Draft Technical Memorandum

Monitoring Plan for Physical Parameters

SAN JOAQUIN RIVER
RESTORATION PROGRAM

September 2008 – Version ii

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List of Abbreviations and Acronyms

ADCP	Acoustic Doppler current profiler
CalEPA	California Environmental Protection Agency
CDEC	California Data Exchange Center
CEQA	California Environmental Quality Act
cfs	cubic feet per second
COC	chain of custody
CVO	Central Valley Operations
CVP	Central Valley Project
DCR	Data Collection and Review Subgroup
Delta	Sacramento-San Joaquin Delta
DFG	California Department of Fish and Game
DHS	California Department of Health Services
DMO	data management organization
DO	dissolved oxygen
DWR	California Department of Water Resources
EC	electrical conductivity
FWUA	Friant Water Users Authority
GAMA	Groundwater Ambient Monitoring and Assessment Program
GIS	geographic information system
GMP	Groundwater Management Plan
HAR	Hydrologic Assessment Report
I-5	Interstate 5
IIMS	Integrated Information Management System
IWRIS	Integrated Water Resources Information System
kW	kilowatt
m	meters
MAGPI	Merced Area Groundwater Pool Interests
M&I	municipal and industrial
msl	mean sea level
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council

NSIP	National Stream Information Program
NWIS	National Water Information System
PEIS/R	Program Environmental Impact Statement/Report
PMT	Program Management Team
QA	Quality Assurance
QC	Quality Control
QCO	Quality Control Officer
RASA	Regional Aquifer System Analysis
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RM	river mile
RWQCB	Regional Water Quality Control Board
SCCAO	Reclamation, South Central California Area Office
Settlement	Stipulation of Settlement
SJRRP	San Joaquin River Restoration Program
SLDMWA	San Luis-Delta Mendota Water Authority
SOP	standard operating procedure
SSPA	S.S. Papadopulos and Associates
State	State of California
SWP	State Water Project
TM	Technical Memorandum
TMDL	total maximum daily load
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
WDL	Water Data Library
WPIE	Water Planning Information Exchange

This Draft Technical Memorandum (TM) was prepared by the San Joaquin River Restoration Program (SJRRP) Team as a draft document in support of preparing a Program Environmental Impact Statement/Report (PEIS/R). The purpose for circulating this document at this time is to facilitate early coordination regarding initial concepts and approaches currently under consideration by the SJRRP Team with the Settling Parties, Third Parties, other stakeholders, and interested members of the public. Therefore, the content of this document may not necessarily be included in the PEIS/R.

This Draft TM does not present findings, decisions, or policy statements of any of the Implementing Agencies. Additionally, all information presented in this document is intended to be consistent with the Settlement. To the extent inconsistencies exist, the Settlement should be the controlling document and the information in this document will be revised prior to its inclusion in future documents. While the SJRRP Team is not requesting formal comments on this document, all comments received will be considered in refining the concepts and approaches described herein to the extent possible. Responses to comments will not be provided and this document will not be finalized; however, refinements will likely be reflected in subsequent SJRRP documents.

1.0 Introduction

This Draft Technical Memorandum (TM) describes a monitoring plan for measuring physical parameters, including flow, water quality, river losses, bank seepage, and sediment transport, resulting from implementation of Interim Flows and Restoration Flows. Publicly available, high quality data are critical for determining the effects of Interim Flows and Restoration Flows on conditions in the San Joaquin River between Friant Dam, the confluence with the Merced River, and beyond to the Sacramento-San Joaquin Delta (Delta). The monitoring plan for ecological parameters will be documented in the Fisheries Management Plan and other TMs.

This TM was prepared by the San Joaquin River Restoration Program (SJRRP) monitoring subgroup, which consists of staff from the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), the California Department of Water Resources (DWR), and the California Department of Fish and Game (DFG). The monitoring plan, as proposed, will be conducted by staff of these agencies and will complement additional independent monitoring by other Federal, State, and private agencies.

1.1 Background

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit challenging the renewal of long-term water service contracts between the United States and the Central Valley Project (CVP) Friant Division contractors. After more than 18 years of litigation of this lawsuit, known as *NRDC et al. v. Kirk Rodgers et al*., a Stipulation of Settlement (Settlement) was reached. On September 13, 2006, the Settling Parties, including NRDC, Friant Water Users Authority

(FWUA), and the U.S. Departments of the Interior and Commerce, agreed on the terms and conditions of the Settlement, which was subsequently approved by the U.S. Eastern District Court of California on October 23, 2006.

The SJRRP will implement the San Joaquin River litigation Settlement. The Implementing Agencies responsible for managing the SJRRP are the U.S Department of the Interior, through Reclamation and the Fish and Wildlife Service (USFWS); U.S Department of Commerce through the National Marine Fisheries Service (NMFS); and the State of California through DWR, DFG, and the California Environmental Protection Agency (CalEPA). Consistent with the Memorandum of Understanding between the Settling Parties and the State of California (State), which was signed at the same time as the Settlement, the State, through DFG, DWR, the Resources Agency, and CalEPA, will play a major, collaborative role in planning, designing, funding, and implementing the actions called for in the Settlement.

The SJRRP is a comprehensive long-term effort to restore flows in the San Joaquin River from Friant Dam to the confluence of the Merced River, ensure irrigation supplies to Friant water users, and restore a self-sustaining fishery in the river.

The Settlement has two primary goals:

- **Restoration Goal –** To restore and maintain fish populations in “good condition” in the mainstem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.
- **Water Management Goal –** To reduce or avoid adverse water supply impacts on all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the Settlement.

Reclamation and DWR have initiated environmental compliance documentation for the SJRRP. The Implementing Agencies have organized a Program Management Team (PMT) and several Technical Work Groups to develop a plan for implementing the Settlement through a joint National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) process, which includes preparation of a Program Environmental Impact Statement/Report (PEIS/R). Reclamation is the lead NEPA agency and DWR is the lead CEQA agency for the SJRRP.

1.2 Study Area

The study area for the PEIS/R (Figure 1-1) encompasses geographic areas that may be affected either directly or indirectly by implementation of actions included in the PEIS/R alternatives. For convenience of organization, the study area consists of three general geographic subareas: the San Joaquin River, the Delta, and water service areas (including Federal, State, and local water service entities). Each of these geographic areas has the potential to be affected directly by implementation of SJRRP alternatives through construction and/or operational changes, or indirectly through biological interactions and/or changes in water project operations.

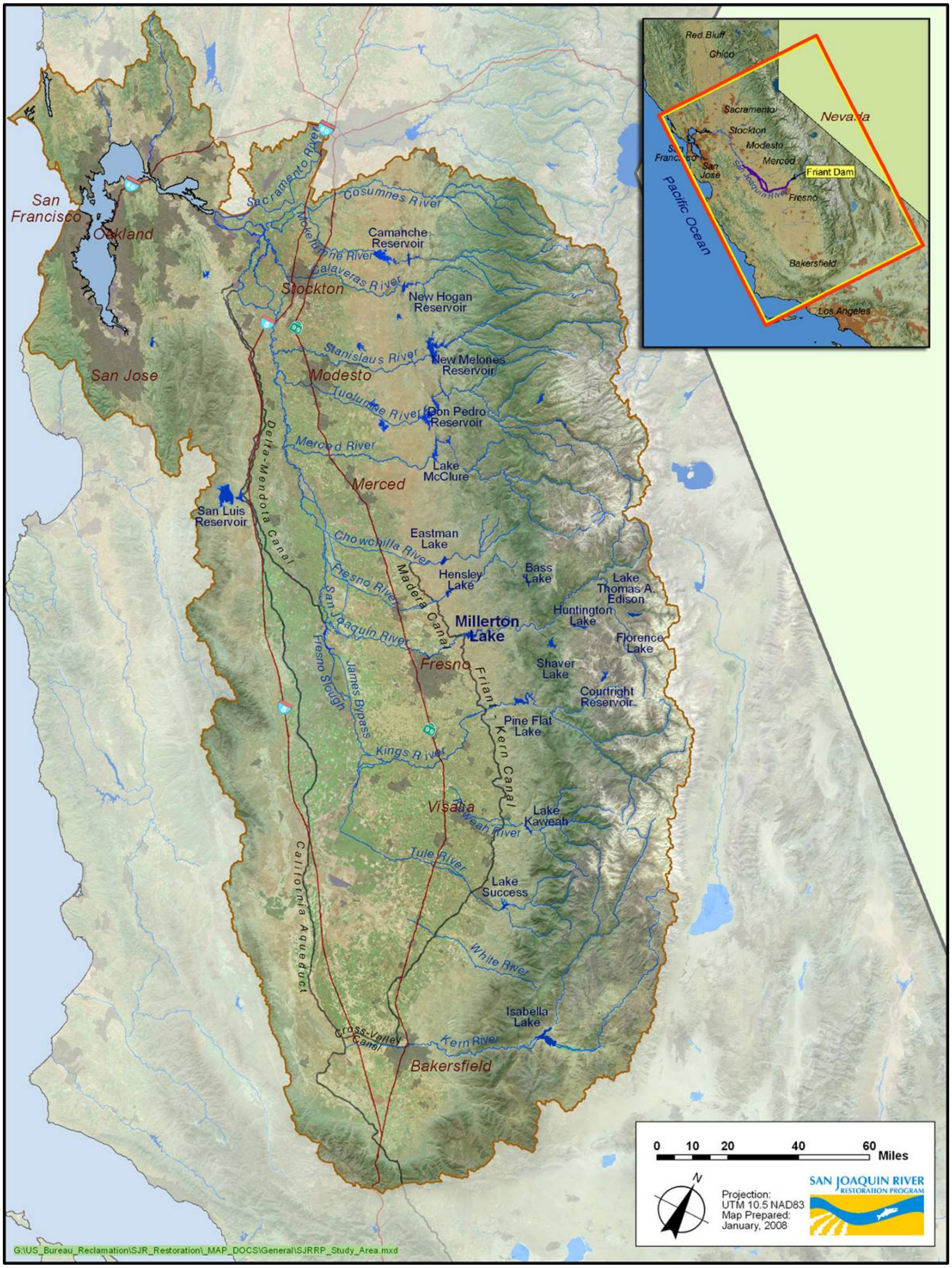

Figure 1-1.
San Joaquin River Restoration Program Study Area

The focus of this TM is monitoring activities to achieve the Restoration Goal for the San Joaquin River from Friant Dam to the Merced River confluence. However, some monitoring activities are planned for areas downstream from the Merced River confluence to adequately assess impacts due to Interim Flows and Restoration Flows.

This TM describes a “Restoration area” boundary located approximately 1,500 feet on either side of the centerline of the mainstem of this section of the San Joaquin River, and the Eastside, Mariposa, and Chowchilla bypasses, with some exceptions, to include or exclude relevant water features such as the Mendota Pool. The ultimate boundary of the Restoration area may be revised through consultation with any agencies having jurisdiction impacted by the SJRRP. The consultation considers such factors as geomorphology, biological resources, and mining pits located adjacent to the currently identified Restoration area. The boundary may also be revised considering locations of future restoration activities. The Settlement divided the Restoration area into reaches based on physical characteristics, as shown in Figure 1-2.

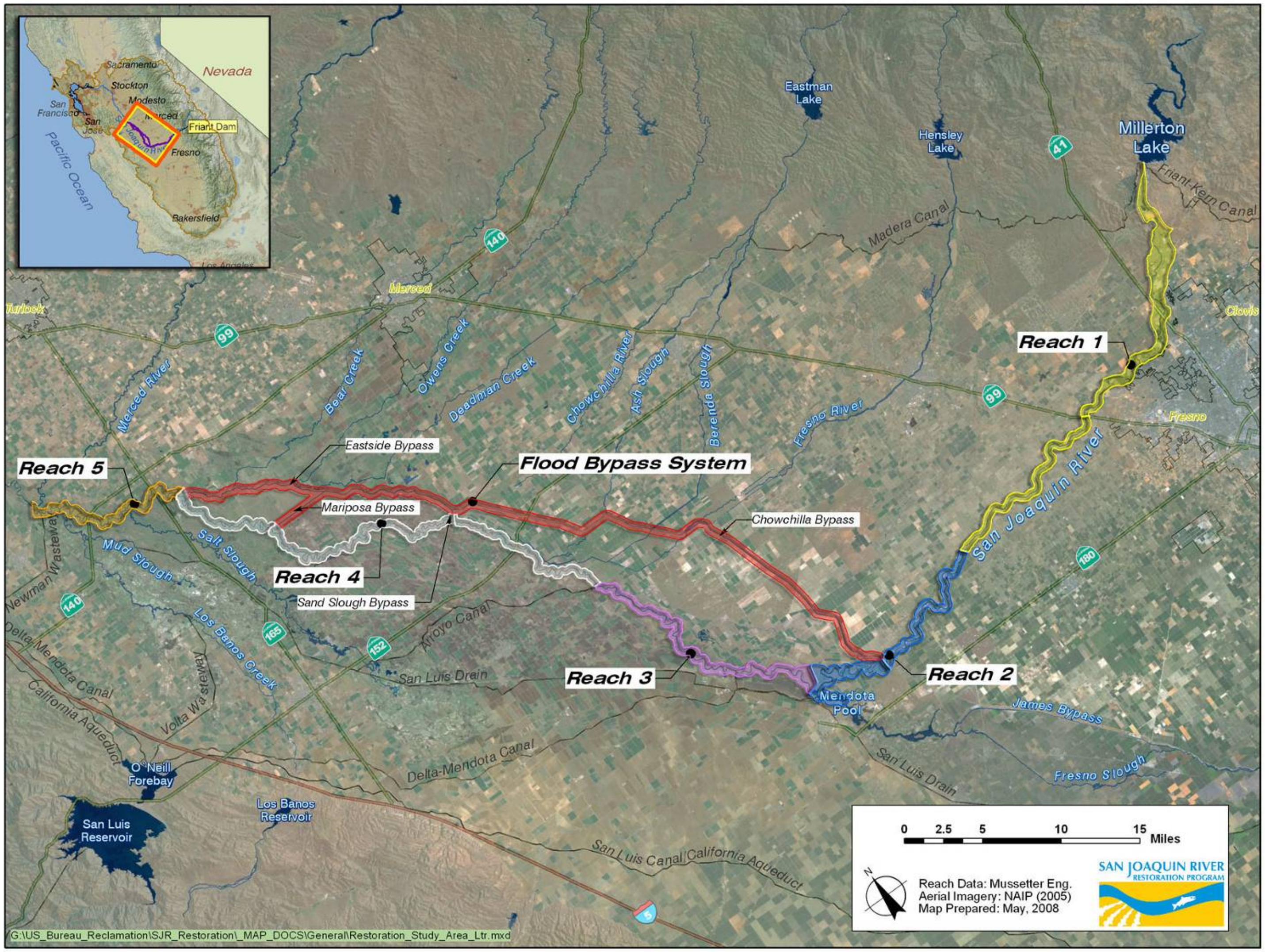

Figure 1-2.
Restoration Area and Study Reaches

1.3 Definition of Key Terms

Key terms defined in the Settlement include the following:

- **Interim Flows –** Releases of water from Friant Dam consistent with Restoration Flow Schedules specified in the Settlement but subject to channel capacity limitations, commencing no later than October 1, 2009, for the purpose of collecting relevant data concerning flows, temperatures, fish needs, seepage losses, recirculation, recapture, and reuse.
- **Restoration Flows –** Collectively, the Base Flows, Buffer Flows, and any additional water acquired by the Secretary of the Interior from willing sellers to meet the Restoration Goal of the Settlement.
- **Base Flows –** Releases from Friant Dam made in accordance with Exhibit B of the Settlement. Together, the Base Flows, Buffer Flows, and any additional water acquired by the Secretary of the Interior from willing sellers to meet the Restoration Goal of the Settlement are collectively referred to as the "Restoration Flows."
- **Buffer Flows –** Releases up to an additional 10 percent of applicable Base Flows, as provided in Paragraph 18 and Exhibit B of the Settlement. Together, the Base Flows, Buffer Flows, and any additional water acquired by the Secretary of the Interior from willing sellers to meet the Restoration Goal of the Settlement are collectively referred to as the "Restoration Flows.
- **Flushing Flows –** A block of water averaging 4,000 cubic feet per second (cfs) from April 16 through 30 in normal-wet and wet years that could be needed to perform geomorphic functions such as flushing spawning gravels in accordance to Exhibit B of the Settlement.
- **Restoration water year type –** Exhibit B of the Settlement identifies six water year-types based on October-to-September unimpaired runoff (inflow) at Friant Dam. These are (in order of increasing "wetness") as follows: critical-low, critical-high, dry, normal-dry, normal-wet, and wet. Except the lowest water year-type (critical-low), water years are defined as falling in a defined range on an exceedence curve of the unimpaired runoff. The Settlement defines year-types based on their occurrence in an 83-year period, from 1922 through 2004, without using a conventional threshold approach. While the associated year-type for each year within the 83-year period is clear, the extrapolation of such a Restoration year-type definition for years outside this period is not. To be consistent with Exhibit B, a threshold was defined using a practical point near the average of the unimpaired runoff amounts of 2 years that bracket the transition. Therefore, the classification of Restoration year-types was recommended for the SJRRP based on annual October-through-September unimpaired flow below Friant Dam threshold levels, as shown in Table 1-1.

Table 1-1.
Water Year-Types and Associated Threshold Levels
Based on the Settlement

Threshold Level	Exceedence Level	Water Year-Type
Equal to or greater than 2,500,000 acre-feet	Wettest 20%	Wet
Equal to or greater than 1,450,000 acre-feet	Next 30% (20 to 50%)	Normal-wet
Equal to or greater than 930,000 acre-feet	Next 30% (50 to 80%)	Normal-dry
Equal to or greater than 670,000 acre-feet	Next 15% (80 to 95%)	Dry
Equal to or greater than 400,000 acre-feet	Remaining 5% (95 to 100%)	Critical-high
Less than 400,000 acre-feet		Critical-low

Key:
Settlement = Stipulation of Settlement

- **Hydrographs** – A chronological graphic record of stream discharge or water level (stage) at a given point on a stream (i.e., a graph of discharge or stage versus time). Hydrographs for various reaches of the San Joaquin River for each water year-type are contained in Exhibit B of the Settlement.

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2.0 Monitoring Objectives

This section describes the monitoring objectives and components identified for evaluating effects of implementing Interim Flows and Restoration Flows on river flow, water quality, river losses, bank seepage, and sediment transport in the Restoration area.

2.1 Objectives Specified in the Settlement

The objectives of the SJRRP include the Restoration Goal and Water Management Goal, as detailed in Section 1.1. Specific monitoring objectives for Restoration Flows, Flushing Flows, and Riparian Recruitment Flows are contained in the Settlement to contribute toward meeting the Restoration Goal and the Water Management Goal, as described below.

2.1.1 Restoration Flows

Paragraph 13 of the Settlement describes implementing Restoration Flows. Flow monitoring objectives specified in Paragraph 13 include the following:

Line 23, Page 14

(g) The Restoration Flows will be measured at not less than the following six locations between Friant Dam and the confluence of the Merced River, and the measurements will be monitored to ensure compliance with the hydrograph releases (Exhibit B) and any other applicable flow releases (e.g., Buffer Flows): (i) at or immediately below Friant Dam (designated as “Friant Release” on the applicable hydrograph); (ii) Gravelly Ford (designated as “Reach 2” on the applicable hydrograph); (iii) immediately below the Chowchilla Bifurcation Structure (designated as “Reach 3” on the applicable hydrograph); (iv) below Sack Dam (designated as “Reach 4” on the applicable hydrograph); (v) top of Reach 4B (designated as “Reach 5” on the applicable hydrograph); and (vi) at the confluence of the Merced River (designated as “Confluence” on the applicable hydrograph).

Line 25, Page 16

(j) Prior to the commencement of the Restoration Flows as provided in this Paragraph 13, the Secretary, in consultation with the Plaintiffs and Friant Parties, shall develop guidelines, which shall include, but not be limited to: (i) procedures for determining water-year types and the timing of the Restoration Flows consistent with the hydrograph releases (Exhibit B); (ii) procedures for the measurement, monitoring and reporting of the daily releases of the Restoration Flows and the rate of flow at the locations listed in Paragraph 13(g) to assess compliance with the hydrographs and any other applicable releases (e.g., Buffer Flows); (iii) procedures for determining and accounting for reductions in water deliveries to Friant Division long-term contractors caused by the Interim Flows and Restoration Flows; (iv) developing a methodology to determine whether seepage losses and/or downstream surface or underground diversions increase beyond current levels assumed in Exhibit B; (v) procedures for making real-time changes to the actual releases from Friant Dam necessitated by unforeseen or extraordinary circumstances; and (vi) procedures for determining the extent to which flood releases meet the Restoration Flow hydrograph releases made in accordance with Exhibit B. Such guidelines shall also establish the procedures to be followed to make amendments or changes to the guidelines.

2.1.2 Flushing Flows

Exhibit B of the Settlement includes the following provisions for Flushing Flows:

Paragraph 5, Page 2

Flushing Flows – In Normal-Wet and Wet Years, the stair-step hydrographs, Exhibits 1A-1F, include a block of water averaging 4,000 cfs from April 16-30 to perform several functions, including but not limited to geomorphic functions such as flushing spawning gravels (“The Flushing Flows”). Therefore, unless the Secretary, in consultation with the Restoration Administrator, determines that Flushing Flows are not needed, hydrographs in Normal-Wet and Wet years will also include Flushing Flows during that period. Working within the constraints of the flood control system, the Restoration Flow releases from Friant Dam to provide these 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 shall be based on monitoring of meteorological conditions, channel conveyance capacity, salmonid distribution, and other physical/ecological factors with the primary goal to mobilize spawning gravels, maintain their looseness and flush fine sediments, so long as the total volume of Restoration Flows allocated for Flushing Flows for that year is not changed. Nothing in this Paragraph 5 is intended to limit the flexibility to move or modify the Flushing Flows as provided in Paragraph 4 above, so long as the total volume of Base Flows allocated during the Spring Period is not changed.

2.1.3 Riparian Recruitment Flows

Exhibit B of the Settlement includes the following provisions for Riparian Recruitment Flows:

Paragraph 6, Page 3

> Riparian Recruitment Flows – In Wet Years, in coordination with the peak Flushing Flow releases, 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 the riparian recruitment release 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 working within the constraints of the flood control system, so long as the total volume of Restoration Flows allocated for the Riparian Recruitment for that year is not exceeded.

