Attachment

Restoration and Water Management Actions in Program Alternatives

Draft
Plan Formulation Appendix

SAN JOAQUIN RIVER
RESTORATION PROGRAM

Draft
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List of Abbreviations and Acronyms

cfs	cubic feet per second
cy	cubic yard
DFG	California Department of Fish and Game
DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
ECWG	Environmental Compliance Work Group
EDWG	Engineering and Design Work Group
FMWG	Fisheries Management Work Group
ft/s	feet per second
FWUA	Friant Water Users Authority
IPAR	Initial Program Alternatives Report
MP	Mile Post
msl	mean sea level
NAD 83	North American Datum 1983
NGVD 29	National Geodetic Vertical Datum 1929
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council
O&M	operations and maintenance
PEIS/R	Program Environmental Impact Statement/Report
PLC	Programmable Logic Controller
PMP	Program Management Plan
RA	Restoration Administrator
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RWA	Recovered Water Account
Settlement	Stipulation of Settlement Agreement
SJRRP	San Joaquin River Restoration Program
Appendix	Appendix
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1.0 Introduction

The purpose of this document is to describe the physical features for the restoration and water management actions included in the program alternatives. These actions will be addressed at a program-level of detail in the San Joaquin River Restoration Program (SJRRP) Program Environmental Impact Statement/Report (PEIS/R) Descriptions of actions include quantitative information, such as construction footprint areas, that will inform impact assessments for the PEIS/R.

Preappraisal designs have been developed by the Engineering and Design Work Group (EDWG) for structural actions that will meet or has the potential to meet the Restoration or Water Management goals defined in the Stipulation of Settlement (Settlement). Selected structural actions will form part of the final program alternatives. The first step taken by the EDWG was to list all possible actions that could meet these objectives, including site-specific projects stipulated for implementation in Paragraph 11 of the Settlement. Other potential restoration actions are included in Paragraph 12 of the Settlement. Actions identified for meeting the Water Management Goal fall into two categories. The first is for recirculation, recapture, reuse, exchange, or transfer of Restoration Flows according to Paragraph 16(a) of the Settlement. Paragraph 16(b) specifies the use of surplus water available to meet the Water Management Goal in wet hydrologic conditions by establishing a Recovered Water Account (RWA). Paragraph 16(b) opportunities are described in a separate attachment.

The development and analysis of alternatives for the SJRRP occurs in three stages: (1) *Initial Program Alternatives Report* (IPAR), completed June 2008 (SJRRP 2008), (2) Plan Formulation Appendix to the PEIS/R, and (3) the PEIS/R. The identified actions were initially referred to as “options” and were labeled as such for the first stage IPAR evaluations. Descriptions of analyses supporting the Plan Formulation Appendix are described below.

1.1 Structural Options Analyses

Identification and analysis of structural options are a key component of the formulation and evaluation of alternatives required for the PEIS/R. Physical actions or options are expected to evolve as additional information becomes available. Structural options will be refined based on available information at a program level of detail. Refinements may address option configurations and ranges, operational assumptions, sizes, site considerations, real estate requirements, and consistency revisions. Evaluations will remain at a preappraisal level of design consistent with a program level of detail. These actions were included in the Plan Formulation Appendix for inclusion in alternatives presented in the PEIS/R.

A parallel process for the design of schedule-critical options being initiated as Stage 1 has been completed. Site-specific evaluations of actions identified in Paragraph 11 of the Settlement must begin before the completion of the PEIS/R to meet the completion dates dictated in the Settlement.

1.2 Purpose of this Document

The purpose of this Restoration and Water Management Actions in Program Alternatives Attachment is to present program-level engineering descriptions of structural projects that may contribute to achieving the Restoration and Water Management goals of the Settlement. This document is intended to provide technical background information of actions included in the program alternatives described in the Plan Formulation Appendix. The engineering descriptions will provide assumptions and anticipated implementation ranges for use in cumulative impact evaluations for the PEIS/R. Nonstructural measures such as management and institutional actions that could contribute to achieving the Restoration and Water Management goals are not presented in this attachment.

1.3 Document Organization

This document, presented in four sections, provides an overview of the restoration and water management actions identified to date for consideration in the Plan Formulation Appendix. To maintain consistency with the Plan Formulation Appendix, the options will be referred to as actions within the descriptions; however, the option name and number will remain unchanged for continuity with previous evaluations. Detailed descriptions for each identified action are provided.

This section (Section 1) describes the purpose of this document. Section 2 describes the approach and methods for how physical actions were evaluated. Section 3 contains the descriptions summaries of the preappraisal action analyses included in the Plan Formulation Appendix. These descriptions include anticipated ranges of implementation, real estate requirements, and operations and maintenance (O&M) requirements, and preliminary environmental considerations. Section 4 contains the sources used to compile this attachment.

2.0 Evaluation Approach and Methods

2.1 Options Matrix

U.S. Department of the Interior, Bureau of Reclamation's (Reclamation), participation in development of the Settlement and the Program Management Plan (PMP) provided the background for initial identification of structural actions. A unique "option" number was assigned as actions were identified. A total of 111 actions were identified as having the potential for achieving the Restoration or Water Management goals. The options matrix list was developed from several sources, as described below:

- **Options 1 through 14 –** These actions were identified from Paragraph 11 of the Settlement.

- **Options 15 through 28, 62 through 67, and 111 –** These were identified as potential Restoration options that could be required to mitigate third-party impacts associated with implementing actions identified in Paragraph 11, or that are necessary to meet the Restoration Goal that were not mentioned specifically in Paragraph 12 of the Settlement.

- **Options 29 through 61 –** These are options to help meet the Water Management Goal. They were identified from the Friant Water Users Authority (FWUA) *San Joaquin River Restoration Program Water Management Goal Potential Programs & Projects Report* (Feinstein Report) (2007) and other early data.

- **Options 68 through 110 –** Additional structural and nonstructural water management options were identified during the review of initial options in the Feinstein Report and the SJRRP team, and Friant long-term contractors identified additional options that also may contribute to the Water Management Goal.

Tables 2-1 and 2-2 list restoration and water management actions included in the program alternatives described in the Plan Formulation Appendix and Figure 2-1 shows the general location of the restoration actions. The preappraisal level analyses for each action in the Plan Formulation Appendix, sorted by option number, are included in the Option Forms for Restoration and Water Management Actions in Program Alternatives Exhibit. This exhibit includes the engineering forms, drawings, and location maps used by the different team members to report the results of their preappraisal evaluation. The geographical locations of these actions are shown in the Restoration and Water Management Actions Location Map Exhibit.

Table 2-1.
Restoration Actions Included in Program Alternatives

Option No.	Option Description	Reference Paragraph in Settlement/ Need	Reach
1	Construct Mendota Pool Bypass and Bifurcation Structure	11(a)(1)	2B
2	Modify Reach 2B to Convey 4,500 cfs	11(a)(2)	2B
3	Modify Reach 4B to Convey 475 cfs	11(a)(3)	4B
4	Modify San Joaquin River Headgate at Sand Slough to Convey Up to 4,500 cfs	11(a)(4)	4B
5	Modify Sand Slough Control Structure for Fish Passage	11(a)(5)	4A
6	6a Screen Arroyo Canal Water Diversion	11(a)(6)	3
	6b Arroyo Canal Water Diversion	12	3
7	Modify Sack Dam for Fish Passage	11(a)(7)	3
8	Modify Structures in Eastside and Mariposa Bypass channels	11(a)(8)	4B
	8a - Control Structure	11(a)(8)	4B
	8b - Drop Structure	11(a)(8)	4B
9	Establish Stable Low-Flow Channels in Eastside and Mariposa Bypasses	11(a)(9)	4B
10	Enable Deployment of Seasonal Barriers at Salt and Mud Sloughs	11(a)(10)	5
11	Modify Reach 4B to Convey at Least 4,500 cfs	11(b)(1)	4B
12	Modify Chowchilla Bifurcation Structure for Fish Passage	11(b)(2)	2A
13	Fill and/or Isolate the Highest Priority Gravel Pits in Reach 1	11(b)(3)	1
	13a - Augment Existing Riffles	12	1
	13b - Establish and Maintain New Riffles	12	1
	13c – Reconfigure Channel	12	1
	13d - Remove Debris	12	1
	13e - Reconfiguration of Floodplain at 23 Sites	12	1
	13f - Obtain Material for 23 Sites	11(b)(3)	1
	13g - Floodproof Wellheads	12	1
	13h - Relocate Floodplain Diversion Pumps	12	1
	13i - Isolate Gravel Pits with Berms - 23 Sites	11(b)(3)	1
	13j - Isolate Gravel Pits with Saddles - 23 Sites	11(b)(3)	1
14	Modify Sand Slough Control Structure to Convey 4,500 cfs	11(b)(4)	4A
16	Screen Small Diversions on San Joaquin River	12	1-5
19	Modify Reach 3 Levees to Convey 4,500 cfs	12	3
22	Evaluate San Joaquin River Crossings Requirements	12	1-5
62	Control and Monitoring of Invasive Plants	12	1-5
63	Restore Native Riparian Habitat	12	1-5
64	Manage Channel and Floodway Vegetation	12	1-5
65	Install Fish Barrier at Confluence of Eastside Bypass and Sand Slough	12	4B
66	Install Fish Barriers on Tributaries to the Eastside Bypass (Scenario C1)	12	4B
67	Install Fish Barrier on San Joaquin River (Scenario C1)	12	4B

Key: cfs = cubic feet per second

Table 2-2.
Water Management Actions Included in Program Alternatives

Option No.	Option Description	Reference Paragraph in Settlement/Need
58	Construct San Joaquin River Pump Station and Intertie Pipe to Delta Mendota Canal	16
59	Construct San Joaquin River Pump Station and Intertie Pipe to the California Aqueduct	16

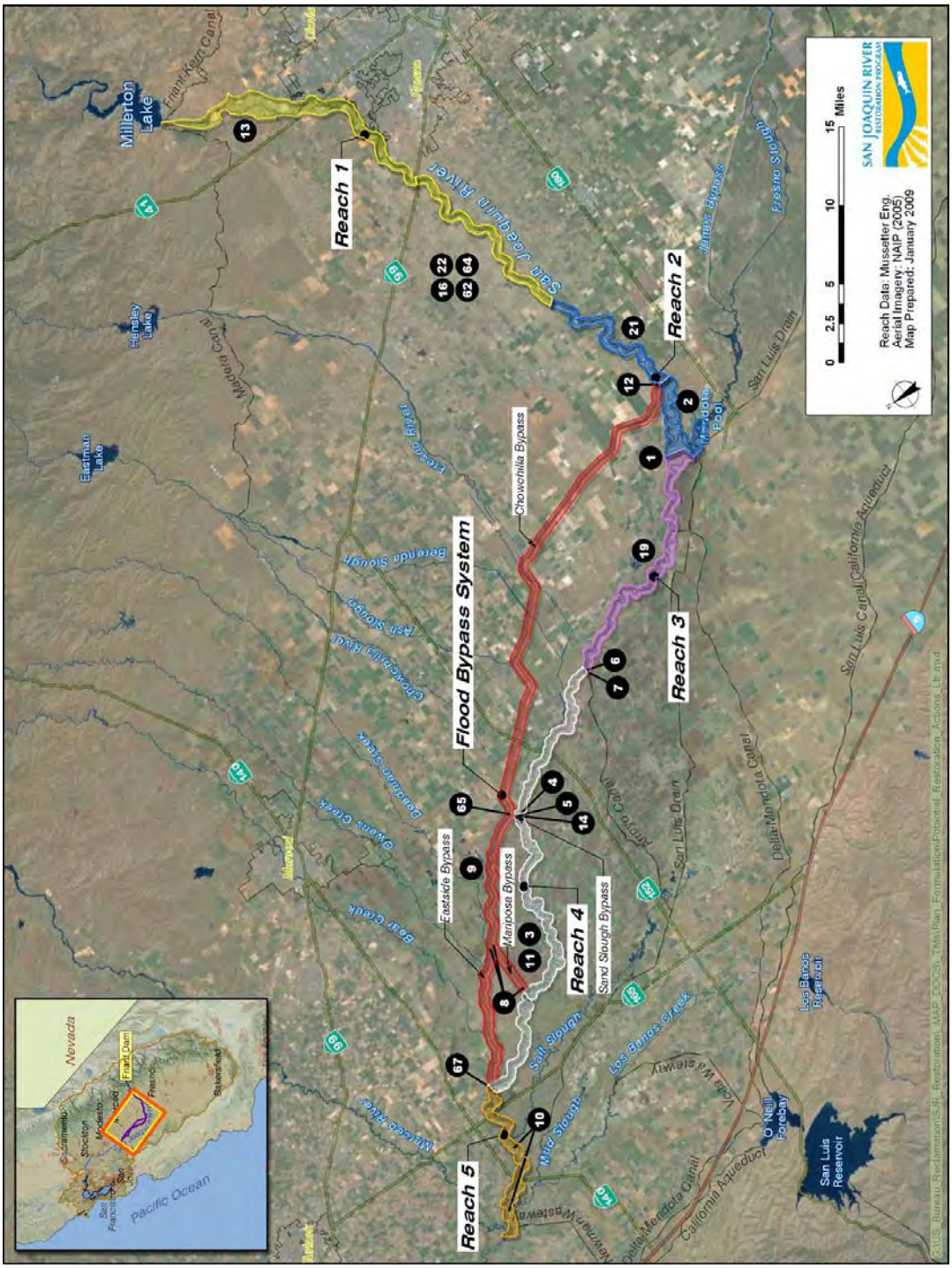

Figure 2-1.
Potential Restoration Actions Included in the Program Alternatives

2.2 Preappraisal Level of Analysis

Before completing the evaluations presented in this appendix, a set of standards for preappraisal design level descriptions was established to provide guidance to technical staff performing the evaluations. A standardized form was developed to report engineering design assumptions and technical descriptions for each structural action. Responsibility for analyses of individual options was assigned to different agencies. These agencies included the California Department of Water Resources (DWR) in Fresno and Sacramento, Reclamation Mid-Pacific Region in Sacramento, and the Reclamation Technical Service Center in Denver.

In the initial stages of analysis, the Environmental Compliance Work Group (ECWG) and the Fisheries Management Work Group (FMWG) were consulted to obtain guidance for the analyses. The ECWG provided a memorandum containing general guidelines concerning vegetation in the restoration reaches of the river (refer to *Draft Design Options to Enhance Ecological Functions and Habitat Values* (SJRRP 2007a)). The FMWG provided guidelines for fish passage, spawning, and rearing (refer to *Chinook Salmon Temporal Occurrence and Environmental Requirements: Preliminary Tables Technical Memorandum* (SJRRP 2007b)). These documents provided important information that was used in the design and sizing of the channels in the river and bypasses.

The preappraisal analyses were performed using available information, including existing studies prepared by others. These forms provide descriptions that include the action's objective, performance and design criteria, construction considerations, schedule, real estate requirements, O&M requirements, potential environmental requirements, and brief construction and design considerations.

2.2.1 Action Design Description

The description of each structural action includes the objective of the action, performance and design criteria. The engineering features were evaluated using available data to develop program-level descriptions of engineering and construction requirements. In some cases, the action analysis has been subdivided into scenarios. The preappraisal level engineering designs are considered to range between 2 percent to 10 percent of complete design, which provides consistent program-level information for alternatives evaluation.

Three general design assumptions were used to develop the preappraisal evaluations:

- Vertical control datum was the National Geodetic Vertical Datum of 1929 (NGVD 29), in which all water surface elevations are provided as mean sea level (msl). Horizontal control datum was the North American Datum of 1983 (NAD 83).

- Fish screen designs conforming to National Marine Fisheries Service's (NMFS) anadromous salmonid passage facility (NMFS 2008) and California Department of Fish and Game (DFG) fish passage criteria.

- Design velocities and depths for fish passage based on DFG *Restoration Manual Part IX* (DFG 2003) and consistent with NMFS anadromous salmonid passage criteria (2008).

2.2.2 Real Estate Requirements

Real estate requirement include general descriptions of potential fee title requirements, access rights for data collection, and permanent and temporary easements. In some cases, depending on the available information, an estimate of the required easement acreages and cost estimates were developed. It should be recognized that information presented in this Attachment reflects a first attempt to identify real estate requirements, thus the areas identified are generalized estimates and have only been used to provide a program-level range of real estate requirements.

2.2.3 Operations and Maintenance Requirements

Descriptions of estimated O&M requirements are provided for each physical action. These descriptions are subdivided into operation, maintenance, and monitoring.

2.2.4 Potential Environmental Impacts

Potential environmental effects described in this Appendix are generalized descriptions prepared by the engineer using available information and engineering judgment. Environmental impacts for these actions have not been evaluated by environmental resources specialists, and no site-specific information has been collected to date regarding biological or cultural resources. The descriptions of potential environmental effects are subdivided into temporary (during construction) and permanent (due to O&M). Significant additional evaluation will be completed by environmental resources specialists in support of the site-specific project studies and the PEIS/R.

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3.0 Descriptions of Restoration and Water Management Actions in Program Alternatives

Descriptions of physical actions are organized by restoration actions stipulated for implementation, other potential restoration actions, and potential water management actions. The identified structural options form part of the program alternatives and will be carried forward to the PEIS/R.

- **Restoration Actions Stipulated for Implementation –** Paragraph 11 stipulates channel and structural improvements. The specified improvements provide more specific actions identified for some parts of the river than for others. Improvements are described for implementation in two phases: Phase 1 improvements (Paragraph 11(a)) to be completed by December 31, 2013, and Phase 2 improvements (Paragraph 11(b)) to be completed by December 31, 2016. Many of these actions are considered necessary to achieve the Restoration Goal. Other actions are considered likely to be necessary, but require additional information to determine whether they are necessary However, the need to initiate project-specific studies of these actions will be identified through analysis of monitoring and management information.

- **Other Potential Restoration Actions** – Paragraph 12 states that additional channel or structural improvements will likely be needed (including, for example, additional fish screening, restoration of side channel habitat, or augmentation of spawning gravel) to help achieve the Restoration Goal. The need for Paragraph 12 actions will be identified through monitoring and management, and will be further described through site-specific studies. The program alternatives include a range of anticipated implementations for Paragraph 12 actions; therefore, the PEIS/R will address the range of potential effects from these potential actions.

- **Water Management Actions –** Paragraph 16(a) calls for developing and implementing a plan for recirculation, recapture, reuse, exchange, or transfer of Interim Flows and Restoration Flows to reduce or avoid impacts to water deliveries for all Friant Division long-term contractors. Paragraph 16(b) calls for developing and implementing an RWA and program to make water available to all of the Friant Division long-term contractors who provide water to meet Interim Flows or Restoration Flows, to reduce or avoid the impact of these flows. Descriptions of potential Paragraph 16(b) groundwater banking opportunities are included in the Paragraph 16(b) Actions Considered in Program Alternatives Attachment to the Plan Formulation Appendix.

3.1 Description of Restoration Actions for Implementation

3.1.1 Option 1 – Construct Mendota Pool Bypass

This action includes a bypass around Mendota Pool to convey 4,500 cubic feet per second (cfs) from Reach 2B to Reach 3 downstream from Mendota Dam, and a fish barrier located across the downstream end of the San Joaquin River where it intersects with the downstream end of the bypass channel. Habitat in the Mendota Pool Bypass will be similar to habitat in Reach 2B. This action also includes construction of a bifurcation structure in Reach 2B to convey up to 4,500 cfs to the Mendota Pool Bypass and at least 2,500 cfs to lower Reach 2B, which conveys flows to Mendota Pool. In addition, the Mendota Pool Bypass will also require the construction of a siphon for the Columbia Canal. These features will be designed to minimize or avoid fish passage into the Mendota Pool.

Engineering Description

Mendota Pool Bypass The Mendota Pool Bypass will be constructed as an unlined earth canal section with 3-to-1 side slopes extending for approximately 9,500 feet starting near Mile Post (MP) 208 to the head of Reach 3 on the San Joaquin River (near MP 203). The overall channel capacity will convey 4,500 cfs with a maximum velocity of 2 feet per second. The bypass channel will contain a center low-flow section to convey 200 cfs (with a base width of 60 feet, and average water depth of 2 feet), a main channel to convey 4,000 cfs (an additional base width of 650 feet, and average water depth of 2.5 feet), and an overbank area to convey the remaining 500 cfs.

Access roads with widths of 20 feet and gravel surfacing 6 inches thick will be placed on each side of the maximum channel section. To provide freeboard, the channel side slope extends 2 vertical feet above that required for water flow, making the combined depth of channel approximately 6.5 feet.

To protect the adjacent agricultural land from high flows, embankment levees are provided on each side of the channel. The levees are sized as 10 feet high (above ground surface) with an 18-foot crest and 3-to-1 side slopes. To provide additional stability, 8 feet of the interior (channel) side of each levee is designated as compacted embankment material. On each side of the channel, at locations where the depth from the channel invert to original ground surface is less than 6.5 feet, the access road is on an embankment. If the area between the channel and levee is not positively filled, fish stranding may occur in small residual pools after periods of high channel flow. In these areas, the resulting embankment is extended from the side of the access road to the side slope of the levee.

To reduce channel slope and resultant erosion for the bypass channel, five drop structures are located at the downstream end of the channel. Each drop structure is a reinforced concrete slab 1.5 feet high, with a length of 30 feet (parallel to the direction of flow) and a width of approximately 710 feet across the interior of the bypass channel.

Bifurcation Structure The Mendota Pool Bypass Bifurcation Structure will consist of reinforced concrete with four 25-foot-wide by 16.5-foot-high spillway radial gates, one 15-foot-wide by 16.5-foot-high sluiceway radial gate, and one 20-foot-wide by 13-foot-high headworks radial gate. Since specific geotechnical information is not available for the cost estimates at this site, 2:1 cut slopes were used as a conservative assumption to obtain estimates of earthwork and concrete and reinforcement quantities for the bifurcation structure.

Columbia Canal Siphon A siphon on the Columbia Canal will be constructed to accommodate the bypass channel over the Columbia Canal. The Columbia Canal diversion headworks are located on the mainstem of the San Joaquin River channel upstream from the existing Mendota Dam and downstream from the Mendota Pool Bypass. The siphon will be reinforced concrete pipe approximately 1,850 feet in length, and have ungated inlet and outlet transitions (of reinforced concrete), and a pipe cover of approximately 6 feet (of compacted backfill).

Construction of the Mendota Pool Bypass and associated facilities will require approximately 1,400,000 cubic yards (cy) of excavation. This includes excavation for the bifurcation structure, bypass channel, and Columbia Canal siphon. A subsequent site-specific study will be initiated as part of the preferred alternative.

Real Estate Requirements

The construction of the Mendota Pool Bypass will require land acquisition with right-of-way along the bypass channel, bifurcation structure, and along the proposed Columbia Canal siphon.

Permanent and temporary easements are expected to be required for construction staging, stockpiling, and borrow areas. Temporary construction easements duration will depend on the construction activities duration.

Approximately 400 acres will be affected by this action. Additional site-specific evaluation will be required to determine the actual fee title acreage and access rights requirements.

Operations and Maintenance Requirements

Typical operations requirements will include onsite or remotely operated radial gates and sluiceway slide gates, and monitoring of the water measurement gages to provide proper delivery of Restoration Flows. Typical maintenance requirements include an annual check of concrete structures. The frequency of maintenance activities will need to be established after experience with operations. Minimal maintenance (periodic inspection, cleaning, lubricating and repainting) would be required for the radial gates at the bifurcation structure.

Potential Environmental Impacts

Potential temporary impacts during construction will include impacts to air quality, biological resources (impact to fish from disturbance of sediments in the river during construction or changes in flow conditions, impact to waterfowl from changes in riparian

areas), cultural resources (excavation and construction activities), and water resources (interruption of water deliveries, changes in water quality from changes in sediment levels). Potential permanent impacts will include changes in localized river hydraulics, sediment transport, and flooding characteristics, increased seepage, changes in groundwater levels, and impacts to production on agricultural lands.

3.1.2 Option 2 – Modify Reach 2B to Convey 4,500 cfs

Paragraph 11(a)(2) of the Settlement prescribes modifications in channel capacity to provide conveyance of 4,500 cfs in Reach 2B between the Chowchilla Bypass Bifurcation Structure and the new Mendota Pool Bypass, incorporating new floodplain and related riparian habitat. Therefore, an increase in channel capacity will be necessary in Reach 2B to achieve the Restoration Goal. New levees will be constructed along both sides of Reach 2B to create an average floodplain width between 500 feet to 3,700 feet, and an associated levee system width between 700 feet to 3,900 feet, and levee heights an average of 4 feet to 5 feet, depending on the level of floodplain modifications incorporated. The specific alignment of setback levees will be determined through site-specific study that considers fisheries requirements, land uses, subsurface conditions, topography, and the condition of existing levees.

Engineering Description

The published design flow capacity for Reach 2B is 2,500 cfs; however, significant seepage has been reported at flows above 1,300 cfs.

For the purpose of describing anticipated implementation ranges of modifications for Reach 2B, measures will only involve activities associated with constructing new levees under three floodplain configurations. While site-specific studies are necessary to identify the feasible and desirable level of vegetation and extent of floodplain modifications necessary at any particular location, the PEIS/R should identify the desired water-level conditions and desired floodplain habitat integration in each river reach so that site-specific project implementation can focus on local conditions only. Vegetation in the floodplain provides habitat for fish but can significantly raise the design flow water elevation. Since the level of vegetation required for fish habitat is unknown at this time, three vegetation levels are used to describe three floodplain configurations to encompass the range of existing and anticipated future configurations. Figure 3-1 provides a conceptual representation of these vegetation ranges. The vegetation ranges are described below:

- **Conveyance Channel to Riparian Ribbon Vegetation –** This configuration represents a range of existing and anticipated future vegetation types ranging from herbaceous and grassy species on the floodplain between the main channel and the toe of the levees to a narrow corridor of trees and woody riparian vegetation approximately one-to-two canopy widths immediately adjacent to the channel, with herbaceous and grassy species within the remaining overbank areas between the narrow corridor and the toe of the levees. Hydraulic model evaluations used roughness coefficients (n-values) of 0.04 and 0.055 to represent a conveyance channel; n-values of 0.06 and 0.085 were used to represent a riparian ribbon channel.

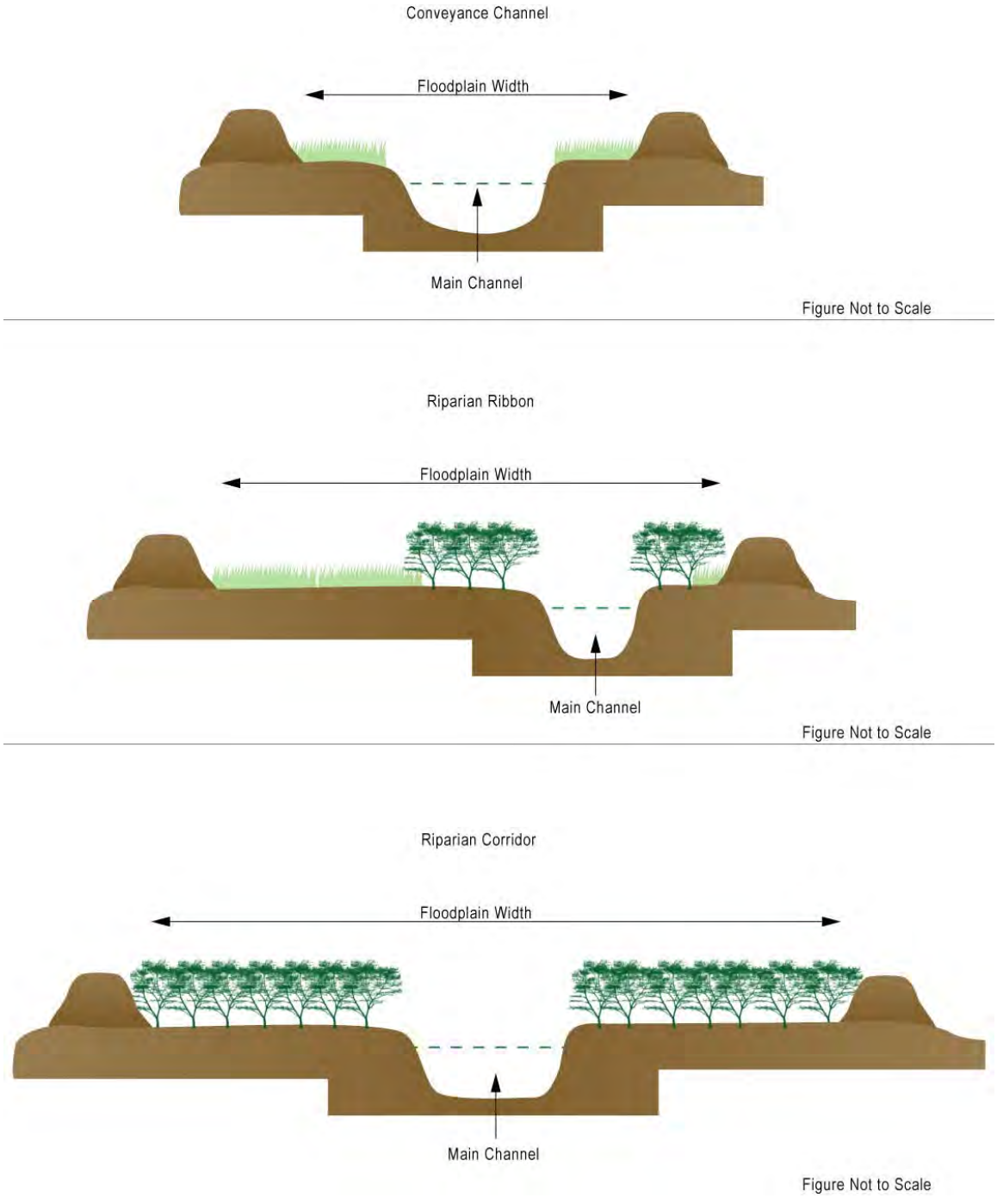

Figure 3-1.
Conceptual Representation of Vegetation Ranges

- **Riparian Ribbon to Riparian Corridor Vegetation –** This configuration represents a range of existing and anticipated future vegetation types ranging from a narrow corridor of trees and woody riparian vegetation approximately one to two canopy widths immediately adjacent to the channel, with herbaceous and grassy species within the remaining overbank areas between the narrow corridor and the toe of the levees to a wide corridor of woody riparian vegetation along the channel and into the overbank areas up to the toes of levees. Hydraulic model evaluations used i-values of 0.06 and 0.085 to represent a riparian ribbon channel; n-values of 0.095 and 0.16 were used to represent a riparian corridor.

- **Opportunistic Vegetation –** This configuration represents a mosaic of conveyance channel vegetation, riparian ribbon vegetation, and riparian corridor vegetation occurring in any reach where this configuration is selected. Anticipated implementation ranges for opportunistic vegetation were estimated using n-values of 0.08 and 0.12.

General modifications associated with constructing new levees under each of the three conveyance configurations are summarized in Table 3-1. Actions to provide conveyance capacity of 4,500 cfs in Reach 2B are described for each of these configurations in the following sections.

Table 3-1.
General Modifications to Existing Levees and Activities Associated With Constructing New Levees for Reach 2B

		Floodplain Vegetation Level[1]		
		Conveyance Channel to Riparian Ribbon	**Riparian Ribbon to Riparian Corridor**	**Opportunistic Vegetation**
Estimated Total Area (acres)		550 - 1,300	900 - 2,100	1,300 - 1,900
Average Cross Section Width (feet)		700 - 1,900	1,200 - 3,900	1,800 - 2,800
Average Floodplain Width (feet)		500 - 1,700	1,000 - 3,700	1,600 - 2,600
Construct New Levee (average)	Left (feet)	35,000	30,600	30,000
	Right (feet)	28,500	26,300	31,500
Construct Seepage Berms	Left (feet)	N/A	N/A	N/A
	Right (feet)	5,600	5,300	6,000
Construct Slurry Walls	Left (feet)	3,500	2,600	3,200
	Right (feet)	NA	NA	NA
Relocate Facilities	Canals	4,500	4,500	4,500
	Utilities	N/A	N/A	N/A
Floodproof Facilities	Wells	6	6	6
	Lift Stations	15	15	15
Number of Diversion		20	20	20

Key:
cfs – cubic feet per second
N/A – not applicable
Notes:
[1] Reported data are based on model results for maintaining floodplain inundation of 1.5 feet at 4,000 cfs.

Conveyance Channel to Riparian Ribbon Vegetation: Construct New Levees For the conveyance channel to riparian ribbon vegetation configuration, actions will consist of constructing new levees on both banks of the river. Although raising existing levees is still under consideration, the feasibility of raising levees in this reach will be determined during site-specific evaluations. Therefore, it was assumed that constructing new levees will provide a maximum range of possible effects in the reach.

The existing average floodplain width will increase from approximately 320 feet to an average floodplain width ranging from approximately 500 feet to 1,700, feet, depending on the level of vegetation selected. The levee system width will range from approximately 700 feet to 1,900 feet. Modeling results show average water surface elevations at approximately 161 feet for a conveyance channel and 162 feet for a riparian ribbon. Based on available topographical data, the height of the right and the left levees will range on average between 4 and 4.5 feet.

For the purpose of seepage analyses, the right levee of Reach 2B was subdivided into five design sections. Each section was assigned subsurface information based on well logs near the sections. Results of analyses indicated that Design Section 2 requires a seepage berm. However, due to a history of seepage in the area and lack of accurate geotechnical data, it was assumed that 20 percent of the right levee will require seepage remediation (stability/seepage berm), or the equivalent to the construction of berms along approximately 1.1 miles of the right bank levee. A 12-foot-wide maintenance road at the landside of the levee will be included.

Subsurface information for the left levee was characterized based on information from well logs near the sections. Results of seepage analyses show that the setback levee alignment on Reach 2B meets the U.S. Army Corps of Engineers (USACE) seepage standards and does not require a slurry wall. However, because of the history of seepage in the area and lack of geotechnical information, it was assumed that 10 percent of the existing left bank levees will require a slurry wall, or the equivalent to the construction of a slurry wall along approximately 0.7 mile of the left bank levee. Typical slurry wall design will be 15 feet deep and 1.5 feet wide with 2-footthick clay cap. A 12-foot-wide, 6-foot-deep inspection trench with 1-to-1 side slopes will be constructed in areas where slurry walls are not required. In areas requiring a slurry wall, the inspection trench will be 16 feet wide and 4 feet deep with 1-to-1 slope. A 12-foot-wide maintenance road at the landside of the setback levee will be included. A graphical representation of a typical cross section for construction of new levees in Reach 2B is shown in Figure 3-2.

Additional site-specific evaluation will be required for consideration of seepage impacts, collection of geotechnical and other subsurface data, and possible changes to operations of upstream and downstream control structures.

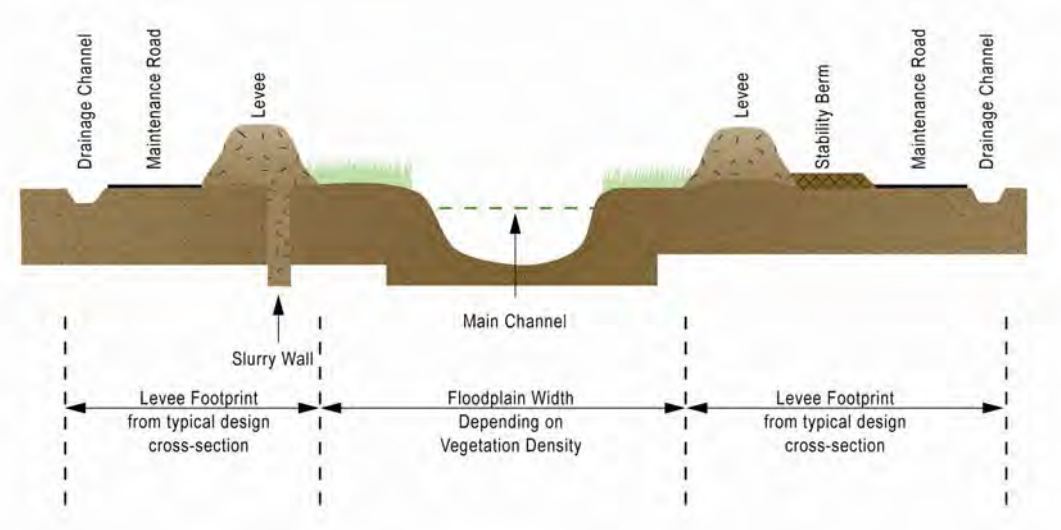

Figure 3-2.
Graphical Representation of Typical Levee Cross Section

Riparian Ribbon to Riparian Corridor Vegetation: Modify Existing or Construct New Levees Actions include constructing new setback levees on both sides of the river. The average water surface elevation for the riparian ribbon to riparian corridor is approximately 162 feet. Based on existing topographical data, the height of the right and the left setback levees will average 4 feet. The average floodplain widths will range from 1,700 feet to 3,700 feet depending on the selected channel vegetation. The levee system width will range from approximately 1,900 feet to 3,900 feet. The levee system width includes typical seepage remediation structures and maintenance roads, as shown in Figure 3-2.

Using the same approach to address seepage from the conveyance to riparian ribbon channel description, it is assumed that 20 percent of the right levee will require a seepage berm, and 10 percent of the left setback levee will require a slurry wall. The design assumptions are the same as for the previous channel description.

Opportunistic Level of Vegetation: Modify Existing or Construct New Levees Actions for establishing an opportunistic habitat channel configuration in Reach 2B include setting back levees on both sides of the river to convey 4,500 cfs. The average water surface elevation for the opportunistic habitat channel will be approximately 162 feet. This elevation is to maintain 1.5 feet of floodplain inundation at 4,000 cfs. Based on existing topographical data, the height of the right and the left setback levees will range on average from 4 feet to 4.5 feet. The average floodplain widths will range from 1,600 feet to 2,600 feet, depending on the selected channel vegetation. The levee system width will range from approximately 1,800 feet to 2,800 feet. The levee system width will include typical seepage remediation structures and maintenance roads, as previously described.

Construction borrow material for building Reach 2B floodplains will consider using excavated material from floodplain areas; however, borrow material for levees and the remaining excavation may be hauled up to 20 miles due to poor soils in the area.

Increase Flow Capacity at Road Crossing This potential action will include improvements to the existing San Mateo Avenue dip crossing. The configuration of the proposed modification will be determined based on the extent of the floodplain. Preliminary evaluations assumed that six 8-foot spans by a 6-foot rise, and corrugated metal arch culvert pipes will be installed at an invert elevation of 151 feet. These modifications will be made to allow reasonable fish passage during Restoration Flows, allow crossing for modified channel or levee alignment, and create additional overbank fish and riparian habitat.

Real Estate Requirements

The construction of new levees in Reach 2B will require land acquisition. The affected areas will depend on the design and extent of the floodplain vegetation and will range between 550 and 2,100 acres of private land.

Operations and Maintenance

O&M activities will involve frequent inspections of levees to identify potential maintenance areas required to conserve levee stability.

Potential Environmental Impacts

Potential temporary impacts during construction will include impacts to air quality, water quality, noise, biological resources, sedimentation from overland flow to river, and others. Potential permanent impacts will include changes in localized river hydraulics (changes in depth and velocities), sediment transport, flooding characteristics, potential seepage increase, changes in groundwater levels, recreation, and impacts to production on agricultural lands.

3.1.3 Option 3 – Modify Reach 4B to Convey 475 cfs

Paragraph 11(a)(3) stipulates channel modifications to Reach 4B to provide conveyance of at least 475 cfs (low flow) during Phase 1 with subsequent modifications to provide conveyance of at least 4,500 cfs during Phase 2, if such modifications will substantially enhance achievement of the Restoration Goal.

Engineering Description

Channel modifications in Reach 4B to provide conveyance of at least 475 cfs will consist of removing in-channel vegetation and other minor obstructions. Based on preliminary evaluation, modifying the existing levee system will not be necessary. The extent of Reach 4B is the Sand Slough Control Structure downstream to the confluence with Bear Creek, a distance of about 32 miles. Preliminary evaluations identified six sections that do not meet the criterion for conveying 475 cfs under existing conditions. The total length of these sections not meeting the required capacity is approximately 12 miles. The modifications will consist of removal of in-channel vegetation to achieve a low-flow channel for optimal fish migration conditions. Modifications will range from a single

low-flow channel to convey 475 cfs, to a series of terraced channels to handle incremental low flows up to 475 cfs.

Three unnamed crossings are located in Reach 4B1; one upstream and two downstream from Turner Island Road. These crossings are constructed with culverts to provide local private crossings, and may be insufficient to convey low flow and/or are barriers to the upstream migration of adult salmon. This action will modify these crossings to provide flow capacity and fish passage, if necessary. These modifications could include installing culverts, restructuring the channel, and/or constructing clear span bridges. Site-specific studies of these crossings will identify the type of modifications that will be necessary to provide flow and fish passage.

Real Estate Requirements

The modification to achieve a low-flow channel will affect approximately 1,200 acres. Site-specific evaluation will determine fee title and temporary and permanent access requirements.

Operations and Maintenance

O&M activities will involve frequent inspections of the low-flow channel to maintain its conveyance and fish passage performance depending on *Fish Management Plan* criteria.

Potential Environmental Impacts

Potential temporary impacts during construction will include impacts to air quality, water quality, noise, biological resources, sedimentation from overland flow to the river, and others. Potential permanent impacts will include changes in localized river hydraulics (changes in depth and velocities), sediment transport, and flooding characteristics, potential seepage increase, changes in groundwater levels, recreation, and impacts to production on agricultural lands.

3.1.4 Option 4 – Modify the San Joaquin River Headgates

This action includes modifications to the San Joaquin River Headgate Structure to provide fish passage and enable routing of 500 cfs to 4,500 cfs through Reach 4B1, consistent with any determination made in Paragraph 11(b)(1).

Engineering Description

The existing San Joaquin River Headgate Structure at Sand Slough will be replaced by a new gated structure with increased flow capacity into Reach 4B. Four 20-foot-wide automated gates will allow flow and fish passage for up to 4,500 cfs. The structure's actual design will pass low-flow requirements for adult (125 cfs) and juvenile (45 cfs) fish, based on preliminary flow duration curves from Settlement hydrographs. In this preliminary analysis, a fish ladder will not be required because depths and velocities will be adequate to pass fish.

Real Estate Requirements

This action will replace an existing structure on project levees and it is not expected that lands will be purchased in fee. The structure should be accessible from State property. Temporary easements to adjacent lands may be required during construction activities.

Operations and Maintenance

It is expected that the structure will be operated automatically to provide adequate depths and velocities throughout the structure. The structure will require annual maintenance to provide reliable and accurate operation. Maintenance will include operating the gates through their full range. Gates and gears will be lubricated, as necessary. Periodic sediment removal may be required after high-flow events. Monitoring will be required to provide that the structure maintains the rated and calibrated flow and depth measurements during operation.

Potential Environmental Impacts

Potential temporary environmental impacts during construction include air quality, biological impacts, water quality, and noise. Potential permanent operations-related impacts will include noise and recreation.

3.1.5 Option 5 – Modify Sand Slough Control Structure to Enable Fish Passage

The Sand Slough Control Structure presents a barrier to upstream migration of adult salmon. Therefore, this action includes modifying the Sand Slough Control Structure to provide fish passage, pursuant to Paragraph 11(a) of the Settlement, by removing the existing flume and replacing it with a gated structure.

