Appendix D

Physical Monitoring and Management Plan

Draft
Program Environmental Impact Statement/Report

Draft
April 2011

Table of Contents

Tables

Figures

Attachments

List of Abbreviations and Acronyms

Act	San Joaquin River Restoration Settlement Act
ADCP	Acoustic Doppler Current Profiler
cfs	cubic feet per second
DWR	California Department of Water Resources
GPS	Global Positioning System
LIDAR	Light Detection and Ranging
Plan	Physical Monitoring and Management Plan
RA	Restoration Administrator
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RTK	Real Time Kinematic
Secretary	Secretary of the Interior
Settlement	Stipulation of Settlement in *NRDC, et al., v. Kirk Rodgers, et al.*
SJRRP	San Joaquin River Restoration Program

1.0 Introduction

The purpose of this Physical Monitoring and Management Plan (Plan) is to provide guidelines during implementation of the Stipulation of Settlement in *NRDC, et al., v. Kirk Rodgers, et al.* (Settlement) for observing and adjusting to changes in physical conditions within the Restoration Area. This Plan consists of five component plans, addressing interrelated physical conditions including flow, groundwater seepage, channel capacity, propagation of native vegetation, and suitability of spawning gravel.

Each component plan identifies objectives for the physical conditions within the Restoration Area, and provides guidelines for the monitoring and management of those conditions, as shown in Table 1-1. The plans identify potential actions that could be taken to further enhance the achievement of the objectives. The component plans include immediate actions that could be taken, for which this Draft Program Environmental Impact Statement/Environmental Impact Report (PEIS/R) provides project-level analysis. The component plans also include long-term actions that are analyzed at a program level of detail in this Draft PEIS/R. Finally, this Plan includes a description of monitoring activities which apply to one or more of the component plans. Monitoring and management guidelines related to biological conditions for fish are separately described in the Fish Management Plan (Appendix F of this Draft PEIS/R).

This Plan is intended to guide potential implementation of immediate actions, and to provide the basis for monitoring and management programs for long-term implementation. U.S. Department of the Interior, Bureau of Reclamation (Reclamation), in coordination with California Department of Water Resources (DWR), shall determine the appropriate monitoring and management actions to implement and the timeline for their implementation. The guidelines in this Plan would need ongoing refinement to develop specific thresholds, and would incorporate input from supporting agencies, the Settling Parties, and appropriate third-parties. More detailed monitoring and management programs would be developed, as necessary, to identify specific methods for implementation, including exact monitoring locations, standards for data collection, and guidelines for implementation of long-term management actions. An example of a more detailed plan is the attached *Draft Seepage Management Plan* developed to guide monitoring and management of seepage during release of Interim or Restoration flows (Draft Seepage Management Plan Attachment).

Table 1-1.
Component Plans of the Physical Monitoring and Management Plan

Component Plan	Objective(s)	Monitoring Parameter	Potential Actions	
			Immediate	Long-Term
Flow	To ensure compliance with the hydrograph releases in Exhibit B of the Settlement and any other applicable flow releases (e.g., Buffer Flows)	Surface water stage and flow rate	None identified	Release purchased water from willing sellers to meet flow targets
Seepage	Reduce or avoid adverse or undesirable groundwater seepage impacts	Groundwater elevation, visual inspection/patrol, landowner contact, soil sampling, soil salinity surveys	Change releases, redirect flows through bypasses	Acquire easements, compensate for damage, pursue engineering solutions
Channel Capacity	Maintain flood conveyance capacity	Aerial/topographic surveys, water surface profile surveys, surface water stage and flow rate, vegetation surveys	Change releases, redirect flows through bypasses, monitor and remove obstructions/debris	Evaluate flow, removal of sediment and vegetation, and channel modifications
Native Vegetation	Establish and maintain native riparian habitat	Seed dispersal and seedling desiccation	Report findings, change releases	Coordinate with RA regarding future recruitment flow schedule, consider channel modifications
Spawning Gravel	Maintain gravels for spawning	Sediment transport rate, bed gradation, sand storage, bathymetry, meso-habitat mapping, micro-habitat evaluation	Report findings, change releases	Coordinate with RA regarding future flushing flow schedule, manually remove sediment, augment gravels, or pursue engineering solutions

Key:
RA = Restoration Administrator

2.0 Flow Monitoring and Management Component Plan

The objective of the Flow Monitoring and Management Component Plan is to ensure compliance with the hydrograph releases in Exhibit B of the Settlement and any other applicable flow releases (e.g., Buffer Flows), without exceeding then-current channel capacity. Exhibit B of the Settlement sets flow targets at six locations: Friant Dam, Gravelly Ford, below Chowchilla Bifurcation Structure, below Sack Dam, at the top of Reach 4B, and at the Merced River confluence.

The flow objective is based on relevant sections of the Settlement, including paragraphs 13(f) and 13(g), and Exhibit B. Paragraph 13(f) of the Settlement requires identifying any increased downstream surface or underground diversions and the causes of any seepage losses above those assumed in Exhibit B. Paragraph 13(g) of the Settlement requires that Restoration Flows are measured at not less than six locations (Friant Dam, Gravelly Ford, below Chowchilla Bifurcation Structure, below Sack Dam, at the top of Reach 4B, and at the Merced River confluence). Exhibit B of the Settlement identifies a schedule of flow targets at the six locations, and assumes seepage losses in Reach 2, inflows from Mud and Salt sloughs, and inflows from the Merced River at its confluence with the San Joaquin River.

2.1 Flow Monitoring Activities

To assess achievement of the flow objective, flows would be monitored at the six locations identified in the Settlement (Friant Dam, Gravelly Ford, below Chowchilla Bifurcation Structure, below Sack Dam, at the top of Reach 4B, and at the Merced River confluence). Flow monitoring, as detailed in Section 7.0 of this document, would be used to assess achievement of the flow objective.

The flow objective would be met if the measured Restoration Flows meet or exceed anticipated flow rates identified in the Settlement at each of the six identified monitoring locations. The Settlement states that nothing in the Settlement shall be construed to limit, affect, or interfere with flood control operations. In the event of flood control operations, the objective is met if the flow targets are met or exceeded at each of the six identified monitoring locations, as constrained by flood operations.

In accordance with Paragraph 15 of the Settlement, to the extent that any of the six gages required in the Settlement are not available to measure flows, Interim and Restoration flows would be measured by establishing temporary gaging locations or by conducting manual flow measurements for the purposes of collecting relevant data.

The installation of new gaging stations and rehabilitation of existing gaging stations at these locations is described in Inst*allation and Rehabilitation of Stream Gages on the San Joaquin River, Fresno, Madera, and Merced Counties, California Environmental Assessment/Finding of No Significant Impact* (Reclamation, 2008), and in *Stream Gage Installation and Operation and Maintenance Project Initial Study/Mitigated Negative Declaration* (DWR, 2009).

In addition to monitoring at gaging stations, additional engineering studies on surface and groundwater flows within the Restoration Area, patrols to identify surface water diversion locations and rates, and/or installation of additional surface water flow and stage monitoring locations or groundwater monitoring wells could be performed to identify locations of losses, if necessary to evaluate the need for management actions to address achievement of the flow objective. In appropriate cases, the enforcement of instream water rights for the Restoration Flows may be required.

2.2 Potential Flow Management Actions

The Settlement identifies several potential factors that could prevent achievement of the flow objective, including higher-than-expected seepage losses and increases in surface and underground diversions. The following sections identify potential immediate and long-term actions to address higher-than-expected seepage losses and increased diversions.

2.2.1 Immediate Actions

Paragraph 13(h) of the Settlement states that the Secretary shall, to the extent permitted by applicable law, undertake all reasonable measures to manage Interim and Restoration flows, including initiation of enforcement actions as necessary to prevent unlawful diversions of or interference with Interim and Restoration flows. To accomplish this, Reclamation would petition the SWRCB for its approval of water right changes pursuant to applicable provisions of the California Water Code. The petition would include dedication of flows to instream fish and wildlife purposes through the entire stretch of the San Joaquin River from Friant Dam, through Delta Channels, to Jones and Banks Pumping Plants. This dedication would also include flows routed through Reaches 2 and 3 of the Eastside Bypass, the entire Mariposa Bypass, and the reach of Bear Creek from the confluence of the Eastside Bypass downstream to the confluence with the San Joaquin River. The petition would also include additional points of rediversion for Interim and Restoration flows, including Mendota Dam and associated canals, Sack Dam and associated canal, the Sand Slough Control Structure, Jones and Banks Pumping Plants, and San Luis Dam.

