Appendix A – Water Year 2010 Interim Flows Project

Final Environmental Assessment and Finding of No Significant Impact/Initial Study and Mitigation Negative Declaration

This page intentionally left blank

The Final Environmental Assessment and Finding of No Significant Impact/Initial Study and Mitigation Negative Declaration for the Water Year 2010 Interim Flows Project may be found here:

http://www.usbr.gov/mp/nepa/nepa_projdetails.cfm?Project_ID=3612

For a hard copy of this document, please contact Ms. Margaret Gidding, SJRRP Outreach Coordinator, at (916)978-5461 or at Mgidding@usbr.gov.

This page intentionally left blank

Appendix B – Water Year 2011 Interim Flows Project

Draft and Final Supplemental Assessments and Finding of No Significant Impact

This page intentionally left blank

The Draft and Final Supplemental Assessments and Finding of No Significant Impact for the Water Year 2011 Interim Flows Project may be found here:

http://www.usbr.gov/mp/nepa/nepa_projdetails.cfm?Project_ID=3612

For a hard copy of this document, please contact Ms. Margaret Gidding, SJRRP Outreach Coordinator, at (916)978-5461 or at Mgidding@usbr.gov.

This page intentionally left blank

Appendix C – Restoration Administrator 2011 Spring Interim Flow Program Real-Time Management Recommendations

This page intentionally left blank

San Joaquin River Restoration Program
Restoration Administrator

Memorandum

Date: April 23, 2011

To: Ali Forsythe – SJRRP Program Manager

cc. Michael Jackson, Ed Salazar
Doug DeFlitch, the TAC

From: Rod Meade – Restoration Administrator

Subject: Transmittal of RA Spring 2011 Interim Flow Program Real-Time Management Recommendations to the Secretary of the Interior

---

Attached for your review and action are my Spring 2011 Real-Time Management Recommendations. As provided for in the Settlement, I prepared these recommendations based on consultation with and assistance from my Technical Advisory Committee (TAC). Prior to submitting the final version of these recommendations I also consulted with federal liaisons to the TAC and with the Fish Management Work Group (FMWG). Suggestions provided by representatives of the FMWG are addressed in my recommendations. The assistance and consultation provided by the TAC and FMWG has been essential; however, as always, the recommendations to The Secretary of the Interior contained in the attached report are mine.

As I indicate in the attached report, these recommendations focus on spring 2011 and on real-time management measures and objectives, not updated Interim Flow release recommendations. Based on the continuing precipitation pattern this spring we have progressed to a point where we recently transitioned from a "normal-wet" year to a "wet" water year. Accordingly, I expect to receive an updated Allocation and Flow Bench Evaluation Report from Reclamation that will provide information needed for me to consider whether I should update my current Interim Flow release recommendation and hydrograph dated March 7, 2011.

In addition, based on the transition to a "wet" water year, I have been discussing the potential for initiating riparian recruitment flows later this spring following the conclusion of the flood releases that have necessitated by continuing rainfall. The Reclamation flood releases are expected to continue at least into May and I am currently in discussions with your staff concerning the process for determining how to move from flood releases to riparian recruitment flows in a manner that is consistent with the terms of the Settlement. After receiving the updated Allocation from Reclamation staff I will consult with the TAC and others to determine whether to prepare an updated Interim Flow release recommendation and hydrograph. I will also consider whether to provide recommendations for initiating riparian recruitment flows later this spring and how to implement such flows.

Thank you for your consideration of these recommendations. I look forward to talking with you soon.

1221 Torrey Pines Road ● La Jolla, California 92037
Tel: 858.531.1705 ● Email: rodmeade@gmail.com

RA SPRING 2011 INTERIM FLOW PROGRAM
REAL-TIME MANAGEMENT RECOMMENDATIONS

1 INTRODUCTION AND PURPOSE

The San Joaquin River Restoration Program Restoration Administrator (RA), after consulting with the Technical Advisory Committee (TAC), is required under the Stipulation of Settlement in *NRDC* v. *Rodgers* (CIV-S- 88-1658-LKK/GGH) (Settlement) to develop recommendations for "implementation of a program of Interim Flows in order to collect relevant data concerning flows, temperatures, fish needs, seepage losses, recirculation, recapture and reuse". My recommendations are provided for consideration by the overall TAC prior to submittal by me to the Secretary of the Interior as the 2011 Interim Flow Program recommendations. The TAC reviewed studies, data, and other activities undertaken by the Implementing Agencies during the Interim Flows to provide consultation to me as necessary.

These Interim Flow recommendations include three objectives: 1) initiate real-time flow management, coordination, and implementation, 2) identify processes needed to refine annual Interim Flow and Restoration Flow releases, and 3) identify short-term monitoring, modeling, and studies needed to address specific areas of uncertainty in implementing required actions of the Settlement, including refinement of Interim and Restoration Flows. The TAC includes members from the California Department of Fish and Game (CDFG) and Department of Water Resources (DWR), with input from the three federal liaison agencies. My 2011 Interim Flow recommendations are based on the best available information.

Interim Flows are defined by the Settlement as those flow releases from Friant Dam that began October 1, 2009, and end when the Restoration Flows commence (no later than January 1, 2014). The goal of the Interim Flows is to provide information to inform and improve implementation of the Settlement to achieve the two primary restoration goals of the Settlement (Paragraph 2):

1) <u>*Restoration Goal*</u>: restore and maintain fish populations in good condition in the mainstem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally-reproducing and self-sustaining populations of Chinook salmon.
2) <u>*Water Management Goal*</u>: Reduce or avoid adverse water supply impacts to all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in this Settlement.

Developing an effective restoration program for Chinook salmon and other fish in the San Joaquin River requires that a number of uncertainties and potentially limiting factors affecting salmon and other fish within the river be identified and addressed. The Settlement acknowledges that additional information needs would be addressed through experiments conducted during the Interim Flow period.

My recommendations are based on an interdisciplinary approach to achieving the Restoration Goal that includes fish biology, hydrology, geomorphology, terrestrial biology, water project operations, engineering, geohydrology, water quality, and recirculation, recapture and reuse. The Interim Flow period provides an opportunity to collect important information that is intended to improve implementation of actions to achieve the Restoration Goal and Water Management Goal by:

- Reducing scientific uncertainties;
- Providing information needed to enable real-time flow management;
- Identifying refinements to the existing flow and water quality monitoring program;

- Providing information to inform decisions on fish migration pathways (*e.g.*, use of Reach 4B versus, or in combination with the Eastside Bypass) and design of physical facilities (*e.g.*, headgates, channel modifications) to better achieve flow routing and fish migration objectives;
- Providing information that will shape and refine the seasonal instream flow releases (hydrographs) under inter- and intra-annual variation in hydrology, including the decision process necessary to accommodate hydrologic and forecasting uncertainties;
- Providing field-based information to calibrate, validate, and/or improve predictive models for guiding future recommendations and management;
- Providing information that will assist planning and decisions regarding potential mechanisms for recirculation, recapture, and reuse;
- Identifying additional information needed prior to reintroduction of salmon into the river;
- Providing baseline information on channel conditions upon which future changes can be documented; and
- Establishing a foundation for future management decisions and program refinements as part of long-term adaptive management for the river consistent with the terms of the Settlement.

2 DESIGNING A REAL-TIME MANAGEMENT PROCESS FOR IMPLEMENTING SPRING 2011 INTERIM FLOW RELEASES

Following the conclusion of the Interim Flow period, Restoration Flow management during the spring "flexible flow period" will require periods of "real-time" flow management to improve the ability to facilitate successful rearing, growth, and outmigration of juvenile Chinook salmon, which in turn will improve our ability to meet the Restoration Goal. In addition, real-time instream flow management may be required for attraction and suitable water depths for upstream adult Chinook salmon migration. Due to the long distance between Friant Dam and the San Francisco Bay-Delta, and the high ambient air temperatures common to the San Joaquin valley during the April-May juvenile and smolt outmigration period, a primary management objective of "real-time" flow releases will be to provide water temperatures that are suitable for successful juvenile and smolt outmigration, at least in select reaches within the mainstem of the river. Real-time flow management will create additional complexity for already complex reservoir and river release management responsibility for Reclamation. For this reason, the primary objective during the spring 2011 Interim Flow period is to begin implementing real-time flow management to identify and begin resolving the management challenges and conflicts to prepare for: (1) Chinook salmon reintroduction by the end of 2012; and (2) commencement of Restoration Flows beginning no later than January 1, 2014. Recommended objectives for spring 2011 Interim Flow releases include the following:

- Identifying preliminary biological management targets for water temperatures, water depths, ramping rates, and seasonal floodplain inundation;
- Identifying real-time data needs that would be required to implement instream flow management such as telemetered water temperature measurements, water surface elevations, groundwater elevations, predicted (*e.g.*, 7-day forecast) meteorological conditions, reservoir inflow, and reservoir water temperatures (cold water pool volume);
- Testing the ability of the existing reservoir water temperature, river water temperature, surface water-groundwater models, flow routing models, and floodplain inundation models to accurately predict the ability to manage and meet downstream fish management targets over a wide range of environmental conditions;

- Testing the ability of the existing analytical tools to provide flexibility in adjusting to variation in basin hydrologic conditions, to serve as the basis for revising instream flow release strategies in near real-time, and to provide a reliable accounting of water allocations, both in the past and near future. The analytical tools must be capable of showing that the Interim Flow recommendations conform with the constraints and requirements of the Settlement Agreement;
- Identifying the lag times that occur between making changes to the instream flow releases at Friant Dam and the resulting changes in conditions at various downstream management locations;
- Determine the flexibility in managing releases on a daily and weekly time steps for accommodating changing environmental conditions (*e.g.*, changes in tributary inflows, downstream diversion operations, variation in air temperatures, etc.);
- Determine the coordination procedures between the RA and Program Implementing Agencies needed to effectively develop, implement, and monitor real-time Interim Flows; and
- If 2011 is a Wet water year, develop a release hydrograph that likely could be capable of naturally recruiting riparian vegetation on target surfaces.