Engineering Description

The modification to Sand Slough will consist of removing the existing flume and replacing it with a gated structure to allow flow and fish passage for a range of flows up to 4,500 cfs. Actual design will be required to pass low-flow requirements for adult (125 cfs) and juveniles (45 cfs) based on preliminary flow duration curves from Settlement hydrographs. The structure will incorporate multiple gates and automated operation to work together with the San Joaquin River Headgate (Option 4) to allow flow flexibility into Reach 4B. The preliminary analysis determined that a fish ladder will not be required due to adequate depths to pass fish; however, site-specific evaluations will make the final determination.

Real Estate Requirements

This action involves modifying an existing structure on project levees, thus, it is not expected that lands will be purchased in fee. The structure should be accessible from State property. Temporary easements to adjacent lands may be required during construction activities.

Operations and Maintenance

It is expected that the structure will be operated automatically to provide adequate depth and velocities into the bypass. The structure will require annual maintenance to provide reliable and accurate operation. Maintenance will include operating the gates through their full range. Gates and gears will be lubricated, as necessary. Periodic sediment removal may be required after high-flow events. Flow measurements will be monitored to provide operation within rated capacity. Periodic calibration will be required if significant changes to the channel or flow conditions are observed.

Potential Environmental Impacts

Potential temporary environmental impacts during construction include air quality, biological impacts, water quality, and noise. Potential permanent operations-related impacts will include noise and recreation.

3.1.6 Option 6 – Screen Arroyo Canal to Prevent Fish Entrainment

This action consists of screening Arroyo Canal to prevent the entrainment of juvenile salmon for a range of flows up to 4,500 cfs.

Engineering Description

To reduce entrainment in Reach 3, a fish screen will be installed in the channel immediately upstream of Arroyo Canal's existing headworks that will redirect fish entering the canal back into the San Joaquin River. Preliminary evaluation determined a screen structure of approximately 265 feet long, 60 feet wide, and as high as the deck of the existing headworks, 133 feet. The screens will be a single vee layout, with two rows spanning the entire opening width and converging to a narrow channel downstream, where a pipe will carry fish out of the structure through a pump house.

A maximum flow of 620 cfs will enter the screen structure, and the velocity of this water will vary between 1 and 2.5 feet per second (ft/s), based on water level and river depth. Water will pass through the screens perpendicularly at a maximum rate of 0.30 ft/s, and the screen spacing will be small enough to prevent fish from passing through. At any given time, the screen will divert approximately 20 cfs of the total flow, along with fish, back to the river downstream of Sack Dam. Depending on the water level in the river, fish will either divert into a gravity-flow pipe running 500 feet directly back to the river or to a fish pump. The outfall point for the bypass pipe would be below Sack Dam. During river flows greater than approximately 1,800 cfs, a condition that occurs an average of 3 weeks annually, the pump will deliver fish into a bypass pipe. A sediment control system will help keep sediment from accumulating inside the structure. A pump located behind the screens will provide a jet of water onto the structure's floor, resuspending the sediment so it can flow downstream. Subsequent site-specific evaluation will be required to refine the design and to analyze potential benefits and effects of this action.

Because excavation would separate the adjoining Arroyo Canal from its water supply, a temporary channel under the roadway will be required to supply water to the canal during construction. The temporary channel will require removal of a 20-foot stretch of the roadway and Helm's Ditch Canal, which will take both out of operation temporarily.

Real Estate Requirements

Fee purchase of approximately one acre of land will need to be obtained from the San Luis Canal company to locate the fish screen. Land between the old Arroyo Canal headworks and the existing headworks, including space on the banks for vehicles, will be required for permanent access to the structure. Permanent access for private lands where the proposed pump house is located and areas above the path of the underground piping will be required. A temporary easement will be necessary to provide space for construction staging and laydown areas. A permanent easement with a width of

approximately 40 feet will also be required for the underground pipe carrying fish from the structure back to the river. A temporary flowage easement will be required for the temporary diversion of the San Joaquin River around the construction site into the Arroyo Canal.

Operations and Maintenance

The proposed fish screen will be operated by a Programmable Logic Controller (PLC). Sensors will communicate to the PLC the water level in the river, the flow rate to the Arroyo Canal, the head differential across the screens, and other pertinent operational data. The PLC will control the screen cleaners, the speed of the bypass pump, and the trash rack cleaner. The site will not require full-time attendance; however, inspections and debris removal may be required based on weather and other factors. An offsite control center will be used to monitor alarms from the PLC.

The trash rack cleaner will move debris from the screens to a debris bin next to the structure. The debris bin will need to be serviced approximately once per week, as necessary. Sediment buildup is anticipated to be an issue, and the structure will have to be dewatered once per year to remove sediment.

Monitoring requirements may include hydraulic evaluation to adjust the flow-control baffles behind the screens and make sure the fish screen is operating within specified criteria, especially the approach velocity to the screens. Biological evaluation might be required, as specified by the *Fish Management Plan*.

Potential Environmental Impacts

Potential temporary impacts will include disruption to operation of the Helm Ditch Canal for a brief period during construction as a result of the temporary water supply channel. Permanent impacts may include impact on fish health due to operation of the fish pump. Other pumps of this type have been evaluated for fish injury and mortality, and have been found to have minimal effect on fish. Other potential temporary environmental impacts during construction include air quality, biological impacts, water quality, and noise; potential permanent operations-related impacts will include noise and recreation.

3.1.7 Option 7 – Modify Sack Dam to Provide Fish Passage

This action includes constructing a fish ladder at Sack Dam to allow flow and fish passage for a range of flows up to 4,500 cfs.

Engineering Description

Sack Dam will be retrofitted with a fish ladder to allow flow and fish passage for a range of flows up to 4,500 cfs. The structure will be required to pass low-flow requirements for adult (125 cfs) and juveniles (45 cfs), based on preliminary flow duration curves from Settlement hydrographs. The proposed fish ladder is approximately 60 feet long and 8 feet wide. The existing structure will provide the same operation to allow Arroyo Canal diversions. The fish ladder will be a pool-and-weir type and the design was based on previous DWR projects using similar DFG passage criteria.

Real Estate Requirements

The proposed actions will replace an existing structure; thus, it is not expected that a significant area of private lands will be purchased in fee. Access requirements will depend on the final outcome of ownership of the structure. Currently, the structure is owned by the San Luis Canal Company. Temporary access to adjacent lands will be required during construction activities.

Operations and Maintenance

The fish ladder will generally be unmanned and operate autonomously. The fish ladder will likely be self cleaning with only some debris removal necessary after large flood events. The fish ladder may need monitoring for debris during or after large flood events to provide proper operation.

Potential Environmental Impacts

Potential environmental impacts include temporary construction-related effects on air quality, water quality, biological conditions and noise; and permanent operations-related effects on biological conditions and recreation.

3.1.8 Option 8 – Modify Structures in Eastside and Mariposa Bypasses to Provide Fish Passage

Paragraph 11(a)(8) stipulates modifications to structures in the Eastside and Mariposa bypass channels to provide anadromous fish passage on an interim basis until completion of Phase 2 improvements. Modifications to structures in the bypass to enable fish passage include several structures. The Mariposa Bypass Bifurcation Structure at the head of the Mariposa Bypass will be modified to allow fish passage for a range of flows up to 4,500 cfs. At the downstream end of the Mariposa Bypass, the Mariposa Bypass Drop Structure presents a barrier to fish passage. This action includes the construction of a fish ladder to allow upstream and downstream fish passage for a range of flows up to 4,500 cfs. Modifications will allow the structure to handle 8,500 cfs while not increasing upstream water levels above existing conditions.

Engineering Description

The Mariposa Bypass Bifurcation Structure will be retrofitted by notching the ogee spillway to allow fish passage for a range of flows up to 4,500 cfs. The structure will be required to pass low-flow requirements for adult (125 cfs) and juveniles (45 cfs), based on preliminary flow duration curves from Settlement hydrographs. The notch will be protected with a sloping concrete floor and baffles and will allow the structure to handle 8,500 cfs while not increasing upstream water levels above existing conditions.

The existing Mariposa Bypass Drop Structure will be retrofitted with a fish ladder to allow fish passage for a range of flows up to 4,500 cfs. The actual design will be required to pass low-flow requirements for adult (125 cfs) and juveniles (45 cfs), based on preliminary flow duration curves from Settlement hydrographs. The fish ladder will be designed to pass fish at low flows and allow the structure to handle 8,500 cfs while not increasing upstream water levels above existing conditions. The proposed fish ladder is approximately 60 feet long and 8 feet wide. A notch will be cut into the existing spillway to provide fish passage.

Real Estate Requirements

The proposed actions will involve modifications of existing structures on project levees; thus, purchased land in fee will not be required. The structures will be accessible from State-owned project levees. Temporary access to adjacent lands may be required during construction activities.

Operations and Maintenance

The modification to the structures will not change the current operations regime. The control structure and fish ladder will be self cleaning with only some debris removal after large flood events. Both structures will need monitoring for debris during or after large flood events to provide proper operation.

Potential Environmental Impacts

Potential environmental impacts include temporary construction-related effects on air quality, water quality, biological conditions and noise, and permanent operations-related impacts on biological conditions and recreation.

3.1.9 Option 9 – Modify Eastside and Mariposa Bypasses to Convey Low Flows

Modifications to the low-flow channel, if necessary, will be identified and completed in an action-specific study. The Eastside and Mariposa bypass channels were constructed with flat channel bottoms. Scouring flows since construction have developed incised low-flow channels. The anticipated range of implementation spans from no action, to modifications to develop a suitable low-flow channel to convey 475 cfs, to a series of terraced channels to handle incremental low flow up to 475 cfs.

Engineering Description

The proposed low-flow channels are to be established in both the Eastside and Mariposa bypass reaches to support the migration of anadromous fish past critical areas of the San Joaquin River. The Eastside Bypass is linked to the San Joaquin River at the Sand Slough Connector at the head of Reach 4B1 and to Bear Creek, which rejoins the San Joaquin River. The Mariposa Bypass splits off of the Eastside Bypass and connects back to the San Joaquin River.

A series of "terraced" low-flow channels with varying side slopes will be necessary to achieve optimal fish migration conditions. The target species will be the spring-run and fall-run Chinook salmon. Adult spring-run Chinook salmon will be present with high relative abundance from April through June. Adult fall-run Chinook salmon will be present in relative abundance from September to November. Fry and smolt migration of fall-run salmon will also have relative high abundance in the Eastside and Mariposa bypasses from February through March.

Channel Design Considerations A design of multiple low-flow channels in each reach will allow for migration criteria to be met over a range of flow conditions. Minimum restoration flows during summer months (May through September) will range from 45 to 85 cfs. From November 1 to 10, attraction flows for fall-run Chinook will provide 475 cfs

through the bypasses. During wet years, April Restoration Flows could reach 3,655 cfs in this reach.

A minimum of 475 cfs will need to be contained within the low-flow channel banks. The design of the new low-flow channels will be set to achieve two goals: (1) inundate the existing floodplain at approximately 2,000 cfs flow, and (2) balance the amount of excavation and fill required for construction. Flows of 2,000 cfs will cause over-bank inundation for approximately 4 weeks every other year. To provide appropriate depth for a range of flow conditions, compound low-flow channels in each reach were designed to be running at bankfull at 85, 475, and 2,000 cfs.

Small HEC-RAS models were developed for different slopes along the bypasses. These models were run at a series of flows and the results were analyzed to better estimate locations along the channel where significant changes in energy slope occur.

Low-Flow Channel Characteristics The average energy slopes were used to estimate a new thalweg profile and low-flow channel sizes at different points along the river. The new thalweg was estimated by determining the channel elevation necessary to achieve a floodplain inundation at approximately 2,000 cfs, and obtain a balance of excavation and fill requirements for construction.

In general, new low-flow channels will be placed above the existing channel inverts and will require excavation of channel banks near the river and compaction of fill to accommodate a greater channel capacity. Material not used to backfill and create the new channel shape will be spread atop the existing floodplain. In this manner, the flood capacity of the bypass between the levees will not be changed, only conveyance capacity of the main channel. It is also estimated that the existing levees will not have to be moved at any location to accommodate the new low-flow channels. No calculations of flood flows were performed.

Water velocities and depths in the low-flow channels will vary depending on the energy slope in the reach. Characteristic low-flow channels were designed to meet established depth and velocity guidelines for juvenile and adult migration. The “lowest” flow channels were designed to be full at 85 cfs and were sized to be a maximum 2 feet deep. Velocity in these channels will vary from approximately 1 to 2 ft/s. For the next “terrace,” the channel was designed to be full at 475 cfs, be a maximum of 5 feet deep, overtop the 85-cfs channel, and have sloping banks to provide gradual inundation at increasing flows. Velocities in these 475-cfs channels vary from approximately 2 to 4 ft/s. Channel shape for flows in excess of 475 cfs was adjusted to minimize impact to the existing channel and to target inundation of the floodplain at 2,000 cfs.

Using the energy slope estimates and existing channel data from the HEC-RAS model, characteristic low-flow channels were developed along the Eastside and Mariposa bypasses to estimate excavation and fill quantities required for construction. A typical section was evaluated for each reach along the channel with a different energy slope. It is estimated that approximately 1.7 million cy of excavation will be required to provide sufficient channel capacity to contain the design flows within the banks. Approximately

1.0 million cy of the excavated material could potentially be reused as part of creating the low-flow channels. The remaining 700,000 cy will be spread along the floodplain, thus leaving the hydraulic capacity within the levees approximately the same.

The Eastside Bypass and Bear Creek have seven bridge crossings between the Sand Slough Connector and the confluence with the San Joaquin River. Existing conditions rarely bring flows into the Eastside or Mariposa bypasses of any significant magnitude. Restoration Flows will potentially bring flows close to 4,000 cfs on a regular basis. The seven bridges along the Eastside Bypass were evaluated to determine which bridges will be overtopped if a flow of 4,500 cfs were to be experienced. The largest flow called for in the Settlement Agreement for this reach is 4,500 cfs. It was determined that three bridges will need to be raised.

This analysis assumed that the newly excavated channels will be stable. Therefore, detailed channel stability calculations and scour and sedimentation analyses should be performed during site-specific evaluations.

Real Estate Requirements

It is assumed that purchasing land between the levees is not required. The area on the floodplain near the river may need to be accessed for periodic vegetation or channel maintenance**.** Flowage easements will be required from landowners. Some fences and other barriers will need to be removed. It is assumed all construction can be accomplished on the existing floodplain within the levees.

Operations and Maintenance

The flow path of the Eastside and Mariposa bypasses has been observed to meander between the levees over time. Periodic maintenance will be required to modify the low-flow channels to assure adequate hydraulic characteristics and vegetative shading for salmon migration. Monitoring of fish migration will probably take place at the control structures at the Mariposa-Eastside bypass junction and at the Sand Slough structures.

Potential Environmental Impacts

Potential temporary impacts during construction will include impact to air quality, water quality, noise, biological resources, sedimentation from overland flow to the river, and others. Channel modifications will maintain existing hydraulic capacity; however, planned vegetation on the side slopes and floodplain could decrease the flood capacity of the bypasses. The magnitude of reduced hydraulic capacity is unknown and may, in a worst case, require movement or expansion of existing levees to provide equivalent flood protection.

3.1.10 Option 10 – Enable Deployment of Seasonal Barriers at Mud and Salt Sloughs

Two tributaries in Reach 5, Salt and Mud sloughs, present false migration pathways to migrating adult salmon. This action includes modifications to enable the deployment of seasonal barriers to prevent adult salmon from entering these false migration pathways. This area’s wide, flat, and shifting sandy channel conditions may require a temporary fish barrier to provide adequate channel migration.

Engineering Description

The proposed seasonal barriers will use wood tripod supports, similar to the Hills Ferry Barrier. A cable anchored at each bank connects to each tripod and helps anchor the entire weir in place. Vertical barrier panels are constructed using polyvinyl chloride pipes arranged in steel channels with appropriately sized holes to evenly space the pipes with roughly 1-inch spacing. The pipes are free to move vertically, which allows for constant contact with the bed of the channel as flows move the sands into and around the structure. Unstable sandy channel conditions will require a temporary setup since a more permanent structure might be rendered useless when the channel migrates to a new location. The weir is essentially constructed on site for each implementation. The benefits of this setup include accommodation of possible channel migration, little preconstruction effort, and only minor channel or bank disturbance.

Real Estate Requirements

The proposed temporary structures inside the channel will require minimal area during construction. However, it is anticipated that O&M does require the use of a portable trailer where 24-hour access is required during operation.

Operations and Maintenance

These proposed temporary barriers require 24-hour operation to remove debris and secure the bottom of the structure tight to the highly mobile sand bottom.

No downtime is expected to be required for this structure. The temporary structures will be completely removed at the end of its seasonal use. Minimal monitoring requirements are assumed, other than to periodically examine the integrity of the structure.

Potential Environmental Impacts

Since the structure is temporary by design, the potential environmental impacts occurring during installation and operation will occur annually and involve site access and locating a portable trailer. Possible effects on biological resources may occur.

3.1.11 Option 11 – Modify Reach 4B to Convey 4,500 cfs

Paragraph 11(b)(1) stipulates modifications to Reach 4B1 to provide a capacity of 4,500 cfs during Phase 2, if such modifications will substantially enhance achievement of the Restoration Goal, as determined by the Secretary in consultation with the Restoration Administrator (RA) and with the concurrence of NMFS and U.S. Fish and Wildlife Service (USFWS).

This action includes modifications to Reach 4B to provide a capacity of at least 4,500 cfs with integrated floodplain habitat. New levees will be constructed along both sides of Reach 4B1 to provide an average floodplain width of about 1,900 feet to 4,800 feet, and levee heights an average of 4 feet to 5 feet, depending on the level of floodplain modifications incorporated. The three vegetation ranges: conveyance channel to riparian ribbon; riparian ribbon to riparian corridor; and opportunistic vegetation were previously described in Section 3.1.2. The specific alignment of setback levees and other modifications will be determined through site-specific study that considers land uses, subsurface conditions, topography, and the condition of existing levees.

Engineering Description

The range of actions for each vegetation scenario is described below:

Conveyance Channel to Riparian Ribbon Range of Vegetation: Modify Existing or Construct New Levees The proposed actions for establishing conveyance to riparian ribbon vegetation channel configuration to convey 4,500 cfs will require setback levees from approximately MP 169 to MP 151, assuming use of the existing State project levees. The ultimate width of the channel will depend on measures to improve or create aquatic or floodplain habitat. Reach 4B anticipated average floodplain width for a conveyance to ribbon configuration will range from 1,900 feet to 3,700 feet. The levee system average width will range from 2,100 feet to 3,900 feet.

The levee system width will include typical seepage remediation structures and maintenance roads. The typical design for levee construction will consist of a 20-foot wide crown, 3-to-1 slope on the waterside, and a 2-to-1 slope on the landside. Modeling results show average water surface elevation at approximately 96 feet for a conveyance channel and riparian ribbon channel. These elevations are based on maintaining an approximately 1.5-foot floodplain inundation at 3,000 cfs. Based on existing topographical data, the height of the right and the left levees will range on average from 4.5 feet to 5 feet. The typical design for levee construction will consist of a 20-foot-wide crown, 3-to-1 slope on the waterside, and a 2-to-1 slope on the landside. The general modifications to existing levees and activities associated with constructing new levees under each of the three vegetation configurations are summarized in Table 3-2.

Table 3-2.
Summary of Activities Associated with Constructing New Levees Under Different Vegetation Configurations for Reach 4B

		Floodplain Vegetation Level		
		Conveyance Channel to Riparian Ribbon	**Riparian Ribbon to Riparian Corridor**	**Opportunistic Vegetation**
Total Area (acres)		2,900 – 5,300	4,100 – 6,500	5,100 – 6,300
Average Cross Section Width (feet)		2,200 – 3,900	3,000 – 5,000	3,700 – 4,600
Average Floodplain Width (feet)		1,900 – 3,700	2,800 – 4,800	3,500 - 4,400
Construct New Levee	Left (feet)	62,200	61,400	62,000
	Right (feet)	57,600	56,400	56,200
Construct Slurry Walls	Left (feet)	6,200	6,100	6,200
	Right (feet)	5,800	5,600	5,600
Potential Relocation of Facilities	Lift Stations	10	10	10
	Road crossings	5	5	5
Floodproof Facilities	Wells	5	5	5
Number of Diversions		26	26	26

Note:
[1] Reported data is based on model results for maintaining floodplain inundation of 1.5 feet at 4,000 cfs
Key: cfs – cubic feet per second N/A – not applicable

For the purpose of seepage analyses, both setback levees were subdivided into four design sections. Each section was assigned subsurface information based on the nearest well logs. The seepage evaluation used an average levee height of 6 feet at both setback levees. While the results of the seepage analyses show that it meets the USACE seepage criteria of 0.5 without a slurry wall, it was assumed that 10 percent of both setback levees requires slurry wall due to the lack of geologic data.

As part of the levee construction and floodplain work, five wells will be floodproofed and 10 lift stations will need to be relocated. Relocating deep wells instead of floodproofing was rejected since it was assumed that floodplains would not be inundated frequently. Abandoning some pumps and wells was rejected to allow a conservative cost estimate.

A house and other buildings will also need to be relocated. This includes a custom home, detached garage, and two other buildings. The estimated area affected by the construction of setback levees is approximately 28 acres.

Riparian Ribbon to Riparian Corridor Range of Vegetation: Modify Existing or Construct New Levees Actions for establishment of a riparian ribbon to riparian corridor vegetation channel configuration to convey 4,500 cfs will require setback levees from approximately MP 168.6 to MP 151. The ultimate width of the channel will depend on measures to improve or create aquatic or floodplain habitat. The Reach 4B anticipated average floodplain width for a riparian ribbon to corridor configuration could range from 3,700 feet to 4,800 feet. The levee system average width will range from 3,900 feet to 5,000 feet. The levee system width will include typical seepage remediation structures and maintenance roads. Modeling results show an average water surface elevation ranging from 95.8 feet for a conveyance channel and 96.1 feet for a riparian ribbon. These elevations are based on maintaining approximately 1.5 feet of floodplain inundation at 3,000 cfs. Based on existing topographical data, the height of the right and the left levees will range on average from 5 feet to 6 feet. Using the same seepage evaluation approach as for a conveyance to ribbon vegetation channel, it was assumed that 10 percent of the length of both setback levees will require slurry walls due to the lack of geologic data.

Opportunistic Vegetation: Modify Existing or Construct New Levees Actions for establishment of an opportunistic vegetation channel configuration to convey 4,500 cfs will require setback levees from approximately MP 168.6 to MP 151. The Reach 4B anticipated average floodplain width for opportunistic vegetation configuration could range from 3,500 feet to 4,500 feet. The levee system average width will range from 3,700 feet to 4,700 feet. The levee system width will include typical seepage remediation structures and maintenance roads. The typical design for levee construction will consist of a 20-foot-wide crown, 3-to-1 slope on the waterside, and a 2-to-1 slope on the landside. Modeling results show average water surface elevation ranging from 95.5 feet for a conveyance channel and 96 feet for a riparian ribbon. These elevations are based on maintaining approximately 1.5 feet floodplain inundation at 3,000 cfs. Based on existing topographical data, the height will range on average from 4.5 feet to 5 feet. The typical design for levee construction will consist of a 20-foot-wide crown, 3-to-1 slope on the waterside, and a 2-to-1 slope on the landside. Using the same seepage evaluation

approach as for a conveyance to ribbon vegetation channel, it was assumed that 10 percent of the length of both setback levees will require a slurry wall due to the lack of geologic data.

Increase Flow Capacity at Road Crossings Potential actions involve modifications to existing road crossings that will be affected by routing the restoration flows through this reach. There are two bridges that will have to be replaced and two dip crossings that will require modifications. An old bridge structure downstream of North Fork Road will also be removed.

The Washington Road Bridge (MP 168.1) and the Turner Island Bridge (MP 157.1) will both be replaced to extend the bridges to proposed setback levees. Proposed improvements for the Washington Road Bridge include installing 11 5-foot-high by 10-foot-wide box culverts at an invert elevation of approximate 100 feet. For Turner Island Bridge, proposed improvements include installing 10 proposed 5-foot-high by 10-foot-wide box culverts.

Two dip crossings will be modified in Reach 4B at MP 156.1 and MP 153.4. These are private crossings and will require demolishing the existing culverts and installing approximately six 8-foot-diameter arch culverts of approximately 80 linear feet each per dip crossing.

Real Estate Requirements

The estimated affected area for construction of the levees will range from 5,100 acres to 6,300 acres depending on the design and extent of the floodplain vegetation.

Operations and Maintenance

O&M activities will involve frequent inspections of levees to identified maintenance areas to conserve levee stability.

Potential Environmental Impacts

Potential temporary impacts during construction will be to air quality, water quality, noise, biological resources, sedimentation from overland flow to river, and others. Potential permanent impacts will be changes to localized river hydraulics (changes in depth and velocities), sediment transport, and flooding characteristics, seepage increase, changes in groundwater levels, recreation, and impacts to production on agricultural lands.

3.1.12 Option 12 – Modify Chowchilla Bypass Bifurcation Structure

Paragraph 11(b)(2) stipulates modifications to the Chowchilla Bypass Bifurcation Structure to provide fish passage and prevent fish entrainment, if such modifications are necessary to achieve the Restoration Goal, as determined by the Secretary in consultation with the RA and with the concurrence of NMFS and USFWS.

Engineering Description

The proposed action includes installation of radial gates and a fish screen to be added to the existing control structure at the head of the Chowchilla Bypass. The fish screen will

screen fish from the bypass for flows up to 2,000 cfs that enter the bypass. The gates and fish screen will be constructed west of the existing structure to allow the existing structure to operate normally and to reduce sedimentation. The proposed structure will incorporate multiple gates and automated operation to allow flow flexibility into the bypass.

Real Estate Requirements

The proposed actions will involve modifications of existing structures on project levees; thus purchased land in fee would not be required. The structures will be accessible from State-owned project levees. Temporary access to adjacent lands may be required during construction activities.

Operations and Maintenance

The proposed action will be operated automatically to provide adequate flows into the bypass. It is expected that the existing flood control operations guidelines will need to be modified. The structure will require annual maintenance to provide reliable and accurate operation. Maintenance will include operating the gates through its operating range. Gates and gears will be lubricated, as necessary. The proposed fish screen may require periodic sediment removal after high-flow events. Periodic calibration will be required if significant changes to channel or flow conditions are observed. The fish screen will require hydraulic evaluation to adjust baffles and make sure it is operating within specified criteria, especially the approach velocity to the screens

Potential Environmental Impacts

Potential environmental impacts include temporary construction-related effects to air quality, water quality, biological conditions and noise, and potential permanent operations-related effects on biological conditions and recreation.

3.1.13 Options 13i, 13j – Fill or Isolate Gravel Pits

Paragraph 11(b)(3) stipulates filling and/or isolating the highest priority gravel pits in Reach 1, based on the relative potential for reducing juvenile salmon mortality, as determined by the Secretary in consultation with the RA.

Engineering Description

This proposed action will involve filling deep depressions and recontouring the stream channel and floodplain within the gravel pit areas, if possible and practical, to mimic more natural conditions. Side channels and other features could be created to encourage spawning and rearing and prevent stranding. Filling gravel pits will eliminate or reduce predator habitat. Soil and coarse clean gravel will be imported to replenish areas where gravel mining has resulted in a significant loss of sediments. DWR preliminarily evaluated 32 sites identified as having the potential for implementing specific actions. Of the 32 identified sites, 28 could require filling of gravel pits to meet the Restoration goal.

This action consists of isolating gravel pits adjacent to the San Joaquin River channel to reduce predation and encourage use of this reach by anadromous fish. The isolation of gravel pits from the river channel will be accomplished by strategic placing of berms and saddle structures throughout Reach 1. Berms will typically be located at the edge of the

design floodways. Saddle structures will be constructed three feet lower than the berms and allow the pond level to equalize with the river level to avoid excess berm damage. Potentially, 11 identified sites could require the construction of berms. Saddle construction will also be required in nine identified sites to avoid excess berm damage. The total estimated berm length is 36,200 linear feet. Due to their location the berms are not designed for flood protection, thus the material used can be composed of native river gravels with moderate compaction. The estimated saddle length is estimated based on a typical 200 feet of berm length; however, each saddle will have to be sized in the future according to the pond area.

Real Estate Requirements

The proposed action affected area will depend on the prioritization of the gravel pits. However, the affected area will range from zero acres to 4,200 acres.

Operations and Maintenance

Maintenance activities will include repairs of damaged berms and/or saddles due to flows that overtop the structure crest.

Potential Environmental Impacts

Potential temporary impacts will include dust and noise during construction of berms or saddles.

3.1.14 Option 14 – Modify Sand Slough Control Structure to Route 4,500 cfs to Reach 4B

Paragraph 11(b)(4) stipulates modifications to the Sand Slough Control Structure to enable routing and conveyance of 4,500 cfs into Reach 4B, consistent with any determination made in Paragraph 11(b)(1).

Engineering Description

The proposed action includes removing and replacing the existing flume with a gated structure to allow flows up to 4,500 cfs into the bypass. The proposed structure will incorporate four 20-foot gates to allow flow flexibility. This structure will likely only be operated as an emergency backup during flood events that exceed the Reach 4B capacity.

Real Estate Requirements

The proposed actions will involve modifications of existing structures on project levees; thus purchased land in fee would not be required. The structures will be accessible from State-owned project levees. Temporary access to adjacent lands may be required during construction activities.

Operations and Maintenance

The proposed structure will be operated manually to provide emergency operation during significant flood events. It is likely that Lower San Joaquin Levee District personnel will operate the gates if flows in Reach 4A are higher than Reach 4B capacity. The structure will require annual maintenance to provide reliable and accurate operation. Maintenance will include operating the gates through their full range. Gates and gears will be lubricated, as necessary. Sediment removal may be required after high-flow events. The

structure will be rated and calibrated to allow accurate flow measurements during operation. Calibration will be required if significant changes to channel or flow conditions are observed.

Potential Environmental Impacts

Potential environmental impacts include temporary construction-related effects on air quality, water quality, biological conditions and noise, and permanent operations-related effects on biological conditions and recreation.

3.2 Description of Other Potential Restoration Actions – Paragraph 12

Paragraph 12 does not stipulate any specific additional actions; rather, it states that additional actions not explicitly identified in the Settlement may further enhance the success of achieving the Restoration Goal. Actions under Paragraph 12 require a process to initiate site-specific studies. This process includes monitoring and/or additional studies during implementation of Settlement-stipulated actions. The range of other potential Restoration actions spans from no action to an estimated maximum. These actions are grouped based on common purposes, as shown in Table 3-3. The actions described below represent those engineering evaluations performed by the EDWG.

Table 3-3.
Plan Formulation Appendix Grouping of
Paragraph 12 Structural Actions

Purpose Description	Option Number
Enhance Spawning Gravel	Partial Option 13 (13a, 13b)
Prevent Redd Superimposition and/or Hybridization	Not Applicable
Supplement Salmon Population	Not Applicable
Modify Floodplain and Side Channel Habitat	Option 62
Enhance In-Channel Habitat	Option 64
Prevent Predation of Juvenile Salmonids	Not Applicable
Prevent Fish Entrainment	Option 16
Enable Fish Passage	Options 21, 22, 65, 66, and 67, partial Option 19
Modify Chowchilla Bypass Bifurcation Structure	Partial Option 12

3.2.1 Options 13a, 13b – Enhance Spawning Gravel

Adult Chinook salmon require suitably sized gravel, refuge, and suitable water depths and velocities. The Settlement does not stipulate any actions to enhance spawning gravel; therefore, a subsequent decision will be required before any such actions could be implemented. The range of potential actions to provide adequate spawning gravel spans from no action to augmenting and/or conditioning gravel at existing riffles, to establishing new riffles.

Engineering Description

Augment at Existing Riffles (Option 13a) This potential action consists of augmenting existing riffles with clean, spawning-sized gravel at 16 identified sites throughout Reach 1. In some instances, more than one location within a site will require augmentation. The depth of the gravel on the spawning riffles will be maintained at approximately 2 feet. The approximate area for this action is 8.5 acres in Reach 1. Actions to augment existing riffles were not identified downstream of MP 244.

Establish New Riffles (Option 13b) This potential action consists of establishing new riffles to increase and enhance salmonid spawning habitat in 11 identified sites throughout Reach 1. The gravel depth on the spawning riffles will be maintained at approximately 2 feet. The approximate area for creating new riffles is 21 acres. Actions to establish new riffles were not identified downstream of MP 244.

Real Estate Requirements

The proposed action affected area will depend on the outcome of monitoring and site-specific investigations; however, the affected area will range from zero acres to 30 acres.

Operations and Maintenance

Maintenance activities will include gravel replenishment.

Potential Environmental Impacts

Potential temporary impacts will include dust and noise during construction of riffles.

3.2.2 Option 16 – Screen Small Diversions

Unscreened and poorly screened small riparian diversions can entrain, and subsequently kill, migrating juvenile fish. The Settlement does not stipulate any actions other than screening of the Arroyo Canal and construction of the Mendota Pool Bypass to prevent fish entrainment; therefore, a subsequent decision will be required before any such actions could be implemented. The range of potential actions to prevent fish entrainment spans from no action to installation or modification of screens at small diversions throughout the Restoration Area. The number of screens installed will be based on the relative impact of individual diversions to fisheries.

Engineering Description

This action consists of retrofitting unscreened and poorly screened riparian diversions with new screens to reduce anticipated fish entrainment. Cylindrical tee and drum screens will be used for smaller diversions, while diversions of several hundred cfs will probably require paneled fish screens. Cylindrical tee and drum screens will include air or water burst cleaning systems for cleaner water applications, or inside and outside cleaning brushes to discourage biofouling. The screens would mount on tracks for easy removal for maintenance or inspection. Cone screens would mount on a small concrete base, handle heavy debris loads, and have an external brush cleaning system. There are approximately 166 diversions listed that range from 100 cfs maximum flow to less than 1 cfs of maximum flow, with an average size of about 8 cfs and a median size of 3 cfs. Table 3-4 summarizes the number of small diversions by reach.

Table 3-4.
Potential Screening of Small Diversion Summary

Reach	Quantity	Max Capacity Range (cfs)
Reach 1A	89	1-100
Reach 1B	13	1- 4
Reach 2A	8	3 – 16
Reach 2B	20	3 - 16
Reach 3	4	< than 4
Reach 4A	3	1 – 8
Reach 4B	25	1 - 35
Reach 5	4	Unknown

Key:
cfs = cubic feet per second

Real Estate Requirements

Real estate requirement will be determined during site-specific evaluations.

Operations and Maintenance

Each screened diversion will be operated individually. In a typical arrangement, the screen cleaning system will be set up with a simple PLC for automatic operation. A short daily inspection of the screened diversion will be required. It is assumed that the owner of the diversion will provide the personnel for daily operation and inspection of the facility.

The individual screened diversions will require some annual maintenance. Typical maintenance will include inspection and cleaning of the screen, replacement of worn cleaning brushes, and lubrication of bearings or moving parts. The maintenance work will require a short shutdown of the diversion. It is assumed that the owner of the diversion will provide the necessary maintenance.

For the majority of the diversions, a simple inspection during startup, to confirm the system is operating properly, is all that will be required for monitoring. For the few larger diversions, a hydraulic evaluation may be required to confirm that the system is operating within specified criteria. Biological monitoring may be required and specified by the FMWG.

Potential Environmental Impacts

Potential temporary impacts may include increases in river turbidity due to in-water construction work and increases in noise due to construction activities. Other potential effects may include breaks in riparian vegetation to accommodate the screen and intake.

3.2.3 Option 19 – Modify Reach 3 Levees to Convey 4,500 cfs Preappraisal-Level Actions to Reduce Fish Stranding in Reach 3

The preappraisal designs for Option 19 describe potential levee improvements and land acquisition actions in Reach 3 to provide 4,500 cfs capacity if needed. The proposed actions in Reach 3 were to raise levees where needed to maintain 3 feet of freeboard. In areas where raising levees may change hydraulics and possibly cause erosion or increase flows downstream, acquiring property was proposed to expand the floodplain. The

analysis identified the potential for fish stranding in the proposed areas of added floodplain.

Engineering Description

This potential action evaluates areas along Reach 3 where fish stranding could occur during high flows. Actions to reduce fish stranding include removal of interior berms, floodplain grading and providing escape channels that drain back to the river as high flows recede.

The park near Firebaugh has no levees so this area was ignored. Two potential solutions were investigated to bookend costs: The first include notching the existing levees to the floodplain elevation at 500-foot lengths at a 2,000-foot spacing along the levees. The second solution includes the removal of the berm.

Real Estate Requirements

The estimated affected area is approximately 280 acres where proposed land acquisitions will increase floodplains.

Operations and Maintenance

O&M regime to be determined.

Potential Environmental Impacts

Potential temporary impacts during construction will include impacts to air quality, water quality, noise, biological resources, sedimentation from overland flow to river, and others. Potential permanent impacts will include changes in localized river hydraulics (changes in depth and velocities), sediment transport, and flooding characteristics, seepage increase, changes in groundwater levels, recreation, and impacts to production on agricultural lands.

3.2.4 Option 21 – Modify Reach 2A to Convey 475 cfs

This action consists of modifications to the channel in reaches outside of the Eastside and Mariposa bypasses and Reach 4B to provide passage during low-flow conditions, as needed. As described above for the action to enhance in-channel habitat through reducing sediment transport, this action could include bed stabilization in areas where the bed is degrading, and bank stabilization in meandering reaches. Dredging will remove in-channel sand to maintain a low-flow channel. The range of actions described above for modifications to floodplain and side-channel habitat, such as managing invasive vegetation and creating and/or enhancing additional floodplain habitat, could also be applied to establish and/or maintain low-flow channels through bed and bank stabilization.

Engineering Description

The proposed action for establishing low-flow channels in Reach 2A will consist of matching the existing channel inverts, usually requiring some excavation to establish a consistent grade. Some regrading of channel banks near the river will be required for development of vegetation and spawning habitat. Any fill required in the channel will be compacted; however, the channel will probably change shape and migrate because of the

sandy nature of the soils. Material not used to backfill and create the new channel shape will be spread atop the existing floodplain. In this manner, capacity of the bypass between the levees will not be changed. For this analysis, no change in channel roughness was assumed due to vegetation.

Water velocities and depths in the low-flow channels will vary depending on the energy-grade slope in the surrounding reach. Characteristic low-flow channels were designed to meet established depth and velocity guidelines. The "lowest" flow channels were designed to contain 165 cfs and were sized to be a maximum of 2 feet deep. Velocity in these channels will vary from approximately 1 to 2 ft/s. For the next terrace, the channel was designed to contain 475 cfs and to have a maximum channel depth of about 4 to 5 feet. In some locations, new channels will be constructed for 475 cfs, but in many locations the natural shape of the river is deemed sufficient to meet migration criteria.

The side slope in the channel will be re-graded as necessary to achieve any additional riparian habitat values. Velocity in these 475 cfs channels varies from approximately 1 to 3 ft/s. At higher flows, velocities will vary greatly from channel to floodplain.

Using the energy slope estimates and existing channel data from the hydraulic model, the characteristic low-flow channels were developed along Reach 2A to estimate excavation and fill quantities required for construction. Two typical sections were evaluated for each reach along the channel with a different energy slope. It is estimated that approximately 590,000 cy will be excavated to create new low-flow channels for salmon in this reach. Approximately 440,000 cy of the excavated material could potentially be used as fill and be compacted to form the low-flow channels. The remaining 150,000 cy will be spread along the floodplain, thus leaving the hydraulic capacity within the levees approximately the same.

This project will require excavation and re-grading of approximately 150 acres of land adjacent to the San Joaquin River. The channel areas in Reach 2A vary from small gravel to sand. Scour rates could be high during higher flows, significantly altering the channel cross section. Sediment and channel stability analyses will be required to provide a better estimate of channel modification requirements.

Real Estate Requirements

The proposed action would affect approximately 150 acres of land within the levees.

Operations and Maintenance

O&M activities will involve frequent inspections of low-flow channel to maintain its conveyance and fish passage performance, depending on *Fish Management Plan* criteria.

Potential Environmental Impacts

Potential temporary impacts during construction will be to air quality, water quality, noise, biological resources, sedimentation from overland flow to river. Channel modifications will maintain existing hydraulic capacity; however, planned vegetation on the side slopes and floodplain could decrease the flood capacity of the bypasses. The

magnitude of reduced hydraulic capacity is unknown and may, in a worst case, require movement or expansion of existing levees to provide equivalent flood protection.

3.2.5 Option 22 – Modify Road Crossings

This action consists of modifying road crossings to provide fish passage. Three road crossings in Reach 1 could be modified to maintain or increase opportunities for fish to pass during Restoration Flows: the North Fork Road Bridge, Ledger Island Bridge, and Crossland Bridge.

Engineering Description

This measure includes changes to road crossings to provide crossings at a frequency equal to or better than existing conditions. The North Fork Road Bridge (MP 266.8), Ledger Island Bridge (MP 262.1), and Crossland Bridge (MP 240.8) will have culverts added to the existing approaches to better convey flood flows and provide fish passage. The Crossland Bridge design will be similar to that at Ledger Island.

The North Fork Bridge modification will include the installation of six 8-foot spans with a 6-foot rise of corrugated metal arch culvert pipes spaced every 5 feet. The existing bridge span will remain unmodified.

The Ledger Island and Crossland bridge modifications will include the installation of six 8-foot span with a 6-foot rise of corrugated metal arch culvert pipes spaced at every 4 feet. Three culverts will be installed on the right bank, and the remaining three will be installed on the left bank (looking downstream). The existing bridge span will remain unmodified.

Real Estate Requirements

The proposed action will replace or modify existing structures, and it is not expected that significant lands will be purchased in fee. Construction staging may require some temporary easements to adjacent lands.

Operations and Maintenance

O&M activities are not applicable to the proposed action.

Potential Environmental Impacts

Potential environmental impacts include temporary construction-related effects on air quality, water quality, biological conditions, noise, and recreation.

3.2.6 Option 62 – Control and Monitor Invasive Vegetation

The objective of this action is to manage invasive plant infestations to confirm that they do not reduce restoration action effectiveness mandated by the Settlement. The evaluation of this action will be included in the Vegetation Management Plan.

3.2.7 Option 64 – Manage Channel and Floodway Vegetation

The objective of this potential action is to manage floodway and fish channel vegetation to prevent that flood flow capacity and stage, and fish channel flow continuity and water

quality are not adversely affected by excessive or invasive vegetative growth. The evaluation of this action will be included in the Vegetation Management Plan.

3.2.8 Option 65 – Install Fish Barriers at Confluence of Eastside Bypass and Sand Slough

This action will consist of installing temporary or permanent barriers in the channel to prevent fish from straying into tributaries, flood bypasses, or river reaches with undesirable habitat conditions. The primary categories of permanent fish barrier structures are picket barriers, velocity barriers, and vertical drop structures. Tributaries, flood bypasses, and river reaches that will be screened under this action depend in part on the flow routing decision made consistent with Paragraph 11(b)(1), but will potentially include Dry Creek and Cottonwood Creek in Reach 1; Deadmans, Bear, and Owens creeks in the Eastside Bypass; the downstream end of Eastside Bypass Reach 2; the downstream end of Reach 4B; and the downstream end of Eastside Bypass Reach 3.

