estimate of the cost to realign the canals to allow water operations to continue without adverse impacts. The details of these realignments will be part of the next phase of design.

3.2.5 Seepage Measures

The pre-design process included a constraint that the material adverse effects due to groundwater seepage must be reduced or avoided. All proposed levee alignments include levee construction to avoid seepage based on site-specific groundwater information. This requirement was included in the pre-design process so that all alternatives and proposed levee alignments have the same level of seepage protection.

3.2.6 Revegetation Plan

Some level of riparian restoration is necessary under all action alternatives to accomplish the Restoration Goal. This need led towards the consideration of several approaches to reestablish or enhance riparian habitat within the Reach 4B Project area. The preferred approach was to develop a hybrid program of passive and active riparian revegetation. The analysis considered areas within the Reach 4B Project area that were suitable for passive recruitment based on soils, groundwater conditions, baseflows, and other local conditions. The extent and type of active revegetation for each alternative was then determined based on where vegetation was most likely to thrive in the long term. This approach also recognized that areas not targeted for active riparian revegetation may require seeding for erosion and invasive pest plant control until vegetation returns passively, and the estimated extent and type of seed application is also provided for cost estimation purposes. In areas where active revegetation of Riparian Establishment Areas occurs, temporary irrigation would be established for three years to insure the plant root systems have developed. More information on the approach to revegetation is in Attachment 6.

3.3 Initial Alternatives

The sections below describe the four alternatives (and their associated proposed levee alignments) remaining after the pre-evaluation screening effort. Additional information on the design is included in Attachment 1 (Hydraulic and Sediment Studies for Reach 4B), Attachment 2 (San Joaquin Reach 4B Levees Appraisal Level Analysis and Design), and Attachment 3 (Design Drawings).

3.3.1 Alternative 1 – Main Channel Restoration

Under Alternative 1, Main Channel Restoration, the San Joaquin River would function as the main route for fish and flows. The San Joaquin River would have a capacity of 4,500 cfs and would receive all Restoration Flows. No improvements would occur in the Eastside and Mariposa bypasses. Restoration Flows up to 4,500 cfs would be routed down the San Joaquin River, while all Flood Flows greater than 4,500 cfs would be routed down the bypass system. 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 bounded by setback levees. During flows greater than 4,500 cfs, fish could be washed into, or could migrate up into the bypass. Due to the infrequency of such events (approximately one year in five for varying durations), no effort would be made to prevent Chinook salmon and other target fish species from entering the bypass system during such flows, though migration barriers would be removed to facilitate safe passage of fish back to the river in either direction. Figure 3-6 presents the flow routing for Alternative 1.

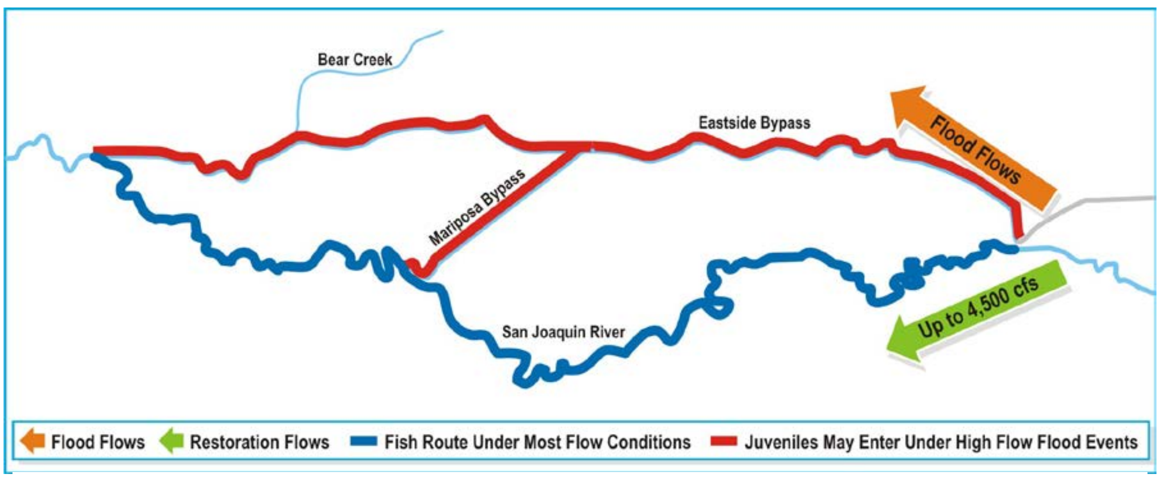

Figure 3-6.
Alternative 1 – Main Channel Restoration

Channel Improvements

All channel improvements would be focused on the San Joaquin River Reach 4B1 channel.

San Joaquin River. The San Joaquin River channel does not have capacity to convey 4,500 cfs in Reach 4B1 under current conditions, so under Alternative 1 would require setback levees as shown in proposed levee alignments B, C, or D to contain 4,500 cfs within the channel and floodplain.

Channel Habitat Modifications

Because all the setback proposed levee alignments provide sufficient flow conveyance, in-channel vegetation would be left in place except for any very dense areas that would be flow or fish impediments within the low flow channel, which would be cleared. Over time, the presence of flows would kill non-riparian vegetation in the active channel and support a natural transition to riparian species. Native riparian vegetation along the channel banks and between the banks and the levees would be preserved and enhanced. Large woody vegetation growing in the existing levees would be preserved where practical by leaving these portions of the levee intact and removing less vegetated sections to allow flow to reach the floodplain. Obstruction to upstream and downstream fish migration would be removed (see details below). Where the channel was disturbed (for example by removal of in-channel obstructions) it would be restored with its existing geometry using native vegetation and biotechnical restoration and stabilization methods. For Alternative 1, 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. Additional riparian vegetation would be planted to provide shade and a riparian corridor where the existing condition was degraded. Large woody debris (LWD) habitat elements would be added to the channel where existing cover is lacking, to provide additional cover and complexity. Where used, LWD structures would be anchored or keyed into the banks. The San Joaquin River channel would provide in-channel rearing and refugia habitat and the area within the levee setbacks would provide floodplain rearing habitat.

Floodplain Habitat Modifications

Under Alternative 1, habitat modifications would only be made in and around the San Joaquin River. With increasing levee setback widths under the different proposed levee alignments, the area of floodplain would increase from 1,265 acres (Levee Alignment B) to 2,985 acres (Levee Alignment C) to 10,150 acres (Levee Alignment D). With proposed Levee Alignments B and C, new secondary floodplain channels would be constructed to provide a wide range of water depth and velocity conditions across a range of floodplain inundation events corresponding to the proposed restoration flows. In proposed Levee Alignment D, some historic secondary channels seen in 1937 aerial photos would be restored by reconnecting them to the active river channel while others that have been graded over would be recreated through channel construction. Between the setback levees and the river channel the floodplain would be graded to eliminate fish stranding areas and to encourage gentle drainage towards the river. Floodplain graded features would be designed to inundate at flows corresponding to species needs and water availability at different times of the year (based on the Restoration Flow schedule). For example, side channels and lower floodplain areas would be designed to provide appropriate velocities and depths of off-channel rearing habitat during spring releases of 1,225 and 2,180 cfs in most years, with other areas designed to provide optimum habitat at higher flows such as 3,655 cfs in wetter years. The depth and extent of inundation depends on the sub-alternative selected, since a range of levee widths have been considered. Proposed Levee Alignment B generates a smaller area of deeper water on the floodplain during spring floods, while proposed Levee Alignments C and D provide more area but shallower water. A mixture of native grasses and trees would be planted between the levees to provide floodplain rearing habitat.

Figure 3-7 presents the potential channel modifications and levee setbacks that could occur under Alternative 1. Figure 3-8 shows example cross sections of the modifications that could occur under Alternative 1.

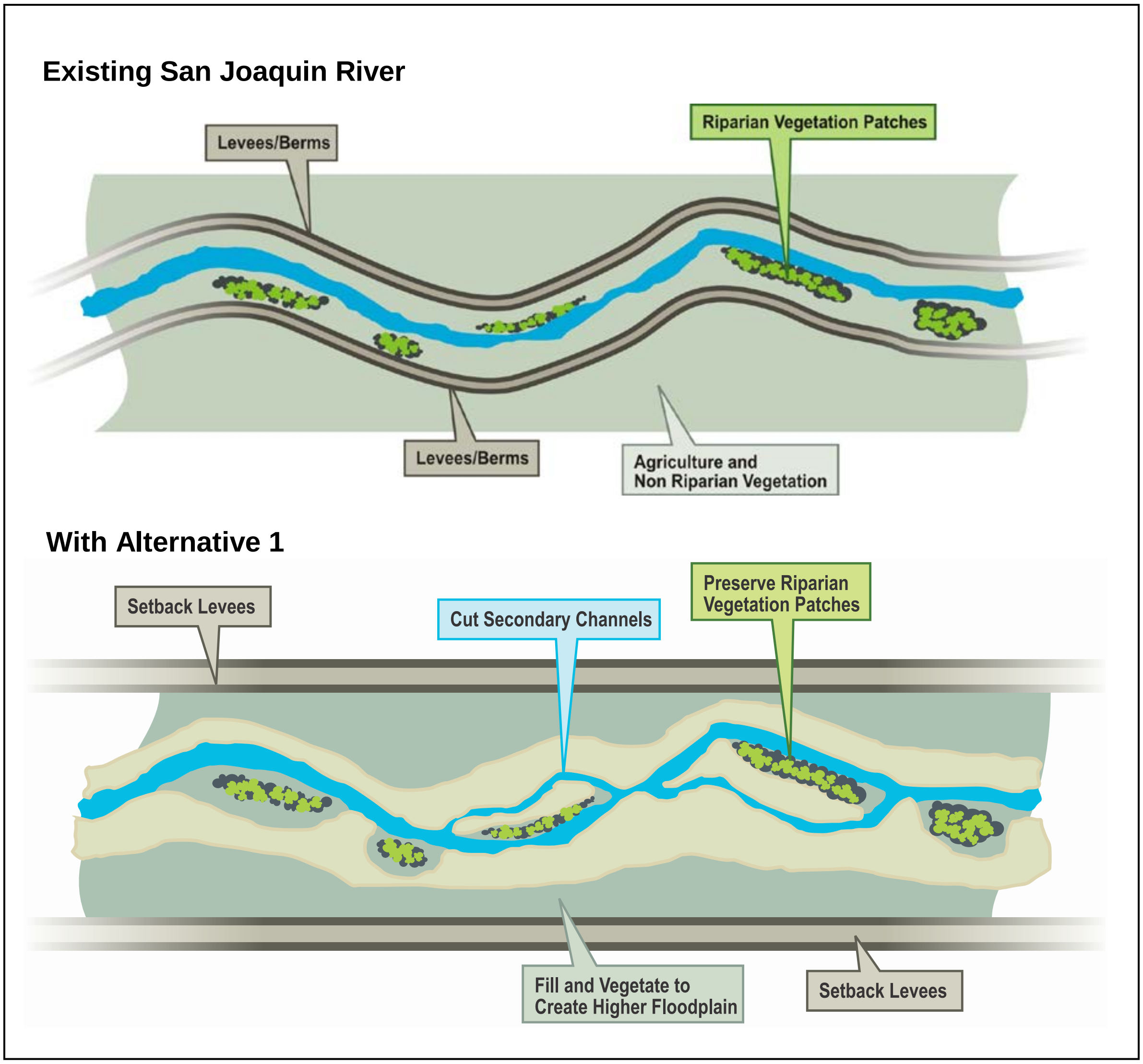

Figure 3-7.
Alternative 1 - Example of Channel Modifications and Levee Setbacks

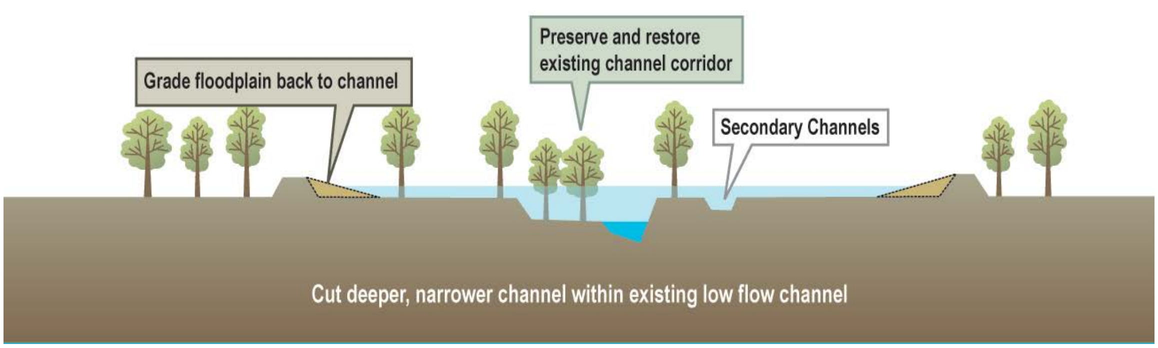

Figure 3-8.
Cross-section of San Joaquin River Floodplain Modifications under Alternative 1

Eastside Bypass and Mariposa Bypass. Under this alternative, Restoration Flows greater than 4,500 cfs and any Flood Flows would be routed through the bypass system. Because such flows would happen infrequently (approximately one year in five), Alternative 1 includes no provision to add channel habitat within the bypasses, though the current conditions in the bypass would provide some floodplain habitat.

Levees

Setback levees would be constructed around the San Joaquin River channel to allow up to 4,500 cfs to flow in the channel and across the floodplain. There are several potential levee alignments for this alternative, Levee Alignment B, Levee Alignment C, or Levee Alignment D. All levees would be at least 250 feet away from the San Joaquin River channel to minimize the risk of erosion along the levees and to allow space for the channel to migrate over time.

Structural Improvements

Structural improvements would include changes to the Reach 4B Headgates and Sand Slough Control Structure, as well as modification of several road crossings in the San Joaquin River.

Reach 4B Headgates. The Headgates at the upstream end of Reach 4B would be removed to allow all flows from Reach 4A to enter Reach 4B. The design capacity at the downstream end of Reach 4A is 4,500 cfs; therefore, all flow from Reach 4A should be able to enter Reach 4B.

Sand Slough Control Structure. For this alternative, up to 4,500 cfs would enter Reach 4B1 of the San Joaquin River from upstream. To accomplish this flow routing, the existing control structure at Sand Slough must be demolished and removed. Following demolition and earthwork, a new Obermeyer-style gate would be installed in the bypass channel with the associated compressor building and controls. This new gate would serve to regulate the water depths at the bifurcation of Reach 4B1 from the Eastside Bypass, Reach 2. The maximum gate height would provide the required water surface elevation at the bifurcation to divert up to 4,500 cfs into Reach 4B1. It is anticipated that this gate would be operated in an upstream control mode, and the gate would be raised or lowered as required to maintain the necessary water surface elevation to divert the flows into Reach 4B1 as required. During higher flow events, or storm/flood events, the gate could be lowered to make full use of the flood capacity of the Eastside Bypass Channel. During emergencies, O&M periods, or other times, the gate could be controlled locally and adjusted manually.

Indiana Road/Washington Road Crossing (San Joaquin River). Hydraulic modeling indicates that this existing bridge crossing would cause a backwater condition (creating a higher water level upstream of the bridge and a potential barrier to fish passage). To correct this condition, the existing crossing, which is approximately 120 feet wide, would be widened to 500 feet. This would require the demolition of the existing bridge, channel widening, and the construction of a new bridge at this location.

Crossing #0 (San Joaquin River). This crossing currently connects the southern levee road to a privately owned park area in the center of the river channel. For the higher flows in this alternative, the park would become inundated and so this crossing would not be maintained.

Crossing #1 (San Joaquin River). This crossing is a privately constructed crossing that was built to provide access to both sides of the existing river channel. With the restoration of the river channel and the addition of the flows on this alternative, this crossing would need to be replaced to prevent a backwatering/seepage problem at this location and upstream. Therefore, this crossing would be excavated, and the culvert pipe would be demolished and removed from the site. The river channel would be then regraded similar to the remainder of the channel to convey the necessary flows for this alternative. The replacement bridge would be similar to the nearby existing bridge crossing at Sandy Mush Road. The spans of the new bridge would be 35 feet long. The new bridge would be two lanes wide, with shoulders to accommodate the typical anticipated traffic. The bridges would be designed to accommodate American Association of State Highway Transportation Officials (AASHTO) HS20-44 loading (standard design loading for highway structures), based on the potential for large construction and agricultural equipment to utilize these crossings. The new bridge would span the new active channel width of 250 feet, and connect to roadways constructed on the floodplain perpendicular to the river alignment. These would be constructed on causeways within the setback levees, with increasing lengths for proposed Levee Alignments B, C and D. These causeways could have culverts or other penetrations to allow connection of the river side channels through the crossing.

Turner Island Road Crossing (San Joaquin River). Hydraulic modeling indicates that this existing bridge crossing would cause a backwater condition. To correct this condition, the existing crossing, which is approximately 90 feet long, would be lengthened to 500 feet. The new bridge would connect to newly constructed causeways within the setback levees, with increasing lengths for proposed Levee Alignments B, C and D. These causeways could have culverts or other penetrations to allow connection of the river side channels through the crossing. This project element would require the demolition of the existing bridge, channel widening, and the construction of a new bridge at this location. The new span over the active channel would be approximately 500 feet long. The bridge would be sized for two lanes of traffic, 12 feet wide to accommodate local traffic and other large agricultural equipment. The bridge was preliminary designed to accommodate an AASHTO HS20-44 loading scheme, which was chosen to accommodate the larger semi-truck traffic or agricultural equipment anticipated to use this bridge crossing. The new bridge alignment would follow the existing alignment of Turner Island Road.