These recommendations focus on spring 2011 Interim Flow releases. Based on the recent progression to a "wet" water year and the prospect for considering implementation of riparian recruitment flows later this spring, I expect to prepare updated Interim Flow recommendations addressing spring releases from Friant Dam. My updated flow recommendations/hydrograph will be based on the updated SJRRP Allocation and Flow Bench Evaluation which is expected to be prepared by Reclamation in the near future. It also is likely that I could be recommending adjustments to fall attractant flow recommendations later this summer.

With respect to the spring real-time management recommendations set forth in this document, I recommend a coordinated process involving myself (as advised by the TAC) and the Implementing Agencies that includes:

1) Collaboration with the Fish Management Work Group (FMWG).

I recommend continuing collaboration by the RA and TAC with the FMWG to identify biological targets to guide 2011 Friant Dam flow releases. These target conditions include:(a) average daily and maximum daily water temperature targets to provide suitable habitat conditions for Chinook salmon spawning and egg incubation, smoltification, and juvenile rearing and fry/smolt outmigration; and (b) ramping rates for periods when managed flows are being reduced to avoid the risk of juvenile stranding, seasonal variation in floodplain inundation and water depths that provide suitable habitat for juvenile Chinook salmon within the river channel and floodplains, and water depths suitable for adult fish passage. These management targets would be expressed as specific numeric conditions, by seasonal period and location.

2) Using the existing analytical models to test hypothetical flow release scenarios.

Based on assumed hydrologic and meteorological conditions, use existing analytical models developed by the SJRRP to assess the instream flows that would be expected to meet the biological targets, by date and location, over the spring flow period. The models can assess the type and resolution of data necessary to develop reliable instream flow management strategies and respond to variation in environmental conditions as reflected in historic hydrology and meteorological conditions within the basin. The models can also identify the specific data required to predict the conditions within the river for each biological target parameter, the lag times required to be taken into account in terms of both predicted future conditions (*e.g.*, long and short range weather predictions), as well as the response time to achieve downstream conditions that meet the biological targets. Model results can be used to develop a template Interim Flow hydrograph for the expected Normal-Wet water year that would identify specific targets that would be met, by date and location, reflecting the anticipated range in environmental conditions (*e.g.*, cool, average, hot weather conditions, wet, normal, dry hydrologic conditions). The targets will: (1) allow instream flows to be managed consistent with the allocations and operations specified by the Settlement Agreement; and (2) provide a framework for testing the accuracy and performance of the existing analytic models through development of specific hydrographs that could be implemented as part of the 2011 Interim Flow release. Flow benches in the template hydrograph will be designed to allow testing of the analytic models to more accurately predict actual conditions observed in the river. A variety of specific biological targets can be tested singularly and in combination. The experimental design enables identifying the specific target(s), expected conditions in the river by date and location, and the monitoring required to assess whether or not the target condition was met based on actual field measurements. This hydrograph formed the basis for my initial 2011 Interim Flow schedule recommendations to the Secretary of Interior.

3) Revising Interim Flow Recommendations

Flow releases associated with a specific biological target may be varied within a prescribed range based on results of field monitoring, in combination with revised modeling of the 2011 Interim Flow recommendations (*e.g.*, water allocation, cold water pool volume, groundwater elevations, etc.). This variation will test the ability of real-time management to refine instream flow releases, as well as test the ability of the project to respond to real-time conditions affecting habitat suitability for all in-river life stages of Chinook salmon. Much of the monitoring and modeling data during the 2011 Interim Flow period will be updated weekly to report results of: (a) predicted and actual conditions within the river; (b) real-time refinements to dam releases that were implemented; (c) updated accounting of water allocations that have been exhausted and those that remain in the 2011 Interim Flow account; and (d) targets and test conditions to be met during the subsequent test period. These results will be used by me, the TAC, Program staff, and other parties to test model predictions and evaluate whether management targets are being met. The results will also be used to refine analytic and accounting tools, field monitoring equipment and reporting, and coordination and communication channels during the spring 2011 Interim Flow period that will serve as the foundation for further developing and refining the restoration strategies.

2.1 Proposed Real-time Management Steps

I recommend that proposed real-time management steps include the following:

1) Develop Biological Management Targets

In consultation with the TAC, and based on our review of the Fisheries Management Plan and consultation with SJRRP staff and FMWG I proposed biological targets for 2011 Interim Flows real-time management (Table 1). These biological targets focus on water temperature targets, adult fish passage targets, anti-stranding down ramping rate targets, and potential inundation area targets for juvenile salmon rearing. Each target is specific to magnitude, location, season, and as needed, duration.

2) Apply Existing Model Runs of the USJRBSI Water Temperature Model (Millerton Reservoir)

Reclamation ran the USJRBSI water temperature model for Millerton Reservoir using actual flow and meteorological conditions for the 1980-2003 time series. Reclamation ran USJRBSI model for the same time series for Restoration Flow releases. Results of these modeling efforts for this time series predict that median Settlement release temperatures always are expected to be less than 55° F for the April-October period, but exceed 55° F in November (SJRRP 2008). In addition, maximum predicted Millerton release temperatures under the Settlement are predicted to be as high as 55-59° F from July-November (SJRRP 2008). Therefore, cold water pool availability at the end of the summer (October-November) may be problematic in some years for spring-run and fall-run spawning and egg incubation target temperatures.

Additional model runs are not recommended for developing the 2011 Interim Flow template hydrographs (predictions from previous model runs will be used instead). I recommend continued monitoring of Millerton release water temperatures and reservoir temperature profiles for 2011 Interim Flows to document cold-water pool conditions.

3) Apply SJR5Q Water Temperature Model Results (San Joaquin River)

Reclamation also ran the SJR5Q water temperature model for the San Joaquin River over the 1980-2003 time series using existing riparian vegetation shading, observed meteorology, observed tributary contributions, actual flow losses, actual flow releases, Settlement hydrographs, and predicted water temperature boundary conditions (Millerton releases, as described above). The model results will be used to predict water temperature at selected management target nodes from Friant Dam to the upstream end of Mendota Pool. Conveyance and seepage constraints limit the magnitude of Interim Flows downstream of Mendota Pool to the Merced River confluence, thus the focus in spring 2011 will be upstream of Mendota Pool. Reclamation would work with the RA (advised by the TAC) to provide the matrix of SJR5Q water temperature model predictions for a wide range of flow releases and Millerton Reservoir release temperatures, as well as for varying meteorological conditions at locations between Friant Dam and the Merced River. The TAC reviewed these water temperature predictions and created a gaming spreadsheet to predict water temperatures at key management target locations for any flow release and seasonal timing. A template Interim Flow hydrograph was developed based on a February Normal-Wet year Restoration Allocation, and serves as the basis for 2011 Interim Flow Recommendations. The Interim Flow releases are based on a “normal” meteorological condition (52% probability), as well as a warmer than normal meteorological condition (89% probability) and cooler than normal meteorological condition (12% probability).

4) Develop or Refine Relationships Between Flow and Stage Change

Developing the relationships between flows and stage changes will enable evaluation of ramping rates at varying locations. It also will enable evaluation of water depths to assess adult passage at critical riffles, and inundation levels to evaluate juvenile rearing on floodplains. DWR surveyed water surface elevations for Friant Dam flow releases up to 1,600 cfs, and if Interim Flow releases or flood control releases exceed 1,600 cfs, additional water surface elevation data should be collected in all reaches to improve hydraulic model predictions of water surface elevations as a function of flow. In addition, water surface elevations have been monitored by CDFG as part of the microhabitat studies, and will be available for hydraulic model calibration if needed.

5) Continue Monitoring Water Temperatures at Real-time Stations.

The SJRRP has a network of real-time monitoring stations between Friant Dam and Merced River. These stations should be continued to be monitored in real-time, as those locations coincide or bracket 2011 Interim Flow biological target locations, as well as future downstream biological target locations. I recommend that real-time water temperature monitoring capability be added to the USGS gaging station immediately below Mendota Pool. I also recommend that real time release temperatures from Friant Dam should continue to be monitored to evaluate Millerton Reservoir temperature model predictions. Results of water temperature monitoring need to be reviewed on a daily basis (real-time), and discussed during the weekly conference calls. Monitoring of non-real-time locations by CDFG will also continue to enable end-of-season comparisons with temperature model predictions and biological targets at key locations (Highway 99 Bridge, Skaggs Bridge).