Engineering Description

The proposed action will include a 600-foot picket barrier that will be constructed at the San Joaquin River's Eastside Bypass to prevent adult salmon from migrating upstream. It will have a design flow of 10,000 cfs and will still allow downstream juvenile fish to pass. The barrier will include 16 spans with piers spaced 36 feet apart. A trash rack with an automated cleaning system will be installed at the upstream side of the picket rack to prevent debris from collecting on the back side of the pickets.

Real Estate Requirements

The proposed action will be constructed within the bypass levees, thus it is assumed that the project could be built under existing easements and rights of way. Temporary easements of private land may be required for construction staging areas.

Operations and Maintenance

This potential barrier will be operated by a PLC. Sensors will communicate to the PLC the water levels upstream and downstream from the barrier, the head differential across the trash rack and bar rack, and other pertinent operation data. The PLC will control the trash rack cleaner. The facilities will not require any permanent personnel onsite, however daily inspections and debris removal will likely be required.

The trash rack cleaner will require a debris bin to be emptied approximately once per week, as necessary. Sediment buildup is also anticipated to be an issue, and accumulated sediment may have to be removed approximately once per year or more. Typical annual maintenance that will be required for all of the facilities will include inspection and cleaning of the bar rack, replacement of worn parts, and lubrication of bearings or moving parts.

A hydraulic evaluation might be required to make sure the barrier is operating within specified criteria. Biological evaluation might be required, as specified by the FMWG.

Potential Environmental Impacts

Potential temporary impacts may include increase in turbidity due to in-water construction work, increase in noise due to construction activities, and increase in dust due to construction activities.

3.2.9 Option 66 – Install Fish Barriers on Tributaries to the Eastside Bypass

This action assumes adult migrating salmonids travel upstream in the Eastside Bypass. To prevent straying, barriers will be constructed on tributaries to the Eastside Bypass. While outmigrating fish are not expected to be present in the tributaries, the fish barriers will allow downstream juveniles to pass the structures.

Engineering Description

This potential action will include the following:

Bear Creek Bear Creek has a stated design capacity of 7,000 cfs. Given the design flow, a bar rack area of at least 7,000 square feet will be required to meet criteria. From the HEC-2 model prepared by Mussetter Engineering, the water surface elevations at the project site are approximately 82.83 feet at 7,000 cfs.

The existing channel invert is at approximately Elevation 70 feet, giving a water depth of 13 feet at the design flow. To meet the 1.0 ft/s velocity criteria, the barrier will need to be approximately 550 feet wide. The existing top of bank at the confluence is at about Elevation 82 feet. Assuming a 40-foot span between pier centers and 36 feet clear space between the piers, 18 spans will provide a total rack area of 8,300 square feet. This will result in an average velocity through the rack of 0.85 ft/s. A conservative design was chosen at this stage due to uncertainties in the hydrology for Bear Creek.

Approximately 20,000 cy of material will need to be excavated beneath the structure to bring the invert to Elevation 70 feet across the full width of the picket rack section. An additional 425,000 cy of material will need to be excavated upstream and downstream of the structure to allow for smooth flow through the facility. During periods of flow below the design flow it is anticipated that sediment will accumulate in the widened channel section, and in and around the structure.

Approximately 1,250 feet of access road on low levee sections will be required to access the structure from the existing levees. In addition, a small side channel to Bear Creek will need to be filled in at the access road crossing to prevent flow from circumventing the barrier structure.

Owen's Creek There is not currently any documented flow data for Owen's Creek. Based on estimates by Mussetter Engineering of tributary inflow to the Eastside Bypass for the March 1995 flood event, a conservative design flow of 4,000 cfs was chosen. Given the design flow, a bar rack area of at least 4,000 square feet will be required to meet criteria. The HEC-2 model prepared by Mussetter Engineering, show the water surface elevations at the project site to be approximately 88.72 feet at 4,000 cfs.

The existing channel invert is approximately at Elevation 78 feet, giving a water depth of 11feet at the design flow. To meet the 1.0 ft/s velocity criterion, the barrier will need to be approximately 375 feet wide. The existing top of bank at the confluence is at about Elevation 90 feet. Assuming a 40-foot span between pier centers and 36 feet of clear space between the piers, 11 spans will provide a total rack area of approximately 4,250 square feet. This will result in an average velocity through the rack of 0.94 ft/s.

Approximately 15,000 cy of material will need to be excavated beneath the structure to bring the invert to Elevation 70 feet across the full width of the picket rack section. An additional 300,000 cy of material will need to be excavated upstream and downstream of the structure to allow for smooth flow through the facility. During periods of flow below the design flow, it is anticipated that sediment will accumulate in the widened channel section, and in and around the structure.

To prevent debris from collecting on the backside of the picket rack, both proposed structures will require trash racks on the upstream side of each structure. Automated trash rack cleaning systems will be required to keep the trash racks free of debris.

Real Estate Requirements

The proposed action will be constructed within the bypass levees, thus it can be assumed that the project could be built under existing easements and rights of way. Temporary easements of private lands may be required for construction staging areas.

Operations and Maintenance

This potential barrier will be operated by a PLC. Sensors will communicate to the PLC the water levels upstream and downstream of the barrier, the head differential across the trash rack and bar rack, and other pertinent operation data. The PLC will control the trash rack cleaner. The facilities will not require any permanent personnel onsite, however daily inspections and debris removal will likely be required.

The trash rack cleaner will require a debris bin to be emptied approximately once per week, as necessary. Sediment buildup is also anticipated to be an issue, and accumulated sediment may have to be removed approximately once per year or more. Typical annual maintenance that will be required for all of the facilities will include inspecting and cleaning the bar rack, replacement of worn parts, and lubrication of bearings or moving parts.

A hydraulic evaluation might be required to make sure the barrier is operating within specified criteria. Biological evaluation might be required, as specified by the FMWG.

Potential Environmental Impacts

Potential temporary impacts may include increase in turbidity due to in-water construction work, increase in noise due to construction activities, and increase in dust due to construction activities.

3.2.10 Option 67 – Install Fish Barrier on San Joaquin River

This potential action assumes a barrier will be constructed on the San Joaquin River at its confluence with the Eastside Bypass to keep upstream migrating adult salmon from going up the San Joaquin River and guide them to the Eastside Bypass. Outmigrating fish may be present in the San Joaquin River, entrained from the Mariposa Bypass Structure under high- or flood-flow conditions. The fish barrier will allow downstream juveniles to pass the structure.

Engineering Description

The stated channel capacity of the San Joaquin River is 26,000 cfs downstream from the Mariposa Bypass to the confluence with the Eastside Bypass. For purposes of fish passage, a design flow of 10,000 cfs was chosen for the barrier. The primary categories of fish barrier structures are picket barriers, velocity barriers, and vertical drop structures. Due to the very flat gradients in the project area, velocity barriers and vertical drop structures will be impractical and were not considered.

Picket barrier design criteria (NMFS 2008) state that the average design river velocity through the pickets should be less than 1.0 ft/s for all design flows, with a maximum velocity less than 1.25 ft/s. Given the design flow of 10,000 cfs, a bar rack area of at least 10,000 square feet will be required to meeting criteria. The HEC-2 model prepared by Mussetter Engineering shows the water surface elevations at the project site to be approximately 78 feet at 10,000 cfs, and 82 feet at 26,000 cfs.

The existing channel invert is at Elevation 60 feet, giving a water depth of approximately 18 feet at a flow of 10,000 cfs. To meet the 1.0 ft/s velocity criteria, the barrier will need to be approximately 600 feet wide. The existing top of bank at the confluence is at about Elevation 74 feet. Flow within the confines of the channel banks is limited to approximately 2,000 cfs. To accommodate the design flow of 10,000 cfs, it will be necessary to move the barrier upstream between the existing levees. Assuming a 40-foot span between pier centers and a 36-foot clear space between the piers, 16 spans will provide a total rack area of 10,200 square feet. This will result in an average velocity through the rack of approximately 1 ft/s.

Approximately 300,000 cy of material will need to be excavated beneath the structure to bring the invert to Elevation 60 feet across the full width of the picket rack section. Additional material will need to be excavated upstream and downstream of the structure to allow for smooth flow through the facility. During periods of flow below the design flow of 10,000 cfs, it is anticipated that sediment will accumulate in the widened channel section, and in and around the structure.

To prevent debris from collecting on the backside of the picket rack, a trash rack will be required on the upstream side of the structure. An automated trash rack cleaning system will be required to keep the trash rack free of debris.

Real Estate Requirements

The proposed action will be constructed within the bypass levees, thus it can be assumed that the project could be built under existing easements and rights of way. Temporary easements of private lands may be required for construction staging areas.

Operations and Maintenance

This potential barrier will be operated by a PLC. Sensors will communicate to the PLC the water levels upstream and downstream of the barrier, the head differential across the trash rack and bar rack, and other pertinent operation data. The PLC will control the trash rack cleaner. The facilities will not require any permanent personnel, although daily inspections and debris removal will likely be required.

The trash rack cleaner will require a debris bin to be emptied approximately once per week, as necessary. Sediment buildup is also anticipated to be an issue, and accumulated sediment may have to be removed approximately once per year or more. Typical annual maintenance that will be required for all of the facilities will include inspection and cleaning of the bar rack, replacement of worn parts, and lubrication of bearings or moving parts.

A hydraulic evaluation might be required to make sure the barrier is operating within specified criteria. Biological evaluation might be required, as specified by the FMWG.

Potential Environmental Impacts

Potential temporary impacts may include increase in turbidity due to in-water construction work, increase in noise due to construction activities, and increase in dust due to construction activities.

3.3 Water Management Actions – Paragraph 16

Water management actions address recirculation, recapture, reuse, exchange, or transfer of water released for Interim Flows and Restoration Flows; and establishing an RWA that provides an opportunity to make water available to Friant Division long-term contractors. Water management structural actions described in this section are directly related to the recirculation of restoration flows to areas in the Friant Division. The evaluation description for potential groundwater water actions will be included in the Paragraph 16(b) Actions Considered in Program Alternatives Attachment to the Plan Formulation Appendix. The PEIS/R provides program-level environmental compliance for system-wide effects resulting from the anticipated range of water management action implementation. Water management actions under consideration for program alternatives are described below.

3.3.1 Options 58, 59 – Construct San Joaquin River Pump Station and Intertie Pipe to the Delta-Mendota Canal and/or the California Aqueduct (1,000 cfs)

The action will provide recirculation facilities from the San Joaquin River to the Delta-Mendota Canal (DMC) and/or the California Aqueduct. This action consists of a turnout

from the San Joaquin River, a 1,000-cfs pumping plant, and a pipeline for conveyance to the DMC and/or the California Aqueduct. Associated features include a trashrack system and single vee-shaped fishscreen structure.

Engineering Description

Pumps and Pumping Plant The pumping plant enclosure is a "bath-type" style with a reinforced concrete substructure. The superstructure for the enclosure consists of reinforced concrete masonry unit walls with a precast concrete double-tee roof and a removable metal plate panel for maintenance access.

Initial capacity for the pumping plant is 1,000 cfs. This capacity was increased by 5 percent to allow for pump wear, resulting in a design flow of 1,050 cfs. The pumps consist of eight identical 130-cfs, double-suction horizontal centrifugal split-case units. A single typical pump size was selected to meet the total design flow of 1,000 cfs. The preappraisal design did not assume for an installed spare pump. Motors for the pumps will be totally enclosed, water to air cooled horizontal synchronous type. The selected motors are rated at 4,500 horsepower.

Pipeline For ease of construction, welded steel pipe was selected for the conveyance piping. The design assumes three 108-inch-diameter welded steel pipes, located in a common trench with 5 feet of cover, extending for approximately 8 miles from the San Joaquin River to the California aqueduct, with a stub-out pipeline to the DMC.

Crossings Six road crossings and two Interstate/railroad crossings were estimated along the pipeline alignment.

Inlet to DMC The DMC inlet is a reinforced-concrete turnout structure built into the sloping sidewall of DMC. A metal safety rack is mounted on the canal side of the turnout structure to match the existing canal sidewall slope. The safety rack prevents trash and debris from entering the bypass piping and pumps.

Inlet to the California Aqueduct and Turnout from San Joaquin River The California Aqueduct inlet is a reinforced-concrete turnout structure built into the sloping sidewall of California Aqueduct. A metal safety rack is mounted on the canal side of the turnout structure to match the existing aqueduct sidewall slope. The safety rack prevents trash and debris from entering the bypass piping and pumps. The turnout from the San Joaquin River is a similar structure that is sized to fit into the bank of the river.

Fish Screen To prevent outmigrating juvenile salmon from entering the Intertie pipeline, a trashracked intake structure and single vee-shaped fish screen is located at the San Joaquin River entrance to the recirculation facilities. The fish screen is modeled after designs for "A" Canal Fish Screen and Long Lake Valley Fish Screen (designed at appraisal level for 2,000 cfs). The fish screen facility includes stainless steel wedge wire fish screens, a flow-control baffle system, a screen cleaning system, a bypass flow-control weir, a backup engine generator set, a fish-friendly pump and motor system, and a fish bypass pressure pipeline that discharges back into the San Joaquin River. The fish

screen operates by sweeping the juvenile salmon to the point of the vee where they enter the return pipeline that connects back to the San Joaquin River.

Estimated quantities for concrete, reinforcement, excavation, and backfill for the new screen facility were obtained by decreasing the Long Lake quantities by 50 percent (the 1,000-cfs flow required for the Intertie divided by the 2,000-cfs flow required for Long Lake Valley).

Real Estate Requirements

Anticipated permanent easement area was estimated at 70 acres. Land acquisition with right-of-way 100 feet on each side along the pipeline alignment will be required. Temporary easement area was estimated at 40 acres. Easements will be required for stockpile/borrow areas A temporary construction trailer site may be needed, depending on anticipated duration and proximity to contactors yards. Flowage easements requirements are unknown.

Operations and Maintenance

The proposed pumping plant will be operated to capture Interim and Restoration flows. Annual maintenance inspections of concrete structures will be required. Typical maintenance according to manufacturer's recommendations will be followed for pumps/motors. Monitoring requirements will include observations of inlet and exit velocities at fishscreen and delivery volumes at the California Aqueduct.

Potential Environmental Impacts

Potential temporary environmental impacts include air quality, biological resources (impact to fish from disturbance of sediment in river during construction or changes in flow conditions, impact to waterfowl from changes in riparian areas), cultural resources (excavation and construction activities), water resources (interruption of water deliveries, changes in water quality from changes in sediment levels).

Potential permanent impacts include changes in localized river hydraulics, sediment transport, and flooding characteristics and increased seepage, changes in groundwater levels, and impacts to production on agricultural lands.

3.4 Real Estate Requirement Summary

A summary of real estate requirements was prepared using the information provided within the action analysis form and refinement of levee analyses for Reaches 2B, 3, and 4B. However, acreage estimates for real estate requirements, such as fee-title, permanent and temporary easement areas, for actions being considered in the program alternatives will be determined by site-specific evaluations. Tables 3-5 and 3-6 show the estimates of affected areas which could require permanent, temporary, and/or flowage access. Fields left blank within the tables mean that real estate requirements are unknown. In all cases, further evaluation is needed to better define real estate requirements for all options.

Table 3-5.
Summary of Areas Affected by Restoration Actions

Option No.	Option Description	Reference Paragraph in Settlement/ Need	Reach	Estimate of Affected Areas (acres)
1	Construct Mendota Pool Bypass and Bifurcation Structure	11(a)(1)	2B	400
2	Modify Reach 2B to Convey 4,500 cfs	11(a)(2)	2B	550 – 2,100
3	Modify Reach 4B to Convey 475 cfs	11(a)(3)	4B	1,200
4	Modify San Joaquin River Headgate at Sand Slough to Convey Up to 4,500 cfs	11(a)(4)	4B	NA
5	Modify Sand Slough Control Structure for Fish Passage	11(a)(5)	4A	NA
	5a - Alternative 1	11(a)(5)	4A	NA
	5b - Alternative 2	11(a)(5)	4A	NA
6	6a Screen Arroyo Canal Water Diversion	11(a)(6)	3	2
7	Modify Sack Dam for Fish Passage	11(a)(7)	3	NA
8	Modify Structures in Eastside and Mariposa Bypass channels	11(a)(8)	4B	NA
	8a - Control Structure	11(a)(8)	4B	NA
	8b - Drop Structure	11(a)(8)	4B	NA
9	Establish Stable Low Flow Channel in Eastside and Mariposa Bypasses	11(a)(9)	4B	3000
10	Enable Deployment of Seasonal Barriers at Salt and Mud Sloughs	11(a)(10)	5	NA
11	Modify Reach 4B to Convey at Least 4,500 cfs	11(b)(1)	4B	2900-6500
	11a - Relocate Levees	11(b)(1)	4B	Inclusive
	11b - Improve Floodplains	11(b)(1)	4B	Inclusive
	11c - Relocate or Floodproof of Wells	12	4B	Inclusive
12	Modify Chowchilla Bifurcation Structure for Fish Passage	11(b)(2)	2A	NA

Key:
cfs = cubic feet per second
NA – not available

Table 3-5.
Summary of Areas Affected by Restoration Action (contd.)

Option No.	Option Description	Reference Paragraph in Settlement/ Need	Reach	Estimate of Affected Areas (acres)
13	Fill and/or Isolate the Highest Priority Gravel Pits in Reach 1	11(b)(3)	1	4,200
	13a - Augment Existing Riffles	12	1	Inclusive
	13b - Establish and Maintain New Riffles	12	1	Inclusive
	13c - Reconfigure Channel	12	1	Inclusive
	13d - Remove Debris	12	1	Inclusive
	13e - Reconfiguration of Floodplain at 23 Sites	12	1	Inclusive
	13f - Obtain Material for 23 Sites	11(b)(3)	1	Inclusive
	13g - Floodproof Wellheads	12	1	Inclusive
	13h - Relocate Floodplain Diversion Pumps	12	1	Inclusive
	13i - Isolate Gravel Pits with Berms – 23 Sites	11(b)(3)	1	Inclusive
	13j - Isolate Gravel Pits with Saddles – 23 Sites	11(b)(3)	1	Inclusive
14	Modify Sand Slough Control Structure to Convey 4,500 cfs	11(b)(4)	4A	NA
16	Screen Small Diversions on San Joaquin River	12	1-5	NA
19	Modify Reach 3 Levees to Convey 4,500 cfs	12	3	NA
21	Modify Reach 2A to Convey 475 cfs	12	2A	NA
22	Evaluate San Joaquin River Crossings Requirements	12	1-5	NA
62	Control and Monitoring of Invasive Plants	12	1-5	NA
64	Manage Channel and Floodway Vegetation	12	1-5	NA
65	Install Fish Barrier at Confluence of Eastside Bypass and Sand Slough	12	4B	NA
66	Install Fish Barriers on Tributaries to the Eastside Bypass (Scenario C1)	12	4B	NA
67	Install Fish Barrier on San Joaquin River (Scenario C1)	12	4B	NA

Key:
cfs = cubic feet per second
NA – not available

Table 3-6.
Summary of Areas Affected by Described Water Management Actions

Option No.	Option Description	Reference Paragraph in Settlement/ Need	Estimate of Affected Areas (acres)
58	Construct San Joaquin River Pump Station and Intertie Pipe to Delta-Mendota Canal (500 cfs)	16	80
59	Construct San Joaquin River Pump Station and Intertie Pipe to California Aqueduct (1,000 cfs)	16	110

Key:
cfs = cubic feet per second
NA – not available

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4.0 References

California Department of Fish and Game. 2003. http://www.dfg.ca.gov/fish/Resources/HabitatManual.asp

DFG. *See* California Department of Fish and Game.

Friant Water Users Authority. 2007. San Joaquin River Restoration Program: Water Management Goal Potential Program & Projects. February.

FWUA. *See* Friant Water Users Authority.

National Marine Fisheries Service. 2008. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.

NMFS. *See* National Marine Fisheries Service.

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2006. Stipulations of Settlement in Natural Resources Defense Council, et al., v. Kirk Rodgers, United States Bureau of Reclamation, et al. Case No. S-88-1658-LKK/GGH United States District Court. September 13, 2006.

———. 2007a. Draft Design Options to Enhance Ecological Functions and Habitat Values on the San Joaquin River Between Friant Dam and the Merced River. October 15.

———. 2007b. Draft Chinook Salmon Temporal Occurrence and Environmental Requirements: Preliminary Tables Technical Memorandum. December.

———. 2008. Initial Program Alternatives Report. 2008. June.

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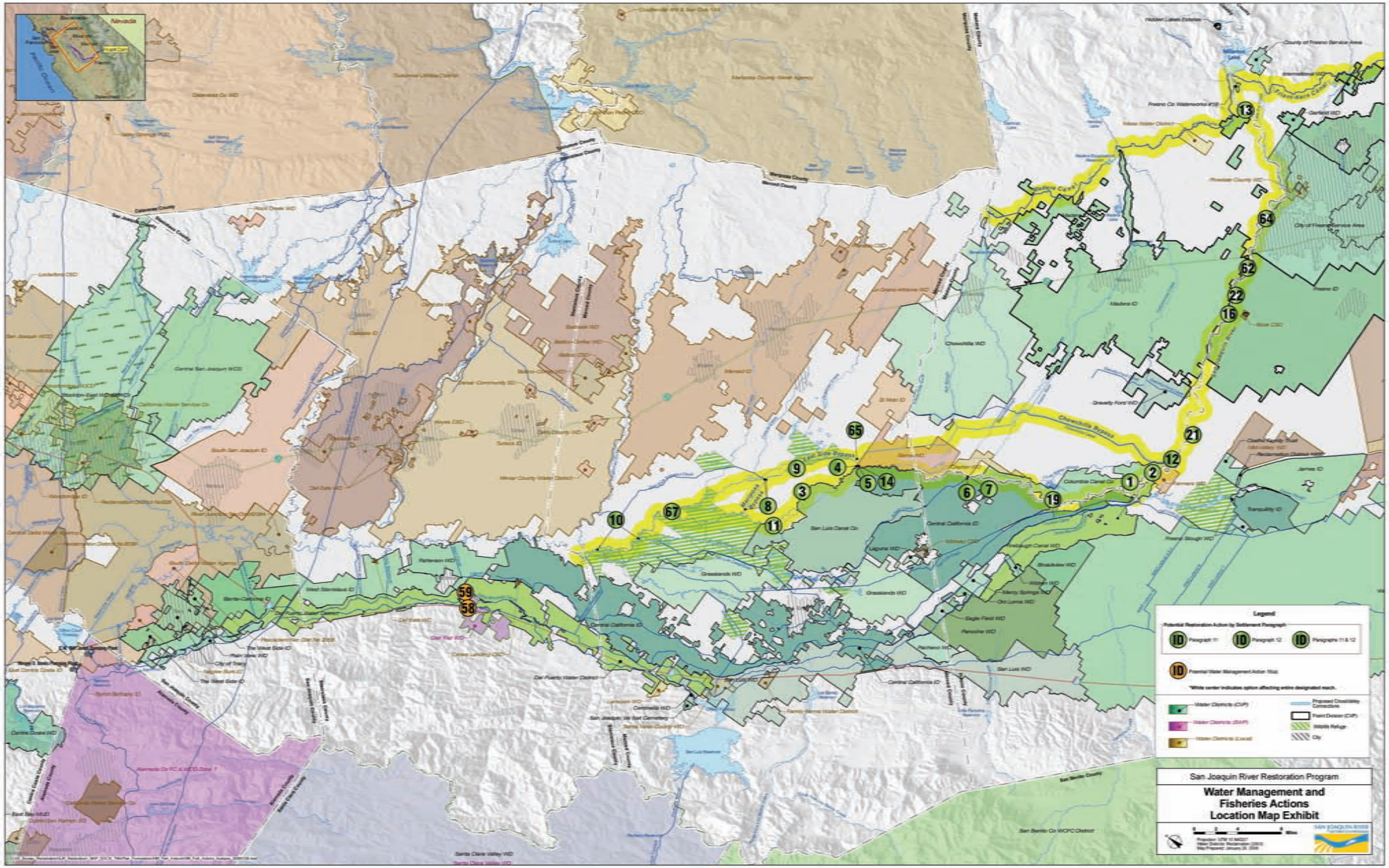
Exhibit

Restoration and Water Management Actions Location Map

Draft
Plan Formulation Technical Appendix

SAN JOAQUIN RIVER
RESTORATION PROGRAM

Draft
April 2011


Legend
Potential Restoration Action by Settlement Paragraph
ID Paragraph 11
ID Paragraph 12
ID Paragraphs 11 & 12
ID Potential Water Management Action 10(a)
*White center indicates option affecting entire designated reach.
Water Districts (CVP)
Water Districts (SWP)
Water Districts (Local)
Proposed Cross/Valley Connections
Friant Division (CVP)
Wildlife Refuge
City
San Joaquin River Restoration Program
Water Management and Fisheries Actions Location Map Exhibit
Miles

Exhibit

Options Forms for Restoration and Water Management Actions in Program Alternatives

Draft
Plan Formulation Technical Appendix

SAN JOAQUIN RIVER
RESTORATION PROGRAM

Draft
April 2011

Restoration Actions Included in Program Alternatives By Option

Option No.	Option Description	Reference Paragraph in Settlement/ Need	Reach
1	Construct Mendota Pool Bypass and Bifurcation Structure	11(a)(1)	2B
2	Modify Reach 2B to Convey 4,500 cfs	11(a)(2)	2B
3	Modify Reach 4B to Convey 475 cfs	11(a)(3)	4B
4	Modify San Joaquin River Headgate at Sand Slough to Convey Up to 4,500 cfs	11(a)(4)	4B
5	Modify Sand Slough Control Structure for Fish Passage	11(a)(5)	4A
6	6a Screen Arroyo Canal Water Diversion	11(a)(6)	3
7	Modify Sack Dam for Fish Passage	11(a)(7)	3
8	Modify Structures in Eastside and Mariposa Bypass channels	11(a)(8)	4B
	8a - Control Structure	11(a)(8)	4B
	8b - Drop Structure	11(a)(8)	4B
9	Establish Stable Low-Flow Channel in Eastside and Mariposa Bypasses	11(a)(9)	4B
10	Enable Deployment of Seasonal Barriers at Salt and Mud Sloughs	11(a)(10)	5
11	Modify Reach 4B to Convey at Least 4,500 cfs	11(b)(1)	4B
12	Modify Chowchilla Bifurcation Structure for Fish Passage	11(b)(2)	2A
13	Fill and/or Isolate the Highest Priority Gravel Pits in Reach 1	11(b)(3)	1
	13a - Augment Existing Riffles	12	1
	13b - Establish and Maintain New Riffles	12	1
	13c – Reconfigure Channel	12	1
	13d - Remove Debris	12	1
	13e - Reconfiguration of Floodplain at 23 Sites	12	1
	13f - Obtain Material for 23 Sites	11(b)(3)	1
	13g - Floodproof Wellheads	12	1
	13h - Relocate Floodplain Diversion Pumps	12	1
	13i - Isolate Gravel Pits with Berms - 23 Sites	11(b)(3)	1
	13j - Isolate Gravel Pits with Saddles - 23 Sites	11(b)(3)	1
14	Modify Sand Slough Control Structure to Convey 4,500 cfs	11(b)(4)	4A
16	Screen Small Diversions on San Joaquin River	12	1-5
19	Modify Reach 3 Levees to Convey 4,500 cfs	12	3
22	Evaluate San Joaquin River Crossings Requirements	12	1-5
62	Control and Monitoring of Invasive Plants	12	1-5
63	Restore Native Riparian Habitat	12	1-5
64	Manage Channel and Floodway Vegetation	12	1-5
65	Install Fish Barrier at Confluence of Eastside Bypass and Sand Slough	12	4B
66	Install Fish Barriers on Tributaries to the Eastside Bypass (Scenario C1)	12	4B
67	Install Fish Barrier on San Joaquin River (Scenario C1)	12	4B

Key: cfs = cubic feet per second

Water Management Actions Included in Program Alternatives By Option

Option No.	Option Description	Reference Paragraph in Settlement/Need
58	Construct San Joaquin River Pump Station and Intertie pipe to Delta Mendota Canal	16
59	Construct San Joaquin River Pump Station and Intertie pipe to the California Aqueduct	16

San Joaquin River Restoration
Structural Option Description
Pre-Appraisal Level

Option No.	Structural Option Name		Revision Date
1	Mendota Pool Bypass		27 May 2008
Reach Number	**River Mile**	**Program Goal**	**Phase**
2B - 3		Water management	***MPRO Input***

Task	Responsible Author	Peer Reviewer
Option Description	Reynolds	Edwards/Bernstein
Engineering	Reynolds	Edwards

Costs (October 2007):
Cost Level: Appraisal - October 2007
Total Construction Cost: Not available at this time.

Annual O&M Cost: ***MPRO Input***
Project life: ***MPRO Input***

Objective of Option
Construct bypass channel
Construct upstream diversion structure
Install fish passage facilities

Performance Criteria

1. Route upmigrating adults and outmigrating juvenile salmon around the Mendota Pool.
2. Spillway radial gates control water surface for the Diversion Dam at Mendota Bypass and allow high water releases.
3. Sluiceway radial gates allow sediment to be flushed from behind the Diversion Dam.
4. Headworks radial gates divert water to the canal system.

Design Criteria

1. NOAA Fisheries Anadromous Fish screen and ladder criteria (2006)
2. Reclamation Cost Estimating Guidelines with SJRR unit costs
3. AISC Steel Construction Specifications
4. ACI Concrete Design Criteria
5. CRSI Reinforcing Steel for Concrete
6. NAAMM Metal Bar Grating Manual
7. ASTM A36 and ASTM A500 structural steel
8. Horizontal dry active earth pressure = 57.6 $lb/ft^2/ft$ of depth
9. Horizontal saturated active earth pressure = 94.8 $lb/ft^2/ft$ of depth
10. Vertical earth load = 120 lb/ft^3 compacted and 130 lb/ft^3 saturated
11. AISC specifications for Radial Gates

Description
General
The report "Draft Restoration Strategies for the San Joaquin River" prepared by Stillwater Sciences (February 2003) recommends a bypass channel around the Mendota Pool in order to facilitate travel of upmigrating adult salmon past the existing Mendota Dam and to prevent entry of outmigrating juvenile salmon into the Mendota Pool. The Appraisal Report for the San Joaquin River Settlement Agreement and Legislation indicates a restoration flow of 4,500 ft^3/s to be directed into the Bypass Channel. From text in other documents and available maps, it appears that several canal systems use the existing Mendota Pool as a headworks for their diversions. To allow these continued diversions, flow would also need to be

maintained in the reach of the San Joaquin River that is traversed by the new Bypass Channel. Figure 2-1 by CH2M Hill contained in the Appraisal Report indicates a required flow of 2,500 ft^3/s for the traversed reach.

Bypass Channel

The location, layout and sizing of the bypass channel follows criteria in the Stillwater Sciences Report dated February 2003 and the San Joaquin Settlement Agreement dated September 2007. Using these criteria, the channel is designed as an unlined earth canal section with 3:1 side slopes extending for approximately 9,500 feet from the end of Reach 2B to the start of Reach 3 on the San Joaquin River.

The overall channel capacity meets the restoration flow of 4,500 ft^3/s with a maximum velocity of 2 ft/sec. The bypass channel contains a center low-flow section to convey 200 ft^3/s (base width of 60 feet, water depth = 2 feet), a main channel to convey 4,000 ft^3/s (an additional base width of 650 feet, water depth = 2.5 feet) and an overbank area to convey the remaining 500 ft^3/s. O & M roads with widths of 20 feet and gravel surfacing 6 inches thick were placed on each side of the maximum channel section. In order to provide freeboard, the channel side slope extends 2 vertical feet above that required for water flow, making the combined depth of channel equal to 6.5 feet. To protect the adjacent agricultural land from high flows, embankment levees are provided on each side of the channel. The levees are sized as 10 feet high (above ground surface) with an 18 foot crest and 3:1 side slopes. To provide additional stability, 8 feet of the interior (channel) side of each levee is designated as compacted embankment material. On each side of the channel, at locations where the depth from the channel invert to original ground surface is less than 6.5 feet, the O&M Road is in embankment. If the area between the channel and levee is not positively filled, there could be a potential for stranding fish in residual small pools after periods of high channel flow. In these areas, the resulting embankment is extended from the side of the O&M Road to the side slope of the levee.

To reduce channel slope and resultant erosion for the bypass channel, five drop structures are located at the downstream end of the channel. Each drop structure is a reinforced concrete slab 1.5 feet high, with a length of 30 feet (parallel to the direction of flow) and a width of approximately 710 feet across the interior of the bypass channel.

Diversion Structure

Located at the head of the Bypass Channel, the diversion dam is a gated, reinforced concrete structure with four 25 foot-wide by 16.5 foot-high spillway radial gates, one 15 foot-wide by 16.5 foot-high sluiceway radial gate and one 20 foot-wide by 13 foot-high headworks radial gate. All the radial gates have wire rope hoists, stainless steel sealing surfaces and embedded metalwork. Steel sheetpile is shown across (underneath) the diversion structure at the upstream and downstream extents to provide additional cutoff for seepage pathways. Precast concrete piles are provided under the diversion structure to increase foundation support in the predominately sandy soil.

The initial layout for the Diversion Structure was modeled after the Kent Diversion Structure. To handle the increased diversion flow (4,500 ft^3/s directed to the Mendota Bypass Channel versus 3,600 ft^3/s for the Kent structure), an additional spillway bay was added to the proposed structure. To more closely match the assumed local water delivery depths and canal dimensions, the overall gate and structure heights were increased by 8 feet (approximately doubling the height). Although the initial layout mirrors the Kent structure, which is adequate for quantity calculations, the actual installation would resemble more of a bifurcation structure with the restoration flow of 4,500 directed to the Bypass Channel through three of the spillway gates and the canal return flow of 2,500 directed to the traversed reach via the headworks gate and the remaining spillway gate. This provides capacities in excess of those required with flow velocities of less than 5 ft/s.

To obtain concrete and reinforcement estimate quantities for the new structure, the previously calculated Kent quantities were increased by a rounded factor of 1.5. This factor was derived from comparisons of the structure concrete volumes on AutoCAD which showed a ratio of approximately 1.45:1 (proposed structure volume versus Kent structure volume). Since both structures are located in similar, relatively flat terrain with similar geology, standard 1:1 cut slopes were initially assumed for the excavations. If the 1:1 cut slopes are maintained, the proposed structure (which is roughly double the height of the Kent structure)

would have earthwork quantities that are approximately 4 times the Kent quantities. If 2:1 cut slopes are used, the proposed structure would have earthwork quantities that are approximately 6.5 times the Kent quantities. Since specific geotechnical information was not available for the appraisal level cost estimates at this site, 2:1 cut slopes were used as a conservative assumption.

Fish Screen / Fish Barrier

To direct outmigrating juvenile salmon to the Bypass Channel and prevent their entry into the Mendota Pool via the traversed reach, a trashracked intake structure and double-vee shaped fish screen is located on the left side of the diversion structure.

The fish screen is modeled after designs for 'A' Canal Fish Screen and Long Lake Valley Appraisal Study (designed at appraisal level for 2,000 ft^3/s). The fish screen facility includes stainless steel wedge wire fish screens, a flow control baffle system, a screen cleaning system, a bypass flow control weir, a backup engine generator set, a fish-friendly pump and motor system, and two fish bypass pressure pipelines that discharge back into the Bypass Channel. The double-vee fish screen operates by sweeping the juvenile salmon to the point of each vee where they enter the return pipeline that connects back to the Bypass Channel. Estimate quantities for concrete, reinforcement, excavation, and backfill for the new screen facility were obtained by increasing the Long Lake quantities by a factor of 1.25, which is equal to the 2,500 ft^3/s flow required for Mendota divided by the 2,000 ft^3/s flow required for Long Lake Valley.

Available mapping shows a canal immediately downstream of the existing Mendota Dam. If this canal is to remain in service, flow would be required between the existing Mendota Dam and the downstream end of the Bypass Channel. To direct upmigrating adult salmon into the Bypass Channel and prevent their entry into any portion of the traversed reach, a rectangular inclined fish barrier would be located across the downstream end of the traversed reach where it intersects with the downstream end of the Bypass Channel. The face of the inclined fish barrier is sloped at 1/4H:1V with the base of the incline extending against the direction of flow to facilitate cleaning and raking of built-up trash and debris. The outer surface of the inclined barrier would be similar to a standard metal trashrack with 2 x ½ bearing bars @ 4 inches o.c. and ¾-inch diameter cross bars @ 4'-0 o.c. Diffuser grating with 2-inch openings would cover the back surface of the barrier to prevent fish entry. The barrier would be side-mounted on concrete piers that in turn support a 12-foot-wide concrete deck / roadway to be used as a staging area for maintenance and cleaning operations. The length of the fish barrier was estimated as 300 feet to traverse the width of the San Joaquin River at this location. The entire barrier assembly is similar to the Nimbus Dam bar rack at the Nimbus fish hatchery.

Columbia Canal Siphon

The Appraisal Report for the San Joaquin River Settlement Agreement and Legislation describes the Columbia Canal Company diversion headworks as being located on the main stem of the San Joaquin River channel upstream of the existing Mendota Dam and downstream of the proposed Mendota Pool Bypass, making it necessary for the Mendota Pool Bypass channel to cross the Columbia Canal. Since specific information for the Columbia Canal Company structure(s), locations, capacities and flow rates was not available, it was assumed that the required capacity of the Columbia Canal would be significantly less than the required restoration flow of 4,500 ft^3/s for the Mendota Pool Bypass. This would indicate that the Columbia Canal Company's diversion should pass under the Mendota Pool Bypass. A siphon structure to accommodate these assumptions was modeled after the Towaoc Canal - Reach 1 - County Road 'N' Crossing (drawings attached) with a flow capacity of 420 ft^3/s, a pipe crossing length of 1850 feet (reinforced concrete pipe), ungated inlet and outlet transitions (reinforced concrete), and a pipe cover of approximately 6 feet (compacted backfill).

Construction Considerations

Flow in the San Joaquin River, operations at the existing Mendota Dam, and operation of the existing Columbia Canal should be maintained during construction of the Mendota Pool Bypass channel, the diversion structure and the Columbia Canal siphon. At Mendota Dam, this includes access across the dam crest to the sluiceway slide gates in two bays and to the stoplogs in the remaining bays in order to provide water surface control. It is anticipated that the majority of the bypass channel can be constructed without interruption to the San Joaquin River flow or the Columbia Canal flow. Concrete sections of the diversion

structure, fish screen and fish barrier will require small cofferdams (install and remove) with a bypass of the river flow to facilitate site dewatering for construction. The siphon will require a cofferdam (install and remove) and a bypass of the Columbia Canal flow to allow construction.

For the fish screen and fish barrier, it is important that the upstream surfaces of the structures and attachments are fabricated with no rough edges, burrs, or sharp corners, and that all the welds are ground smooth to prevent injury to fish during use.

Schedule
Design - 1 year
Construction - 2 years

Real Estate Requirements

- **Fee Purchase** Land acquisition with right-of-way along Bypass Channel, along Columbia Canal Siphon, and at Diversion Structure site.
- **Access Rights** Access agreements from landowners adjacent to the Bypass Channel, Levee and Diversion Structure site locations.
- **Permanent and Temporary Easements** Stockpile/borrow areas. Verify that existing access to site(s) will accommodate construction equipment loads. Temporary construction trailer site may be needed depending on anticipated duration and proximity to contactors yards.
- **Flowage Easements** Unknown

Coordination with Other Options
Implementation of this option (1) would preclude "Option 27 – Rehabilitate Mendota Dam" and "Option 28 – Removal and Relocation of Mendota Dam".

Operational and Maintenance Requirements

- **Operations**

Spillway radial gates and sluiceway slide gates operated at site or remotely. Monitoring of water measurement gages to insure proper delivery / restoration flows.

- **Maintenance**

Annual check of concrete structures. Manually clean the fish screen and fish barrier entrances of debris and growth. The diffuser grating at the fish barrier may also require cleaning. The frequency of cleanings would need to be established after experience with operation. Minimal maintenance (periodic inspection, cleaning, and repainting) required for radial gates at the Diversion Structure.

- **Monitoring Requirements**

Hydraulic evaluation to adjust gate operation. Field verify inlet and exit velocities at diversion structure and fish facilities to calibrate gate operations and delivery volumes.

Future Requirements for Design
Feasibility studies for final design will need to look into disposition of sluiced bedload material passed through the sluiceway at the Diversion Structure. Studies should ensure that there is enough velocity to carry sluiced material through the system or make provisions for dredging operations to periodically remove the sluiced deposits.
Need existing (for cofferdam construction) flow data in San Joaquin River, site specific surveys to finalize structure sizes and elevations, subsurface investigations, geotechnical report, groundwater levels, specific species of fish to be considered, borrow areas, and stockpile sites. Need exact locations, dimensions and descriptions of any existing structures such as canals, etc within the proposed construction site(s). Permits for 401 water quality, 404 dredge and fill, environmental compliance (NEPA, CEQA, ESA, CESA, CWA, CAA, CDFG Code Section 1600 Agreement) for work within San Joaquin River along with water rights data. Delivery flow, delivery water surface elevations, and reservoir water surface elevations will be required to accurately size the radial gates at the Diversion Structure.

Potential Environmental Impacts

- **Temporary (During Construction)**

Impact to air quality, biological resources (impact to fish from disturbance of sediment in river during construction or changes in flow conditions, impact to waterfowl from changes in riparian areas), cultural resources (excavation and construction activities), water resources (interruption of water deliveries, changes in water quality from changes in sediment levels).

- **Permanent (Operation-Related)**

Changes in localized river hydraulics, sediment transport, and flooding characteristics. Increased seepage, changes in groundwater levels, impacts to production on agricultural lands.

Sub-Options considered but Rejected

If it is determined that uninterrupted flow would not be required between the existing Mendota Dam and the downstream end of the bypass channel, the existing Mendota Dam could be used as a barrier to upmigrating adult salmon by closing the existing six sluiceway slide gates and installing the stoplogs to maximum height in the remaining bays. Although less efficient, this would reduce costs (both construction and maintenance) by eliminating the inclined fish screen. This sub-option was rejected due to the potential for upmigrating adult salmon to be trapped (dead-ended) in this reach without probability of returning to the Bypass Channel.