2.2 Monitoring Plan Components

This monitoring plan is organized by the following monitoring components, which are either explicitly identified in the Settlement language, or implicitly required for evaluating the SJRRP objectives: flow, water quality, river losses, bank seepage, and sediment transport. Objectives specific to each of these five components are described below.

2.2.1 Flow Monitoring Objectives

The primary objective of the stream gaging program will be to obtain publicly available, high-quality, continuous streamflow data to support the river restoration effort. Raw data will be collected at 15-minute intervals, allowing computation of average hourly and average daily flows. A continuous record of average hourly flow in the San Joaquin River will be computed at the primary monitoring stations using standard stream gaging techniques, as described in the U.S. Geological Survey (USGS) publication series *Techniques of Water Resource Investigations* (Buchanan and Somers, 1968, 1969; Carter and Davidson, 1968). While hourly flow will be measured and available provisionally to the public, average daily flows will be published in the final flow record. The primary monitoring stations are specified in the Settlement, Paragraph 13 and Exhibit B:

1. Friant Dam
2. Gravelly Ford
3. Below Chowchilla Bifurcation Structure
4. Below Sack Dam
5. Top of Reach 4B
6. Merced River confluence

2.2.2 Water Quality Monitoring Objectives

The water quality monitoring data collected will be used to verify that Interim Flows and Restoration Flows are sufficient in condition (e.g., temperature) for meeting life history requirements for spring- and fall-run Chinook salmon in the San Joaquin River between Friant Dam and the Merced River confluence in accordance with the Fisheries Management Plan that is under development. Water quality monitoring is implicitly required to meet the Restoration and Water Management goals of the Settlement (Section 2.1).

2.2.3 River Losses Monitoring Objectives

River losses monitoring is included in Paragraph 13(j) (iv) of the Settlement for verifying seepage losses and/or downstream surface or underground diversions affecting Interim Flows or Restoration Flows. The objective of the river losses monitoring will be to determine whether the seepage losses and/or downstream surface or underground diversions significantly differ from the levels that were assumed in Exhibit B of the Settlement. The Settlement provides the option of releasing water acquired from willing sellers to compensate for any unexpected losses in Paragraphs 13(c)(1) and 13(c)(2); therefore, quantification of these losses will allow calculation of the amount of water to be acquired.

2.2.4 Bank Seepage Monitoring Objectives

The objective of the bank seepage monitoring will be to monitor groundwater level changes in response to Interim Flows or Restoration Flows along portions of the San Joaquin River. The purposes of groundwater monitoring will be first to help identify horizontal flow gradients to assess, through a generalized gradient analysis, the likely impacts to surrounding land use areas that are considered potentially vulnerable to ponding or high groundwater and, second, to update and recalibrate groundwater models in the vulnerable areas.

2.2.5 Sediment Transport Monitoring Objectives

Sediment transport forms the physical structure of the channel and therefore impacts all intended functions of the river (e.g., water delivery), flood control, and restoration activities. Monitoring sediment loads provides data to anticipate changes and develop strategies to plan against or take advantage of geomorphic processes that could impact or govern the beneficial uses of the river. Future channel change that might be attributed to Restoration Flows will require empirical information to support conclusions.

The need for sediment monitoring is implicitly included in Exhibit B, Paragraphs 5 and 6 (see Section 2.1). Sediment monitoring is necessary for several evaluations required by the Settlement to achieve the primary goals of mobilizing spawning gravels, maintaining their looseness, flushing fine sediments, and establishing native riparian vegetation. Sediment monitoring is also necessary to achieve the objective of maintaining desired channel conveyance capacity.

3.0 Current Monitoring Programs and Data Sources

This section provides an overview of current flow, water quality, groundwater, and sediment monitoring programs in the Restoration area. The SJRRP will coordinate with and expand on these monitoring programs, where feasible, to meet the program monitoring objectives. In some cases, data are also available from other sources that are potentially useful for the SJRRP.

3.1 Current Flow Monitoring Programs and Data Sources

Flow monitoring programs are currently underway by Reclamation, USGS, DWR, and San Luis-Delta Mendota Water Authority (SLDMWA) in the Restoration area. The current monitoring programs provide flow data in support of CVP/State Water Project (SWP) operations for Reclamation, DWR, and their contractors, and as part of the National Streamflow Information Program (NSIP) for USGS. Reclamation and DWR also monitor flow in support of the San Joaquin River Real-Time Water Quality Management Program. Streamflow gages used in these monitoring programs are listed in Table 3-1, and shown in Figure 3-1.

Table 3-1.
Current Flow Monitoring in the Restoration Area

Reach	Gage Name	Station Identifier(s)[1]	Responsible Agency	Flow Data Frequency	Period of Record
1A	Friant Dam (Millerton)	MIL	Reclamation	Daily, Event	4/1/2000-present
	San Joaquin River below Friant Dam	11251000/SJF	USGS	Event	10/1/07-present
	Cottonwood Creek near Friant	CTK	Reclamation	Hourly	11/1/97-present
	Little Dry Creek near Friant	LDC	Reclamation	Hourly	11/1/97-present
	San Joaquin River at Highway 41	H41	Reclamation	Hourly	8/18/2005-present
1B	San Joaquin River at Donny Bridge	DNB	Reclamation	Event	6/16/2004-present
	San Joaquin River at Skaggs Bridge	N/A	Reclamation	Daily	N/A
2A	San Joaquin River at Gravelly Ford	GRF	Reclamation	Hourly	3/20/1997-present
2B	San Joaquin River below Bifurcation	SJB	DWR	Event	6/20/1997-present
	Chowchilla Bypass at Bifurcation Structure	CBP	SLDMWA	Hourly	6/20/1997-present

Table 3-1.
Current Flow Monitoring in the Restoration Area (continued)

Reach	Gage Name	Station Identifier(s)[1]	Responsible Agency	Flow Data Frequency	Period of Record
3	James Bypass (Fresno Slough) near San Joaquin	11253500/JBP	USGS/SLDMWA	Daily/Hourly	3/20/1997-present
	San Joaquin River near Mendota	11254000/MEN	USGS/DWR	Hourly	1/1/84-present
4B	Mariposa Bypass near Crane Ranch	N/A	DWR	Daily	N/A
	Eastside Bypass near El Nido	ELN	DWR	Hourly	1/1/84-present
5	San Joaquin River near Stevinson	SJS	DWR	Hourly	3/20/1997-present
	Salt Slough at Highway 165 near Stevinson	11261100/SSH	USGS	Hourly	10/1/94-present
	San Joaquin River at Fremont Ford Bridge	11261500/FFB	USGS	Event	5/12/2004-present
	Mud Slough near Gustine	11262900/MSG	USGS	Hourly	6/4/2004-present
Downstream from 5	San Joaquin River near Newman	11274000/NEW	USGS/DWR	Hourly	1/1/84-present
	Merced River near Stevinson	11272500/MST	DWR	Hourly	3/20/1997-present

Note:
[1] USGS gage number and/or CDEC identifier
Key:
CDEC = California Data Exchange Center
DWR = California Department of Water Resources
N/A = Not applicable or not available
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
SLDMWA = San Luis-Delta Mendota Water Authority
USGS = U.S. Geological Survey

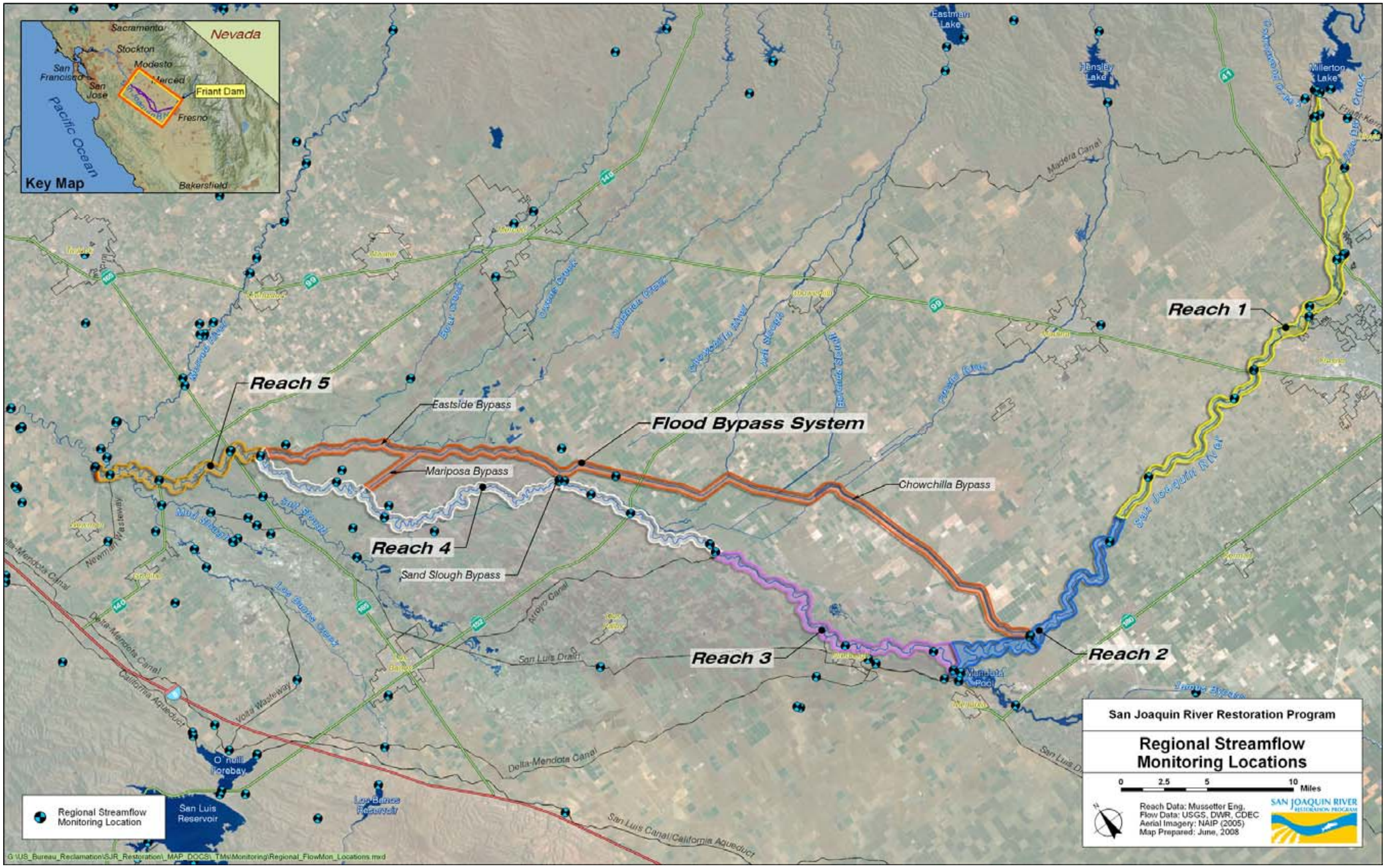

Figure 3-1.
Existing Streamflow Gages in the San Joaquin Region

3.2 Current Water Quality Monitoring Programs and Data Sources

Water quality monitoring programs are currently underway by Reclamation, USGS, DFG, DWR, and the Central Valley Regional Water Quality Control Board (RWQCB) in the Restoration area. The U.S. Environmental Protection Agency (USEPA) maintains a database of existing water quality monitoring programs in the San Joaquin River watershed through the San Joaquin River Monitoring and Assessment Strategy Web site. The SJRRP will coordinate with other water quality monitoring programs by participating in the USEPA San Joaquin River Monitoring and Assessment Strategy, a program that facilitates coordination between water quality monitoring programs. Water quality monitoring programs and data sources are listed in Table 3-2 (USEPA, 2008). Locations of existing water quality gages are shown in Figure 3-2.

**Table 3-2.
Current Water Quality Monitoring Programs and Data Sources in the Restoration Area**

Water Quality Monitoring Program	Lead Agencies	Period of Record	Parameters	Frequency
IEP Environmental Monitoring Program	DWR	1971-present	Biological community, basic parameters, sediments, clarity (turbidity, Secchi depth), nutrients, organics, toxicity	Monthly, continuous, quarterly
Subsurface Agricultural Drainage Monitoring Program	Central Valley RWQCB	2000-present	Basic parameters, ions & minerals, trace elements & metals	Weekly
San Joaquin-Tulare Basins National Water Quality Assessment Program	USGS	1991-present	Basic parameters, nutrients, organics, pesticides, sediments	By-weekly
Central Valley Project Baseline Water Quality Monitoring Program	Reclamation	1998-present	Trace metals, ions & minerals, nutrients	Quarterly
DFG Water Quality Sampling	DFG	2003-present	Basic parameters	Hourly
Grasslands Bypass Project	Reclamation, Central Valley RWQCB	1996-present	Basic parameters, ions & minerals, nutrients, trace elements & metals	Weekly, Monthly
San Joaquin District – Surface Water Monitoring Sites	DWR	1959-present	Basic parameters, nutrients, trace elements & metals	Monthly
San Joaquin River Real-time Water Quality Management Program	Reclamation, DWR	1996-present	EC, DO, temperature	Hourly
Surface Water Ambient Monitoring Program (SWAMP)	Central Valley RWQCB	1999-present	Basic parameters, organics, bacteria, pathogens	Weekly, by-monthly, Semiannually
Reclamation Flow Data	Reclamation	1944-present	Basic parameters	Daily
Irrigated Lands Program	Westside San Joaquin River Watershed Coalition, Central Valley RWQCB	2004 - present	Basic parameters, sediments, clarity (turbidity), pesticides, macroinvertebrates, ultraviolet absorbance, hardness, ions & minerals, organics, nutrients	Monthly, by-monthly
Municipal Water Quality Investigations	DWR	1982-present	DBPs, basic parameters, ions & minerals, nutrients, pathogens, arsenic	Monthly (May to Oct), weekly (Nov to Apr)

Key:
DFG = California Department of Fish and Game
DWR = California Department of Water Resources
EMP = Environmental Monitoring Program
IEP = Interagency Ecological Program
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
RWQB = Central Valley Regional Water Quality Control Board,
USGS = U.S. Geological Survey
Biological community = benthic macroinvertebrates, phytoplankton, and zooplankton
Basic parameters = dissolved oxygen (DO), pH, electrical conductivity (EC), water temperature
Nutrients = nitrogen, phosphorus; clarity = Secchi depth; DBPs = disinfection by-products
Ions and minerals = calcium, magnesium, potassium, sodium, chloride, fluoride, silica, sulfate, iron, manganese, boron, arsenic
Trace elements & metals = molybdenum, selenium, mercury, thallium, copper, zinc
Organics = total organic carbon (TOC), dissolved organic carbon (DOC)
Pathogens = fecal coliforms, total coliforms, *E. Coli*
Sediments = total suspended solids (TSS), total dissolved solids (TDS)

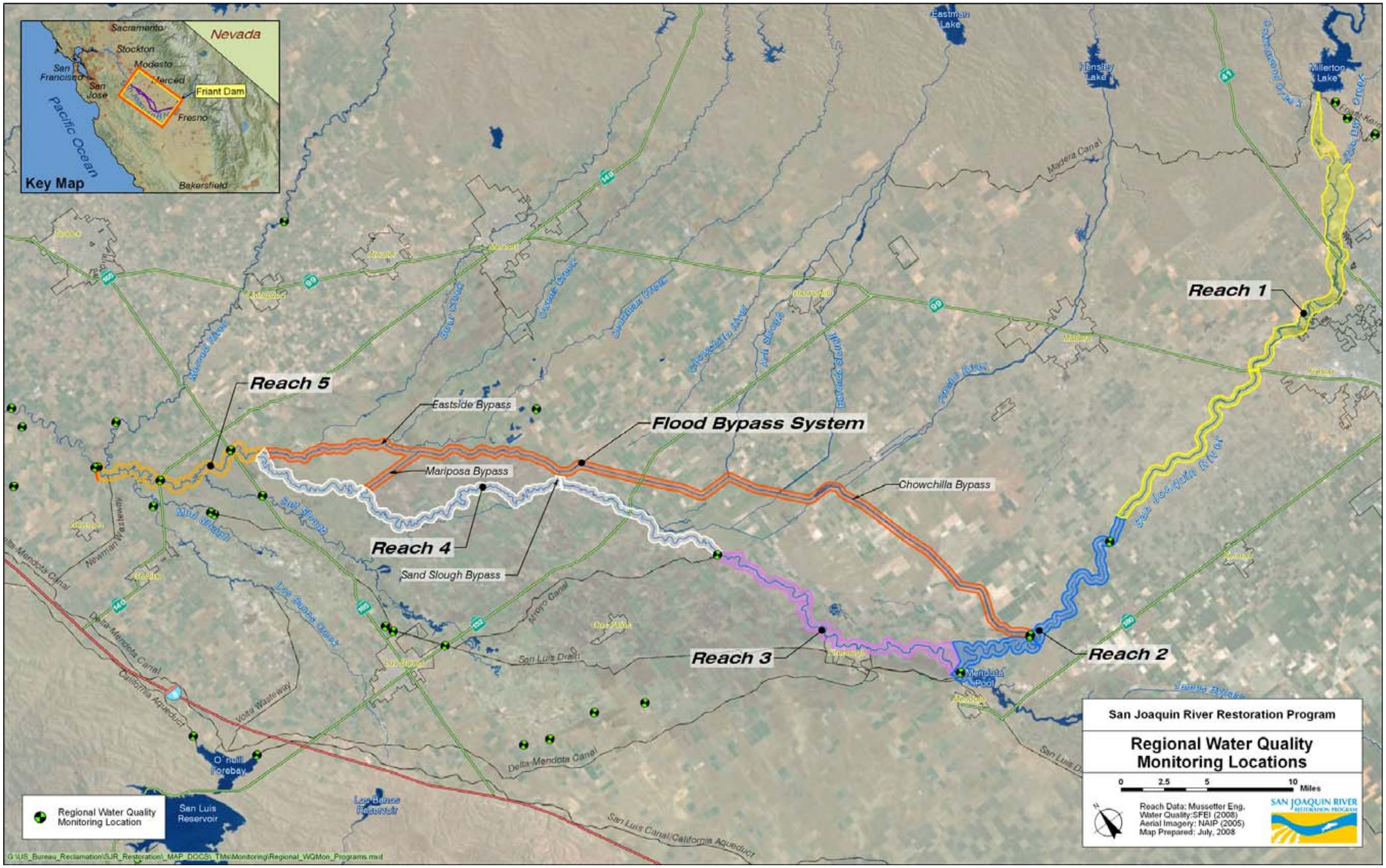

Figure 3-2.
Existing Water Quality Gages in the San Joaquin Region

3.3 Current Groundwater Monitoring Programs and Data Sources

Numerous current groundwater monitoring programs and existing sources of groundwater data are available for the Restoration area and the San Joaquin River region (see Figure 3-3). Current groundwater monitoring programs are briefly discussed below:

- Since 1963, DWR San Joaquin District has collected data on groundwater levels from thousands of wells throughout the San Joaquin Valley. DWR, with the aid of cooperating Federal and local agencies, also currently collects groundwater levels from about 4,500 Central Valley wells annually. Generally, these wells are measured in both the spring and fall. DWR produces contour maps on an annual basis, portraying the springtime elevation of the regional water table in the unconfined aquifer in the vicinity of the San Joaquin River. DWR also collects water levels and electrical conductivity (EC) data from shallow groundwater wells and sumps west of the San Joaquin River from Mendota to Dos Palos under the Drainage Monitoring Program. Reclamation is a cooperating agency with DWR in the collection of groundwater level data. DWR and Reclamation also monitor groundwater elevations for the Central Valley Project Baseline Water Quality Monitoring Program.

- California Department of Health Services (DHS) conducts groundwater monitoring for its water quality monitoring program. DHS's groundwater monitoring program is coordinated with groundwater monitoring by other agencies participating in the Groundwater Ambient Monitoring and Assessment Program (GAMA). GAMA is being conducted by multiple agencies statewide (including the Restoration area) to monitor groundwater quality. Participants include USGS, DWR, DHS, and county and local water management authorities (USGS, 2008a).

- Multiple local agencies throughout the Restoration area conduct groundwater monitoring programs for groundwater level and groundwater quality as described in their adopted groundwater management plans (GMP). GMPs were adopted by Madera Irrigation District; Merced Area Groundwater Pool Interests (MAGPI); Consolidated Irrigation District, Fresno; Fresno County; Fresno Irrigation District; Gravelly Ford Irrigation District; and Root Creek Water District, Madera County (DWR, 2008).

Other sources of existing groundwater data include the following:

- USGS had a groundwater initiative associated with its Regional Aquifer System Analysis (RASA) Program for the Central Valley. Work was completed between 1978 and 1995 (USGS, 2008b).

- S.S. Papadopulos & Associates (SSPA) used a DWR data set to assemble a groundwater data set specific to the needs of a groundwater modeling study of the San Joaquin River that was completed in 2000 (SSPA, 2000). A set of 477 wells has been identified within approximately 1 mile on either side of the San Joaquin River over Reaches 1 through 5. Of these wells, the SJRRP will identify those that support the assessment of seepage-related river losses and seepage-related third party impacts.

- As part of the San Joaquin River Pilot Project Studies conducted between 1999 and 2001, a network of shallow "alluvial" monitoring wells and piezometers was installed in Reaches 1B and 2 of the San Joaquin River. The SJRRP proposes to use these wells to monitor groundwater levels during the spring and summer of 2008 to provide data for further seepage loss estimates in Reach 2. All work will be conducted by Reclamation staff between the riverside toes of the project levees except where existing wells are located beyond the levee toes.

- DWR San Joaquin District maintains about 160,000 well completion reports on file. Well completion reports contain information regarding location, depth, static water level, and geologic logs. The SJRRP proposes to use these well completion reports to track any new groundwater wells constructed in the Restoration area by outside parties for potential data-sharing or coordination.