6) Monitor 7-day Meteorological Forecasts.

I recommend that during the flexible flow period, 7-day maximum air temperature forecasts for Firebaugh and Fresno be conducted prior to weekly conference calls to evaluate potential changes in flow recommendations in response to forecasted changes in air temperatures. Forecasted and actual meteorological conditions should be discussed during the weekly conference calls, and based on how "normal" those forecasted maximum air temperatures are expected to be based on the historical range of values, flow recommendations may be adjusted up or down in an attempt to meet biological water temperature targets in a water-efficient manner.

7) Update Water Year Forecast and Restoration Allocation.

Restoration Allocation to the San Joaquin River is based on a smoothing of Exhibit B water year release volume blocks; as predicted unimpaired runoff forecasts change through the spring, corresponding Restoration Allocation likewise changes. Therefore, as DWR and Reclamation update runoff forecasts through the spring, I recommend that the corresponding Restoration Allocation and flow recommendations be revisited during weekly conference calls.

8) Convene Weekly Coordination Conference Calls with the RA, TAC, and SJRRP Program Staff

To facilitate technical input between SJRRP Program Staff and the RA/TAC, I recommend that the weekly coordination conference calls, such as the Flow Scheduling Subgroup calls recently initiated by Reclamation, continue through the flexible flow period in the spring. These conference calls provide valuable opportunities to summarize current flows, runoff forecasts, restoration allocations, actual water temperatures and other water quality parameters, comparisons of measured water temperatures with target values, and forecasted precipitation and meteorological conditions. The conference calls facilitate discussion and input on real-time changes to flow recommendations and ongoing monitoring activities, particularly those that may require adjustments to the flow recommendations.

I recommend that Steps 4-8 should be repeated on a weekly basis until the end of the flexible flow period, or when the water temperature model results and real-time water temperature modeling lead to the conclusion that meteorological conditions are too warm to reasonably meet water temperature target in a water-efficient way. In the event riparian recruitment flows are implemented later in the spring, it would be advisable to continue repeating Steps 4-8 through the implementation period for those recruitment flows.

2.2 Proposed follow-up to support future real-time management

To support future real-time flow management, I recommend that the following steps be implemented *after* the conclusion of spring 2011 Interim Flow releases:

1) Evaluate and Revise the Unsteady Flow Routing Model (San Joaquin River)

I recommend that DWR run the HEC-RAS unsteady flow model for actual 2010 Interim Flows (including actual tributary accretion, flood control releases, and flow losses) for the reach from Friant Dam to Mendota Pool, and perhaps to the Merced River confluence.

2) Evaluate and Revise the San Joaquin River Water Temperature Model

I will work with the TAC to compare predicted and measured water temperatures at various locations between Friant Dam and Mendota Pool. In collaboration with Reclamation and the FMWG and TAC and based on their evaluation of the performance of the water temperature model, I will recommend whether additional calibration of the SJR5Q model is necessary, or whether a physically-based water temperature model is needed to improve water temperature predictions.

3) Evaluate and Revise Millerton Reservoir Water Temperature Model

I will work with the TAC to compare predicted and measured Millerton Release water temperatures. In collaboration with Reclamation and the FMWG, I will work with the TAC to evaluate the performance of the Millerton Reservoir water temperature model, and recommend whether additional calibration of the USJRBI Millerton Reservoir model needed is to improve temperature predictions.

2.3 Real-time Management Strategy

The proposed approach for developing the management strategy for the spring 2011 Interim Flow experimental investigations is based on establishing a set of biologically based habitat metrics (target conditions) used to predict the real-time releases from Friant Dam needed to achieve the target objectives. The target objectives were developed based on the life history of Chinook salmon and life-stage specific habitat requirements. The target objectives for real-time management were developed to reflect the seasonal time period as well as the geographic locations where habitat requirements would be relevant to each life stage of interest. A broad range of habitat objectives were initially developed for each Chinook salmon life stage from review of information available in the scientific literature and results of habitat and fish studies conducted in other Central Valley streams and rivers. The habitat criteria were then evaluated to assess which criteria would be most important for testing as part of the 2011 Interim Flow investigations. Criteria will be based on results of prior field monitoring, as well as on modeling of the response of habitat conditions to changes in seasonal flow releases from Friant Dam, consistent with the Settlement Agreement. As a result of constraints on implementation of non-flow physical habitat modifications within the river prior to the 2011 Interim Flow period, the management strategy focused on real-time management of Friant Dam releases to meet downstream habitat target objectives. The target objectives for spring 2011 Interim Flow releases reflect consideration of multiple metrics, including:

- Water temperatures, seasonally and geographically adjusted, for suitable habitat conditions for all in-river life stages of Chinook salmon;
- Instream flows to provide sufficient water depths for upstream passage by adult spring-run Chinook salmon;
- Water temperatures suitable for upstream migration of adult spring-run Chinook salmon and downstream migration of juvenile Chinook salmon;
- Seasonal floodplain inundation for support juvenile Chinook salmon rearing habitat;
- Ramping rates (rate of change in instream flows) that reduce the risk of juvenile Chinook salmon stranding; and
- River stage changes that reduce the risk of Chinook salmon redd dewatering.

For each of these management targets, numeric objectives were established at specific locations and time periods within the river based on the habitat use predicted by spring-run Chinook salmon after reintroduction. Based on these habitat targets, results of various models and data analyses were used to predict, based on a range of seasonal climate conditions (*e.g.*, cool, average, and warm seasonal air temperatures), the instream flow releases from Friant Dam that would meet the objectives. Results of these analyses were then compiled and integrated for use as a basis for establishing an initial Interim Flow hydrograph for a Normal-Wet water year and corresponding water allocation established by the Settlement Agreement for Interim Flow experimentation. The flow release magnitude is capped based on downstream conveyance constraints (*i.e.*, <1,445 cfs in Reach 2).

2.4 Real-time Management Objectives

Target habitat objectives developed for use in designing and managing the spring 2011 Interim Flows are summarized in Table 1. The target objectives are presented by month and location based on the habitat needs that were identified for each of the key life stages of spring-run Chinook salmon that will be ultimately addressed as part of instream flow management under both the interim and long-term restoration and reintroduction of salmonids into the river. The target objectives selected for use in the 2011 studies are based on TAC review of information available in the scientific literature, review of draft sections of the San Joaquin River Fish Management Plan, discussions with fishery biologists working on habitat issues and river management for salmonids in other Central Valley river systems, and comments provided by the San Joaquin River Fish Management Work Group. The targets were also selected to examine and further refine key relationships been seasonal instream flows and habitat metrics that are reflected in the predictive models that have been developed as part of the technical foundation for the restoration program. Analyses are currently underway using the available modeling tools to assess which among the various parameters selected for use in designing the 2011 Interim Flow program are the key limiting drivers for determining seasonal timing and magnitude of instream flows that would be released over a range of hydrographs and varying watershed hydrologic conditions. Based on results of these analyses, a series of initial hydrographs were developed for use as a planning base and framework for the 2011 Interim Flow program of Friant Dam instream flow releases.

Table 1. Proposed initial long-term management objectives for Interim Flow releases.

Habitat Parameter	Metric	Target Location (s)	Sept-Nov	Dec	Jan	Feb	Mar	Apr	May	June
Spawning and egg incubation	Daily maximum water temp < 13ºC	Reach 1	X	X	X	X	X			
Juvenile migration	Daily maximum water temp < 20ºC	Reaches 1-5				X	X	X	X	
Juvenile migration	3-day running average daily average water temp < 17ºC	Reaches 1-5				X	X	X	X	
Juvenile smoltification	Daily maximum water temp < 12ºC	Reaches 1-5		X	X	X	X	X	X	
Juvenile rearing	Daily average water temp 13-15ºC	Reach 1A	X	X	X	X	X	X	X	X
Juvenile rearing	Daily average water temp 13-15ºC	Reaches 1-5				X	X	X	X	
Juvenile rearing	3-day running average daily average water temp 15-18ºC	Reaches 1-5				X	X	X	X	
Adult passage	>25% of wetted width greater than 0.8 ft deep	Reaches 1-5	X				X	X	X	X
Adult passage	Daily maximum water temp < 20ºC	Reaches 1-5	X				X	X	X	X
Adult attraction	10-day daily average flow>775 cfs just above Merced River confluence	Reach 5	X				X	X	X	X
Floodplain inundation	1.0<depth<3.3 ft Velocity<1.5 ft/sec	Reaches 1-5				X	X	X	X	
Juvenile stranding	Daily stage drop<0.5 ft/day	Reaches 1-5				X	X	X	X	
Redd dewatering	Water depth over redd > 0.8 ft	Reach 1	X	X	X	X	X			

Assumptions:

- All spawning and egg incubation occurs in Reach 1A
- Juvenile outmigration and adult spring-run upstream migration may sometimes be feasible in May and perhaps June; this needs to be checked for water temperature feasibility by water year type
- Redd dewatering criteria may be modified based on channel configuration and spawning gravel distribution
- Primary adult fall-run passage is assumed to be October-November, range of passage is assumed to be September-December.