Crossing #2 (San Joaquin River). This crossing is a privately constructed crossing that was built to provide access to both sides of the existing river channel. With the restoration of the river channel and the addition of the flows on this alternative, this crossing would need to be replaced to prevent a backwatering/seepage problem at this location and upstream. Therefore, this crossing would be excavated, and the culvert pipe would be demolished and removed from the site. The river channel would be then regraded similar to the remainder of the channel to convey the necessary flows for this alternative. The replacement bridge would be similar to the nearby existing bridge crossing at Sandy Mush Road. The spans of the new bridge would be 35 feet long. The new bridge would be two lanes wide, with shoulders to accommodate the typical anticipated traffic. The bridges would be designed to accommodate AASHTO HS20-44 loading, based on the potential for large construction and agricultural equipment to utilize these crossings. The new bridge would span the new active channel width of 250 feet, and connect to roadways constructed on the floodplain perpendicular to the river alignment. These would be constructed on causeways within the setback levees, with increasing lengths for proposed Levee Alignments B, C and D. These causeways could have culverts or other penetrations to allow connection of the river side channels through the crossing.

Crossing #3 (San Joaquin River). This crossing is a privately constructed crossing that was built to provide access to both sides of the existing river channel. With the restoration of the river channel and the addition of the flows on this alternative, this crossing would need to be replaced to prevent a backwatering/seepage problem at this location and upstream. Therefore, this crossing would be excavated, and the culvert pipe would be demolished and removed from the site. The river channel would be regraded similar to the remainder of the channel to convey the necessary flows for this alternative. The replacement bridge would be similar to the nearby existing bridge crossing at Sandy Mush Road. The spans of the new bridge would be 35 feet long. The new bridge would be two lanes wide, with shoulders to accommodate the typical anticipated traffic. The bridges would be designed to accommodate AASHTO HS20-44 loading, based on the potential for large construction and agricultural equipment to utilize these crossings. The new bridge would span the new active channel width of 250 feet, and connect to roadways constructed on the floodplain perpendicular to the river alignment. These would be constructed on causeways within the setback levees, with increasing lengths for proposed Levee Alignments B, C and D. These causeways could have culverts or other penetrations to allow connection of the river side channels through the crossing.

Eastside Bypass Control Structure. For this alternative, there is no proposed change to the structure or operations of the Eastside Bypass Control Structure.

Mariposa Bypass Control Structure. For this alternative, there is no proposed change to the structure or operations of the Mariposa Bypass Control Structure.

Mariposa Drop Structure. For this alternative, there is no proposed change to the structure or operations of the Mariposa Bypass Control Structure.

Fish Screens/Barriers

No fish screens or barriers would be added to the system.

Merced NWR Weir

The Merced NWR has two weirs currently used for their watering operations that have the potential to be fish migration barriers. These weirs consist of a reinforced concrete substructure, with a structural steel and grating superstructure. This alternative would not require any changes to the refuge weirs as the Eastside Bypass would not be the primary fish corridor.

Road Crossings at El Nido Road and Dan McNamara Road

This alternative does not include any changes at these roads because improvements are not needed for fish passage and this alternative would not increase the frequency of inundation compared to existing conditions.

Land Acquisition

Under Alternative 1 land would be acquired along the San Joaquin River to establish floodplain habitat, with the amount depending on the levee setback selected. Current sub-alternatives range in width from 1,300 feet to 11,000 feet. Land acquisition would vary from approximately 3,000 acres under the narrowest setbacks to 10,000 acres under the widest setbacks.

Revegetation Plan

Active riparian restoration would be necessary within the expanded floodplain along the San Joaquin River channel, alongside channels (if constructed), at reconfigured bridge and road crossings, and areas where vegetation is removed along the river channel. Additional erosion control revegetation efforts would be necessary within the expanded floodplain where agricultural fields are removed and fish stranding features are filled. No revegetation along the bypass system would be proposed. The quantities of revegetation efforts would vary by proposed levee alignment:

- Levee Alignment B: Approximately 30 percent of the floodplain would be targeted for active planting and the total acreage of actively planted riparian vegetation within the corridor would be approximately 896 acres. Approximately 955 acres within the entire corridor would be seeded with a riparian seed mix and approximately 1,134 acres within the entire corridor would be seeded with an upland erosion control mix.

- Levee Alignment C: Approximately 30 percent of the floodplain would be targeted for active planting and the total acreage of actively planted riparian vegetation within the corridor would be approximately 1,859 acres. Approximately 1,173 acres within the entire corridor would be seeded with a riparian seed mix and approximately 3,164 acres within the entire corridor would be seeded with an upland erosion control mix.

- Levee Alignment D: Approximately 25 percent of the floodplain would be targeted for active planting and the total acreage of actively planted riparian vegetation within the corridor would be approximately 2,538 acres. Approximately 1,805 acres within the entire corridor would be seeded with a riparian seed mix and approximately 5,807 acres within the entire corridor would be seeded with an upland erosion control mix.

Flood Routing

Restoration flows up to 4,500 cfs would be directed into the San Joaquin River by raising the gates on the proposed new Sand Slough Control Structure. At flows above 4,500 cfs the gates would be lowered to allow excess flow into the Eastside Bypass. Flows above 4,500 cfs would be controlled as under existing conditions, though the overall flood capacity of the system would be increased due to the setback levees along the San Joaquin River.

Operation and Maintenance

There would be additional O&M requirements for the Sand Slough Control Structure to ensure that it performed correctly. These would include mechanical maintenance of the gates as well as potential periodic sediment and in-channel vegetation removal from immediate vicinity of the structure if deposition affected its hydraulic performance.

3.3.2 Alternative 2 – Bypass Restoration

Under Alternative 2, all Restoration Flows and up to 16,000 cfs of Flood Flows would be routed down the Eastside Bypass, which would be made slightly steeper by removing the Mariposa Drop Structure and regarding the Eastside Bypass. Reach 4B1 of the San Joaquin River would be modified to convey up to 475 cfs of flood relief for the Eastside Bypass and to compensate for reductions in flood capacity in the Eastside Bypass due to the effects of hydraulic roughness from habitat restoration. If additional flood conveyance capacity was needed in the Eastside Bypass beyond that provided by the San Joaquin River the levees of the Eastside Bypass would be locally modified.

Flow Routing

The first 8,500 cfs of flow in the Eastside Bypass would pass through the Mariposa Bypass and into Reach 4B2, with flows over this level continuing down the Eastside Bypass. Adult salmon migrating upstream would enter the San Joaquin River Reach 4B2, be directed up the Mariposa Bypass Channel over modified or removed structures that allow fish passage, and would pass up the upper Eastside Bypass before rejoining the San Joaquin River channel at the junction of Reach 4B1 and Reach 4A. Juvenile salmon migrating downstream would enter the system from the San Joaquin River Reach 4A or the Eastside Bypass Reach 1 and move downstream through the Eastside Bypass Reach 2, Mariposa Bypass, and San Joaquin River Reach 4B2. 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 lower Eastside Bypass 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.

Figure 3-9 presents the flow and fish routing for Alternative 2.

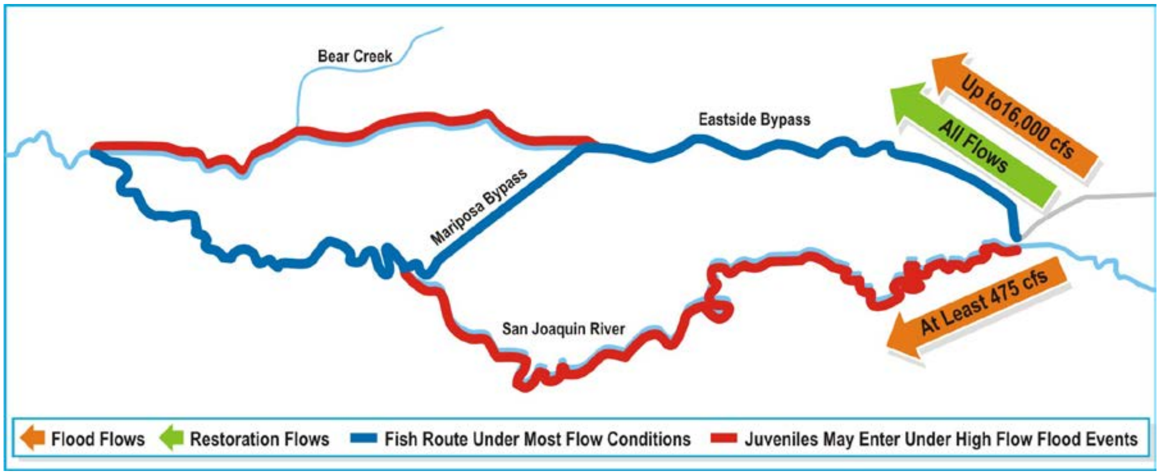

Figure 3-9.
Alternative 2 – Flow Routing for Main Restored Channel in Bypass

Channel Improvements

All channel improvements for restoration would be focused in the Eastside Bypass channel, though some channel clearing would be undertaken in the San Joaquin River channel to increase conveyance.

San Joaquin River

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 3-10). 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, but levee improvements may be necessary to provide three feet of freeboard and reduce seepage.

Habitat Modifications

No new habitat features would be added to the San Joaquin River because of the infrequency that fish will enter the reach.

Figure 3-10.
Alternative 2 – Example of Channel Excavation and Vegetation Clearing in the San Joaquin River

Eastside Bypass and Mariposa Bypass

Under this concept, all Restoration and Flood 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 development in the Eastside and Mariposa bypasses, 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.

Channel Habitat Modifications

Under existing conditions, the sill of the Mariposa Bypass Control Structure is six feet higher than the sill of 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 in the Eastside Bypass Reach 1 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 (see Figure 1-1 for these locations). These actions would allow the channel through the bypass to be regraded to gradually lose elevation over the length of the bypasses. 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 meet fish needs, including riparian habitat and cover. This alternative might also require levee strengthening in the Mariposa Bypass to accommodate higher Flood Flow velocities.

Under Alternative 2 the existing channel in the Eastside Bypass Reach 1 would be enhanced to provide a channel suitable for both fish passage and rearing of Chinook salmon and other target fish species. A 50 foot wide, approximately five foot 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 riparian species or tules and other emergent vegetation over time. The multi-stage primary channel through the bypass system would be capable of containing at least 475 cfs, the 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. Grading within the main channel would create a low flow channel that concentrated flows of 175 cfs, 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. Creating a more concentrated channel would also reduce sediment deposition and thermal loading of the channel during low flows. Channel enhancement actions would include creating a riparian corridor of 50-75 feet on either side around the channel to provide shade, cover, and inputs of nutrients and woody debris. Establishing a riparian corridor in the bypasses is expected to 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 would be introduced into the channel where bank stabilization is needed to improve rearing and shelter for target fish species. LWD would need to be anchored or keyed into the banks to minimize movement during Flood Flows.

Floodplain Habitat Modifications

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 would occur at flows between 475 cfs and 1,225 cfs (the magnitude of the smallest spring pulse flows included in the default Restoration Flow hydrographs). 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. Such side channels or the bed of the bypass would function as floodplain to the primary channel. Additional secondary channels and higher and lower areas would be graded into the floodplain to provide a diversity of depth and velocities across a range of flow levels corresponding to the likely Restoration Flows and superimposed flood flows. The floodplain portion of the bypass would be generally graded towards the channel to prevent fish stranding when flows recede. In addition, numerous ponds and borrow areas would be filled to prevent fish stranding.

Vegetation management practices would be modified to allow vegetation that is beneficial to habitat (e.g. native herbaceous and wood species) to persist while maintaining the conveyance capacity of the bypass system to the extent not offset by new San Joaquin River conveyance.

Figure 3-11 presents an overview of Alternative 2 in the Eastside Bypass. Figures 3-12 and 3-13 show the existing cross section the Eastside Bypass and potential modifications included in Alternative 2.

Figure 3-11.
Alternative 2 – Example of Channel Excavation in the Eastside Bypass

Figure 3-12.
Existing Channel in Eastside Bypass

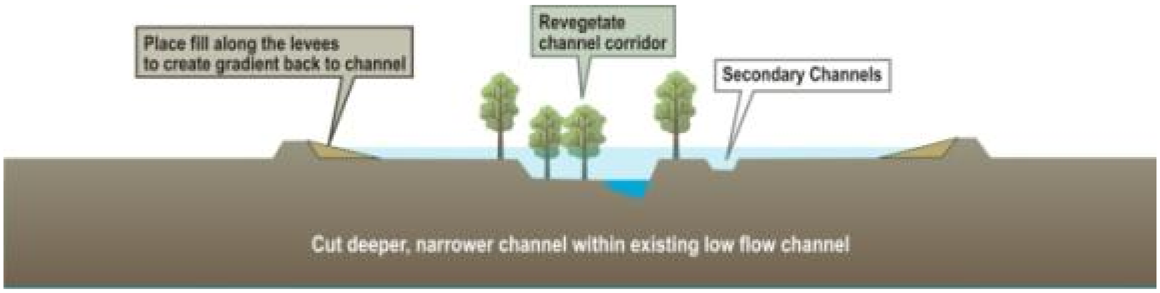

Figure 3-13.
Cross-section of Eastside Bypass Channel Modifications under Alternative 2

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

Levees

Preliminary hydraulic analysis suggests that increasing the gradient of the Eastside Bypass would offset the loss of conveyance due to increased hydraulic roughness from habitat except for the upper three miles of the Bypass. In this area water surface elevation during Flood Flows would increase by approximately 0.5 feet, though still leaving approximately three feet of freeboard on the levees. If necessary the Restoration Project would work with the Levee District to mitigate potential reductions in flood capacity by modifying the levees in these locations.

Merced NWR Weirs

The Merced NWR has two weirs currently used for their watering operations that have the potential to be fish migration barriers. These weirs consist of a reinforced concrete substructure, with a structural steel and grating superstructure. For this project, two modification options are being developed to alter the Merced NWR weirs to provide for fish passage. Both options would require a change in the current operations of the weirs by the Refuge Staff to accommodate fish passage, and still provide for their watering needs.

The first option would excavate pools within the refuge area within the Eastside Bypass. The excavation depths would step up or down to match the elevations of the Eastside Bypass channel, with smaller pilot channels leading into and away from the large pools.

Under the second option, both weirs and their associated rip-rap and earthen embankments would be completely removed. The channel would then be graded back to a natural state. Larger mobile, trailer-based screened pumps would be required to lift water out of the Eastside Bypass and into the Merced NWR. For this option, the demolition cost was estimated as part of Alternative 2. However, because the required pumped water surface elevation and flow rates have not been fully defined, the required pump size and power requirements were not estimated. These requirements are currently being researched with the Refuge Staff, but will not be available for this stage of the study.

Structural Improvements

Structural improvements would include changes to the Reach 4B Headgates and Sand Slough Control Structure, as well as modification of several road crossings in both the San Joaquin River and the Eastside Bypass.

Reach 4B Headgates. 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. The existing slide gates at the headworks structure would be demolished and removed. A small section of the concrete floor slab, approximately three feet wide below the existing gates, would be removed to facilitate the installation of the new gates. The remainder of the existing structure would remain intact. New slide gates of the same dimensions as the existing gates (63 inches wide by 66 inches open height) would be installed, and new concrete placed to create a transition to the new gates. A small concrete stair with handrail would be added to each side of the existing gate structure to improve O&M access and safety. A new electrical line would be brought in from the local grid to operate the gates. This new line would carry up to 480 volt, 3-phase electrical power to operate the motors on the new gates. This power supply could also be utilized for lighting or other purposes at this structure.

This alternative is designed to pass 475 cfs into the San Joaquin River channel. Flows would be routed into the channel only when needed to help with flood management as the bypass system has flows nearing its capacities. It was decided not to utilize a fish screen at this location for this alternative, so no designs were completed to screen fish out of this structure. If it is decided later that a fish screen would be required at this location, it could be added to the upstream side of the new gate structure without any substantial design challenges.

Sand Slough Control Structure. For this alternative, up to 475 cfs would be passed from upstream into Reach 4B1 of the San Joaquin River during flood events. To provide the required invert elevation of the channel, and associated flow routing, the existing reinforced concrete Parshall flume structure would be demolished and removed. Additionally, the earthen embankment berms with grouted rip-rap that provide pedestrian O&M access to this facility would be demolished and removed. Once completed, the invert elevation of the bypass channel would be excavated to varying elevations. The invert of the bypass channel would remain at elevation 94.41 feet, with sloping banks in the active channel. The floodplain elevation surrounding the active channel would slope back to the low flow channel, and have a minimum elevation of 98.8 feet, which would be needed to direct flows into Reach 4B1. There is no gate design for this alternative at this location, as the headgates of Reach 4B1 could control the flows, and all other flows would be directed down the Eastside Bypass Reach 2.

Crossings #0, 1, 2, and 3 (San Joaquin River). Crossing #0 currently connects the southern levee road to a privately owned park area in the center of the river channel, while Crossings #1-3 are private crossings that provide access across the river channel. With the restoration of the river channel and the addition of the flows on this alternative, these crossings would need to be replaced to prevent a backwatering/seepage problem at these locations and upstream. Therefore, these crossings would be excavated, and the culvert pipes demolished and removed from the site. The replacement structures would be partially embedded box culverts. New roadways would be constructed from the levee roads, perpendicular to the flow, to the new box culvert structure.

Eastside Bypass Control Structure. For this alternative, there is no proposed change to the structure or operations of the Eastside Bypass Control Structure.

Mariposa Bypass Control Structure. Alternative 2 includes notching the existing Mariposa Bypass Control Structure to lower the channel invert elevation in four of the center bays for the 4,500 cfs flows to enter the Mariposa Bypass. The structure's current configuration would allow fish passage at flows above approximately 4,500 cfs; therefore, improving passage at low flows should allow fish passage at a full range of flows.