2.2.2 Long-Term Actions

Paragraph 13(c) of the Settlement provides for adjusting releases due to unexpected seepage losses. These actions could include but would not be limited to acquisition and release of purchased water from willing sellers. The procedures for purchasing and releasing additional water are under development and would be detailed in the

Restoration Flow Guidelines, a document which would be attached to the Friant Operation Guidelines.

This page left blank intentionally.

3.0 Seepage Monitoring and Management Component Plan

The objective of the Seepage Monitoring and Management Component Plan is to reduce or avoid adverse groundwater seepage impacts to third parties due to Interim and Restoration flows. Section 10004, paragraphs (d) and (h) of the Act describe requirements for a Seepage Monitoring and Management Component Plan for Interim Flows. Paragraph (d) states that impacts associated with Settlement implementation and measures to mitigate impacts on adjacent and downstream water users and landowners must be identified. Paragraph (h) sets forth requirements for Interim Flows related to seepage including:

- An analysis of potential for levee or groundwater seepage (Paragraph (h)(1)(A))
- A description of the associated seepage monitoring program (Paragraph (h)(1)(B))
- Address any material adverse impacts to third parties from groundwater seepage caused by Interim Flows (Paragraph (h)(3))

Portions of the Restoration Area have historically experienced groundwater seepage to adjacent lands associated with flood flows. Groundwater seepage and associated rises in the groundwater table have the potential to cause waterlogging of crops and salt mobilization in the crop root zone. Similarly, some portions of the Restoration Area have experienced levee instability resulting from underseepage and through-seepage during periods of flood flows. The effects of underseepage, through-seepage, and associated levee stability issues are addressed through actions described in Chapter 2.0, “Description of Alternatives” in the Draft PEIS/R. This plan is intended primarily to address groundwater seepage, though it was developed in part on evidence of seepage potential based on past levee seepage, and many actions under this plan address both groundwater and levee seepage.

Lands with elevated potential for groundwater seepage effects based on past seepage were used to define a supplemental seepage buffer, shown in Figures 3-1 through 3-8. The supplemental seepage buffer was developed using parcel information identified by the RMC during the public review period for the WY 2010 Interim Flows Project Environmental Assessment/Initial Study, as having been previously affected by seepage associated with San Joaquin River flows between 475 and 1,300 cfs; and by identifying parcels affected by flooding in 2006 as identified in the 2006 Flood Video developed by the Lower San Joaquin Levee District. The supplemental seepage buffer includes 89,216 acres, as shown in Figures 3-1 through 3-8.

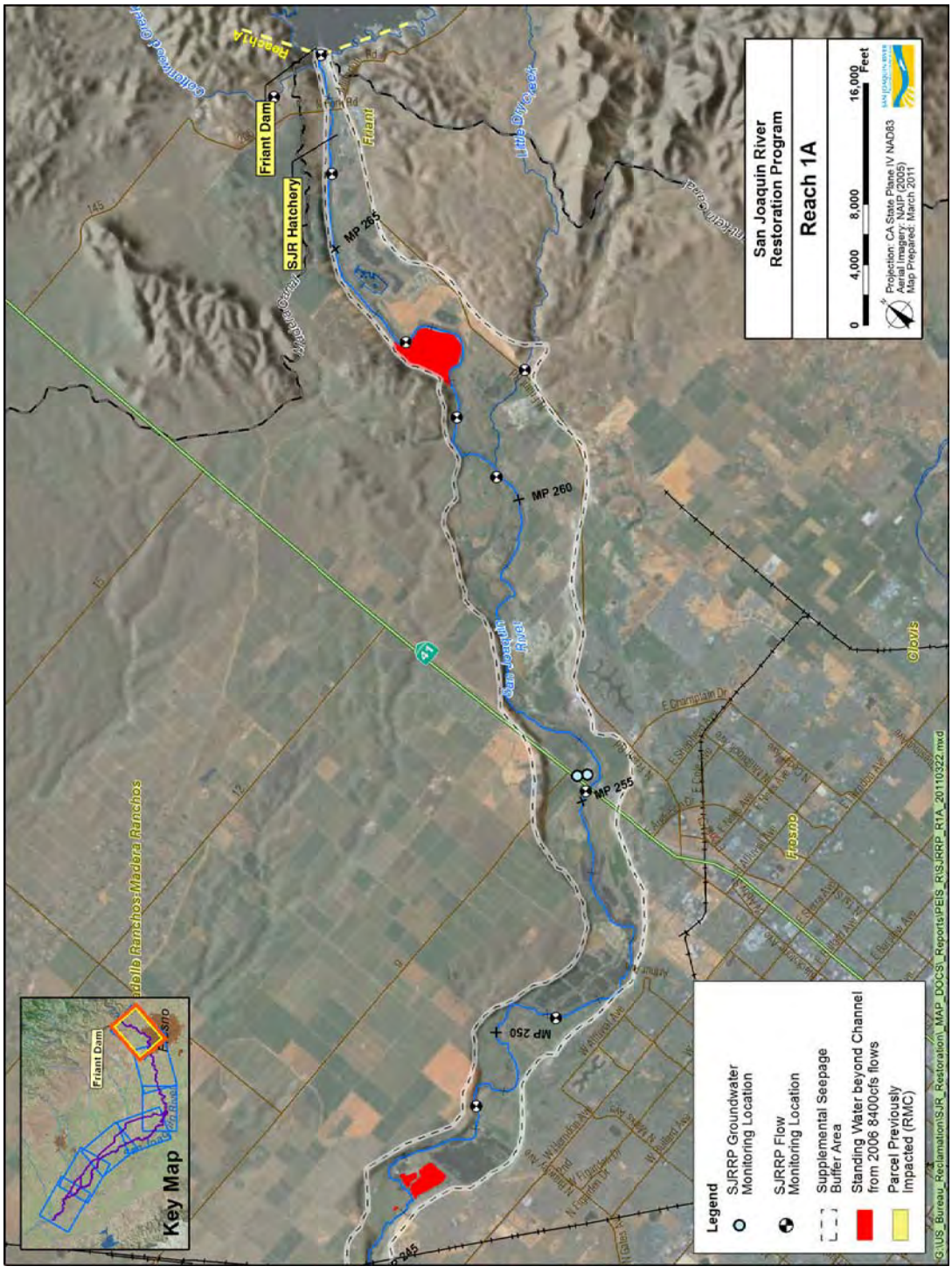

Figure 3-1.
Supplemental Buffer Zones of Groundwater and Levee Seepage Along Reach 1A of the San Joaquin River