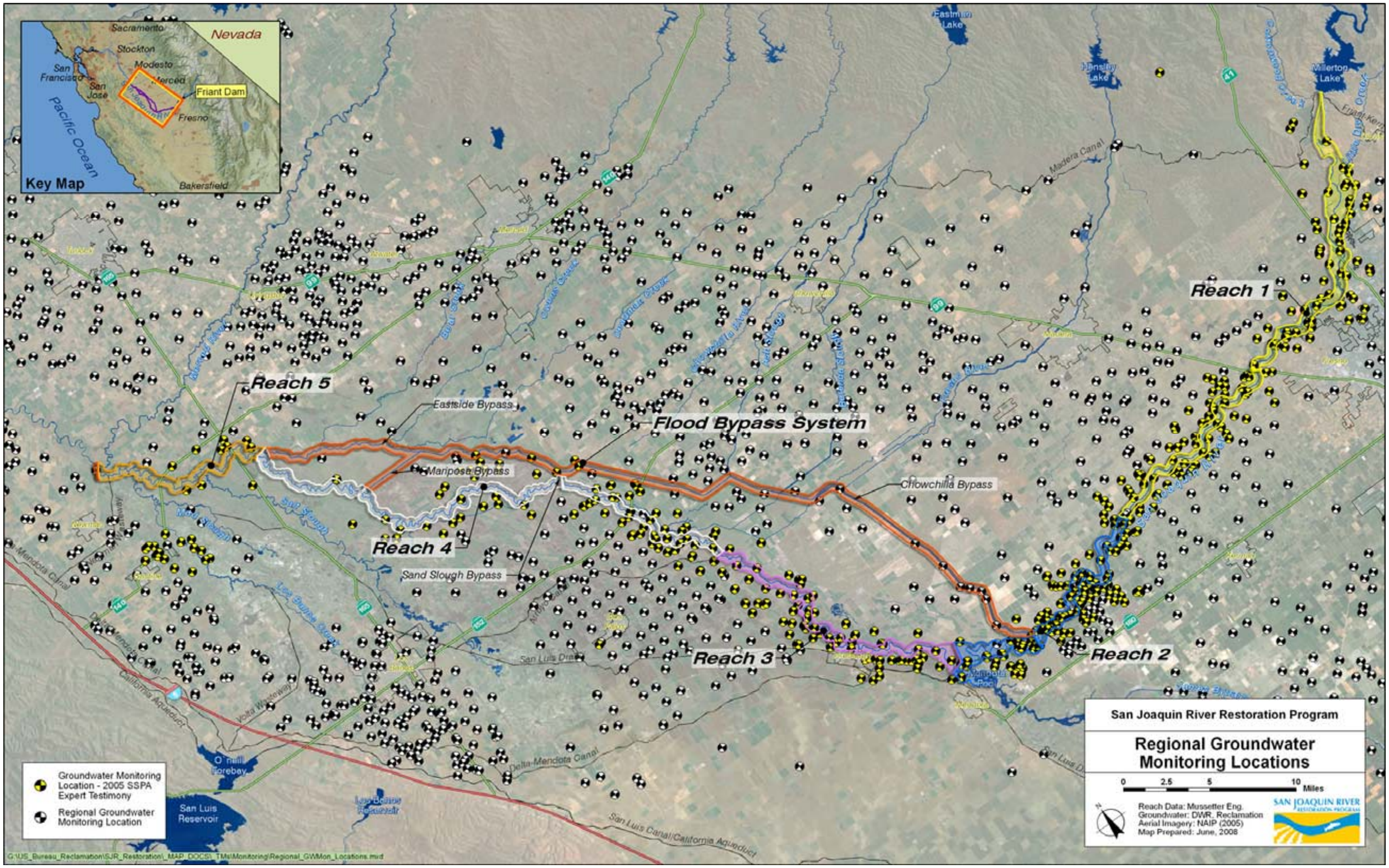

Figure 3-3.
Existing Groundwater Wells in the San Joaquin River Region

3.4 Current Sediment Monitoring Programs and Data Sources

There are no current sediment monitoring stations in the Restoration area, and existing reservoir surveys do not extend upstream from Millerton Lake. However, previous monitoring activities could serve as a data source on Panoche Creek, which may be ephemerally connected to the San Joaquin River near Mendota. Sediment was monitored along Panoche Creek at Interstate 5 (I-5) as part of a program to reduce erosion and sedimentation and improve water quality in Panoche Creek (WRCD, 2003). Differences in watershed geology, orientation, and scale limit the potential applicability of the program to San Joaquin studies.

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4.0 Monitoring Methodology

This section provides an overview of the methodology for the development and implementation of the monitoring plan. Monitoring site selection is described for each monitoring component (flow, water quality, river losses, bank seepage, and sediment transport), followed by measurement methodology.

4.1 Flow Monitoring Methodology

The Settlement requires that Interim Flows and Restoration Flows be measured at six locations between Friant Dam and the Merced River. This section presents the analysis of and recommendation for site selection and measurement method.

4.1.1 Site Selection Methodology

Site selection methodology for flow monitoring includes consideration of the SJRRP need for flow monitoring, and locations of existing stream gages for identification of flow monitoring sites to meet Settlement requirements.

SJRRP Need

Publicly available, high-quality, continuous streamflow data are critical for demonstrating compliance with the provisions of the Settlement. Accurate streamflow data will be essential for computing a water balance for the Interim Flows and Restoration Flows; verifying assumptions made regarding hydrographs contained in Exhibit B of the Settlement Agreement; and planning and evaluating a wide variety of restoration projects. The SJRRP will have limited success in predicting, implementing, and evaluating the effects of restoration actions on the fish, wildlife, and water resources of the San Joaquin River without reliable, high-quality streamflow data. Sediment monitoring will also require intermittent streamflow data, as discussed in Section 4.5

Identification of Monitoring Sites

The locations for flow measurement identified in Paragraph 13(g) of the Settlement are summarized in Table 4-1, along with existing station identifiers when a station exists at the identified location. Interim Flows and Restoration Flows will be measured using existing stream gages, where possible. Where existing gages are not available, or are inadequate to measure Interim Flows and Restoration Flows, new gages will be installed or, in some cases, formerly used gages will be retrofitted to measure the Interim Flows and Restoration Flows. A detailed description of the monitoring locations follows the table.

**Table 4-1.
Interim Flow and Restoration Flow Monitoring Locations Specified in the Settlement**

Location	Station Identifier(s)[1]	Responsible Agency	Remarks
Friant Dam Release	MIL	Reclamation	Flows will be measured at Friant Dam outlets and spillway.
Gravelly Ford	GRF	Reclamation	Existing gage adequate to measure Interim Flows and Restoration Flows.
Below Chowchilla Bifurcation Structure	CBP, SJB	Reclamation	Existing gages will be retrofitted to measure Interim Flows and Restoration Flows.
Below Sack Dam	None	DWR	Abandoned (Dos Palos) stream gage will be retrofitted.
Top of Reach 4B	None	DWR	New stream gage(s) may be required.
Merced River Confluence	None	USGS	A new stream gage will be installed just upstream from the confluence.

Note:
[1] California Data Exchange Center identifiers.
Key:
CBP = Chowchilla Bypass below Bifurcation Structure
DWR = California Department of Water Resources
GRF = San Joaquin River at Gravelly Ford
MIL = Millerton Lake
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
SJB = San Joaquin River below Bifurcation Structure
USGS = U.S. Geological Survey
Settlement = Stipulation of Settlement

Friant Dam Release

The Settlement requires that Interim Flows and Restoration Flows be measured “at or immediately below Friant Dam” (designated as “Friant Release” on the hydrograph in Exhibit B of the Settlement Agreement document). The purpose of this section is to describe how Interim Flow and Restoration Flow releases to the San Joaquin River from Friant Dam will be measured, monitored, and reported in compliance with the Settlement.

Friant Dam is located on the San Joaquin River at river mile (RM) 267.5, approximately 25 miles northeast of Fresno, California. The dam is an integral part of the Friant Division of the CVP and is operated by Reclamation for the purposes of water supply, flood control, and recreation. Facilities of the Friant Division provide deliveries of irrigation and municipal and industrial (M&I) water supplies through the Friant-Kern Canal and Madera Canal from Millerton Lake, and releases to the San Joaquin River for riparian diversion above Gravelly Ford, fish hatchery operation, power generation, and flood damage reduction purposes.

Under normal operating conditions, water is released to the San Joaquin River through the river outlet works at Friant Dam. The river outlet works consists of four 110-inch-diameter (2.79-meter (m)) steel pipes (R1, R2, R3, and R4), each controlled by a 96-inch-diameter (2.43 m) hollow-jet valve. Smaller volume releases to the river can be made through two 24-inch-diameter (0.60 m) steel pipes that branch from outlet pipes R3 and

R4, and are controlled by two 18-inch-diameter (0.45 m) needle valves. Smaller volume releases can also be made through a 48-inch-diameter (1.21 m) steel pipe, which branches from outlet pipe R1 and delivers water to the Friant Power Authority 2,000-kilowatt (kW) powerplant located adjacent to the outlet works stilling basin. The total capacity of the river outlet works is 16,400 cfs at a gross pool elevation of 580.6 feet above mean sea level (msl). The flows released to the San Joaquin River through the outlet works are controlled by adjusting the percent opening on each valve. To achieve the desired flow rate for a river outlet valve, a percent opening is manually calculated for a given reservoir elevation using the appropriate rating table for each valve. The reservoir elevation is measured continuously to the nearest .01 feet in a stilling well on the upstream face of the dam, and determines the net hydraulic head on the valves. Under normal operating conditions, the valve openings are calculated and adjusted on a daily basis by operations staff according to demand for water in the San Joaquin River.

Releases to the San Joaquin River can also be made over the spillway at Friant Dam. The spillway consists of an ogee overflow section, chute, and stilling basin in the center of the dam. The spillway has a discharge capacity of 83,160 cfs at a gate height of 18.0 feet. Spillway releases are controlled by one 18-foot-high by 100-foot-wide drum gate in the center of the dam, and two comparably sized Obermeyer gates, which are located on both sides of the drum gate. Spillway releases to the San Joaquin River are computed using a stage-discharge relation for each gate. To achieve the desired flow rate for a spillway gate, a gate opening is manually calculated for a given reservoir elevation using the appropriate rating table for each gate. The combination of measurements at the valves and spillway gates will be used to calculate the total release from Friant Dam in compliance with the Settlement.

Gravelly Ford

The Settlement requires that Interim Flows and Restoration Flows be measured at Gravelly Ford (designated as Reach 2 on the applicable hydrograph). Gravelly Ford is the boundary between Reaches 1 and 2 on the San Joaquin River (See Figure 3-1). Reclamation currently operates a stream gage at RM 229 on the San Joaquin River at Gravelly Ford that is adequate to satisfy the requirement for measuring, monitoring, and reporting Interim Flows and Restoration Flows. Under current operations, the primary purpose of the gage is to measure compliance with contractual commitments to supply water to riparian water right holders in Reach 1.

The gage consists of a stilling well and gage house on the left bank of the river. River stage is measured continuously to the nearest 0.01 feet using a mechanical float and Stevens recorder unit. The system is equipped with a shaft encoder that translates the mechanical stage measurements into an electronic signal recorded by a data logger.

Below Chowchilla Bifurcation Structure

The Settlement requires that Interim Flows and Restoration Flows be measured immediately below the Chowchilla Bifurcation Structure (designated as Reach 3 on the applicable hydrograph). The Chowchilla Bifurcation Structure is located at RM 216, and controls the flow split between the mainstem San Joaquin River and the Chowchilla Bypass (See Figure 3-1). This portion of the San Joaquin River is typically dry under presettlement operating conditions, unless flood releases are being made from Friant Dam. An existing stream gage is located approximately 250 feet downstream from the structure on the right bank of the San Joaquin River.

This gaging station was installed by FWUA and is currently operated by SLDMWA under an agreement with Reclamation. This station is primarily used to monitor flood flows that are being routed through the structure and into Mendota Pool, and is not adequate for measuring the full range of Interim Flows and Restoration Flows anticipated at the site. The gage consists of a 4-foot-diameter corrugated metal stilling well structure with a 4-inch-diameter galvanized intake pipe (communication line) anchored to the stream channel. To measure the lower range of anticipated Interim Flows and Restoration Flows in the San Joaquin River Channel downstream from the bifurcation structure, the stilling well will need to be deepened by approximately 10 feet, and the communication line will need to be extended approximately 30 feet into the deepest part of the stream channel. Another gage is located on the Chowchilla Bypass just upstream from the bifurcation structure. Reclamation will be the lead agency for retrofitting, operating, and maintaining both stream gages.

River stage will be measured continuously to the nearest 0.01 foot using a mechanical float and Stevens recorder unit. The system will be equipped with a shaft encoder that translates the mechanical stage measurements into an electronic signal recorded by a data logger.

Below Sack Dam

The Settlement requires that Interim Flows and Restoration Flows be measured below Sack Dam (See Figure 3-1, designated as Reach 4 on the applicable hydrograph). An abandoned stream gage present at the site is known as the San Joaquin River at Dos Palos gage (USGS Station 11256000). The stream gage is located on the left bank of the San Joaquin River approximately 3,800 feet downstream from Sack Dam, and approximately 7 miles east of the town of Dos Palos. The gage is currently not operational and has only been operated intermittently since 1954, when USGS ceased using it as a monitoring station. Reclamation used the station for monitoring streamflow in 1986, 1987, and 1995. The station consists of a corrugated metal stilling well housing with a single 2-inch-diameter galvanized intake pipe at the base of the stilling well.

Under the monitoring plan, this station will be retrofitted, operated, and maintained by DWR. DWR proposes to equip the San Joaquin River near the Sack Dam station with a WaterLog H350XL/H355 gas bubbler/data logger system, as well as a GOES transmitter (H-222DASE). The gas bubbler system is reliable and requires little maintenance. The gas bubbler system measures the amount of pressure exerted by the water column on the orifice at the end of plastic tubing attached to the bubbler. The data logger translates the pressure measurement as stage, from which streamflow can be estimated.

In addition to the electronic data collection and transmitting equipment, the following will also be installed: an air dessicator, a nonspillable 12-volt battery, and a solar panel/controller. Also, a new graduated staff gage will be placed at each site to visually note the stage of the river during field visits. Furthermore, concrete anchors 18 inches in diameter, 12 to15 inches deep, and cured for a minimum of 30 days, will be used to keep pipes that contain the bubbler tubing and Sonde electrical lines stable while streamflow measurements are recorded.

Top of Reach 4B

The Settlement requires that Interim Flows and Restoration Flows be measured at the top of Reach 4B (See Figure 3-1, designated as Reach 5 on the applicable hydrograph). The San Joaquin River channel at this site currently conveys significant amounts of water only during periods of heavy runoff, such as in 2005 and 2006. Most of the time, the channel conveys only small quantities of drain water or local runoff. During periods of low flow, water in the San Joaquin River channel flows over a Parshall flume located just upstream from the Washington Avenue Bridge and into the Eastside Bypass.

The flow capacity of the flume is not known; however, it is not large enough to measure the entire range of Interim Flows and Restoration Flows anticipated in the Settlement Agreement for this reach. It is also not known if the flume presents an obstacle to fish passage for the range of Interim Flows and Restoration Flows expected at this site. During times of high flows in the bypass, such as in 2005 and 2006, water backs into the river channel from the bypass channel, and can completely submerge the Parshall flume.

Head gates at the top of Reach 4B currently prevent any water from flowing down the San Joaquin River into the Reach 4B channel. The head gates consist of four slide gates that are approximately 4 feet by 5 feet each. It is not known when the gates were last operated, but it appears to have been years or decades since this occurred. The flow capacity of the structure is also unknown. The Reach 4B channel downstream from the head gate structure is choked with vegetation (aquatic and along the bank). An abandoned stilling well constructed for the purpose of measuring river stage is located upstream from the head gate structure on the left bank, on the outside of a sharp bend in the river. USGS formerly measured two stations in the general area: San Joaquin River near El Nido Station 11260000, and San Joaquin River plus Chamberlain Slough near El Nido Station 11260001. Both stations were measured from 1939 to 1949. The abandoned stilling well is probably the former stream gage operated by USGS from 1939 through 1949, referred to as San Joaquin River near El Nido gage 11260000.

It has not been decided which channel(s) (bypass and/or river) will be used for restoration purposes. Alternatives under consideration by the SJRRP include constructing the restored channel in the Eastside Bypass or in the Reach 4B channel, or using the Reach 4B channel as a low flow channel. For purposes of measuring Interim Flows and Restoration Flows at this site, beginning in October 2009, two stream gages are being considered while the implementation is subject to the final selection of restoration channel(s).

Two new stream gages may be constructed and operated by DWR at the top of Reach 4B. A proposed monitoring station for the Reach 4B channel would be located on the right bank of the San Joaquin River, approximately 800 feet downstream from the Reach 4B head gates on the Old River channel (RM 168.3, Lat. 37 deg. 6 min. 47.96 sec N, Long. 120 deg. 35 min. 32.44 sec W). The proposed monitoring station for the connector channel would be located on the left bank, approximately 200 feet downstream from the Parshall flume on the connector channel leading to the Eastside Bypass (RM 168.4, Lat. 37 deg. 6 min. 46.70 sec N, Long. 120 deg. 35 min. 18.51 sec W).

River stage sensors will be installed at the stations to monitor streamflow. All stations will be equipped with a WaterLog H350XL/H355 gas bubbler/data logger combination, as well as a GOES H-222DASE transmitter. The gas bubbler system is reliable and requires little maintenance. The gas bubbler system measures the amount of pressure exerted by the water column on the orifice at the end of plastic tubing attached to the bubbler. The data logger translates the pressure measurement as stage, from which streamflow can be estimated. The gas bubbler system has a self-maintaining purging option to prevent sediment accumulation and system failure.

In addition to the electronic data collection and transmitting equipment, the following will also be installed: an air dessicator, a nonspillable 12-volt battery, and a solar panel/controller. Also, a new graduated staff gage will be placed at each site to visually note the stage of the river during field visits. Furthermore, concrete anchors 18 inches in diameter, 12 to15 inches deep, and cured for a minimum of 30 days, will be used to keep pipes that contain the bubbler tubing and Sonde electrical lines stable while streamflow measurements are recorded.

Merced River Confluence

The Settlement requires that Interim Flows and Restoration Flows be measured at the confluence of the Merced River (designated as “confluence” on the applicable hydrograph). The term “confluence” refers to the junction of two streams. Four existing stream gages currently in operation near the junction of the San Joaquin and Merced rivers were evaluated for the purpose of measuring the Interim Flows and Restoration Flows (Table 4-2, Figure 4-1).

Three alternatives were considered for determining the flow of the San Joaquin River at the Merced River confluence. The first alternative consisted of using the San Joaquin River near Newman gage in combination with the Merced River near Stevinson gage to determine the flow. The second alternative consisted of using the San Joaquin River at Fremont Ford Bridge (California Highway 140 crossing) gage in combination with the Mud Slough near Gustine gage to determine the flow at the confluence. The third alternative included establishing a new stream gage on the San Joaquin River just upstream from the junction with the Merced River. After a detailed comparison of the three alternatives, the third alternative was selected as the preferred alternative.

Table 4-2.
Summary of Existing Monitoring Stations near the Merced River Confluence

Gage Name	Station Identifier(s)[1]	Responsible Agency	Remarks
San Joaquin River at Fremont Ford Bridge	11261500/FFB	USGS	San Joaquin River water quality upstream Grasslands discharge
San Joaquin River near Newman	11274000/NEW	USGS	Measures flow of San Joaquin River and Merced rivers
Mud Slough near Gustine	11262900/MSG	USGS	Water quality of Grasslands drainage discharge
Merced River near Stevinson	11272500/MST	USGS/DWR	Measures Merced River water quality upstream from the confluence with San Joaquin River

Note:
[1] USGS gage number and/or CDEC identifier
Key:
CDEC = California Data Exchange Center
DWR = California Department of Water Resources
USGS = United States Geological Survey

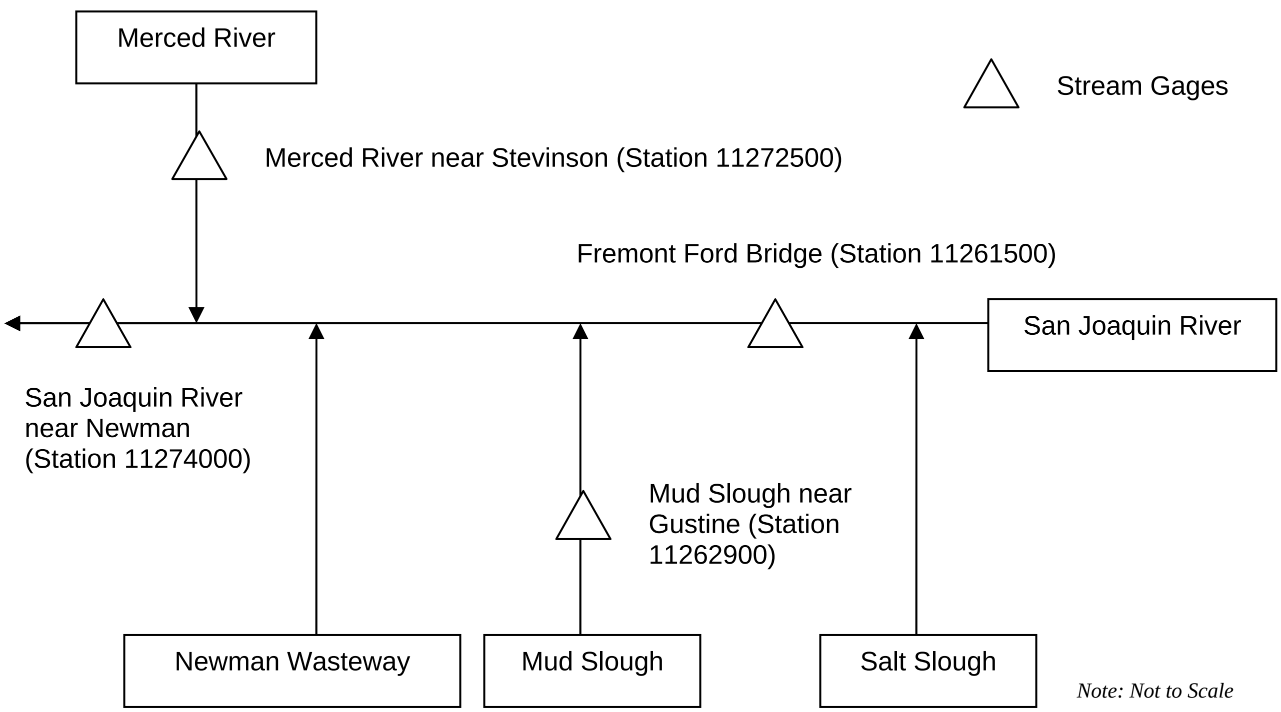


Figure 4-1.
Schematic Showing Existing Stream Gages near the Confluence of the San Joaquin and Merced Rivers

Alternative 1
USGS operates the San Joaquin River near Newman gage (Station 11274000), located approximately 3 miles northeast of the town of Newman in Stanislaus County. The gaging station is on the left bank of the San Joaquin River 650 feet downstream from the confluence with the Merced River, and measures the combined flows of both the San Joaquin and Merced rivers. The gage has been in operation since 1912, and corrected flow data are published annually and input into the National Water Information System (NWIS) database, which is available to the public. Flow at the Newman gage could be used in combination with flow measured on the Merced River upstream near Stevinson (Station 11272500) to estimate flow of the San Joaquin River at the confluence. The Stevinson gage is located on the right bank of the Merced River, 4.4 miles upstream from the confluence with the San Joaquin River (Figure 4-1). DWR operates the Stevinson gage on the Merced River. The Stevinson gage has been in operation intermittently since 1940, and corrected flow data are published annually and input into the NWIS database, which is available to the public. Merced River flow measured at the Stevinson gage could be subtracted from the combined flow of the Merced and San Joaquin rivers measured at the Newman gage to estimate flow on the San Joaquin River at the confluence of the two rivers.