Drawings

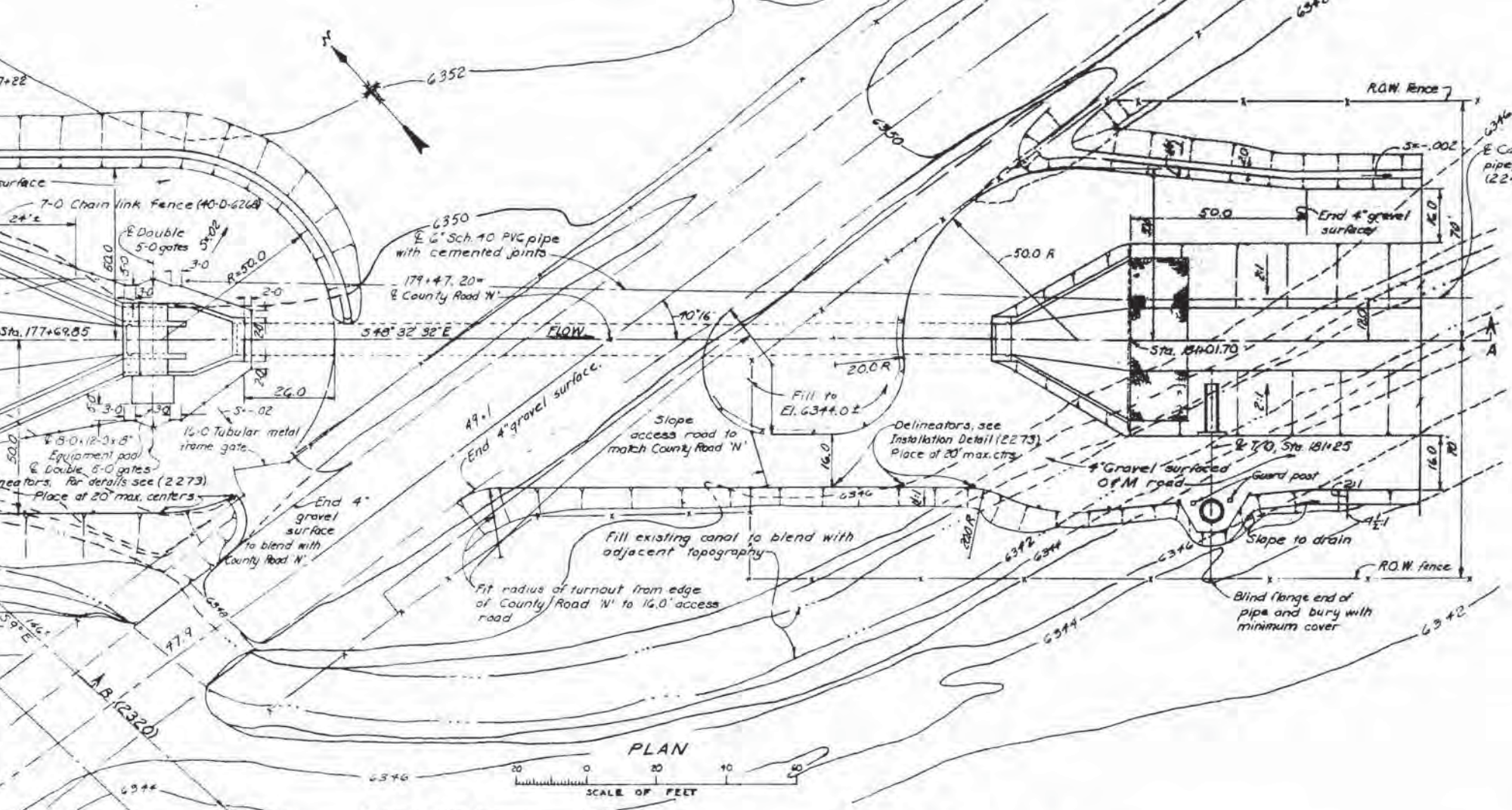
1 Siphon (Towaoc Canal - 2 sheets)
2 Vee Fish Screen (2 sheets)
3 Fish Barrier (1 sketch, 1 photograph)
4 Diversion Structure (Kent Diversion structure - 3 sheets)
5 Option 1 – General Plan
6 Option 1 – Mendota Pool Bypass – Sections and Details (1 sheet)

Figures

1
2
3
4
5

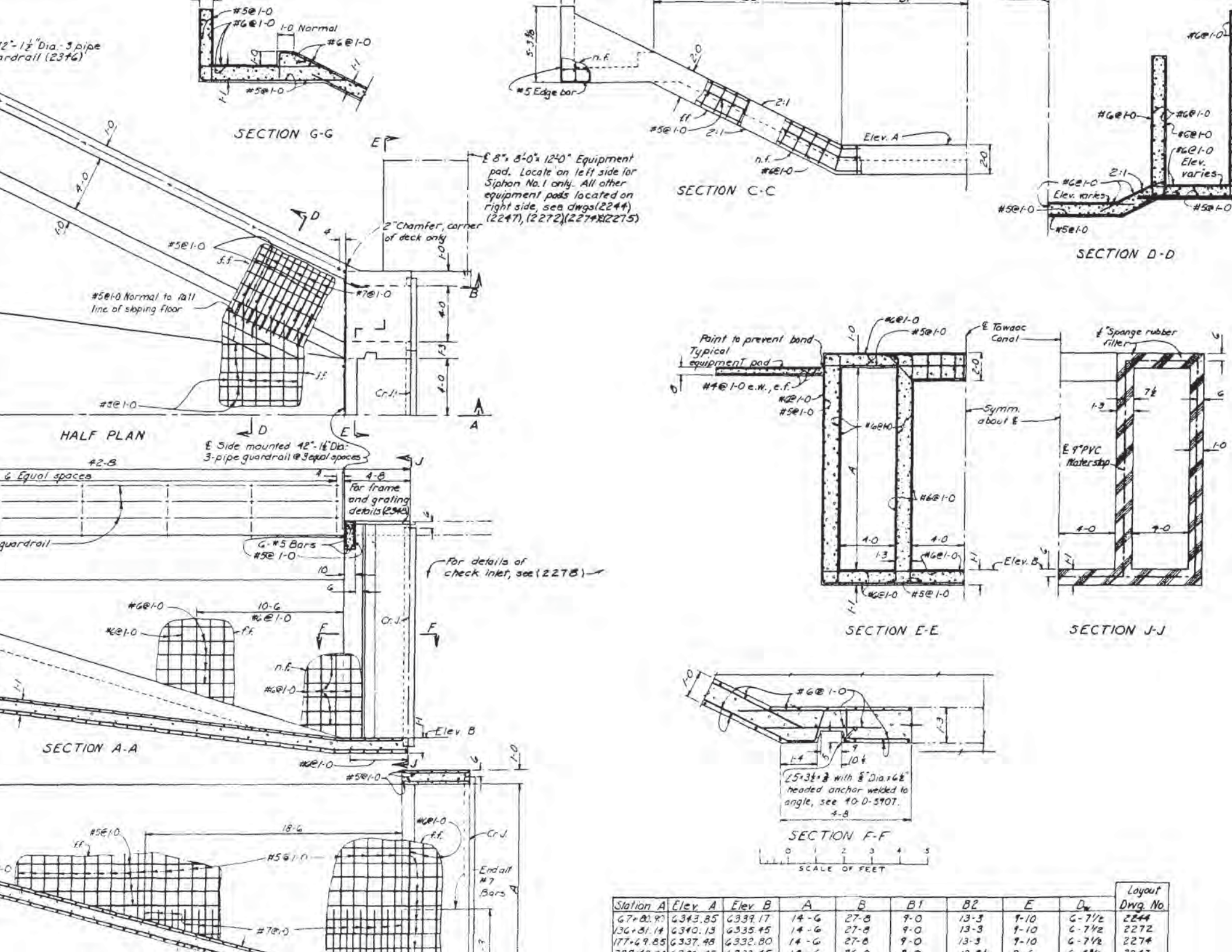
Attachments

1
2
3
4



DRAWING 1-

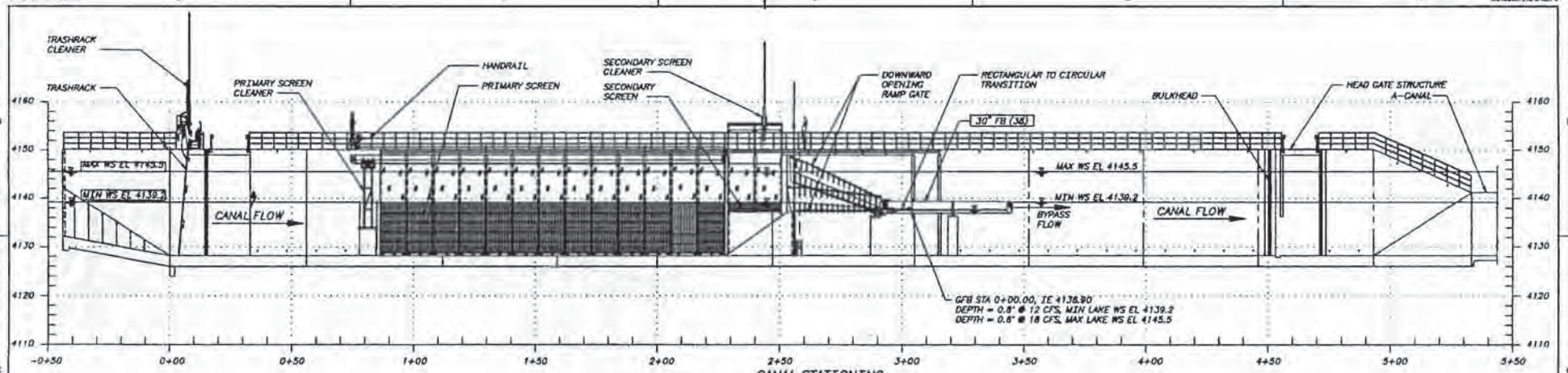
UNITE
DEPARTMENT
BUREAU O
DOLORES PR
TOWAO
R



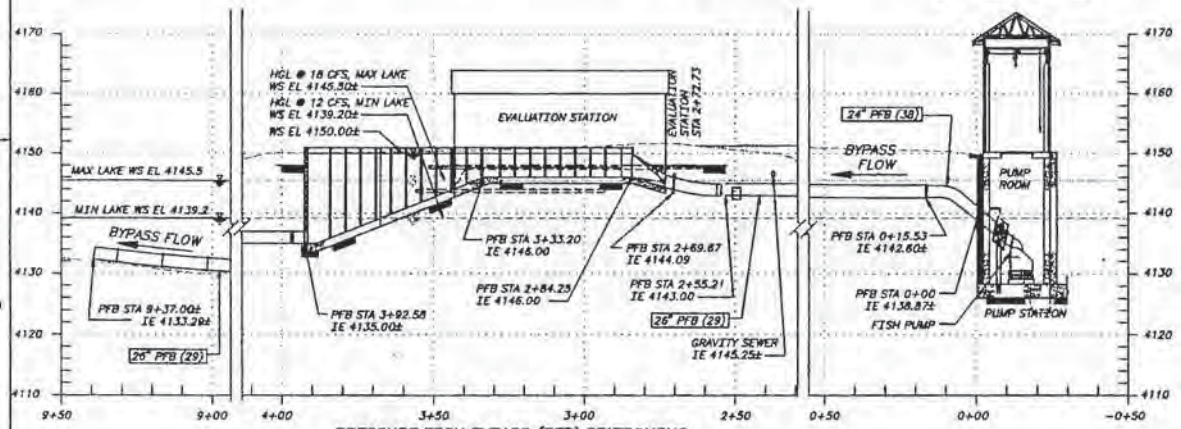
Station A	Elev. A	Elev. B	A	B	B1	B2	E	D_w	Layout Dwg. No.
67+80.80	6343.85	6339.17	14-6	27-8	9-0	13-3	9-10	6-7½	2244
136+81.14	6340.13	6335.45	14-6	27-8	9-0	13-3	9-10	6-7½	2272
177+69.85	6337.48	6332.80	14-6	27-8	9-0	13-3	9-10	6-7½	2274


To upper Klamath Lake
Howard Bay
Highway 140
Pumping station
Pressure fish bypass
Trashrack structure
Fish evaluation station
Fish screen structure
Pump station and control building
Emergency generator
Headgate structure
Check structure
Canal to Long Lake Reservoir
100
ALWAYS
UPPER KLAMATH
LONG
CALEDONIA AND
FISH SCRE
STRUCTUR

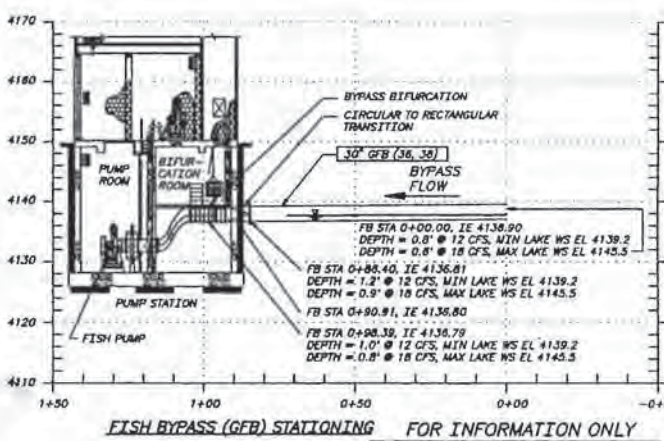
FIGURE 4



CANAL STATIONING



PRESSURE FISH BYPASS (PFB) STATIONING



FISH BYPASS (GFB) STATIONING

FOR INFORMATION ONLY

PROFILE

HORIZONTAL SCALE OF FEET

VERTICAL SCALE OF FEET

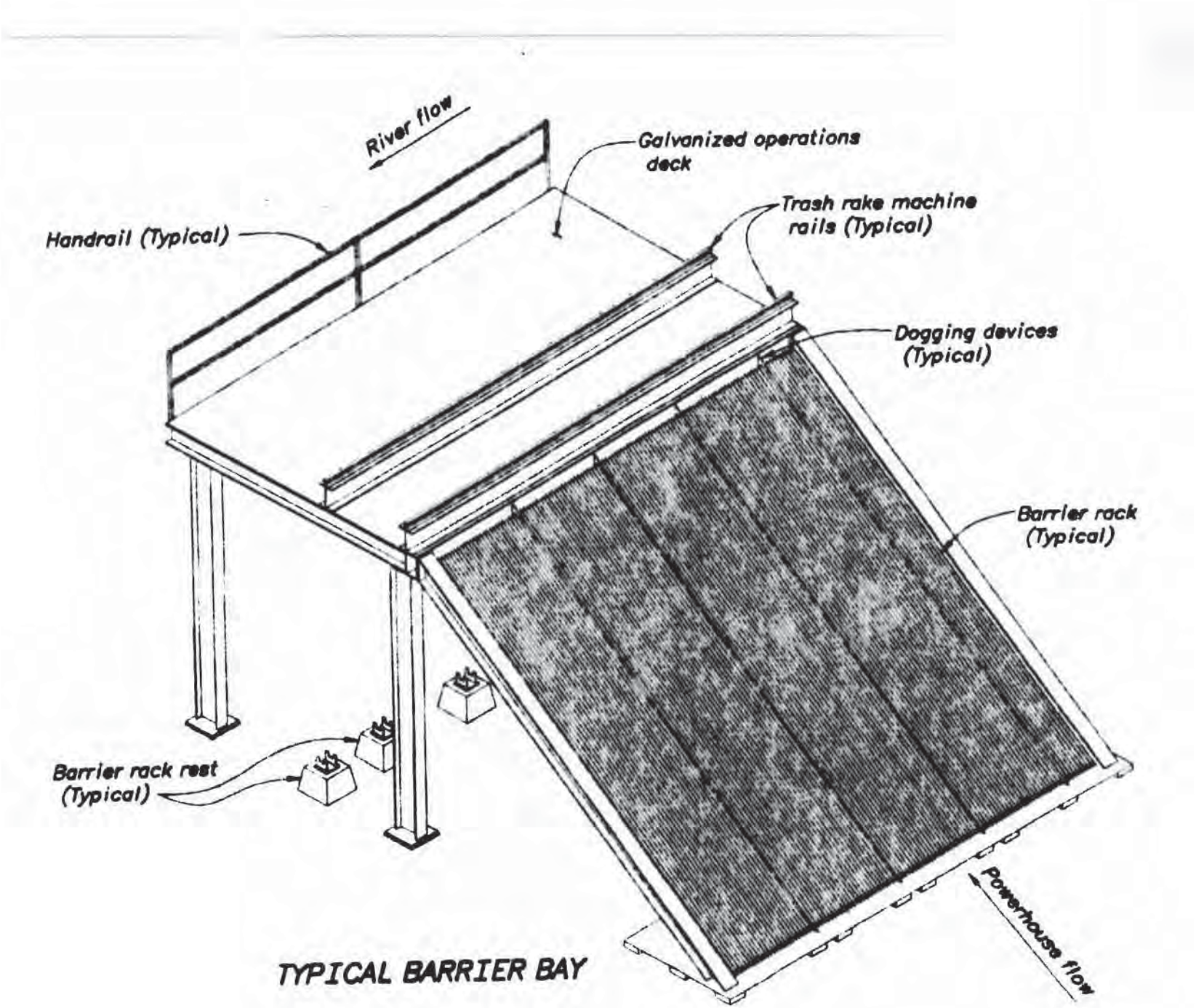
REGISTERED PROFESSIONAL ENGINEER 11407 OREGON JAMES E. DORRATCAGUE

ALWAYS THINK SAFETY

KLAMATH PROJECT
MAIN DIVISION - OREGON
A CANAL FISH SCREEN
GENERAL
HYDRAULIC PROFILE AND DESIGN CRITERIA

17-208-851

FIGURE 4



TYPICAL BARRIER BAY

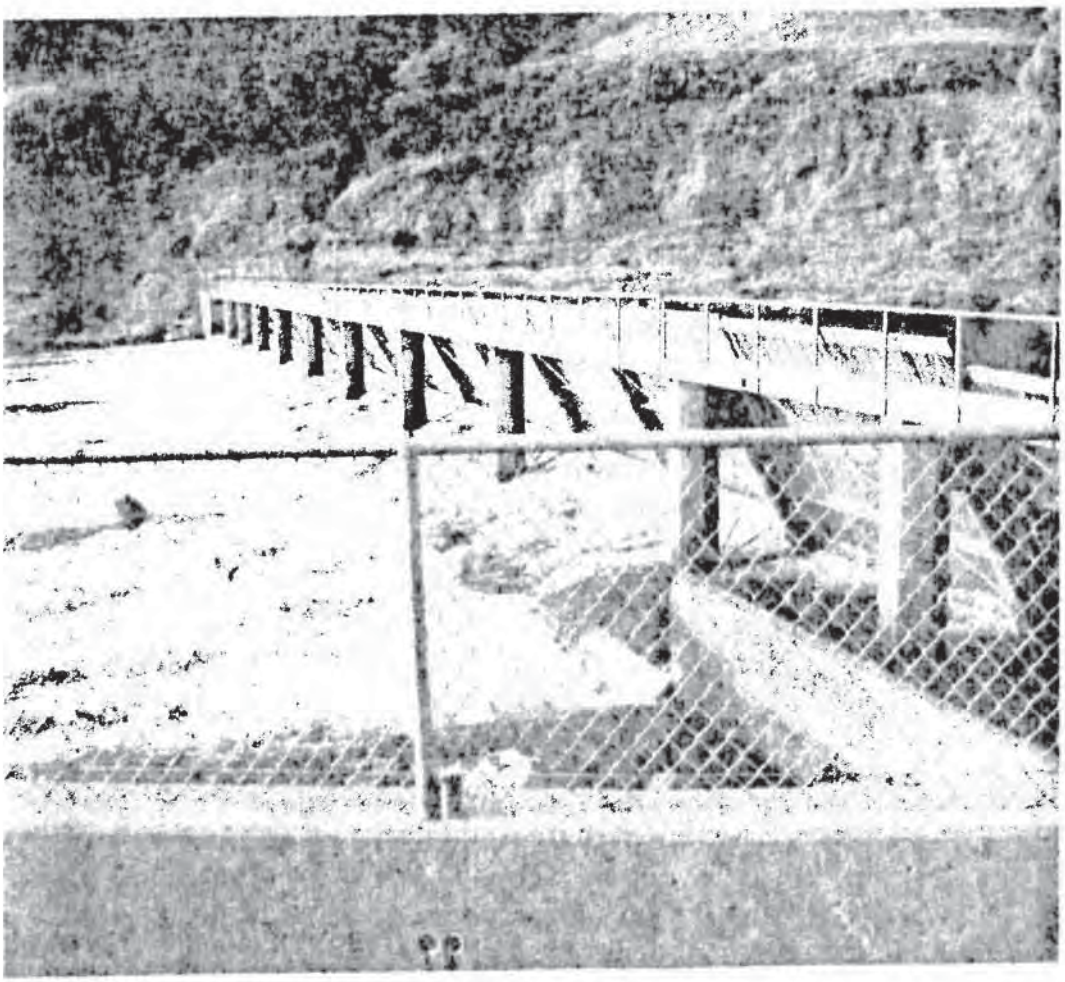
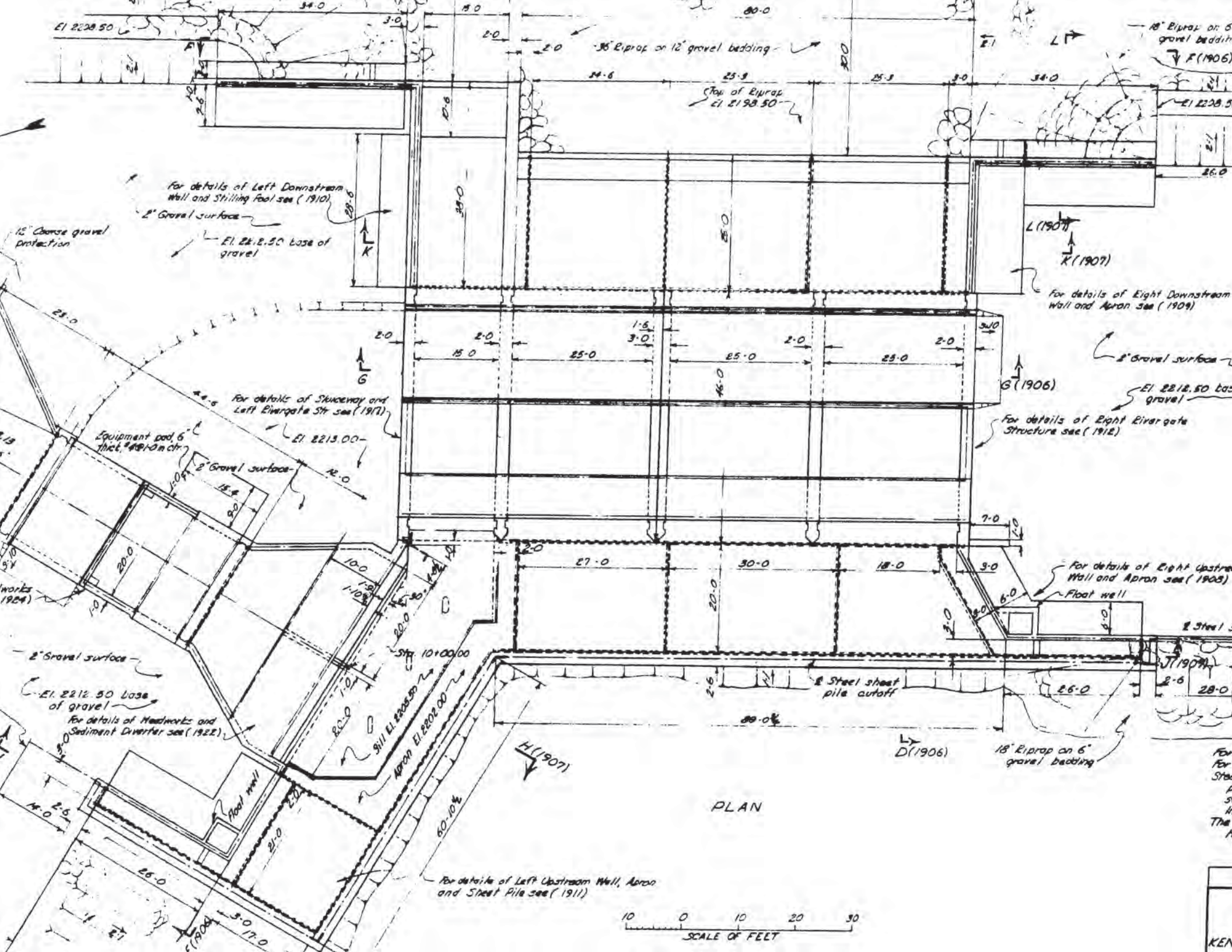
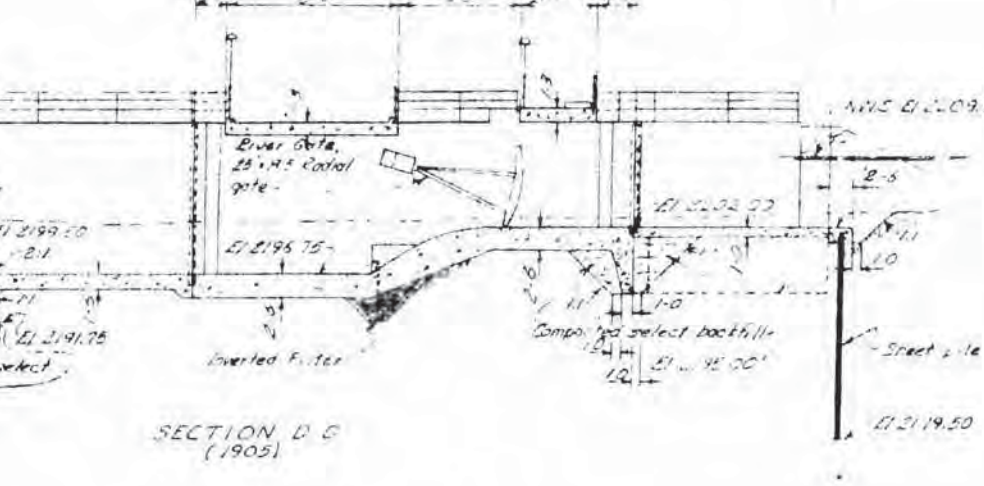


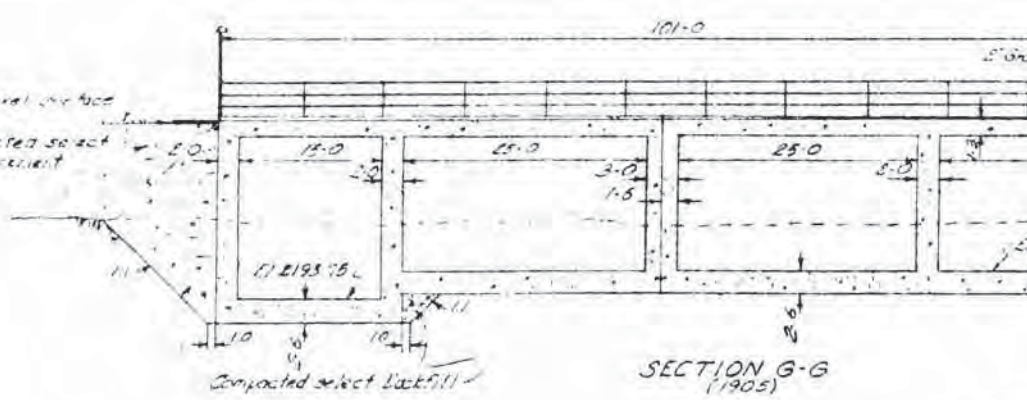
Figure 130.—Nimbus Dam bar rack barrier, American River, near Sacramento, California. (Nimbus Fish Hatchery).

DRAWING 1-3 SKETCH

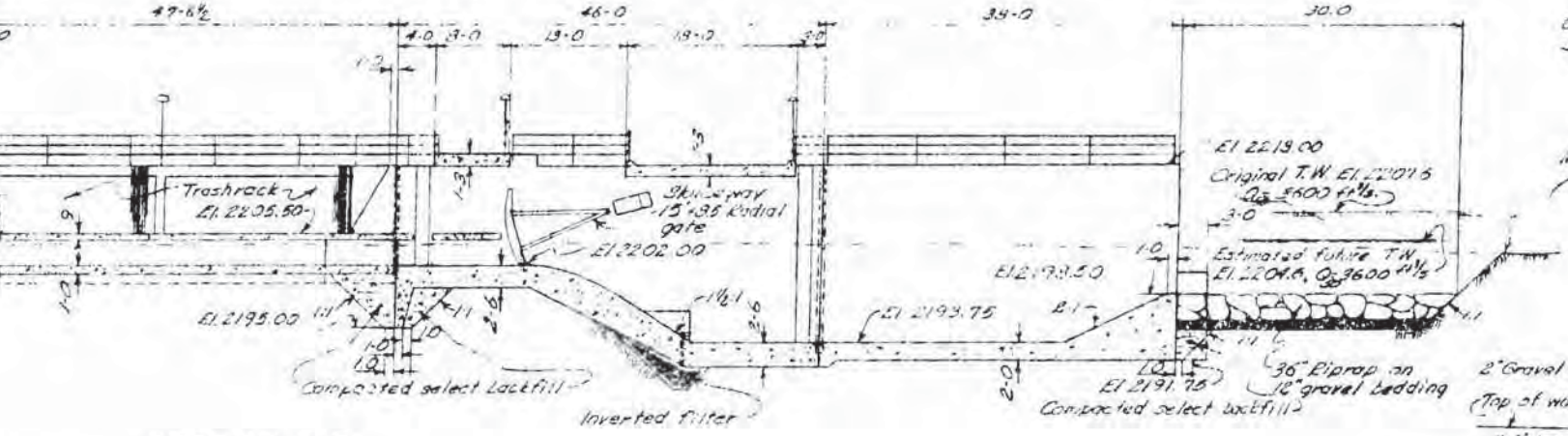

El 2228.50
36" Riprap on 12" gravel bedding
Top of Riprap El 2198.50
18" Riprap on 6" gravel bedding
F(1906)
For details of Left Downstream Wall and Stilling Pool see (1910)
2" Gravel surface
El 2212.50 base of gravel
12" Coarse gravel protection
K
K(1907)
L(1907)
For details of Right Downstream Wall and Apron see (1909)
G
G(1906)
For details of Sluiceway and Left Rivergate Str see (1917)
El 2213.00
Equipment pad 6" thick, #4@12"c/c
For details of Right River gate Structure see (1912)
For details of Right Upstream Wall and Apron see (1903)
Float well
Sta 10+00.00
Sill El 2205.50
Apron El 2202.00
8" Steel sheet pile cutoff
J(1907)
D(1906)
18" Riprap on 6" gravel bedding
H(1907)
PLAN
For details of Headworks and Sediment Diverter see (1922)
For details of Left Upstream Wall, Apron and Sheet Pile see (1911)
C(1904)
SCALE OF FEET



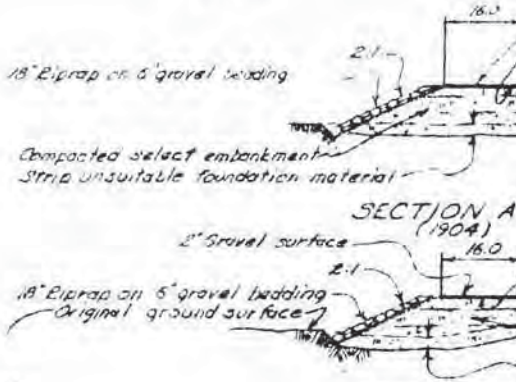
SECTION D-D
(1905)



SECTION G-G
(1905)

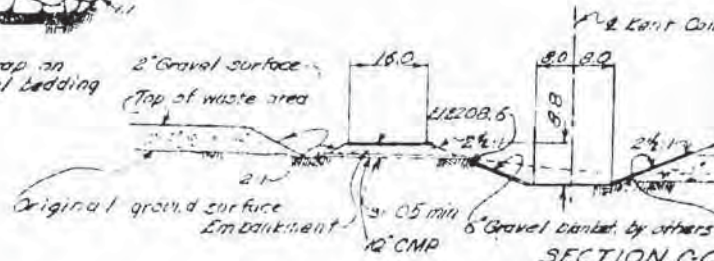


SECTION E-E
(1905)



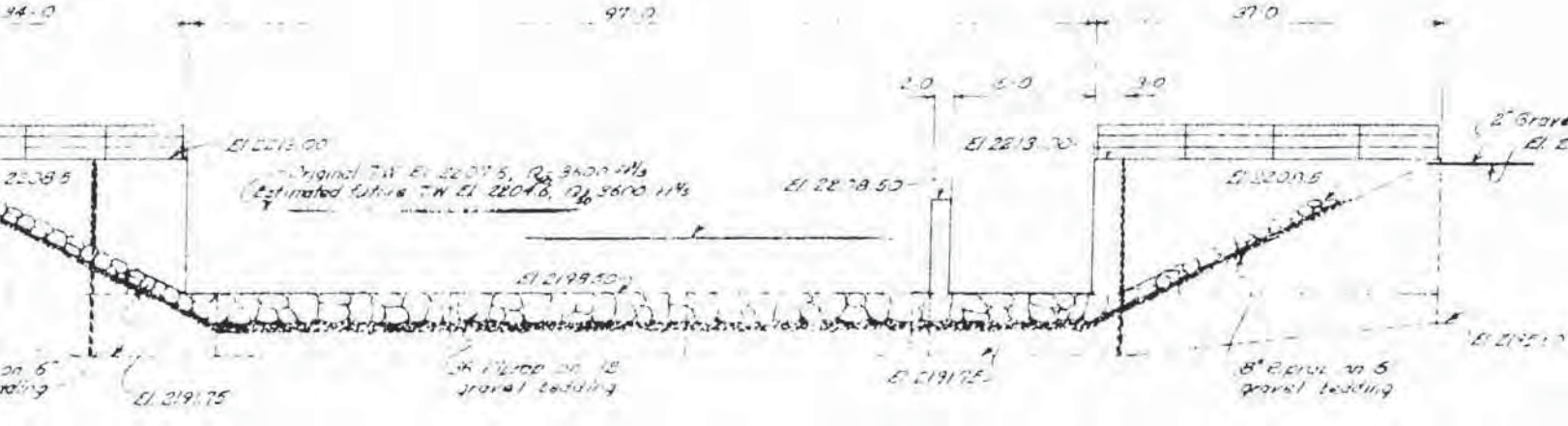
SECTION A
(1904)

SECTION B
(1904)



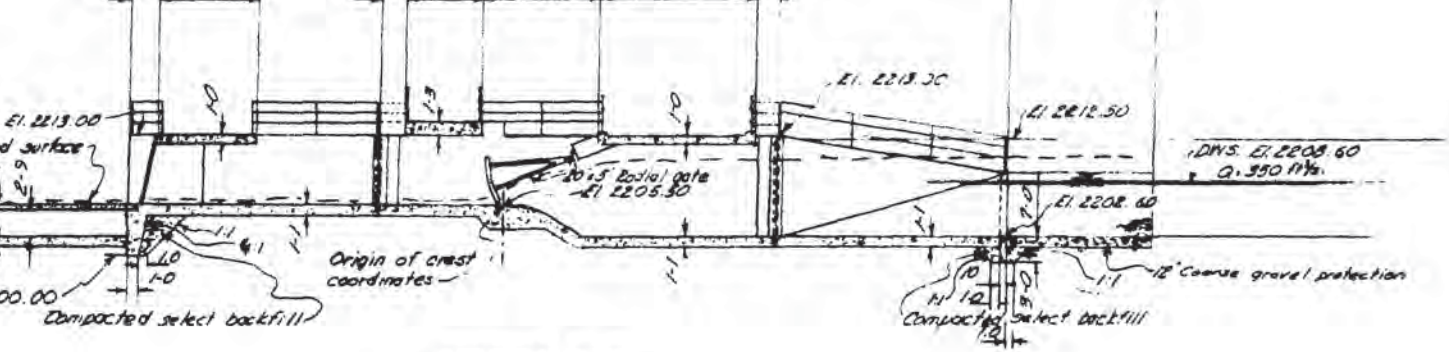
SECTION C-C
(1904)

20 0 20
SCALE OF FE

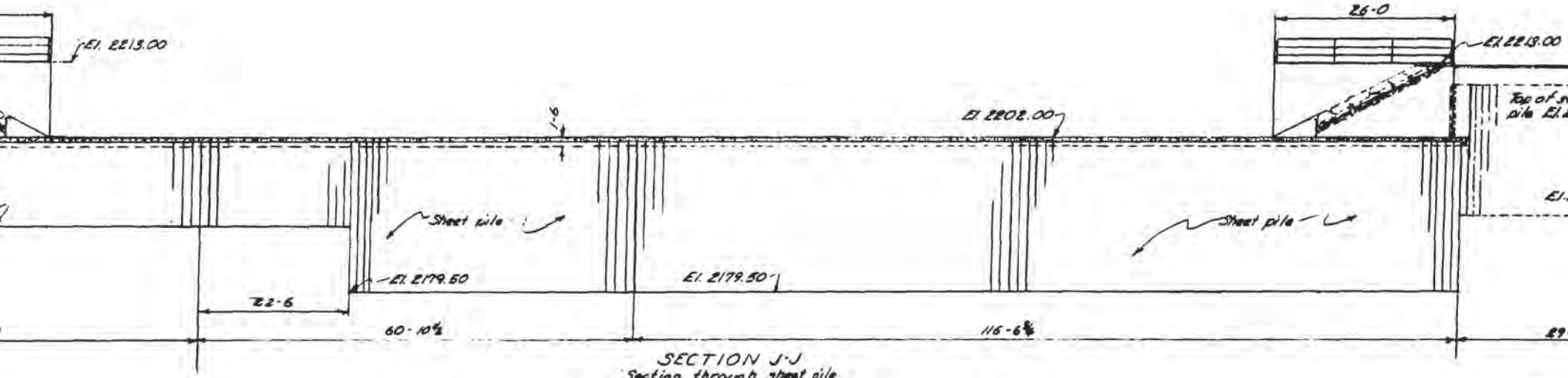


DRAWIN

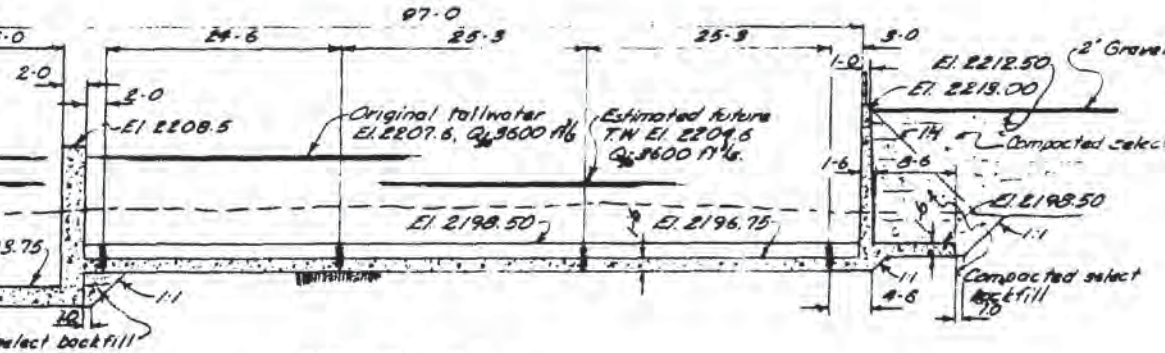
DEP
RICE ISLA
NORTH
KENT CANAL



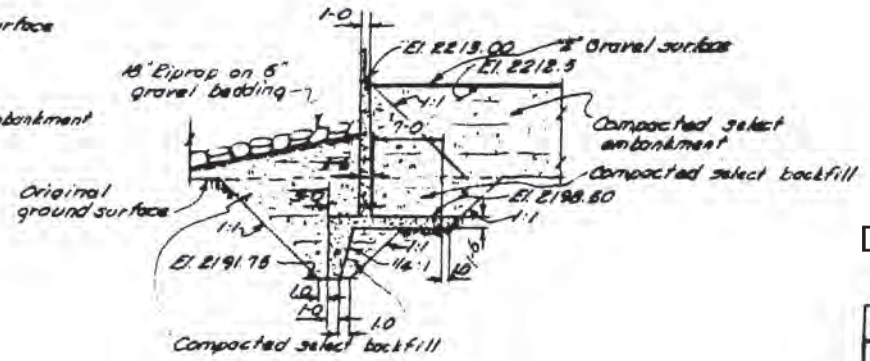
SECTION H-H
(1905)



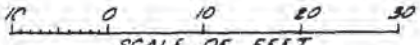
SECTION J-J
Section through sheet pile
(1905)

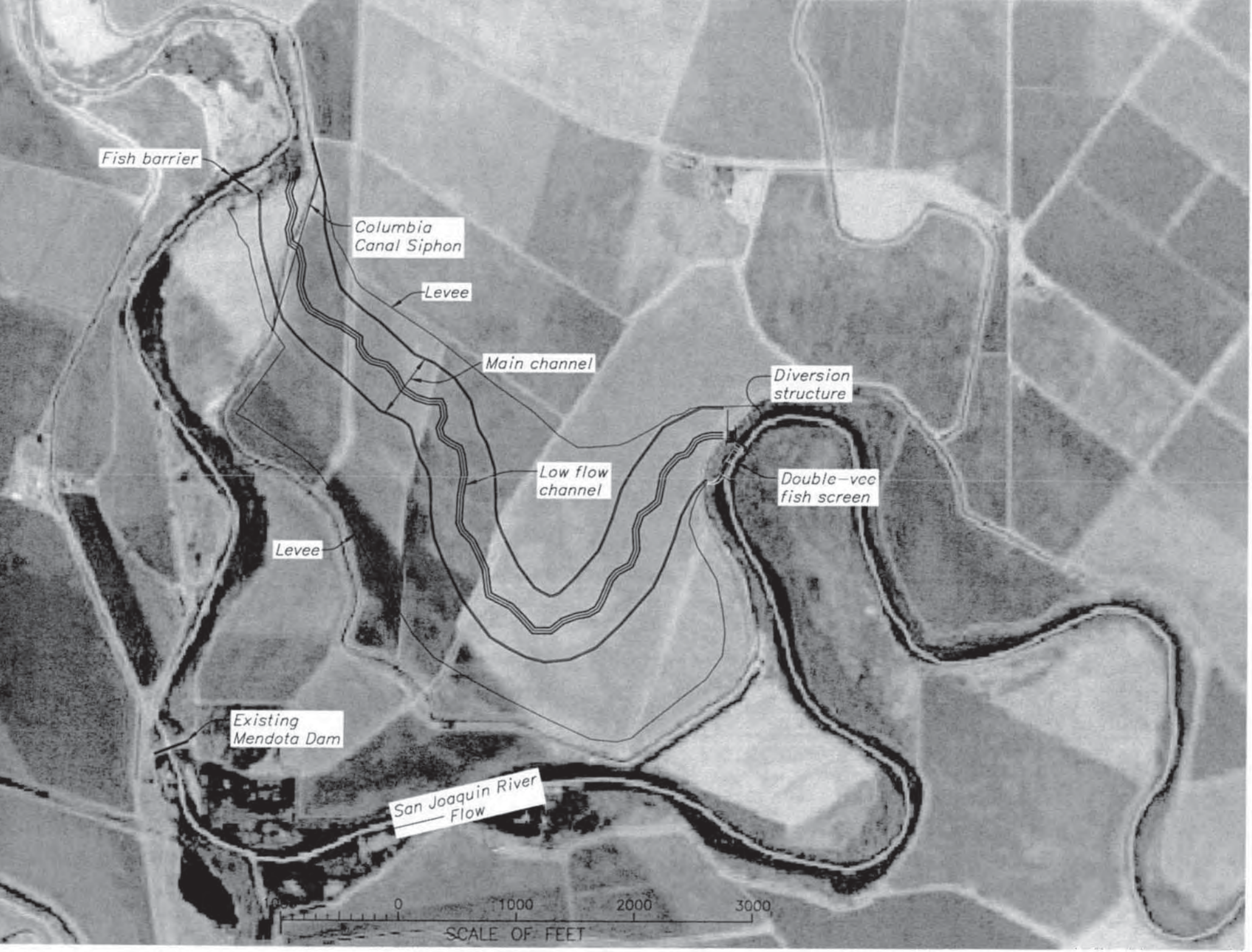


SECTION K-K
(1905)

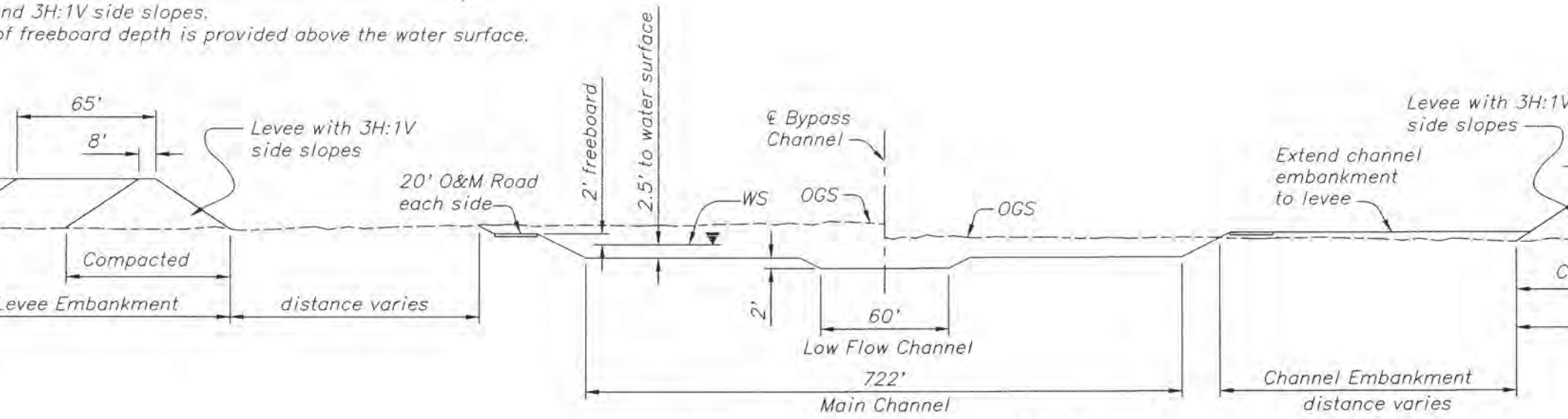


SECTION L-L
(1906)




Fish barrier
Columbia Canal Siphon
Levee
Main channel
Diversion structure
Low flow channel
Double-vee fish screen
Levee
Existing Mendota Dam
San Joaquin River Flow
1000
0
1000
2000
3000
SCALE OF FEET

nd 3H:1V side slopes.
of freeboard depth is provided above the water surface.