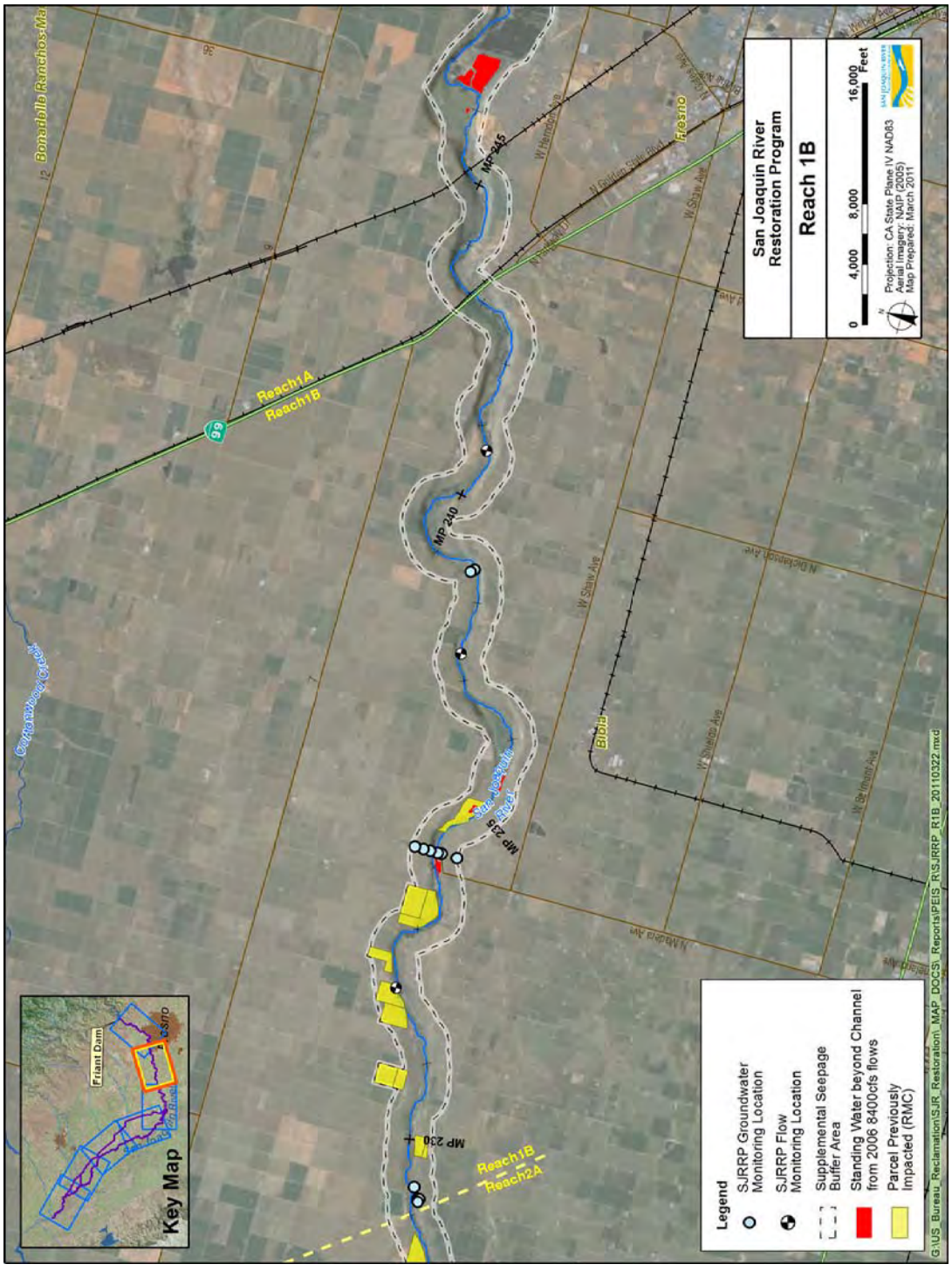

Figure 3-2.
Supplemental Buffer Zones of Groundwater and Levee Seepage Along Reach 1B of the San Joaquin River

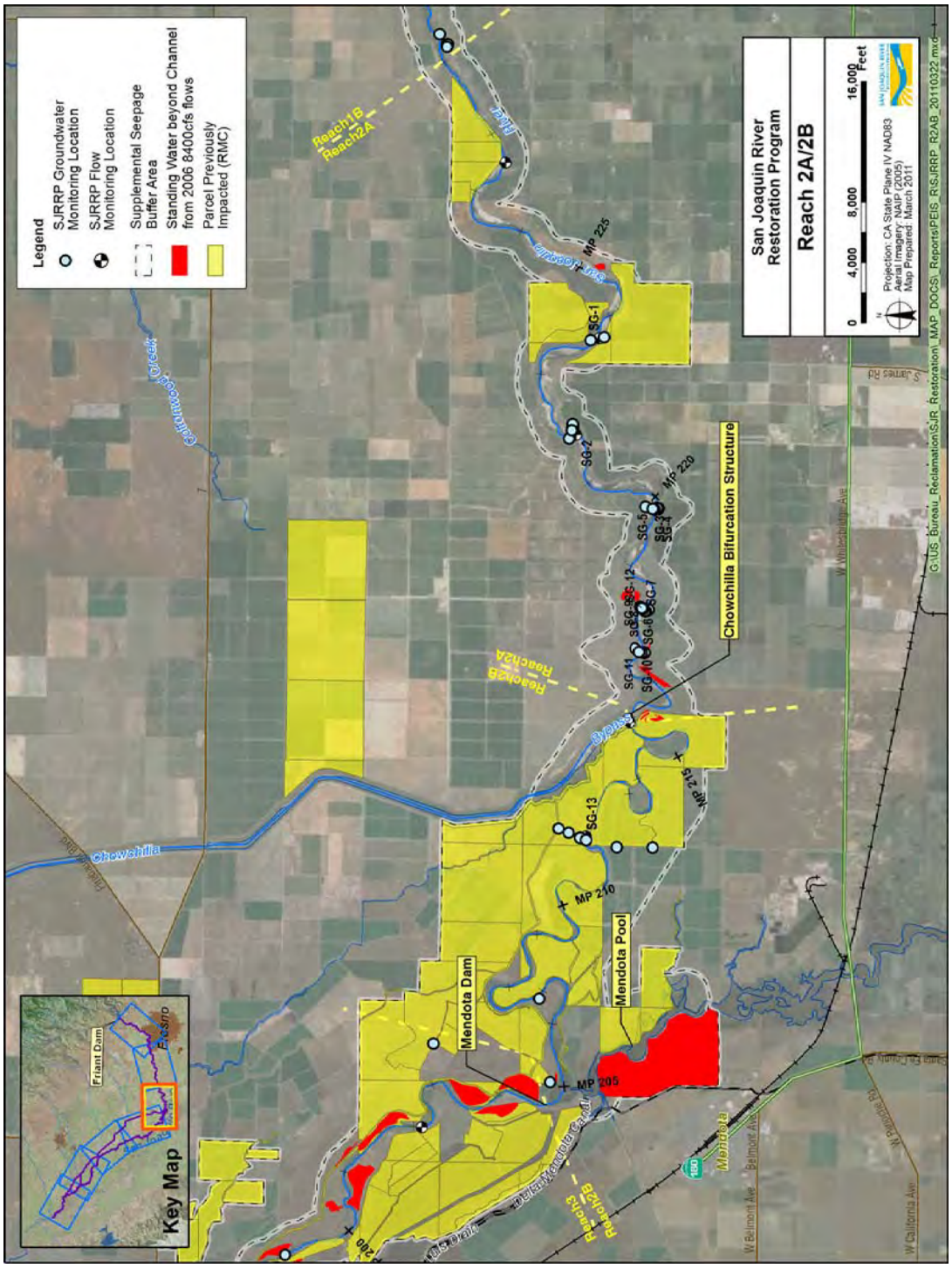

Figure 3-3.
Supplemental Buffer Zones of Groundwater and Levee Seepage Along Reach 2A and 2B of the San Joaquin River