Many of these objectives are preliminary because salmon reintroduction has not yet occurred. Thus, the objectives focus on the overall goal of simulating real-time management of flow releases if fish were in the system. Due to the initial year of real-time management, and based on discussions with the FMWG, a smaller subset of the above management objectives identified in Table 1 are targeted for 2011 Interim Flow releases and indicated in Table 2. The management target locations for 2011 Interim Flows focus on Reaches 1-2 rather than Reaches 3-5 because conveyance and seepage constraints will likely limit Interim Flow volumes through and beyond Mendota Dam at magnitudes well below Friant Dam releases. In other words, SJRRP ability to conduct Friant Dam releases to meet management targets downstream of Mendota Pool will be limited, thus we are focusing management targets upstream of Mendota Pool.

Table 2. Proposed real-time biological management objectives targeted for 2011 Interim Flows.

Month	Life history stage	Temperature target	Target location
January	Egg Incubation	<13°C	Downstream Boundary Reach 1A (HWY 99 Bridge)
February	Egg Incubation	<13°C	Downstream Boundary Reach 1A (HWY 99 Bridge)
March	Smoltification	<12°C	Middle of Reach 1B (Skaggs Bridge)
April	Juvenile and Adult Migration	<17°C 3-day mean, <20°C daily max	Middle of Reach 1B, upstream of Mendota Pool (San Mateo Crossing)
May	Juvenile and Adult Migration	<17°C 3-day mean, <20°C daily max	Middle of Reach 1B, upstream of Mendota Pool (San Mateo Crossing)
June	Juvenile and Adult Migration	<20°C	Middle of Reach 1B, upstream of Mendota Pool (San Mateo Crossing)

The Table 2 thresholds were translated into graphical format in Figure 1, and for a given flow release, Friant Dam release temperature, and day of year, the predicted water temperature at the target locations was extracted from the temperature model database.

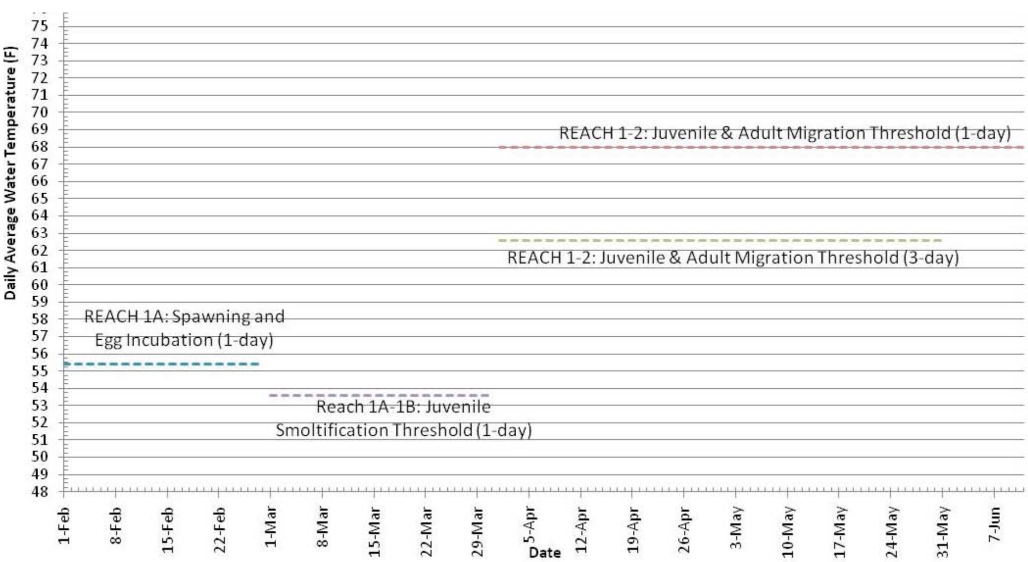


Figure 1. Proposed real-time management objectives, target locations, and time periods specifically targeted for 2011 Interim Flows.

2.5 Real-time Management Tools

A variety of analytical tools were developed based on results of monitoring within Millerton Lake and the lower San Joaquin River that are available to be used as a foundation for the 2011 real-time Interim Flow investigation. These predictive models can assess the expected Interim Flow releases from Friant Dam that will be needed to meet specific water temperature, water depth, or floodplain inundation targets. These tools were used, in combination with assumptions about a range of possible late winter and spring climate conditions, as the basis for developing the template 2011 Interim Flow hydrograph. The modeling tools used included:

- Millerton reservoir temperature model
- SJR temperature model
- HEC-RAS model (adult fish passage, flow routing, flow inundation curves)

In addition to their use in developing the initial hydrograph, these model predictions will be used on an iterative basis to revise and refine the real-time flow releases based on results of field monitoring results. The field monitoring results collected as part of the 2011 Interim Flow releases will also be used to independently validate the predictions of the various models and will be used to revise and refine each of the models if necessary.

3 CONSTRAINTS ON SPRING 2011 INTERIM FLOWS

The February 1, 2011 Allocation and Default Flow Schedule document (SJRRP 2011) identifies the 2011 downstream conveyance limitation as 1,445 cfs at Gravelly Ford, which translates into a maximum Friant Dam release of approximately 1,630 cfs depending on assumed Reach 1 riparian demands. Therefore, my current flow release recommendations do not exceed 1,630 cfs to remain consistent with the Settlement's direction on conveyance constraints. However, as noted in SJRRP (2011), there may be additional seepage constraints that may require reductions in flow releases. Because these additional seepage constraints are still being evaluated, they are not incorporated into my current 2011 Interim Flow Real-time Management Recommendations. However, Reclamation may impose additional restrictions on Friant Dam Interim Flow releases as those seepage constraints become better quantified. In addition, based on observations of shallow groundwater tables in Reach 4 during the 2010 Interim Flow releases, I expect Reclamation to continue to limit Interim Flow releases downstream of Mendota Pool throughout the spring 2011 Interim Flow releases.

4 2011 INTERIM FLOW RECOMMENDATIONS

On January 21, 2011, I worked with the TAC to develop initial 2011 Interim Flow release recommendations based on Reclamation's unimpaired inflow forecast for February 1, 2011, using the 90% exceedence value of 2,170,000 ac-ft (Table 3). The inflow forecast translates to a Restoration Allocation of a release of 501,041 ac-ft at Friant Dam, or a flow volume of 384,300 ac-ft at Gravelly Ford. Based on Reclamation's computations of default hydrograph releases constrained by the then used downstream conveyance capacity, the February 1, 2011 Restoration Allocation for Interim Flow releases at Friant Dam was estimated in the January 24, 2011 Interim Flow recommendations to be 404,041 ac-ft, or 287,300 ac-ft at Gravelly Ford. The TAC and I conducted numerous gaming exercises of Friant Dam Interim Flow releases to achieve the real-time management targets in Table 3 and in Figures 2 and 3 for use as a basis for 2011 Interim Flow recommendations, to assure that:

1. Net flow volume did not exceed the February 1, 2011 Restoration Allocation;

2. Flow magnitude on any given day did not exceed Schedule 2 of State Board Order WR 2010-0029-DWR; and

3. Flow magnitude did not exceed downstream conveyance constraints of 1,445 cfs at Gravelly Ford.

The RA further consulted with the TAC and the Flow Scheduling Subgroup to provide a revised Interim Flow recommendation on March 7, 2011 that responded to a revised SJRRP Restoration Allocation, and to SJRRP concerns and observations regarding the relationship between river flows and groundwater seepage in lands adjacent to the river channel (Table 4, Figure 4, and Figure 5). Interim Flow update summaries also were provided to SJRRP staff by me on February 28, 2011 and March 14, 2011.

Table 3. January 24, 2011 RA Recommended Releases from Friant Dam and Target Flows at Gravelly Ford: February 1, 2011 through February 29, 2012.