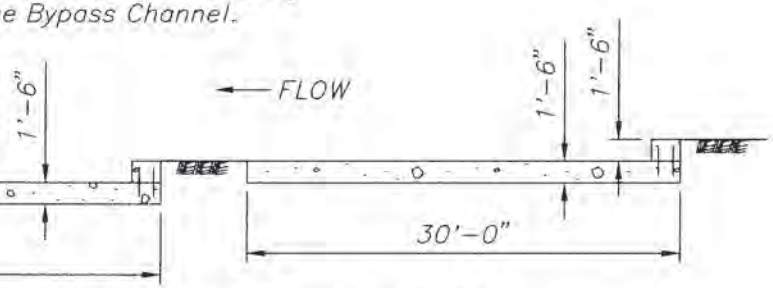


BYPASS CHANNEL SECTION

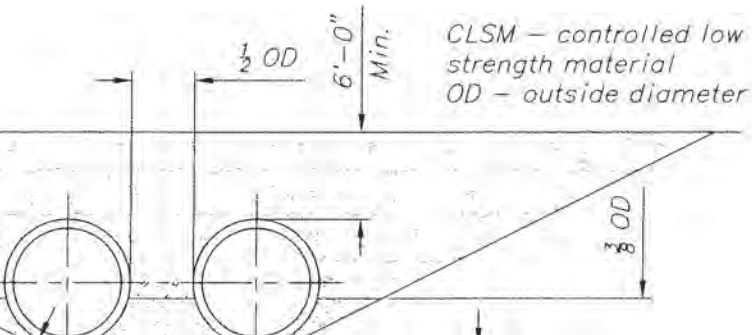
NOT TO SCALE

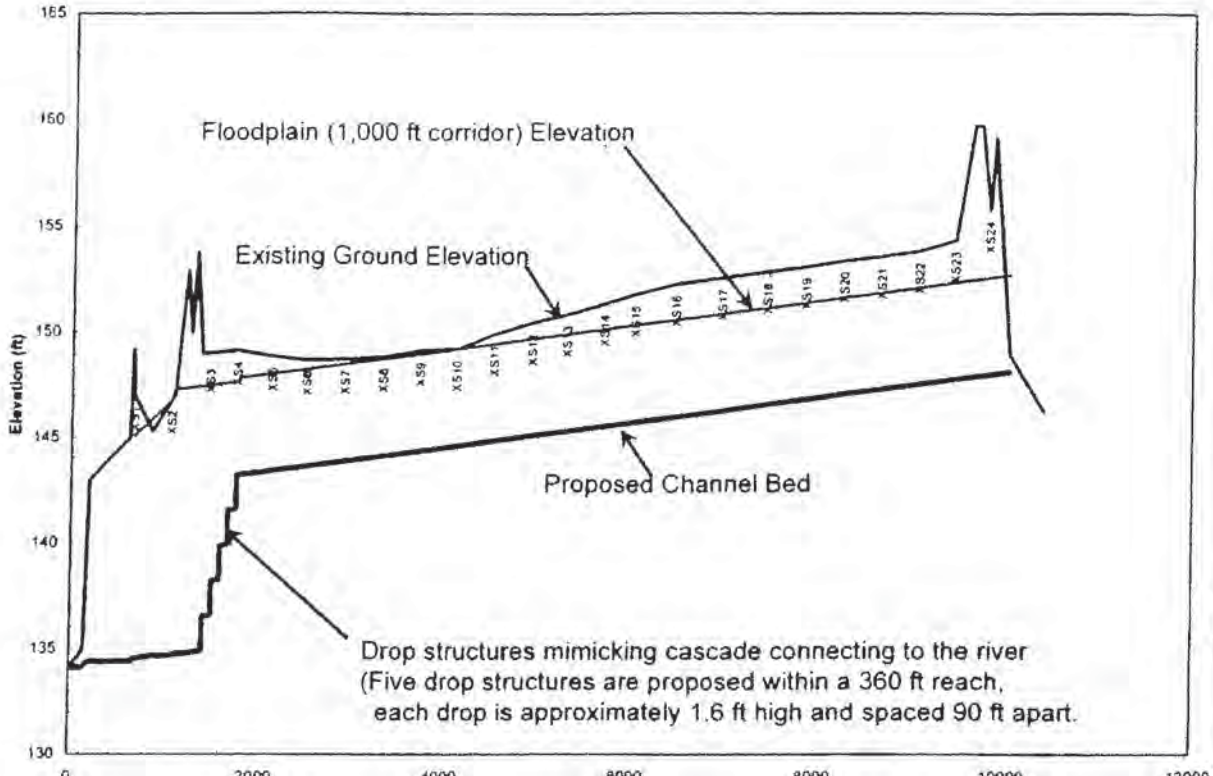
TRUCTURES

ted near the downstream
.
ncrete slab, 1.5' thick,
of flow) and extending
e Bypass Channel.



DROP STRUCTURE DETAIL





San Joaquin River Restoration
Structural Option Description
Pre-Appraisal Level

Option No.	Structural Option Name		Revision Date
2a	Reach 2B Channel Capacity – Levee Work		28 Feb 2008
Reach Number	**River Mile**	**Program Goal**	**Phase**
2B	207 to 216	Restoration	I

Task	Responsible Author	Peer Reviewer
Option Description	P. Romero	K. Faulkenberry
Engineering	A. Sanchez	P. Romero

Costs (October 2007):
Cost Level: Pre-appraisal
Total Construction Cost: Not available at this time.
Annual O&M Cost: Not available at this time.
Project life: Not available at this time.

Objective of Option
Improve right bank levee and add left bank setback levee to allow 4,500 cfs channel capacity between the Chowchilla Bifurcation and proposed Mendota Pool Bypass channel. This option only includes the levee work. Additional options forms will describe channel work, land acquisition and relocations.

Performance Criteria
1. Levee design addresses levee seepage and slope stability will be evaluated.
2. Preventing levee seepage was not specifically addressed; however, in many cases it should be reduced.
3. Levees will have 3 feet of freeboard at 4,500 cfs.
4.

Design Criteria
1. Corps of Engineers levee guidelines were used.
2. Reclamation Cost Estimating Guidelines with SJRR unit costs
3. Unit prices are based on current DWR Civil Works contracts pay estimate except slurry wall
4. Slurry wall unit prices are based on URS Memo dated 3/22/07 for LSJLD seepage remediation
5.

Description
Channel capacity analysis (including setback levee alignment) was performed in 2002 by Mussetter Engineering. Evaluation was not adjusted to account for any hydraulic adjustments from proposed Mendota Pool Bypass channel or revised channel modifications (including riparian vegetation changes and low-flow channel habitat). Approximate location of Mendota Pool Bypass channel was also assumed. Existing channel modifications on right back include raising levee to provide 3 feet of freeboard. Left bank setback levee was designed to reduce significant relocations of canals and structures. Figure 1 shows the existing right bank levee and proposed left bank setback levee alignment. Typical proposed levee cross-sections are shown in Figure 2. The typical levee designs were developed from slope stability and seepage analysis.

Construction Considerations
Sufficient borrow material within 1 mile haul was identified near the construction sites from NRCS soils maps. Borrow was assumed to be taken from fee title lands. Access to the existing left bank levee should not significantly increase construction costs. Low levee raises and adding material to existing levee slopes could increase costs. It was assumed that of clearing and grubbing will be necessary on all locations.

Schedule

Real Estate Requirements

- **Fee Purchase** Acquisition of fee lands is included in the floodplain options forms.
- **Access Rights** Necessary land rights will be based on ownership of levee.
- **Permanent and Temporary Easements** Temporary land rights will be necessary for access to existing right levee for construction.

Coordination with Other Options

This option includes raising levees, acquiring lands, channel and floodplain development, and relocations. Though these elements are broken up, they are part of the complete option. The location and height of levees will likely be determined after an evaluation of the location and hydraulics of the Mendota Pool Bypass channel option.

Operational and Maintenance Requirements

- **Operations**

There would be no operations needed for the levees.

- **Maintenance**

The levees will need to have periodic inspections for burrowing animals, problematic vegetation, and erosion/sloughing. It is not yet clear who will be responsible for this maintenance.

- **Monitoring Requirements**

None.

Future Requirements for Design

The level of design is very preliminary and much analysis is needed to further the reliable of the design. Next steps will include: 1) Refine modeling to include adjacent proposed options and future conditions for restoration, 2) Evaluate the setback levee alignment to address landowner preferences, 3) Evaluate channel capacity needs to address water rights, 4) Perform geotechnical and soils analysis to account for local soils, and 5) Include more detailed topographic mapping. Refined costs of the options will require a more detailed evaluation of adequate borrow areas and land costs. Permits that may be required prior to construction include: Nationwide Permit (404), water quality certification (401), Stream Alteration Agreement, Reclamation Board Encroachment Permit, Section 7 and/or 2081 Take Permits, CEQA and any applicable county permits.

Potential Environmental Impacts

- **Temporary (During Construction)** –Air quality, biological, water quality, noise
- **Permanent (Operation-Related)-** Agricultural, biological, water quality, land use, recreation, cultural

Sub-Options considered but Rejected

Slurry walls throughout the entire reach was rejected since analysis showed it was not necessary.

Drawings

2a-1 Reach 2B Raised and Setback Levee Plan View (Sheet 1)
2a-2 Reach 2B Raised Levee Typical Section (Sheet 2)
2a-3 Reach 2B Setback Levee Typical Section (Sheet 3)

Figures

2a-1 Figure 1-1 Analysis Process

Attachments

2a-1 Summary of Appraisal Design on Levee Work (Reach 2B and 4B) TM
2a-2 Slope and Seepage Analysis Details

San Joaquin River Restoration Program

December 26, 2007

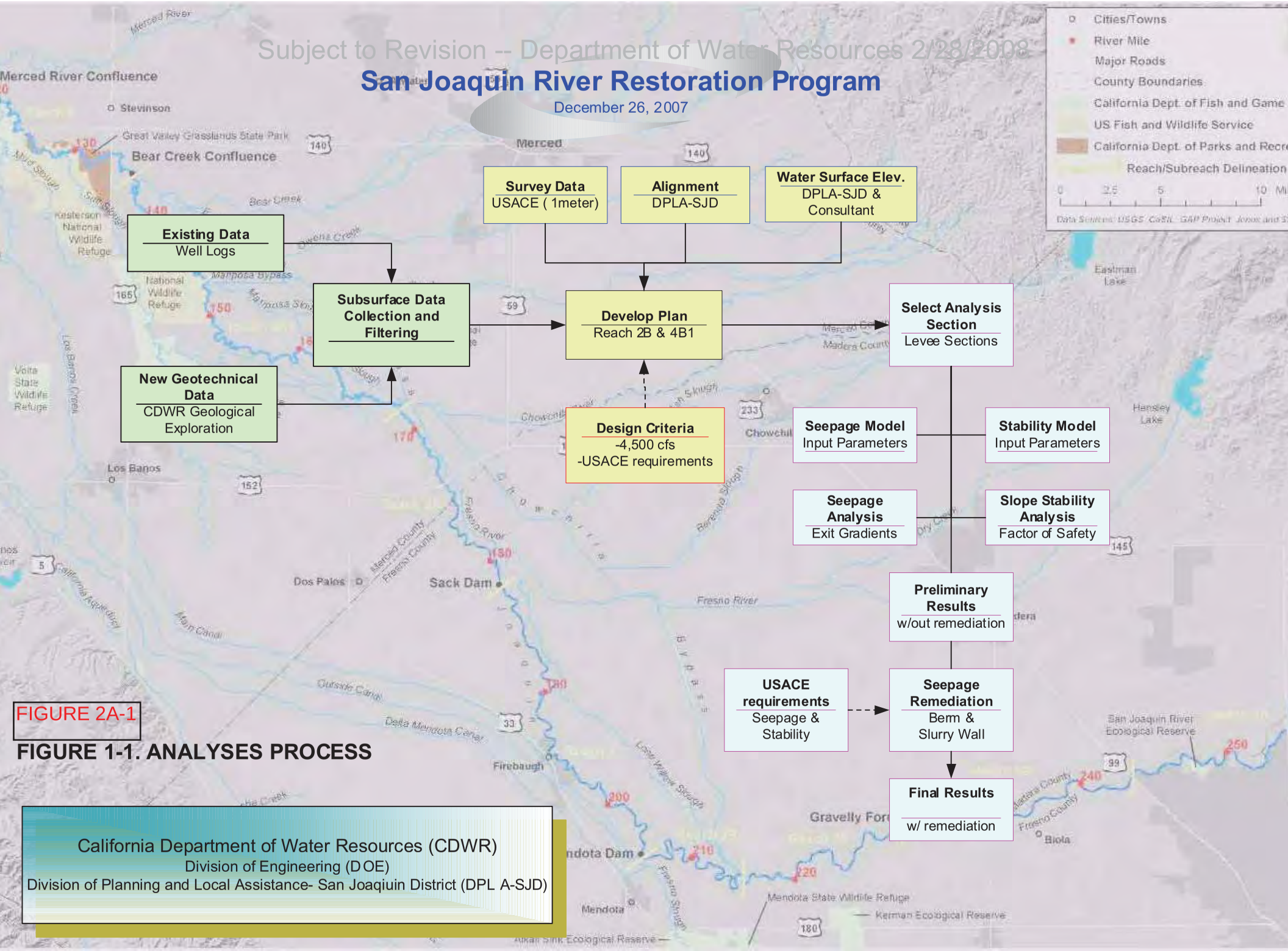
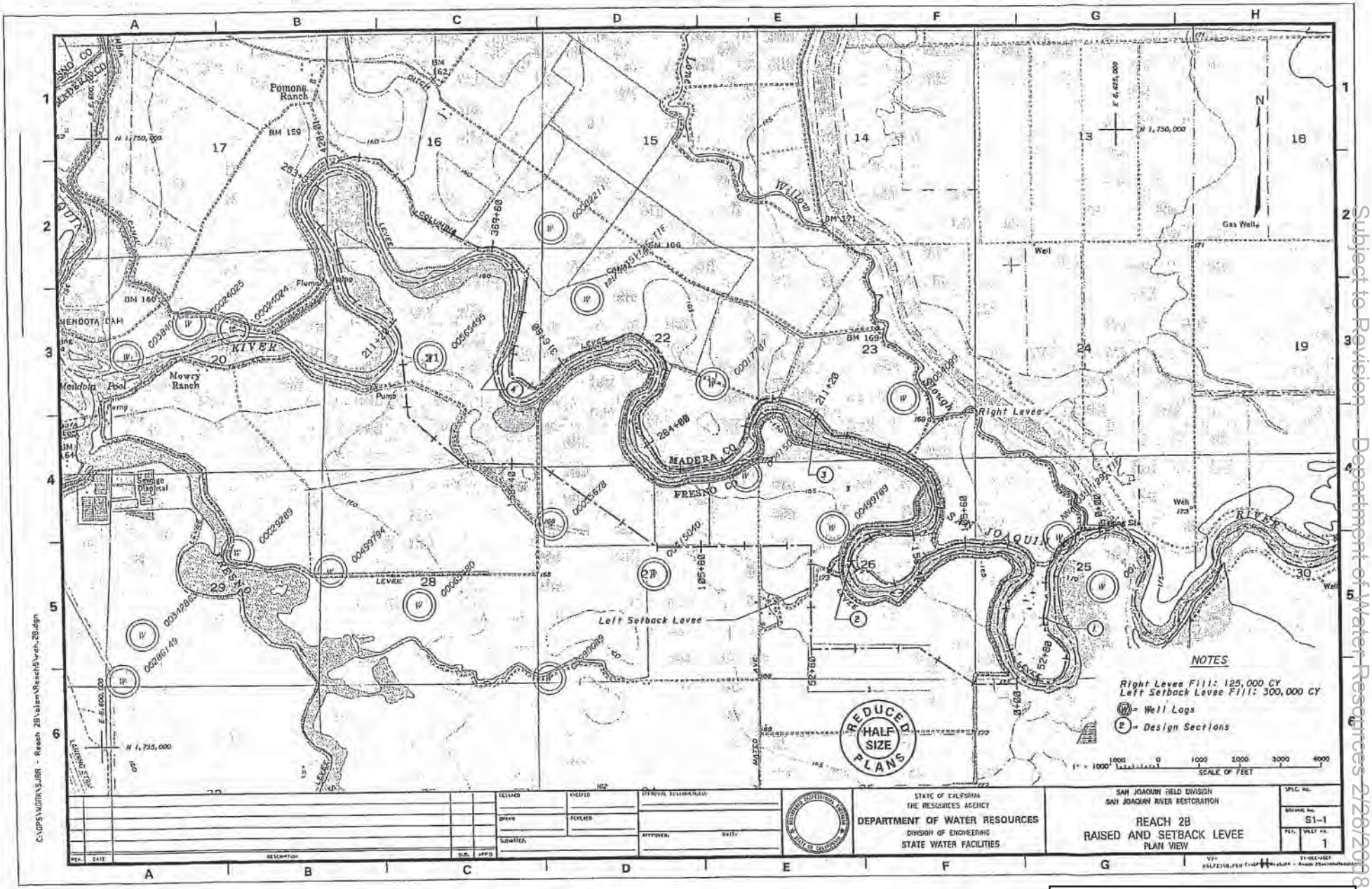


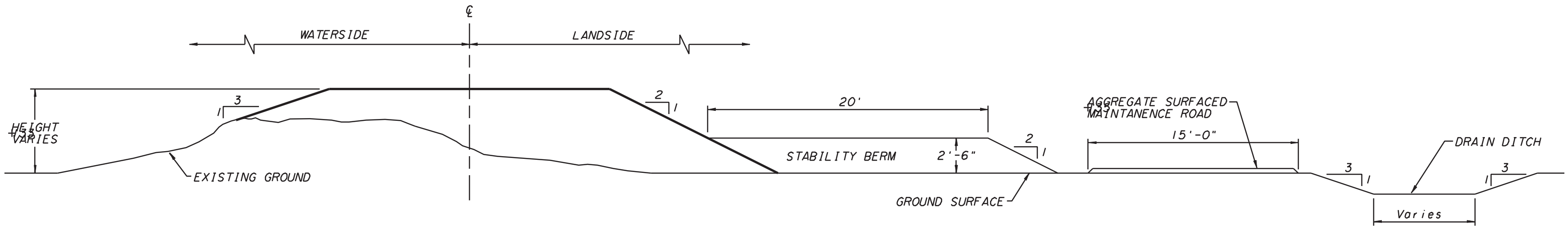
FIGURE 2A-1

FIGURE 1-1. ANALYSES PROCESS

California Department of Water Resources (CDWR)
Division of Engineering (DOE)
Division of Planning and Local Assistance- San Joaquin District (DPLA-SJD)



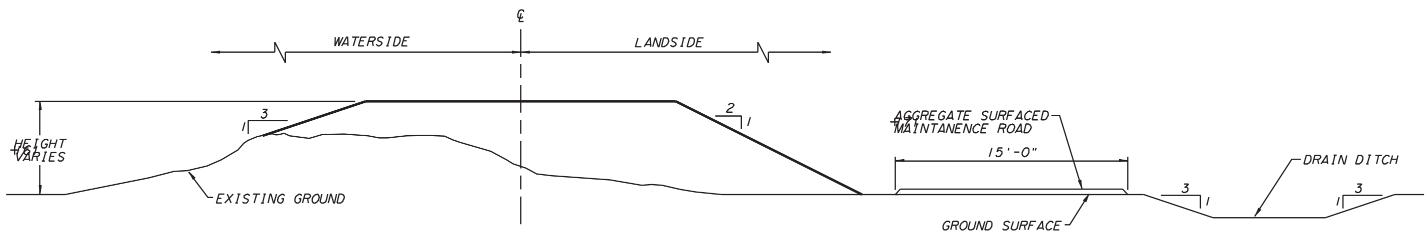
Drawing 2a-1: Reach 2B Raised and Setback Levee Plan View



STABILITY BERM SECTION

Scale: 1/4" = 1'

TYPICAL



RAISED LEVEE SECTION

Scale: 1/4" = 1'

TYPICAL

DETAIL SECTION	STABILITY BERM	
	WIDTH	HEIGHT
1	N/A	N/A
2	20'	2.5'
3	N/A	N/A
4	N/A	N/A
5	N/A	N/A
6	N/A	N/A

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | DRAWN | REVIEWED | SUBMITTED:

APPROVAL RECOMMENDED: | APPROVED: | DATE:

REG. | STAMP

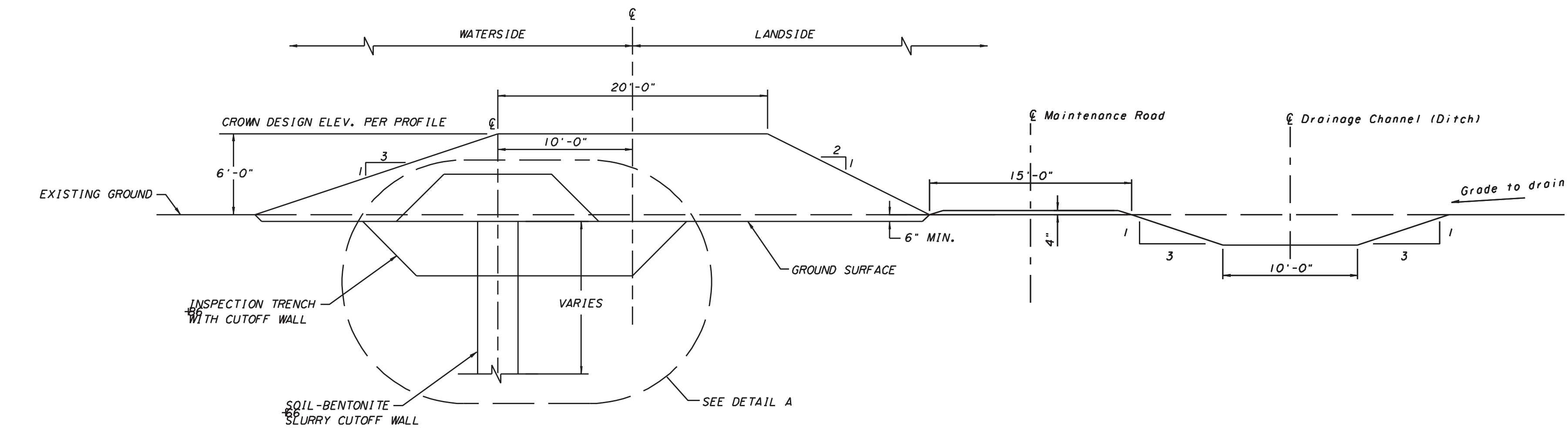
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

DIVISION OF
SAN JOAQUIN RIVER RESTORATION

RAISED LEVEE SECTIONS
REACH 2B – RIGHT LEVEE

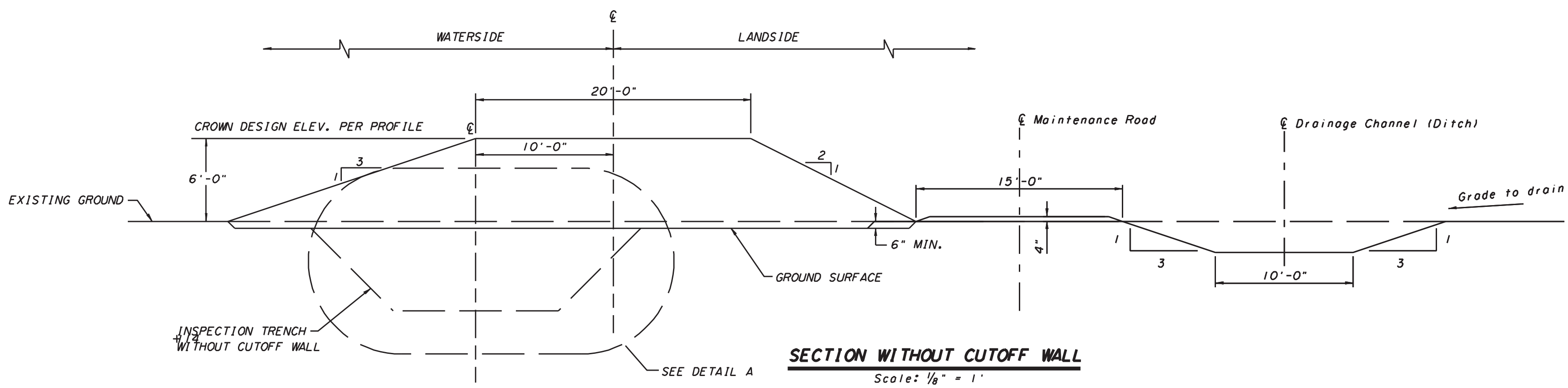
SPEC. No. | DRAWING No. | REV. | SHEET No.

Drawing 2a-2: Raised Levee Typical Section



SECTION WITH CUTOFF WALL

Scale: 1/8" = 1'
TYPICAL



SECTION WITHOUT CUTOFF WALL

Scale: 1/8" = 1'
TYPICAL

REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED | CHECKED | DRAWN | REVIEWED | SUBMITTED: | APPROVAL RECOMMENDED: | APPROVED: | DATE:

REGISTERED PROFESSIONAL ENGINEER — STATE OF CALIFORNIA | REG. | STAMP

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

DIVISION OF
SAN JOAQUIN RIVER RESTORATION
LEVEE SECTION
REACH 2B – LEFT LEVEE (SETBACK)

SPEC. No. | DRAWING No. | REV. | SHEET No.

$$$$$DESIGNFILESPECIFICATION$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
V1* $$$$$PRFNAME$$$$$$$$$ $$$DATE$$$$ $$$DESIGNFILESPECIFICA$$$$

For full size plot, Snap fence corners to thin red rectangle.
For 11 x 17 plots, Snap corners to green dots.

Drawing 2a-3: Setback Levee Typical Section

OFFICE MEMO **DRAFT**

TO: Cosme Diaz, Acting Chief Geotechnical and Structures Branch	**DATE:** 12-26-2007
FROM: Joe Royer, Chief Dams and Canals Section Division of Engineering	**SUBJECT:** Summary of Appraisal Design on Levee Work – San Joaquin River Restoration Program

This memorandum presents the Division of Engineering, Dams and Canals Section's appraisal design of the levee work including a cost estimate as part of the joint venture with the United States Bureau of Reclamation (USBR) on the San Joaquin River Restoration Program. The documents included the following:

- Cost Estimate
- Quantities
- Plans and Sections
- Seepage Analyses on Reach 2B and 4B1– Samples and Results
- Stability Analyses on Reach 2B and 4B1– Samples and Results

The levee appraisal work was done with the help from the Division of Planning and Local Assistance San Joaquin District (SJD). Existing topographic maps were acquired by SJD from the United States Army Corps of Engineers (USACE) Comp Study while local government agencies and private entities provided the well logs and agricultural soil surface used in the seepage analyses portion of this project. DOE understands that no existing CPT or SPT boring logs and lab test data are available in this appraisal design. The task in developing the design water surface elevation and reach alignment was done by SJD with the help of a consultant company to do the hydraulics and hydrology.

Analyses Process:

DOE staff patterned the analyses process from the Guidance Document - Geotechnical Analyses provided by URS for CDWR's Urban Levee Geotechnical Evaluations Program (Revision 5 dated November 2007) in order to facilitate consistency in the analysis approach, methodology and analysis results presentation. Because the geotechnical data provided were crude using historical well logs provided by the local agencies and private entities, DOE staff used professional engineering judgment in the application of existing subsurface information and developed the parameters needed to initiate appraisal design seepage and stability analyses. A visual overview of the analyses process

is presented in the Figure 1-1 and illustrates the role analyses play in the evaluation program and the recommendations that followed. Because no geotechnical testing data was available for the stability analyses, the strength parameters were based on the Feather River Setback Levee Design Criteria dated November 30, 2007 which is part of the Division of Flood Management Early Implementation Program (EIP).

Reach 2B:

Right Levee

The alignment of the right levee begins at one of the bifurcation flow control structures near the Chowchilla Bypass at Station 0+00 or Levee Mile 216.0. Reach 2B ends at Station 420+01 or approximately Levee Mile 207.5 near the Mendota Pool. For the purpose seepage analyses, the right levee of Reach 2B was subdivided into 5 design sections. Each section was assigned subsurface information based on the well logs near the sections. Based on the Inroads program using the existing topographic data, majority of the right levee on Reach 2b requires raised elevation and increased in width (20 feet wide, 3:1 waterside slope and 2:1 landside slope) in order to meet the design water surface elevation, the 3 feet of freeboard, and the USACE levee construction standards. The analyses also show that Design Section 2 (Station 50+00 to 200+00) requires seepage berm based on the data provided. Seepage berms will be 20 feet wide, 5 feet in height and 2 to 1 slope. However, due to historical seepage in the area and lack of accurate geotechnical data, we assume that 20 percent of the right levee requires seepage remediation (seepage berm).
In addition, we included a 12-foot wide maintenance road at the landside as part of this exercise.

Left Levee

The left levee will be setback to meet the design flow criteria. By following the USACE standards (Engineering Manual (EM) 1110-2-1913 – Design and Construction of Levees (USACE, 2000), a 12 feet wide and 6 feet deep inspection trench with 1 to 1 slope will be constructed in areas where there are no slurry wall. With the slurry wall, the inspection trench will be 16 feet wide and 4 feet deep with 1 to 1 slope. The alignment begins at Bifurcation Flow Control Structure (Station 0+00 or LM 216.0) near the Chowchilla Bypass and ends at Station 253+00 or LM 207.0 just a few miles short of the Mendota Pool.

For the purpose seepage analyses, the left levee of Reach 2B was subdivided into 2 design sections. Each section was assigned subsurface information based on the well logs near the sections. The design levee height is 6 feet with 3 feet of water surface elevation (average levee height of 6 feet).

From the seepage analyses, the setback levee alignment on Reach 2b meets the USACE seepage standards and does not require slurry wall. For the purpose of this exercise and due to historical seepage in the area and lack of geotechnical data, we assume 10 percent of the 5 mile setback levee will require slurry wall. The slurry wall for Reach 2B setback will be designed for 15 feet deep and 1.5 feet wide with 2-foot thick clay cap.
In addition, we included a 12-foot wide maintenance road at the landside as part of this exercise.

Reach 4B1:

Both levees for Reach 4B1 will be setback to meet the design flow criteria. The setback levee will be constructed at 3 to 1 slope on the waterside and 2 to 1 slope on the landside with 20 feet wide levee crest. By following the USACE standards (Engineering Manual (EM) 1110-2-1913 – Design and Construction of Levees (USACE, 2000), a 12 feet wide and 6 feet deep inspection trench with 1 to 1 slope will be constructed in areas where there are no slurry wall. The inspection trench will be 16 feet wide and 4 feet deep with 1 to 1 slope for levees with the slurry wall.

For the purpose of seepage analyses, both setback levees were subdivided into 4 design sections. Each section was assigned subsurface information based on the nearest well logs. The design height of levee elevation used for analyses is 6 feet (Average levee elevation at both setback levees). The results of the seepage analyses show that the meet the USACE seepage criteria of 0.5 without a slurry wall. Due to the lack of geotechnical data, we assume 10 percent on both setback levees requires slurry wall. The slurry wall for Reach 4B1 setback will be designed for 15 feet deep and 1.5 feet wide with 2-foot thick clay cap.

In addition, we included a 12-foot wide maintenance road at the landside as part of this exercise.

Borrow Material:

Reach 2B

SJD provided maps of both Reach 2B and 4B showing the soil symbol and drainage characteristics or the topsoil material. Reach 2B is showing “somewhat” poorly drained material in the areas where the setback levee alignment is located. The right levee is showing a combination of “somewhat” poorly drained and excessively drained material. Somewhat poorly drained material usually indicates silt, silty sand or sandy silt while excessively drained material represents poorly graded sand, well graded sand or poorly graded sand with gravel. Due to the presence of excessively drained material, imported backfill material may be required to complete the remediation of the right levee.

SJD provided maps of both Reach 2B and 4B1 showing the soil symbol and drainage characteristics or the topsoil material. The right setback at Reach 4B1 is showing "somewhat" poorly drained material while the left setback is showing poorly drained material. Poorly drained materials usually indicates lean clay, sandy clay or silt material while somewhat poorly drained material usually indicates clayey sand, silty sand or sandy silt. This material may be sufficient for the construction of the new setback levees.

Costs:

The unit costs used for this exercise were based on the current CDWR cost estimating practice provided by Ben Lasarte, the Chief Cost Estimator for the Division of Engineering Construction Office. The unit cost for the slurry wall was provided by URS through the Division of Flood Management based on the memo dated March 22, 2007 by URS to CDWR regarding the cost associated with Alternative Repair Evaluation for the Lower San Joaquin Levee District (PL 84-99, Project No. 26815885.4000). The estimated cost for Reach 2B levee work which includes setback at the left side and raised levee with seepage berm on the right side is approximately $36 million. The estimated cost for Reach 4B1 setback levees is approximately $68 million.

Summary and Recommendation:

The appraisal design of the levee remediation shows that both Reach 2B and 4B1 will require setback levees to meet the design flow of the system. Setback levees at the left side of Reach 2B and for the entire stretch of Reach 4B1 will be constructed, on average 6 feet in height with 20 feet crest width with the USACE foundation trench. The right levee alignment of Reach 2B will require an average 2 feet of raised elevation and a little increased in crest width. Seepage and stability remediation for all setback levees is not required based on the technical analysis. However, due to the historical seepage in the area and the lack of accurate geotechnical data, DOE recommends the construction of slurry walls on 10 percent of all setback levees. Also, the results of the seepage analyses on Reach 2B show that one Design Section (~2 miles) requires seepage berm.

The overall cost for levee remediation work is approximately $104 million based on the current CDWR and URS unit cost estimates.

Table 1-Reach 2B-Preliminary Design Sections and Mitigation Measures
San Joaquin River Restoration Program

Levee Reach	Design Section	Beginning Station	End Station	Calculation Station	Issue Identified	Planned Design Measure
2B-North Levee (Rigth Levee_Existing)	1	0+00	50+00	30+00	Height	Raised Levee
	2	50+00	200+00	140+00	Height and Underseepage	Raised Levee & 20' L x 2.5' H Seepage Berm (2:1 Slope)
	3	200+00	290+00	210+00	Height	Raised Levee
	4	290+00	390+00	340+00	Height	Raised Levee
	5	390+00	510+00	500+00	Height	Raised Levee

Levee Reach	Planned Design Measure
2B-South Levee (Left Levee_Setback)	90% Inspection Trench Only 10% Inspection Trench with 10' Slurry Wall

Notes:
1. The average height of the mitigated existing (right) levee was assumed to be 13 feet in the seepage and stability analysis.
2. The average height of the setback (left) levee was assumed to be 6 feet.
3. The calculated cross sections are based on the Comp Study topo because we did not receive the 1M Topo until two days before the deadline.
4. Because of the late coming updated information, the original calculated Sta. 500+00 was used in the analysis to represent Design Section 5 even though Section 5 ends at arounc The updated cross sections for Section 5 are comparable to original Sta. 500+00. The soil layers used were interpolated from well logs around that area.
5. More permeable upper sand layer (coarse sand) was used in the seepage analysis. Original assumptions of less permeable sand layer (fine sand) near the surface were still used in the stability analysis because the strenghts of both types of soils were assumed to be the same.

ogram

	Design Section	Beginning Station	End Station	Calculation Station	Underseepage Mitigation Measure Evaluated_Run 1	i_{uplift}	Underseepage Mitigation Measure Eval
	1	0+00	50+00	30+00	Raised Levee Only	0.3	
	2	50+00	200+00	140+00	Raised Levee Only	0.7	Widened Levee and 20' L x 2.5' H Seepage
	3	200+00	290+00	210+00	Raised Levee Only	0.35	
	4	290+00	390+00	340+00	Raise Levee Only	0.5	
	5	390+00	510+00	500+00	Raised Levee Only	0.3	

	Levee Material	i_{uplift}
	CL/ML	0.35

Table 2-Reach 2B-Preliminary Slope Stability Summary
San Joaquin River Restoration Program

Levee Reach	Calculation Station	Case 1 End of Construction (Lowest SF)	Case 2 Steady State Seepage (Shallow Sloughing)	Case 2 Steady State Seepage (Circle through 1/3 Landside Crest)	Case 2 Steady State Seepage (Circle through Waterside Crest)	Case 2 Steady State Seepage (Circleto Design WSE)
	without Seepage Berm					
2B-North Levee (Rigth Levee)	30+00	2.74	1.06	1.61	3.01	4.40
	140+00	3.07	0.86	1.5	2.39	3.77
	210+00	2.96	1.19	1.62	2.58	3.97
	340+00	1.93	0.71	1.40	2.58	2.70
	500+00	2.15	0.97	1.51	2.23	3.58

Levee Reach	Levee Material Type	Case 1 End of Construction (Lowest SF)	Case 2 Steady State Seepage (Shallow Sloughing)	Case 2 Steady State Seepage (Circle through 1/3 Landside Crest)	Case 2 Steady State Seepage (Circle through Waterside Crest)	Case 2 Steady State Seepage (Circle to Design WSE)
	without Seepage Berm					
2B-South Levee (Left Levee) Setback Levee	CL/ML	2.52	0.76	1.49	2.65	3.84

Attachment 2a-1


Coarse Sand
Clay
Coarse Sand
Sandy Clay
Coarse Sand
Coarse Sand
Clay
Sand
Clay
Sand
Clay (Clay at Depth)
Sand
Coarse Sand
Fine Sand
Clay
Sand
Clay (Clay at Depth)
Sand
Coarse Sand
Clay
Fine Sand
Clay (Clay at Depth)
Fine Sand
Clay (Clay at Depth)
Coarse Sand
Clay
Sand
Clay
Sand
Clay (Clay at Depth)
Sand
Coarse Sand
Clay
Sand
Clay (Clay at Depth)
Sand

Typical Material Properties_End of Construction

Material Properties				
Type	Unit Weight	Friction Angle (deg.)	Cohesion (psf)	Layer Color
Embankment (Cl/Ml or SM/SC)	120	25	90	
Top Soil	115	25	700	
Fine Sand	120	32	0	
Coarse Sand	120	32	0	
Clay	115	0	800	
Clay at Depth	115	0	1200	
Cutoff Wall	115	0	500	
Cutoff Wall Cap/Inspection Trench	115	20	70	

Typical Material Properties-Steady State

Material Properties				
Type	Unit Weight	Friction Angle (deg.)	Cohesion (psf)	Layer Color
Embankment (Cl/Ml or SM/SC)	120	30	0	
Top Soil	115	30	0	
Fine Sand	120	32	0	
Coarse Sand	120	32	0	
Clay	115	30	0	
Clay at Depth	115	30	0	
Cutoff Wall	115	30	0	
Cutoff Wall Cap/Inspection Trench	115	25	0	

Attachment 2a-2: Slope and Seepage Analysis Details

Design Permeability Values

Material Type	Soil Description	K_h		K_v/K_h	Rsulting K_v		Layer Color
		cm/s	ft/day		cm/s	ft/day	
Levee Fill	Primarily CL, ML	1.00E-05	0.028	0.25	2.50E-06	0.007	
	Primarily SM, SC	1.00E-04	0.28	0.25	2.50E-05	0.07	
Top Soil	Sandy, Silty, Clayey Loam	2.00E-04	0.56	1	2.00E-04	0.56	
Low to Medium Clay	Weathered Clay	1.00E-05	0.028	0.25	2.50E-06	0.007	
	Unweathered Clay at Depth	1.00E-05	0.028	0.1	1.00E-06	0.0028	
Sand	Fine Sand	5.00E-03	14	0.25	1.30E-03	3.5	
	Coarse Sand	2.00E-02	56	0.25	5.00E-03	14	
Slurry Cutoff Wall	Cement-Bentonite	1.00E-06	0.003	1	1.00E-06	0.003	
Inspection Trench	Sandy, Clayey, Silty Soil Mix	1.00E-05	0.028	0.25	2.50E-06	0.007	

San Joaquin River Restoration
Structural Option Description
Pre-Appraisal Level

Option No.	Structural Option Name		Revision Date
2b	Reach 2B Channel Capacity – Floodplain Work		28 Feb 2008
Reach Number	**River Mile**	**Program Goal**	**Phase**
2B	207.5 – 216.1	Restoration	I

Task	Responsible Author	Peer Reviewer
Floodplain modifications	Mussetter Engineering, Inc.	P. Romero

Costs (October 2007):
Cost Level: Pre-appraisal
Total Construction Cost: Not available at this time.
Project life: N/A

Objective of Option
Improve channel and floodplain to effectively convey 4,500 cfs within Reach 2B. The existing channel will convey 1,500 cfs and the floodplain will be developed to conveyance capacity of 3,000 cfs. This option form does not include the levee work or pump and well relocations. Additional options forms will include this work.