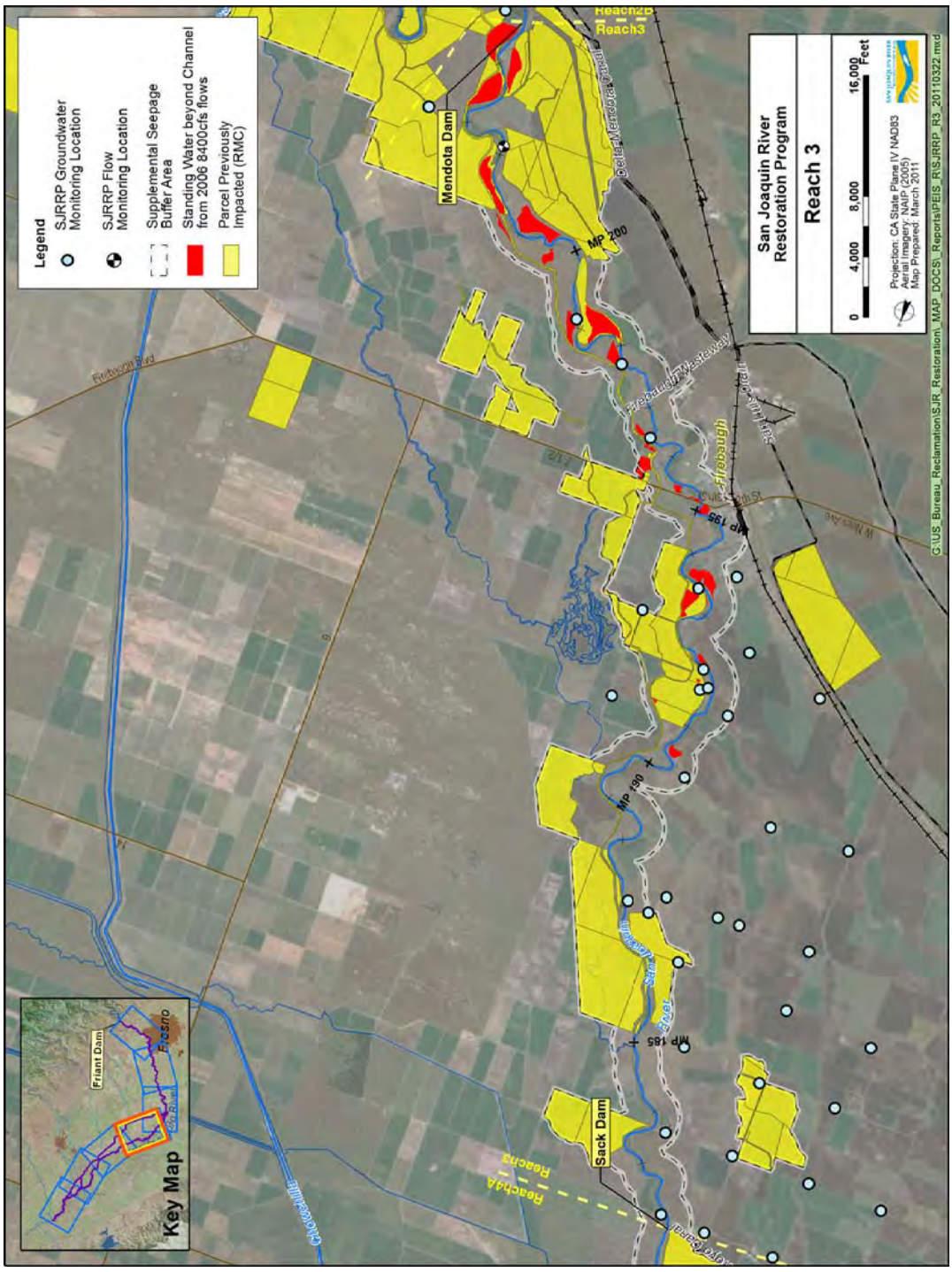

Figure 3-4.
Supplemental Buffer Zones of Groundwater and Levee Seepage Along Reach 3 of the San Joaquin River

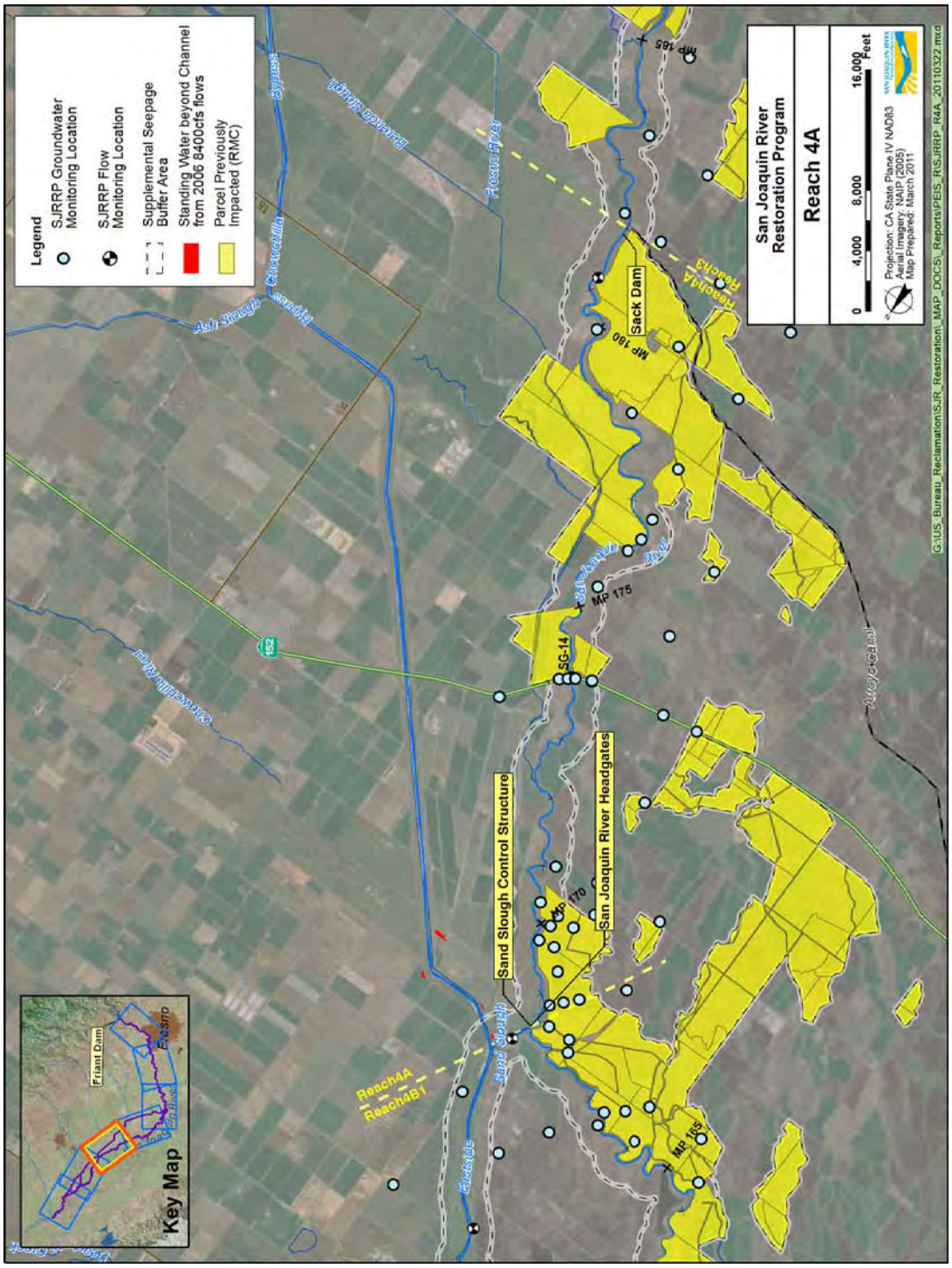

Figure 3-5.
Supplemental Buffer Zones of Groundwater and Levee Seepage Along Reach 4A of the San Joaquin River