Alternative 2
USGS operates a stream gage on the San Joaquin River at the Fremont Ford Bridge (Highway 140 crossing, Station 11261500), located approximately 2 miles downstream from Salt Slough in Merced County (Figure 4-1). The gaging station is on the left bank of the San Joaquin River 6.7 miles upstream from the confluence with the Merced River. The gage has been in operation intermittently since 1937, and corrected flow data are published annually and input into the NWIS database, which is available to the public. Flow at the Fremont Ford Bridge gage could be used in combination with flow measured at Mud Slough (the last major tributary to the San Joaquin River upstream from the confluence with the Merced River) to estimate flow at the confluence with the Merced River. The Mud Slough gage is operated by USGS (Station 11262900), and is located on the right bank of Mud Slough at the terminus of the San Luis Drain, approximately 6 miles upstream from the confluence with the San Joaquin River (Figure 4-1). The Mud Slough gage has been in operation since 1985, and corrected flow data are published annually and input into the NWIS database, which is available to the public.

Alternative 3
A new stream gage could be installed on the San Joaquin River just upstream from the confluence of the Merced River. Considerations for siting a new station include measurement of flows from the Newman Wasteway, backwater effects from the Merced River at high flow, potential flow in bypass channels at high flow, the mobile nature of the streambed in Reach 5, and accessibility to a new stream gage site. Since Alternatives 1 or 2 discussed above did not provide estimates of the flows at the Merced River confluence that were as good as, or better than, those of the proposed new stream gage, installation of the new stream gage was selected as the preferred alternative. The decision to install a new stream gage was made after an analysis of the existing monitoring network was completed.

4.1.2 Measurement Methodology

Measurement methodology described below includes measurement of river stage and discharge. Much of the language in the following paragraphs describing the measurement of stage and discharge, and dissemination of data, is excerpted from the USGS publication *Stream-Gaging Program of the U.S. Geological Survey – U.S. Geological Survey Circular 1123* (Wahl, Thomas, and Hirsch, 1995).

Stage Measurement

The basic measurement made at each stream gaging station is the river stage, which is the height of the water surface above a reference elevation. Stream discharge (flow) is derived from stage data through use of a relation between stage and discharge. The stage-discharge relation for a specific stream location is defined from periodic discharge measurements made at known stages.

The most common method of measuring the stage of a river is through use of a stilling well. Stilling wells are located on the bank of a stream or on a bridge pier and are topped by a shelter that holds recorders and other instruments associated with the station. The well is connected to the stream by several intakes such that when the water level changes in the stream, the level simultaneously changes in the well. Thus, the water surface in the well is maintained at the same level (stage) as the water surface of the stream. The well damps out momentary fluctuations in the water surface in the stream because of waves and surging action that may be present in the river. An outside reference gage, typically a graduated staff gage, is read periodically to verify that the water level in the well is indeed the same as the water level in the stream, and that the intakes are not plugged. As the water level in the well rises or falls, a float in the well also rises or falls. A graduated tape or beaded cable attached to the float, and with a counterweight on the other end, is hung over a pulley. This pulley drives a recording device. Historically, the recording device would have used a pen that recorded a graph of the river stage as it changed with time. The gaging stations at Friant Dam, Gravelly Ford, and the Chowchilla Bifurcation Structure are equipped with stilling wells.

In some cases, stilling wells are impractical because of difficulties either in installation or operation. Stations that use a bubbler system are an alternative because the shelter and recorders can be located hundreds of feet from the stream. In a bubbler system, an orifice is attached securely below the water surface and connected to the instrumentation by a length of tubing. Pressurized gas (usually nitrogen or air) is forced through the tubing and out through the orifice. Because the pressure in the tubing is a function of the depth of water over the orifice, a change in the stage of the river produces a corresponding change in pressure in the tubing. Changes in the pressure in the tubing are recorded and are converted to a record of the river stage. The gaging stations below Sack Dam and at the top of Reach 4B will be equipped with gas bubbler systems.

Discharge Measurement

The most practical method of measuring the discharge of a stream is through the velocity-area method. This method requires the physical measurement of the cross-sectional area and the velocity of the flowing water. Discharge is determined as the product of the area times the velocity. Velocity is measured by using a current meter. The meter consists of a propeller rotated by the action of flowing water. The rotation depends on the velocity of the water passing by the propeller. With each complete rotation, an electrical circuit is completed and recorded in some fashion. Given the number of revolutions in a given time interval, velocity can be determined for the location of the current meter.

Measuring the average velocity of an entire cross section is impractical; therefore, an incremental method is used. The width of the stream is divided into a number of increments; the size of the increments depends on the depth and velocity of the stream. The purpose is to divide the section into about 25 increments with approximately equal discharges. For each incremental width, the stream depth and average velocity of flow are measured. For each incremental width, the meter is placed at a depth where average velocity is expected to occur. That depth has been determined to be about 0.6 of the distance from the water surface to the streambed when depths are shallow. At greater depths, the average velocity is best represented by averaging velocity readings at 0.2 and 0.8 of the distance from the water surface to the streambed. The product of the width, depth, and velocity of the section is the discharge through that increment of the cross section. The total of the incremental section discharges equals the discharge of the river.

When the stage is low, and the stream can be waded, measurements are made by wading with the current meter mounted on a wading rod. The meter is positioned at the appropriate depth on the wading rod, which also is used to measure the water depth. If the water is too deep for wading, the measurement is made either from a boat, bridge, or cableway across the stream. If the measurement is made from a boat, bridge, or cableway, the meter is suspended on a thin cable wound on a reel. A torpedo-shaped weight is attached below the meter to permit it to be lowered into the water and to hold it in position once submerged. If measuring from a bridge, the reel is mounted on a wheeled frame (or crane) that permits the lowering of the meter assembly over the bridge rail; from a cableway, the reel is mounted in a cable car suspended from the cableway that crosses the river.

Acoustic Doppler Current Profiler

The acoustic Doppler current profiler (ADCP) is an acoustic instrument used to measure water velocities, boat velocities, and water depths. Water-velocity measurements are made by transmitting sound at a known frequency into the water and measuring the Doppler shift, or change in sound frequency, from signals reflected off particles in the water. ADCPs also can measure water depths and, when deployed from a moving boat, can measure velocity of the boat. The capability of ADCPs to measure water velocity, depth, and boat velocity enables them to measure discharge in rivers. U.S. Department of the Interior agencies have used the ADCP to measure discharges in rivers and streams since the mid-1980s, and an ADCP was used during hydrographic surveys on the San Joaquin River in 2005. The primary advantages of making discharge measurements using the ADCP, compared with point velocity meters such as the Price AA current meter, are that in most situations (1) the time required to complete a measurement is reduced, which is an advantage for personnel safety and for making measurements in unsteady flow conditions, (2) the ADCP allows data to be collected throughout most of the water column and cross section rather than at discrete points, (3) the ADCP is deployed at the water surface, thus appreciably reducing the chance of snagging by debris, another safety advantage, (4) the instrument can be boat-mounted, thus eliminating the installation, maintenance, and liability of costly manned cableways, (5) complex flow regimes, such as vertical bidirectional flow, can be accurately identified and measured, and (6) many parameters are available for analyzing measurement quality. Where it is appropriate, the ADCP will be used to supplement discharge measurements made on the San Joaquin River using point velocity meters. Discharge measurements made with the ADCP will follow quality assurance guidelines established by USGS (Oberg, Morlock, and Caldwell, 2005).

Determining a Continuous Record of Discharge

Rating curves will be used to derive streamflow from stage data at each stream gage. The stage-discharge relationship is used to correlate river stage to streamflow. The rating curve for each gage site will be developed by making successive streamflow measurements at many different stream stages to define and maintain a stage-discharge relationship. These streamflow measurements, and their corresponding stages, are then plotted on a graph. Continuous streamflow throughout the year can be determined from the rating curve and the record of river stage. The rating curve is important because it allows the use of river stage, which is easily measured, to estimate the corresponding streamflow at virtually any stream stage.

The stage-discharge relationship for the stream gages located in the sand-bedded reaches of the San Joaquin River (i.e., Reaches 2 through 5) is not expected to be permanent. Scour and deposition, as well as the growth of riparian vegetation, can alter the channel cross section and roughness, thus changing the stage-discharge relationship at the gage site. Discharge measurements will be made at least twice a month, and more frequently, if feasible, during and immediately following high-flow events (i.e., spring and fall pulse flows and flood flows) to assess the stage-discharge relationship at the gage. Shift corrections (adjustments in stage) will be applied to the base stage-discharge rating in computing the final discharge record for the gage.

Real-time data provided by USGS are shift-corrected, incorporating mathematical adjustments for ease of use. The shift adjustments will be applied to individual ratings, as measured data becomes available, resulting in an adjusted rating. Some ratings may change as often as weekly; others may not change for months or years.

Because the relationship between stage and discharge may vary with time, discharge is known only with certainty at the time of discharge measurements. If the relationship is changing, then judgment must be used to determine the most probable status of the stage-discharge relationship for times between discharge measurements. In fact, changes in the stage-discharge relationship may not be evident until a whole series of measurements is available for analysis. Therefore, the computational process usually has the following steps:

1. Following a measurement, a preliminary evaluation is made of the degree to which the stage-discharge relationship has changed on the basis of measurements made to that time. Provisional discharges are determined, assuming that the most recent measurements define the channel condition.

2. This process is repeated following each measurement. However, with each measurement, more measurements are available to evaluate the stage-discharge relationship. This may lead to changes in the provisional discharges that were computed for previous months.

3. At the end of the year, all measurements are available for review. The entire set of measurements is used to reevaluate rating conditions for the year. Final decisions are made about the stage-discharge relationships in effect during the year, and the record is refined or recomputed, as necessary. This record is then passed through a rigorous review process and, once approved; the data are considered final and are placed in the archives and published.

4.2 Water Quality Monitoring Methodology

Water quality monitoring methodology is described below for site selection and real-time and laboratory measurement of multiple water quality parameters.

4.2.1 Site Selection Methodology

Site selection methodology for water quality monitoring includes consideration of SJRRP need for water quality monitoring and identification of water quality monitoring sites.

SJRRP Need

Adverse impacts to water quality may limit the operation of the program to meet the Restoration Goals of a self-sustaining fishery and water supply management. The SJRRP water quality monitoring plan will support the following program needs:

- **Fish management** – Monitoring activities will inform real-time adjustments to SJRRP Restoration releases to meet water temperature and quality needs for fisheries within some portions of the Restoration Area according to Settlement flow guidelines.
- **Water supply management –** Monitoring activities will help identify potential recovery opportunities and constraints for the beneficial use by farmers in the Friant Division.

- **Impact assessment** – Monitoring activities will be used to meet the monitoring requirements of the Settlement and provide information to evaluate the impacts of Restoration Flows on San Joaquin River water quality.

Identification of Monitoring Sites

Monitoring sites were identified using a hypothesis-based method. The hypothesis-based method includes answering a list of questions posed to direct selection of the sites and parameters to be monitored. Questions posed for water quality monitoring for the SJRRP are listed in Appendix A. In summary, most of the water quality monitoring locations were chosen because they are established monitoring sites, funded by other projects, have sufficient historical data, and are likely to continue operation for at least 10 more years. The sites of water quality monitoring stations for the SJRRP water quality monitoring plan are summarized in Table 4-3.

Table 4-3.
Water Quality Monitoring Stations Identified to Support the SJRRP

Location	Responsible Agency	Parameters	Frequency	Remarks
Friant Dam (Millerton)	Reclamation (SCCAO)	Physical [1]	Continuous	Multiple parameter sonde*
San Joaquin River below Friant Dam	Reclamation (SCCAO)	Physical [1]	Continuous	Multiple parameter sonde
	Reclamation (MP157)	Short list* [2] Baseline [3]	Daily composite* Quarterly	Autosampler* Grab sample
San Joaquin River at Gravelly Ford	Reclamation (SCCAO)	Temperature	Continuous	Multiple parameter sonde*
San Joaquin River Below Bifurcation	Reclamation (SCCAO)	Temperature	Continuous	Multiple parameter sonde*
San Joaquin River near Mendota	Reclamation (SCCAO)	Physical [1]	Continuous	Multiple parameter sonde
	Reclamation (MP157)	Short list* [2] Baseline* [3]	Daily composite* Quarterly*	Autosampler* Grab sample*
San Joaquin River below Sack Dam	TBD	Physical* [1]	Continuous*	Multiple parameter sonde*
San Joaquin River at top of Reach 4B	TBD	Conductivity* Temperature* Dissolved oxygen* Turbidity*	Continuous*	Recommend using established site at Fremont Ford
San Joaquin River at Fremont Ford Bridge	USGS	Physical [1]	Continuous	Multiple parameter sonde
	Central Valley RWQCB	Selenium Boron Nutrients [4] Others [5]	Weekly	Grassland Bypass Project Station H
San Joaquin River at Hills Ferry	TBD	Physical* [1]	Continuous*	Multiple parameter sonde
	SLDMWA	Selenium Boron	Weekly	Grassland Bypass Project Station H
	Reclamation (MP157)	Short list* [2] Baseline* [3]	Daily composite* Quarterly	Autosampler* Grab sample*
San Joaquin River near Crows Landing	USGS	Physical [1]	Continuous	Grassland Bypass Project Station N
	Central Valley RWQCB	Selenium Boron Nutrients [4] Others [5]	Daily composite Weekly	Autosampler* Grab sample

Notes:
* New equipment or sampling for the San Joaquin River Restoration Program water quality monitoring plan.
[1] Real-time measurements of electrical conductivity (salinity), temperature, pH, dissolved oxygen, turbidity, and chlorophyll; calibration, as needed.
[2] Short list of constituents for lab analysis – to be determined (e.g., selenium, boron).
[3] Central Valley Project Baseline Water Quality Monitoring Program; full Title 22 organic and inorganic compounds, plus bacterial.
[4] Parameters included in the Nutrient Series are nitrate, ammonia, total kjeldahl nitrogen, total phosphate, and ortho phosphate, required by the Waste Discharge Permit for Grassland Bypass Project. Nutrient Series sampling period increases to every other week during irrigation season (March through August).
[5] Other constituents include bacteria, trace elements, total organic carbon, and other minerals.

Key:
Central Valley RWQCB = Central Valley Regional Water Quality Control Board
MP157 = Reclamation Mid-Pacific Region, Environmental Monitoring Branch
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
SCCAO = Reclamation, South Central California Area Office
SJRRP = San Joaquin River Restoration Program
SLDMWA = San Luis Delta-Mendota Water Authority
TBD = to be determined
USGS = U.S. Geological Survey

4.2.2 Measurement Methodology

Several sampling techniques will be used to collect water samples for quality measurement, including real-time and laboratory analyses of grab and composite samples. The following sections describe the measurement methodology for real-time and laboratory measurement of water quality.

Real-Time Water Quality Monitoring Parameters

Continuous measurement of physical conditions, including temperature, electrical conductivity (salinity), pH, dissolved oxygen (DO), turbidity, and chlorophyll, will be recorded at eight stations using multiple parameter sondes connected to digital dataloggers. Each parameter will be measured every 15 minutes and sent via satellite to the Internet as preliminary data.

Parameters that will be monitored on a real-time basis at the stations discussed above for the SJRRP are described below. Methods of measurement, along with range, resolution, and accuracy of specified sensors, are shown in Table 4-4.

Sampling for Laboratory Analysis of Water Quality

The following sections describe constituents for laboratory analyses of water quality, as well as methods for water quality sampling and chain of custody documentation.

Constituents

The complete list of constituents to be measured at various sites along the Restoration area will be determined according to the needs of the scientists handling the fish restoration. Parameters may include selenium, mercury, boron, nutrients, and other compounds that cannot be measured with field sensors. The Water Quality section of the SJRRP *Conceptual Model and Draft Fisheries Management Plan* will present further details. Additional constituents that are not included in this plan could be considered later as part of an adaptive management approach within the provisions of the Settlement.

Sampling methods

Grab samples will be collected using a stainless steel sampling device. This device is a cage on a pole that holds the sampling bottle. Grab samples will be collected from the stream bank directly into sample bottles or into a churn-splitter. This technique is for samples collected weekly or less frequently. Each sample will be collected in a specified manner. Depth/width integrated samples will be collected where parameters may not be evenly mixed across the river channel. This method involves collecting samples at regular intervals across the channel.

Autosamplers will be used to collect time composite samples at three locations. Daily composite samples will consist of up to eight subsamples taken per day and mixed into one sample. Weekly composite samples will consist of seven consecutive daily subsamples mixed into one sample. Reclamation and the Central Valley RWQCB currently use Sigma brand autosamplers to collect daily composite samples from the Delta-Mendota Canal, San Luis Drain, and San Joaquin River at Crows Landing.

Table 4-4.
Real-Time Monitoring Physical Parameters

Parameter	Temperature
Method	Digital thermometer (YSI 6600 sonde)
Range	-5 to +45 ºC
Resolution	0.01 ºC
Accuracy	± 0.15 ºC
Parameter	Salinity – Specific Conductance
Method	Conductivity meter (YSI 6600 sonde)
Range	0 to 100 mS/cm
Resolution	0.001 to 0.1 mS/cm (range-dependent)
Accuracy	± 0.5%, ±0.1 mS/cm
Parameter	Dissolved oxygen
Method	Digital probe (YSI 6600 sonde)
Range	0 to 50 mg/L
Resolution	0.01 mg/L
Accuracy	0 to 20 mg/L: ± 2% of reading or 0.2% mg/L 20 to 50 mg/L%: ± 6% of reading
Parameter	pH
Method	Digital probe (YSI 6600 sonde)
Range	0 to 14 units
Resolution	0.01 unit
Accuracy	± 0.2% unit
Parameter	Turbidity
Method	Turbidity meter (YSI 6600 sonde)
Range	0 to 1,000 NTU
Resolution	0.1 NTU
Accuracy	± 5% of reading or 2 NTU
Depth	200 feet
Parameter	Chlorophyll
Method	Digital sensor (YSI 6600 sonde)
Range	0 to 400 µg/L
Resolution	0.1 µg/L Chl; 0.1% FS
Depth	200 feet

Key:
ºC = degrees Celsius
CHl = chlorophyll
FS = fluorescence
µg/L = micrograms per liter
mg/L = milligrams per liter
mS/cm = milliSiemens per centimeter
NTU = nephelometric turbidity unit

Chain of Custody Documentation

Chain of custody (COC) documentation will be initiated during sample collection for all matrices and maintained throughout analytical and storage processes. All individuals transferring and receiving samples will sign, date, and record the time on the COC that the samples are transferred. Each agency will follow its established COC procedures and use various agency and laboratory COC records.

Laboratory COC procedures are described in each laboratory's Quality Assurance Program Manual, which is kept on file with the Quality Control Officer (QCO). Laboratories must receive the COC documentation submitted with each batch of samples and sign, date, and record the time the samples are transferred. Laboratories will also note any sample discrepancies (e.g., labeling, breakage). This documentation must be maintained for a minimum of 5 years. After generating the laboratory data report for the client, samples will be stored for a minimum of 30 days in a secured area prior to disposal.

4.3 River Losses Monitoring Methodology

Monitoring of river losses includes combining data from surface water discharges, surface water diversions, near surface and regional groundwater conditions, new or increased groundwater extractions, and riparian vegetation conditions in the vicinity of the San Joaquin River. Monitoring of riparian vegetation conditions will be completed as detailed in the *Conceptual Model and Draft Fisheries Management Plan*, and is therefore not detailed in this document. The methodology is described below for site selection, real-time, and field analysis for the remaining components to monitor total river losses.

4.3.1 Site Selection Methodology

Site selection methodology for river losses monitoring includes consideration of SJRRP need for river losses monitoring and identification of monitoring sites for each component.

Program Need

Monitoring and modeling of various instream, floodplain and near stream parameters will meet the program need to determine whether seepage losses (and/or downstream surface or underground diversions) increase beyond the levels assumed in the hydrographs contained in Exhibit B of the Settlement. Settlement Paragraphs 13(c)(1) and 13(c)(2) give the option of releasing water acquired from willing sellers to compensate for unexpected losses. Monitoring river losses allows quantification of water to be acquired to compensate for any losses beyond the levels assumed in Exhibit B of the Settlement.

Identification of Monitoring Sites

Identification of surface water monitoring sites was as described under Section 4.1 and identification of groundwater monitoring sites is described under Section 4.4. Identification of surface water diversion and new underground diversions is described below.

Identification of Surface Water Diversion Monitoring Sites

Over 180 surface water diversions were documented by DFG on the San Joaquin River between Friant Dam and the confluence with the Merced River in 2001 (McBain and Trush, 2002). The DFG survey data consist of a detailed description of each surface water diversion including the location, type, and other relevant characteristics. The SJRRP will monitor surface water diversions in the Restoration area by conducting a physical inspection on the river at the beginning and the end of the Interim Flow period (i.e. in October, 2009 and October, 2012). Any surface water diversions discovered during the inspection will be added to the list of monitoring sites from DFG for the SJRRP.

Identification of New Underground Diversions

The SJRRP will track construction of “new” water wells in the vicinity of the San Joaquin River in the Restoration area. Section 13751 of the California Water Code requires that every person who drills a water well to file a well completion report with DWR within 60 days from its completion. The well completion report contains information regarding the location, depth, static water level, and a geologic log for the well that could be valuable to the SJRRP. About 160,000 well completion reports are on file at the San Joaquin District office of the DWR and about from 200 to 300 more arrive each month. The SJRRP will utilize appropriate screening criteria such as distance from the new well to the San Joaquin River for inclusion in the “new” well dataset. An example of potential screening criteria would be for the SJRRP to track the number of new production water wells drilled within 1 mile of the San Joaquin River by River Reach starting at the beginning of the Interim Flow period in 2009, and continuing on an annual basis thereafter.