Performance Criteria
1. In channel conveyance capacity of 1,500 cfs
2. Floodplain capacity of approximately 3,000 cfs w/ an average depth above 1 foot.
3.
4.

Design Criteria
1. Reclamation Cost Estimating Guidelines with SJRR unit costs
2.
3.
4.
5.

Description
The proposed modifications to Reach 2B are designed to ensure an in-channel capacity of approximately 1,500 cfs, provide adequate fish passage, and allow safe passage of 4,500 cfs while creating additional overbank fish and riparian habitat. Reach 2B extends from the Bifurcation Structure downstream to the Mendota Dam. 7.5 miles of the left (south) levee and 1 mile of the right (north) levee will be relocated to provide conveyance in the floodplain. 200 acres of the floodplain will need to be cut to maintain conveyance. 114 acres of depression areas within the floodplain will need to be filled. Approximately 3,000 linear feet of canals will need to be relocated. Work in the active channel was not deemed necessary since channel has sufficient capacity to carry 1,500 cfs and provides adequate fish passage and habitat during restoration flows.

Construction Considerations
Excavation of floodplain will be used for borrow material for levees and the remaining excavation will be hauled up to 20 miles due to poor soils in some areas.

Schedule
N/A

Real Estate Requirements

- **Fee Purchase** 1075 acres of private land are located within the proposed levee alignment and must be acquired.

Coordination with Other Options

This option will need to be coordinated with the design of the Mendota Pool Bypass Channel and the design of the new 2B levees (part of this option). San Mateo Bridge (part of Option 22) will be modified once channel and levee designs are completed.

Operational and Maintenance Requirements

Future Requirements for Design

The level of design is very preliminary and much analysis is needed to further the reliable of the design. Next steps will include: 1) Refine plan and analysis for the existing channel capacity, 2) Refine acquired acreage with setback levee alignment that addresses landowner preferences and water rights, 3) Refine modeling to include adjacent proposed options and future conditions for restoration, 4) Develop floodplain revegetation plan for floodplain, 5) Verify canal relocation, and 6) Include more detailed topographic mapping. Refined costs of the options will require a more detailed location of adequate spoil areas and land costs. Permits that may be required prior to construction include: Nationwide Permit (404), water quality certification (401), Stream Alteration Agreement, Reclamation Board Encroachment Permit, Section 7 and/or 2081 Take Permits, CEQA and any applicable county permits.

Potential Environmental Impacts

- **Temporary (During Construction) –** Sedimentation from overland flow to the river. Air quality, biological, water quality, noise

Permanent (Operation-Related) – Changes to depth and velocities within the channel. Agricultural, biological, water quality, land use recreation, cultural

Sub-Options considered but Rejected

Developing floodplain north of river was rejected due to significant realignment of existing canal. Rework active channel to provide improved fish passage was rejected since adequate fish passage was assumed. Acquiring lands as flood easements was rejected to allow more control of the floodplain habitat. These assumptions will be analyzed further during next level of design.

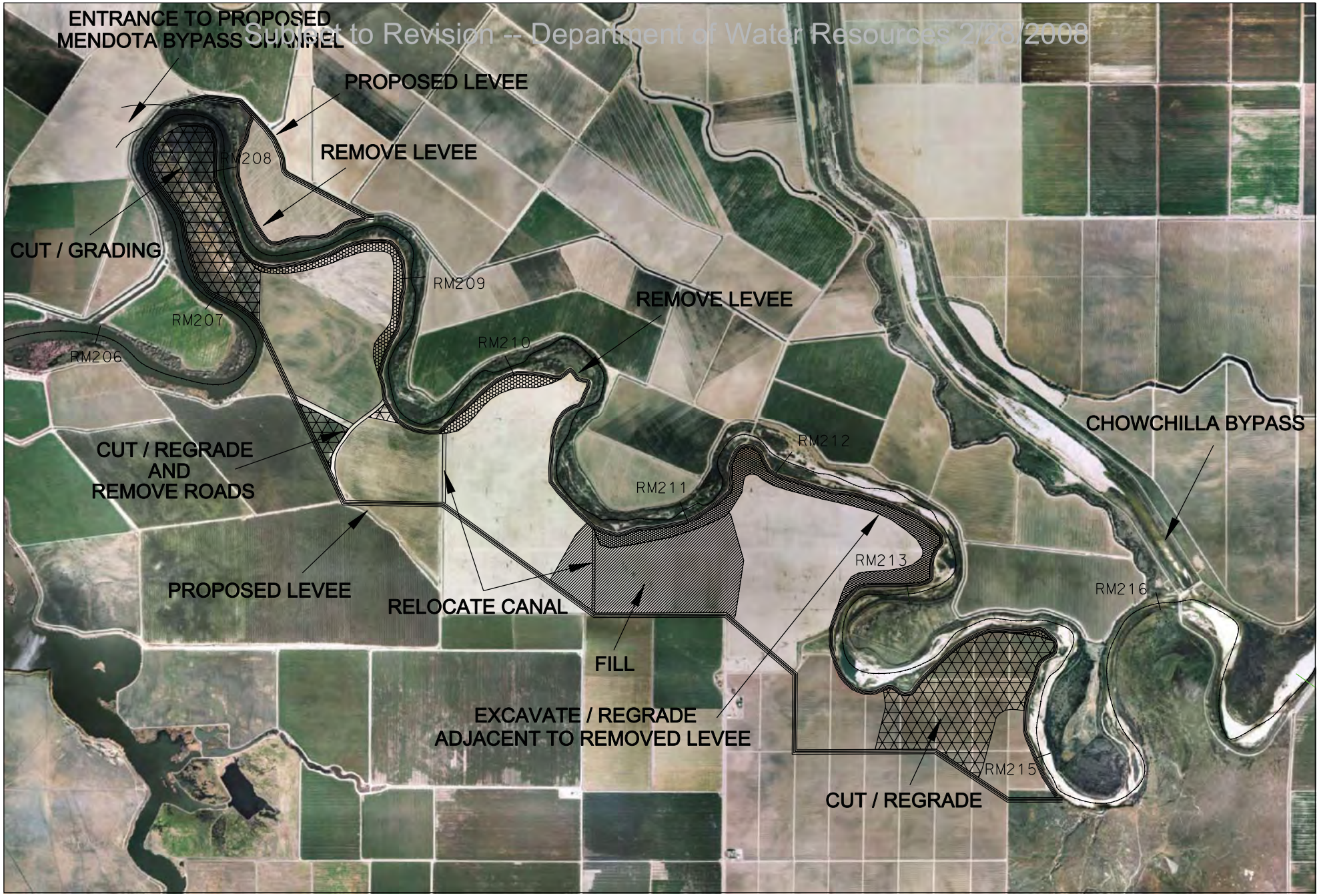
Drawings

2b-1 Reach 2B aerial plan view (Sheet 1)
2b-2 Cross section view river mile 207.8 (Sheet 2)
2b-3 Cross section view river mile 210.9 (Sheet 3)
2b-4 Cross section view river mile 212.3 (Sheet 4)

Figures

Attachments

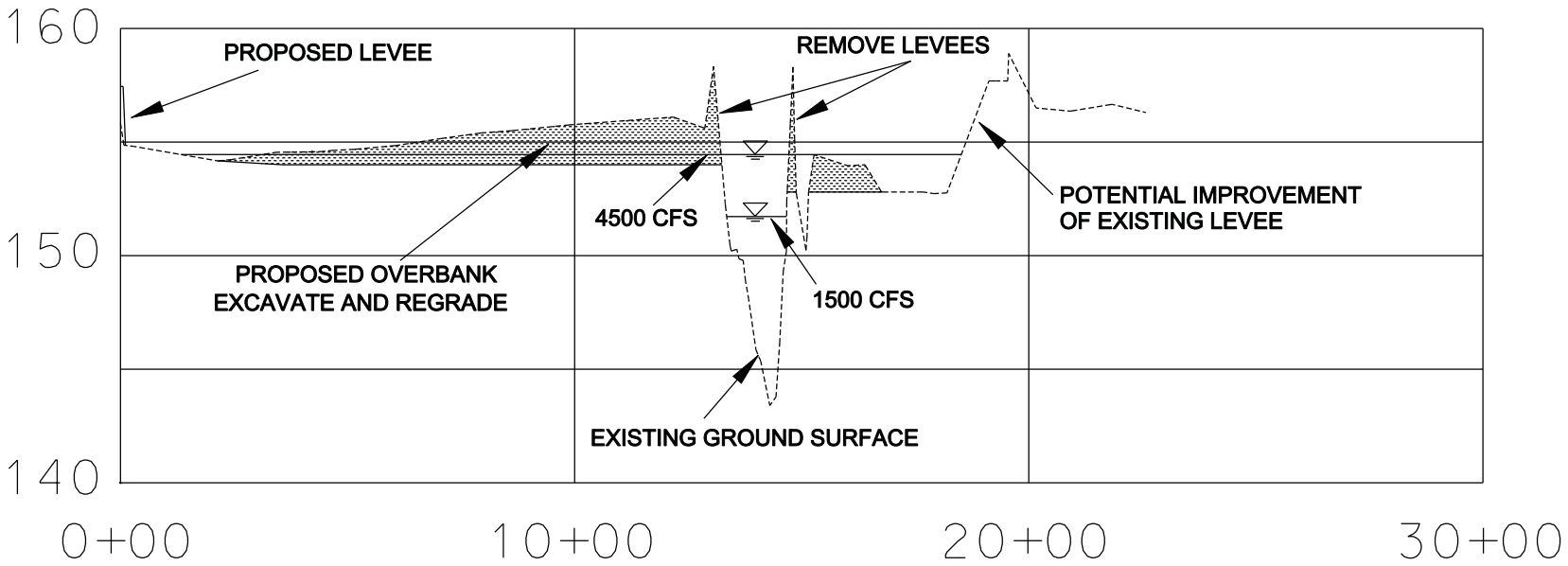
2b-1 Reach 2B Channel and Overbank Capacity TM
2b-2 Land Costs Memo



Sheet 1 of 4	Designed By: KJP Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	SAN JOAQUIN RIVER RESTORATION PROGRAM	AERIAL PLAN VIEW REACH 2B CONCEPTUAL SKETCH PROPOSED CHANNEL AND OVERBANK IMPROVEMENTS	0 600 1200 2400 N	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

Drawing 2b-1

CROSS SECTION (APPROX RM 207.8)

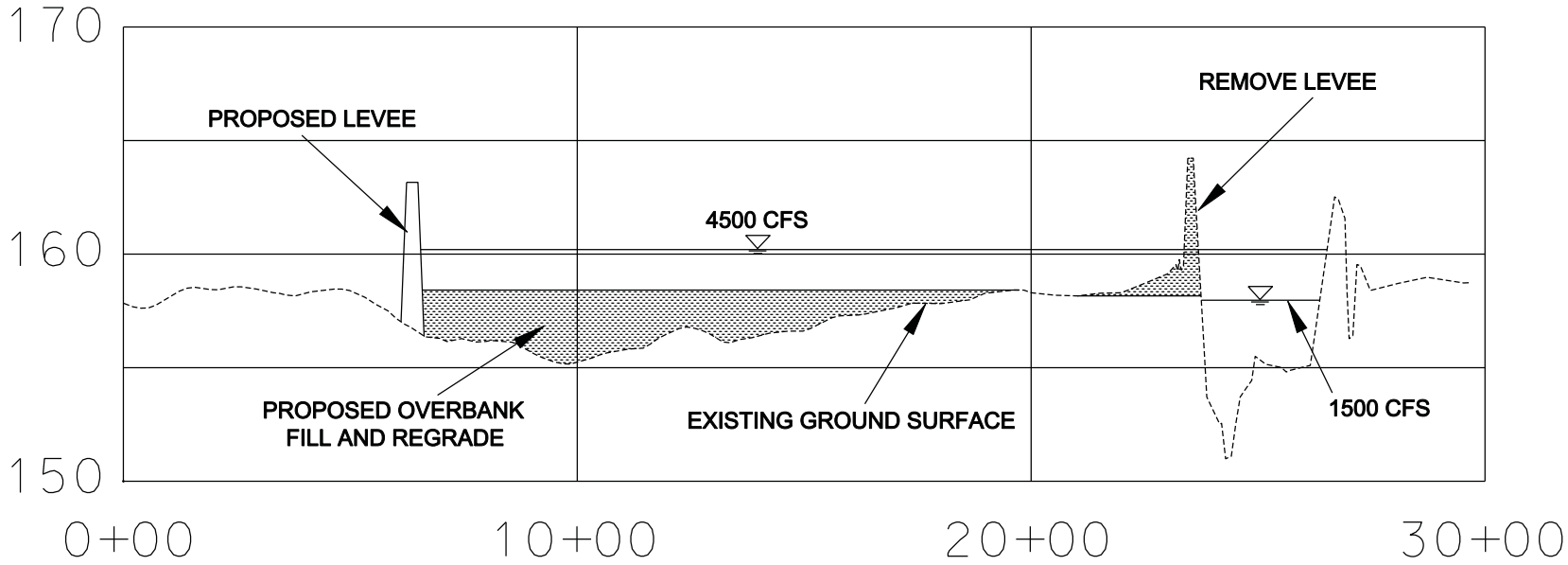


LOOKING DOWNSTREAM

Sheet 2 of 4	Designed By: KJP Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	SAN JOAQUIN RIVER RESTORATION PROGRAM	CROSS SECTION VIEW REACH 2B CONCEPTUAL SKETCH PROPOSED CHANNEL AND OVERBANK IMPROVEMENTS	SCALE HORIZ: 1"= 400' VERT: 1" = 8'	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

Drawing 2b-2

CROSS SECTION (APPROX RM 210.9)

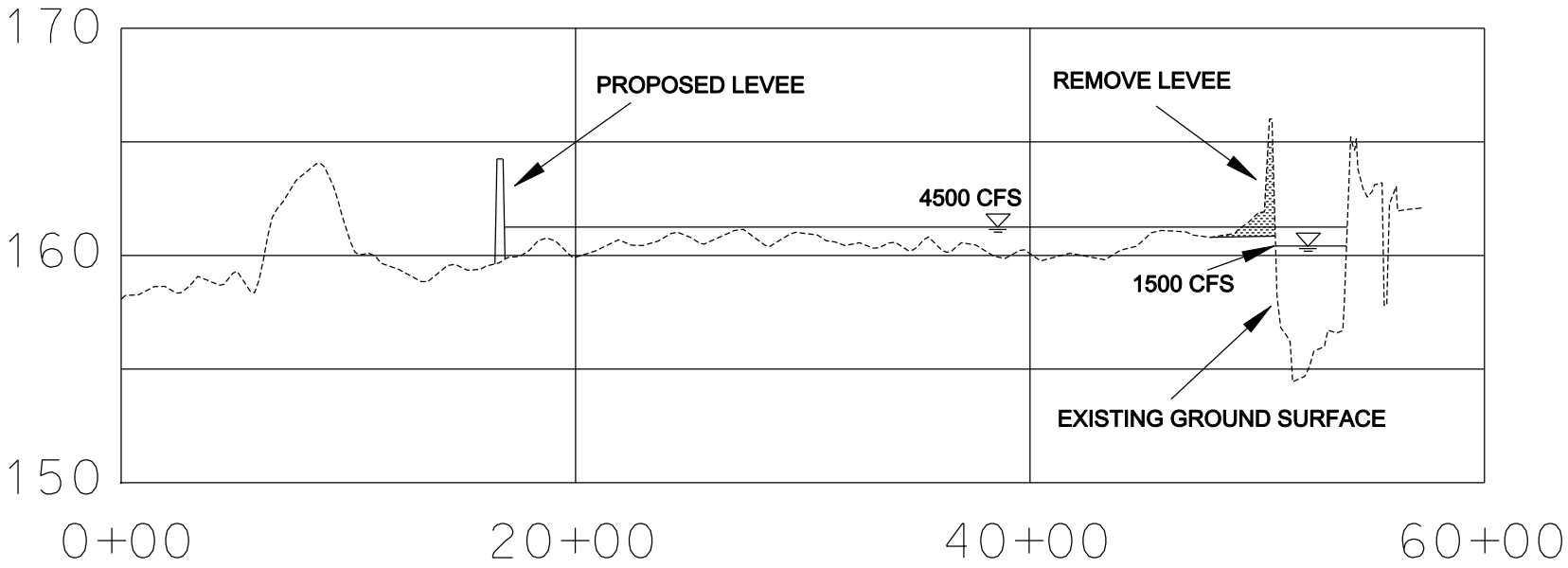


LOOKING DOWNSTREAM

Sheet 3 of 4	Designed By: KJP Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	**SAN JOAQUIN RIVER RESTORATION PROGRAM**	**CROSS SECTION VIEW** REACH 2B CONCEPTUAL SKETCH PROPOSED CHANNEL AND OVERBANK IMPROVEMENTS	SCALE HORIZ: 1"= 400' VERT: 1" = 8'	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

Drawing 2b-3

CROSS SECTION (APPROX RM 212.3)



LOOKING DOWNSTREAM

Sheet 4 of 4	Designed By: KJP Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	**SAN JOAQUIN RIVER RESTORATION PROGRAM**	**CROSS SECTION VIEW** REACH 2B CONCEPTUAL SKETCH PROPOSED CHANNEL AND OVERBANK IMPROVEMENTS	SCALE HORIZ: 1"= 800' VERT: 1" = 8'	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

Drawing 2b-4

San Joaquin River Reach 2B
Channel and Overbank Capacity Improvements

December 21, 2007

1. INTRODUCTION

This Technical Memorandum summarizes the results of an appraisal-level analysis to meet the terms of the Settlement Agreement between the Natural Resource Defense Council (NRDC), Friant Water Users Authority (FWUA) and the Federal Government in the upstream portion of Reach 2B of the San Joaquin River. Reach 2B extends from the Chowchilla Bypass Bifurcation Structure [River Mile (RM) 216.1] to Mendota Dam (RM 204.6). A bypass channel is proposed to carry flows around Mendota Dam. This memo presents proposed modifications to the portion of Reach 2B from the head of the bypass channel at approximately RM207.6 to the Bifurcation Structure. Mussetter Engineering, Inc. (MEI) conducted the work under a contract with the California Dept. of Water Resources (CDWR).

2. RESTORATION PLAN

The published design capacity of Reach 2B is 2,500 cfs. Although a significant portion of the existing levees in this reach can contain a higher flow based on their crest elevations, seepage and boils at these higher flows can result in levee failures (Mr. Chris White, CCID, personal communication).

The proposed modifications to Reach 2B are designed to create an in-channel capacity of approximately 1,500 cfs and within levee capacity of 4,500 cfs to provide adequate fish passage and create additional overbank fish and riparian habitat.

To increase the capacity to 4,500 cfs while simultaneously increasing the potential for riparian habitat within the floodplain, the left (south) levee and a small portion of the right (north) levee was set back to the alignment shown in **Figure 1**. The majority of the right (north) levees were left in place due to the significant existing canal infrastructure in that area. The setback levees will allow the overbank to convey more flow, hence lowering water-surface elevations and the pressure on the existing right (north) levee. It may still be necessary to structurally improve or raise the existing right (north) levees to safely contain the flow. This issue is being assessed by others and is not included in this memo. To ensure adequate floodplain conveyance, all elevated features such as roads and canals, as well as existing topography within the setback levees that would potentially block overbank flow were also removed. In-channel fish passage in Reach 2B is only affected by an existing dip crossing at San Mateo Ave. (Figure 1). This structure was redesigned to provide adequate fish passage. The details of the design are included in a separate technical memorandum.

3. MODEL DEVELOPMENT

The hydraulic modeling was based on an existing conditions model of the San Joaquin River from Friant Dam to Mendota Dam (MEI, 2002a), which was previously developed by MEI to evaluate conditions along the reach and assist in developing objectives of the Settlement Agreement. The modeling was carried out using the Corps of Engineers HEC-RAS computer software (USACE, 2005).

The model for this analysis was developed by extending and realigning the cross sections in the existing conditions model (MEI, 2002a) to accommodate the proposed levee alignment shown in Figure 1. The downstream boundary conditions for this analysis were lowered to reflect the proposed Mendota Bypass Channel, as described in MEI (2002b). Because the proposed levee alignment is beyond the limits of the detailed mapping for the reach, elevations for the cross section extensions were obtained from 1-meter vertical accuracy data collected in 2004 using Interferometric Synthetic Aperature Radar (IFSAR) mapping technology developed and compiled by Intermap Technologies Inc. Existing internal levee features were removed from the overbank portions of the cross-sectional geometry, but no changes were made to the model within the confines of the channel. For purposes of this preliminary analysis, the main-channel and overbank Manning's n roughness values were assumed to be the same as existing conditions, ranging from 0.035 to 0.061 within the channel, and from 0.045 to 0.1 in the overbank.

4. MODEL RESULTS

The revised Reach 2B hydraulic model was used to evaluate the capacity of the channel relative to a desired flow of 1,500 cfs, and to develop a levee setback alignment that will safely convey flows up to 4,500 cfs while providing additional overbank habitat. The model results were also developed to provide estimated water-surface profiles at the design flow of 4,500 cfs for use by DWR in assessing the adequacy of the existing north bank levees.

Based on the hydraulic results, the existing channel in Reach 2B has a capacity of approximately 1,500 cfs between the Bifurcation Structure and the inlet to the proposed Bypass Channel (**Figure 2**). The proposed overbank elevation is lower than the computed 1,500 cfs water surface elevation in 7 localized areas, but this will result in minimal overbank flow. This may warrant refinement in future phases of this work.

The proposed design flow of 4,500 cfs was also modeled. Figure 2 indicates that, at a flow of 4,500 cfs, overbank flow depths range from about 1 ft to 2 ft with the levee setback alignment. Figure 2 also indicates that some areas of the channel have the capacity to contain flows up to 4500 cfs.

5. PRELIMINARY COST ESTIMATE

Appraisal-level quantities and costs for the above described channel and overbank modifications in Reach 2B were developed. The estimate includes costs of land acquisition, earthwork costs to remove internal levees, excavation and grading of high areas that would impede overbank flow, filling of isolated low overbank areas, and removal and possible realignment of canals within the proposed levees. This cost estimate does not include

construction of the setback levees nor modifications to structures that are necessary to accommodate the flow of 4500 cfs. These are described in a separate memorandum.

The total estimated cost for the Phase I modifications in Reach 2B described above is approximately $61,060,000. An itemized breakdown of the costs is shown in the Cost Estimate Sheet **(Attachment 1**).

6. REFERENCES

Mussetter Engineering, Inc., 2002a. Hydraulic and Sediment Continuity Modeling of the San Joaquin River from Friant Dam to Mendota Dam, California, prepared for the U.S. Bureau of Reclamation, Fresno, California.

Mussetter Engineering, Inc., 2002b. Hydraulic Model of Mendota Pool Bypass. Prepared for Stillwater Sciences for the Friant Water Users Authority and Natural Resources Defense Council, September 18.

U.S. Army Corps of Engineers, 2005. HEC-RAS, River Analysis System, Users Manual, Version 3.1.3, Hydrologic Engineering Center, Davis, California.

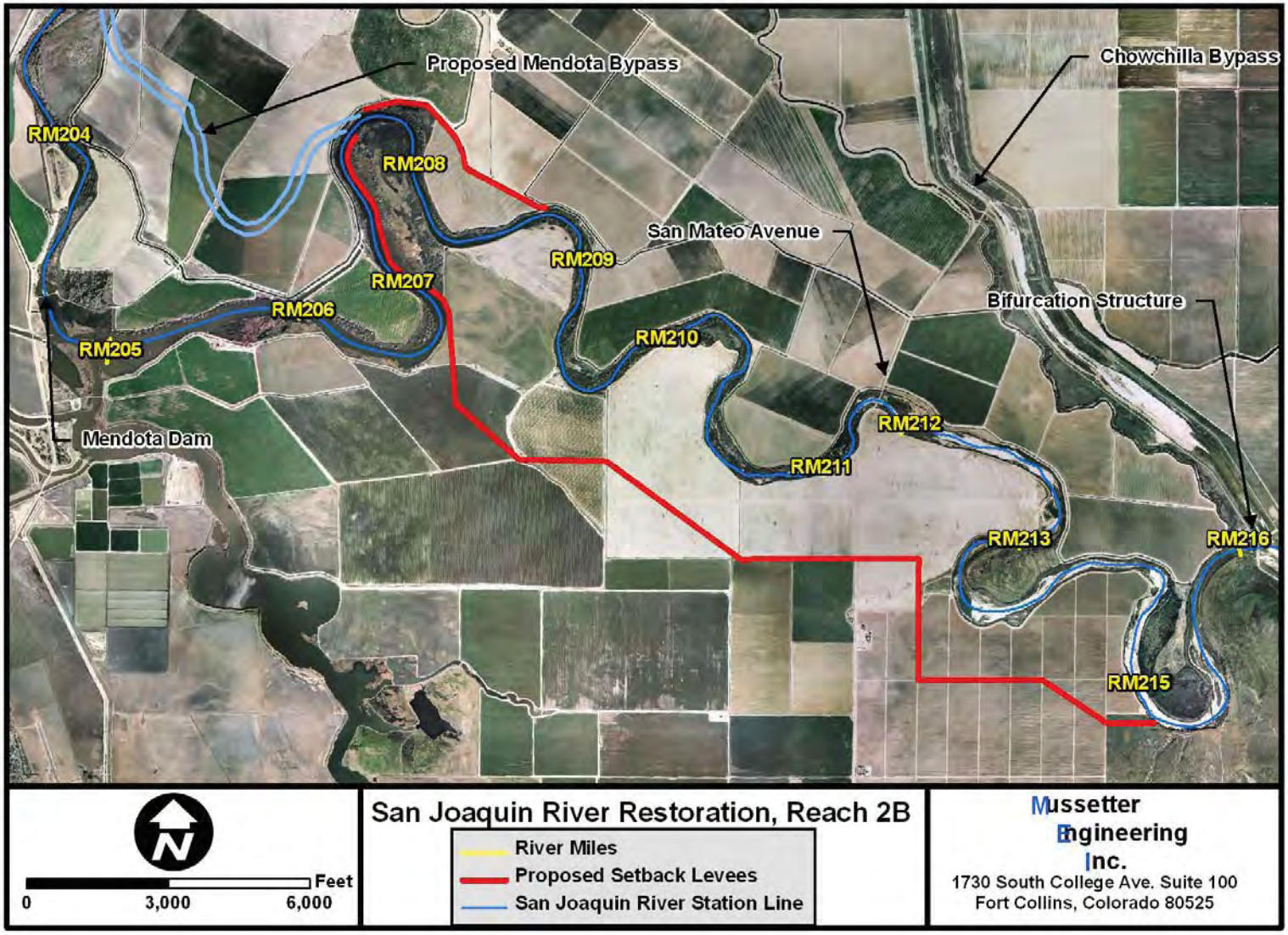


Figure 1. Computed water-surface profiles.

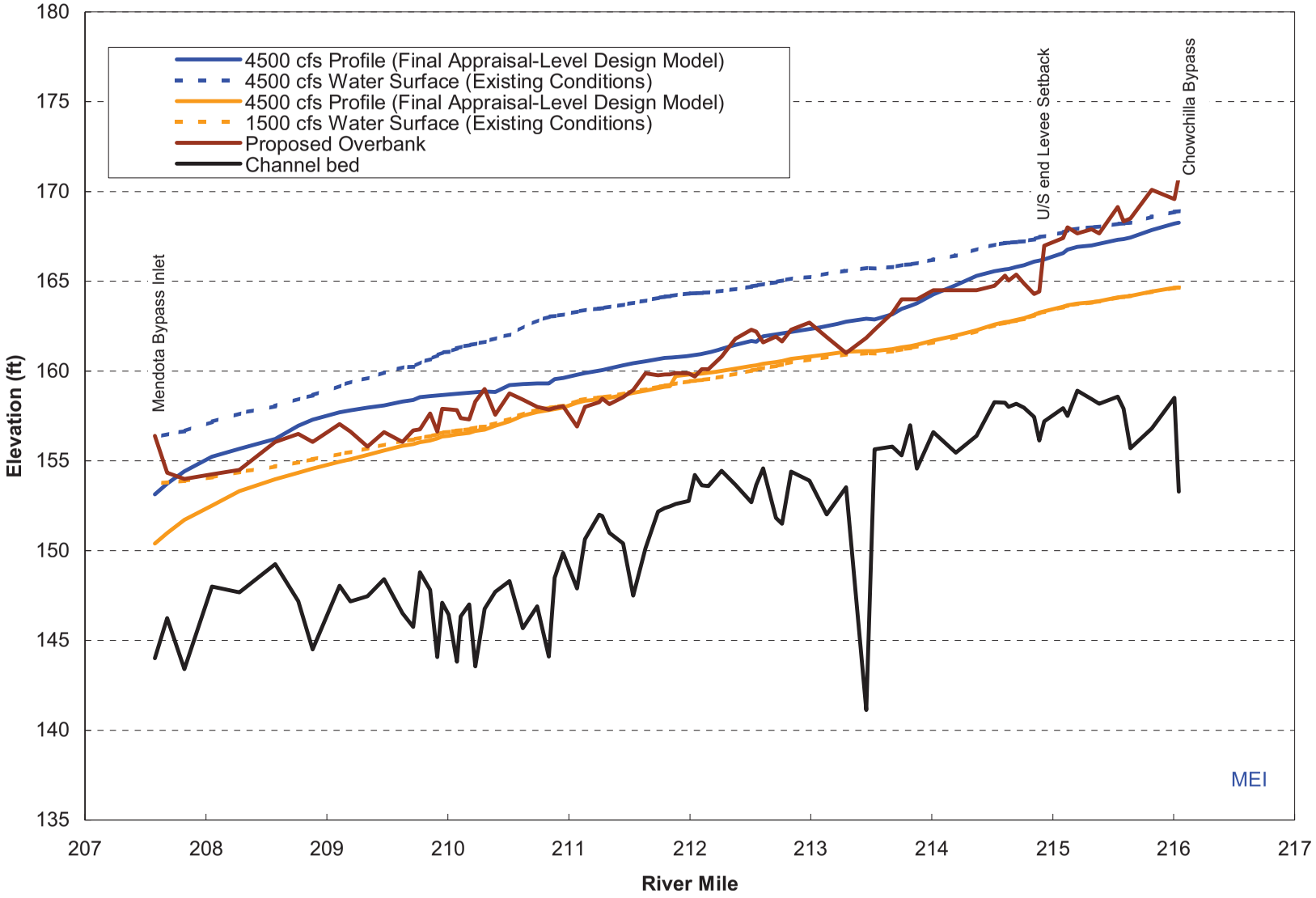


Figure 2. Aerial plan view, Reach 2B.

SAN JOAQUIN RIVER RESTORATION PROGRAM
LAND ACQUISITION COSTS
(Excerpts from Provost & Pritchard Summary Report to DWR)

Property Values

Property values in California have been volatile the last couple of years. P&P proposes a value of $30,000 per acre for acquisition of fee title land as a unit price for use in the appraisal level estimates. One unit price was selected for simplicity. A case can be made that different values could be applied for land in the “trough of the valley” and/or more distant from development. However, there should be recognition that values adjacent to the River would be higher due to severance of properties and potential impacts to water rights. The price will obviously vary depending on where the property is along the river, if there are permanent crops, irrigation systems, etc. on the property, and the parcel size. We are not appraisers, and therefore our discussion is based on limited information. Property has gone up significantly in California in the last couple of years. The market has slowed and may even be going down in price right now. Therefore, the price may be high.

The “Report of Supplemental Expert" from Tony Correia dated 9/19/2005 was provided by Mussetter Engineering and reviewed. This report is an analysis of the market values for land acquisition in the area surrounding reach 2B in 2005. The market analysis from sales of the 23 properties evaluated, ranged from $3,200 to $13,000 per acre for sales between March 2003 and July 2005. Very few of these properties were actually along the San Joaquin River. The higher value land was for properties with mature almonds. The actual appraisal ranged from $1,500/acre for “native land,” $6,000-7,000/acre for irrigated field crops, $10,000/acre for first leaf almonds, $12,000/acre for vineyards, and $14,000/acre for mature almonds. P&P attempted to contact Mr. Correia to see how values may have changed since 2005, but we were unable to discuss the previous report with Mr. Correia. The Correia report also indicates that damages due to the severance of facilities by dividing a property are not included in the price.

The 2005 Correia report also included the cost for purchasing wells at $135,000 per well. Estimates to construct a deep well, including pump and electrical are approximately $200,000 today. Well drillers have been so busy that it is difficult to even obtain a driller in the time period that one would want a well completed. California has been in a drought and well drillers are very difficult to even get to your site. Well prices have gone up significantly in the last few years also. It is unclear if Correia was assuming some sort of depreciation, or just what it would cost to re-drill a well for someone.

P&P contacted a realtor with 20 years experience who presently works for Pearson Realty. The realtor indicated that a large well known commercial farming company recently purchased some land along the San Joaquin River for $6,500/acre. The realtor did not think $8,000/acre was a bad number, and that he would use $10,000/acre if he

was estimating. When pressed if the realtor could find us some property for sale with almonds on it for $8,000/acre there was none available.

P&P made a call to a Merced County realtor regarding Merced County properties for a 20-25 acre parcel, and they indicated about $18,000-$24,000/acre. Instead of buying the properties in Merced County with structures on them, it is likely simpler and less expensive to move the proposed set-back levees.

For a recent pipeline project in eastern rural Fresno County not too distant from the San Joaquin River, the appraisal for the property was going for $30,000/acre for open ground without permanent plantings or irrigation systems. Four years ago, some land just southwest of Fresno was purchased for $8,500/acre by a local irrigation district. Recent appraisals for property in the same area, for a new project are on the order of $22,000-$25,000/acre. The properties in Reach 1A/2B/4B are property that would have the ability to have some sort of riparian water rights that also would add value with the property. If the State takes those lands, they may be severing the ability to maintain those riparian rights which would be expected to have a cost involved. Parcels in Reach 2B have the ability to pull out of Mendota Pool if they have surface water supply from the Central Valley Project.

DWR has indicated that the local conservancy has been paying about $20,000/acre on river bottom land in Reach 1A. We would question if there is additional value that the property owner receives? For example, the landowners counting part of their property valuation as a donation that is above and beyond the $20,000/acre price? This is often done by conservancies/land trusts, where they pay a portion in cash and give a portion as a taxable donation. Also, we would question if there were any sort of water rights involved in the sale of the property? A permanent transfer of water rights could be as much as $2,000/acre-foot depending on the type of right and where the water will be used (i.e. agricultural or municipal water). It should also be noted that if a property receives water from a canal company, the water from the canal company is associated with the ownership of stock in the canal company (a corporation) and is not tied to the land.

P&P used a value of $30,000/acre in our unit prices. We believe the Correia report is low. It could be argued that costs could be lower in some portions of the reaches covered. We concur. Since this was an appraisal level estimate, we used one number and did not get into the discussion and political sensitivities that could result from identifying varying values. We realize that there is information available that could substantiate a lower value and we were being conservative in our estimate. The $30,000/acre was intended to be the price that the current fee owner receives. Other costs of the acquisition including boundary research, land surveys, legal descriptions, etc. should be included elsewhere.

San Joaquin River Restoration
Structural Option Description
Pre-Appraisal Level

Option No.	Structural Option Name		Revision Date
2c	Reach 2B Channel Capacity—Relocations		28 Feb 2008
Reach Number	**River Mile**	**Program Goal**	**Phase**
2B	207.5 – 216.1	Restoration	I

Task	Responsible Author	Peer Reviewer
Relocations	Provost & Pritchard	P. Romero

Costs (October 2007):
Cost Level: Pre-appraisal
Total Construction Cost: Not available at this time.
Project life: N/A

Objective of Option
Improve floodplain to convey 4,500 cfs in Reach 2B using the existing channel. This option form only includes the relocations from expanding the floodplain. Option forms for the levee and floodplain work is included under separate form (except canal relocation).

Performance Criteria
1 Identify and relocate all structures and facilities as needed.
2
3
4

Design Criteria
1 Reclamation Cost Estimating Guidelines with SJRR unit costs
2
3
4
5

Description
The proposed modifications to Reach 2B are designed to ensure an in-channel capacity of approximately 1,500 cfs, provide adequate fish passage, and allow safe passage of 4,500 cfs while creating additional overbank fish and riparian habitat. Reach 2B extends from the Bifurcation Structure downstream to the Mendota Dam. 7.5 miles of the left (south) levee and 1 mile of the right (north) levee will be relocated to provide conveyance in the floodplain. 200 acres of the floodplain will need to be cut to maintain conveyance. 114 acres of depression areas within the floodplain will need to be filled. Approximately 3,000 linear feet of canals will need to be relocated. As part of the floodplain work and land acquisition, 6 wells need to be floodproofed and 15 lift pumps need to be relocated.

Construction Considerations

Schedule

Real Estate Requirements

- **Fee Purchase** - Land acquisition is included in the floodplain options form.

Coordination with Other Options

Operational and Maintenance Requirements

N/A

Future Requirements for Design

The level of design is very preliminary and much analysis is needed to further the reliable of the design. Next steps will include: 1) Refine floodplain widths and depths, 2) Refine acquired acreage with setback levee alignment that addresses landowner preferences, 3) Verify need to relocate (or abandon) pumps and wells and refine costs for all relocations. Permits that may be required prior to construction include: Section 7 and/or 2081 Take Permits, CEQA and any applicable county permits.

Potential Environmental Impacts

- **Temporary (During Construction)** –Air quality, biological, noise
- **Permanent (Operation-Related)-** Agricultural, biological, land use recreation, cultural

Sub-Options considered but Rejected

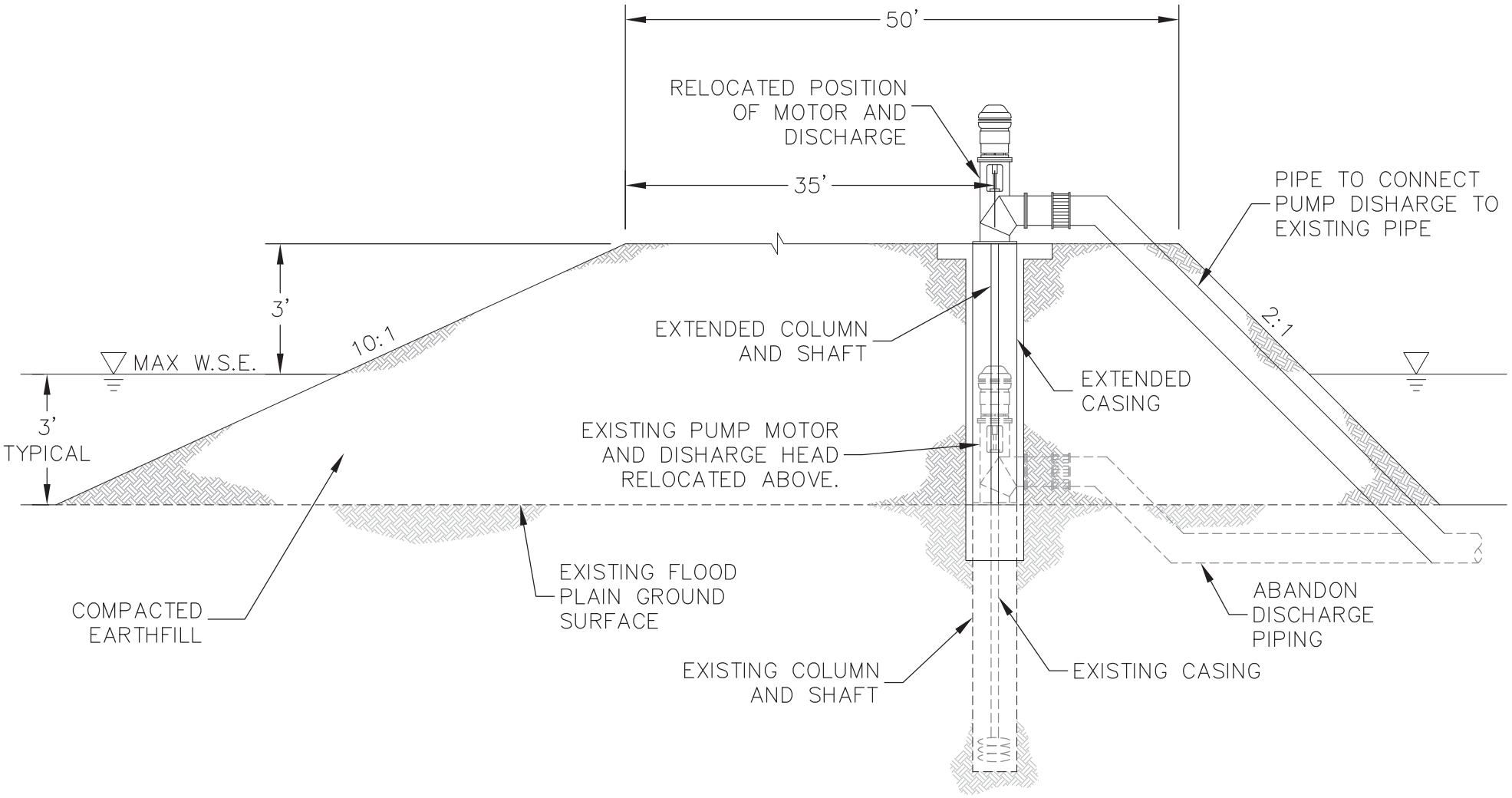
Relocating deep wells instead of floodproofing was rejected since it was assumed that floodplains would not be inundated frequently. Abandoning some pumps and wells was rejected to allow a conservative cost estimate. These assumptions will be further evaluated in the next level of analysis.