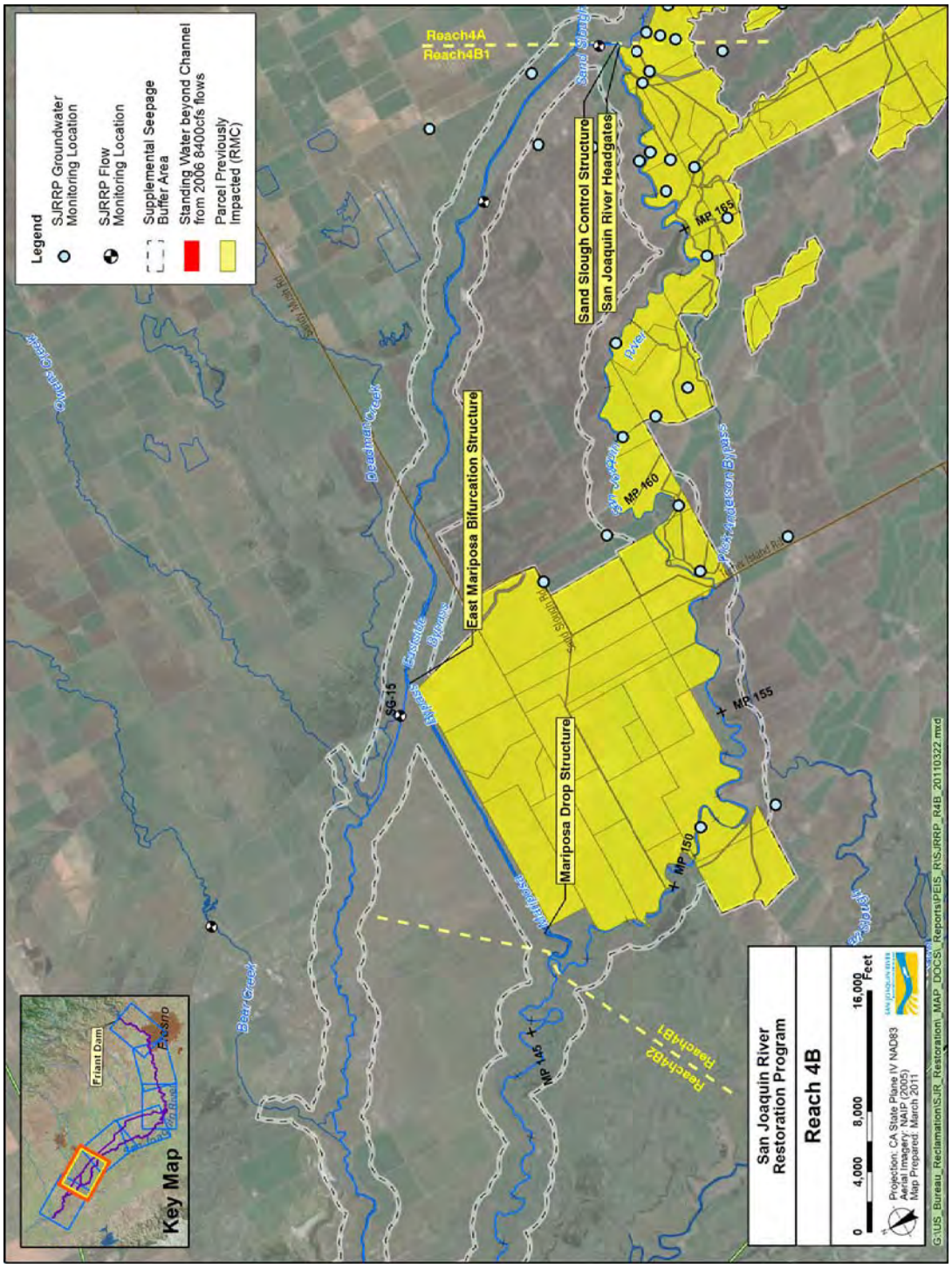

Figure 3-6.
Supplemental Buffer Zones of Groundwater and Levee Seepage Along Reach 4B of the San Joaquin River

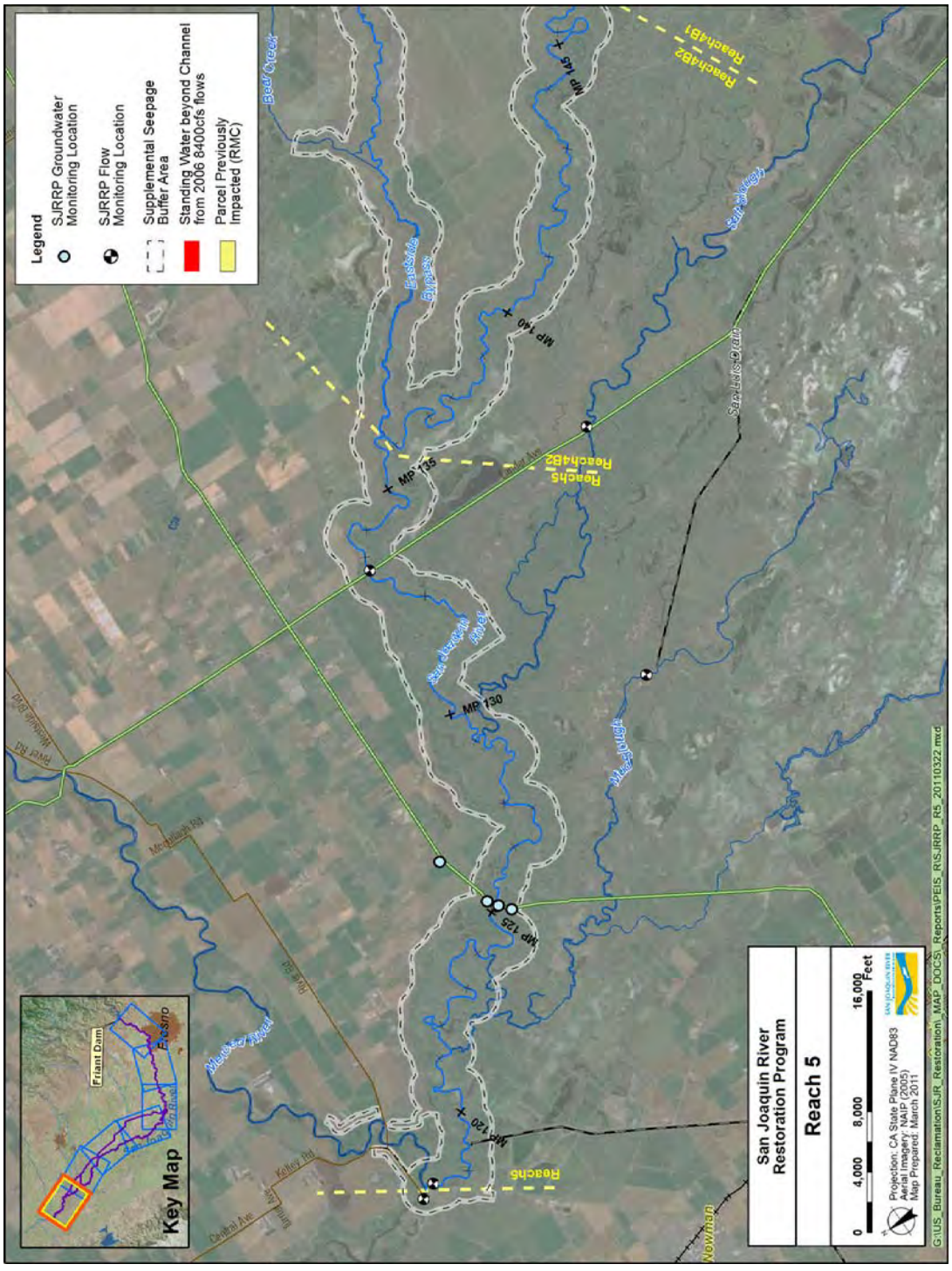

Figure 3-7.
Supplemental Buffer Zones of Groundwater and Levee Seepage Along Reach 5 of the San Joaquin River

3.1 Seepage Monitoring Activities

To monitor achievement of the groundwater seepage objective the following monitoring activities, as discussed in Section 7.0, would be undertaken on an as-needed basis:

- Flow monitoring
- Groundwater level monitoring

During Interim and Restoration flows, the seepage management objective would be achieved if adverse groundwater seepage impacts to third parties resulting from Interim or Restoration flows are reduced or avoided by keeping groundwater levels below the thresholds. Potential conditions that might trigger actions depend on site-specific concerns, and include the following:

- Groundwater elevations indicating an impending rise of the water table into root zones
- Root zone indicating increased salinization due to rising groundwater elevations and capillary fringe
- Levee stability problems and lateral seepage, as evidenced by visual observation of boils or piping
- Landowner communication of seepage problems

Implementation of these monitoring programs could involve identification of additional monitoring locations and installation of groundwater monitoring wells. Coordination with local landowners would provide information to improve the effectiveness of the monitoring program. Reclamation and DWR would monitor groundwater levels in installed wells. Observed groundwater levels would be used by the Secretary to determine when to reduce flow releases from Friant Dam, as required by the Act. Following installation of each monitoring well, groundwater elevation thresholds would be developed in consideration of nearby land uses, known groundwater and subsurface conditions, and other information available or provided by landowners.

In general, groundwater depth thresholds would be classified in three ranges, as illustrated in Figure 7-1. These include an acceptable level at which groundwater levels are not expected to affect agricultural production, a potential buffer zone indicating an increased likelihood that groundwater seepage could affect agricultural production without flow modification, and a threat zone representing groundwater levels that affect agricultural production. The threat zone would be determined based in part on the rooting depth associated with any crops located near the monitoring well. Maximum rooting depths of crops commonly found in the Restoration Area are shown in Table 7-1.