To accomplish the structure modification, the Eastside Bypass Reach 2 channel would be regraded to the center of the Mariposa Bypass Control Structure, and align with bays 6, 7, 8, and 9 (as numbered from channel left on the design drawings). The removable bridge deck and attached utilities would be removed from above six bays (four center bays and adjacent two bays for access). The existing reinforced concrete pier walls on each side of these four bays would be demolished. Additionally, the apron slab, downstream sill blocks, apron slab end wall, ogee curve slab and invert slab of the structure would be demolished in these four bays. Natural bedding material one foot thick would be placed in the invert of the center four bays to create a nature-like passage at this facility. This material and grouted rip-rap would extend approximately two channel widths downstream to complete the transition, as well as to fill in the existing scour pools that are present immediately downstream of this feature.

Mariposa Drop Structure. Alternative 2 includes demolition and removal of the existing Mariposa Bypass Drop Structure to remove a fish passage barrier and facilitate the regrading of this channel. With the improvements to the bypass channel system from regrading, the Mariposa Bypass Drop Structure should no longer be required to retain sediment and prevent channel erosion. Additional studies will be performed to assess whether the regarded channel would require grade control to prevent incision around the current location of the Mariposa Drop Structure. If is the studies find a risk of erosion, an alternative approach would consider replacing the drop structure with a roughened channel or other form of fish-passable grade control.

Fish Screens/Barriers

A migration barrier would be required at the downstream end of the Eastside Bypass to prevent adult fish from migrating upstream and becoming stranded at the Eastside Bypass Control Structure.

Road Crossing at Dan McNamara Road

The current Dan McNamara Road crossing is a crossing during low flows that is submerged during high flow periods in the Eastside Bypass. The crossing would be modified to accommodate fish passage at low flows, or traffic would be diverted to other nearby crossings.

Land Acquisition

A small amount of land would be acquired in the San Joaquin River to construct proposed Levee Alignment A to provide 475 cfs of capacity. No land would be acquired in the Eastside Bypass under Alternative 2 unless levee modifications were needed along the Eastside Bypass to offset increases in roughness due to habitat vegetation that were greater than the additional capacity from channel modifications in the bypasses and the San Joaquin River channel. Preliminary hydraulic modeling suggests that water surface elevations may increase by 0.5 feet in the upper three miles of the Eastside Bypass, and the Reach 4B team would work with the Levee District to mitigate this change in elevation.

Revegetation Plan

San Joaquin River Channel

With the infrequency of flows under Alternative 2, active riparian revegetation of the existing floodplain would not occur. Areas disturbed by construction or clearing activities would be seeded to prevent invasive plant establishment and stabilize soils. It is assumed that at least 50 percent of the floodplain would require seeding along the San Joaquin River; therefore, a total of 633 acres would be seeded with an erosion control mix.

Bypass System

The new low flow channel along the Eastside Bypass Reach 2 and the Mariposa Bypass would need to be vegetated for channel stability. In order to provide for channel stability, areas were selected for active restoration to include all areas identified as potentially suitable and to provide at least minimal nodes of riparian vegetation along the corridor (approximately 36 acres per river mile). All areas of the low floodplain that are not targeted for active planting would be seeded with a riparian mix. Areas of the upper floodplain disturbed by construction activities (e.g., areas filled to prevent fish stranding or modify road crossings) would be seeded with an upland seed mix. Approximately 502 acres would be actively planted, 209 acres would be seeded with riparian grasses and forbs along the bypass, and approximately 1,605 acres of the upper floodplain would be seeded with an erosion control mix.

Flood Routing

All flows up to 16,000 cfs would be directed into the Eastside Bypass. At flows above 16,000 cfs the Reach 4B Headgates would be opened to allow 475 cfs into the San Joaquin River channel. In Reach 2 of the Eastside Bypass the first 8,500 cfs would be sent down the Mariposa Bypass by restricting flow through the Eastside Bypass Control Structure. Above this level excess flows would be allowed to pass into the Eastside Bypass Reach 3.

Operation and Maintenance

There would be additional O&M requirements for the Reach 4B Headgates, but reduced requirements due to the removal of the Mariposa Drop Structure. Maintenance at the Reach 4B headgates would include mechanical maintenance of the gates to ensure that they function properly if needed, as well as vegetation and sediment management in the Reach 4B channel to ensure the needed flood capacity is available if needed.

3.3.3 Alternative 3 – Bypass All Pulse Flows

Under this alternative, Restoration Flows of up to 475 cfs would be routed down the San Joaquin River. Some minor levee improvements would be conducted in the San Joaquin River channel and some flow obstructions would be removed to bring its capacity up to 475 cfs. Restoration Flows greater than 475 cfs and all Flood Flows would be routed down the Eastside Bypass. No Restoration Flows would be routed down the Mariposa Bypass, but flows over 2,500 cfs would be split with 70% passing down the Eastside Bypass and 30% going down the Mariposa Bypass. Under this alternative, during flows up to 475 cfs adult and juvenile salmon would migrate through the San Joaquin River 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 the river or bypass system. This condition would occur approximately 20% of the time. The Eastside Bypass channel would function as a floodplain (comparable to the Yolo Bypass during flood years on the Sacramento River). 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 3-14 presents the flow and fish routing for Alternative 3.

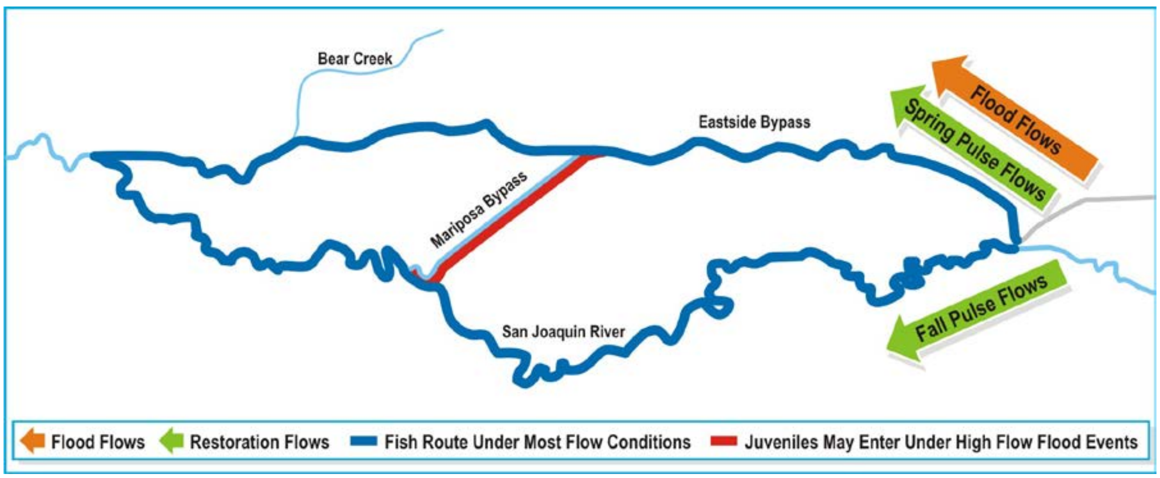

Figure 3-14.
Alternative 3 – Flows Below 475 cfs in San Joaquin River with Eastside Bypass as High Flow Floodplain

Channel Improvements

Channel improvements for restoration and fish migration would take place in both the San Joaquin River and the Eastside Bypass channel.

San Joaquin River

Under Alternative 3, flows up to 475 cfs would be routed down the San Joaquin River. The San Joaquin River channel does not have capacity to convey 475 cfs in Reach 4B1 under current conditions. Under this alternative 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 3-9 under Alternative 2). Some local reaches of levee would need to be upgraded along the river banks. 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. In addition, crossings that pose a barrier to fish migration would be removed or replaced by structures that meet fish passage needs.

Channel Habitat Modifications

Alternative 2 would include habitat enhancement within the Reach 4B channel. 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 in sparsely vegetated reached where existing shelter and complexity is a limiting factor on fish migration and rearing. 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.

Floodplain Habitat Modifications

No floodplain habitat would be established along Reach 4B of the San Joaquin River.

Eastside Bypass and Mariposa Bypass

Under this alternative, all Restoration and Flood flows greater than 475 cfs would be routed through the Eastside Bypass Reaches 2 and 3. Such flows would occur approximately 20% of the time. Fish and Restoration Flows would not be routed down the Mariposa Bypass under this alternative, though 30% of flows greater than 2,500 cfs would pass down the Mariposa Bypass.

Channel Habitat Modifications

In Alternative 3, the Eastside Bypass functions as a floodplain and no major modifications are planned for the existing low flow channel through the Bypass, though potential fish migration barriers would be removed.

Floodplain Habitat Modifications

Parts of the bypass floodplain area would be locally regraded to fill borrow areas and ponds that might act as fish stranding sites. Vegetation management practices would be modified to allow vegetation that is beneficial to habitat to recruit and persist while maintaining the conveyance capacity of the bypass system to the extent not offset by new San Joaquin River conveyance.

Figure 3-15 presents an overview of Alternative 3 in the Eastside Bypass. Figures 3-16 and 3-17 show the existing cross section the Eastside Bypass and potential modifications included in Alternative 3.

Figure 3-15.
Alternative 3 – Example of Channel Excavation in the Eastside Bypass

Figure 3-16.
Existing Channel in Eastside Bypass

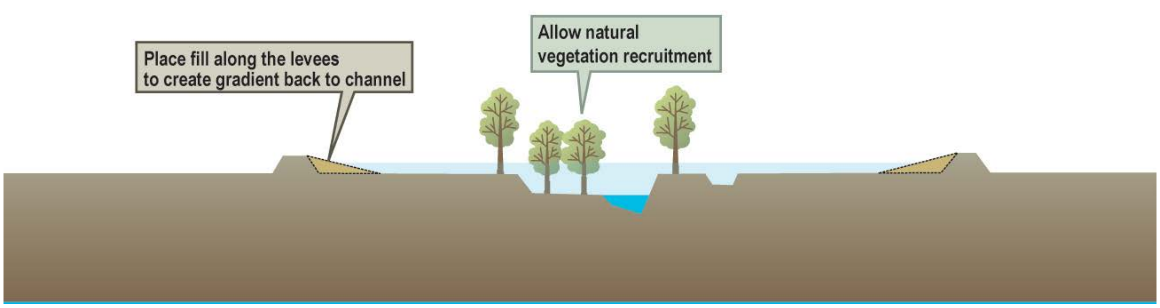

Figure 3-17.
Cross-section of Eastside Bypass Channel Modifications under Alternative 3

Levees

No levee improvements are proposed for the Eastside Bypass under Alternative 3.

Structural Improvements

Structural improvements would include changes to the Reach 4B Headgates and San Slough Control Structure, as well as modification of several road crossings in both the San Joaquin River and the Eastside Bypass.

Reach 4B Headgates. A new headgate would be constructed at the upstream end of Reach 4B to allow Restoration Flows up to 475 cfs into Reach 4B1. For this alternative, the existing slide gates at the San Joaquin River, Reach 4B1 headworks structure would be demolished and removed and new gates would be installed, similar to that described for Alternative 2. This alternative differs from Alternative 2 in that fish would be present and allowed to pass through the structure and into Reach 4B1 of the San Joaquin River. When flows upstream of this structure are up to approximately 1,150 cfs, the Headgates could pass the design flow (475 cfs) with sufficiently low velocity (under six feet per second) to serve as a fish passage. At flows over 1,150 cfs on the upstream side, the velocities through the gates require an alternative passage facility. Because these higher flows would be regularly encountered during the spring and fall seasons, an alternate passage is required.

To provide passage of fish over a large flow range, a roughened channel fishway is proposed. This fishway would be constructed from the upstream side of the Headgate structure to the downstream side of the structure in Reach 4B1. The fishway would be constructed at a three percent invert slope to provide passage for a large range of fish species. The channel would consist of a series of grouted rocks and boulders formed into weirs, with resting pools in between. These pools are approximately 1.5 to two channel widths long to provide for the necessary energy dissipation volumes. The weirs would be formed from grouted-in-place rocks and cobbles, with paths in between to create flow complexity and provide for opportunistic passage for various species. The steps were designed to be one feet tall from pool to pool to meet adult upstream passage criteria.

Sand Slough Control Structure. To accomplish this flow routing, the existing control structure at Sand Slough would be demolished and removed. Following demolition and earthwork, a new Obermeyer-style gate would be installed in the bypass channel with the associated compressor building and controls. This new gate would serve to regulate the water depths at the bifurcation of Reach 4B1 from the Eastside Bypass, Reach 2. The maximum gate height would provide the required water surface elevation at the bifurcation to divert up to 475 cfs into Reach 4B1. It is anticipated that this gate would be operated in an upstream control mode, and the gate would be raised or lowered as required to maintain the necessary water surface elevation to divert the flows into Reach 4B1 as required. During higher flow events, or storm/flood events, the gate could be lowered to make full use of the flood capacity of the Eastside Bypass Channel. During emergencies, O&M periods, or other times, the gate could be controlled locally and adjusted manually.

Crossings #0, 1, 2 and 3 (San Joaquin River). Crossing #0 currently connects the southern levee road to a privately owned park area in the center of the river channel, while Crossings #1-3 are private crossings that provide access across the river channel. With the restoration of the river channel and the addition of the flows on this alternative, these crossings would need to be replaced to prevent a backwatering/seepage problem at these locations and upstream. Therefore, these crossings would be excavated, and the culvert pipes demolished and removed from the site. The replacement structures would be partially embedded box culverts. The structures would be a series of concrete box culverts set side-by-side, providing the necessary cross-sectional area (and resulting maximum velocities and other hydraulic conditions acceptable to the NMFS and CDFW fish passage requirements). New roadways would be constructed from the levee roads, perpendicular to the flow, to the new box culvert structure. Per NMFS Guidelines, the inverts of the box culvert structures are to be in-filled with natural bedding material. These culvert crossings were designed using a six foot/second maximum velocity for adult passage, because they were less than 60 feet long.

Eastside Bypass Control Structure. For this alternative, the Eastside Bypass Control Structure would be retrofitted with a roughened bypass channel to allow passage of salmonids and other fish.

For this alternative, the existing Eastside Bypass Control Structure would not require any modification, except for the removal of the stoplogs and the addition of a roughened channel fishway constructed through the right bank, under the access road to the structure, and back into the Eastside Bypass between the structure and Deadman Slough. This would provide for fish passage at this facility, while still providing for the hydraulic control necessary for operations.

To accomplish this modification, the stoplogs currently used to divert flows into the Mariposa Bypass would be removed during the identified periods of fish migration. These stoplogs would be stored as needed for operations that occur outside of the fish passage timeframes. A roughened channel fishway would be constructed around the existing Eastside Bypass Control Structure, into the right bank. The fishway would have a three percent invert slope and 2:1 sideslopes. The fishway would be approximately 260 feet long, with inlet and outlet forebays to transition out of and back into the Eastside Bypass. This fishway channel would operate at normal depths using natural rock weirs to form a pool-and-weir style ladder. The rock weirs would have apertures large enough to permit non-jumping species to pass between the rocks, and set to create flow complexity. The velocities in the ladder were designed to not exceed an average of four feet per second, which was chosen to provide passage for the listed species at this site. The fishway would cross under the existing structure access road via a new bridge that would be constructed as part of this work.

Mariposa Bypass Control Structure. For this alternative, there is no proposed change to the structure of the Mariposa Bypass Control Structure.

Mariposa Drop Structure. For this alternative, the existing Mariposa Bypass Drop Structure would be retained to prevent upstream migration of fish into the Mariposa Bypass.

Fish Screens/Barriers

No fish screens or barriers would be added to the system.

Merced NWR Weir

The Merced NWR has two weirs currently used for their watering operations that have the potential to be fish migration barriers. Alternative 3 includes removal or reoperation of these weirs in the same way as described above for Alternative 2.

Road Crossing at Dan McNamara Road

The current Dan McNamara Road crossing is a crossing during low flows that is submerged during high flow periods in the Eastside Bypass. The crossing would be modified to accommodate fish passage at low flows, or traffic would be diverted to other nearby crossings.

Land Acquisition

Similar to Alternative 2, Alternative 3 would acquire only a small amount of land in the Reach 4B channel and no land in the bypass system.

Revegetation Plan

San Joaquin River

The revegetation approach under Alternative 3 would apply active riparian restoration to areas along the San Joaquin River that would be disturbed during vegetation removal, to channel bank areas where bridges and road crossings are modified, and target suitable areas to expand the existing riparian corridor and to provide riparian cover at fairly regular intervals along Reach 4B1. Riparian enhancement may be targeted within existing riparian scrub communities to improve structural diversity.

Approximately 40 percent of the floodplain would be targeted for active planting and the total acreage of actively planted riparian vegetation within the corridor would be approximately 509 acres. Approximately 468 acres within the entire corridor would be seeded with a riparian seed mix and approximately 288 acres within the entire corridor would be seeded with an upland erosion control mix.

Bypass System

Even though a new channel is not proposed as part of Alternative 3, active revegetation of riparian habitat is desirable to support fish migration and rearing. Areas for active restoration would be distributed approximately 35 acres per channel mile, the same as Alternative 2. Areas disturbed by filling and grading activities would be seeded with an upland erosion control mix.

Flood Routing

For flows below 475 cfs, the new Sand Slough Control Structure would be closed and all flows would be directed down the San Joaquin River. When flows reached 475 cfs the

Sand Slough Control Structure would be opened and all flows above 475 cfs would be directed into the Eastside Bypass. In the Eastside Bypass the first 2,500 cfs would be sent down the Eastside Bypass by opening the Eastside Bypass Control Structure. Above this level excess flows would be split with 70% passing down the lower Eastside Bypass and 30% being directed down the Mariposa Bypass.

Operation and Maintenance

There would be some additional O&M requirements for the Sand Slough Control Structure. This would include mechanical maintenance of the gates and potentially local removal of vegetation and sediment from the channel around the structure to ensure proper hydraulic function.