Completion of the 2010 Restoration Year (2/1/2011 through 2/28/2011)		
Start/End Dates	Estimated Friant Dam Release Necessary to Achieve Gravelly Ford Target Flows (cfs)	Gravelly Ford Flow Targets (cfs)*
Feb 1 – Feb 7	200	105
Feb 8 – Feb 19	350	255
Feb 20 – Feb 28	460	365
Implementation of the 2011 Restoration Year (Allocation of 287,300 acre-feet for the Period 3/1/2011 through 2/29/2012)		
Start/End Dates	Estimated Friant Dam Release Necessary to Achieve Gravelly Ford Target Flows (cfs)	Gravelly Ford Flow Targets (cfs)*
Mar 1 – Mar 7	550	425
Mar 8 – Mar 19	1,200	1,075
Mar 20 – Mar 31	1,450	1,325
Apr 1 – Apr 10	1,000	855
Apr 11 – Apr 22	1,100	955
Apr 23 – Apr 30	1,450	1,305
May 1 – May 18	1,630	1,445
May 19 – May 31	350	165
June 1 – June 30	350	165
July 1 – Aug 31	350	125
Sept 1 – Sept 30	350	145
Oct 1 – Oct 31	350	195
Nov 1 – Nov 10	700	575
Nov 11 – Dec 31	350	235
Jan 1 – Feb 29	350	255
Total March 1-Feb 29 Allocation:	404,254 ac-ft	287,308 ac-ft
Total March 1-Feb 29 Rec’d Volume:	404,112 ac-ft	286,969 ac-ft

*Computed using Settlement Exhibit B seasonal riparian releases and flow-specific Reach 2 losses

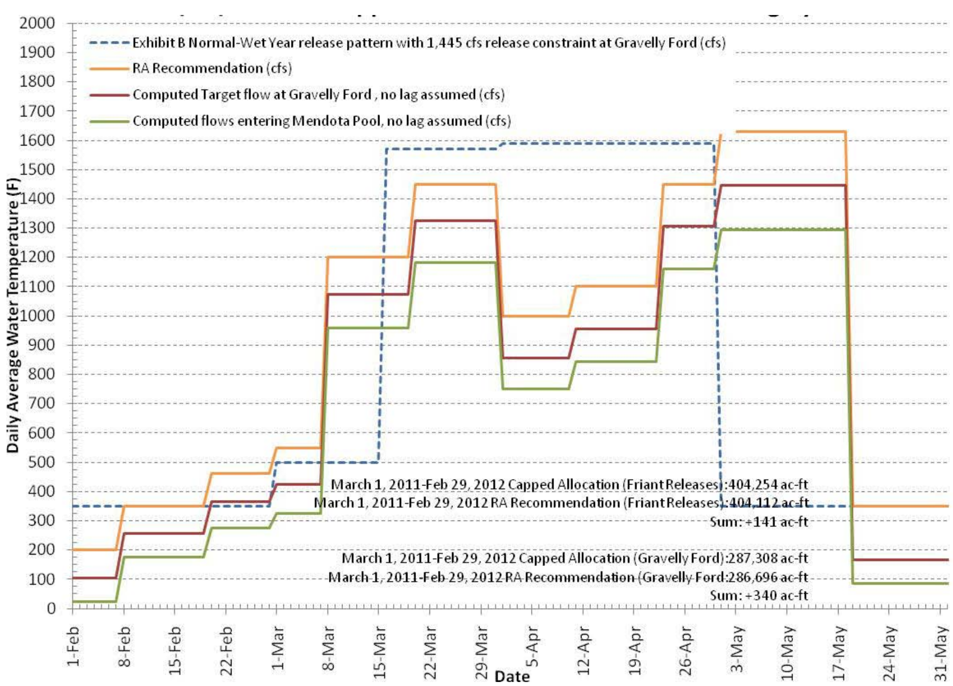


Figure 2. January 24, 2011 Illustrative Friant Dam Spring Release Hydrograph for 2011 Interim Flows to achieve real-time temperature management targets, and corresponding flows at Gravelly Ford and entering Mendota Pool assuming no travel time.

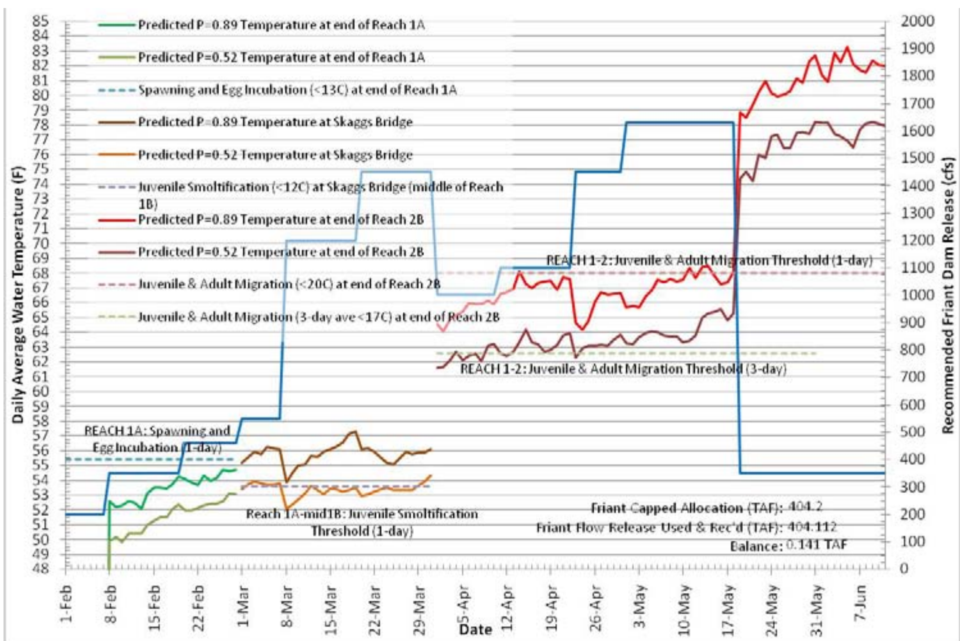


Figure 3. January 24, 2011 Illustrative Friant Dam Spring Release Hydrograph for 2011 Interim Flows, showing corresponding predicted water temperatures at management target locations for historic median (0.52 probability) and warm (0.89 probability) conditions.

Table 4. March 7, 2011 RA Recommended Releases from Friant Dam and Target Flows at Gravelly Ford: February 1, 2011 through February 29, 2012.

Completion of the 2010 Restoration Year (2/1/2011 through 2/28/2011)		
Start/End Dates	Estimated Friant Dam Release Necessary to Achieve Gravelly Ford Target Flows (cfs)	Gravelly Ford Flow Targets (cfs)*
Feb 1 – Feb 7	200	105
Feb 8 – Feb 19	350	255
Feb 20 – Feb 28	460	365
Implementation of the 2011 Restoration Year (Allocation of 287,300 acre-feet for the Period 3/1/2011 through 2/29/2012)		
Start/End Dates	Estimated Friant Dam Release Necessary to Achieve Gravelly Ford Target Flows (cfs)	Gravelly Ford Flow Targets (cfs)*
Mar 1 – Mar 7	550	425
Mar 8 – Mar 16	900	775
Mar 17 – Mar 19	1,200	1,075
Mar 20 – Mar 31	1,450	1,325
Apr 1 – Apr 10	1,000	855
Apr 11 – Apr 22	1,100	955
Apr 23 – Apr 30	1,450	1,305
May 1 – May 18	1,630	1,445
May 19 – May 31	350	165
June 1 – June 30	350	165
July 1 – Aug 31	350	125
Sept 1 – Sept 30	350	145
Oct 1 – Oct 31	350	195
Nov 1 – Nov 10	700	575
Nov 11 – Dec 31	350	235
Jan 1 – Feb 29	350	255
Total March 1-Feb 29 Allocation:	404,254 ac-ft	287,308 ac-ft
Total March 1-Feb 29 Rec'd Volume:	398,757 ac-ft	281,613 ac-ft

*Computed using Settlement Exhibit B seasonal riparian releases and flow-specific Reach 2 losses

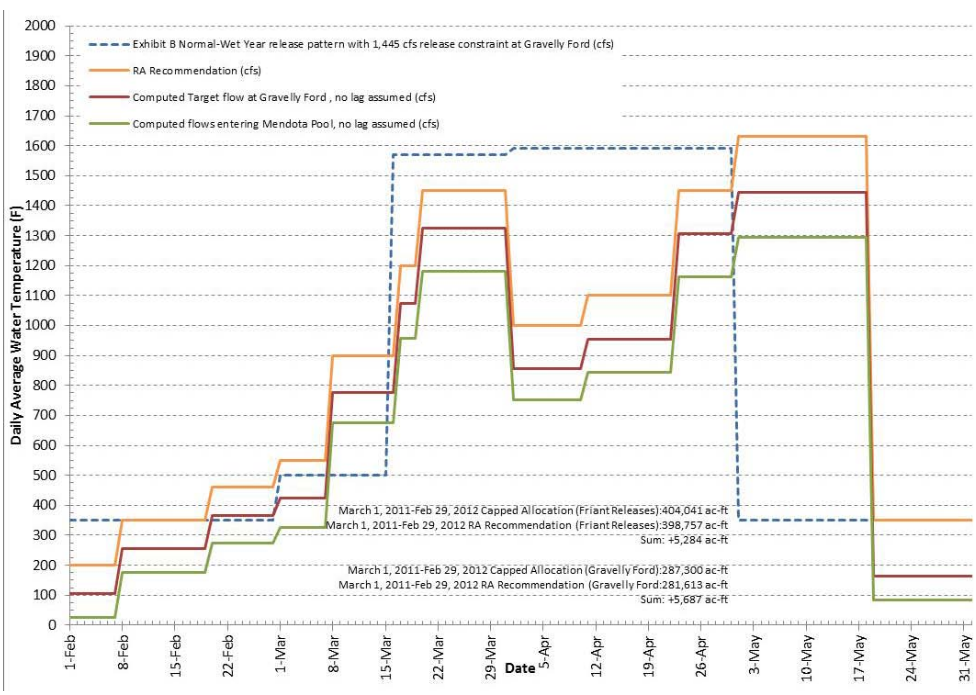


Figure 4. March 7, 2011 Illustrative Friant Dam Spring Release Hydrograph for 2011 Interim Flows to achieve real-time temperature management targets, and corresponding flows at Gravelly Ford and entering Mendota Pool assuming no travel time.