Drawings

Figures

2c-1 Typical Deep Well & Pump Floodproofing
2c-2 Pump Station Relocation Improvements

Attachments

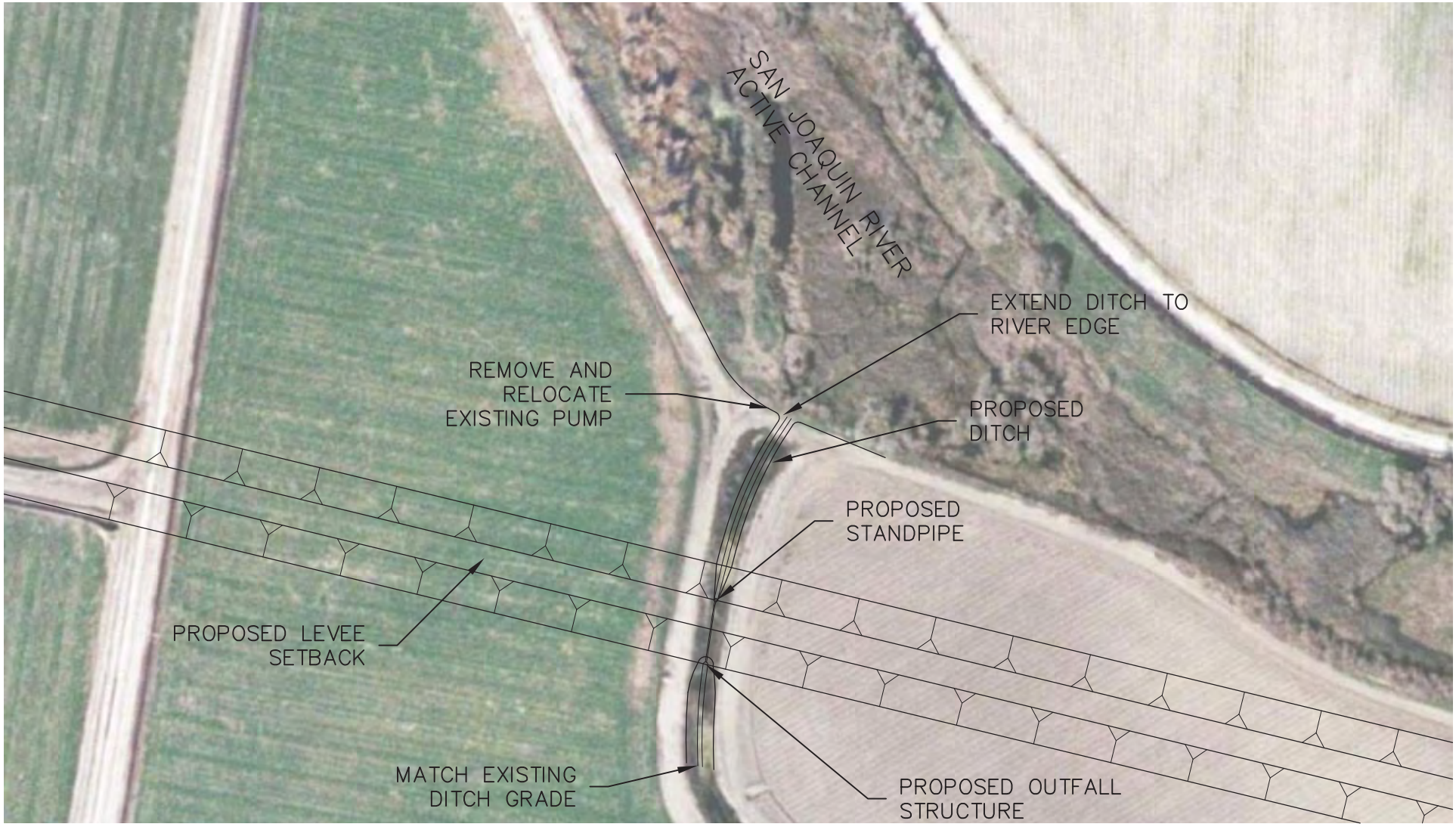


WELL SITE SECTION
NOT TO SCALE

EST. 1968
PROVOST & PRITCHARD INC
ENGINEERING GROUP
286 WEST CROMWELL AVENUE
FRESNO, CALIFORNIA 93711-6162
559/449-2700 FAX 559/449-2715

Figure 2c-1

TYPICAL DEEP WELL AND PUMP
"FLOOD PROOFING" IMPROVEMENTS
SAN JOAQUIN RIVER
DECEMBER 19, 2007

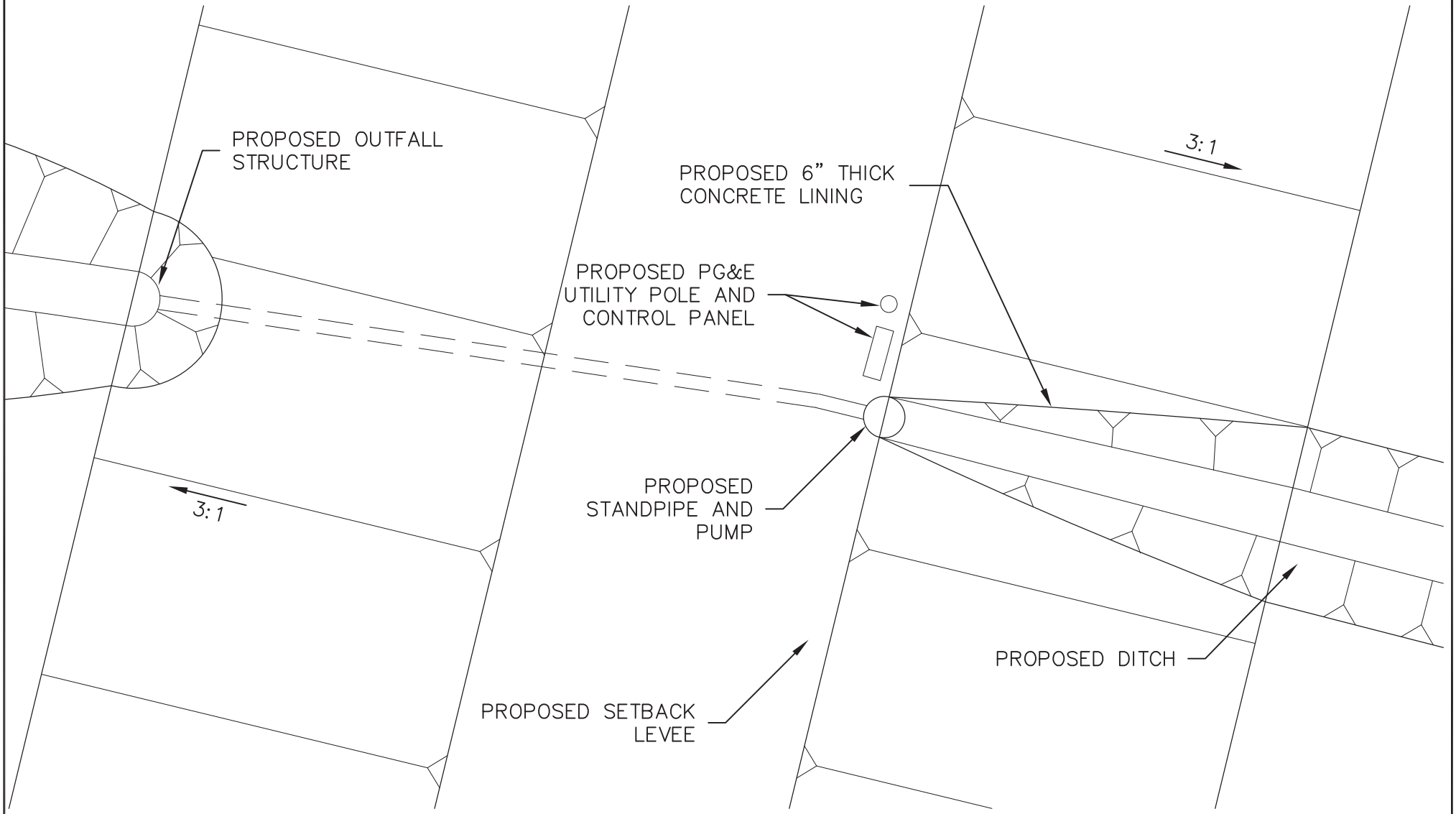


AERIAL PLAN VIEW

EST. 1968
PROVOST & PRITCHARD INC
ENGINEERING GROUP
286 WEST CROMWELL AVENUE
FRESNO, CALIFORNIA 93711-6162
559/449-2700 FAX 559/449-2715

Figure 2c-2 Sheet 1 of 3

TYPICAL PUMP STATION
RELOCATION IMPROVEMENTS
SAN JOAQUIN RIVER
REACH 2B/4B
DECEMBER 19, 2007

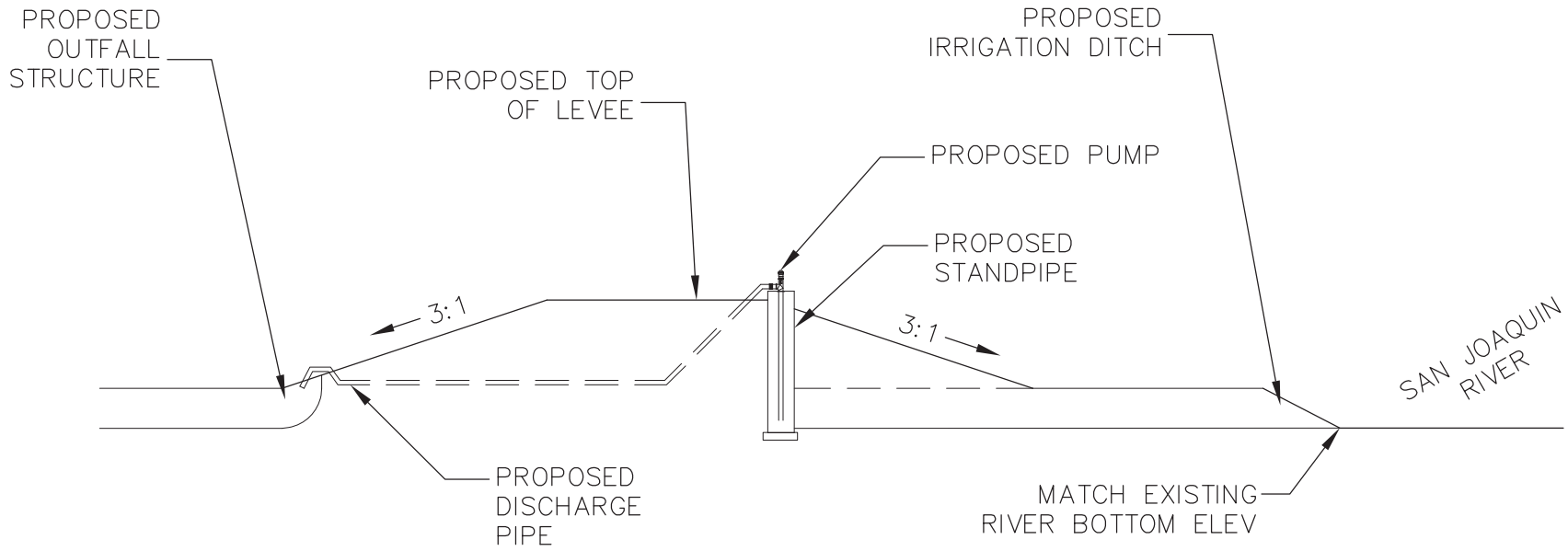


EST. 1968
PROVOST & PRITCHARD INC
ENGINEERING GROUP
286 WEST CROMWELL AVENUE
FRESNO, CALIFORNIA 93711-6162
559/449-2700 FAX 559/449-2715

Figure 2c-2 Sheet 2 of 3

TYPICAL PUMP STATION RELOCATION IMPROVEMENTS

SAN JOAQUIN RIVER
REACH 2B/4B
DECEMBER 19, 2007



PUMP STATION SECTION

NOT TO SCALE

EST. 1968
PROVOST & PRITCHARD INC
ENGINEERING GROUP

286 WEST CROMWELL AVENUE
FRESNO, CALIFORNIA 93711-6162
559/449-2700 FAX 559/449-2715

Figure 2c-2 Sheet 3 of 3

TYPICAL PUMP STATION
RELOCATION IMPROVEMENTS
SAN JOAQUIN RIVER
REACH 2B/4B
DECEMBER 19, 2007

San Joaquin River Restoration
Structural Option Description
Pre-Appraisal Level

Option No.	Structural Option Name		Revision Date
3	Reach 4B 475 cfs Channel Capacity		28 Feb 2008
Reach Number	**River Mile**	**Program Goal**	**Phase**
4B	168.5 - 135.8	Restoration	I

Task	Responsible Author	Peer Reviewer
Channel Modification	Mussetter Engineering, Inc.	P. Romero

Costs (October 2007):
Cost Level: Pre-appraisal
Total Construction Cost: Not available at this time.
Project life: N/A

Objective of Option
Achieve a channel capacity of 475 cfs in Reach 4B from Sand Slough to the Bear Creek confluence.

Performance Criteria
1 Contain a flow of 475 cfs within the main channel
2
3
4

Design Criteria
1 Reclamation Cost Estimating Guidelines with SJRR unit costs
2
3
4
5

Description
Evaluate and create, if necessary, a 475 cfs channel capacity in Reach 4B from the Sand Slough Control Structure downstream to the confluence with Bear Creek a distance of about 32 miles. Six sections have been identified as not meeting this criterion under existing conditions. The total length of these sections is approximately 12 miles. 8 miles will require the removal of in-channel vegetation to increase channel conveyance with a total surface area of 120 acres. 3.5 miles will require the removal of earthen material to widen the existing channel for a total of approximately 400,000 CY. Additional work in the active channel was deemed unnecessary since the channel was assumed to provide adequate fish passage and habitat during probable restoration flows.

Construction Considerations
Channel work will be performed when the channel is dry. Limited access with large equipment could significantly increase the cost of construction.

Schedule
N/A

Real Estate Requirements
Assumed that no permanent land acquisition is needed for this option.

Coordination with Other Options
The 475 cfs channel is part of Phase I of the Settlement. If a decision is made to skip Phase I of the Reach 4B work, the channel capacity will be part of Option 11 and may be significantly different.

Operational and Maintenance Requirements
N/A

Future Requirements for Design
The level of design is very preliminary and much analysis is needed to further the reliable of the design. Next steps will include: 1) Refine analysis for the existing channel capacity and need to create 475 cfs, 2) Refine modeling to include future conditions for restoration, 3) Develop channel revegetation plan and costs, 5) Include more detailed topographic mapping, and 6) Determine land acquisition needs and costs. Permits that may be required prior to construction include: Nationwide Permit (404), water quality certification (401), Stream Alteration Agreement, Reclamation Board Encroachment Permit, Section 7 and/or 2081 Take Permits, CEQA and any applicable county permits.

Potential Environmental Impacts

- **Temporary (During Construction)**

Air quality, biological, water quality, and noise. Sedimentation from overland flow to the river.

- **Permanent (Operation-Related)**

Biological, water quality, and cultural. Changes to depth and velocities within the channel.

Sub-Options considered but Rejected
Leaving the channel as-is was rejected to keep the Option in line with the Settlement. Evaluating the channel capacity only up to Mariposa Bypass was rejected (though this may be the intent of the Settlement) to obtain a conservative cost of this Option. Rework active channel to provide improved fish passage was rejected since adequate fish passage was assumed. These assumptions will be further evaluated in the next level of analysis.

Drawings
3-1 Reach 4B aerial plan view (Sheets 1 through 5)
3-2 Cross Section view river mile 166 (Sheet 6)

Figures

Attachments
3-1 San Joaquin River Reach 4B Channel and Overbank Improvements TM

Sheet 1 of 6	Designed By: MCB Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	SAN JOAQUIN RIVER RESTORATION PROGRAM	AERIAL PLAN VIEW REACH 4B CONCEPTUAL SKETCH PHASE 1 PROPOSED CHANNEL IMPROVEMENTS	0 400 800 1600 N	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

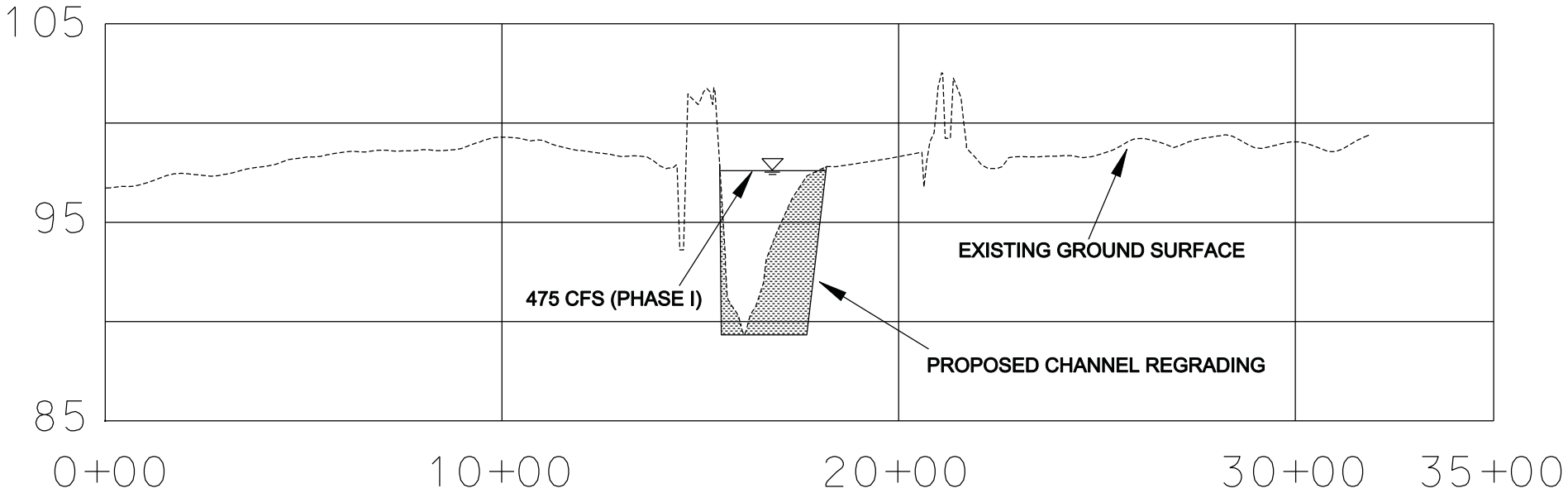
Sheet 2 of 6	Designed By: MCB Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	SAN JOAQUIN RIVER RESTORATION PROGRAM	AERIAL PLAN VIEW REACH 4B CONCEPTUAL SKETCH PHASE 1 PROPOSED CHANNEL IMPROVEMENTS	0 400 800 1600 N	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

Sheet 3 of 6	Designed By: MCB Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	SAN JOAQUIN RIVER RESTORATION PROGRAM	AERIAL PLAN VIEW REACH 4B CONCEPTUAL SKETCH PHASE 1 PROPOSED CHANNEL IMPROVEMENTS	0 400 800 1600 N	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

Sheet 4 of 6	Designed By: MCB Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	SAN JOAQUIN RIVER RESTORATION PROGRAM	AERIAL PLAN VIEW REACH 4B CONCEPTUAL SKETCH PHASE 1 PROPOSED CHANNEL IMPROVEMENTS	0 400 800 1600 N	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

Sheet 5 of 6	Designed By: MCB Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	SAN JOAQUIN RIVER RESTORATION PROGRAM	AERIAL PLAN VIEW REACH 4B CONCEPTUAL SKETCH PHASE 1 PROPOSED CHANNEL IMPROVEMENTS	0 400 800 1600 N	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

CROSS SECTION (APPROX RM 166)



LOOKING DOWNSTREAM

Drawing 3-2: Cross Section View RM 166

Sheet 6 of 6	Designed By: MCB Drawn By: MCI Checked By: CEM Approved By: RAM Job No: 07-27.8 Date: 12-21-07	SAN JOAQUIN RIVER RESTORATION PROGRAM	CROSS SECTION VIEW REACH 4B CONCEPTUAL SKETCH PHASE 1 PROPOSED CHANNEL IMPROVEMENTS	SCALE HORIZ: 1"= 400' VERT: 1" = 8'	Mussetter Engineering Inc. 1730 South College Ave. Suite 100 Fort Collins, Colorado 80525 (970) 224-4612

San Joaquin River Reach 4B
Channel and Overbank Capacity Improvements

December 21, 2007

1. INTRODUCTION

This Technical Memorandum summarizes the results of an appraisal-level analysis to meet the terms of the Settlement Agreement in Reach 4B of the San Joaquin River, in accordance with the terms of the Settlement Agreement between the Natural Resource Defense Council (NRDC), Friant Water Users Authority (FWUA) and the Federal Government. Reach 4B extends from the Sand Slough Control Structure [River Mile (RM) 168.5] to the confluence with Bear Creek (RM 135.8). (**Figure 1**) The work was conducted by Mussetter Engineering, Inc. (MEI) under a contract with the California Dept. of Water Resources (CDWR).

2. RESTORATION PLAN

The existing channel in Reach 4B does not meet the 475 cfs in-channel capacity required for Phase I, nor the in-levee capacity of 4,500 cfs required under Phase II of the Settlement Agreement (**Figure 2**). In order to meet these requirements, two phases of channel modifications were developed for this appraisal-level design:

1. Clearing of vegetation to reduce flow resistance and in-channel excavation to increase the channel width, as necessary to meet the 475 cfs capacity requirement, and

2. Removal of the existing local levees between RM150.8 and RM168.5 (17.7 miles) and construction of new levees that will be designed to accommodate flows of 4,500 cfs with three feet of freeboard. The alignment of the proposed new levees is shown in Figure 1.

To ensure adequate floodplain conveyance, all elevated features within the floodplain, such as roads, canals, and high topographic surfaces are to be removed.

3. MODEL DEVELOPMENT

An HEC-RAS (USACE, 2005) hydraulic model of Reach 4B was developed from an existing conditions HEC-2 model of the San Joaquin River that extends from Friant Dam to the Merced River (MEI, 2002). The original HEC-2 model was previously developed by MEI to evaluate hydraulic conditions along the reach to assist in developing restoration alternatives prior to the Settlement Agreement.

The existing conditions HEC-RAS model was developed by extending and realigning the cross sections on the original HEC-2 model to accommodate the proposed levee alignment (Figure 1). Because the proposed levee is beyond the limits of the available detailed mapping of the reach, elevations for the extended portions of the cross section were obtained from 1-meter vertical accuracy data collected in 2004 using Interferometric Synthetic Aperature Radar (IFSAR) mapping technology developed and compiled by Intermap Technologies Inc. Existing internal

levee features were removed from the overbank portions of the cross section. For purposes of this preliminary analysis, the main-channel and overbank Manning's n roughness values were assumed to be the same as existing conditions, ranging from 0.035 to 0.07 within the channel, and from 0.045 to 0.1 in the overbank. The downstream limit of the HEC-RAS model is at the San Joaquin River near Newman gage (USGS Gage No. 11274000); thus, the starting water-surface elevations were established based on the gage rating curve.

4. MODEL RESULTS

The above model was used to evaluate the existing channel capacity and to evaluate the proposed channel widening and levee setback conditions. The existing conditions results indicate that the in-channel capacity is less than 475 cfs in approximately 12 miles of the 18 mile reach. The limited capacity in approximately 8.5 of the 12 miles is caused by vegetation growing within the channel, which increases the flow resistance and deceases the channel capacity.

Removal of the vegetation was simulated in the model by reducing the main-channel roughness to 0.035. In the approximately 3.5 miles of the reach where the channel is under-sized, the existing cross sections were widened as necessary to meet the required capacity. Results from the revised model indicate that the proposed modification will provide the necessary conveyance (**Figure 2**).

The proposed design flow of 4,500 cfs was also modeled with the existing and project conditions models (Figure 2). Project conditions were modeled by removing the high topographic surfaces such as existing levees within the proposed levee boundaries. Low elevation areas within the new floodplain were filled in to eliminate potential for ponding during the recession limb of the flood hydrograph. The project conditions model indicates that the proposed levee setback design lowers the water-surface elevations at 4,500 cfs throughout the reach compared to existing conditions, with overbank flow depths ranging from 1 to 10 feet and averaging 3.5 feet.

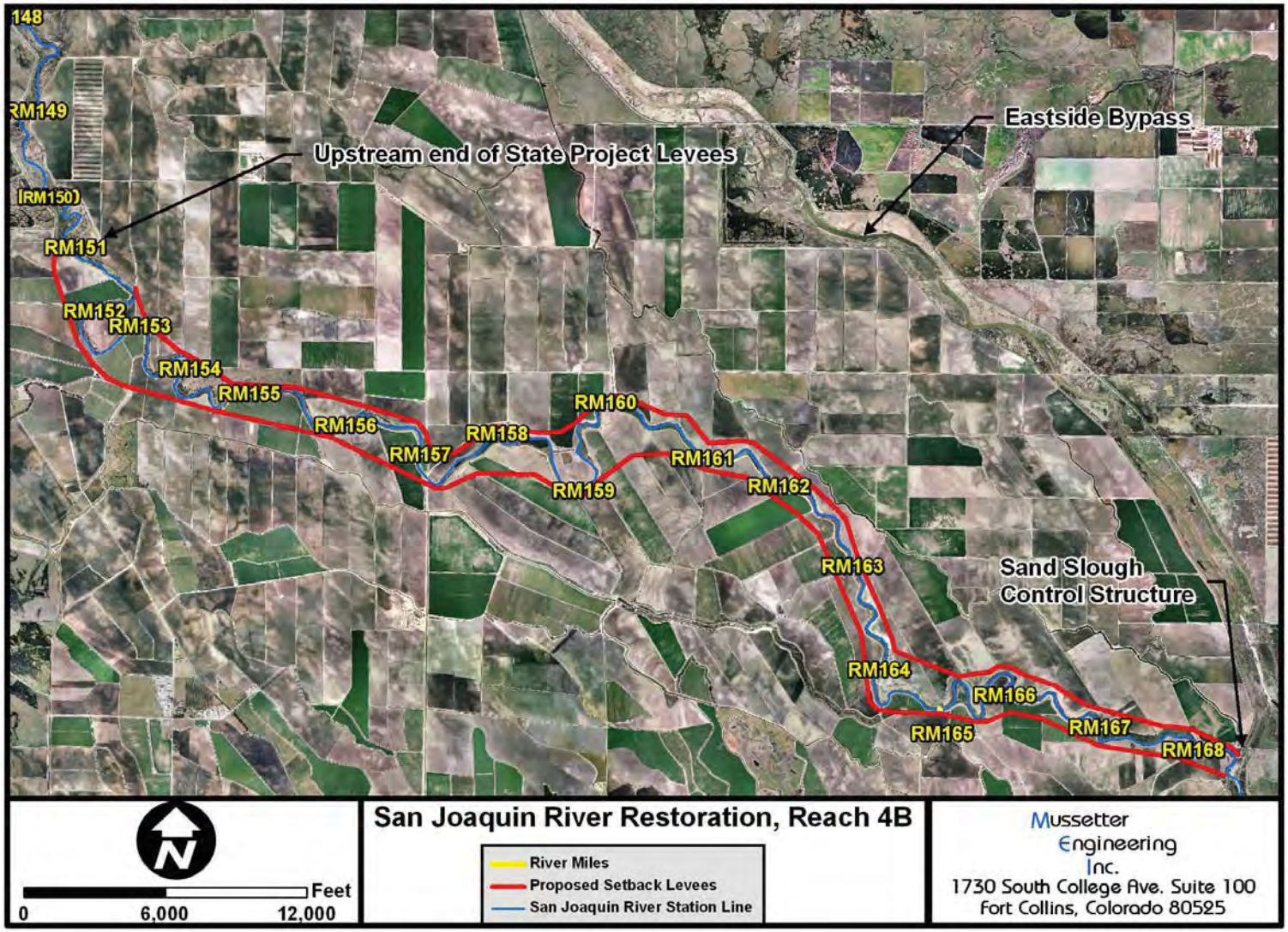


Figure 1. Site location map of Reach 4B showing the proposed setback levee alignment.

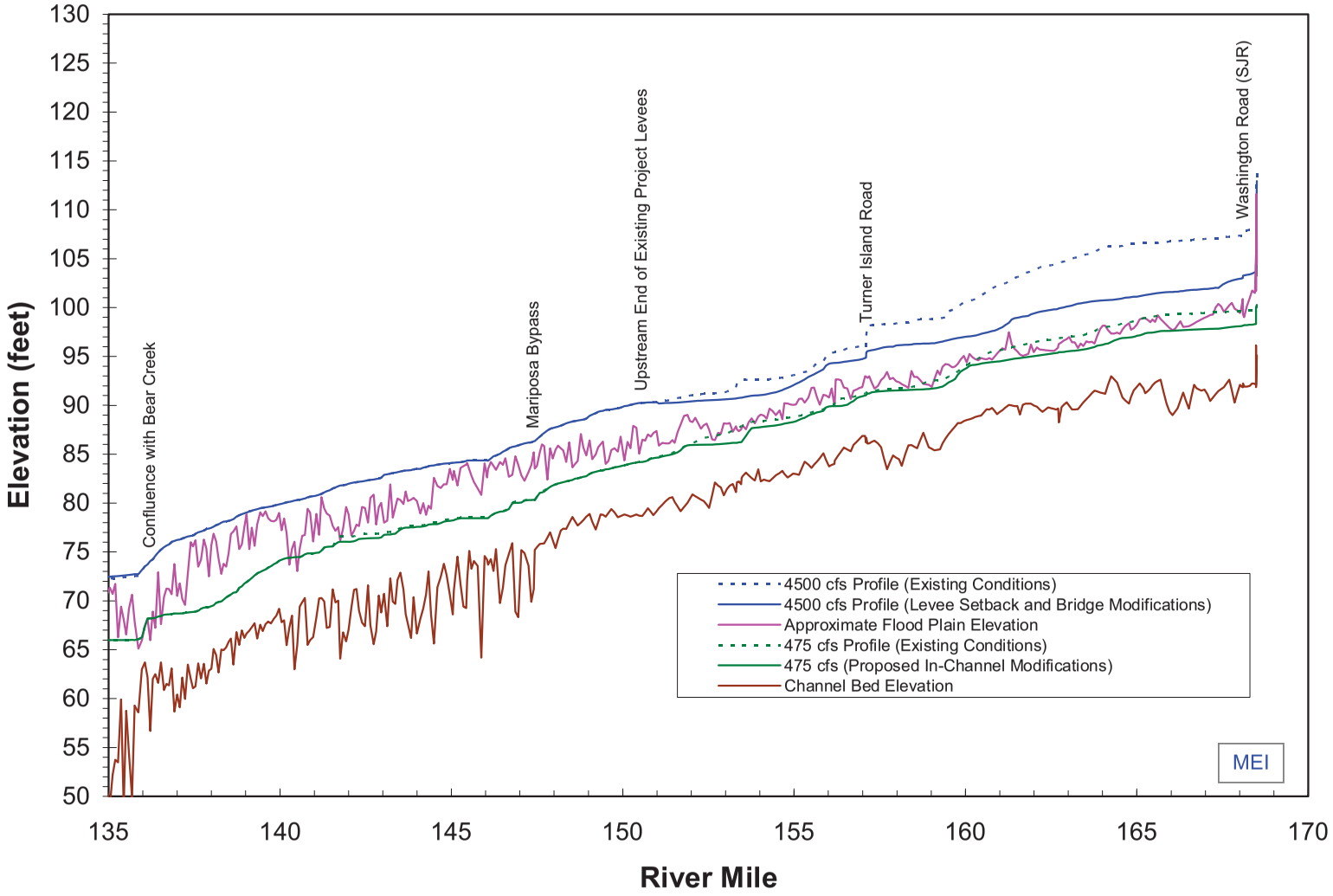


Figure 2. Comparison of the water-surface elevation for existing conditions and for the proposed channel modifications conditions (Phase 1 and II modifications) at a discharge of 475 and 4,500 cfs. The solid blue line represents the estimated water-surface profile at 4,500 cfs with the proposed levee setback alignment and modifications to the Turner Island and Washington Road Bridge that are described in a separate memo.

San Joaquin River Restoration
Structural Option Description
Pre-Appraisal Level

Option No.	Structural Option Name		Revision Date
4	San Joaquin River Headgate at Sand Slough		28 Feb 2008
Reach Number	**River Mile**	**Program Goal**	**Phase**
4B	168.5	Restoration	I

Task	Responsible Author	Peer Reviewer
Option Description	P. Romero	K. Faulkenberry
Engineering	G. Enas	P. Romero

Costs (October 2007):
Cost Level: Pre-appraisal
Total Construction Cost: Not available at this time.
Annual O&M Cost: Not available at this time.
Project life**:** Not available at this time.

Objective of Option
Increase the capacity of the Reach 4B Headgates to provide flow and fish passage for a range of flows up to 4,500 cfs.

Performance Criteria
1. Structure capacity provides 3 feet of freeboard for upstream levees at 4,500 cfs
2. Structure will pass flow and sediment to reduce sedimentation problems.
3. Automatic gate regulation based on impoundment water level
4.

Design Criteria
1. CA. DFG Restoration Manual, Chapter IX (2003)
2. NOAA NMFS salmonid passage criteria (2000)
3. Reclamation Cost Estimating Guidelines with SJRR unit costs
4.
5.

Description
Existing headgate structure will be removed and replaced with a gated structure to allow flow and fish passage for a range of flows up to 4,500 cfs. Actual design will be required to pass low flow requirements for adult (125 cfs) and juveniles (45 cfs) based on preliminary flow duration curves from Settlement hydrographs. Structure will incorporate four 20-foot wide gates to allow flow depth and velocity flexibility under a range of flows in Reach 4A and will have an automated gate operation. In this preliminary analysis, a fish ladder will not be required due to adequate depths to pass fish. Design velocities and depths for fish passage were based on DFG Restoration Manual, Chapter 9.

Construction Considerations
Construction will be performed when the channel is dry to reduce costs and environmental considerations.

Schedule

Real Estate Requirements

- **Fee Purchase** The structure will replace an existing structure on Project levees and it is not expected that lands will be purchased in fee.
- **Access Rights** The structure should be accessible from State property.
- **Permanent and Temporary Easements** Construction may require some temporary access to adjacent lands.

Coordination with Other Options

This option will be completed under Phase I of the Settlement. If the decision is made to permanently send fish and flows into the Eastside Bypass, there may not be a need to construct this option. If restoration flows to Reach 4B will not exceed 500 cfs, the existing structure may only be reconditioned to provide flow (and fish passage).

Operational and Maintenance Requirements

- **Operations**

It is expected that the structure will be operated automatically to provide adequate depths and velocities through the structure.

- **Maintenance**

The structure will require annual maintenance to ensure reliable and accurate operation. Maintenance will include operating the gates through its full operating range. Gates and gears will be lubricated as necessary. Periodic sediment removal may be required after high flow events.

- **Monitoring Requirements**

The structure will be rated and calibrated to allow accurate flow and depth measurements during operation. Periodic calibration will be required if significant channel or flow conditions are observed.

Future Requirements for Design

The level of design is very preliminary and much analysis is needed to further the reliable of the design. Next steps will include: 1) Refine design for specific location, 2) Perform surveys of area to refine design of structure, 3) Refine flow duration curves, 4) Refine modeling to incorporate higher resolution of fish passage evaluation and design and possible 2-D modeling of structure, 5) Evaluate the land acquisition, and 6) Perform geotechnical and soils analysis to account for local soils. Refined costs of the options will require a more detailed evaluation of price and source of concrete. Permits that may be required prior to construction include: Nationwide Permit (404), water quality certification (401), Stream Alteration Agreement, Reclamation Board Encroachment Permit, State Lands Permit, CEQA and any applicable county permits.

Potential Environmental Impacts

- Temporary (During Construction)-Air Quality, biological, water quality, noise
- Permanent (Operation-Related)-Noise, recreation

Sub-Options considered but Rejected

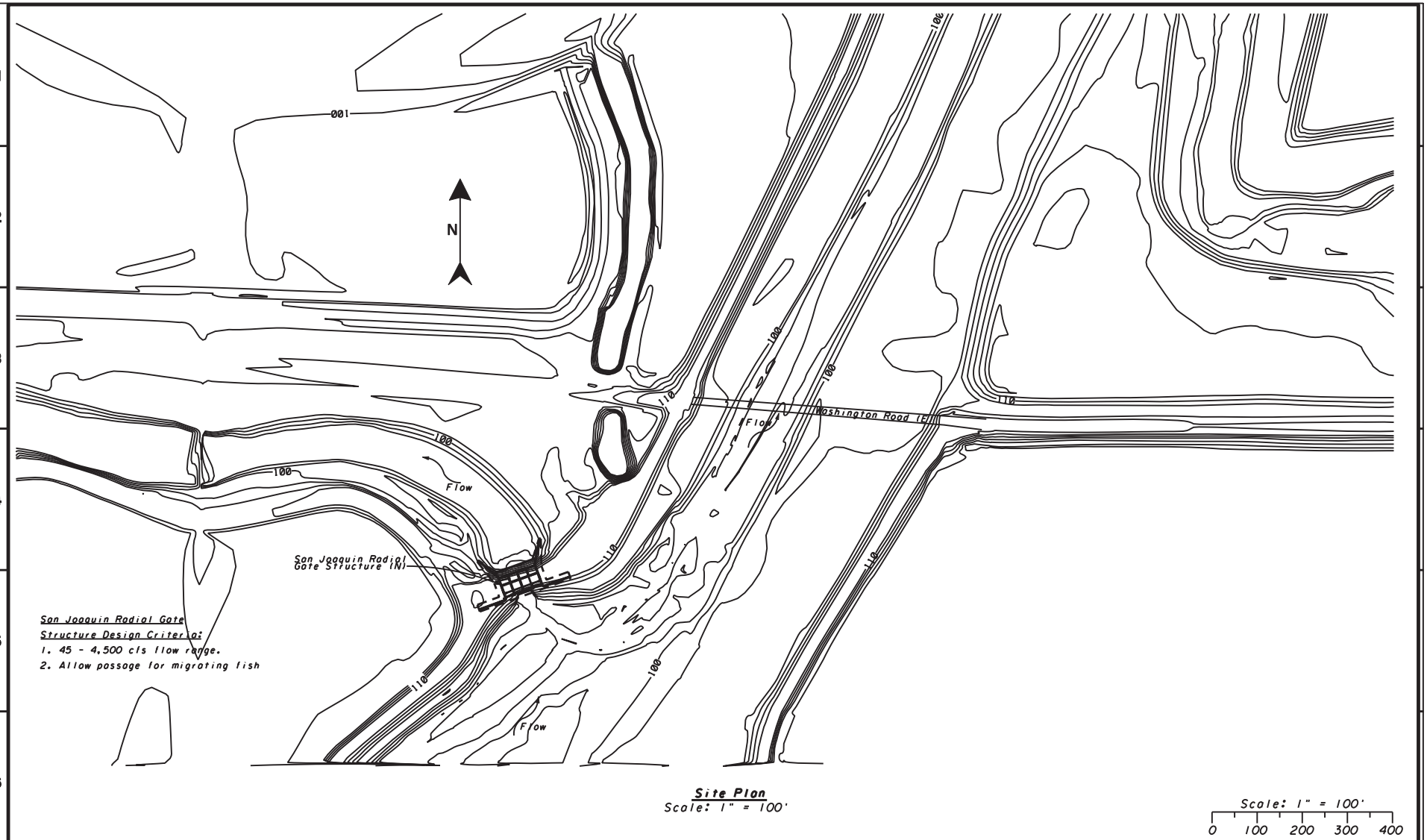
Modify existing structure to provide adequate flow and fish passage up to 4,500 cfs was rejected since existing structure has only 1,500 cfs capacity.

Drawings

4-1 Site and Structure Plan
4-2 Structure Profile view

Figures
4-1 Design Criteria Table

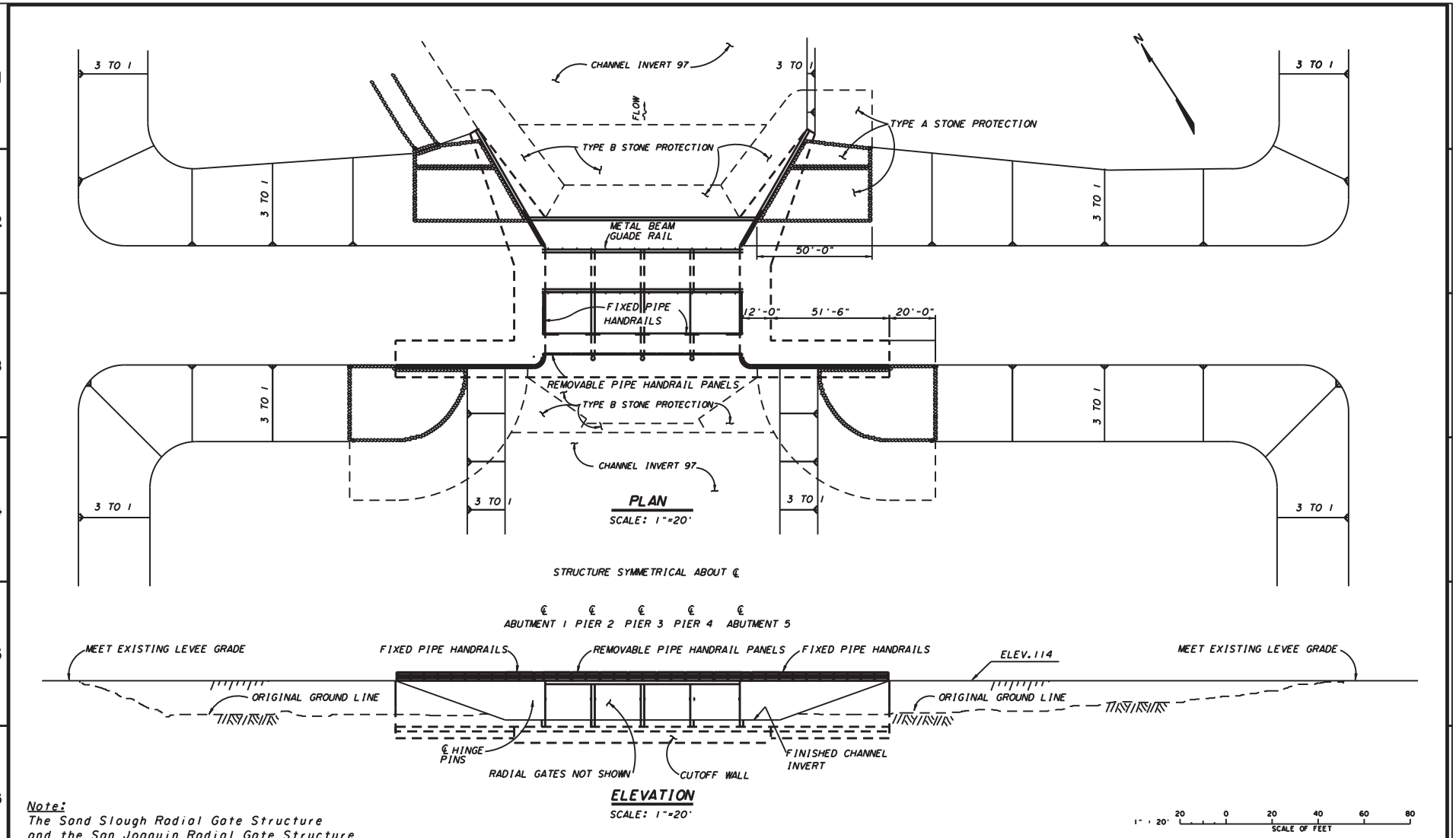
Attachments
4-1 Levee and Structures Draft Design Assumptions TM
4-2 Draft Fish Passage Criteria For the San Joaquin River Restoration Project TM



DESIGNED: G. Pandey	CHECKED:	APPROVAL RECOMMENDED:	STATE OF CALIFORNIA THE RESOURCES AGENCY	San Joaquin River Restoration	SPEC. No.
DRAWN: -NB-	REVIEWED:	APPROVAL RECOMMENDED:	DEPARTMENT OF WATER RESOURCES	San Joaquin River	DRAWING No. G1
SUBMITTED:		APPROVED: DATE:	DIVISION OF ENGINEERING	Near Sand Slough	REV. SHEET No. 01
REV. DATE DESCRIPTION SUB. APP'D			STATE WATER FACILITIES	Radial Gates	

Sand Slough.dgn 1/23/2008 11:00:46 AM

Drawing 4-1: Site and Structure Plan



Note:
The Sand Slough Radial Gate Structure and the San Jooquin Radial Gate Structure are identical.