3.3.4 Alternative 4 – Split Pulse Flows and Restore Both

Under this alternative, Restoration Flows would be split between the San Joaquin River and the bypass system. The Initial Alternatives TM (SJRRP 2011) did not identify a specific flow rate in the San Joaquin River channel. For the purposes of analysis, a flow of 1,500 cfs is used because it is the design capacity of this reach, but this may change as the alternative is refined. A flow of 1,500 cfs could be conveyed by the San Joaquin River channel with the addition of levees based on proposed Levee Alignment A (upgraded levees located on the existing edge of channel alignment approximately 250-400 feet apart), Levee Alignment B (1,300 to 2,000 feet apart), or Levee Alignment C (3,500 to 5,500 feet apart). As Restoration Flows exceeded 1,500 cfs (a situation that would occur approximately 10% of the time) the surplus would be routed down the Eastside Bypass Reach 2, returning to Reach 4B2 via the Mariposa Bypass. Flood Flows would be routed into the bypass system. Under this alternative, adult salmon migrating upstream would travel up the San Joaquin River during flows less than 1,500 cfs 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. All Flood Flows would be routed down the Eastside Bypass Reach 2 and the Mariposa Bypass, with overflows passing into the Eastside Bypass Reach 3. Figure 3-18 presents the flow and fish routing for Alternative 4.

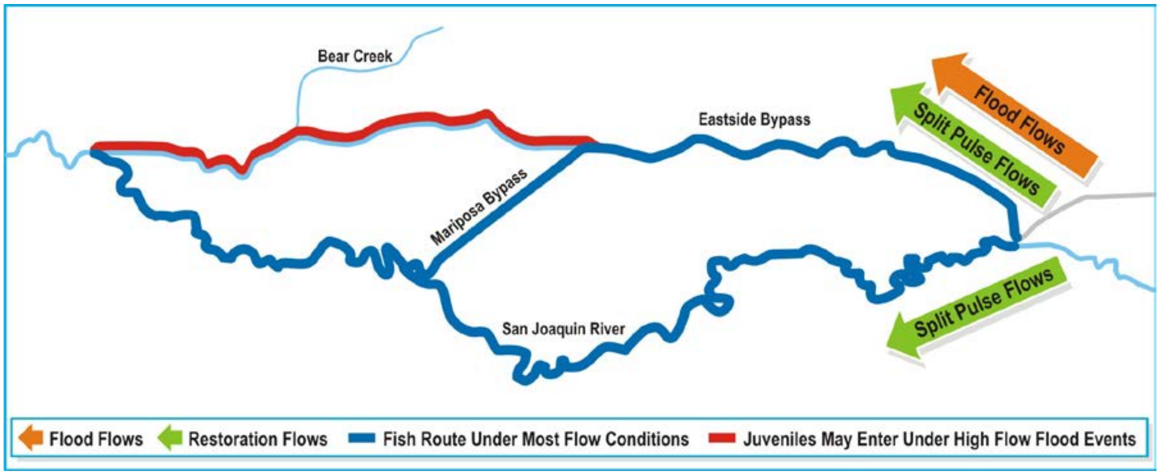

Figure 3-18.
Alternative 4 – Split Flow, Fish-Friendly Bypass

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 levees to allow for floodplain rearing habitat.

Channel Habitat Modifications

Under Alternative 4, flows up to 1,500 cfs would be routed down the San Joaquin River. The San Joaquin River channel does not have capacity to convey 1,500 cfs in Reach 4B1 under current conditions, so levees would be required. The addition of levees would permit more in-channel vegetation to be left in place compared with Alternatives 2 and 3, except for any major flow impediments, which would be cleared. The channel modifications would be similar to Alternative 1, with a continuous corridor of woody riparian vegetation alongside the river and LWD being restored to reaches where it is a limiting factor on fish rearing. 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.

Floodplain Habitat Modifications

Floodplain modifications would be similar in design and function to Alternative 1 but includes a narrower proposed levee alignment (A) and excludes the widest alignment (D). 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 and lower floodplain areas would be designed to provide appropriate velocities and depths of off-channel rearing habitat during spring releases of 1,225 cfs in most years Figure 3-19 presents the potential channel modifications and levee setbacks that could occur under Alternative 4. Figures 3-20 and

3-21 show example cross sections of the modifications that could occur under Alternative 4.

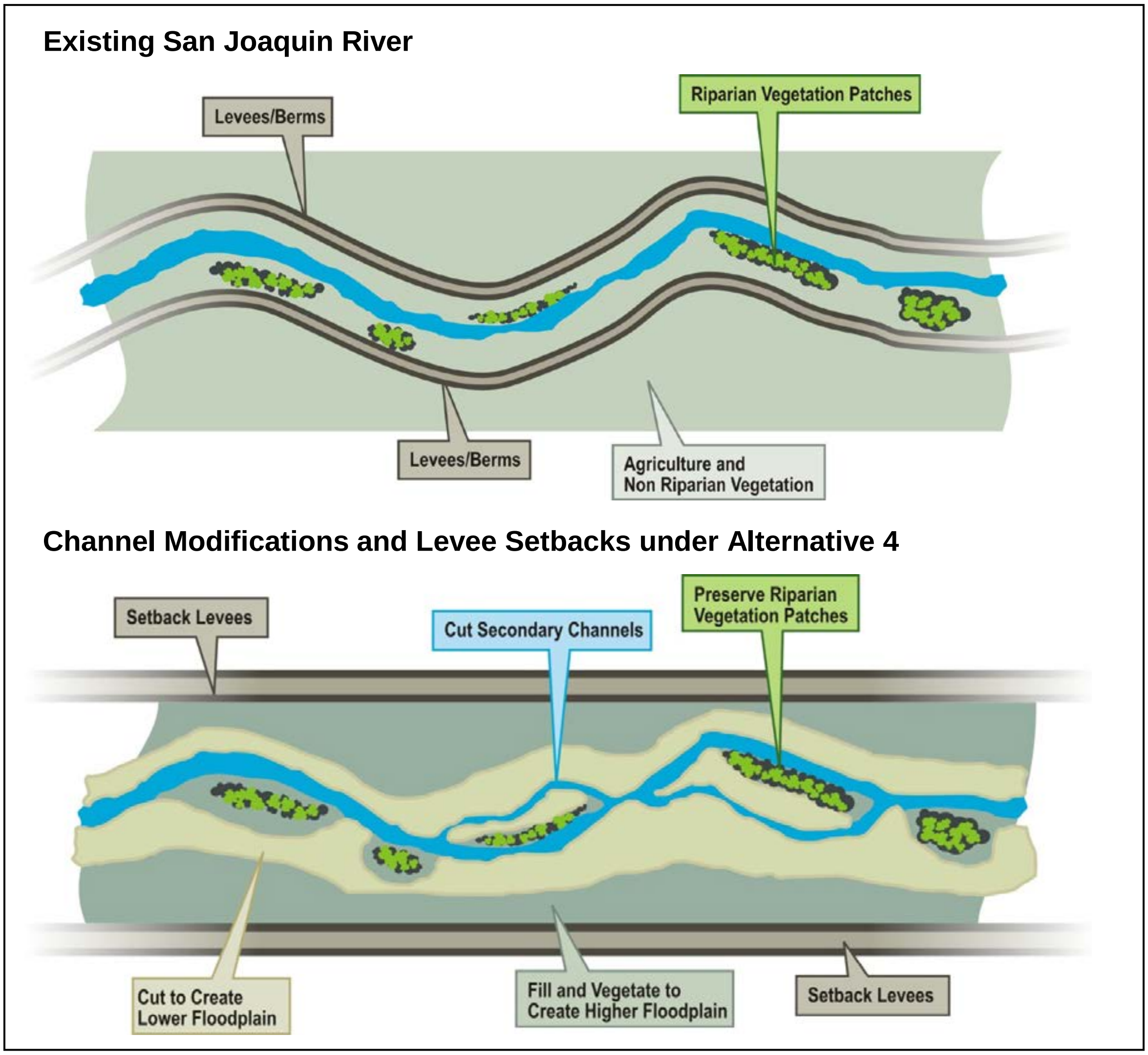

Figure 3-19.
Alternative 4 – Example of Channel Excavation and Vegetation Clearing in the San Joaquin River

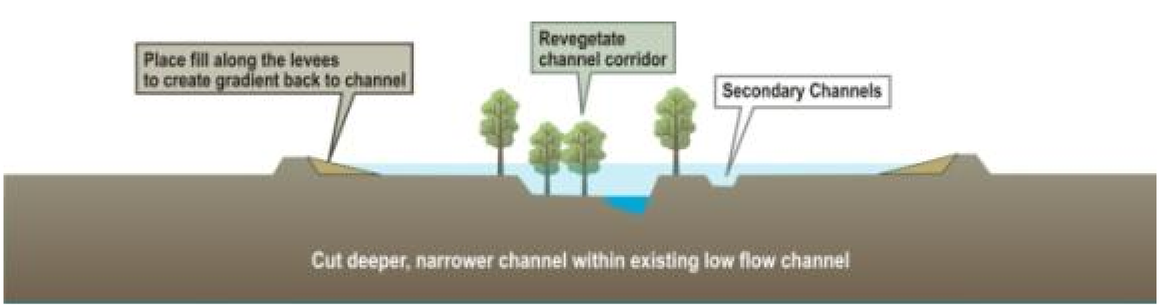

Figure 3-20.
Alternative 4 - Example of Channel Modifications and Levee Setbacks

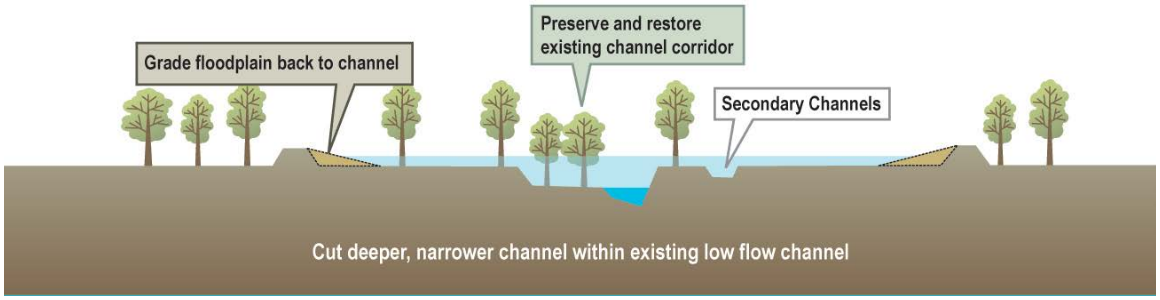

Figure 3-21.
Cross-section of San Joaquin River Floodplain Modification under Alternative 4

Eastside Bypass and Mariposa Bypass

Under this concept, Restoration Flows greater than 1,500 cfs and all Flood flows would be routed through the Eastside Bypass. Such flows would occur approximately 10% of the time. Fish and Restoration Flows would be routed down the Mariposa Bypass and returned to Reach 4B2 of the San Joaquin River.

Channel Habitat Modifications

In Alternative 4, no structural changes would be made to the channel within the Eastside Bypass. Potential fish migration barriers along the Eastside Bypass would be removed.

Floodplain Habitat Modifications

There would be little habitat modification in the Eastside Bypass compared with Alternative 2, and a similar level as with Alternative 3. Some regrading would be carried out to fill borrow areas and ponds that might act as fish stranding sites. 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.

Figure 3-22 presents an overview of Alternative 4 in the Eastside Bypass. Figures 3-23 and 3-24 show the existing cross section the Eastside Bypass and potential modifications included in Alternative 4.

Figure 3-22.
Alternative 4 – Example of Channel Excavation in the Eastside Bypass

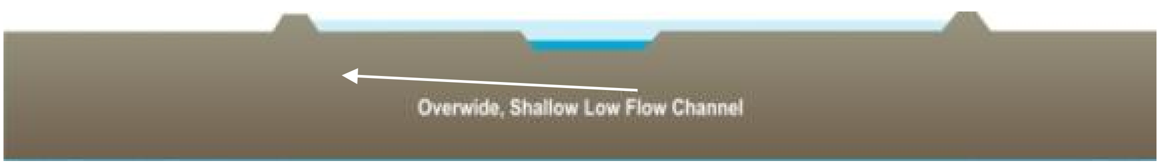

Figure 3-23.
Existing Channel in Eastside Bypass

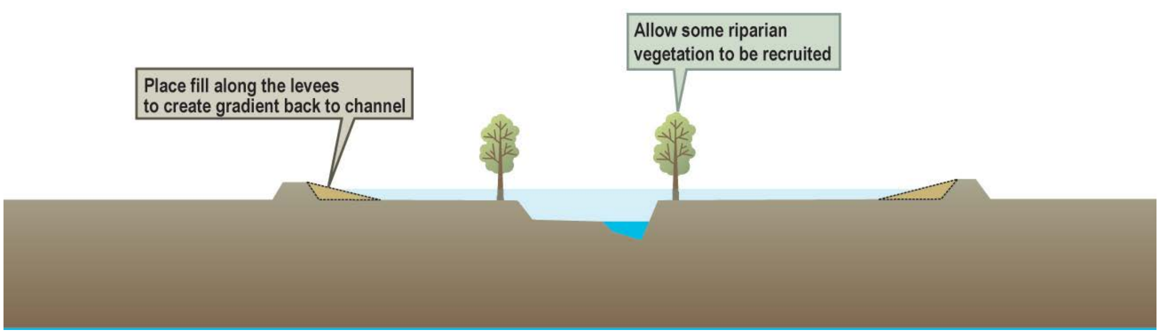

Figure 3-24.
Cross-section of Eastside Bypass Channel Modifications under Alternative 4

Levees

Because Reach 4B1 currently has a capacity lower than 1,500 cfs, levees would be required in the San Joaquin River Channel. These would be on the existing alignment in Levee Alignment A (approximately 240-500 feet apart), between 1,300 and 2,000 feet apart in Levee Alignment B or 3,500-5,500 feet apart in Levee Alignment C. Under Levee Alignments B and C, the levees would be at least 250 feet away from the San Joaquin river channel to minimize the risk of levee erosion and to allow for some channel migration over time, but under proposed Levee Alignment A they would be closer in many locations. Levees would be constructed with three feet of freeboard above the 4,500 cfs maximum design flow, and with 3:1 horizontal to vertical side slopes. No changes would be made to the levees along the Eastside Bypass.

Structural Improvements

Structural improvements would include changes to the Reach 4B Headgates and Sand Slough Control Structure, as well as modification of several road crossings in both the San Joaquin River and the Eastside Bypass.

Reach 4B Headgates. A new headgate would be constructed at the upstream end of Reach 4B1 to allow the first 1,500 cfs of Restoration Flows to flow into the San Joaquin River channel. The existing Reach 4B1 headworks structure would be demolished and replaced with a new radial gate structure. The new radial gate structure would be similar to the existing structure, with the levee road crossing on a reinforced concrete deck above the radial gate bays, and an operations platform on the upstream side of the structure. A roughened channel fishway would be located on the upstream (left) side of the new radial gate structure, and extend downstream from the structure into Reach 4B1.

Sand Slough Control Structure. The Sand Slough Control Structure would be replaced by a new structure to direct the first 1,500 cfs of flow down the San Joaquin River channel. To accomplish this flow routing, the existing control structure at Sand Slough would be demolished and removed. Following demolition and earthwork, a new Obermeyer-style gate would be installed in the bypass channel with the associated compressor building and controls. This new gate would serve to regulate the water depths at the bifurcation of Reach 4B1 from the Eastside Bypass, Reach 2. The maximum gate height would provide the required water surface elevation at the bifurcation to divert up to 1,500 cfs into Reach 4B1. It is anticipated that this gate would be operated in an upstream control mode, and the gate wiykd be raised or lowered as required to maintain the necessary water surface elevation to divert the flows into Reach 4B1 as required. During higher flow events, or storm/flood events, the gate could be lowered to make full use of the flood capacity of the Eastside Bypass Channel. During emergencies, O&M periods, or other times, the gate could be controlled locally and adjusted manually.

Crossings #0, 1, 2, and 3 (San Joaquin River). Crossing #0 currently connects the southern levee road to a privately owned park area in the center of the river channel, while Crossings #1-3 are private crossings that provide access across the river channel. With the restoration of the river channel and the addition of the flows on this alternative, these crossings would need to be replaced to prevent a backwatering/seepage problem at these locations and upstream. Therefore, these crossings would be excavated, and the culvert pipes demolished and removed from the site. The replacement structures would be partially embedded box culverts. The structures would be a series of concrete box culverts set side-by-side, providing the necessary cross-sectional area (and resulting maximum velocities and other hydraulic conditions acceptable to the NMFS and CDFW fish passage requirements). New roadways would be constructed from the levee roads, perpendicular to the flow, to the new box culvert structure. Per NMFS Guidelines, the inverts of the box culvert structures are to be in-filled with natural bedding material. These culvert crossings were designed using a six foot/second maximum velocity for adult passage, because they were less than 60 feet long.

Eastside Bypass Control Structure. Alternative 4 does not include changes to the structure or operation of the Eastside Bypass Control Structure.

Mariposa Bypass Control Structure. For this alternative, the Eastside and Mariposa Bypass channels would be regraded from the confluence of the Chowchilla Bypass to the confluence of the Mariposa Bypass channel with Reach 4B2. As a result of this regrading, the existing Mariposa Bypass Control Structure invert elevation would need to be lowered in three of the center bays for the 3,000 cfs flows to enter the Mariposa Bypass. A natural bedding material one foot thick would be placed in the invert of the center three bays to create a fish passage at this facility. This material and grouted rip-rap would extend approximately two channel widths downstream to complete the transition, as well as to fill in the existing scour pools that are present immediately downstream of this structure.

Mariposa Drop Structure. Alternative 4 includes construction of a fish ladder or roughened channel to allow upstream migration by adult fish through the Mariposa Bypass channel.