4.3.2 Measurement Methodology

Measurement methodology is described below for each component of river losses. Measurement methodology for surface water monitoring is described in Section 4.1 and methodology for groundwater monitoring is described in Section 4.4. Measurement methodology for surface water diversions and new underground diversions is described below.

Measurement Methodology for Surface Water Diversion Monitoring

The SJRRP will use the 2001 DFG survey data as a baseline data set to monitor the number, location and relevant characteristics of surface water diversions in the Restoration area. The SJRRP will monitor surface water diversions in the Restoration area by conducting a physical inspection on the river at the beginning and the end of the Interim Flow period (i.e., in October 2009 and October 2012). The surface water diversion data will be compared to the baseline dataset to assess potential impacts of any “new” diversions as part of the effort to “determine whether the seepage losses (and/or downstream surface or underground diversions) increase beyond the levels that were assumed in Exhibit B of the settlement agreement.”

Measurement Methodology for New Underground Diversion Monitoring

The SJRRP will use well completion reports kept on file by DWR as a baseline data set to monitor the potential number, location and relevant characteristics of underground diversions in the Restoration area. Although the information collected from DWR well completion reports is relatively qualitative in nature, it will allow the SJRRP to make a general assessment by river reach how many new wells (i.e., underground diversions) are being constructed in the vicinity of the river.

4.4 Bank Seepage Monitoring Methodology

The methods to evaluate bank seepage within the Restoration area rely greatly on geographically based information, data describing stream and groundwater system characteristics, and published reports and anecdotal information. Historically observed seepage, in conjunction with measured groundwater levels, streamflow, stage, geophysical properties, land surface elevations, land use and aerial photo data, will be used to identify areas most vulnerable to seepage-related impacts. These data will also be used to develop and measure the effectiveness of structural and operational solutions intended to prevent these impacts. The methodology is described below for site selection, and real-time and field measurement of these components to monitor bank seepage.

4.4.1 Site Selection Methodology

Site selection methodology for identifying areas potentially vulnerable to seepage includes consideration of SJRRP need for groundwater monitoring and identification of groundwater monitoring sites.

SJRRP Need

Monitoring of groundwater levels, streamflow, river stage, land use, and geophysical data will meet the program need to understand surface water – groundwater interactions by capturing the variability in groundwater levels. Monitoring of groundwater levels and river stage will help to determine whether seepage losses increase and result in impacts to areas with productive lands. The purpose of these monitoring points is to establish groundwater levels and a horizontal and vertical hydraulic gradient from the river towards adjacent areas. (Transects will also include a stage recorder in the river.)

Identification of Monitoring Sites

The following approach was taken to identify groundwater monitoring sites for evaluation of bank seepage:

- **Regularly spaced "background" monitoring transects** – Initially, groundwater monitoring transects were spaced at intervals approximately every 8 to 10 miles along the San Joaquin River from Friant Dam to the confluence with the Merced River. Each reach will have at a minimum two transects. The purpose of these transects is to ensure that background data are collected throughout the extent of the river to support model parameterization and calibration and to provide empirical data to support analysis of program-related changes at a broad and general level.

- **Special interest monitoring transects** – These groundwater monitoring transects would be placed in areas of special interest. For example, the special interest may be vulnerability-related, as in the evaluation of third party impacts related to bank seepage. Other special interest transects relate to the evaluation of river losses. The following information will be used to evaluate the need for special transects:

  - Geographically based information, such as river bottom and landside elevations, aerial photos, and groundwater level hydrographs, are used to screen the Restoration area to identify special interest areas that are potentially vulnerable to seepage. This reconnaissance-level screening is intended to remove from further review areas that are not susceptible to bank seepage; this is an important consideration given the scale of the Restoration area which spans the lower San Joaquin River between Friant Dam to the Merced River confluence with the San Joaquin River.

  - Site-specific information, such as local groundwater levels and geophysical data collected from driller's logs, will be used to further refine the areas potentially vulnerable to bank seepage. The published reports and anecdotal information are used to help corroborate these findings. The site-specific and reported information are also used to prioritize and rank areas according to their vulnerability for potential bank seepage to occur. Within these more vulnerable areas, monitoring plans will be designed capable of measuring and monitoring bank seepage during Restoration Flow conditions.

- **Groundwater Monitoring Transects** – Groundwater monitoring transects may include four to six shallow alluvial monitoring wells and two deeper monitoring wells. The number and locations of wells will be based on site-specific information and relative vulnerability of each site. Figure 4-2 depicts a conceptual drawing of a typical transect planned for the SJRRP. Data loggers will be installed in all monitoring points to obtain high-frequency water level data. Existing groundwater monitoring transects will be used and augmented as needed by the SJRRP.

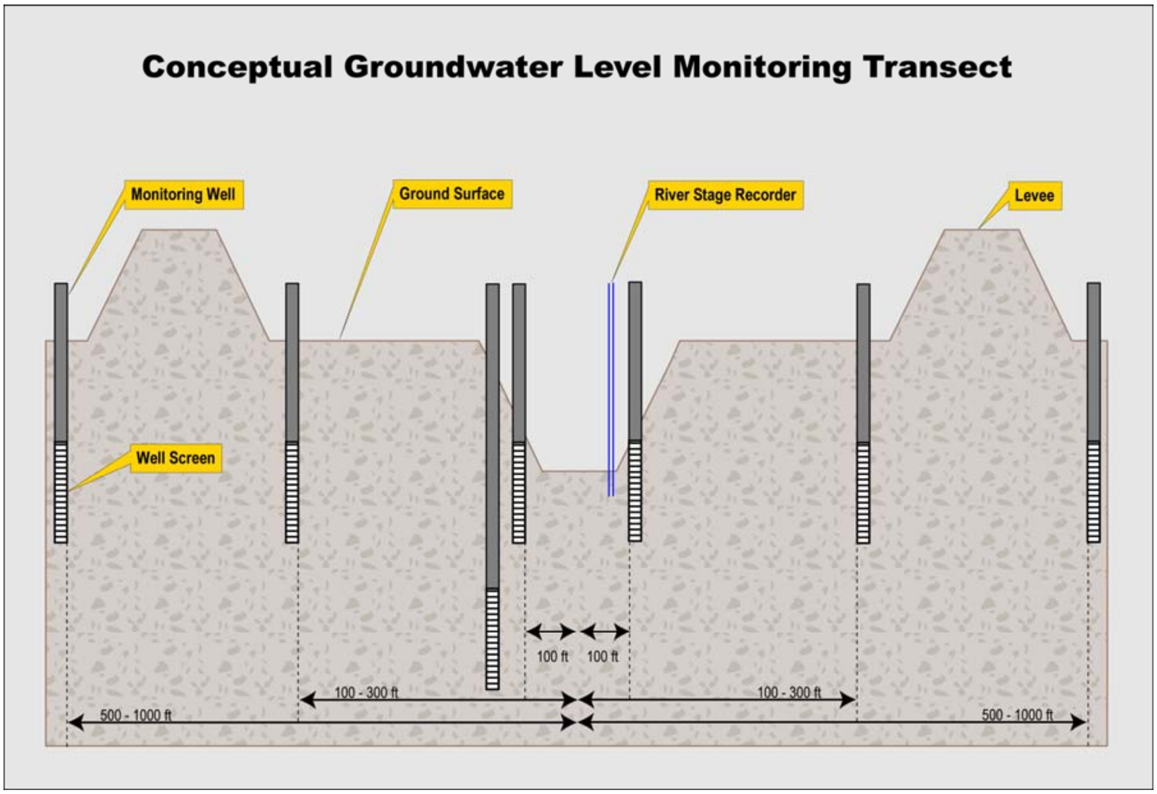


Figure 4-2.
Conceptual Design of Groundwater Monitoring Well Transect

4.4.2 Measurement Methodology

Measurement methodology described below includes measurement of groundwater levels and evaluation of well logs.

Groundwater Level Measurement

The basic measurement made at each groundwater monitoring well is the groundwater level, which is the level of water in the monitoring well under static conditions. The most common method of measuring groundwater levels is through the manual use of a tape or sounding device. The frequency of manual measurements depends on the need; measurements can be as frequent as several times an hour but manual measurements are more often used when the frequency is monthly or semiannually. Alternatively, groundwater monitoring wells can be instrumented with pressure transducers capable of recording groundwater levels automatically as often as desired. For the purposes of the SJRRP, both manual and instrumented measurement techniques will be used, as deemed necessary, to collect the data required to meet the needs of the SJRRP.

New groundwater monitoring wells will be completed to accommodate automatic data loggers for monitoring water levels and temperature in real-time. All well completions will be submitted to DWR in a timely fashion. A sensor for monitoring water quality field parameters may also be of interest at some transects. Staff gages, equipped with data loggers where possible, should be placed in the river at all transect locations.

New groundwater monitoring wells will be identified by the State Well Numbering System, issued by DWR. Under this system each well is assigned a unique number referred to as the State Well Number. State Well Number components include Township, Range, Section, Tract, Sequence Number, and Base & Meridian Pair. A detailed explanation of the State Well Numbering System can be found in *Water Facts: Numbering Water Wells in California, No. 7* (DWR, 2000).

Monitoring sites should be established prior to the initiation of Interim Flows on October 1, 2009, to allow for the collection of sufficient data for analysis and identification of problem areas prior to the establishment of full Restoration Flows. Data loggers will be installed in all monitoring wells to obtain high-frequency water level data.

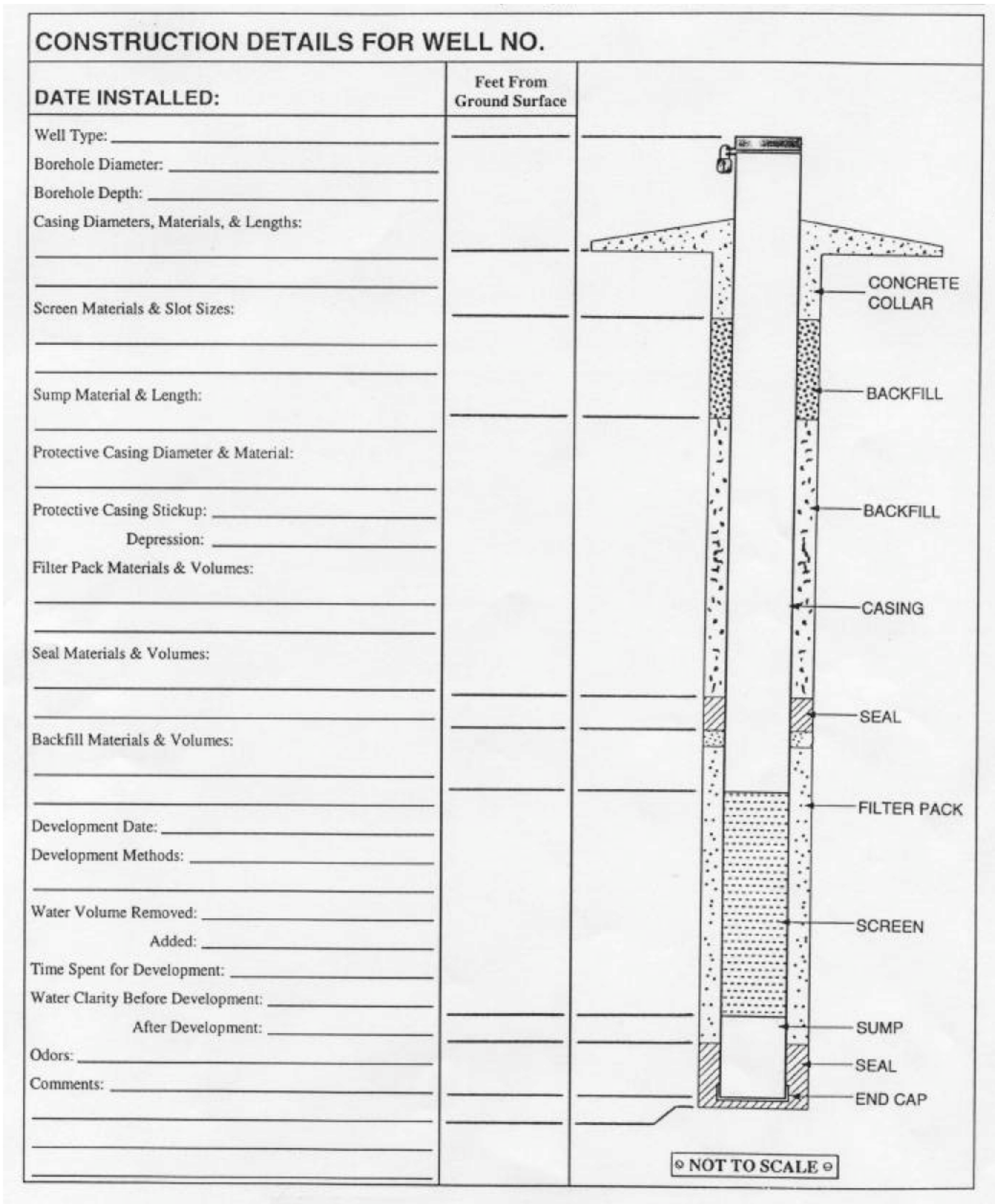
Well Log Evaluation

Figure 4-3 shows an example of a log from a monitoring well drilled in shallow alluvial conditions for restoration monitoring purposes (Hathaway/SSPA, 2008). This concept well could be a suitable design for alluvial wells for the monitoring plans described herein. A simpler design may also be appropriate, such as a piezometer. The advantages of a monitoring well are that it is more likely to be in contact with the water table under fluctuating conditions (because of a longer screen), and the ability to collect geophysical properties when installing the monitoring well. All of these factors will be taken into consideration as part of developing specific monitoring designs for each monitoring transect site along the San Joaquin River. During construction of the monitoring well transects, additional data collection will occur, including the following:

- **Lithologic characterization** of the upper 50 feet of aquifer, to assess presence of fine-grained units that could function as perching beds or maintain soil moisture following managed release events

- **Hydraulic conductivity assessment** at selected locations, such as slug tests or short duration pumping tests, to support characterization of the aquifer response to managed release events

- **Surveyed locations and elevations**



CONSTRUCTION DETAILS FOR WELL NO.

DATE INSTALLED:

Feet From Ground Surface

Well Type: ______

Borehole Diameter: ______

Borehole Depth: ______

Casing Diameters, Materials, & Lengths:

Screen Materials & Slot Sizes:

Sump Material & Length:

Protective Casing Diameter & Material:

Protective Casing Stickup: ______

Depression: ______

Filter Pack Materials & Volumes:

Seal Materials & Volumes:

Backfill Materials & Volumes:

Development Date: ______

Development Methods: ______

Water Volume Removed: ______

Added: ______

Time Spent for Development: ______

Water Clarity Before Development: ______

After Development: ______

Odors: ______

Comments: ______

Form 3. Well construction form for cased wells.

Figure 4-3.
Construction Details for Example Monitoring Well

4.5 Sediment Monitoring Methodology

Sediment monitoring methodology is described below for site selection and real-time and laboratory measurement of sediment in the San Joaquin River.

4.5.1 Site Selection Methodology

Site selection methodology for sediment monitoring includes consideration of SJRRP need for sediment monitoring and identification of sediment monitoring sites paired with flow measurements.

SJRRP Need

Adverse impacts of sediment displacement may limit the operation of the program to meet the Restoration Goal of a self-sustaining fishery. The sediment impacts include reduced channel capacity due to deposition, and infrastructure risk due to systemic scour. Maintenance of habitat depends on sediment transport rates. Sediment measurements will not address local scour that might occur in the immediate vicinity of a structure. Sediment transport information supports the following:

- Fish management
  - Persistence of spawning gravel and augmentation rates
  - Quality of spawning gravel and embeddedness
  - Floodplain connectivity and habitat
- Water management
  - Canal sedimentation rates
- Impact assessment
  - Infrastructure risk from degradation
  - Flood capacity risk and maintenance costs from aggradation
  - General stability of the river system

Identification of Monitoring Sites

Site selection and recommendations include spatial distribution and hypothesized future morphologic processes. Spatial considerations include the following:

- **Reach functions** – Reaches were delineated to serve different functions and address different concerns. Sampling programs account for the different uses.
- **Connectivity** – Sediment monitoring requires a systemic approach because material from upstream can be deposited in downstream reaches. Sediment impacts may originate from areas outside the immediate area. The sediment monitoring locations were identified considering where material may originate. A large quantity of sand in storage will begin shifting when flows begin.

- **Coverage –** Monitoring locations were chosen to characterize the entire Restoration area and not leave significant information gaps. Gages were selected to support analysis of areas likely to experience erosion or deposition that could be related to Restoration Flows.

Hypothesized morphologic processes include the following:

- **Erosion rate of gravel materials from spawning sites –** Successful spawning is anticipated to require gravel augmentation because of a lack of natural sources. Transport of gravels will determine necessary augmentation rates and the likely locations and destinations of mobilized materials.
- **Sand supply and embeddedness –** Sand supply from the bed, banks, and external sources is likely to impair the quality of the spawning gravel. The amount of sand in motion supports techniques for evaluation methods of controlling the source and manipulating the bed through natural processes. Sand supply will impact the channel form in all reaches.
- **Erosion and shifts in the sand-gravel transition –** The transition from a sand bed to a gravel reach is anticipated to shift downstream as a result of degradation. This shift will result in isolation of floodplain projects and desiccation of riparian vegetation. Subsequent armoring may limit the extent of protection required.
- **Degradation in Reach 2A –** Sand is anticipated to erode from Reach 2A beyond the transition zone and generate a supply of material while isolating the floodplain.
- **Deposition of sand in Reach 2B and Reach 3 –** Increases in flows will transport material from upper reaches into lower reaches. The existing changes in valley slope and settlement flows will likely cause deposition and reduce the level of flood protection.

- **Changes in bed profile in Reaches 4, 5, and the bypass system –** Insufficient information is present to hypothesize a process, but the addition of flow presents a liability to the SJRRP. Supporting data to identify the impacts will assist in management decisions.

In addition, because sediment monitoring requires a concurrent flow record, sediment monitoring sites were selected based on availability of flow data. From the list of flow gages specified by the Settlement, and other gages available in the Restoration area, sites were selected that will enable calibration of numerical techniques to extend the information beyond the limited spatial scope of any single or group of gages. The following sites were considered for long term monitoring:

- **Cottonwood Creek near confluence –** This site was included to empirically address potential tributary inputs of sand and gravel. Although the tributary is considered of minor importance, a high degree of uncertainty remains and known residential development upstream might increase loads. Periodic measurements during high flow events could verify the degree of importance to the sediment budget. There is an existing flow gage at this site and the location is considered wadeable; therefore, the question might be answered more definitively at a relatively low cost. An alternative to this gage would be sampling at the San Joaquin River below Friant gage, but use of that gage would require overcoming several logistical hurdles.

- **Dry Creek near confluence –** This site was proposed for periodic measurements of suspended and bed load sediments during high flow events. This is a lower priority site because little sediment seems to enter the San Joaquin River because of significant gravel mining on the creek. There is an existing flow gage at this site. An alternative approach is to sample above and below the confluence and check for changes in grain composition. The alternative approach is recommended.

- **San Joaquin River Reach 1A/1B split –** Gages within Reach 1A and Reach 1B collect data to identify key morphologic processes for the flow of sand and the impacts on degradation and spawning gravel quantity. Sampling would consist of periodic measurements during high flow events. Options include the following:

  - San Joaquin River below Friant Dam gage to provide an upstream boundary for information on gravel mobility. Little sand is anticipated to move past this section. Gravel augmentation is anticipated to include site-specific short-term monitoring studies. This gage was considered a lower priority and would include infrequent measurements.

  - The Highway 41 gage is located in an area upstream from the majority of the gravel pits, and would provide an estimate of sand and gravel loads entering the gravel pit system. This information would support a sediment budget to manage sand. The ease of access makes this site ideal for intensive sampling.

  - The Donny Bridge gage was excluded from consideration because of the complex flow pattern and poor accessibility. Other gages would be able to effectively capture processes.

  - Skaggs Bridge, Highway 145, is in the middle of the transition zone from sand to gravel and includes a wide channel area. This area would be sampled by boat. Gravelly Ford was discussed as an option for capturing this information, but lacks the gravel materials and experiences a different flow regime. This area would be intensively sampled.

- **San Joaquin River at Gravelly Ford gage –** This site is proposed for short-term and long-term suspended sediment monitoring efforts. The short-term monitoring efforts at this gage will provide baseline data prior to implementation of restoration alternatives, and can be used for calibration of sediment transport models and automated sampling methods. Since a portion of the observed bed material at Gravelly Ford consists of fine to coarse gravels, bed load sampling may improve the ability to accurately estimate total sediment load through Reach

2A. This site would be a good location for testing surrogate techniques for suspended sediment. This is a flow monitoring site specified under the Settlement. The historic significance of the Gravelly Ford gage, its importance as a reach break, and substantial change in processes makes this an important location. Although Skaggs Bridge was considered as a potential substitute, both Skaggs Bridge and Gravelly Ford were determined to be necessary for an initial sampling program because of a lack of information. It is anticipated that monitoring at Skaggs Bridge may be discontinued if Highway 41 and Gravelly Ford can provide adequate processes.

- **Chowchilla Bifurcation Structure –** Two sites are proposed for monitoring suspended sediment when the Chowchilla Bypass is active during high flows. This information will help define the total suspended sediment load and the splits between both Chowchilla Bypass and the San Joaquin River main channel. This is a flow monitoring site specified under the Settlement. The levee district maintains a settling basin and incurs a regular maintenance cost in the bypass. Past analyses have assumed a proportional split of sediment according to flow. Site options include the following:

  - **Chowchilla Bypass downstream from the Bifurcation Structure –** This site was excluded because of the large sediment trap. Haul and maintenance records could provide an adequate surrogate. Periodic sampling may address concerns.

  - **San Joaquin River downstream from the Bifurcation Structure –** Mendota pool is periodically flushed and experiences changes in transport capacity. While sediment may periodically be stored in the reach, material is transported. The existing gage experienced several feet of bed degradation.