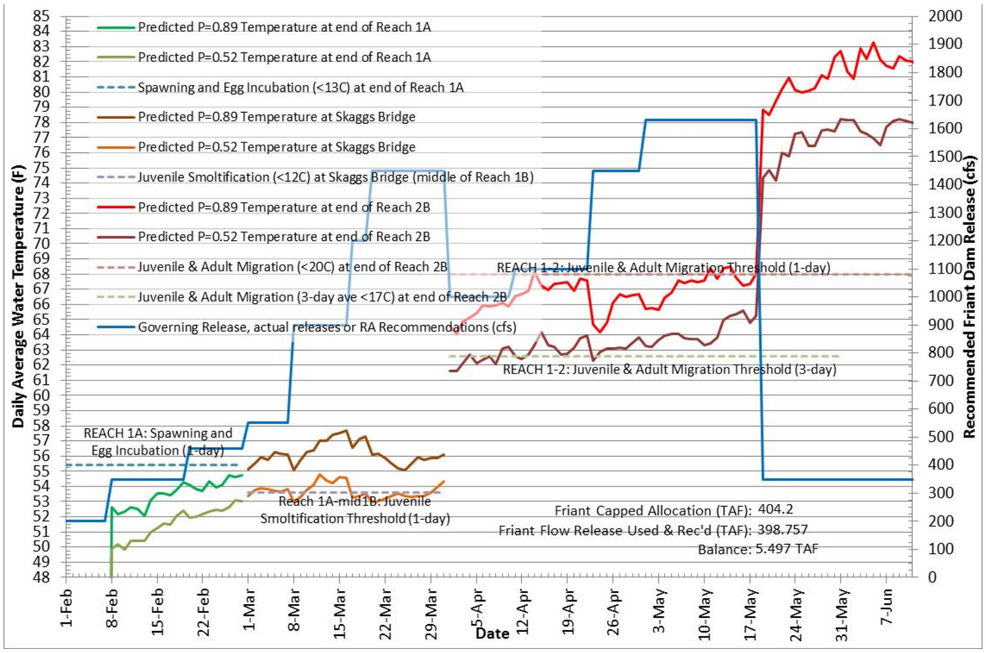


Figure 5. March 7, 2011 Illustrative Friant Dam Spring Release Hydrograph for 2011 Interim Flows, showing corresponding predicted water temperatures at management target locations for historic median (0.52 probability) and warm (0.89 probability) conditions.

4.1 Downstream Extent of Interim Flows

I recommend that, consistent with the terms of the Settlement, the 2011 Interim Flow releases continue to be routed downstream past Mendota Dam, past Sack Dam, through the Eastside and Mariposa bypasses, into the downstream half of Reach 4B and past the confluence with the Merced River. Flow losses are expected to be greatest in Reach 2A. Flow accretions and losses are also expected in downstream reaches, and there is even less data available to estimate the location and magnitude of those possible accretions and losses. While these accretions and losses in downstream reaches are expected to be on a much smaller scale than Reach 2A, there is substantial need to gain a better quantitative understanding of the location and scale of those accretions and losses.

4.2 Recommendations Related to Downstream Interim Flow Targets

While the latest conveyance capacity estimates for at the upstream end of Reach 2 indicate a conveyance capacity of up to 1,445 cfs at the upper end of the Reach, SJRRP staff are continuing to investigate the conveyance capacity in Reaches 2, 3 and 4 and continuing to investigate potential seepage impacts on agricultural lands adjacent to these Reaches. At this time, the information needed to enable specific Interim Flow recommendations below Mendota Pool is still being compiled and evaluated. I expect that evolving information on seepage impacts will continue to constrain releases downstream of Mendota Pool and Sack Dam.

Accordingly, lacking reliable information concerning potential impacts of higher flows in Reaches 3 and 4, I do not recommend specific target flows for Reaches 3, 4, and 5 at this time. As Interim Flow monitoring information on seepage impacts in Reaches 3 and 4 continues to be compiled and analyzed, and as the Program analyzes and remedies these seepage impacts, I recommend that Interim Flow releases from Mendota Dam and Sack Dam be ramped up in stages consistent with conclusions that flow increases would not result in material, unmitigated impacts to San Joaquin River facilities or adjacent landowners consistent with the terms of the Settlement. As soon as downstream conditions permit, I recommend that flows into Reaches 3 and 4 ultimately be increased to achieve the 1,225 cfs target flows set forth in Exhibit B of the Settlement.

5 REFERENCES

San Joaquin River Restoration Program (SJRRP) 2008. *Temperature Model Sensitivity Analysis Set 3*, Draft Technical Memorandum, June 20, 2008.

Appendix D – Steelhead Monitoring Plan

This page intentionally left blank

Steelhead Monitoring Plan

For the detection and relocation of *O. mykiss* above the Merced River confluence during spring interim flow releases on the San Joaquin River

Background

There is little detailed information on the historic distribution and abundance of steelhead, *Oncorhynchus mykiss*, in the San Joaquin River, however they are believed to have been historically abundant (McEwan 2001). In large river systems where steelhead still occur, they are almost always distributed higher in a watershed than Chinook salmon (Voight and Gale 1998, as cited in McEwan 2001, Yoshiyama et al. 1996). Therefore, in the San Joaquin River (SJR) mainstem, steelhead would likely have spawned at least as far upstream as the natural barrier located at the present-day site of Mammoth Pool (RM 322), and in the upper reaches of San Joaquin River tributaries (McBain and Trush 2002).

The Southern Sierra Nevada Diversity Group for the Central Valley steelhead DPS includes tributaries to the San Joaquin River that drain the western slopes of the Sierra Nevada Mountains (i.e.., Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, upper San Joaquin, Kings, Kaweah, and Kern rivers, and Caliente Creek;NMFS 2009). Though immigrating steelhead can still access the lower elevation valley and foothill reaches of the Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers, they are prevented from reaching critical spawning reaches by impassible dams. Steelhead are currently extirpated from all waters in the diversity group that are upstream of the Merced-San Joaquin confluence (i.e., Chowchilla, Fresno, upper San Joaquin, Kings, Kaweah, and Kern rivers, and Caliente Creek; Eilers et al. 2010).

Construction of Friant Dam on the mainstem San Joaquin River began in 1939 and was completed in 1942, which blocked access to upstream habitat. Nevertheless, runs of 30,000 to 56,000 spring-run Chinook salmon were reported in the years after Friant Dam was constructed, with salmon holding in the pools and spawning in riffles downstream of the dam. Friant Dam began filling in 1944, and in the late 1940s began to divert increasing amounts of water into canals to support agriculture. Flows into the mainstem San Joaquin River were reduced to a point that the river ran dry in the vicinity of Gravelly Ford. By 1950, spring-run Chinook salmon were extirpated from the San Joaquin River (Fry 1961). Although not documented, it is likely, as well, that the construction of Friant and subsequent drying of the river bed would have caused the extirpation of steelhead from the SJR.

Small, remnant populations of Central Valley steelhead are known to occur on the Stanislaus and Tuolumne rivers, as *O. mykiss* are encountered in annual monitoring efforts. Adult Central Valley steelhead begin to migrate into the region's watersheds (San Joaquin, Stanislaus, Tuolumne, and Merced rivers) in late fall and early winter, particularly when increased flows are released from San Joaquin River tributaries to enhance fall-run Chinook salmon spawning habitat or when early winter rains cause increased flows in the system. Adult escapement numbers have been monitored for the past several years with the installation of an Alaskan style weir on the lower Stanislaus River between Ripon and Riverbank. Typically, very few adult *O.*

mykiss have been observed moving upstream past the weir, potentially due to the removal of the structure at the end of December. However, in the years from 2006 to 2010, the weir has been operational in the winter and spring leading to the detection of adult *O. mykiss* migrating upstream in numbers ranging from 8-15 annually (Anderson et al 2007, FishBio unpub. data). The Tuolumne River weir has only detected one adult *O. mykiss*, but adult *O. mykiss* are detected through snorkel surveys throughout the river (MID/TID 2010). Monitoring is much less rigorous on the Merced River; however their presence is assumed on the Merced River due to proximity, similarity of habitats, and historical presence (Eilers et al 2010).

Microchemistry analysis of otoliths collected between 2001-2007 indicate that a very small percentage of *O. mykiss* captured in the Stanislaus, Tuolumne and Merced rivers are anadromous (i.e., steelhead). Two of six *O. mykiss* captured in the lower San Joaquin River, at a point where all juvenile *O. mykiss* emigrating from the system must pass, were of anadromous origin (Zimmerman 2008).

Additionally, Zimmerman (2008) detected one adult *O. mykiss* on the Merced River of anadromous maternal origin, suggesting a remnant population also occurs on this, the most upstream tributary to the San Joaquin, and the delineation of the end of the San Joaquin River Restoration Area.