DESIGNED	
CHECKED	
DRAWN	Y. Liu
REVIEWED	
SUBMITTED:	
APPROVAL RECOMMENDED:	
APPROVAL RECOMMENDED:	
APPROVED: DATE:	

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

San Jooquin River Restoration
Sand Slough and San Jooquin
Radial Gate Structures

SPEC. No.
DRAWING No. C1
REV. SHEET No. 04

Sand Slough.dgn 1/23/2008 11:03:45 AM

Drawing 4-2: Structure Profile View

Table 1

San Joaquin River Restoration Program

Design Criteria for Appraisal Designs of Structures

Structure	Description	Species	Life Stage		Flow Range*		Passage **		Design Criteria & Comments
			Juvenile	Adult	Low	High	Screen	Passage	
Chowchilla Bifurcation	SJR Structure	Chinook	X	X	125 Juve 205 adult	4,500		X	Existing control structure will be retrofitted for fish passage. Modified structure will pass flows into the San Joaquin River without increasing upstream water surface elevations in Reach 2A from existing conditions and with 3 feet of freeboard at 4,500 cfs (which should not be a problem since the structure is similar to Chowchilla Bypass structure. At this level of analysis, HEC-RAS modeling can be used to determine stage on the existing and new structures.
	Bypass Structure	Chinook	X	X	N/A	2,000	X	X (exist structure)	Design new screened structure to allow 2,000 cfs (or greater if capacity is available) in Chowchilla Bypass. The new structure will be placed to the west of current flood control structure to reduce issues with sedimentation. The existing structure will remain. New structure will prevent fish passage and entrainment and maintain 3 feet of freeboard on the existing levees at maximum operation (which is assumed to be flows up to 6,500 cfs in Reach 2A). Flows over 2,000 cfs will enter the bypass through the existing structure, allowing flow and fish into the bypass. In future analyses, the new structure may be evaluated to prevent fish entrainment at a maximum water surface elevation that occurred in high flows of 2006 (even though existing gate opened, new structure may be used as necessary to increase flood protection for flows over 8,000 cfs.) Existing structure will need to pass fish for flows above 2,000 cfs.
Sack Dam		Chinook	X	X	45 Juve 125 adult	4,500		X	Existing structure will be modified with a fish ladder to provide appropriate fish passage. Modified structure will maintain existing heads for Arroyo Canal diversion while not increasing heads during flood flows. Need to determine heads for Arroyo Canal diversion.
Reach 4B Headgate		Chinook	X	X	45 Juve 125 adult	4,500		X	New structure will be required with appropriate fish passage. New structure will pass 4,500 cfs without increasing upstream water surface elevations from existing condition. Since no data is likely available, structure should pass 4,500 cfs with 3 feet of freeboard on the upstream levees.
Sand Slough Control Structure	Phase 1–No fish in bypass	Chinook	X	X	N/A	4,500	X		New structure will be required to allow flow but not fish in bypass. All fish will be routed into Reach 4B. New structure will pass flows up to 4,500 cfs with a minimum of 3 feet freeboard on existing upstream levees.
	Phase 1--Fish in bypass	Chinook	X	X	45 Juve 125 adult	4,500		X	New structure will be required with appropriate fish passage. New structure will be designed to allow all fish and flows into bypass up to 4,500 cfs with a minimum of 3 feet freeboard on existing upstream levees.
	Phase 2	Chinook	X	X	N/A	4,500			This new structure will prevent flows and fish into the bypass. Gates will be provided in the structure to allow flows up to 4,500 cfs into the bypass to provide flood flexibility. Since all flows and fish will generally enter Reach 4B, no fish passage will be included. Flows up to 4,500 cfs can be routed with a minimum 3 feet freeboard on the upstream levees.
Mariposa Bypass	Control Structure at Eastside Bypass	Chinook	X	X	45 Juve 125 adult	8,500		X	Existing structure will be retrofitted for fish passage. Structure will pass 8,500 cfs into the Mariposa Bypass with a minimum 3 feet freeboard on the upstream levees.
	Drop Structure	Chinook	X	X	45 Juve 125 adult	8,500	X ?	X	Existing structure will be retrofitted for fish passage under Phase 1. Structure will pass 8,500 cfs into the Mariposa Bypass with a minimum 3 feet freeboard on the upstream levees. Under Phase 2, the structure will need to evaluated to verify that it is an adequate barrier to upstream passage. Additional analysis may be need to evaluate if the drop structure is a barrier, but too far away from the river and will strand fish. This analysis will be performed in the next level of analysis.
Eastside Bypass	Barrier Structure above Sand Slough	Chinook	?	?	2,000	5,500		Barrier	The barrier structure may be needed to be evaluated if the Eastside Bypass will convey flow and fish. The need for the structure will be during times when the Chowchilla Bypass is flowing. The need for this structure has not been evaluated and will be looked at with an evaluation of the flood events.
	Control Structure at Mariposa Bypass	Chinook	?	?	?	13,500	?	?	Do we need to screen this structure for fish passage for flows greater than 8,500 cfs in the bypass? Assumed that no modification will be done at this level of effort and future analysis is needed to evaluate the need for fish passage during high flood events.
	Control Structure at San Joaquin River	Chinook	?	?	?	?	?	?	The need for this structure has not been evaluated.
San Joaquin River at Mariposa Bypass		Chinook	?	?	?	?	?	?	The barrier structure may need to be evaluated if the Eastside Bypass will convey flow and fish. At this time, the need for the structure is unknown and it will be determined in a later analysis.

Notes:

* Low passage flows are based on DFG Habitat Restoration Manaul, Part IX. 95% exceedance flow for juveniles and 50% exceedance flow for adult anadromous salmonids. Low flows values are preliminary. High passage flows are maximum restoration release or channel design capacity.

** Passage is assumed to be upstream adult and downstream juvenile

12/13/2007

Figure 4-1: Design Criteria Table

Memo

To: Kevin Faulkenberry
From: Paul Romero
Date: 1/11/2008

Re: Assumptions for Levee and Structures Work from Reach 2A to Reach 4B

The following information and assumptions were developed to allow an understanding of the information that we had and assumptions that were made to formulate the appraisal-level designs. Many of the information and assumptions are very sketchy and are based on my understanding of the restoration program, flood operations, and channel characteristics. In Table 1 (attached), I have put together a summary of how these assumptions (and your fisheries information) will affect the designs of the structures. I assume further work will be done to firm up these assumptions. I also assume that comments to this memo and Table 1 from the engineering group and fisheries group will better define the designs.

Reach 2A

General Information

- Seepage problems occur as levee get higher. Reggie Hill's comments state that seepage problems start around MP 220.0.
- Channel capacity, reported at 8,000 cfs has significant space for 4,500 cfs flows with 3 feet of freeboard.
- Levee stability is the main issue that the program needs to address in this location and drilling will assist in this determination. Seepage issues can also be significant during high flows.
- Structures will need to pass 4,500 cfs flows without increasing head for maximum anticipated flood events—assume 1986, 1997, and 2006 floods as maximum flood events.
- SJR and Chowchilla structures at the bifurcation are similar with the exception of a trash rack at the SJR structure.
- Structures will need to pass 8,000 cfs without increasing the flood elevations from existing conditions.
- Existing gates on the Chowchilla Bypass control structure will not be modified, so the system can operate as it does currently. Screened gates will be added and may provide additional flexibility during floods when needed.
- A fish screen will be designed at Chowchilla Bypass to pass flows up to 2,000 cfs without letting fish into the bypass. Flows greater than 2,000 cfs will be released unscreened (a flow that is expected to be adequate for fish passage).

Appraisal-level Design Assumptions

- Levee analysis will only address levee stability in this reach. If stability is fine, seepage issues will not be addressed (though it should be reduced).
- San Joaquin River control structure at Chowchilla Bypass will be evaluated and, if necessary, retrofitted for fish passage. Structure will pass flows into the San Joaquin River without increasing upstream water surface elevations in Reach 2A from existing conditions and with 3 feet of freeboard at 4,500 cfs. Since this structure is similar to the Chowchilla Bypass structure, passing 4,500 cfs with 3 feet of freeboard should not be a problem.
- Chowchilla Bypass control structure at SJR will be retrofit with a new screened structure to allow 2,000 cfs into the bypass. The new structure will be placed to the west of current flood control structure to reduce issues with sedimentation. New structure will prevent fish passage and entrainment and maintain 3 feet of freeboard on the existing levees at maximum operation (which is assumed to be flows up to 6,500 cfs in Reach 2A). The existing structure will remain to allow the flood control structure to operate as existing. Flows over 2,000 cfs will enter the bypass through the existing structure, allowing flow and fish into the bypass (it is assumed that flows greater than 2,000 cfs will be adequate for fish passage in the bypass). In future analyses, the new structure may be evaluated to prevent fish entrainment at a maximum water surface elevation that occurred in high flows of 2006 (even though existing gate opened, new structure may be used as necessary to increase flood protection for flows over 8,000 cfs.) The existing structure will need to pass fish for flows above 2,000 cfs.
- The eventual design of the fish screen will likely need to accommodate the peak pulse flow from Friant Dam. Since the upstream channel can pass 8,000 cfs, a routing of this pulse flow and the resulting peak may require the screen to handle a flow larger than 6,500 cfs so fish are all sent into the river. However, I assume that the designed peak hydrograph will be formulated so that the attenuated peak at the Chowchilla Bypass will be not greater than 4,500 cfs.
- At this level of analysis, existing HEC-RAS models will be used to determine stage on the existing and new structures
- Change in n-values due to increase water flow or riparian habitat restoration will not be taken into account at this level of analysis.

Reach 2B

General Information

- The MEI determination of setback levee needs to be verified if adequate for appraisal-level design. If adequate, assume that the south levee will be set back and the north levee will be raised or strengthened as needed. Levees will have 3 feet of freeboard minimum.
- Assume Mendota Pool hydraulics will be the same as MEI has previously modeled (this analysis did not include the Mendota Pool bypass channel). Mussetter is currently updating the hydraulics, but this information will not be timely enough for our analysis.

- Levee stability is the main issue that the program needs to address in this location and drilling will assist in this determination. Seepage issues can also be significant during high flows.
- The SJ Exchange contractors have the ability to take 2,500 cfs from Friant Dam when the Delta Mendota Canal is not able to supply adequate supplies. This flow may require Reach 2B to have a design capacity of 7,000 cfs if both maximum water rights and restoration flows are necessary and concurrent.

Appraisal-level Design Assumptions

- Evaluations of existing levees will only address levee stability in this reach and not mitigate seepage impacts. If stability is fine, seepage issues will not be addressed (though it will likely be reduced).
- New levees will be designed to reduce seepage and modifications to existing levees may reduce the seepage that would occur under existing conditions for the same water surface elevation. An analysis of the seepage, including quality (type of land use and crops) and quantity of areas, will be performed in future analyses.
- Existing levees along the right bank will be widened to meet 20-foot crest width even if the levee has sufficient height.
- Levee design will use the Mussetter analysis from their Scenario 1 TM to design the setback levee and evaluate the existing levees. This analysis assumes that the south levee will be setback and the north levee will remain and be modified as necessary. Future analysis will evaluate the adequacy of the setback alignment and adjacent landowner preferences on setback alignment (including switching the levee that is being setback).
- All levees will provide a minimum of 3 feet of freeboard at 4,500 cfs.
- Appraisal-level levee designs assume that private lands will be acquired in fee.
- Increased capacity to meet water rights flows for the San Joaquin Exchange Contractors will not be incorporated into the capacity of Reach 2B. Preliminary analysis appears to show that there is a significantly low probability that maximum riparian water rights will be needed during the two weeks in late April of the wettest years on the system. The need for increased capacity would require the DMC to be completely out, water users to have a maximum need for water in later April of a significantly wet year—this appears to be a low risk of all these occurrences at once. The reduced need to increase water supplies was in agreement with an analysis performed by Jeff Payne of MWH. However, in the need to reduce impacts on stakeholders of the program, it will be assumed that if this occurrence was present, the fisheries will take the risk and water rights diversion will be taken from restoration flows and these flows will be reduced for fish downstream of these diversions. The actual risk and need to account for potential water rights in the channel capacity will be taken into account during the next level of analysis.
- Change in n-values due to increase water flow or riparian habitat restoration will not be taken into account or analyzed.

Reach 3

General Information

- Verify the MEI conclusion in their Potential Flood—Reaches 3 & 4A TM analysis showing adequate channel capacity (with 3 feet of freeboard) is adequate for appraisal level designs.
- Since MEI analysis includes the use of exterior levees whose use may incur some encroachment on private lands, further analysis will be required.
- Levee stability is the main issue and seepage issues will not be addressed at this level of effort. Seepage may be significant in some areas during high flows.
- The SJ Exchange contractors report that they have the ability to take up to 800 cfs water deliveries from Mendota Dam into the Arroyo Canal. This flow may require Reach 3 to have a design capacity of 5,300 cfs if both maximum water rights and restoration flows are necessary and concurrent.
- Sack Dam structure will be required to provide fish passage. New or modified structure will need to maintain existing heads for Arroyo Canal diversion while not increasing heads during flood flows.

Appraisal-level Design Assumptions

- Mussetter analysis from their Potential Flood—Reaches 3 & 4A TM will be the bases to evaluate and modify the existing levees. Since this analysis includes the use of private lands and levees, an evaluation of the cost to modify interior levees or acquire lands beyond of the interior levees will be made. Existing interior levees will be raised unless raises confine existing floodplain flows (changing the hydraulics).
- Appraisal-level designs assume that private lands will be acquired in fee.
- All lands within the interior levees will not need to be acquired as it is assumed these lands are State Lands. This assumption will need to be reevaluated during the next level of design.
- All levees will provide 3 feet of freeboard at 4,500 cfs. Levees will not be widened to have a 20-foot crest if levee already has sufficient height.
- Existing levees will only be evaluated for stability in this reach and not mitigate seepage impacts. If stability is fine, seepage issues will not be addressed (though it will likely be reduced).
- Sack Dam structure will be retrofit with a new fish ladder to provide fish passage while maintaining 3 feet of freeboard at 4,500 cfs. Modified structure will maintain existing heads for Arroyo Canal diversion as illustrated in existing hydraulic models.
- Increased capacity to meet water rights flows for the San Joaquin Exchange Contractors will not be incorporated into the capacity of Reach 3. Preliminary analysis appears to show that there is a significantly low probability that maximum water rights will be needed during the two weeks in late April of the wettest years on the system. However, in the need to reduce impacts on stakeholders of the program, it will be assumed that if this occurrence was present, the fisheries will take the risk and water rights diversion will be taken from restoration flows and these flows will be reduced for fish downstream of these diversions. This will likely include sending an equal amount of flow into the screened gate into the Chowchilla Bypass and lower flows for fish will occur in Reach 2B and below Sack Dam. The actual risk and need

to account for potential water rights in the channel capacity will be taken into account during the next level of analysis.
- Change in n-values due to increase water flow or riparian habitat restoration will not be taken into account or analyzed.

Reach 4A

General Information

- Verify the MEI conclusion in their Potential Flood—Reaches 3 & 4A TM analysis showing adequate channel capacity (with 3 feet of freeboard) is adequate for appraisal level designs.
- Since MEI analysis includes the use of exterior levees whose use may incur some encroachment on private lands, further analysis will be required.
- Levee stability is the main issue and seepage issues will not be addressed at this level of effort. Seepage may be significant in some areas during high flows.

Appraisal-level Design Assumptions

- The Mussetter analysis from their Potential Flood—Reaches 3 & 4A TM shows that the existing levees all have adequate 3 feet of freeboard at 4,500 cfs. Therefore, no modifications are planned for this reach. This analysis (including the need that all levees have a 20-foot crest) will be performed in further analysis.

Reach 4B

General Information

- In 2002, MEI performed an analysis on a setback levee to allow the reach to convey 4,500 cfs. In this analysis, MEI developed a channel and setback levees on both sides of the river. Their channel has a capacity of 1250 to 1500 cfs. Need to evaluate if the adequacy of this analysis for use with our appraisal level designs. This is especially important since the Settlement infers a channel capacity of 475 cfs.
- Levees will have 3 feet of freeboard minimum.
- Levee stability is the main issue and seepage issues will not be addressed at this level of effort. Seepage may be significant in some areas during high flows.
- SJR Headgate will be redesigned to pass flow and fish at 4,500 cfs without increasing upstream water surface elevations from existing condition. Since no existing high water data is likely available at this location, the structure should be designed to pass 4,500 cfs with 3 feet of freeboard on the upstream levees.

Appraisal-level Design Assumptions

- Levee design will use the Mussetter analysis from their Scenario 1 TM to design the setback levees. Setback levee elevations will be increased a reasonable amount to account for the decrease in capacity of the actual channel inferred in the Settlement (due to the accuracy of the topo, this was not done in this level of analysis). Future analysis will evaluate the adequacy of the setback alignment and adjacent landowner

preferences on setback alignment (including switching the levee that is being setback).

- New levees will be designed to reduce seepage. An analysis of the seepage, including quality (type of land use and crops) and quantity of areas, will be performed in future analysis.
- All levees will provide 3 feet of freeboard at 4,500 cfs.
- Appraisal-level designs assume that private lands will be acquired in fee.
- SJR Headgate will be replaced with a new structure to provide flow and fish passage at 4,500 cfs with 3 feet of freeboard on the upstream levees. Future analysis will be performed, if necessary, to determine if the existing structure can pass flow and fish up to 475 cfs.
- Change in n-values due to increase water flow or riparian habitat restoration will not be taken into account or analyzed.

Eastside Bypass

General Information

- Structures on the Eastside Bypass (and Sand Slough connector channel) between the Sand Slough control structure and Mariposa Bypass will require fish passage under Phase 1 of the Settlement. There is the likelihood that all fish will be screened out of the bypass and into the SJR with the 475 cfs flow.
- Under Phase 2 of the Settlement, structures on the Eastside Bypass may need to pass fish that enter the bypass from the Chowchilla Bypass at the SJR. Otherwise, structures will need to act as barriers to fish passage just upstream of the Sand Slough connector channel inlet.
- Flood events larger than the Mariposa Bypass capacity will require flow to continue into the Eastside Bypass below the Mariposa Bypass. It may be necessary to screen fish out of this portion of the bypass.

Appraisal-level Design Assumptions

- Phase 1 – No fish in the bypass. Sand Slough control structure will be replaced with a new structure to allow flow but not fish in bypass. All fish will be routed into Reach 4B. New structure will pass flows up to 4,500 cfs with a minimum of 3 feet freeboard on existing upstream levees.
- Phase 1 – All fish in Bypass. Sand Slough control structure will be replaced with a new structure to allow flow and fish in bypass. New structure will be designed to allow all fish and flows into bypass up to 4,500 cfs with a minimum of 3 feet freeboard on existing upstream levees.
- Phase 2. Sand Slough control structure will be replaced with a structure to allow flow, but will not address fish passage. Since Phase 2 has all fish and flow into Reach 4B, the structure will only exist as an emergency backup to allow flood waters to enter the bypass. No screen will be placed on the structure and no fish passage will be evaluated. New structure will pass flows up to 4,500 cfs into the bypass with a minimum 3 feet freeboard on the upstream levees.

- Eastside Bypass control structure at the Mariposa Bypass will not be modified. The need to fish passage during extreme flow events will be addressed in future analysis.

Mariposa Bypass

General Information

- Structures on the Mariposa Bypass will require fish passage under Phase 1 of the Settlement. Under Phase 2, the drop structure on Mariposa Bypass will need to be a barrier to fish passage.
- Under Phase 1, Mariposa Bypass control and drop structures will need to pass fish at all restoration flows. The structure will also need to divert 8,500 cfs into the Mariposa Bypass with a minimum 3 feet freeboard on the upstream levees.
- Under Phase 2, the Mariposa Bypass drop structure will need to be a barrier for fish passage. The range of flows that this structure will be a barrier needs to be determined.
- The location of the Mariposa Bypass may be an issue with stranding fish even if it was a barrier. A separate barrier may need to be added closer to the river.

Appraisal-level Design Assumptions

- Mariposa Bypass control structure will be retrofitted for fish passage. The retrofit will be evaluated to ensure that the structure will pass 8,500 cfs into the Mariposa Bypass with a minimum 3 feet freeboard on the upstream levees.
- Mariposa Bypass drop structure will be evaluated to determine whether it is a barrier to fish passage or not. The structure will then be modified to meet the requirements of fish passage in Phase 1 and 2.
- The location of the Mariposa Bypass as an adequate barrier will not be evaluated at this level of analysis. Future analysis is warranted regarding the barrier's proper location.

San Joaquin River at Mariposa Bypass

General Information

- A barrier structure may be needed on the San Joaquin River upstream of the Mariposa Bypass to prevent fish passage into the river for Phase 1.

Appraisal-level Design Assumptions

- The need for the barrier structure is unknown and it will be determined in a later analysis.

Fish Passage Criteria
For the
San Joaquin River Restoration Project

Introduction

The Fish Passage Improvement Program (FPIP), in cooperation with Stockton East Water District, is evaluating anadromous fish passage through structures on the Calaveras River System from New Hogan Dam to its confluence with the San Joaquin River. The process used to identify structures and evaluate them is covered briefly in this memo. As a part of the evaluation process, we are modeling and evaluating the hydraulic performance of identified structures with respect to anadromous fish passage.

Objective

The objective of this memo is to provide FPIP and its staff with hydraulic criteria by which to evaluate **unimpaired** juvenile and adult anadromous fish passage through structures on the Calaveras River, Mormon Slough, and the Stockton Diverting Canal.

Overview of Evaluation Process

The first phase of the evaluation process included an inventory of the types and locations of structures on the system. After the inventory was complete sites, suspected of posing possible fish passage problems were identified by agencies or individuals. Survey information is being gathered at these sites and hydraulic models are being developed to be used in the evaluations of fish passage performance. The second phase entails collecting more specific information on each of the structures so that more problematic sites can be identified and in depth modeling and analysis can be conducted.

Physical data from structures identified in Phase I as problematic are being used for development of models that characterize the structures hydraulic attributes. Criteria used to evaluate these attributes are being developed using guidelines set forth by California Department of Fish and Game and the National Marine Fisheries Service for all types of stream crossings. The type of structures being evaluated include:

- Low flow crossings or fords
- Culverts
- Dams
- Flashboard Dams
- Weirs
- Flumes

- Bridges
- And any combination thereof.

Criteria Development

When evaluating these structures, the primary attributes to be considered are velocity, depth, and drop or jump. All other attributes are related to, or dependent on, these attributes. The following table from the CDFG 2003 report summarizes recommendations for criteria to evaluate structures with FishXing software.

Species or Lifestage	Minimum Water Depth (ft)	Prolonged Swimming Mode		Burst Swimming Mode		
		Maximum Swim Speed (fps)	Time to Exhaustion (min.)	Maximum Swim Speed (fps)	Time to Exhaustion (sec)	Maximum Leap Speed (fps)
Adult anadromous salmonids	0.8	6.0	30	10.0	5.0	15.0
Resident trout and juvenile steelhead >6"	0.5	4.0	30	5.0	5.0	6.0
Juvenile salmonids <6"	0.3	1.5	30	3	5.0	4.0

(These values are used to assist in prioritizing stream crossing for treatment and do not represent whether or not a stream crossing currently meets DFG or NMFS passage criteria).

Table 1. Minimum water depth requirements and swimming and leaping ability inputs for FishXing.

The CDFG report also makes design recommendations for minimum depths of 1.0 foot for adult salmonids and 0.5 feet for juveniles (Table 2). These are not significantly different than the criteria for FishXing software but will make a significant difference when identifying issues with passage.

Maximum Average Water Velocity And Minimum Depth of Flow		
Species/Lifestage	**Maximum Average Water Velocity (fps)**	**Minimum Flow Depth (ft)**
Adult Anadromous Salmonids	See Table 3	1.0
Adult Non-Anadromous Salmonids	See Table 3	0.67
Juvenile Salmonids	1	0.5
Native Non-Salmonids	Species specific swimming performance data is required for the use of the hydraulic design option for non-salmonids. Hydraulic design is not allowed for these species without this data.	
Non-Native Species		

Table 2. Maximum Average Water Velocity and Minimum Depth of Flow.

Maximum design swim velocities shown in Table 1 are further reduced when structure length exceeds 60 feet. Velocities for various culvert lengths are listed in Table 3 (CDFG 2003). Data for the table was taken from the "Alaska Curve" presented in a report by the USDOT (1990).

Culvert Length vs Maximum Average Water Velocity for Adult Salmonids		
Culvert Length (ft)	**Adult Non-Anadromous Salmonids (fps)**	**Adult Anadromous Salmonids (fps)**
<60	4	6
60-100	4	5
100-200	3	4
200-300	2	3
>300	2	2

Table 3. Culvert length vs. maximum average water velocity fro adult salmonids.

The design maximum fall from the structure water surface into a 2 foot pool is given in the following table and should be considered at all flows (CDFG 2002 and CDFG 2003). The NMFS 2000 report also recommends a minimum pool depth of 1.5 times the jump height, but not less than 2.0 feet.

Maximum Drop at Culvert Outlet	
Species/Lifestage	**Maximum Drop (ft)**
Adult Anadromous Salmonids	1
Adult Non-Anadromous Salmonids	1
Juvenile Salmonids	0.5
Native Non-Salmonids	Where fish passage is required for native non-salmonids, no hydraulic drop shall be allowed at the culvert outlet unless data is presented which will establish the leaping ability and leaping behavior of the target species of fish.
Non-Native Species	

Table 4. Maximum Drop at Culvert Outlet.

Rip-rap run out is also a major consideration and concern at each structure. The reports consider areas of high slope, velocity and turbulence as problem areas but no specific criteria is set. Special consideration of these areas may be necessary to effectively evaluate their influence on passage. During communications with George Heise CDFG (September 2004), it was suggested that we use 5.0% maximum slope for riprap and a 3.0% maximum slope for structures. CDFG 2003 and NMFS 2001 do give a guideline for slopes of a maximum of 0.5 % but this was thought to be too conservative. The 3.0% was chosen because it was the point at which most culverts begin to flow mostly in the critical regime and 0.5% slope would be predominantly sub-critical. The value for the rip-rap is even higher (5%) because its 'n' values are much higher and will likely stay sub-critical at a much higher slope.

Guidelines for the hydrology or the range of flow at which these attributes will be considered are also developed by CDFG (2003) and presented in Table 5.

Species/Lifestage	Upper Passage Flow	Lower Passage Flow	
	Exceedance Flow (%)	Exceedance Flow (%)	Alternate Minimum Flow (cfs)
Adult Anadromous Salmonids	1	50	3
Adult Non-Anadromous Salmonids	5	90	2
Juvenile Salmonids	10	95	1
Native Non-Salmonids	5	90	1
Non-Native Species	10	90	1

Table 5. Low Design Flow for Fish Passage.

Currently, hydrology for the mainstem at New Hogan Dam and at the Mormon Slough Gauge has been developed, but nothing has been developed for the Old Calaveras River from the headworks to its confluence with the Stockton Diverting Canal.

Recommendations for Criteria Used to Evaluate Unimpeded Fish Passage

The application of most of the guidelines given in the reports can be easily applied to the structures that we are evaluating. However, whether or not to apply the depth guidelines to rip-rap areas is a major concern. Since the rip-rapped aprons on these projects have material diameters ranging from a few inches to a few feet, it seems questionable to assign 1.0 ft as an adequate depth. I would recommend adding the average diameter of the rip-rap or doubling the minimum depths. Since the average diameter of the rip-rap was not recorded during field visits, we will double recommended minimum depths. This would better insure that there is a clear space for migration. However, some visual confirmation of the performance of the rip-rap during these flows may be necessary. This will confirm that most of the depth is not being lost to inter rip-rap flows.

A maximum slope of 3.0% should be applied to structures and will be a good indicator of passage, since it will also indicate the point at which most culverts will flow critical. However, 5.0% should be applied to riprap (personal comm. George Heise September 2004). The higher value is allowed because rip-rap has a higher roughness which will prevent critical flows from occurring as quickly as structures. Rip-rap slope can be evaluated by measuring drop in elevation of the rip-rap over its length from the outfall to the backwater pool below the structure.

Minimum depth recommendations ranged from 0.8 to 1.0 feet for adults and 0.3 to 0.5 for juvenile salmonids. The depths are intended to insure that the fish is completely submerged and capable of meeting swimming performance criteria. To insure that the fish are able to meet their performance criteria the more conservative of the numbers was selected. Meaning that 1.0 ft for adults and 0.5ft for juveniles on structures and double these values for rip-rap will be used to evaluate structure performance.

The complete set of recommendations are the following:

	Velocity (fps)		Depth (ft)		Slope (%)		Fall (ft)	
	adult	**juvenile**	**adult**	**juvenile**	**adult**	**juvenile**	**adult**	**juvenile**
Structures	See Table 7	1.0	1.0	0.5	3.0	3.0	1.0	0.5
Rip-Rap	See Table 7	1.0	*2.0	*1.0	5.0	5.0	1.0	0.5

Table 6. Recommended criteria for unimpaired passage of juvenile and adult salmonids.

* Double minimum depth criteria for the structure .

Table 7 lists the suggested maximum allowable velocities for adult salmonids. This table is similar to Table 3 except that additional information has been added for lengths less than 60ft. Originally the table was created using the 'Alaska Curve' (USDOT 1990) and this same curve was used to add information to the Table.

Structure Length vs Maximum Average Water Velocity for Adult Salmonids	
Culvert Length * (ft)	**Adult Anadromous Salmonids (fps)**
<20**	10
20-40**	8
40-60**	6
60-100	5
100-200	4
200-300	3
>300	2

Table 7. Recommended maximum velocities vs. structure length for adult salmonids.

* When evaluating the maximum velocity, the length of the rip-rap run, from the structure outlet to the backwater pool is added to the length of the structure, should be used when selecting the maximum velocity for the site.

** This information was interpolated from the "Alaska Curve" taken from the USDOT 1990.

The hydrology recommended for use is the same as that listed in table 5. However, this criteria will be difficult to apply until the hydrology and routing is developed for the Calaveras River, Mormon Slough and the Stockton Diverting Canal. This will likely be revisited when the hydrology is further developed.

References

California Department of Fish and Game 2002. "Culvert Criteria for Fish Passage"

California Department of Fish and Game, Chapter IX 2003. "California Salmonid Stream Habitat Restoration Manual"

George Heise, CDFG September 9, 2004. Personal Communications

National Marine Fisheries Service 2000. "Guidelines for Salmonid Passage at Stream Crossings"

U.S. Department of Transportation, Federal Highway Administration 1990. "Fish Passage Through Culverts" Report No. FHWA-FL-90-006

San Joaquin River Restoration
Structural Option Description
Pre-Appraisal Level

Option No.	Structural Option Name		Revision Date
5b	Sand Slough Control Structure – Alt. 2		28 Feb 2008
Reach Number	**River Mile**	**Program Goal**	**Phase**
4B	168.5	Restoration	I

Task	Responsible Author	Peer Reviewer
Option Description	P. Romero	K. Faulkenberry
Engineering	G. Enas	P. Romero

Costs (October 2007):
Cost Level: Pre-appraisal
Total Construction Cost: Not available at this time.
Annual O&M Cost: Not available at this time.
Project life: Not available at this time.

Objective of Option
Provide gated facility in the Sand Slough connector channel to pass flows and fish for a range of flows up to 4,500 cfs.

Performance Criteria
1. Structure capacity provides 3 feet of freeboard for upstream levees at 4,500 cfs.
2. Structure will pass flow and sediment to reduce sedimentation problems.
3. Automatic gate regulation based on impoundment water level
4.

Design Criteria
1. CA. DFG Restoration Manual, Chapter IX (2003)
2. NOAA NMFS salmonid passage criteria (2000)
3. Unit costs were determined from recent DWR projects.
4. Reclamation Cost Estimating Guidelines
5.

Description
The existing flume will be removed and replaced with a gated structure to allow flow and fish passage for a range of flows up to 4,500 cfs. Actual design will be required to pass low flow requirements for adult (125 cfs) and juveniles (45 cfs) based on preliminary flow duration curves from Settlement hydrographs. Structure will incorporate multiple gates and automated operation to allow flow flexibility into Reach 4B. In this preliminary analysis, a fish ladder will not be required due to adequate depths to pass fish. Design velocities and depths for fish passage were based on DFG Restoration Manual, Chapter 9.

Construction Considerations
Construction will be performed when the channel is dry to reduce costs and environmental considerations.

Schedule

Real Estate Requirements

- **Fee Purchase** The structure will replace an existing structure on Project levees and it is not expected that lands will be purchased in fee.
- **Access Rights** The structure should be accessible from State property.
- **Permanent and Temporary Easements** Construction may require some temporary access to adjacent lands.

Coordination with Other Options

This option will be completed under Phase I of the Settlement. Since the Settlement is not specific on the corridor for fish, this alternative assumes that all fish will be routed into the bypass. If the decision is made to send all fish into Reach 4B, there is no need to construct this option. Alternative 1 of this option will be constructed to meet Phase 1 of the Settlement and if fish are to be conveyed into Reach 4B.

Operational and Maintenance Requirements

- **Operations**

It is expected that the structure will be operated automatically to provide adequate depth and velocities into the bypass.

- **Maintenance**

The structure will require annual maintenance to ensure reliable and accurate operation. Maintenance will include operating the gates through its full operating range. Gates and gears will be lubricated as necessary. Periodic sediment removal may be required after high flow events.

- **Monitoring Requirements**

The structure will be rated and calibrated to allow accurate flow measurements during operation. Periodic calibration will be required if significant channel or flow conditions are observed.

Future Requirements for Design

The level of design is very preliminary and much analysis is needed to further the reliable of the design. Next steps will include: 1) Perform surveys of area to refine design of structure, 2) Refine modeling to incorporate higher resolution of fish passage evaluation and design and possible 2-D modeling of structure, 3) Evaluate the land acquisition, and 4) Perform geotechnical and soils analysis to account for local soils. Refined costs of the options will require a more detailed evaluation of price and source of concrete. Permits that may be required prior to construction include: Nationwide Permit (404), water quality certification (401), Stream Alteration Agreement, Reclamation Board Encroachment Permit, State Lands Permit, CEQA and any applicable county permits.

Potential Environmental Impacts

- **Temporary (During Construction)** -Air Quality, biological, water quality, noise
- **Permanent (Operation-Related)-** Biological, recreation

Sub-Options considered but Rejected

Modification of the existing flume was rejected since this structure was deemed not adaptable to passing fish. This assumption will be evaluated in future analysis.

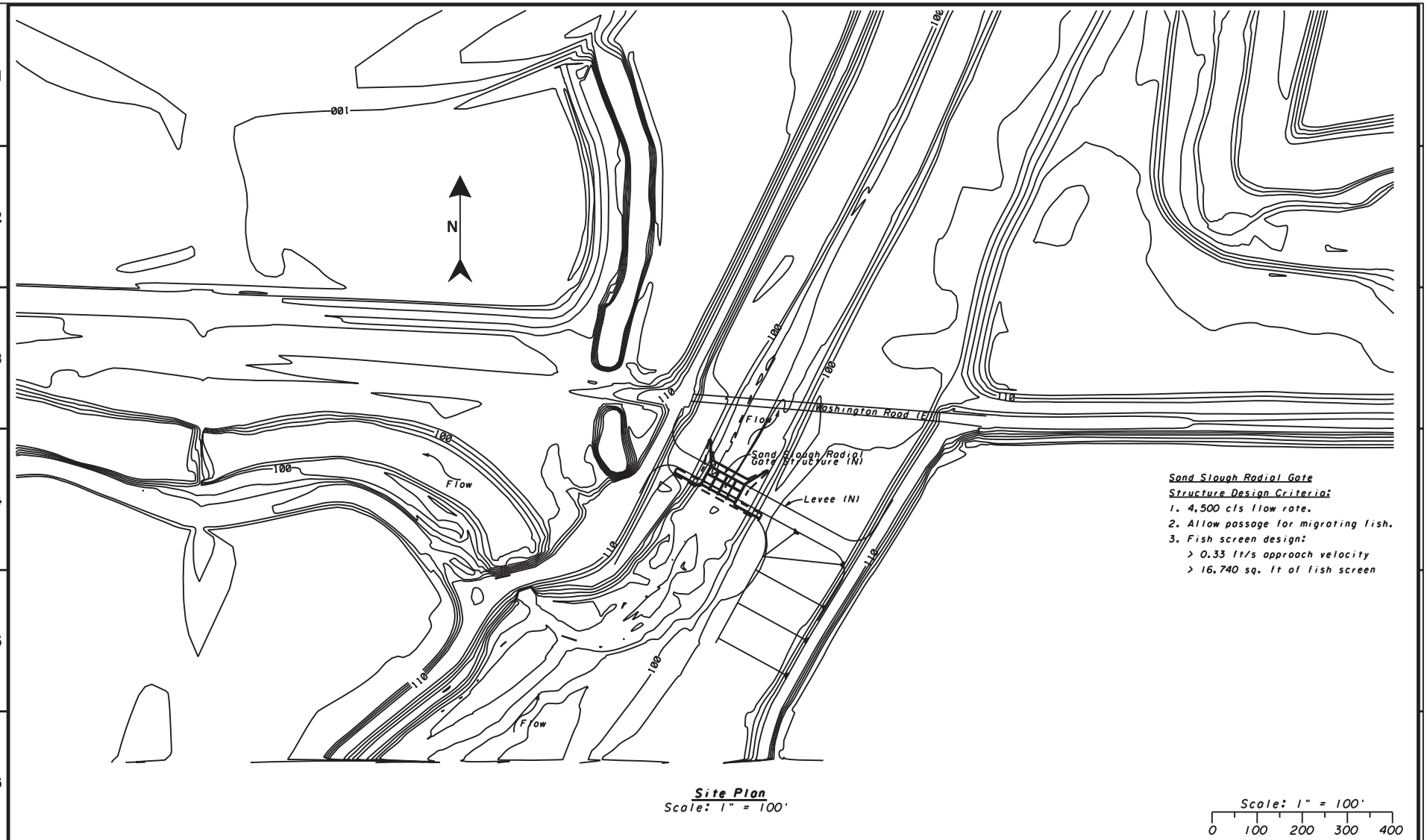
Drawings

5b-1 Site Plan
5b-2 Radial Gate Structure Plan & Profile view

Figures

5b-1 Design Criteria Table (included in Option 4)

Attachments



REV.	DATE	DESCRIPTION	SUB.	APP'D

DESIGNED: G. Pandey | CHECKED: | APPROVAL RECOMMENDED:
DRAWN: -NB- | REVIEWED: | APPROVAL RECOMMENDED:
SUBMITTED: | APPROVED: DATE:

REGISTERED PROFESSIONAL ENGINEER — STATE OF CALIFORNIA — REG. STAMP

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

San Joaquin River Restoration
Sand Slough
Radial Gates

SPEC. No.
DRAWING No. G3
REV. | SHEET No. 03

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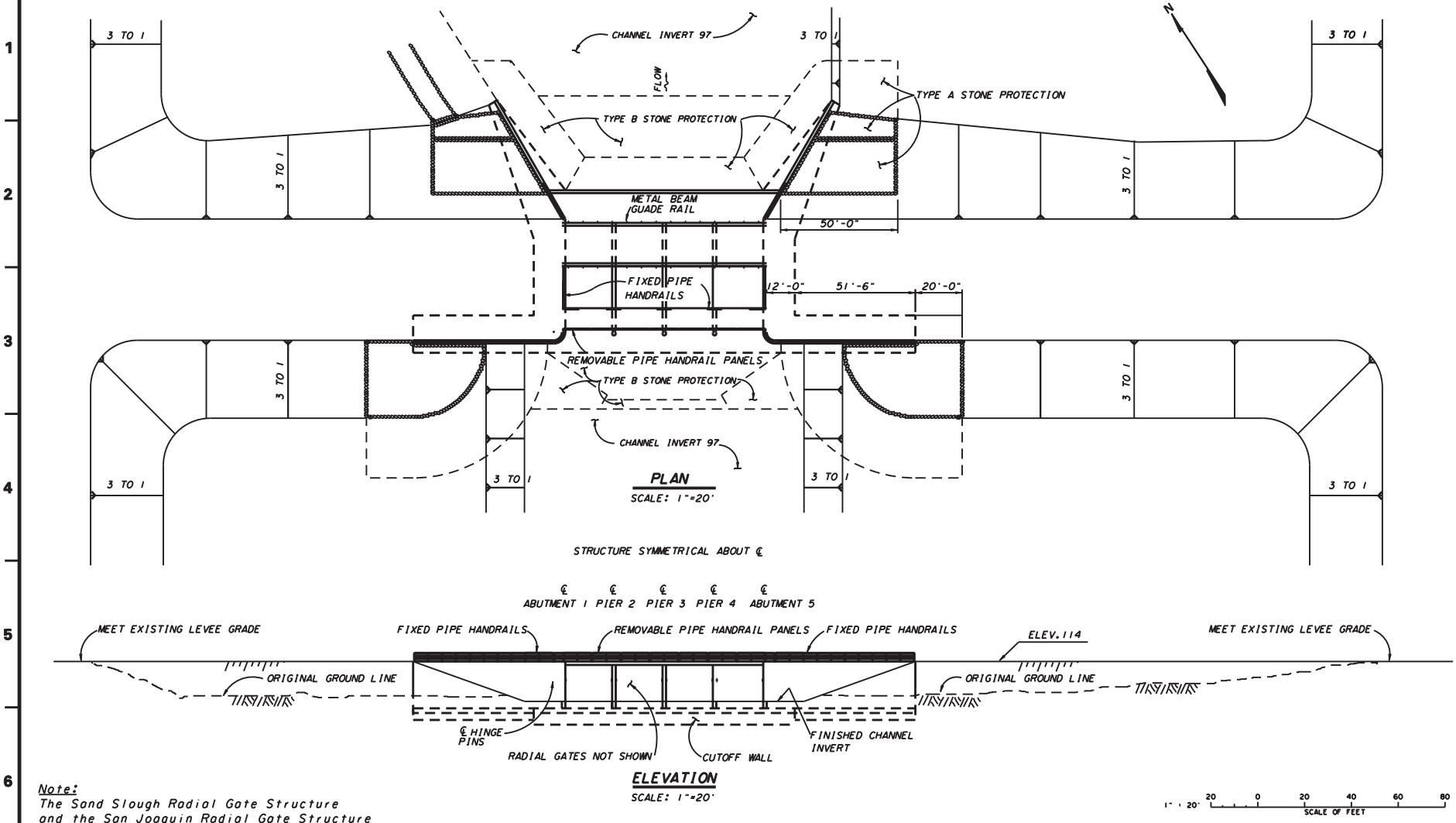
Drawing 5b-1: Site Plan



Note:
The Sand Slough Radial Gate Structure and the San Jooquin Radial Gate Structure are identical.

DESIGNED	
DRAWN	Y. Liu
CHECKED	
REVIEWED	
SUBMITTED:	
APPROVAL RECOMMENDED:	
APPROVAL RECOMMENDED:	
APPROVED: DATE:	

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STATE WATER FACILITIES

San Jooquin River Restoration
Sand Slough and San Jooquin
Radial Gate Structures

SPEC. No.
DRAWING No. C1
REV. SHEET No. 04

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Drawing 5b-2: Radial Gate Structure Plan & Profile