- **San Joaquin River near Mendota –** This site is proposed for monitoring suspended sediment to examine the impacts of increased flows on potential sediment load increases into canals. This information will support future concerns for canal maintenance and flow conveyance. There is an existing flow gage at this site. Mendota Pool traps sediment and is periodically flushed during flood flows when the boards on the dam are removed. This pulse of material may carry important implications for downstream flood protection and loads to Arroyo Canal. This TM assumes that the gage will be downstream from the proposed bypass. Studies may be coupled with Mendota Pool bathymetry.

- **San Joaquin River below Sack Dam –** This site is proposed for monitoring suspended sediment during high flow releases. Sample collection is recommended at a minimum frequency of once per week. These data will be important to quantifying the sediment traveling through canal and dam systems. A flow monitoring gage is planned at the upstream end of Reach 4B, as specified under the Settlement. This gage identifies the amount of material passing into the Arroyo Canal versus being delivered to the downstream system. Tracking the motion of slugs of material from Mendota Pool will assist in managing the river system for habitat and flood protection.

- **San Joaquin River Reach 4B/Eastside Bypass** – These sites are proposed for monitoring suspended sediment over the full range of flows. During low flows, sample collection is recommended at a minimum frequency of once per month. Under high flow conditions, sample collection is recommended at a minimum frequency of once per week. All sampling should be conducted far enough downstream from any structures that the structure does not impact hydraulic conditions at the sampling sites. There is an existing flow gage at this site. Monitoring will address potential capacity losses in the bypass. Scour and deposition problems will likely include a Restoration Flow component that the SJRRP will need to address. Reach 4B landowner issues and future motion of the channel will benefit from a record of the processes. Options include gages near the Sand Slough Control Structure or gages from the Washington Road Bridge for both channel splits. A second gage, Eastside Bypass near El Nido (ELN) can provide bypass information.

- **San Joaquin River near the Merced River confluence** – This location represents the downstream boundary of the study reach and is important for bracketing sediment loads leaving the system as a result of Restoration Flows. The location will coincide with the location of the proposed new stream gage just upstream from the confluence, as specified under the Settlement.

Simulated flows below Friant Dam were generated by superimposing the historical hydrology from 1981 to 2003 on future operations under post-Settlement conditions. Based on this hydrology, annual peak flows typically occur in late March to April, with some years having peaks into late May. These peak flows and another smaller simulated event in October were used to determine sediment collection needs shown in Table 4-5.

Table 4-5.
Summary of Sediment Collection Needs

Location	Station Identifier(s)[1]	Responsible Agency	Remarks
San Joaquin River Below Friant Dam	11251000/SJF	USGS	Suspended and bed load sampling High flows only
Cottonwood Creek near Confluence	11250500/CTK	USGS	Suspended and bed load sampling High flows only
San Joaquin River at Highway 41	H41	USGS	Suspended and bed load sampling High flows only
Skaggs Bridge	None	USGS	Suspended and bed load sampling High flows only
Gravelly Ford[2]	GRF	USGS	Suspended and bed load sampling High flows and low flows
San Joaquin River Below Bifurcation	SJB	USGS	Suspended sampling High flows only
Chowchilla Bypass	CBP	USGS	Suspended sampling High flows only
San Joaquin River near Mendota	11254000	USGS	Suspended sampling High flows and low flows
Below Sack Dam	None	USGS	Suspended sampling High flows and low flows; location will be same as flow gage
Top of Reach 4B	None	USGS	Suspended sampling High flows and low flows; location will be same as flow gage
Eastside Bypass	ELN	USGS	Suspended sampling High flows and low flows
Merced River Confluence	None	USGS	Suspended sampling High flows and low flows; location will be same as flow gage

Note:
[1] USGS gage number and/or CDEC identifier.
[2] Good site to test USGS surrogate techniques for measuring suspended sediments.
Key:
CDEC = California Data Exchange Center
TBD = to be determined
USGS = U.S. Geological Survey

All sites on the mainstem San Joaquin River and in the bypasses will be sampled periodically during these high flow events and seasonally. During dry/low flow years, sampling may consist of sampling every week or every other week during the higher flow periods which typically last 4 to 6 weeks in the spring. Samples will be collected two to three times for the remainder of the year during low flows. The fall attraction flow in the first weeks of November will be sampled 1 to 2 times. Sampling during low flow periods could be reduced at the stations where almost no sediment transport is taking place during low flows. During wet/high flow years, high releases over 1,000 cfs may last from 2 to 8 months. Sampling should be conducted once a week or every other week at each station. Between 4 and 16 samples are recommended during the high flows at each station.

Sediment monitoring recommendations do not include specific studies to better understand processes in a specific area. Sites only include those required to establish long-term system-wide characterization of the sediment movement.

4.5.2 Measurement Methodology

Sediment collection methods depend on the bed material load at the site, and include suspended as well as bed load. Data collection should follow standard USGS techniques. Considerations include for sampling methods include the following:

- **Suspended load –** Sandy materials are anticipated to require suspended sampling only.
- **Bed load –** Gravelly or mixed materials are anticipated to require bed load in addition to suspended sampling.
- **Continuous Sediment Record –** A subset of sites will require a continuous sediment record through the use of surrogate techniques.
- **Periodic Measurements –** The majority of sites will make use of intermittent samples for the purpose of developing a rating curve.
- **Accessibility –** Wadeable reaches, bridges and cableways, or boat access.

To begin a more complete approach to data collection is used that can be scaled back depending on results of the monitoring. The monitoring information is intended to support analytic and numerical techniques. Recommended sediment sampling sites include the following:

- **Cottonwood Creek –** This site is wadeable and may be sampled by Friant and Reclamation South Central California Area Office (SCCAO) staff.
- **San Joaquin River below Friant –** The cableway at this site requires a retrofit.
- **Highway 41 –** Sampling is feasible from wide unused lanes on the new southbound bridge.
- **Skaggs Bridge (Highway 145) –** Sampling is anticipated to occur by boat.

- **Gravelly Ford –** In the immediate future, suspended sediment sampling is recommended to begin over the full range of flows. Sample collection is recommended at a minimum frequency of once per week during high flow releases and once per month during low flows. Sampling is not necessary for flows less than 50 cfs. A long-term objective should be to establish an automated sampling system at this gage. Historical channel disturbances have occurred upstream from the gage, but conditions have likely returned to background. This site will likely be sampled by boat.

- **San Joaquin below Chowchilla Bifurcation Structure –** This site is anticipated to be sampled either by boat or at the structure if turbulence does not result in nontransporting entrainment in eddies and vortexes.

- **San Joaquin near Mendota (below Mendota Dam) –** An existing cableway will provide access.

- **San Joaquin River below Sack Dam –** Inadequate information is available to determine methods at this time.

- **San Joaquin River Reach 4B/East Side Bypass flows –** Inadequate information is available to determine methods at this time.

5.0 Summary of Recommended Monitoring Locations

Locations for monitoring flow, water quality, groundwater, and sediment are summarized below according to river reach. Monitoring locations will be field-verified; therefore, maps may be subject to revision. Alternative stations are presented if a single monitoring station or combination of monitoring stations has not been selected yet to meet a given monitoring requirement.

5.1 Reach 1A

Table 5-1 describes locations for all monitoring within Reach 1A, as shown in Figure 5-1.

Table 5-1.
Monitoring Locations Within Reach 1A

Station Name	Monitoring Type	Responsible Agency	Status[1]	Revision
Friant Dam (Millerton)	Water Quality	Reclamation	Expanded Existing	Add YSI 6600 multiparameter sonde
	Flow	Reclamation	Existing	Flow measured at Friant outlets and spillway
San Joaquin River below Friant Dam	Water Quality	Reclamation	Expanded Existing	Add autosampler
	Sediment	USGS	Expanded Existing	Add sediment monitoring
Cottonwood Creek near Confluence	Sediment	USGS	Expanded Existing	Add sediment monitoring
San Joaquin River at Highway 41	Sediment	USGS	Expanded Existing	Add sediment monitoring
T-255.7 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-248.5 (3 shallow wells)	Groundwater	TBD	Proposed	Three new wells (shallow)

Note:

[1] Existing stations will be used where noted. Expanded existing means that new equipment will be installed or new measurements will be made at a location with an existing station. Proposed stations are planned at locations without an existing gage or well.

Key:

Reclamation = U.S. Department of the Interior, Bureau of Reclamation

TBD = to be determined

USGS = U.S. Geological Survey

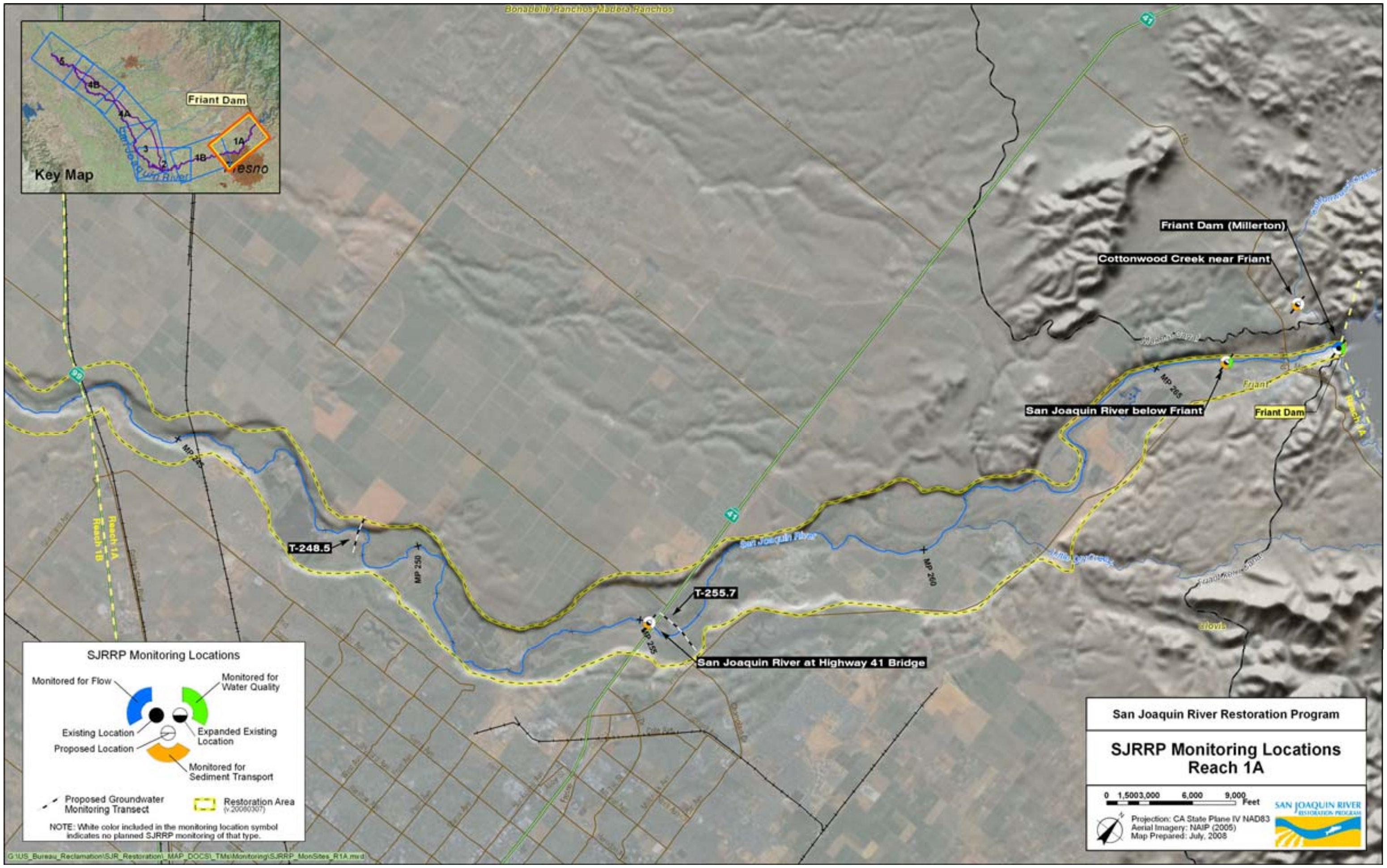


Figure 5-1.
Reach 1A Monitoring Locations

5.2 Reach 1B

Table 5-2 describes locations for all monitoring within Reach 1B, as shown in Figure 5-2.

Table 5-2.
Monitoring Locations Within Reach 1B

Station Name	Monitoring Type	Responsible Agency	Status[1]	Revision
San Joaquin River at Skaggs Bridge	Sediment	USGS	Expanded Existing	Add sediment monitoring
T-240.7 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-236.3 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-234.2 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-231.1 (3 shallow wells)	Groundwater	TBD	Proposed	Three new wells (shallow)
T-229.2 (5 shallow wells)	Groundwater	TBD	Existing	None

Note:
[1] Existing stations will be used where noted. Expanded existing means that new equipment will be installed or new measurements will be made at a location with an existing station. Proposed stations are planned at locations without an existing gage or well.

Key:
USGS = U.S. Geological Survey
TBD = to be determined

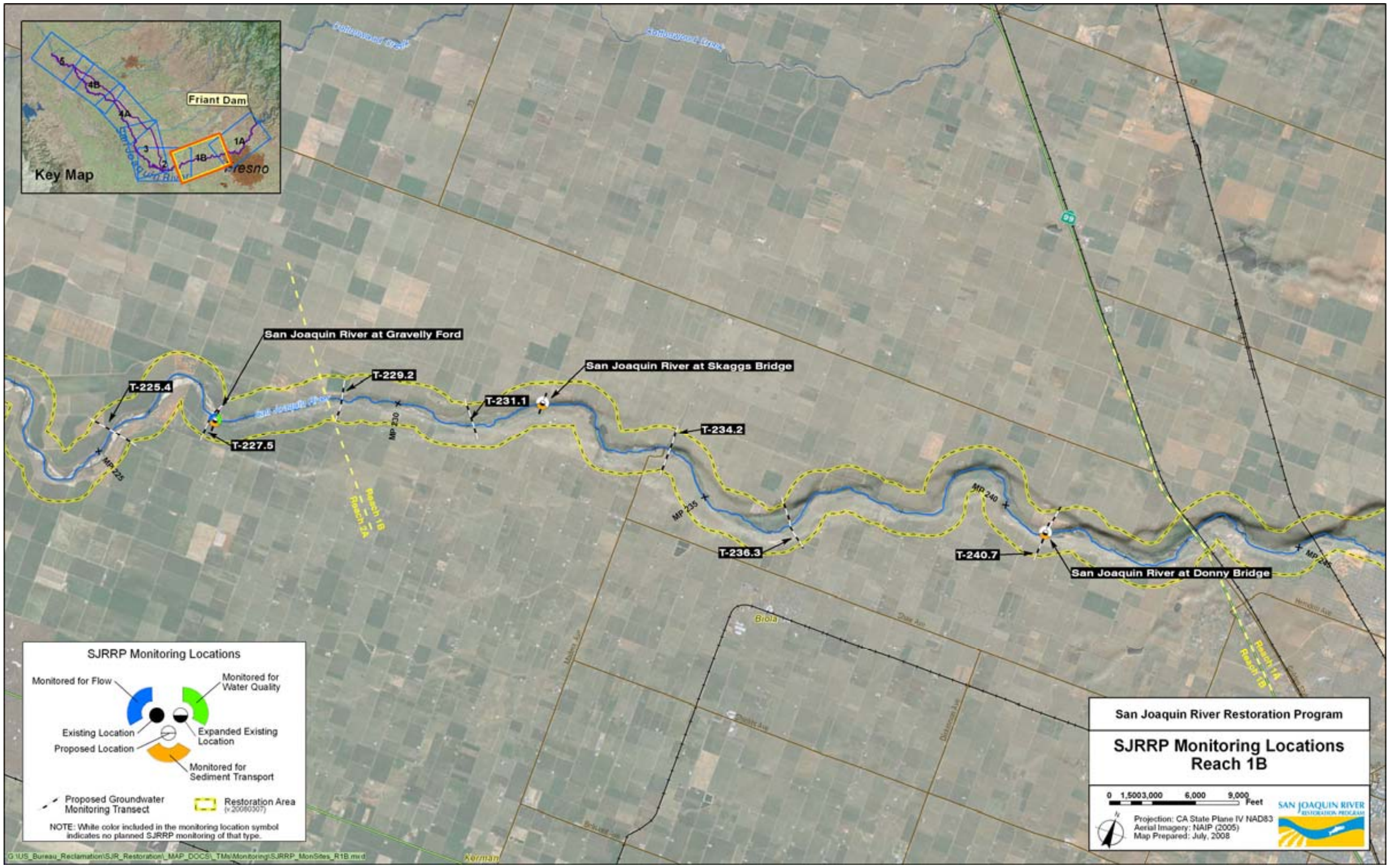


Figure 5-2.
Reach 1B Monitoring Locations

5.3 Reach 2

Table 5-3 describes locations for all monitoring within Reach 2, as shown in Figure 5-3. Monitoring locations are separated according to Reach 2A and 2B.

Table 5-3.
Monitoring Locations Within Reach 2

Station Name	Monitoring Type	Responsible Agency	Status[1]	Revision
Reach 2A				
San Joaquin River at Gravelly Ford	Water Quality	Reclamation	Expanded Existing	Add YSI 6600 multiparameter sonde
	Flow	Reclamation	Existing	None
	Sediment	USGS	Expanded Existing	Add sediment monitoring
T-227.5 (6 shallow and 1 deep wells)	Groundwater	TBD	Proposed	Seven new wells (six shallow and one deep)
T-225.4 (6 shallow and 1 deep wells)	Groundwater	TBD	Proposed	Seven new wells (six shallow and one deep)
T-222.0 (7 shallow and 1 deep wells)	Groundwater	TBD	Proposed and Existing	Four new wells (three shallow and one deep)
T-219.8 (8 shallow and 1 deep wells)	Groundwater	TBD	Proposed and Existing	Four new wells (3 shallow and one deep)
T-218.2 (10 shallow and 1 deep wells)	Groundwater	TBD	Proposed and Existing	Six new wells (five shallow and one deep)
T-217.2 (8 shallow and 1 deep wells)	Groundwater	TBD	Proposed and Existing	Six new wells (five shallow and one deep)
Reach 2B				
San Joaquin River Below Bifurcation	Water Quality	Reclamation	Expanded Existing	Add YSI 6600 multiparameter sonde
	Flow	Reclamation	Expanded Existing	Gage retrofit
	Sediment	USGS	Expanded Existing	Add sediment monitoring
Chowchilla Bypass at Bifurcation Structure	Flow	Reclamation/DWR	Expanded Existing	Gage retrofit
	Sediment	USGS	Expanded Existing	Add sediment monitoring
T-211.8 (7 shallow and 1 deep wells)	Groundwater	TBD	Proposed and Existing	Seven new wells (six shallow and one deep)

Note:
[1] Existing stations will be used where noted. Expanded existing means that new equipment will be installed or new measurements will be made at a location with an existing station. Proposed stations are planned at locations without an existing gage or well.

Key:
DWR = California Department of Water Resources
Reclamation = U.S. Department of Interior, Bureau of Reclamation
TBD = to be determined
USGS = U.S. Geological Survey

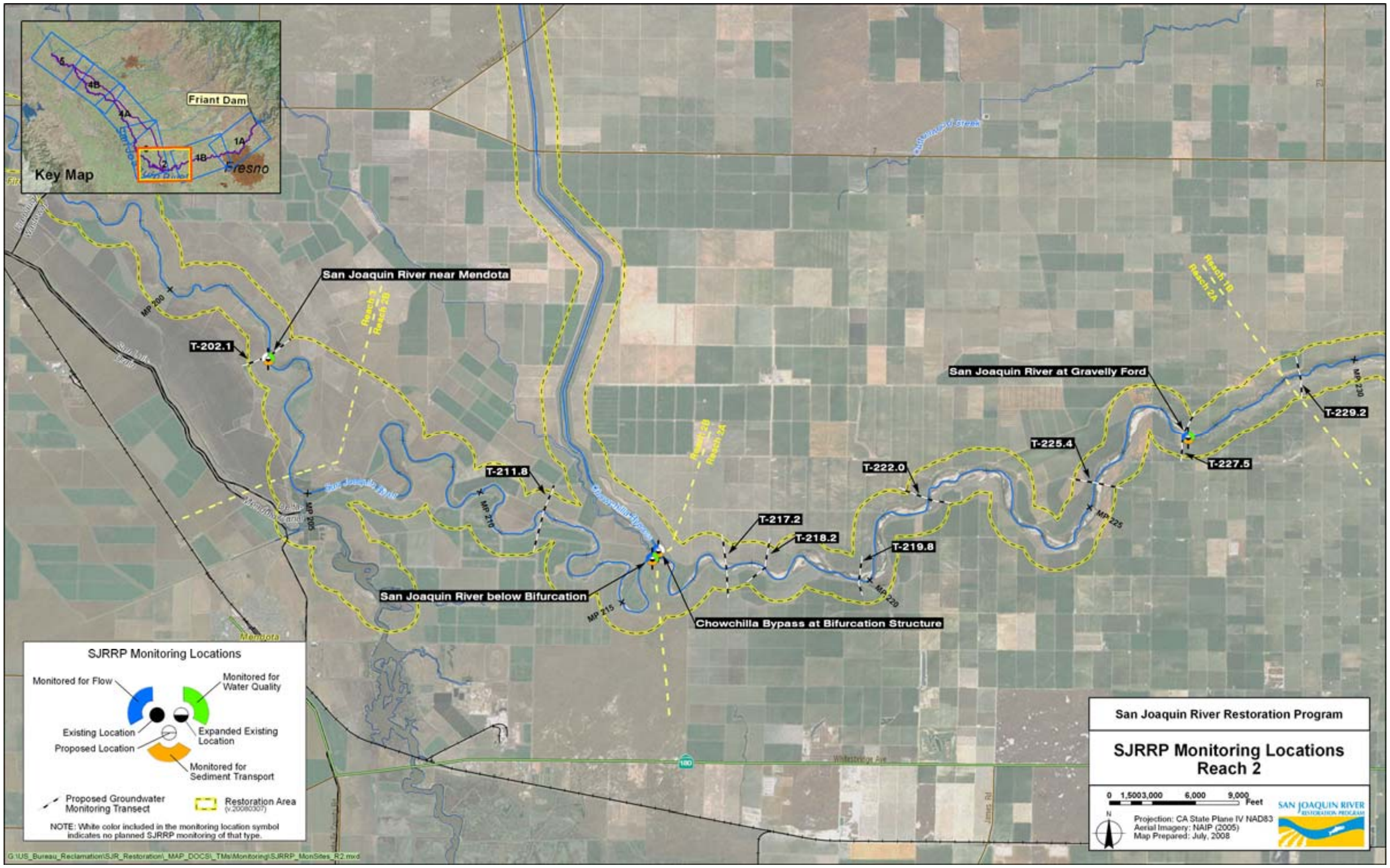


Figure 5-3.
Reach 2 Monitoring Locations

5.4 Reach 3

Table 5-4 describes locations for all monitoring within Reach 3, as shown in Figure 5-4.