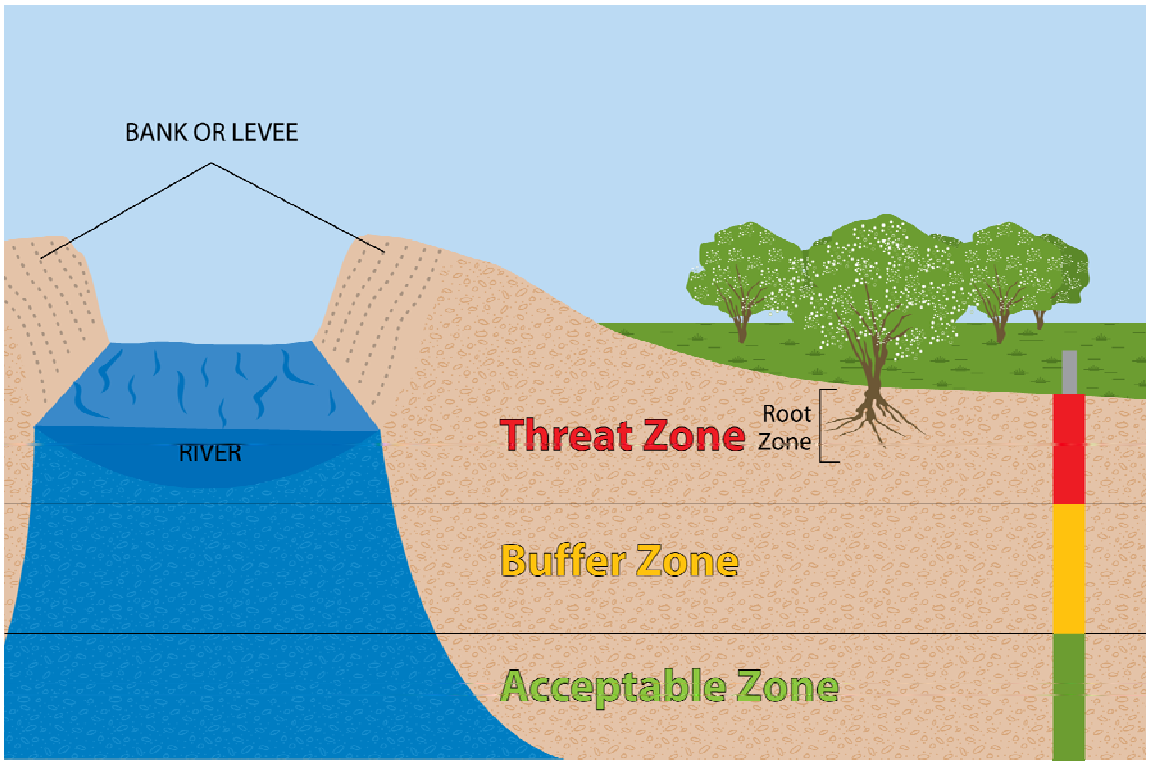

Figure 3-8.
Potential Groundwater Seepage Threshold Zones

Table 3-1.
Maximum Rooting Depth of Crops Commonly Found in the Restoration Area

Crop	Maximum Root Depth (feet)
Alfalfa[1]	6
Almonds[1]	6-9
Cotton[1]	5-6
Grape[2]	3-6
Melon[1]	5-6
Pistachio[2]	3-5
Tomato[1]	5-6

Notes:
[1] Westlands Water District, 2009.
[2] Allen, R.G., et al.

Additional monitoring actions could include levee patrols, landowner contact, soil sampling, and soil salinity surveys. Levee patrols would be conducted in coordination with the Lower San Joaquin Levee District to assist with identifying seepage. These patrols could identify the formation of boils, piping, and other indicators of potential or

real damages to the levees or associated facilities. Landowners would be able to report observed conditions through the SJRRP Web site or through a phone number. Soil sampling and soil salinity surveys could be conducted in response to landowner reports of seepage impacts.

An evaluation would be made whenever a condition is identified that could potentially require action. The evaluation would be performed to determine the appropriate actions to meet the groundwater seepage objective of the need for immediate or long-term actions management actions, and criteria would include a determination of the following:

- Type of system response identified
- Immediacy of the system response
- Need for collection of more information, potentially including site visits

3.2 Potential Seepage Management Actions

The need for action may result from either third-party seepage impacts or indications of likely third-party seepage impacts. Potential immediate and long-term actions are described below.

3.2.1 Immediate Actions

Potential immediate responses to the detection or anticipation of adverse groundwater seepage impacts would be based, in part, on monitoring of groundwater thresholds, as previously described, and include the following:

- **Reductions of Interim or Restoration Flow Releases at Friant Dam** – Reductions in the release rate from Friant Dam to limit the potential for seepage impacts to occur downstream. Planned thresholds for reductions at Friant would need to consider travel time and associated response delays.
- **Redirection of Interim or Restoration Flows at Chowchilla Bypass Bifurcation Structure** – Directing flow into the bypass system at the Chowchilla Bypass Bifurcation Structure would reduce flow in Reach 2B and downstream reaches.
- **Delivery of Interim or Restoration Flows at Mendota Pool** – Delivery of water to Mendota Pool would reduce flows in Reach 3 and downstream reaches.
- **Delivery of Interim or Restoration Flows at Arroyo Canal** – When San Luis Canal Company is not diverting at the full capacity of Arroyo Canal, additional water diversions to the canal would reduce flows in Reach 4A and downstream reaches.

- **Redirection of Interim or Restoration Flows at Sand Slough Control Structure** – During the first year of Interim Flows, water would not be directed into Reach 4B. In subsequent years, diverting flows into the bypass system at Sand Slough Control Structure would reduce flows in Reach 4B.

3.2.2 Long-Term Actions

The need for additional long-term actions may result from the inability to meet the objectives of the other component plans, such as the flow objective, due to immediate actions taken to achieve the groundwater seepage objective. Additional action would require a determination of need, identification for funding additional action, and site-specific environmental compliance documentation. Potential actions could include but would not be limited to the following: purchasing easements and/or compensation for seepage effects, construction of slurry walls to reduce seepage flows, construction of seepage berms to protect against levee failure, construction of drainage interceptor ditches to protect affected lands, or installation of tile drains on affected lands. If property or crop losses occur attributable to Interim and Restoration flow seepage, Reclamation would work in good faith with landowners to negotiate fair and reasonable easements and/or compensation for seepage effects.

4.0 Channel Capacity Monitoring and Management Component Plan

The objective of the Channel Capacity Monitoring and Management Component Plan is to maintain channel capacity within the Restoration Area. Section 10004, Paragraph (h) of the Act sets forth requirements for Interim Flows related to channel capacity including:

- Prepare an analysis of channel conveyance capacities (Paragraph (h)(1)(A))
- Release Interim Flows to the extent that such flows would not exceed existing downstream channel capacities (Paragraph (h)(2)(B))

The need for action may result from channel capacity restrictions that are identified during the release of Interim and Restoration flows. For example, increased flows or altered flow timing under the Settlement could result in increased growth of riparian vegetation or the accumulation of sediment within low flow channels of downstream reaches. These changes could lead to an increase in water surface elevation during flood events and overtopping of levees or areas that show a degradation of salmonid migration habitat.

4.1 Channel Capacity Monitoring Activities

To determine if the objectives are met, the following types of actions, as described in Section 7.0, would be undertaken on an as-needed basis:

- Flow monitoring
- Aerial and topographic surveys
- Water surface profile surveys
- Vegetation surveys
- Sediment mobilization monitoring

Additional monitoring actions useful in implementation of the plan could include suspended sediment monitoring, and bedload sediment/gravel monitoring. Field visits and inspections of vegetation density would be triggered by those areas that show a substantial increase in vegetation (based on aerial photographs). Once areas of potential reduced channel capacity are confirmed on the ground, they would be addressed by actions to the extent feasible. Evaluations of bank erosion and deposition would be completed each time aerial photography is collected by the Implementing Agencies and topographic surveys would be completed as necessary, to record potential changes in channel capacity.

4.2 Potential Channel Capacity Management Actions

The following sections identify potential immediate and long-term actions to address decreases in channel capacity due to Settlement implementation.

4.2.1 Immediate Actions

Potential immediate actions to address a reduction in channel capacity include removal of vegetation and debris. Vegetation removal would be conducted by mechanical or chemical means. Nonnative plant removal would receive priority over removal of native species. Immediate actions are described at a project-level in the PEIS/R. Any significant or potentially significant impacts of vegetation removal would be appropriately mitigated as described in the PEIS/R.

Potential responses to a reduction in channel capacity include removal of vegetation and debris and/or restrictions on Restoration flows that would exceed channel capacity. Vegetation removal would be conducted by mechanical or chemical means. Nonnative plant removal would receive priority over removal of native species. Any environmental impacts of vegetation removal would be appropriately mitigated.

4.2.2 Long-Term Actions

Potential long-term actions could include but would not be limited to the following: providing a larger floodplain between levees through the acquisition of land and construction of setback levees, regrading of land between levees, construction of sediment traps, construction of grade control structures, or channel grading. Long-term actions would require a determination of need, identification for funding, and site-specific environmental compliance documentation.

5.0 Native Vegetation Monitoring and Management Component Plan

The objective of the Native Vegetation Monitoring and Management Component Plan is to establish and maintain native riparian habitat. Establishment of native vegetation would be subject to the attainment of channel capacity objectives, as previously described. The Settlement sets forth requirements for Riparian Recruitment Flows related to native vegetation. In Wet Years, Restoration Flows should be gradually ramped down over a 60-90 day period to promote the establishment of riparian vegetation at appropriate elevations in the channel. The precise timing and magnitude of riparian recruitment releases shall be based on monitoring of meteorological conditions, channel conveyance capacity, salmonid distribution, and other physical/ecological factors with the primary goal to establish native riparian vegetation (Exhibit B Paragraph 6).