Fish Screens/Barriers

A weir or low drop structure would be added to the downstream boundary of the Eastside Bypass to prevent adult fish from migrating up into the Bypass and becoming stranded below the Eastside Control Structure during Flood Flows.

Merced NWR Weir

The Merced NWR has two weirs currently used for their watering operations that have the potential to be fish migration barriers. Alternative 4 includes removal or reoperation of these weirs, as described in Alternative 2.

Road Crossings at El Nido Road and Dan McNamara Road

The current El Nido Road and Dan McNamara Road crossings are low-flow inundated crossings that are submerged during high flow periods in the Eastside Bypass. These crossings would be replaced by approximately 1,500 foot long, two lane concrete bridges to provide for year-round access. The bridges would be designed to accommodate larger semi-trucks and agricultural equipment.

Land Acquisition

Under Alternative 4, land would have to be acquired along the San Joaquin River between the setback levees. The total acquired land would be 1,265 acres under Levee Alignment A, 2,985 acres under Levee Alignment B, 6,195 acres under Levee Alignment C.

Revegetation Plan

San Joaquin River

The same revegetation approach along the San Joaquin River would be implemented as described above for Levee Alignment A under Alternative 3 and Levee Alignments B and C under Alternative 1.

Bypass System

Revegetation of the bypass system under Alternative 4 would be the same as proposed for the bypass system under Alternatives 2 and 3.

Flood Control

For flows below 1,500 cfs the Sand Slough Control Structure would be closed and all flows would be directed down the San Joaquin River. When flows reached 1,500 cfs the Sand Slough Control Structure would be opened and all flows above 1,500 cfs would be directed into the Eastside Bypass. In the Eastside Bypass the first 8,500 cfs would be sent down the Mariposa Bypass by closing the Eastside Bypass Control Structure. Above this level excess flows would be allowed into the lower Eastside Bypass.

Operation and Maintenance

There would be some additional O&M requirements for the Sand Slough Control Structure. Mechanical maintenance of the gate would be required, as well as localized vegetation and sediment removal to maintain the correct flow split between the Eastside Bypass and Reach 4B.

4.0 Initial Alternatives Evaluation Criteria

This section describes the evaluation criteria that will be used to evaluate and screen the Initial Alternatives. The purpose of the evaluation is to compare and contrast initial alternatives to select a wide range of alternatives that meet most of the Purpose and Need/Objectives of the project, but that also represent a variety of different environmental impacts and alternatives that may lessen or avoid any potential significant environmental impacts.

Seven primary evaluation criteria categories were developed for the Reach 4B Project initial alternatives, including project objectives, technical feasibility, environmental acceptability, cost, flood control, geomorphology/sediment transport, and fisheries. These primary criteria were selected based on the project's goals and objectives, available data, technical expertise of the Implementing Agencies, spring and fall-run Chinook salmon requirements, public comments received during the public scoping process and at landowner meetings, and modeling results from the analytical tools selected for analysis of the Reach 4B Project. Each primary criterion is further defined by "performance measures" that help measure each alternative's performance related to the criterion.

4.1 Project Objectives

The project objectives evaluation criterion considers how well the initial alternatives would achieve the project objectives. The Reach 4B Project Team developed six performance measures for the project objectives category that correspond to the six project objectives outlined in the Reach 4B Project's Purpose and Need/Project Objectives statement (see Section 3.1.1.1). Each Initial Alternative is compared to the six performance measures to see how many objectives it would meet. Some of these performance measures are mutually exclusive – if one objective is met, another objective does not need to be met. These objectives are indicated to be not necessary.

Performance Measures

The six performance measures associated with the purpose and need/project objectives 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
- 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
- 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

4.2 Technical Feasibility

The Technical Feasibility criterion considers how practical the initial alternatives are for implementation, based on the technologies proposed for use, the complexity of operating the system and using those technologies, and the amount of time the project would take to implement.

Performance Measures

The performance measures for technical feasibility include:

- Number of structures with technologies untested in similar conditions
- Estimate of operational complexity (low, medium, or high)
- Implementation timing, estimated with length of construction

4.3 Environmental Acceptability

The Environmental Acceptability criterion helps to determine the environmental effects of the initial alternatives. This criterion was further divided into four secondary criteria: biological effects, social effects (including economic impacts), physical effects, and regulatory constraints.

4.3.1 Biological Effects

The biological effects criterion evaluates how habitat and species could be affected by construction of any of the initial alternatives. The first performance measure includes how many acres of different habitat types would be affected (disturbed or removed completely) by each Initial Alternative. While native vegetation in the study area would be preserved wherever possible, the presence of construction vehicles and equipment could cause noise, dust, and vibration impacts and physical damage that could affect vegetation and wildlife. Therefore, while not all the existing vegetation would be removed; any areas that would be disturbed during construction are considered affected for this analysis. Vegetation data used to assess preliminary impacts associated with the proposed levee options along Reach 4B1 includes data collected by DWR in 2000 (DWR 2002) and interpolated data by the study team. DWR mapped vegetation along the San Joaquin River using aerial photographs from 1998 with limited field verification within

Reach 4B (DWR 2002). Vegetation polygons were mapped at a scale of 1:4,000 generally with a minimum polygon size of 0.3 acre. Where coverage from DWR (2002) was unavailable, vegetation was interpolated by the study team to expand coverage within the proposed levee area. The vegetation types that were expanded for this purpose were agriculture and herbaceous. The total amount of vegetation that would be affected by the initial alternatives was determined by overlaying the four proposed levee alignments on the existing vegetation map in Geographic Information Systems (GIS). The results were displayed in acres by vegetation type. While it is recognized that existing vegetation in the San Joaquin River channel would be removed even under Levee Alignment A (existing levee alignment), determining the amount of vegetation affected by Levee Alignment A was not possible due to the scale and limitations of the vegetation data. While there may be additional vegetation affected by construction of flood control structures, road crossings, or stockpiling and staging areas, this detailed construction information was not available at the time of this document.

Because of the presence of the San Luis NWR Complex in the project area and the large variety of bird species that have the potential to occur in the area, the second performance measure includes how many months of construction would occur during sensitive wildlife periods.

Performance Measures

The performance measures for biological effects are:

- Acres of disturbed habitat
- Number of months when construction activities overlap with sensitive wildlife periods (February through September - nesting/breeding season for birds, including raptors)

4.3.2 Social Effects

Through the public scoping process and the various landowner meetings held for the Reach 4B Project, landowners have expressed concerns about the potential to remove agricultural lands from production and the associated economic impacts. The performance measures for social effects examine how many acres of agricultural lands would be removed and the reduction in annual agricultural production that would occur. Additionally, the performance measures include the total amount of land that would be affected under each Initial Alternative and the total number of parcels that would be affected.

To determine the quantity of farmland removed from production, the United States Department of Agricultural, National Agricultural Statistics Service 2011 Cropland Data Layer for Merced County was obtained in GIS shapefiles (United States Department of Agriculture NASS 2012). This data contains crop types for agricultural lands in Merced County, including the Reach 4B Project study area. The four proposed levee alignments were superimposed on the crop type data to determine the total acres of agricultural lands that would be removed from production. This analysis made the conservative assumption that all crops grown within or beneath the proposed levees would be eliminated; wider levee alignments may include agricultural development within the levees.

After the total acres of each crop type were determined, the Merced County 2010 Report on Agriculture was used to determine the value of the crops that would be removed from production. This was done by first determining the total production of each crop per acre. For instance, 1.36 tons of beans are produced per acre. This was multiplied by the total number of acres that would be removed from production to get a total amount of beans produced in tons. Then the 2010 value of the crop per ton was multiplied by the total number of tons produced. Table 4-1 below presents the production per acre, unit, and price per unit used to determine the total value of the crops removed from production. This analysis is not meant to establish the real value of the crops that would be removed from agricultural production; it is only meant to provide a means to compare each of the initial alternatives. The Reach 4B Project EIS/R will identify more recent crop data and crop values.

Table 4-1.
Crop Production per Acre and Price per Unit

Crop Cost per Acre	Production Per Acre (2010)	Unit	2010 Value Per Unit
Alfalfa	6.47	tons	$143.17
Almonds (Kernel Basis)	0.78	tons	$3,699.98
Cantaloupes	599.38	40lb container	$4.73
Corn (Corn Silage)	27.74	tons	$31.67
Cotton (Alcala)	2.88	500 lb bale	$553.63
Double Crop			
Oats (Hay Grain)	3.12		$78.14
Corn (Corn Silage)	27.74	tons	$31.67
Double Crop			
Winter Wheat (Wheat)	2.89	tons	$175.15
Corn (Corn Silage)	27.74	tons	$31.67
Dry Bean (Dry Lima)	1.36	tons	$972.53
Fallow/Idle Cropland	0.00	N/A	$0.00
Grapes (Wine)	9.03	tons	$334.27
Oats (Hay Grain)	3.12	tons	$78.14
Other Hay (Hay Alfalfa)	6.47	tons	$143.17
Pistachios	1.86	tons	$4,949.71
Pomegranates	Not Available	Not Available	Not Available
Tomatoes (Processing)	44.71	tons	$66.65
Walnuts	1.64	tons	$2,069.46
Winter Wheat (Wheat)	2.89	tons	$175.15

Source: Merced County Department of Agriculture 2010
Note:
lb = pound
N/A = Not Applicable

The total amount of affected land was determined through GIS by overlaying the four different proposed levee alignments. All land within the levees and land beneath the levees was included as affected. The total number of parcels was also determined using this method. All parcels between and beneath the levees, including those that would only have a portion of the parcel affected, were included. While there may be additional land or parcels affected by construction of flood control structures, road crossings, or stockpiling and staging areas, this detailed construction information was not available at the time of this document.

Performance Measures

The performance measures for social effects are:

- Quantity of farmland removed from production
- Reduction in annual agricultural production values based on crop type
- Total amount of affected land and parcels

4.3.3 Physical Effects

Physical effects represent direct physical impacts on the environment that would result from implementation of the initial alternatives. The performance measures for this subcategory examine air quality, noise, groundwater seepage, and road inundation. The performance measures focus on providing comparative estimates of potential impacts by using indicators of what those impacts could be. For example, air quality emissions are unknown at this phase of the project; however, an alternative would likely have greater emissions if it has more construction activities at a given time (estimated by dollars per month of construction).

Performance Measures

The performance measures for physical effects are:

- Estimated magnitude of induced groundwater seepage
- Intensity of air quality impacts (average $/month of construction)
- Noise impacts (total construction duration in months)
- Frequency of road crossing inundation

4.3.4 Regulatory Constraints

There are a number of permits or other regulatory approvals that would be necessary to obtain prior to construction of any of the initial alternatives. Two of the main permits that will likely be required are the Clean Water Act Section 404 permit for impacts to other waters and wetlands, and the United States Code 408 approval which requires approval by the USACE for any modifications to existing flood control projects authorized by the United States. The performance measures identify the initial alternatives’ impacts on existing waterways, flood control structures, and channels. It is assumed that the greater the number of affected structures or miles of channel, the more difficult, expensive, and time consuming the permitting or approval process could be.

The miles of disturbed waterway were calculated by determining the total number of miles of the San Joaquin River, Eastside Bypass, and/or Mariposa Bypass that would require excavation, grading, placement of fill, new floodplain habitat, or other construction activities that would disturb the channel bed or banks. In the Eastside Bypass under some alternatives, ponds and borrow pits would be filled, but they may not require modification of the entire channel. However, because detailed information on the miles of modification is not available, it is assumed that if any work is required, the entire length of the channel would be disturbed. This information will be refined as additional details become available. Reach 4B2 of the San Joaquin River is assumed to have a capacity of 10,000 cfs and would not require any channel or levee modifications to pass fish or flows; therefore, Reach 4B2 would not be disturbed under any of the initial alternatives.

The number of modified flood control structures includes any flood control structures that would require removal or modification under each of the initial alternatives. The five flood control structures in the Reach 4B Project study area that could require modifications include the Reach 4B Headgates, the Sand Slough Control Structure, the Eastside Bypass Control Structure, the Mariposa Bypass Control Structure, and the Mariposa Bypass Drop Structure. The numbers of structures that need to be modified depend on the routing of fish and flows. Routes that would only be passable by fish under high flood flow events would occur infrequently and would not require modifications to flood control structures.

Performance Measures

The performance measures for regulatory constraints are:

- Miles of disturbed waterway in San Joaquin River
- Miles of disturbed waterway in Eastside Bypass and/or Mariposa Bypass
- Number of modified flood control structures (in San Joaquin River, Eastside Bypass, and/or Mariposa Bypass)

4.4 Cost

The performance measures under the cost category include the one-time cost of construction and the present value of the cost of long-term O&M. Costs for land acquisition and revegetation are not yet available, but estimates from similar projects in nearby areas have been used as preliminary indicators of the comparative costs of alternatives. For alternative comparison purposes, land acquisition costs are estimated to be $10,000 per acre based on information from the Reach 2B Project. Restoration costs are estimated based on other similar restoration projects near the Reach 4B study area.

Performance Measures

The performance measures for costs are:

- Construction Cost – total cost of construction in 2011 dollars
- Annual O&M Cost – present value of O&M.
- Total cost of land acquisition – assuming $10,000/acre.

- Total cost of revegetation – preliminary estimates based on similar restoration projects.

4.5 Flood Control

The Reach 4B Project has several flood control constraints. It must maintain current operational flexibility and channel conveyance capacities to ensure there are no impacts on the existing Flood Control Project. All alternatives meet this requirement; however, some may offer a benefit to operational flexibility by increasing the combined capacity of the river and bypasses. The flood control performance measures have been developed to help determine how well each of the initial alternatives would address these constraints.

Performance Measure

The flood control performance measure is:

- Change in combined hydraulic capacity of the San Joaquin River and bypass system (by comparing existing capacity to capacity anticipated under each of the initial alternatives)

4.6 Geomorphology/Sediment Transport

The geomorphology/sediment transport evaluation criterion focuses on how well the initial alternatives can maintain channel form and function. Geomorphic stability is important for two reasons: first, a channel in geomorphic equilibrium is more likely to provide features that support fish rearing and migration (e.g. a diverse range of channel forms, feeding lanes, exposed root wads); second, a stable channel is less likely to require maintenance activities (e.g., excess sediment removal) that affect the riparian and aquatic habitat and would also preserve the channel capacity.

Analyses of channel stability and the maintenance of diverse channel forms were completed for this document using hydraulic and sediment transport models, as described in detail in Attachment1.

4.6.1 Performance Measures

The performance measures for geomorphology/sediment transport are:

- Sediment-in equals sediment-out (San Joaquin River channel and Bypass). The Bypass system is transport limited and depositional under existing conditions, meaning that more sediment is transported in than is transported out. The sediment transport modeling estimates whether each alternative would be erosive (more sediment leaving the reach than entering), depositional (less sediment leaving the reach than entering), or stable.

- Low flow and migration channels (Bypass and San Joaquin River channel) persist without sediment deposition/plugs or excessive channel enlargement. The sediment transport model estimates the long-term stability of the low flow and migration channels.

- Channel does not headcut or create fish passage barriers. Excessive incision is unlikely due to the depositional nature of the channel, but is most likely to occur when the existing channel gradient is changed significantly and grade control is removed (note however that steepening the gradient may increase stability by bringing sediment transport capacity more in line with sediment supply).

- Pools and bedforms (fishery habitat complexity) can be naturally sustained. This measure is highly linked to the overall geomorphic stability of the river and to the presence or absence of bankside woody vegetation.

- Riparian vegetation sustainability. Riparian native vegetation is present in sufficient density to support channel geomorphic functions and persist over time.

- Volume of in-stream woody debris is consistent with similar size rivers and persists over time. The volume of LWD can be designed, but is also related to the width of the existing and proposed riparian corridor and the availability of flows that are high enough to periodically cause bank erosion and recruit new LWD.

4.7 Fisheries

The evaluation criteria for fisheries determine how well the initial alternatives would address the fish needs of spring- and fall-run Chinook salmon, including predation, fish passage, habitat complexity, and water quality. All fisheries performance measures were rated as low performance, medium performance, and high performance. For criteria that required quantitative comparisons, such as number of pools, the value for each alternative was divided by the highest value to scale all values by the highest score. If the values of a given criteria were positively related to fish benefits then scaled scores were categorized accordingly: low (0.0-0.33), medium (0.33-0.66), or high (0.66-1). If values of a given criteria were negatively related to fish benefits then scaled scores were reversed. Criteria evaluated for each life stage (adults, juveniles) were only evaluated during the time period salmon of each life stage were expected to be present in the Reach 4B Project study area.

4.7.1 Predation

Predation, especially of juvenile fish that are much smaller in size than the adults, can occur in areas where larger fish hide and wait for smaller fish to swim by. Areas with high predation tend to be areas with deep pools or structures have slower water velocities and allow predators to hide and wait without expending large amounts of energy fighting currents.

Performance Measure

The performance measure for predation is:

- Number of pools with average depth greater than 1.5 meters (m). Kondolf et al. (2008) found that unnaturally deep reaches (1.5-11 m deep) that were former in-channel gravel pits provide ideal predator habitat for non-native basses which consumed up to 2/3 of outmigrating juvenile salmonids in the Merced and Tuolumne rivers. Pools identified below reservoir passage facilities have, in generally, demonstrated the potential to increase predation on migrating juvenile salmonids (Ward and Zimmerman 1999).

4.7.2 Passage

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. Water quality such as temperature, DO, water source and chemical/biological constituents (e.g. nutrients, contaminants, pathogens) can also create passage barriers. These passage performance measures were selected based on the main passage issues that fish could encounter in the Reach 4B Project study area and consider passage for both juveniles and adults.