Monitoring of steelhead populations in the SJR and its tributaries is especially challenging due to extremely low abundance of fish. Steelhead populations in this region are depressed to the point where monitoring opportunities are limited because sample sizes are too low to use statistical analyses (Eilers et al. 2010), and depressed to the point that even presence/absence determination is difficult.

The only recent fisheries monitoring in the mainstem SJR from the confluence of the Merced River upstream to the Highway 140 bridge that currently could detect the presence of *O. mykiss* is the fish community sampling conducted as part of the Grasslands Bypass Project (GBP; Beckon et al. 2007). As part of the biological monitoring in the GBP, fish community assessments have been conducted since 1996 and continued through 2009. The US Bureau of Reclamation (USBR) is currently in the process of preparing a new contract for 2011. Although the fish community in the sloughs affected by the GBP consists principally of warmwater species, anadromous coldwater fish migrate through the portion of the San Joaquin River into which these sloughs discharge. Fish community assessments to describe relative abundance and species diversity are conducted in Mud Slough, in the San Joaquin River at Highway 140 (Fremont Ford), and in the San Joaquin River upstream of the Merced confluence (Hills Ferry Barrier location). Fish community sampling occurred during March, June, August/September, and November/December from 1996 – 2007 and 43 fish species were detected including juvenile Chinook salmon (*O. tshwaytscha*;Beckon et al 2007). Little information can be gleaned from this study regarding the presence of *O. mykiss* above the Merced River confluence in years prior to interim flow implementation because *O. mykiss* were not detected. One could speculate that few or no adult *O. mykiss* migrated into the SJR above the Merced River, or one could assume that numbers were too low to facilitate detection due to few sampling sites (3) and infrequent site visits (once per season) described in the GBP protocols.

Purpose and Need

Spring interim flows occurring from February 1 to June 1 could attract adult steelhead into the Restoration Area. Steelhead attracted into the Restoration Area would not have access to appropriate spawning habitat due to a number of barriers to passage (e.g., Sack Dam, Mendota Dam). If not attracted to the San Joaquin, these fish would have the opportunity to contribute to the spawning populations in the San Joaquin tributaries (Stanislaus, Tuolumne and Merced rivers). The HFB is not installed during this time period, so to address this potential effect from interim flow releases, USBR and the Fisheries Management Work Group (FMWG) have committed to preparing a Steelhead Monitoring Plan to facilitate detection and relocation of steelhead the San Joaquin River upstream of the Merced River confluence. As stated in the 2010 Environmental Assessment for interim flows available at www.restoresjr.net under the interim flows Environmental Requirements tab or: (http://www.usbr.gov/mp/nepa/nepa_projdetails.cfm?Project_ID=3612).

> *Reclamation will develop a monitoring plan, in coordination with the SJRRP Fisheries Management Working Group, to check for Central Valley steelhead in the Restoration Area during spring Interim Flows and submit this plan to NMFS prior to February 1, 2011. The plan will include notification of NMFS in the event that a steelhead is encountered in the Restoration Area and include the recovery and return downstream in an appropriate location designated by DFG and/or NMFS of stranded steelhead. Such recovery would be conducted under and consistent with DFG's ESA Section 4(d) research permit.*

The EA also states that the changes in hydrology at the confluence with the Merced River are expected to be low.

> *Historic streamflow conditions upstream from the Merced River confluence during the spring averaged from 119 cfs to 13,050 cfs, with peak flows reaching 59,000 cfs in 1997. WY 2011 Interim Flows may add an average of up to 220 cfs at this location beginning on February 1, 2011, with peak flows reaching 1,300 cfs in the spring. This small increase is not anticipated to trigger any change to Central Valley steelhead migration patterns in the San Joaquin Basin.*

Monitoring needs to occur when it is expected that the increased input from interim flows are significant enough to create a false attraction for adult *O. mykiss*. Two situations potentially preclude the need for monitoring: 1) When the SJR and/or its tributaries are conducting flood releases the migratory behavior of steelhead is no longer under the influence of the interim flow releases and would be considered what would have occurred historically under "natural" conditions; and 2) During the VAMP period typically beginning on March 15th, the interim flows at the Merced River confluence would not be greater than those released in the tributaries, thus steelhead migration behavior would not be altered by interim flows(i.e., they would not be attracted to the Restoration Area).

Fall interim flows occurring from October 1 to December 1 could also attract adult steelhead into the Restoration Area if the interim flows are higher than the flows in the SJR tributaries. However, during fall interim flows, the Hills Ferry Barrier (HFB) is in place just upstream of the confluence with the Merced River and ongoing fish monitoring occurs at HFB. Steelhead that reach the HFB could be detected, and potentially trapped in monitoring efforts at HFB. In the fall of 2010, a trap was installed and operated by DFG in conjunction with USBR staff from the Denver Technical Science Center to assess the effectiveness of the HFB. Some fall-run Chinook were able to pass the barrier during the 2010 interim flow period, so the effectiveness of HFB is in question. No *O. mykiss* were detected, but bar spacing on the trap could allow steelhead, smaller and slimmer than salmon, to escape the trap undetected. A summary report on HFB effectiveness is anticipated this spring (Don Portz, personal communication February 2, 2011).

Methods

Study Site

The Restoration Area for the San Joaquin River Restoration Program includes the San Joaquin River between Friant Dam and it's confluence with the Merced River. Figure 1 depicts this area with information regarding potential passage barriers and false attraction pathways. It is important to note that a number of drop structures and check dams exist in the bypass system (Eastside, Mariposa, and Chowchilla bypasses) that are not depicted on this map, but may contribute to migration delays and/or passage impediments to migrating salmonids (Eric Guzman and Matt Bigelow, pers. comm, Feb. 2, 2011). Additionally, anecdotal reports from local irrigators and/or canal company employees report the presence of salmonids around the Road 9 crossing of the Chowchilla Bypass (the location of two drop structures not depicted on the map) in the spring, as well as other locations along the bypass and canal systems. While these are currently unconfirmed, they bring to issue the fact that for monitoring to be most successful, keeping monitoring locations must be kept as far downstream in the system as possible before fish are faced with multiple pathways. For the purposes of this study, Sack Dam (RM 170) is considered the upstream extent of monitoring needed for this study. Sack Dam serves as a complete barrier in low water year types, but is passable under high flow conditions (~1000 cfs and greater).

Another consideration of the study area is the potential routes for migratory fish. While Sack Dam marks the dividing line between Reach 3 and Reach 4a, it is important to note that Reaches 4b1 has been perennially dried for the majority of the past 40+ years (with the exception of agriculture return water and during periods of significant flood events. While 4b2 receives water through the refuge system, the channel is significantly choked with cattails and other vegetation as to make passage difficult at best. Water is routed down the Eastside Bypass at the head of Reach 4B, and most attraction water in Reach 5 comes from the Eastside Bypass, and not the river channel.

Three alternative methods have been developed for this monitoring plan to encompass the range of opportunities and constraints involved in monitoring adult *O. mykiss*.

Alternative 1 – use of electrofishing at partial barriers and false attraction points

A number of potential barriers to migration occur in the study area, as well as false upstream migration pathways. Many of the identified 'potential barriers' are drop structures that consist of a concrete sill. These sites may not preclude passage at all flows, but potentially cause migration delays that may increase the detection probabilities for adult steelhead at these structures, as fish may congregate at the downstream side.

Electrofishing is a common method used in monitoring steelhead populations (e.g., Mill Creek, Deer Creek, Feather River, American River, Mokelumne River, Stanislaus River, Merced River). One potential drawback for using electrofishing in rivers involves the difficulty in obtaining permits due to the possibility of injuring fish in anadromous salmonid waters (Eilers 2008). While permitting may be difficult, electrofishing offers a distinct advantage to alternative methods (e.g., snorkel surveys) to detect presence in naturally turbid rivers like the San

Joaquin.