According to Scott et al. (2000), successful establishment and long-term survival of riparian trees in Reach 2 and the downstream portion of Reach 1 could be prevented by four potential causes:

- Seedlings fail to survive because flows at the end of the growing season are insufficient to sustain shallow alluvial groundwater tables, and seedlings die of desiccation (Hypothesis 1)

- Seedlings fail to establish in sufficient numbers because peak flows occur outside the peak seed dispersal period (Hypothesis 2)

- Seedlings fail to survive beyond a few years because they are killed or removed by reoccurring high flows (Hypothesis 3)

- Seedlings fail to survive the early summer because the declining limbs of flow peaks during the seed dispersal period are too rapid and seedlings established near high stage elevations die of desiccation (Hypothesis 4)

Experimental flow releases and associated monitoring were conducted in 1999, 2000, and 2001 (i.e., during the “pilot projects”) and showed that each of these factors plays a role (FWUA and NRDC 2000, Jones & Stokes and MEI 2002, SAIC 2002, 2003). It appears that ultimately most seedlings that were established by Riparian Recruitment Flows largely died because of insufficient flows during the summer (Hypothesis 1).

5.1 Native Vegetation Monitoring Activities

To monitor achievement of the native vegetation objective, the following monitoring programs would be undertaken on an as-needed basis and are described in further detail in Section 7.0:

- Flow monitoring
- Groundwater level monitoring
- Vegetation surveys

The vegetation surveys include monitoring seed dispersal, and seedling and sapling establishment. Seed dispersal monitoring would address hypothesis 2. Hypotheses 1, 3, and 4 would be addressed by seedling and sapling establishment monitoring. The data collected would focus on understanding the causes of seedling mortality, and are crucial for the effective management of Riparian Recruitment Flow release schedules. Flow monitoring and vegetation surveys would be used to determine success of the Riparian Recruitment Flow releases, and to determine the need for implementing immediate or long-term management actions.

Seed that is deposited at a low stage, too close to the base-flow channel, would likely be scoured away in subsequent winters. Flows at the end of the growing season would be monitored along with groundwater levels to determine if the shallow alluvial groundwater table is sustained.

5.2 Potential Native Vegetation Management Actions

The need for actions may result from a lack of native vegetation establishment during the release of Interim and Restoration flows.

5.2.1 Immediate Actions

Potential immediate actions to enhance achievement of the native vegetation objective include modifications to Restoration Flow Guidelines to improve the success of Riparian Recruitment Flows. Riparian Recruitment Flows could be adjusted for the purposes of target species recruitment based on seed dispersal reports and/or seedling establishment and mortality responses. Peak recruitment releases (i.e., the releases that determine at what elevation in the floodplain the seedlings would establish) should ideally coincide with the peak dispersal time of either of the two target species, Fremont cottonwood or Goodding's black willow. Fremont cottonwood is more difficult to establish and maintain in regulated rivers and if possible, accounting for other constraints, peak recruitment releases should be made when this species shows peak dispersal. If early releases are infeasible, then the Riparian Recruitment Flows should be timed to coincide with the peak dispersal of Goodding's black willow. Whether Fremont cottonwood or Goodding's black willow is the main target for establishment has consequences for the allowable

recession rates of flows, because Fremont cottonwood appears to require slower recession rates than Goodding's black willow (Stella et al. 2007).

5.2.2 Long-Term Actions

A lack of native vegetation establishment during the release of Interim and Restoration flows would result in the need for additional long-term actions. Potential additional actions could include, but would not be limited to, active plantings and irrigation of desired native plants. Additional actions would require a determination of need, identification for funding additional action, and site-specific environmental compliance documentation.

This page left blank intentionally.

6.0 Spawning Gravel Monitoring and Management Component Plan

The objective of the Spawning Gravel Monitoring and Management Component Plan is to maintain gravel beds in suitable condition for Chinook salmon spawning. Paragraph 5 in Exhibit B of the Settlement states that flows in Normal-Wet and Wet years would include Flushing Flows from April 16-30. Flushing Flows would perform several functions, including but not limited to geomorphic functions such as flushing fine sediment from spawning gravels. Exhibit B states that the Flushing Flows shall include a peak release as close to 8,000 cfs as possible for several hours and then recede at an appropriate rate. The precise timing and magnitude of the Flushing Flows have the primary goal to mobilize spawning gravels, maintain their looseness, and flush fine sediments.

6.1 Spawning Gravel Monitoring Activities

The spawning gravel management objective would be met if gravel beds of sufficient quality and quantity are available for Chinook salmon spawning.

Monitoring information needed to assess the success of this plan is detailed in Section 7.0 and includes the following:

- Flow monitoring
- Sediment mobilization monitoring

Additionally, information on bed gradation, bathymetry, sand storage, meso-habitat mapping, and micro-habitat evaluations would help determine if the objective is met. Monitoring of the fine material in the bed is the most direct method to determine if the increase in flow is effective in reducing the fraction of fine bed material.

6.2 Potential Spawning Gravel Management Actions

The need for action may result from a lack of success in maintaining gravels of sufficient quality and quantity for Chinook salmon spawning.

6.2.1 Immediate Actions

The immediate response to meet the spawning gravel management objective is to modify releases from Friant Dam to adjust flows for the purposes of gravel flushing or mobilization based on the monitoring reports of spawning gravel conditions including

potential modifications to Restoration Flow Guidelines to improve the success of Flushing Flows.

6.2.2 Long-Term Actions

A lack of success in maintaining gravels of sufficient quality and quantity for Chinook salmon spawning would result in the need for additional long-term actions. Additional actions would require a determination of need, identification for funding additional action, and site-specific environmental compliance documentation. Potential actions to enhance spawning gravel could include, but would not be limited to: gravel augmentation and/or conditioning at existing riffles, establishment of new riffles, engineered channel modifications, construction of sediment traps on the San Joaquin River or tributaries with high sediment loads, or construction of grade control structures.

7.0 Monitoring Programs

This section describes the monitoring pertaining to objectives for flow, seepage, channel capacity, native vegetation, and spawning gravel. The monitoring required for assessments of each management objective may include flow monitoring, groundwater level monitoring, aerial and topographic surveys, vegetation surveys, sediment mobilization monitoring, and spawning gravel surveys, as described below. The monitoring methods described below could be modified and updated as needed.

7.1 Flow Monitoring

The purpose of the flow monitoring program would be to obtain information about streamflow and water surface elevation. Paragraph 13 and Exhibit B of the Settlement specify measurement of Interim and Restoration flows on the San Joaquin River at the first six locations listed below. In addition to the six gages identified by the Settlement, a seventh gage is scheduled for installation to monitor Interim and Restoration flows to the Eastside Bypass. Additional flow measurements would be collected at multiple locations during flow events, but would not be part of the long-term flow monitoring network described above. Periodic monitoring the cross sections would be performed at each gage to maintain the accuracy of flow measurements made at those gages.

7.2 Groundwater Level Monitoring

The purpose of the groundwater level monitoring program would be to obtain groundwater level information. Currently, over 125 wells are included in the groundwater monitoring well network established for the SJRRP. This groundwater monitoring well network includes wells installed on both public and private lands as well as previously existing wells. Additional wells on private property could be installed, pending access agreements currently under negotiation with landowners and environmental clearance. Access limitations and information from monitoring, analysis, and trouble spots identified by local landowners would determine the final location of additional groundwater transects and wells developed with the specific intent of monitoring potential groundwater seepage. Information collected as part of the initial phases of monitoring may require changing locations or adding or decommissioning wells in the future.

7.3 Aerial and Topographic Surveys

The purpose of the aerial and topographic surveys is to obtain information about the river stage, hydraulic roughness, river width, and bed elevation. Surveys of the San Joaquin River between Friant Dam and the Merced River confluence would be conducted to assist with engineering and scientific studies of the Restoration Area during and as a result of

Interim and Restoration flow releases. These surveys would include aerial photography and topographic surveys.

True color aerial photographs would be inspected and compared to previous aerial photographs to identify areas of increased vegetation cover, sediment mobilization, bar formation, or bank erosion. After these areas have been initially identified using aerial photography, they would be visited and inspected. If inspections indicate that a management issue exists, management actions would be taken to address the issue.

Topographic surveys of waterways could be conducted from a boat with an attached Acoustic Doppler Current Profiler (ADCP) or depth sounder linked to a Real Time Kinematic (RTK) Global Positioning System (GPS). The dry reaches could be surveyed on foot or with an all-terrain-vehicle.