Performance Measures

The performance measures for passage are:

- Adequate pool and channel depths. Minimum channel depths required for adult anadromous salmonid passage are one foot and for juvenile salmonids are 0.5 feet (California Department of Fish and Game [DFG] 2009).
- River channel and bypass flow (for adults). Adult anadromous salmonids were found to experience exhaustion in flows with velocity of six feet/second or greater for 30 minutes (DFG 2003).
- Number of obstructions to migration:
  - Adults: number of obstructions (culverts, fish ladders, or chutes)
  - Juveniles: number of obstructions (agricultural pumps or diversions, culverts, or structures that create a scour pool)
- Water quality barriers (for adults): Habitat in the lower San Joaquin River showed total barrier to adult Chinook salmon migration at DO levels below 4.5 mg/L, and a partial barrier at DO between 4.5 and 5.0 mg/L (Newcomb and Pierce 2010). Hallock et al. (1970) found that temperature above 70^0F was a barrier to upstream migrating Chinook salmon. Higher rates of passage occurred at temperatures below 66^0F. If any part of reach has DO less than 4.5 milligrams per liter (mg/L) or

temperatures greater than 70 Degrees Fahrenheit (^{0}F), then the reach is considered a total barrier to adult migration (low performance rating). A DO concentration of 4.5-five mg/L or temperatures between 66 and 70^{0}F are considered a partial barrier (medium performance). A DO concentration greater than five mg/L or temperatures less than 66^{0}F are considered suitable for passage (high performance).

- Number of hydraulic jumps/vertical barriers (for adults): the number of potential vertical barriers, defined as a change in elevation > one foot and a jump pool depth of <1.5 times jump height or <two feet (DFG 2003).

4.7.3 Habitat Complexity

Complexity of salmonid rearing habitat has been described in terms of structural components (such as LWD, vegetation, boulders), hydraulic variation, and the diversity of depth, velocity, and substrate. Habitat complexity is positively related to salmon growth and survival by providing refuge from predation, sources of food production, and areas for resting and storing energy resources (Quinn and Peterson 1996). Therefore, the complexity of available rearing habitat for juvenile salmonids relates directly to the carrying capacity of a given stream reach.

Performance Measures

The performance measures for habitat complexity are:

- Acres of riparian vegetation: more areas with the potential to develop riparian vegetation would indicate greater potential habitat complexity. Attachment 6 describes the process to estimate suitability for riparian vegetation. The analysis considered whether areas would be likely to sustain riparian vegetation in the long term based on groundwater conditions (which were found to be suitable throughout the study area), soil conditions, and baseflows.

- Quantity and quality of rearing habitat: The quantity and quality of rearing habitat was estimated using a habitat suitability index (HSI), as described in Attachment 1. The HSI considered depth and velocity information from the hydraulic modeling and preliminary temperature data from the modeling for the Program EIS/R to estimate suitability for fish. The HSI considers this information for each area of the floodplain and channel rearing habitat during periods that the fish would likely be present in Reach 4B. A higher score indicates that an alternative has a higher area of suitable rearing habitat when fish would likely be present in the reach.

- Floodplain food production: Suitable floodplain rearing habitat also needs to produce an adequate food supply for the juveniles to grow during their time in Reach 4B. Attachment 1 describes the approach in more detail to evaluate how well each alternative would produce food on the floodplain.

4.7.4 Water Quality

Water quality is an important component of habitat for Chinook salmon. Water quality criteria were selected to indicate fish health and survivability.

Performance Measures

The performance measures for water quality are:

- Temperature (°F): the period for spring-run Chinook fry rearing and migration in Reach 4B would extend from approximately the end of November to the end of February, and the period for spring-run smolts would be from approximately early March through the end of June. The period for fall-fun Chinook fry rearing and migration in Reach 4B from extend from approximately early January through March, and the period for fall-run smolts would be from approximately April through July. An alternative received a high performance rating if it provided suitable temperatures (less than 64 degrees F) during this entire rearing and migration period. A medium performance rating indicates that the alternative would have suitable temperatures for spring-run fry and smolts. A low performance rating indicates that the alternative would have suitable temperatures only for spring-run fry migration and rearing.
- Relative pesticide concentration:
  - Adults and Juveniles: The number of agricultural returns.

4.8 Summary of Evaluation Criteria

Table 4-2 presents a summary of the evaluation criteria for evaluation of the Reach 4B Project initial alternatives.

Table 4-2.
Evaluation Criteria Summary

Evaluation Criteria	Performance Measure
Purpose and need/project objectives	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
	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
	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
Technical feasibility	Number of structures with technologies untested in similar conditions
	Estimate of operational complexity (low, medium, or high)
	Implementation timing, estimated with length of construction

Evaluation Criteria	Performance Measure
Environmental acceptability: biological effects	Acres of disturbed habitat
	Number of months when construction activities overlap with sensitive wildlife periods (February through September - nesting/breeding season for birds, including raptors)
Environmental acceptability: social effects	Quantity of farmland removed from production
	Reduction in annual agricultural production values based on crop type
	Total amount of affected land and parcels
Environmental acceptability: physical effects	Estimated magnitude of induced groundwater seepage
	Intensity of air quality impacts (average $/month of construction)
	Noise impacts (total construction duration in months)
	Frequency of road crossing inundation
Environmental acceptability: regulatory constraints	Miles of disturbed waterway in San Joaquin River
	Miles of disturbed waterway in Eastside Bypass and/or Mariposa Bypass
	Number of modified flood control structures (in San Joaquin River, Eastside Bypass, and/or Mariposa Bypass)
Cost	Construction Cost – total cost of construction in 2011 dollars
	Annual O&M Cost – present value of O&M.
	Total cost of land acquisition – assuming $10,000/acre
	Total cost of revegetation – preliminary estimates based on similar restoration projects
Flood control	Change in combined hydraulic capacity of the San Joaquin River and bypass system
Geomorphology/ sediment transport	Sediment in equals sediment out (San Joaquin River channel and Bypass)
	Low flow and migration channels (Bypass and San Joaquin River channel) persist without sediment deposition/plugs or excessive channel enlargement
	Channel does not headcut or create fish passage barriers
	Pools and bedforms (fishery habitat complexity) can be naturally sustained
	Riparian vegetation sustainability
	Volume of in-stream woody debris is consistent with similar size rivers and persists over time
Fisheries: predation issues	Number of pools with average depth greater than 1.5 meters
Fisheries: passage issues	Adequate pool and channel depths
	River channel and bypass channel velocities
	Obstructions to migration
	Water quality barriers
	Hydraulic jumps/vertical barriers

Evaluation Criteria	Performance Measure
Fisheries: habitat complexity	Acres of riparian vegetation
	Quantity and quality of rearing habitat
	Floodplain food production
Fisheries: water quality	temperature
	Relative pesticide concentration

4.9 Applying Criteria and Rating Initial Alternatives

The study team designated a high, medium, or low performance rating for each of the performance measures. Most of the data presented use objective measurements for each performance measure, such as acres, dollars, or miles, based on appraisal-level designs for each alternative. However, some of the criteria in the evaluation use qualitative assessments and rely on professional judgment to estimate results. Assumptions about current conditions and future effects of the alternatives are inherently involved at the current level of design. These assumptions have been based on information collected from similar projects and professional experience.

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5.0 Initial Alternatives Evaluation Results

This section presents the results of the initial alternatives evaluation. The performance of the alternatives is generally represented by colors: dark blue indicates a high level of performance, medium green represents a medium level of performance, and light green represents a lower level of performance. Attachment 5, Initial Alternatives Evaluation Results, includes the more detailed information that helped define the level of performance.

5.1 Project Objectives

All alternatives meet the project objectives to some extent. In some instances, depending on the fish and flow routing, some of the objectives are not met because they are not necessary. For instance, if fish are not passing through the Eastside and Mariposa bypasses, then no improvements would be made to these channels.

5.2 Technical Feasibility

In general, all of the alternatives have been designed to be technically feasible. All of the structures and features use concepts that have been proven in similar applications. While all of the alternatives would be feasible, some would be more complex than others. None of the alternatives would be highly complex, but Alternatives 3 and 4 would have moderate complexity. Both of these alternatives would have a moderately complex system of interconnected features at the Reach 4B Headgate. The system would need to coordinate the operations of three features to control flows and fish: an Obermeyer gate at the site of the existing Sand Slough Control Structure, a new slide or radial gate at the existing Reach 4B Headgate, and a fishway to convey fish when Reach 4A flows are high. Alternatives 1 and 2 would have low complexity (leading to a high performance rating for these alternatives). Figure 5-1 shows the results of the technical feasibility evaluation. A high performance rating indicates that an alternative has low complexity.

The length of the schedule to implement the alternatives may be another indicator of the complexity of the construction. Alternative 1 would take longer to construct, leading to a lower rating in Figure 5-1; however, none of the alternatives would involve particularly difficult or complex construction techniques.

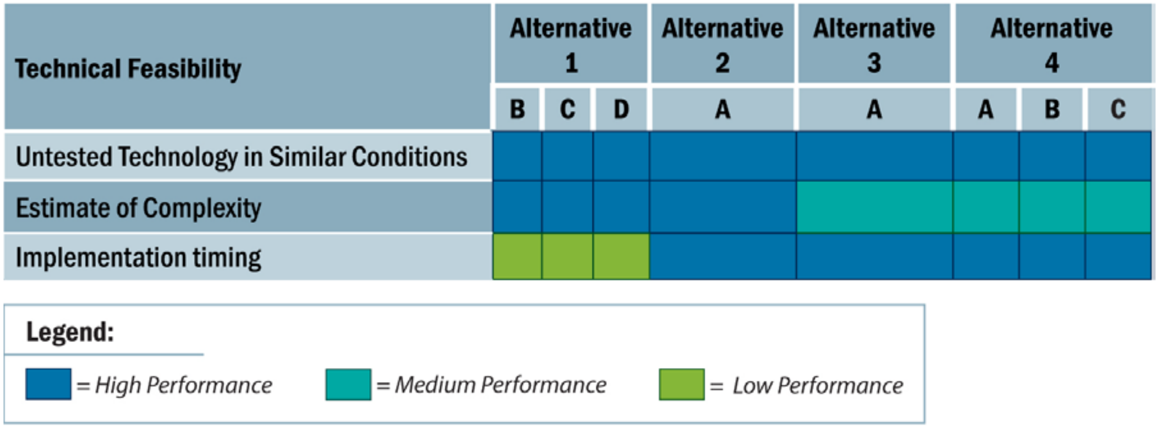

Figure 5-1.
Technical Feasibility Evaluation Results

5.3 Environmental Acceptability

This section presents the results of the Environmental Acceptability evaluation, including biological effects, social effects, physical effects, and regulatory effects.

5.3.1 Biological Effects

Figure 5-2 presents the biological effects of the alternatives, including impacts on vegetation and construction-related disturbances (noise, dust) during sensitive wildlife periods (February through September). Alternative 1 has the potential for the greatest impacts on existing vegetation, leading to lower performance ratings in Figure 5-2. Under proposed Levee Alignment D, Alternative 1 could affect up to approximately 250 acres of habitat. (Design of the alternative would work to allow existing habitat to remain, but inundation of new areas could affect this existing habitat.) Alternatives 2, 3, and 4 would have the least amount of impacts on existing vegetation if Levee Alignment A was selected, leading to a high performance rating.

Alternative 3 would result in the least amount of construction during sensitive wildlife periods, with a total of approximately 18 months, and received a high performance rating. Alternative 1 would result in the greatest amount of construction during sensitive wildlife periods (32 months) and therefore received a low performance rating. Alternatives 2 and 4 would have 20 months of construction during sensitive wildlife periods and received a medium performance rating.

There was insufficient data available to determine if the spread of invasive vegetation is restrained (change in acres by invasive vegetation type).

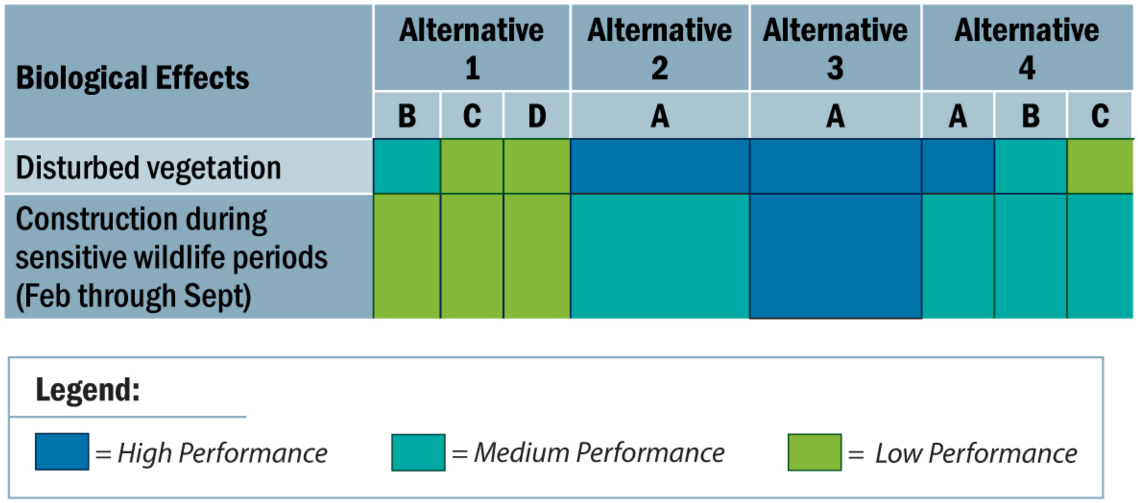

Figure 5-2.
Biological Effects – Vegetation Impacts and Disturbance During Sensitive Wildlife Periods

5.3.2 Social Effects

The potential social effects are indicated by the area of agricultural lands affected, the potential loss in agricultural production, and the overall affected land (see Figure 5-3). The alternatives' performance related to affected agricultural lands was tied to the proposed levee alignments considered, which define the footprint of each alternative. The wider alignments (C and D) could accommodate agricultural development inside of the levees; however, the existing agricultural uses may need to change and are counted as affected land. Alternative 1 has the potential to affect the largest area of agricultural land (approximately 8,000 acres) if proposed Levee Alignment D is implemented; therefore, it received the lowest performance rating. Proposed Levee Alignment C, in Alternatives 1 and 4, would affect the next largest area (approximately 4,500 acres). Alternatives 2, 3, and 4 have the potential to affect the least amount of agricultural lands if proposed Levee Alignment A is selected (369 acres) and received the highest performance rating.

Similar to affected agricultural lands, the change in agricultural production was conservatively estimated by assuming that production on all of the lands within the levees would stop. This may be an over-estimate of the changes because the wider alignments could allow agricultural development within the levees. Alternative 1 has the potential to result in the largest economic loss (greater than $12 million per year) if proposed Levee Alignment D is implemented; therefore, it received the lowest performance rating. Alternatives 2, 3, and 4 would result in the least amount of agricultural production losses (approximately $700,000 per year) under proposed Levee Alignment A and received the highest performance rating.

Changing the use of lands could also create social impacts. Alternative 1 could affect the most land (up to 10,150 acres of land and 139 parcels) under proposed Levee Alignment D; therefore it received the lowest performance rating. Proposed Levee Alignment C, under Alternatives 1 and 4, could affect 6,195 acres and 100 parcels and received a medium performance rating. Alternatives 2, 3, and 4 with proposed Levee Alignment A would affect the least amount of land (1,265 acres and 52 parcels) and received the highest performance rating.

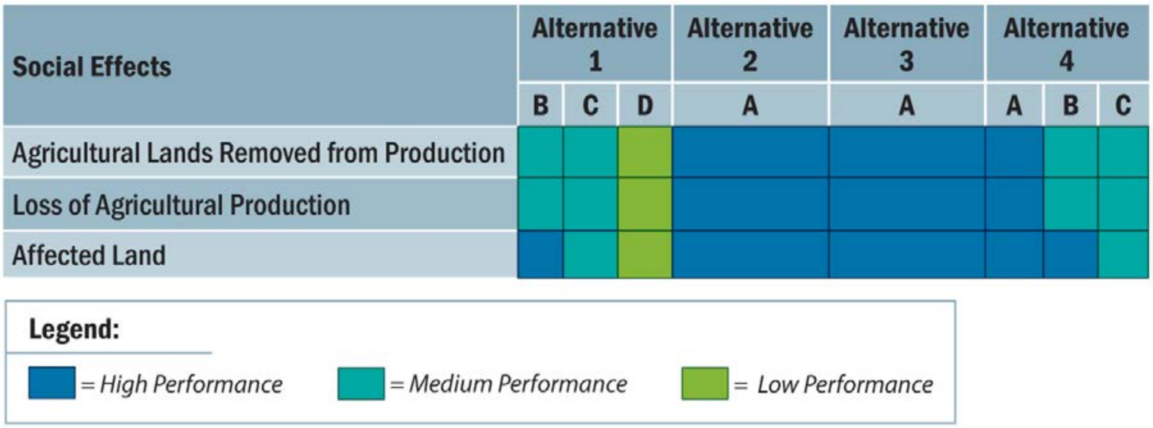

Figure 5-3.
Social Effects Evaluation Criteria

5.3.3 Physical Effects

As part of pre-design, the study team evaluated potential seepage areas and included seepage barriers in the levee designs. Each proposed levee alignment was held to the same standard for preventing seepage; therefore, all alternatives perform the same related to groundwater seepage at this level of the evaluation.

Similarly, the pre-design process included replacements for any roads that would be inundated more frequently under the initial alternatives than they are now. During the next steps, the study team will determine if road crossings need to be replaced as year-round crossings, and if some crossings may be adequate in their existing configuration. All alternatives perform the same related to inundation of road crossings.