Table 5-4.
Monitoring Locations Within Reach 3

Station Name	Monitoring Type	Responsible Agency	Status[1]	Revision
San Joaquin River near Mendota	Water Quality	Reclamation	Expanded Existing	Add autosampler, grab sample
	Sediment	USGS	Expanded Existing	Add sediment monitoring
T-202.1 (6 shallow and 1 deep wells)	Groundwater	TBD	Proposed	Seven new wells (six shallow and one deep)
T-194.8 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-186.8 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)

Note:
[1] Existing stations will be used where noted. Expanded existing means that new equipment will be installed or new measurements will be made at a location with an existing station. Proposed stations are planned at locations without an existing gage or well.

Key:
Reclamation = U.S. Department of Interior, Bureau of Reclamation
TBD = to be determined
USGS = U.S. Geological Survey

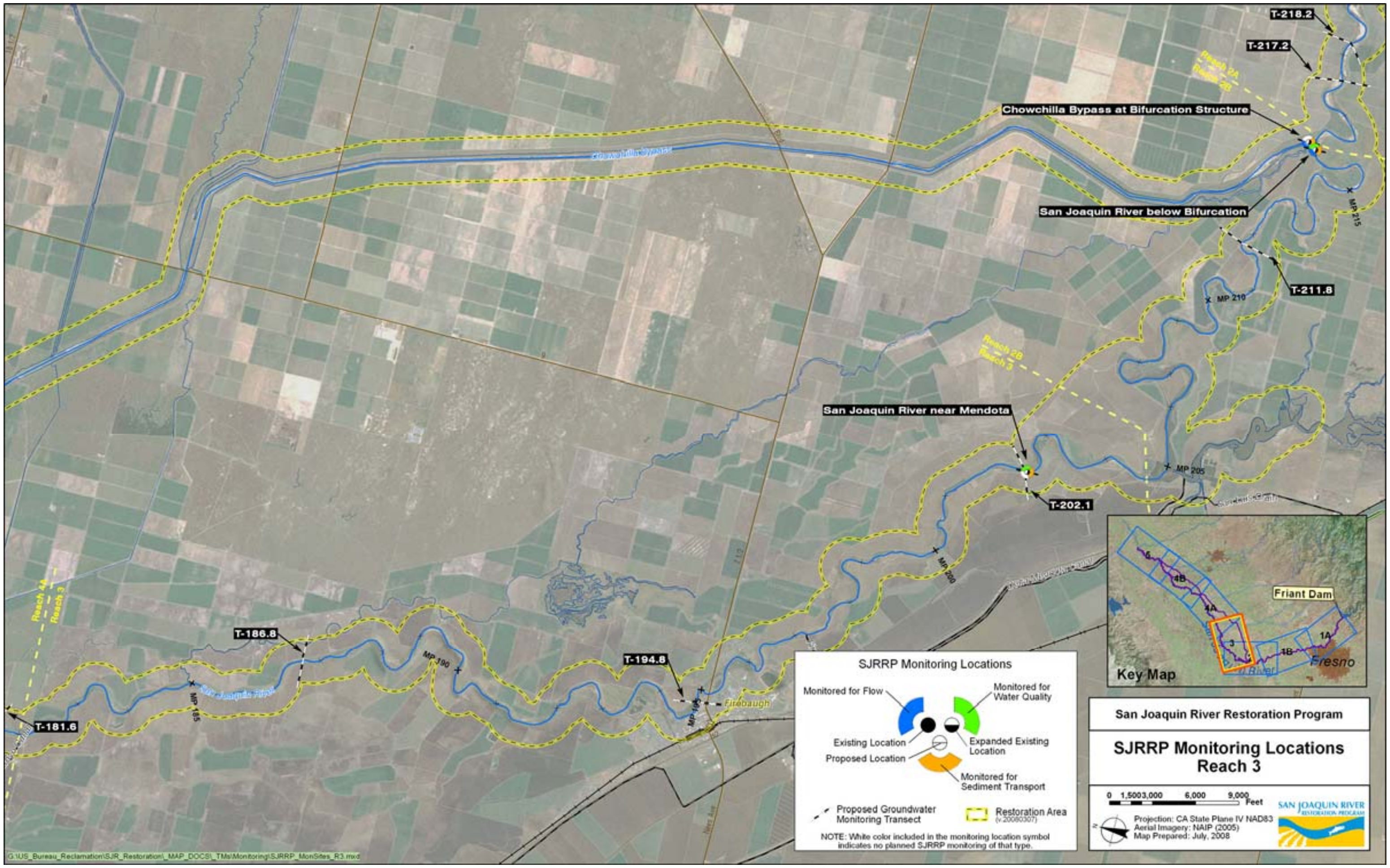


Figure 5-4.
Reach 3 Monitoring Locations

5.5 Reach 4A

Table 5-5 describes locations for all monitoring within Reach 4A, as shown in Figure 5-5.

Table 5-5.
Monitoring Locations Within Reach 4A

Station Name	Monitoring Type	Responsible Agency	Status[1]	Revision
San Joaquin River Below Sack Dam	Water Quality	TBD	Proposed	Add YSI 6600 multiparameter sonde
	Flow	DWR	Proposed	Abandoned Dos Palos gage retrofit
	Sediment	USGS	Proposed	Add sediment monitoring
T-181.6 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-173.9 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-168.9 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)

Note:
[1] Existing stations will be used where noted. Expanded existing means that new equipment will be installed or new measurements will be made at a location with an existing station. Proposed stations are planned at locations without an existing gage or well.

Key: N/A = Not applicable

DWR = California Department of Water Resources

TBD = to be determined

USGS = U.S. Geological Survey

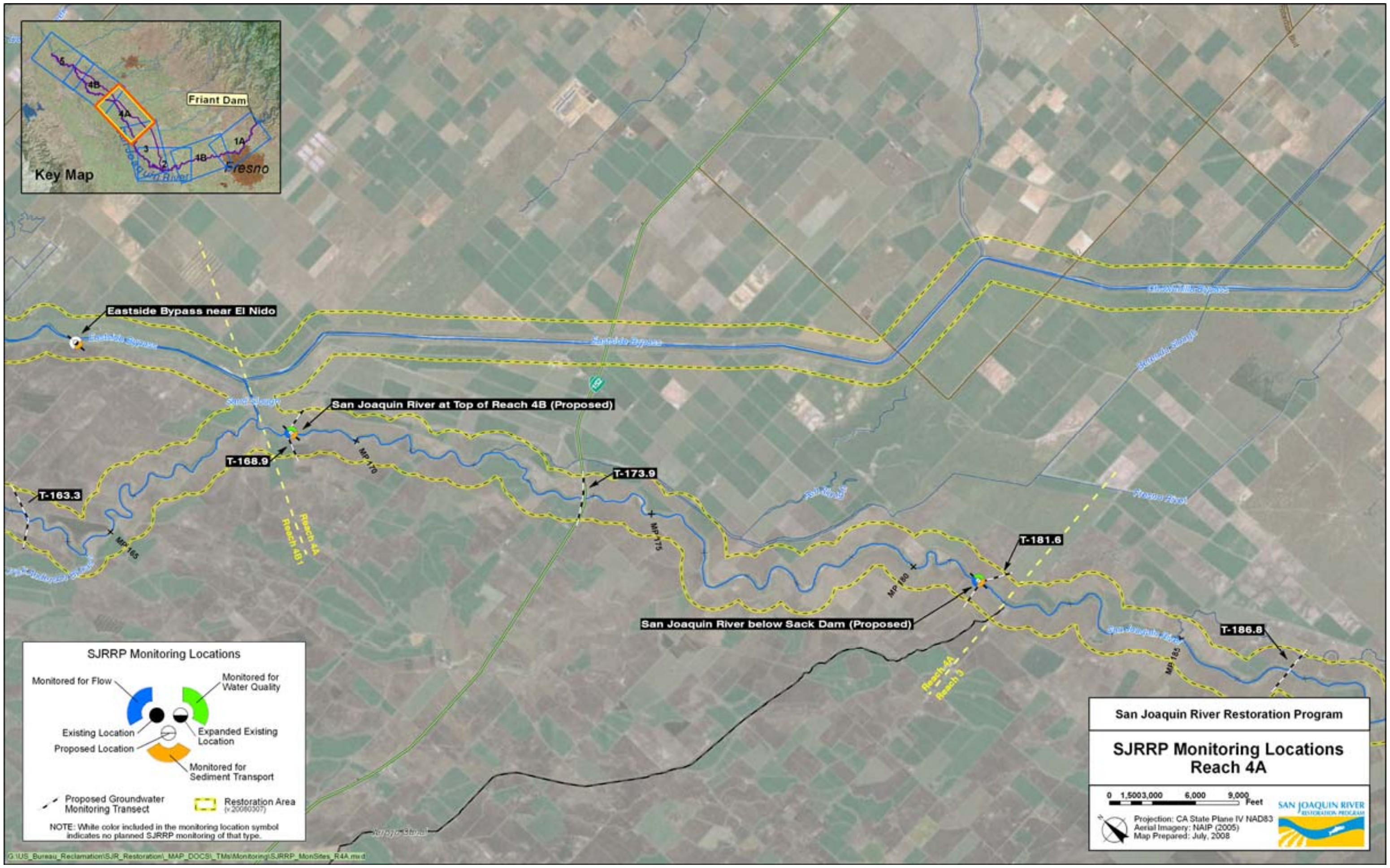


Figure 5-5.
Reach 4A Monitoring Locations

5.6 Reach 4B

Table 5-6 describes locations for all monitoring within Reach 4B, including Reaches 4B1 and 4B2 as shown in Figure 5-6.

Table 5-6.
Monitoring Locations Within Reach 4B

Station Name	Monitoring Type	Responsible Agency	Status[1]	Revision
Reach 4B1				
San Joaquin River at top of Reach 4B	Water Quality	TBD	Proposed	Add YSI 6600 multiparameter sonde
	Flow	DWR	Proposed	Add or select two gages
	Sediment	USGS	Proposed	Add sediment monitoring
Eastside Bypass near El Nido	Sediment	USGS	Expanded Existing	Add sediment monitoring
T-163.3 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-154.9 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
Reach 4B2				
T-143.3 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)

Note:
[1] Existing stations will be used where noted. Expanded existing means that new equipment will be installed or new measurements will be made at a location with an existing station. Proposed stations are planned at locations without an existing gage or well.

Key:
DWR = California Department of Water Resources
TBD = to be determined
USGS = U.S. Geological Survey

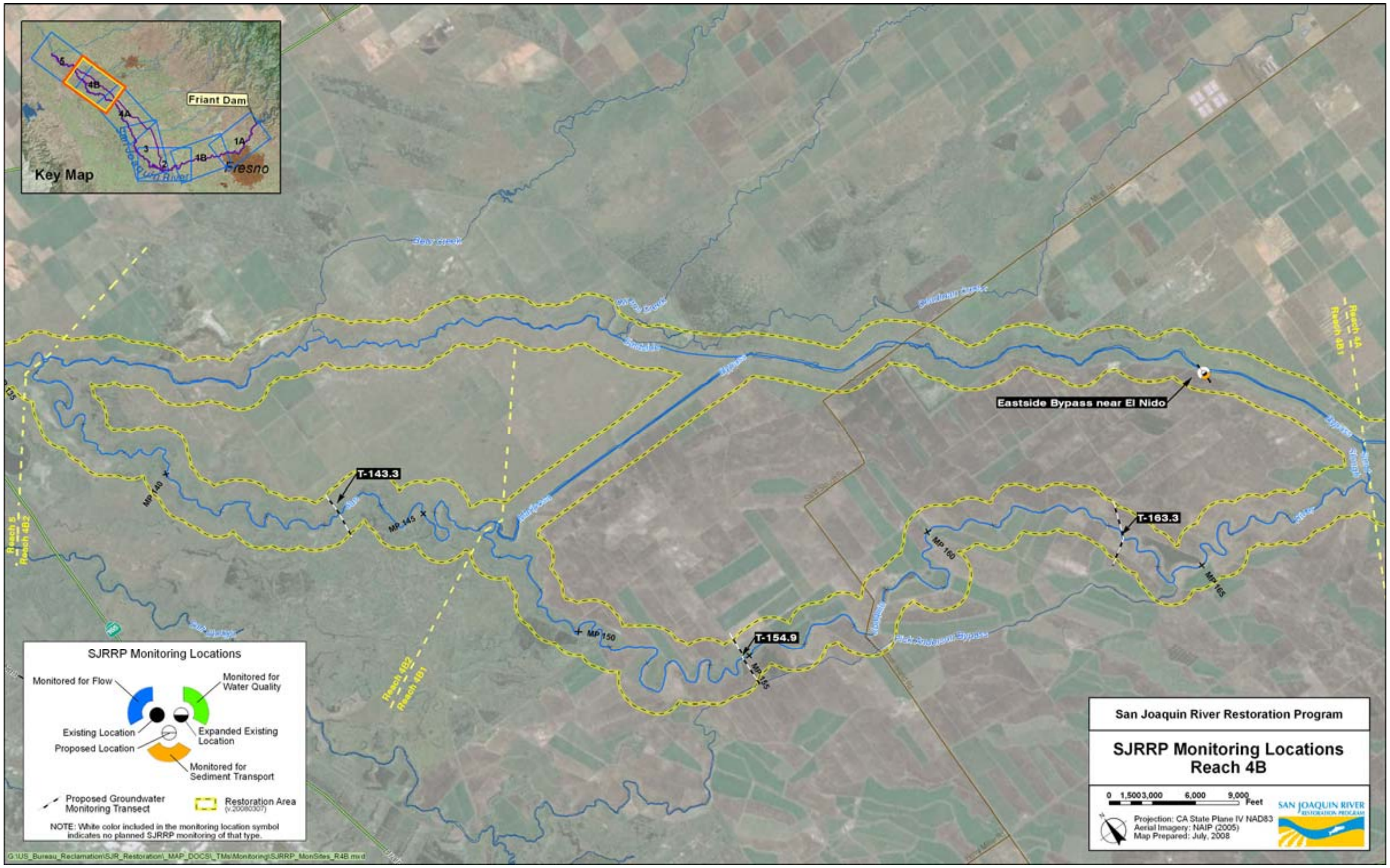


Figure 5-6.
Reach 4B Monitoring Locations

5.7 Reach 5 and Downstream from the Merced River Confluence

Table 5-7 describes locations for all monitoring within Reach 5 and downstream from the Merced River confluence, as shown in Figure 5-7.

Table 5-7.
Monitoring Locations Within Reach 5 and Downstream from the Merced River Confluence

Station Name	Monitoring Type	Responsible Agency	Status[1]	Revision
Reach 5				
San Joaquin River at Hills Ferry	Water Quality	TBD/SLDMWA/ Reclamation	Expanded Existing	Add autosampler, grab sample
San Joaquin River at Fremont Ford Bridge	Water Quality	USGS/Central Valley RWQCB	Existing	None
T-132.8 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-125.1 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
T-119.8 (6 shallow wells)	Groundwater	TBD	Proposed	Six new wells (shallow)
Merced River Confluence	Flow	USGS	Proposed	Add new gage
	Sediment	USGS	Proposed	Add sediment monitoring
Downstream from the Merced River Confluence				
San Joaquin River near Crows Landing	Water Quality	USGS/Central Valley RWQCB	Expanded Existing	Add autosampler

Note:
[1] Existing stations will be used where noted. Expanded existing means that new equipment will be installed or new measurements will be made at a location with an existing station. Proposed stations are planned at locations without an existing gage or well.

Key:
Central Valley RWQCB = Central Valley Regional Water Quality Control Board
DWR = California Department of Water Resources
Reclamation = U.S. Department of Interior, Bureau of Reclamation
SLDMWA = San Luis Delta-Mendota Water Authority
TBD = to be determined
USGS = U.S. Geological Survey

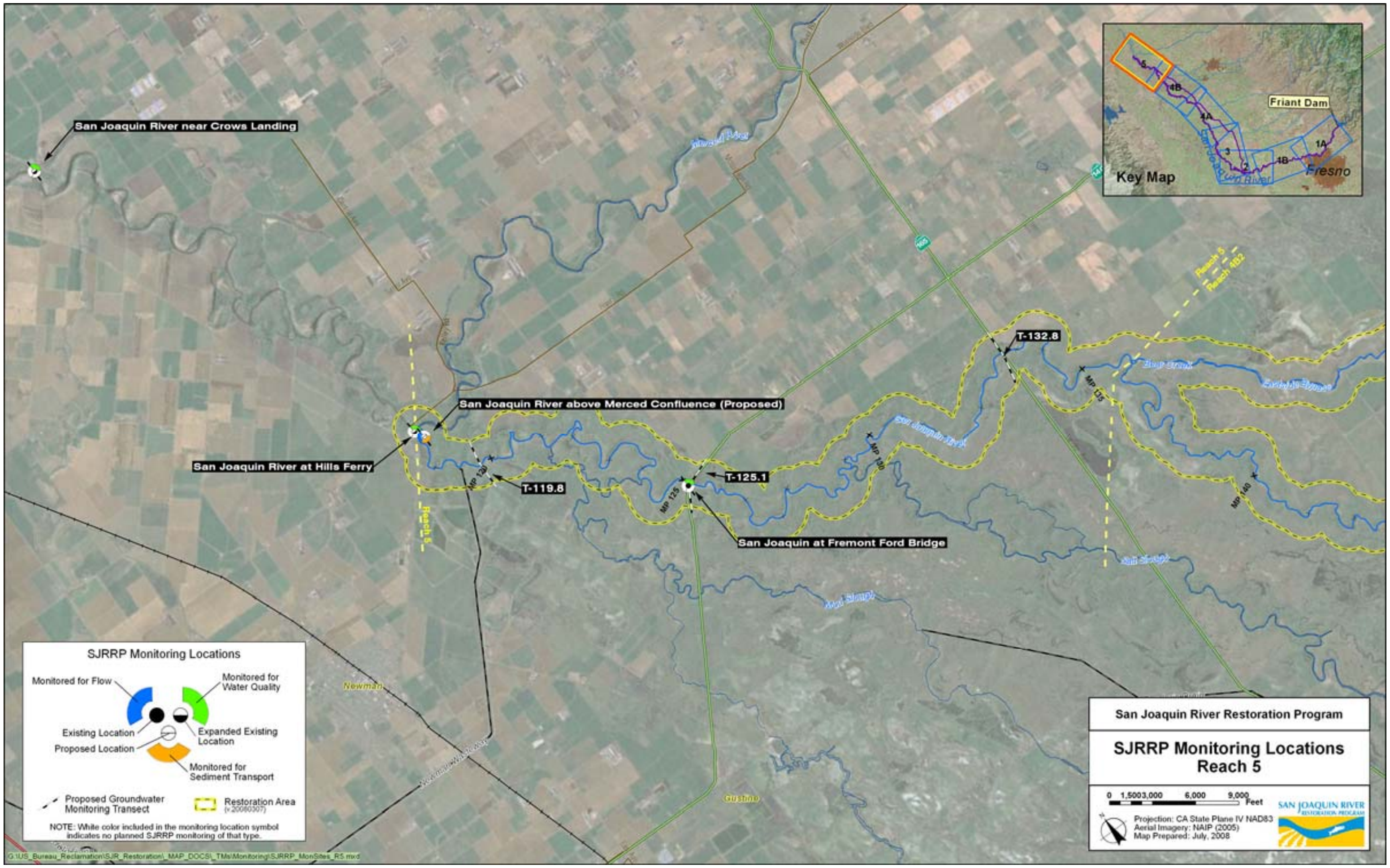


Figure 5-7.
Reach 5 and Downstream from the Merced River Confluence Monitoring Locations

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6.0 Data Reporting

The following sections describe the data reporting protocol for real-time and/or laboratory measurement of flow, water quality, river losses, bank seepage, and sediment transport, including the responsible agencies, methods for quality assurance/quality control (QA/QC), and dissemination of data. For all physical parameters, a Data Collection and Review (DCR) subgroup could be formed within the SJRRP to review all data collected and evaluate the choice of the sites to promote representative sites. The DCR would make appropriate recommendations to the SJRRP given a belief or finding of inadequacy.

6.1 Flow Monitoring Data Reporting

The following sections describe the data reporting protocol for real-time measurement of flow, including the responsible agencies, methods for QA/QC, and dissemination of data.

6.1.1 Responsible Agency

Each agency and contractor collecting data shall be responsible for its own data reduction (analysis), internal data quality control, data storage, and data retrieval. Responsible agencies for each flow monitoring station are listed in Table 4-1. The SJRRP will provide funding for the responsible agencies.

6.1.2 Monitoring Data Quality Assurance/Quality Control

The SJRRP proposes to employ the services of USGS to provide QA oversight of the stream gaging program. Stream gage operators shall adopt the standards used by USGS for the operation of stream gages, as described in *USGS Open File Report 96-618* (1996). The Quality Assurance Program shall consist of the following tasks:

- Provide QA for the stream gages required by the Settlement in accordance with protocols established by USGS (1996).
- Perform a field review at each stream gage twice per year. A discharge measurement will be made during each field review. Field reviews will be conducted during both a high and low flow period, if possible.
- Review flow and water quality records from gages twice per year. The first record review should be made during April in the office of the gage operator. The stream gage operator shall be notified in writing of any deficiencies in the operation of the stream gage that would prevent USGS from publishing the flow record not later than 2 weeks after the record review. The final record review will be conducted after the end of the water year in the office of the gage operator. The records to be reviewed will include the following:

- Daily values summary
- Hydrograph of daily discharges
- List of discharge measurements
- PC sheets (hourly gage heights, shifts, datum corrections)
- Copy of any graphic record used for computation
- New rating tables and new rating curves
- Station analysis

- Input the quality controlled flow record and water quality records into the NWIS database for public access over the internet.
- Publish mean daily flow records and water quality data annually for the primary SJRRP gages in the USGS Water Data Report Series.

Current QA/QC of flow data is described below for each proposed SJRRP monitoring station.