A complete above-and-below water terrain surface could be developed using Photogrammetry or Light Detection and Ranging (LIDAR). Photogrammetry has been used in the past to collect the terrain information. However, LIDAR is becoming more common and may be more cost effective in the future. Traditional LIDAR surveys can be used to obtain the topographic information above water. Bathymetric LIDAR may be able to obtain the bathymetry information (below-water areas). Bathymetric LIDAR uses different laser frequencies to penetrate beneath the water surface. It can be used in locations where the water is relatively clear and the depths are not too large. If Bathymetric LIDAR cannot be used or does not sufficiently describe the channel bottom, a boat survey can be used to obtain the bathymetry in below water areas. The boat should be equipped with a depth sounder and RTK GPS to link the bathymetric data to the topographic data. Periodic LIDAR surveys could provide information about aggradation and degradation trends in the channel and confirm changes in topographic surveys used to identify channel sediment deposition. Before the terrain is developed, the control network should be updated to account for subsidence that may continue in the region. Reaches 2B, 3, 4A, and the Chowchilla and Eastside Bypasses, in particular, may be affected by subsidence.

7.4 Vegetation Surveys

The purpose of the vegetation surveys is to obtain information on the establishment and recruitment of vegetation. Vegetation surveys would be conducted for both seed dispersal, and seedling and sapling establishment, as described below.

7.4.1 Seed Dispersal Surveys

Target tree species would be monitored using monitoring methods similar to those described by Stillwater Sciences in 2002 (Stillwater Sciences 2003). Monitoring the period of seed dispersal and timing of peak dispersal of target species, likely Fremont cottonwood and/or Goodding's black willow, would help determine the optimal release dates of Riparian Recruitment Flows. Recruitment flows would be effective if they coincide with seed dispersal of the two target species. The period of seed dispersal and timing of peak dispersal differs among species (McBain and Trush 2002) and also may

differ between years by several weeks, depending on weather conditions. Fremont cottonwood seed release typically peaks during the first two weeks of May, while Goodding's black willow typically peaks in late May or early June. Actual peak release dates for both species are typically earlier in the year with warmer weather and later in the year with cooler weather.

7.4.2 Seedling and Sapling Establishment Surveys

Native riparian vegetation establishment monitoring would be based on the methods developed by Scott et al. (2000), and implemented in the pilot projects performed by the San Joaquin River Riparian Habitat Restoration Program in 1999 through 2003. By using sampling locations and methods used in the pilot projects, the data collected during monitoring can be interpreted based on relationships between vegetation and hydrology established during the pilot projects.

Vegetation monitoring would record the size and number of plants presents (riparian tree seedlings as well as all other native and exotic herbaceous and woody plants) at designated sites. This information would be used to estimate vegetative cover. Vegetative cover is an important measure of the suitability of sites for establishment of willow and cottonwood seedlings, since these species grow best in full sun and without competition from other plants.

7.5 Sediment Mobilization Monitoring

The purpose of the Sediment Mobilization Monitoring Plan is to obtain information on sediment mobilization, bar formation, and bank erosion. Aerial photography and/or ground surveys would provide information on sediment mobilization, bar formation, and bank erosion. Comparison of aerial photographs or ground surveys would be used to determine changes in bank line indicating potential erosion.

Previous information documents sediment and geomorphology within the system. Information developed by Reclamation includes preliminary analyses conducted to identify locations susceptible to potential erosion through comparison of present day channel positions (2004) and historical channel positions (1937, 1938). Reclamation identified areas that may be susceptible to future erosion using the following criteria:

1. Areas of channel change between 1937 and 2004 or between 1983 and 2004 where channel has shown lateral erosion along an outer bend or where it has the potential to reoccupy an old channel position and laterally erode banks along an outer bend, and that also have low topography (for instance, several outer bends in Reach 1A are located adjacent to high bluffs, which would be considered an area of slower erosion and are thus not identified)

2. Meander necks where channel sinuosity is high and could create a cutoff

3. Areas along outer bends where excavated gravel pits are located close to the active channel, regardless of whether any historical channel change has occurred

4. Areas along outer bends that are located adjacent to developed areas (such as at Firebaugh)

Areas with the potential for future erosion identified through this process were prioritized for monitoring based on potential impacts to infrastructure. The highest priorities were those with residential developments, buildings, and bridges. Other high priority areas included those containing levees, irrigation canals, and roads with an apparent high potential to experience some lateral migration or bank erosion. Sediment mobilization monitoring would focus on areas identified through this process, and would evaluate current and estimate potential future erosion at the sites. Channel bed deposition could be evaluated by analyzing changes identified in topographic survey data and LIDAR surveys.

7.6 Spawning Gravel Surveys

The purpose of the spawning gravel surveys is to obtain information on gravel distribution. Pebble count sampling would focus on riffles, and may not be required outside of Reach 1. Pebble counts should be conducted in the wet portion of the channel at low flow. Several cross sections in each riffle would be sampled. Photographic sampling of the river bed may possibly supplement or replace the pebble count methods. Pebble count methods are labor intensive and new photographic techniques that determine grain size distributions are emerging. Photographs taken of the bed at the same locations as the pebble counts would allow evaluation of the photographic techniques.

Spawning gravel quantity and quality would also be evaluated through meso-habitat mapping and micro-habitat evaluations. Meso-habitat mapping is intended to document the longitudinal distribution of habitat units. The time period for mapping would be dependent on the flow regime. Potential spawning habitats (riffles) in Reach 1 would be evaluated as part of the micro-habitat measurements taken in coordination with pebble counts to determine gravel size and distribution.

8.0 References

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998. Crop evapotranspiration – Guidelines for computing crop water requirements. FAO Irrig. And Drain. Paper 56, Food and Agric. Organ. United Nations, Rome, Italy.

California Department of Water Resources. 2009. Stream Gage Installation and Operation and Maintenance Project Initial Study/Mitigated Negative Declaration. March.

Friant Water Users Authority and Natural Resources Defense Council (FWUA and NRDC). 2000. 1999 San Joaquin River Riparian Flow Release Pilot Project. Unpublished.

FWUA and NRDC. *See* Friant Water Users Authority and Natural Resources Defense Council.

Jones & Stokes and Mussetter Engineering, Inc. 2002. *San Joaquin River Pilot Project 2000, baseline vegetation and physical variable data collection summary*. Final. January 2002. (J&S 00-218.) Sacramento, California. Prepared for Friant Water Users Authority, Lindsay, California.

McBain and Trush. 2002. *San Joaquin River Restoration Study Background Report.* Edited by McBain and Trush. Prepared for Friant Water Users Authority and Natural Resources Defense Council. Chapter 8.Vegetation. Arcata, California.

SAIC. *See* Science Applications International Corporation.

Science Applications International Corporation (SAIC). 2002. *San Joaquin River Pilot Project 2001. Preliminary Final. Vegetation and Hydrologic Monitoring Report*. Prepared for Friant Water Users Authority. Prepared by Science Applications International Corporation. Santa Barbara, California.

———. 2003. *Draft 2002 San Joaquin River Vegetation and Hydrologic Monitoring Report*. Prepared for Friant Water Users Authority. Prepared by Science Applications International Corporation. Santa Barbara, California.

Scott, M. L., G. T. Auble, and P. B. Shafroth. 2000. *Evaluating effectiveness of flow releases for restoration of riparian vegetation on the San Joaquin River*. U.S. Geological Survey. Fort Collins, Colorado.

Stella, J. C., J. J. Battles, J. R. McBride, and B. K. Orr. 2007. Physiological adaptations increase survival for riparian tree seedlings subject to river stage decline. Presentation to the Ecological Society of America, Annual Meeting. August 5-10, 2007.

Stillwater Sciences. 2003. March. *Restoration Objectives for the San Joaquin River*. Final. Berkeley, California. Appendix D. San Joaquin River 2002 riparian tree seed release timing.

U.S. Department of the Interior, Bureau of Reclamation (Reclamation). 2008. Installation and Rehabilitation of Stream Gages on the San Joaquin River, Fresno, Madera, and Merced Counties, California Environmental Assessment. December.

———. 2009. San Joaquin River Restoration Program Seepage Well Installation on Public Lands Categorical Exclusion Checklist. March.

Westlands Water District. 2009. Crop Characteristics. Available at http://www.westlandswater.org/wtrcon/handbook/crops/crops.htm. Accessed August 7, 2009.