To estimate which alternatives could have greater air quality impacts, the cost per month of construction was calculated. Alternatives with higher monthly costs have the potential for more air quality impacts because they would likely involve a higher intensity of construction with more equipment and vehicles that would produce emissions. Alternative 1, proposed Levee Alignment D and Alternative 4, proposed Levee Alignments B and C all received the lowest performance rating for air quality emissions based on the average construction cost per month of construction (see Figure 5-4). Alternative 1, proposed Levee Alignment B and Alternative 2 received the highest performance rating for air quality.

To determine noise impacts, the total months of construction were compared for each of the alternatives. The alternatives requiring the most months of construction were expected to produce the longest lasting noise impacts. As shown in Figure 5-4, Alternative 1 would require the most months of construction and therefore received the lowest performance rating. Alternative 2, and 3, and 4 all received a medium performance rating for noise impacts.

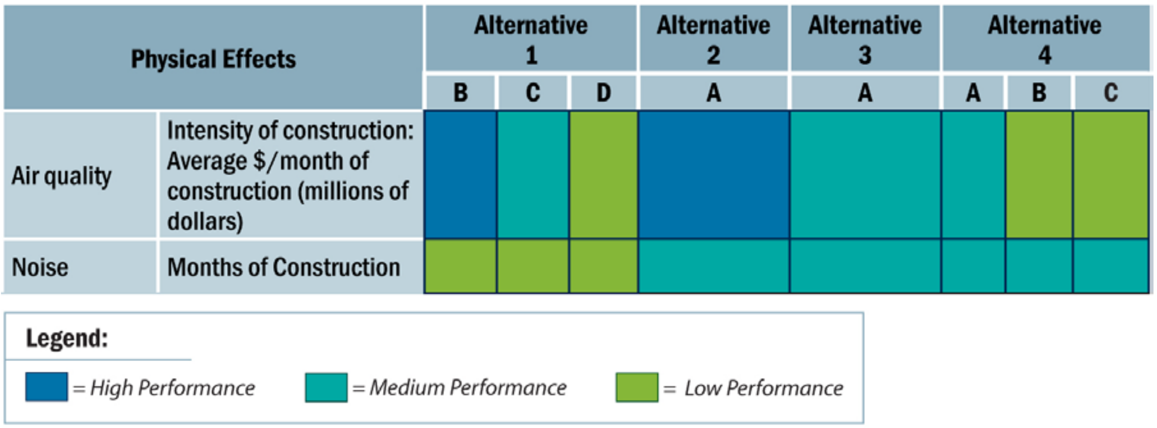

Figure 5-4.
Physical Effects

5.3.4 Regulatory Effects

All of the alternatives could result in some disturbance to waterways because levee work and channel clearing would be required in Reach 4B1 under all the Alternatives (see Figure 5-5 below). All of the alternatives would disturb the full length of Reach 4B1, and none of them would disturb Reach 4B2; therefore, the disturbance in the river was the same for all alternatives. Alternative 1 would not involve construction in the bypass system; therefore, it received the highest performance rating relative to disturbed waterways in the bypass system. Alternative 1 would also require the least amount of flood control structure modifications; only the Reach 4B Headgates and the Sand Slough Control Structure would need to be modified. It also received the highest performance rating for the modified flood control structures criterion.

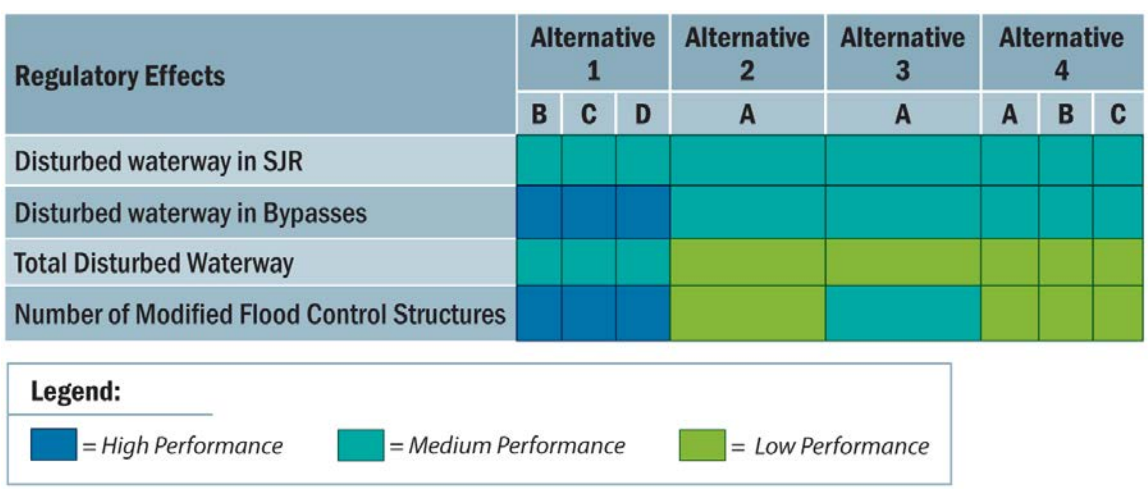

Figure 5-5.
Channel and Flood Control Structure Modifications

5.4 Cost

Figure 5-6 shows the preliminary costs for each alternative. These costs are preliminary and provided to help compare alternatives. Attachment 4 includes cost estimates for construction and O&M costs associated with each component of each alternative. Alternative 1, proposed Levee Alignments C and D, and Alternative 4, proposed Levee Alignment C would result in the highest construction costs. These also have the greatest land acquisition and revegetation costs. The O&M costs are the highest for Alternatives 3 and 4 because of the operational complexity at the new Reach 4B Headgates and Sand Slough Control Structure.

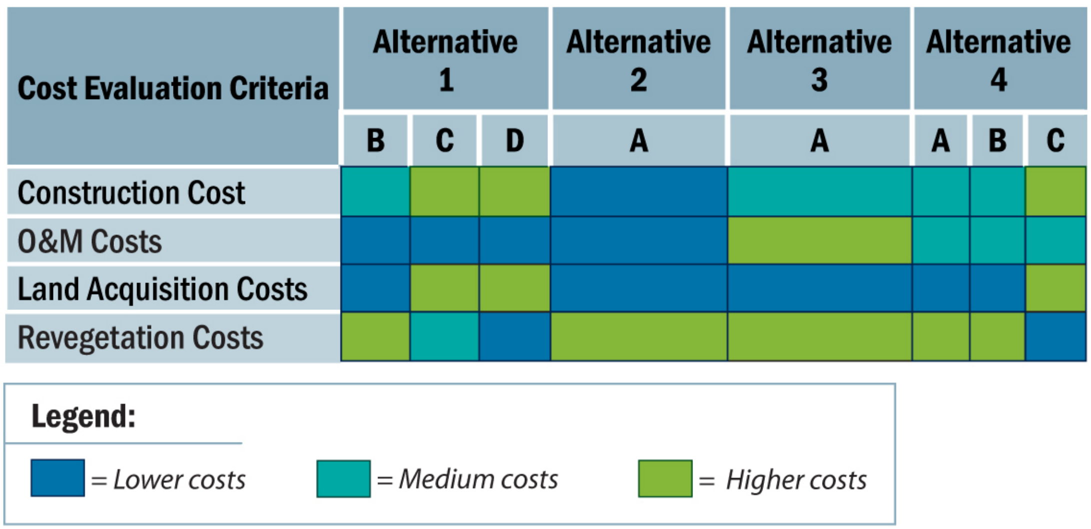

Figure 5-6.
Costs

5.5 Flood Control

The Reach 4B Project has a constraint that it cannot affect flood control capacity or operational flexibility. The pre-design process has required all alternatives to meet this constraint. The alternatives, however, have the potential to increase flexibility to manage floods by increasing the combined capacity of the river and bypass system. Figure 5-7 shows how well each alternative improves operational flexibility for flood control.

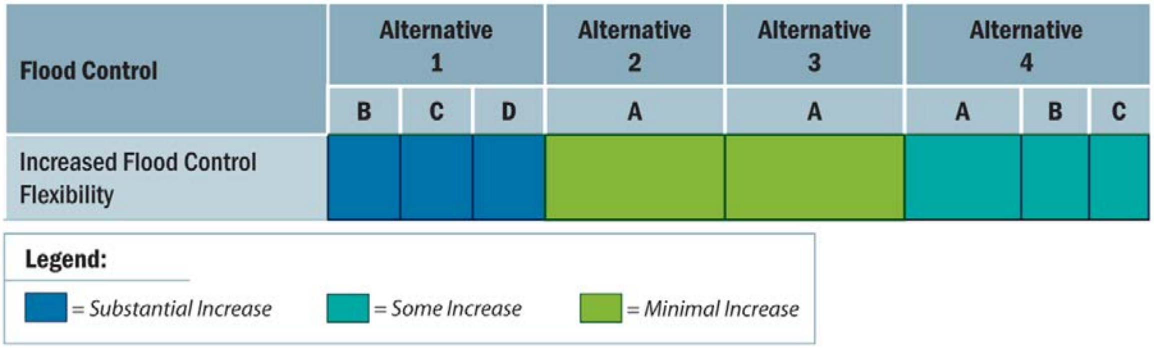

Figure 5-7.
Flood Control Operational Flexibility

5.6 Geomorphology/Sediment Transport

This section describes the results of the geomorphology/sediment transport evaluation. Figure 5-8 below shows the results of the evaluation for all the alternatives and associated proposed Levee Alignments. Scenarios in parentheses have not been modeled; the value was inferred from closest equivalent simulation.

5.6.1 Sediment Continuity and Channel Stability

Alternative 1, proposed Levee Alignments C and D, have the highest performance rating for sediment continuity and channel stability. They use an existing low flow channel year-round with a range of flows that should support geomorphic diversity (alternating scour and deposition). The sediment transport model confirms that for the alternatives that employ the San Joaquin River as the main pathway for fish migration, Alternative 1, proposed Levee Alignment C has the smallest amount of change in channel elevation (1.2 feet of channel deposition at the upstream end shifting to 0.7 feet of channel lowering at the downstream end of Reach 4B1). Alternative 1, proposed Levee Alignment D was not modeled but with a wider floodplain and identical flows to proposed Levee Alignment C it would likely behave in a similar way and also received a high performance rating. Alternative 1, proposed Levee Alignment B confines flow between narrower levees, and as a consequence is slightly more erosive at the downstream end (up to 1.5 feet of channel lowering in Reach 4B1, with up to 1.2 feet of channel deposition at the upstream end). However, for a sand bed river this is not a significant amount of scour.

Alternative 2 has the lowest performance rating for channel stability and sediment continuity. Alternative 2 would put all flow in the Eastside Bypass, which is a challenging environment for vegetation establishment and for sediment continuity. The sediment transport model shows mostly erosion in the Eastside Bypass (up to 1.4 feet of channel lowering), with up to four feet of deposition in Reach 4B2 for this alternative. While 1.2 feet of erosion is not considered a major problem, four feet of deposition would have a severe impact on both fisheries habitat and flood conveyance, potentially requiring dredging. In addition to the sediment transport analysis, evidence from other projects suggests that there would be channel adjustment prior to vegetation establishment in the Eastside Bypass.

Geomorphology/Sediment Transport Evaluation Criteria	Alternative 1			Alternative 2	Alternative 3	Alternative 4		
	B	C	D	A	A	A	B	C
Sediment in equals sediment out (Channel)	Mix of erosion and deposition	Mix of erosion and deposition	Assumed (mix of erosion and deposition)	SJR (deposition) EB (mixed)	Mix of erosion and deposition	Mix of erosion and deposition	Assumed (no sediment transport modeling)	Assumed (no sediment transport modeling)
Sediment in equals sediment out (floodplain)			Assumed	(depositional EB)		(depositional EB)	Assumed	Assumed
Low flow and migration channels (Bypass and main channel) persist without sediment deposition/ plugs or excessive channel enlargement	Mix of erosion and deposition	Mix of erosion and deposition	Mix of erosion and deposition	Initially Maturing EB (mix of erosion and deposition)	Mix of erosion and deposition	Mix of erosion and deposition	Assumed (no sediment transport modeling)	Assumed (no sediment transport modeling)
Channel does not headcut or create fish passage barriers				EB	SJR and EB	SJR EB	Assumed in SJR (no sediment transport modeling) EB (no sediment transport modeling)	Assumed in SJR (no sediment transport modeling) EB (no sediment transport modeling)
Pools and bedforms (fishery habitat complexity) can be naturally sustained				Initially After 10 yrs	SJR EB	SJR EB	SJR EB	SJR EB
Riparian Vegetation Sustainability				Initially After 10 yrs	SJR EB	SJR EB	SJR EB	SJR EB

Legend:
= High Performance *= Medium Performance* *= Low Performance*

Key
EB = Eastside Bypass *SJR = San Joaquin River*

Figure 5-8.
Evaluation Criteria for Geomorphology/Sediment Transport

Alternative 3 would have relatively low and constant flows in the San Joaquin River. It would have a good channel form to start with but might stagnate geomorphically at these flow rates. The sediment transport model shows moderate to high amounts of deposition at the upstream end (up to two feet of channel deposition) and small amounts of erosion at the downstream end (up to 0.5 feet of lowering). Two feet of deposition is likely to affect habitat quality and could trigger a need for dredging. The Eastside Bypass channel would be hard to establish and stabilize, especially with the first 475 cfs that might support riparian vegetation going into the San Joaquin River.

Under Alternative 4, proposed Levee Alignment A, Reach 4B would likely maintain a relatively good geomorphic form as it is already established and would be exposed to a range of flows up to and exceeding bankfull. The Eastside Bypass channel would be very hard to establish, especially with so much flow going down the San Joaquin River. The sediment transport model shows a relatively high level of channel erosion (up to 3.2 feet) in the downstream end of Reach 4B1 because of the narrow proposed levee alignment.

Though proposed Levee Alignments B and C were not modeled, they would likely perform better from a channel erosion perspective because of less confinement and therefore reduced erosive energy.

5.6.2 Headcut Risk

Alternative 1 has slight headcut risk, focused in the lower parts of Reach 4B where the channel would downcut slightly from higher flows. Under this alternative, there would be no structural changes to Eastside Bypass and lower flows, but flow would be sent down the San Joaquin River for the first time in many decades. The headcut risk is slight as the San Joaquin River would use the existing, well developed channel and the degree of erosion is predicted to be small.

Alternative 2 would have a medium headcut risk based on qualitative factors. This is because the Eastside Bypass would be steepened and several grade control structures would be removed or notched before vegetation was established in the new channel, creating the potential for incision to migrate upstream as the channel adjusted to high flows. However, the sediment transport model suggests little channel vertical adjustment would occur, reducing the risk of headcuts once initial channel adjustment had taken place.

Alternative 3 would have a slight risk of headcutting because more flow would be going down the Eastside Bypass, but since the channel gradient would not be changing, this would be a relatively small risk. The sediment transport model shows there would be little risk of headcutting in the San Joaquin River channel due to the low flows involved.

Alternative 4, proposed Levee Alignment A would have a very minor risk in the Eastside Bypass as flows would be similar to existing conditions and there would be no structural changes. There would be a relatively high risk of headcutting in the San Joaquin River from adding flows, with up to 3.2 feet of channel incision in Reach 4B. This could create situation where incision migrated headwards until it encountered a hard structure such as a weir or flow control structure, creating a potential fish passage barrier. However, provided that no hard structures are left in the channel, incision at the downstream end would likely dissipate in the middle or upper reaches. Although proposed Levee Alignments B and C have not been modeled, widening the levees would likely reduce the risk of channel incision and also headcutting.

5.6.3 Pools and Bedforms

Alternative 1 is expected to be the best alternative for sustaining pools and bedforms for the following reasons: it uses the existing channel which has some existing riparian vegetation cover, LWD, meander bends that cause and sustain geomorphic complexity, and would pass a wide range of flows, inducing alternating erosion and deposition that sustains channel complexity. Alternatives 2 through 4 all score lowest for bedforms in the Eastside Bypass as it would initially have no riparian corridor and would be challenging to establish a corridor. The scores for the San Joaquin River reflect increasing flows - the wider the flow range passing down the San Joaquin River the more likely forms are to be sustainable and not fill in with sediment.

5.6.4 Riparian Vegetation

This assessment focused on the probability of successful establishment and sustainability, not on the acres planted.

Alternative 1 received the highest performance rating for establishing and sustaining riparian vegetation since a riparian corridor is already established and the proposed flow regime would sustain it.

Alternative 2 received the lowest performance rating because it would require establishing a riparian corridor in the Eastside Bypass. This would be very challenging due to the lack of existing cover, sandy soils, and probability of excessive deposition leading to channel avulsions.

For Alternative 3, the San Joaquin River would probably be fairly good, but absence of disturbance flows might lead to uniform vegetation classes over time. For the Eastside Bypass, successful establishment and sustainability of riparian vegetation would be very challenging for the reasons noted in Alternative 2. Additionally, the lack of summer base flows would limit the survival of riparian vegetation.

In Alternative 4, the San Joaquin River would be better than Alternative 3 due to some higher flows, but not as good as Alternative 1 due to lack of disturbance flows. For the Eastside Bypass, successful establishment and sustainability of riparian vegetation would be very challenging for the reasons noted in Alternatives 2 and 3.

5.6.5 Large Woody Debris

This criterion was not evaluated. However, this could be designed for all reaches. Alternative 1 would likely start with a higher amount than the other alternatives.

5.6.6 Geomorphology/Sediment Transport Summary

Overall, Alternative 1 is superior for geomorphic function and sediment transport. Contributing factors are that the widest range of flows is kept in an existing well-developed meandering channel with a mature riparian corridor and a well connected floodplain that allows channel migration and fine sediment deposition. In addition, flows are not split between two systems, contributing to greater sediment transport equilibrium.