Release to the San Joaquin River from Friant Dam

Operations data are first manually input into a Friant Operations Log spreadsheet. The spreadsheet performs a quality control check on the input parameters using lookup tables. The data are then manually input into a Hydrologic Assessment Report (HAR), and an additional quality control check is performed before the HAR database is updated. The Millerton Lake Daily Operations Report is posted by Friant operations staff on the HAR database by 9:00 a.m. each day (7 days a week).

San Joaquin River at Gravelly Ford

Flow measurements are made at the station at least twice a month by Reclamation staff. A record of discharge is made in the field, and QC-checked and verified by Reclamation operations staff. A corrected monthly flow record consisting of mean daily flows for the station is produced that incorporates any required shift corrections. The corrected flow data are currently stored on the local network at the Reclamation SCCAO. Several existing data archives are under consideration for storing and retrieving SJRRP flow data (see Section 6.1.3). The corrected flow data will be archived in the system that is selected to store and retrieve flow data for the SJRRP.

San Joaquin River below Chowchilla Bypass

Flow measurements will be made at the station at least twice a month by Reclamation staff. Discharge records made in the field will be QC-checked and verified by Reclamation operations staff. A corrected monthly flow record consisting of mean daily flows for the station will be produced that incorporates any required shift corrections. Several existing data archives are under consideration for storing and retrieving SJRRP flow data (see Section 6.1.3). The corrected flow data will be archived in the system that is selected to store and retrieve flow data for the SJRRP.

San Joaquin River below Sack Dam

Flow measurements will be made at the station at least twice a month by DWR staff. A corrected monthly flow record consisting of mean daily flows for the station will be produced annually that incorporates required shift corrections. Several existing data archives are under consideration for storing and retrieving SJRRP flow data (see Section 6.1.3). The corrected flow data will be archived in the system that is selected to store and retrieve flow data for the SJRRP.

San Joaquin River at the Top of Reach 4B

Flow measurements will be made at the station at least twice a month by DWR staff. A corrected monthly flow record consisting of mean daily flows for the station will be produced annually that incorporates any required shift corrections. Several existing data archives are under consideration for storing and retrieving SJRRP flow data (see Section 6.1.3). The corrected flow data will be archived in the system that is selected to store and retrieve flow data for the SJRRP.

San Joaquin River at Merced River Confluence

QA/QC of flow data is described in Section 4.1

6.1.3 Dissemination of Data

Primary gaging stations for the SJRRP will be equipped with satellite telemetry and electronic data loggers that use a 12-volt battery power supply with a solar panel recharging system. The data loggers will monitor and record gage heights at 15-minute intervals. Data will be downloaded and stored when making flow measurements. The data will also be periodically transmitted to a GOES using a radio transmitter. The stations will typically transmit data every 3 hours. The data will be relayed via the satellite to a ground station and, in turn, via landline to a computer system operated by DWR or USGS. Computer software will decode the data, which often (but not always) will arrive in binary format, and will place the data in a format that hydrologic data processing software can recognize. Gage-height data will be stored and manipulated to provide streamflow in cfs. Software will continuously access the various data files (site information, gage height, and discharge) and portray the information graphically. Provisional real-time streamflow data for the primary monitoring stations will be made available on the Internet via the California Data Exchange Center (CDEC) Web site, at http://cdec.water.ca.gov, or USGS Web site, at http://www.usgs.gov.

Automated telemetry provides water data users with provisional stage and discharge information in a time frame that meets water management needs. This technology will permit field offices to monitor operation of the hydrologic stations continuously, schedule visits to stations to coincide with times of maximum need for data (such as during floods), and service equipment at the stations.

Reporting Flow Data

Releases of water to the San Joaquin River are reported by Friant operations staff on a daily basis as part of the Millerton Lake Daily Operations Report. The report contains a summary of a daily water balance for Millerton Lake that includes reservoir elevation, reservoir storage, 24-hour change in reservoir storage, and 24-hour average inflow and outflows to the San Joaquin River and the canal systems.

Daily discharge data (mean daily flows) will be published on a water-year basis for each primary monitoring station for the SJRRP. A water year is the 12-month period from October 1 through September 30, and is designated by the calendar year in which it ends. Because of the need for review of the completed computations, these reports will be published from 3 to 6 months after the end of the water year.

Archiving Flow Data

Daily flow data for the existing primary monitoring stations on the San Joaquin River are currently stored in several data archives. One or more of these existing data archives will be adequate to serve the needs of the SJRRP for storing and retrieving the flow data. A brief description of the alternatives under consideration for archiving the flow data follows:

- CDEC – California Data Exchange Center (State of California)

  http://cdec.water.ca.gov/

  CDEC provides a centralized location to store and process real-time hydrologic information gathered by various cooperators throughout California. The focus of CDEC is solely to distribute provisional real-time data. Therefore, it is important to note that <u>none of the data available from CDEC are quality controlled</u>. Provisional flow data are available to the public under the station identifiers listed in Table 4-1.

- CVO – Central Valley Operations (Reclamation)

  http://www.usbr.gov/mp/cvo/

  The CVO maintains an internal database with a variety of reservoir- and operations-related data. Some of the data are publicly available in the form of automated daily and monthly reports posted to the Web site. Some of the data are also posted to CDEC, such as flows released to the San Joaquin River from Friant Dam.

- IIMS – Integrated Information Management System (Reclamation)

  http://www.trrp.net/science/IIMS.htm

  IIMS is a local data repository with some built-in data visualization tools, and is currently under development by Reclamation. IIMS will contain a variety of multidisciplinary spatial and tabular data. IIMS is being developed with generalized database architecture to facilitate easy deployment across multiple Reclamation offices; data sharing; and standardization of data formats.

- IWRIS – Integrated Water Resources Information System (State of California)

http://gis.wrime.com/iwris/

IWRIS is a pilot project currently under development by the Conjunctive Water Management Branch of DWR. IWRIS is being designed to serve as a central data portal for a variety of conjunctive water-management-related data in a network of distributed local databases. Data are accessed from one integrated, geographic information system (GIS) based graphical user interface. IWRIS provides the capability to integrate data and model/analysis results with GIS map layers for decision support purposes.

DWR is considering using Proposition 84 funding to expand the IWRIS effort to cover a much wider array of data in an effort to facilitate local water planning efforts and development of Bulletin 160. The proposed expansion is called Water Planning Information Exchange (WPIE).

- NWIS – National Water Information System (USGS)

http://waterdata.usgs.gov/nwis

NWIS is a large public online central database that stores water resources data (surface water, groundwater, water quality) for approximately 1.5 million sites across the United States. Published, quality-controlled data are available as well as provisional real-time and provisional recent daily data.

6.2 Water Quality Monitoring Data Reporting

The following sections describe the data reporting protocol for real-time and laboratory measurement of water quality parameters, including the responsible agencies, methods for QA/QC, and dissemination of data.

6.2.1 Responsible Agency

Each agency and contractor collecting data shall be responsible for its own data reduction (analysis), internal data QC, data storage, and data retrieval. Each will provide its data to the independent data management organization for compilation, publication and distribution of printed copies, and posting of reports on a dedicated Web site. The independent data management organization (DMO) will specify the format for all reports, data tables, graphics, and charts. The DMO will specify how raw data will be presented by the collecting agencies and how the final reports will be published (e.g., Adobe PDF). The SJRRP will provide funding for the responsible agencies.

6.2.2 Monitoring Data Quality Assurance/Quality Control

QC is the overall system of technical activities that measure the attributes and performance of a process, item, or service against defined standards to verify that stated requirements are met. QA is an integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer.

A Quality Assurance Project Plan will be written for all SJRRP flow, water quality, groundwater level, and sediment monitoring. QA objectives will be used to validate the data for this project. The data will be accepted, rejected, or disqualified based on how sample results compare to established acceptance criteria. Precision, accuracy, and contamination criteria will be used by the QCO to validate the data for this project. The criteria will be applied to the blind external duplicate/split, blank, reference, or spiked samples submitted with the production samples to the analytical laboratories by the participating agencies to provide an independent assessment of precision, accuracy, and contamination.

Laboratories analyze their own QC samples with the client’s samples. Laboratory QC samples, including laboratory fortified blanks, matrix spikes, duplicates, and method blanks, assess precision, accuracy, and contamination. Laboratory QC criteria are stated in the analytical methods or determined by each laboratory. Since internal control ranges are often updated in laboratories based on instrumentation, personnel, or other influences, it is the responsibility of the QCO to verify that these limits are well documented and appropriately updated during system audits. The preferred method of reporting the QC results is for the laboratory to provide a QC summary report with acceptance criteria for each QC parameter of interest.

For water and sediment results, the QCO will use a statistical program to determine if current concentrations for parameters at given sites are consistent with the historical data at these sites. A result is determined to be a historical outlier if it is greater than three standard deviations from the average value for the site. The presence of an outlier could indicate an error in the analytical process or a significant change in the environment.

Samples must be prepared, extracted, and analyzed within the recommended holding time for the parameter. Data may be disqualified if the sample was analyzed after the holding time expires. Completeness refers to the percentage of project data that must be successfully collected, validated, and reported to proceed with its intended use in making decisions.

Constraints with regard to time, money, safety, and personnel were some of the factors in choosing the most representative sites for this project. Monitoring sites have been selected by considering the physical, chemical, and biological boundaries that define the system under study. Sites also were selected to be as representative of the system as possible.

Comparability between each agency’s data is enhanced through the use of standard operating procedures (SOP) that detail methods of collection and analysis. Each agency has chosen the best available protocol for the sampling and analyses for which it is responsible based on the agency’s own expertise. Audits performed by the QCO will reinforce the methods and practices currently in place and serve to standardize techniques used by the agencies.

6.2.3 Dissemination of Data

Provisional real-time water quality data for the primary monitoring stations will be made available on the Internet via the CDEC Web site, at http://cdec.water.ca.gov, or USGS Web site, at http://www.usgs.gov. Preliminary real-time data will also be posted on the SJRRP web site by the DMO. The data will be clearly marked to be preliminary and subject to revision. The purpose of these data is to provide an instant estimate of field conditions. The DMO will maintain a graphic display on the Web site that will show the current volume and temperature of water at the ten monitoring locations. Real-time data will be posted on the Web site as preliminary, subject to change. The data will be available for 5 years, after which the data will be archived by Reclamation and provided on request.

The DMO will prepare quarterly data compilation reports that will list mean daily available flow and temperature at the monitoring locations, plus all available water quality results. The report will include summary calculations, charts, and graphics to show cumulative effects. Provisional data will be posted on the SJRRP Web site by the collecting agencies in quarterly data summary reports. The data will be subject to revision. The purpose of these data is to provide reliable information for analyzing trends and changes in water quality in the river. The DMO will maintain a database for download by interested parties. Each quarterly data report will be reviewed by the DCR, then posted on the SJRRP Web site and distributed to the public. Quarterly data reports will be available for download by any interested party for the entire term of the SJRRP.

Final data will be completely verified by the respective collecting agencies and published in an Annual Synthesis Report. The DCR will collaborate to prepare the Annual Synthesis Report, which will synthesize all flow and water quality monitoring data for the SJRRP, and will provide a scientific review of the data to determine how the SJRRP is meeting its objectives. The Annual Synthesis Report must be completed within 3 months of the end of a calendar year, and will be published on the Web site and made available for download by any interested party for the entire term of the SJRRP.

6.3 River Losses Monitoring Data Reporting

The following sections describe the data reporting protocol for real-time and laboratory measurement of river losses, including the responsible agencies, methods for QA/QC, and dissemination of data.

6.3.1 Responsible Agency

Each agency and contractor collecting data shall be responsible for its own data reduction (analysis), internal data QC, data storage, and data retrieval. The SJRRP will provide funding for the responsible agencies.

6.3.2 Monitoring Data Quality Assurance/Quality Control

Measurement methodology is described below for each component of river losses. QA/QC procedures for surface water monitoring are described in Section 6.1.2 and QA/QC procedures for groundwater monitoring are described in Section 6.4.2. Measurement methodology for surface water diversions and new underground diversions is described below.

Surface Water Diversions

Surface water diversions are to be observed and documented based on field visits, and compared with historical records, including the DFG survey of 2001 (McBain and Trush, 2002). A standard report form will be developed and used for recording a detailed description of each surface water diversion, including location, type, and other physical characteristics at the diversion location. The reported conditions will be compared with the DFG survey and differences noted. Additional field visits will be scheduled, as needed, to address corrective actions, such as accessibility constraints at the time of the initial visit, diversions that could not be located, and other discrepancies noted.

New Underground Diversions

New underground diversions (i.e., wells constructed in the vicinity of the river) will be assessed by river reach based on how many wells are being constructed in the vicinity of the river. For this effort, construction of new wells will be tracked. Screening criteria will be developed to identify which new wells would follow under this review. These screening criteria will be reviewed by the SJRRP Monitoring Subgroup (or its successor) for review and comment. Finalized screening criteria will be applied to new well information. California Water Code requires that for every water well drilled, a well completion report must be filed with DWR with 60 days of the well completion. The SJRRP will coordinate its review efforts with DWR to ensure all filings are reviewed.

6.3.3 Dissemination of Data

Dissemination of data is described below for each component of river losses. Dissemination of surface water monitoring data is described in Section 6.1.3 and dissemination of groundwater monitoring data is described in Section 6.4.3. Dissemination of data related to measured surface water diversions and new underground diversions will be accomplished through annual reports. Each annual report will first be distributed to the SJRRP Monitoring Subgroup (or its successor) for review and comment. Questions and comments will be addressed before finalizing the report for final review by the Settling Parties. The final report will be maintained in the SJRRP document archives in both hard copy and electronic form.

6.4 Bank Seepage Monitoring Data Reporting

The following sections describe the data reporting protocol for real-time and laboratory measurement of seepage, including the responsible agencies, methods for QA/QC, and dissemination of data.

6.4.1 Responsible Agency

Each agency and contractor collecting data shall be responsible for its own data reduction (analysis), internal data QC, data storage, and data retrieval. The SJRRP will provide funding for the responsible agencies.

6.4.2 Monitoring Data Quality Assurance/Quality Control

SOPs should be employed to enable data to be measured consistently and correctly. The SOPs discussed in this section are guidelines and may vary or change as required by the SJRRP. The procedures are comparable to those used by agencies collecting data as part of ongoing groundwater monitoring programs.

For a given monitoring well, a survey mark should be placed on the riser pipe or casing as a reference point. All measurements are recorded in reference to this point. All measurements should be made as accurately as possible, with a minimum accuracy of 0.1 feet. Potential problems with the well should be noted, such as cascading water, oil, or other product floating on the water column, nearby pumping, and any physical changes to the protective concrete pad. Manual measurements should be made with an electric water level indicator or chalked steel tape. Electrical tapes are lowered to the water surface whereas chalked steel tapes are lowered generally a foot or more below the water surface. Steel tapes are generally chalked so that a 1-to 5-foot-long section will fall below the expected water level.

The following QA/QC procedures should be considered: document all observed data; measurement instrumentation should be operated in accordance with operating instructions, as supplied by the manufacturer; the water level should be measured at each well twice to compare results and, if results do not agree to within 0.02 feet, a third measurement should be taken and the readings averaged; measurements should be compared to historical measurements and significant discrepancies noted; wells for which no or questionable measurements are obtained should be noted using consistent codes; all data entered into electronic form should be double-keyed and proofed by a second staff member; and questionable wells or measurements noted during data collection need to be followed up with corrective action if applicable. These SOPs assume that only uncontaminated wells are being measured. If not, a Health and Safety Plan should be developed.

Wells should be manually measured on a monthly basis to check the accuracy of data loggers, and QA/QC procedures on the recorded data should be conducted following each monthly field visit.

6.4.3 Dissemination of Data

Groundwater data will be managed and distributed using the existing DWR Water Data Library (WDL). All groundwater monitoring data will be posted to the WDL Web site: http://wdl.water.ca.gov

The water data library provides online access to hydrologic data. Groundwater data are listed by State well identification number. New groundwater monitoring wells installed for the SJRRP would be assigned a State well identification number prior to beginning operation. The water data library is maintained by DWR, Division of Planning and Local Assistance.

6.5 Sediment Transport Monitoring Data Reporting

The following sections describe the data reporting protocol for real-time and laboratory measurement of sediment transport, including the responsible agencies, methods for QA/QC, and dissemination of data.

6.5.1 Responsible Agency

USGS maintains an extensive network of stream gages collecting information, including sediment transport. Site collection techniques include periodic calibration and verification by experts, with regular collection undertaken by trained individuals on location. On-site regular collection should be performed by trained Reclamation staff managed from the SCCAO. The SJRRP will provide funding for the responsible agencies.

6.5.2 Monitoring Data Quality Assurance/Quality Control

QA/QC of monitoring data will be as described under Section 6.2.2. USGS is recommended to provide quality control via the NWIS site.

6.5.3 Dissemination of Data

USGS is recommended to provide dissemination of data via the NWIS site.

7.0 Next Steps

The objective of the Draft Monitoring Plan for Physical Parameters is to establish a programmatic monitoring framework to support the attainment of both the Restoration Goal and Water Management Goal established in the Settlement Agreement for restoration of the San Joaquin River. The intent is that this document will be used as a planning tool, and to communicate proposed monitoring strategies to SJRRP cooperating agencies and stakeholders.

Next steps for the SJRRP monitoring program include the following:

- External review
- Coordination with cooperating agencies and stakeholders
- Implementation, to include the following:
  - Environmental compliance activities
  - Obtaining permitting and access agreements with landowners as needed
  - Construction of monitoring networks as needed
  - Operation and maintenance of monitoring networks
  - Reporting

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Draft Technical Memorandum

Monitoring Plan for Physical Parameters

Appendix A
Questions to Consider for Establishing a Hypothesis-Based Water Quality Monitoring Plan

SAN JOAQUIN RIVER RESTORATION PROGRAM

September 2008 – Version ii

Appendix A
Questions to Consider for Establishing a Hypothesis-Based Water Quality Monitoring Plan

DRAFT – Questions to Consider for Establishing a Hypothesis-Based Water Quality Monitoring Plan

1. Have designated beneficial uses of water established by the Central Valley Regional Water Quality Control Board (Central Valley RWQCB) for the San Joaquin River Restoration Program (SJRRP) reaches changed recently (i.e., since publication of McBain and Trush, 2002 – Table 6-2)?

2. Have the San Joaquin River reaches in the study area designated as impaired and placed on the Central Valley RWQCB Section 303(d) list changed recently (i.e., since publication of McBain and Trush, 2002 – Table 6-3)?

3. Have the water quality objectives established by Central Valley RWQCB for the San Joaquin River by river reach changed recently (i.e., since publication of McBain and Trush, 2002 – Table 6-4)?

4. What are the current temperature objectives for the San Joaquin River in the Central Valley RWQCB Basin Plan? Will the actions of the SJRRP result in revisions to the temperature objectives in the Basin Plan?

5. Will Restoration Flow releases from Friant Dam provide an adequate flow regime (i.e., velocity, depth, and temperature) to support the various salmonid life cycle requirements (i.e., spawning, rearing, holding, and passage) in Reaches 1 through 5?

6. How far downstream will Restoration Flow releases from Friant Dam affect stream temperatures by year-type, season, and hydrograph component (i.e., what is the relationship between flow and discharge in Reaches 1 through 5 for the various restoration hydrograph components)?

7. Do early summer and late fall temperatures of Restoration Flows released from Friant Dam exceed salmonid life cycle criteria in Reaches 1 through 5?

8. Do summer and fall temperatures in deep holding pools within Reach 1 exceed salmonid life cycle criteria (i.e., are there suitable holding conditions in the pool(s) for adult spring-run salmon)?

9. Do spring and fall temperatures in spawning habitat in Reach 1 exceed salmonid life cycle criteria?

Note: There are probably many other specific fishery-related temperature questions. These questions should be coordinated closely with the Fisheries Management Team.

10. How can the (limited) cold-water pool in Millerton Lake be optimally managed to support a cold-water fishery for the various water year-types, seasons, and restoration hydrographs?

11. How much impact will isolation of the gravel pits from the active restored channel in Reach 1 have on instream water temperatures?

12. Restoration Flow releases from Friant Dam will mix with water imported from the Sacramento-San Joaquin Delta (Delta) in Mendota Pool prior to construction of the Mendota Pool Bypass, and downstream from the Mendota Pool Bypass after construction of the bypass channel. How does mixing of the Restoration Flow releases from Friant Dam with Mendota Pool releases (i.e., water imported from the Delta) impact instream temperatures and water quality in Reach 3 and downstream?

13. How does the diversion of Central Valley Project (CVP) water supply at Sack Dam affect downstream water temperature and water quality in Reach 4?

14. Will total maximum daily load (TMDL) requirements for salt, selenium, boron, mercury, and pesticides on the San Joaquin River require monitoring by the SJRRP in addition to existing monitoring programs?

15. Are salt, selenium, boron, mercury, pesticide, and nutrient concentrations limiting factors for aquatic resources in Reaches 3 through 5 of the San Joaquin River?

16. Is existing monitoring for salt, selenium, boron, and pesticides on the San Joaquin River adequate to meet regulatory requirements? If not, what needs to be addressed and what role will the SJRRP play?

17. What are the impacts of groundwater accretion in Reach 5 on water temperature and water quality (i.e., temperature, salinity, selenium, boron, and pesticides)? How will the interaction of surface water and groundwater in Reaches 3 through 5 impact salinity and temperature of the San Joaquin River? Are salt and boron concentrations in the shallow groundwater in Reach 5 limiting recruitment and establishment of riparian vegetation?

18. Low dissolved oxygen (DO) in Reach 5 may approach levels that inhibit restoration of salmonids and other native fish resources (McBain and Trush, 2002). Are summer and fall DO concentrations in Reaches 3 through 5 limiting for salmonid life cycle criteria? Is there a DO “sag” downstream from Mud and Salt sloughs in Reach 5 that may be limiting for salmonid life cycle criteria?

19. Will excessive nutrient concentrations affect restoration of the fishery and riparian resources along the lower reaches of the river (i.e., Reaches 3 through 5)?

20. Will legacy contaminants such as DDT or mercury in riverbed sediments be mobilized as a result of SJRRP actions? If so, what are the impacts to the fishery?

21. Current levels of suspended sediments (turbidity) in the San Joaquin River may inhibit feeding efficiency and represent a major limiting factor for juvenile fish rearing in the study reaches below Mendota Dam (McBain and Trush, 2002). How will SJRRP actions affect turbidity in the San Joaquin River in Reaches 3 through 5?

22. What existing monitoring programs are currently ongoing in the study area?

23. Are there opportunities for the SJRRP to partner with existing programs to leverage resources where the objectives of the programs overlap?

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