Under Alternative 4, the San Joaquin River channel would score ‘Medium’ to ‘High’ for many geomorphic functions, with higher performance than Alternative 3 but lower performance than Alternative 1. Alternative 4, proposed Levee Alignment A scores poorly for channel sediment continuity due to the confined levee alignment, but higher scores would be likely if sediment transport modeling were performed on proposed Levee Alignments B and C. The San Joaquin River channel would have a reasonable level of function because it is a well established meandering channel with a mature riparian corridor that contributes LWD. It has a higher erosion resistance than a new channel in the Eastside Bypass would and would be both more stable and more diverse, contributing to ecological function. It would be less functional than the Alternative 1 channel because the range of flows would be smaller, with flows capped at 1,500 cfs, and the flows would be split relatively frequently between the San Joaquin River and the Eastside Bypass, causing excess sedimentation. However, the wider range of flows and the presence of a floodplain within a setback levee system under proposed Levee Alignments B and C would lead to better function than Alternative 3, with channel migration and deposition of fine sediment on the floodplain possible. Proposed Levee Alignment A would constrain channel migration and minimize floodplain area.

Alternatives 2 and 3 have similar levels of function though for different reasons. Alternative 2 has the highest functioning approach to the Eastside Bypass channel design of all the alternatives, by eliminating the Mariposa Drop Structure and developing a more natural channel gradient and overall morphology. However, the Eastside Bypass would likely not function as well as the San Joaquin River for a period of decades. Alternative 3 makes more use of the San Joaquin River channel for restoration flows, but at flows above 475 cfs the majority of fish would likely be exposed to a channel with less good geomorphic functions and associated habitat.

5.7 Fisheries

This section describes the results of the fisheries evaluation. A high performance rating generally denotes a more beneficial impact on fisheries; while a low performance rating is less beneficial.

5.7.1 Predation

As part of the engineering designs, all pools at structures are eliminated in Reach 4B1 and the bypasses under the various alternatives; therefore, all alternatives received the same high performance rating.

5.7.2 Passage

The engineering design process used the criterion that the maximum depth of any large pools in channel or near structures must be less than 1.5 meters and all habitat areas must be greater than one foot for all flows above 45 cfs. Therefore, all alternatives received the same high performance rating for large pools in channel or near structures and adequate pool and channel depths.

All structures and crossings have been designed with velocities less than six feet per second. All fish passage structures have been designed to have a zero water surface drop and a maximum three percent slope. All alternatives received the same high performance rating for river channel and bypass flow.

The number of obstructions to adult migration criterion received medium performance ratings for Alternatives 1 and 2, with one obstruction identified for each alternative. The number of obstructions to adult migration criterion received low performance ratings for Alternatives 3 and 4, with two obstructions identified for each alternative. The number of obstructions to juvenile migration criterion received low performance ratings for all alternatives, with at least 35 obstructions identified for each alternative.

There is insufficient information available to evaluate water quality barriers.

No hydraulic jumps/vertical barriers were identified for any of the alternatives; therefore, all alternatives received a high performance rating.

5.7.3 Habitat Complexity

Alternative 1, proposed Levee Alignments C and D would have the largest area suitable for riparian vegetation and received a high performance rating. Alternative 4, proposed Levee Alignment C also received a high rating because it includes greater areas of riparian vegetation. Proposed Levee Alignment B, under both Alternatives 1 and 4, would have moderate potential for riparian vegetation and received a medium performance rating. Alternatives 2, 3, and 4 (proposed Levee Alignment A) would have the least potential for riparian vegetation.

The quantity and quality of rearing habitat was estimated using an HSI rating, as described in Attachment A. The HSI was the highest for Alternative 1, proposed Levee Alignment D, followed by Alternative 1, proposed Levee Alignment C. Both of these alternatives would involve wider floodplain areas that have the potential to produce more rearing areas with suitable depths, velocities, and temperatures when fish are present. These alternatives both received a high performance rating. Alternative 1, proposed Levee Alignment B has a moderate HSI and received a medium performance rating. The remaining alternatives either had a narrower levee alignment or lower enough flows that reduced the occurrences of suitable conditions on the floodplain. These alternatives have lower HSI scores and received low performance ratings.

Higher flows and wider floodplains generally accommodate greater productivity; therefore, Alternative 1 received the highest ratings for floodplain food production. All other alternatives received low ratings.

5.7.4 Water Quality

Attachment 7 shows the initial temperature modeling results divided into different periods for each alternative. The alternatives generally have similar results. All alternatives have temperatures below the suitability criterion for fish (64 degrees F) during February for all flow rates. During March, temperatures are suitable with higher flows but above the suitability criterion when flows are lower. From April through June, temperatures exceed the suitability criterion. Based on the timing of the presence of spring-run and fall-run fry and smolts, all alternatives received a low performance rating.

The Settlement includes a high degree of flexibility in managing the flows in the river system to optimize conditions for fish. The temperature modeling analysis used a flow pattern based on the Exhibit B flows, but this flow schedule could vary significantly. If the flows are released earlier in the year, the temperatures for all alternatives would likely be suitable for all (or most) of the spring-run and fall-run juveniles. If the flows are released later in the year, the temperatures are likely to be higher than the suitable temperature for most of the juveniles in Reach 4B.

Groundwater conditions in the Reach 4B vicinity indicate that some areas of the stream are gaining and some are losing. The temperature modeling does not take into account any changes to temperature from groundwater. Reaches receiving inflows from groundwater may experience temperature changes associated with the groundwater-surface water interaction.

Agricultural returns were identified using aerial photographs of the Reach 4B Study Area. Alternatives 3 and 4 received low performance ratings because they would have the greatest number of agricultural returns identified along the fish route. Alternative 1 was in the middle (medium), with slightly fewer agricultural returns. Alternatives 2 received a high performance rating, with the lowest number of agricultural returns identified along the fish route.

5.7.5 Fisheries Summary

Alternative 1, proposed Levee Alignment D received the highest overall performance ratings, followed by Alternative 1, proposed Levee Alignments C and B. Alternative 3, proposed Levee Alignment A received the lowest overall performance ratings. Figure 5-9 summarizes the overall performance of the alternatives relative to the fisheries performance measures.

Evaluation Criteria				Lifestage	Alternative 1			Alternative 2	Alternative 3	Alternative 4		
					B	C	D	A	A	A	B	C
Fisheries	Predation Issues	Large pools in channel or near structures	Number of pools with average depth > 1.5 m	Juvenile	High	High	High	High	High	High	High	High
	Passage Issues (Adults and Juveniles)	Adequate pool and channel depths	**Adults:** Habitat area with depths < 1.0 ft	Adults	High	High	High	High	High	High	High	High
			Juveniles: Habitat area with depths < 0.5 ft	Juveniles	High	High	High	High	High	High	High	High
		River channel and bypass channel flow	**Adults:** Habitat area with velocities > 6.0 ft/sec	Adults	High	High	High	High	High	High	High	High
		Obstructions to migration	**Adults:** Number of obstructions (culverts, fish ladders, or chutes)	Adults	Medium	Medium	Medium	Medium	Low	Low	Low	Low
			Juveniles: Number of obstructions (ag pump or diversion, culverts, structure that creates a scour pool)	Juveniles	Low	Low	Low	Low	Low	Low	Low	Low
		Hydraulic jumps/ Vertical Barriers	The number of potential vertical barriers, defined as a change in elevation > 1 ft and a jump pool depth of <1.5 times jump height or <2 ft.	Adults	High	High	High	High	High	High	High	High
	Habitat Complexity	Quality of riparian habitat	Area suitable for riparian recruitment, considering soils and baseflow elevations	Both	Medium	High	High	Low	Low	Low	Medium	High
		Quantity and quality of rearing habitat	Habitat suitability index	Juveniles	Medium	High	High	Low	Low	Low	Low	Low
		Floodplain food production	Floodplain food production indicator	Juveniles	Medium	High	High	Low	Low	Low	Low	Low
	Water Quality	Temperature	Suitable temperatures (less than 64 degrees F) during rearing and migration periods for spring-run and fall-run Chinook fry and smolts	Juveniles	Low	Low	Low	Low	Low	Low	Low	Low
		Relative Pesticide concentration	The number of agricultural returns	Both	Medium	Medium	Medium	High	Low	Low	Low	Low

Legend:
= *High Performance* = *Medium Performance* = *Low Performance*

Figure 5-9.
Evaluation Criteria for Fisheries

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6.0 Conclusions and Recommendations

This section presents the conclusions of the Initial Alternatives Evaluation, including the alternatives recommended to be carried forward for further analysis, the alternatives recommended to be removed from further consideration, and additional analysis that is recommended for the alternatives being carried forward. It also presents the next steps involved in the Reach 4B Project.

6.1 Alternatives Carried Forward for Further Analysis

As shown in Section 5, no one alternative performs well according to all evaluation criteria. Alternatives 2 and 3 would include proposed Levee Alignment A, and would have fewer impacts on existing land uses, crop productivity, or existing vegetation. Alternatives 1 and 4, however, could use other proposed levee alignments that would take more land out of production. These alignments would have increased effects on existing land uses and vegetation, but would have increased benefits for fisheries and geomorphic function. All of the alternatives remaining meet most of the purpose and need/project objectives. The process to recommend alternatives to move forward considered which alternatives could minimize environmental effects and create the best range of alternatives with different benefits and impacts. This range of alternatives allows the EIS/R to evaluate trade-offs at a more detailed level to help decision-makers.

Based on the results of the alternatives evaluation and screening presented in Section 5, the following alternatives are recommended to be carried forward for further analysis in the Reach 4B Project EIS/R.

6.1.1 Alternative 1 - Main Channel Restoration

Section 11(b)(1) of the Settlement indicates that in the long-term, the Reach 4B Project should include modifications "…to ensure conveyance of at least 4,500 cfs through Reach 4B," unless the Secretary (with the RA, NMFS, and USFWS) determines that these modifications would not substantially enhance achievement of the Restoration Goal. Because the Settlement describes a scenario similar to Alternative 1, this alternative will move forward for further analysis in the EIS/R. Additionally, Alternative 1 performs the best for the geomorphology and fisheries evaluation criteria.

Alternative 1 could include proposed Levee Alignments B, C, and D. All three proposed levee alignments would incorporate varying amounts of in-channel and floodplain rearing habitat. All three proposed levee alignments will move forward for additional analysis.

6.1.2 Alternative 2 - Bypass Restoration

Alternative 2 would use the Eastside and Mariposa bypasses as the main restored channel, and improvements for fish would be focused on the bypass system. Reach 4B1 would be improved to convey at least 475 cfs for only Flood Flows. This alternative would reduce some of the potential effects associated with changing land use along the

Reach 4B corridor to establish floodplain habitat and construct levees (with seepage management systems).

This appendix received review from multiple stakeholders as well as a Value Planning study completed by Reclamation. The Value Planning study recommended an alternative that would keep all Restoration and Flood flows together in the bypass system to help with geomorphic function and temperatures. The study also recommended incorporating setback levees in the bypass system to accommodate additional habitat features within the bypass system without affecting flood control capacity or operational flexibility. These recommendations will be incorporated into Alternative 2 when moving forward into the EIS/R.

6.1.3 Alternative 3 - Bypass All Pulse Flows

Alternative 3 describes improvements to Reach 4B of the San Joaquin River to provide in-channel rearing habitat. Reach 4B1 would have a capacity of at least 475 cfs, and flows greater than this capacity would use the bypass system. Reach 4B would function as the primary channel and the bypass system would function as the floodplain habitat.

This alternative could reduce potential biological, social, and physical effects associated with Alternative 1 (see Section 5.3). However, while it would meet fisheries needs, it would provide fewer fish benefits than the other alternatives (see Figure 5-9). These changes would show informative trade-offs between different alternatives and help create a reasonable range of alternatives.

Alternative 3 will move forward for further evaluation in the EIS/R because it has the potential to reduce environmental effects of other alternatives.

While Alternative 3 is recommended to move forward for additional analysis, it is also recommended to consider an alternate flow path through the bypass system. Alternative 3 currently routes flows through the Eastside Bypass Reach 3 instead of the Mariposa Bypass. The pre-design process identified that routing flows through the Mariposa Bypass could help achieve suitable flows and habitat. Recommendations include a provision to consider two flow routes in the bypass system for Alternative 3: the Eastside Bypass Reach 3, and the Mariposa Bypass to Reach 4B2. The additional flow route would require notching the Mariposa Bypass Control Structure and constructing a fishway at the Mariposa Drop Structure to provide fish passage. Both flow routes will be considered during the project design and alternatives evaluation phase, but if this alternative is selected for implementation, improvements on only one flow route would be constructed.

6.2 Alternatives Removed from Further Consideration

Based on the results of the alternatives evaluation and screening presented in Section 5.0, the following alternatives are recommended to be removed from further consideration.

6.2.1 Alternative 4 - Split Pulse Flows and Restore Both

Alternative 4, proposed Levee Alignments B and C are recommended to be removed from further consideration. Proposed Levee Alignment B is proposed to move forward under Alternative 1; therefore, it would already be analyzed and is not necessary to move forward under Alternative 4. The floodplain habitat in proposed Levee Alignment C would not function well with the range of flows that would occur under Alternative 4; therefore, this alignment will not move forward into the EIS/R.

As described in Appendix A, Alternatives 3 (Bypass All Pulse Flows) and 4 (Split Pulse Flows and Restore Both) are very similar. Both alternatives would split flows between the San Joaquin River and the Eastside Bypass; they only vary by the quantity of flow. The alternatives include the same proposed levee alignment (and almost identical levee size) in the San Joaquin River Reach 4B and the same types of improvements in the bypass system. The potential environmental effects of both alternatives are likely to be very similar, if not identical for many resource areas.

Alternative 3 addresses the requirements associated with Section 11(a) of the Settlement, and would provide environmental coverage if the Secretary decides to just implement these requirements in Phase I. Most elements of Alternative 4 would be the same as Alternative 3, and the environmental effects would be addressed through the analysis of Alternative 3. The primary difference would be the flow split and the change in inundation timing.

Alternative 1 would also split flows by routing 4,500 cfs of Restoration Flows into the San Joaquin River Reach 4B1 and any greater flows into the Eastside Bypass. Potential issues associated with the flow split and inundation timing would be bookended by Alternatives 1 and 3; the potential impacts of Alternative 4 would fall in between these two alternatives. Therefore, the impacts of split flows would also be addressed through other alternatives and Alternative 4 is not proposed to be carried forward for further analysis in the Draft EIS/R.

6.3 Additional Recommendations

In addition to the above recommendations to remove or modify alternatives, several additional recommendations have been made to modify the alternatives:

- Fish barriers – this document describes fish barriers at a very general level of detail. Stakeholders have recommended eliminating the fish barriers and providing fish passage throughout the system to increase the effectiveness of fish passage throughout the Reach 4B Project Study Area. This is primarily applicable in Reach 3 of the Eastside Bypass. Several alternatives included barriers at the downstream end of the reach to prevent adults from entering the reach. In the future, the alternatives will not include these barriers, but will instead incorporate fish passage at the Eastside Bypass Control Structure to allow fish to pass upstream or downstream during high flow events.

The pre-design process has provided a substantial amount of information; however, additional information will help refine the alternatives before the EIS/R is prepared. These items are recommended for additional analysis:

- Road crossings – the existing assumptions indicate that new road crossings would be passable year-round, but this assumption may not be necessary. Additional information about the uses of the crossings will help determine if new road crossings could be seasonally inundated.

- Refuge water demands and surface water elevations – the NWR weirs in the bypass system create a barrier for fish; however, reoperation of the weirs may help address this problem. Additional information is needed about when the refuge diverts water to determine if the boards can come out of the weirs during times that fish would be passing the area.

- Canal realignments – the existing analysis assumes that any affected canals would be realigned; however, the specific canal realignments have not yet been developed. The next step in the analysis is to use specific canal locations to determine how the realignment requirements would vary for different proposed levee alignments.

6.4 Next Steps

This document recommends three Alternatives be carried forward for further review: Alternative 1 (proposed Levee Alignments B, C, and D), Alternative 2 (proposed Levee Alignment A), and Alternative 3 (proposed Levee Alignment A). Table 6-1 below summarizes the main elements of these alternatives carried forward for analysis in the Reach 4B EIS/R.

These alternatives will be further refined and additional analysis will be completed, as necessary. A Project Description TM will then be developed, which provides detailed descriptions of the alternatives to be analyzed in the EIS/R and documents any additional analysis or refinements that have occurred. The Project Description TM will provide the basis of the Project Description chapter of the EIS/R. After the Project Description TM is complete and approved by Reclamation and DWR, work will start on the Reach 4B Project Draft EIS/R.

Table 6-1.
Summary of Alternatives Proposed to Move Forward for Analysis in Reach 4B EIS/R

Channel/ Structure	Alternative 1 Main Channel Restoration	Alternative 2 Bypass Restoration	Alternative 3 Bypass All Pulse Flows
San Joaquin River Flows	Up to 4,500 cfs (all Restoration Flows)	At least 475 cfs of Flood Flows	Restoration Flows of at least 475 cfs
Bypass System Flows	Flood Flows greater than 4,500 cfs	All flows up to capacity	Flow greater than 475 cfs
Fish Routing	SJR	Eastside Bypass Reach 2, Mariposa Bypass	SJR, Eastside Bypass Reach 2, Mariposa Bypass; or SJR, Eastside Bypass Reach 2, Eastside Bypass Reach 3
Habitat	SJR	Bypass	SJR and Bypass
Floodplain Habitat Grading	SJR	Bypass	SJR and Bypass
Channel Slope Grading	No change	Change channel slope in Eastside and Mariposa bypasses	No change
Reach 4B Headgates	Remove Headgate	Simple Gate	Construct gates and roughened channel fishway
Eastside Bypass Control Structure	No Change	Roughened channel fishway	Roughened channel fishway
Mariposa Bypass Control Structure	No Change	Notch Center Bays	Notch Center Bays
Mariposa Drop Structure	No Change	Remove Drop Structure	Fish Passage
San Joaquin River proposed Levee Alignments	B, C, D	A	A

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