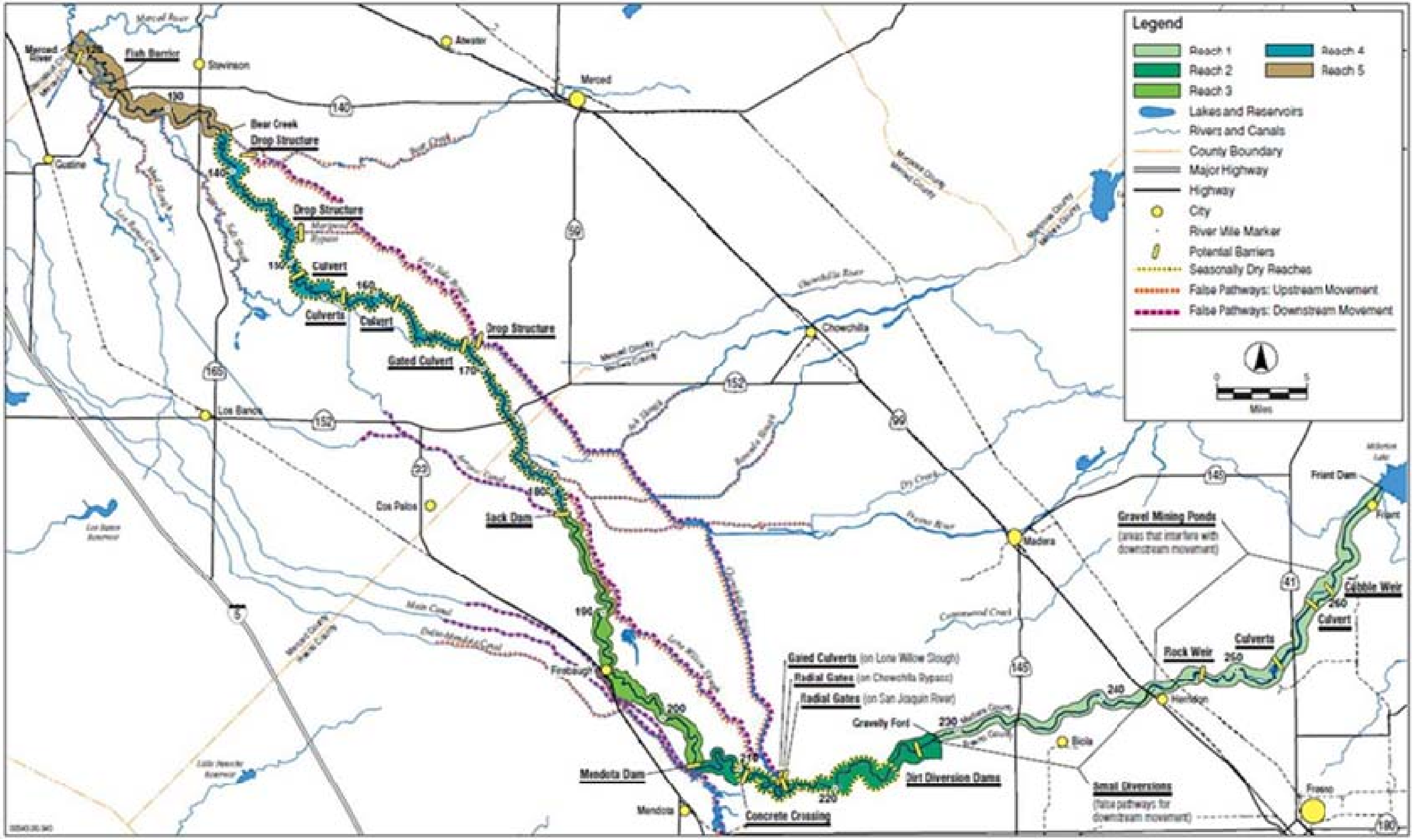


Figure 1. Map of the San Joaquin River Restoration Area, associated reaches, and potential barriers, entrainment risks for migratory fish. Source: McBain and Trush 2002

Proposed priority sampling locations for this alternative include: the mouth of Mud slough, Salt slough, and Newman Wasteway, the drop structures at the mouth of the Eastside Bypass, Mariposa Bypass, the Sand Slough control structure, and the base of Sack Dam (Figure 1). Mud and Salt sloughs are tailwater drains for the extensive canal system on the west side of the San Joaquin River, and once fish enter these sloughs they can be entrained in a number of canals and agricultural drains. Additional drop structures are present in the bypass system that are not identified in Figure 1, including two drop structures in the Chowchilla Bypass at the Road 9 crossing, and numerous check weirs in the Eastside Bypass. There have been anecdotal reports of seeing salmonids at the drop structures in the Chowchilla Bypass in the spring after flood releases (Matt Bigelow, pers. comm. 2/2/2011). The proposed study assumes monitoring low in the system offers the best opportunity for detection, as once fish get into a bypass or canal system the routes they can take are numerous, and the probability of detection would be minimal. In future years, the SJRRP should consider temporary barriers at the mouths of the sloughs to prevent entrainment of upstream migrating adults. Temporary installations could reduce the number of sampling locations necessary, but for the purpose of this proposal permitting would preclude this activity this season.

Electrofishing effectiveness and safety have improved over time (Bonar et al 2009). Design specifications to reduce injury to fish, and a comprehensive review of electrofishing literature can be found in Snyder (2003). Sampling frequency should be weekly during February and March due to the short duration of potential interim flow effects and the presumed low numbers of fish to compensate for low detection probabilities. Electrofishing methods would refer to the NMFS guidelines for sampling waters with anadromous fish as much as is applicable. Noting that, the guidelines are for backpack electrofishing juveniles, but state:

> *"…researchers wishing to use electrofishing in waters containing listed salmon and steelhead are not necessarily precluded from using techniques or equipment not addressed in these guidelines (e.g., boat electrofishers). However, prior to authorizing the take of listed salmonids under the ESA, NMFS will require substantial proof that such techniques/equipment are clearly necessary for a particular study and that adequate safeguards will be in place to protect threatened or endangered salmonids"(NMFS 2000)*

These methods would need to be covered under California Department of Fish and Game's 4(d) research permit activities.

This alternative has a high potential to be successfully implemented during 2011 spring interim flows. The significant constraints to this method are permitting, staff resources, and access to appropriate sampling locations.

Alternative 2 – operation of large fyke trap(s) above the Merced Confluence and below all false attraction and entrainment points

Historically, wire fyke traps were used to estimate population abundance of steelhead immigrating into the Sacramento River Basin (Hallock et al. 1957), the results of which provide almost all of our baseline information on historical steelhead populations. The Central Valley Steelhead Monitoring Plan (Eilers et al 2010) is recommending that a pilot study be undertaken to evaluate the current effectiveness of wire fyke traps in the mainstem Sacramento River (Figure 2). The same concept could be adapted for use in the San Joaquin River above Hills Ferry

Barrier. While the pilot program for the mainstem Sacramento River looks to build a mark-recapture estimate of population abundance, less rigorous protocols could be employed in the San Joaquin River since our objective is merely detection and relocation. The method of capturing fish for the SJR would be to employ one or two 12-foot diameter by 20-foot long wire fyke trap(s) set along the river bank above the confluence of the Merced River, but below potential entrainment features (Mud and Salt Sloughs, the Eastside Bypass). Since DFG has limited access to the HFB site, but this site may provide the most feasible option.

The value of this method is that it limits the sampling to one location downstream of all entrainment features and provides a method where fish are captured and easily handled for relocation downstream. Constraints of this method include potential permitting issues, availability of existing traps, or construction time/costs to fabricate new traps, access to appropriate sampling sites (depth, channel width) and staff resources, and it poses a navigation barrier in the mainstem San Joaquin River. Oversized load permits are needed to transport the traps from storage to sites on the river. CalTrans permits are needed when transporting the traps on state highways and freeways, and county permits are needed when the traps are being transported via county roads. If traps are to be stored at and moved from an offsite location, county permits will be needed from the appropriate county. Transportation of traps and setup for fishing takes approximately 4-5 hours per trap (Eilers et al 2010).

Figure2. California Department of Fish and Game Region 3 Wire Fyke Trap *Source: Eilers et al 2010*

Trap(s) would be set with the catch openings facing downstream and run continuously once set and checked as infrequently as every 3 days, but preferably every other day during the sampling period. Hallock et al. (1957) reported that trapped steelhead were found to be in very good condition, and fish that were left in the trap for up to three days remained in excellent condition. The size of the trap (approximately 20 ft. long x 12 ft. diameter) requires it be rolled into the river, limiting locations where the traps can be deployed. Banks cannot be too steep, undercut, or contain brushy vegetation. Water depths need to cover the height of the trap (water depth of 10.5-12 feet), but not overly deep as to reduce efficiency.

Alternative 3 – use of weirs (barriers) with or without trapsat false attraction locations and existing structures to detect, trap and relocate *O. mykiss*

Immigrating adult steelhead are difficult to monitor using techniques commonly used to assess salmon populations due to their unique life-history traits (e.g., carcass mark-recapture surveys, snorkel surveys, redd). Steelhead are iteroparous, and may not die after spawning; therefore, carcasses are not available for a mark-recapture survey. In addition, steelhead immigrate and spawn during the late-fall, winter and spring months when rivers have periods of flashy flows, high flows, and turbid water conditions which reduce visibility. Poor water quality conditions have negative impacts on all of the above mentioned salmon monitoring techniques (Eilers 2008). Additionally, low abundance in the San Joaquin River basin further reduces the detection probability in the study area.

A weir is a barrier built across a stream to divert fish into a trap. Fisheries scientists frequently use weirs to enumerate adult fish returning to spawn to determine population status and trends. Weirs are usually only used in small rivers because they are expensive to construct, can be navigation barriers, and frequently trap debris, which can lead to structure failure and flooding (Hubert 1996). However, where feasible, weirs are commonly regarded as the best method of quantifying escapement (Cousens et al. 1982). Counts from weirs, often referred to as absolute counts, have been observed to be significantly better than modeled estimates (O'Connell 2003) and although other methods can be used to generate escapement data, weirs are generally the standard against which other techniques are measured (Zimmerman and Zabkar 2007).

The current Hills Ferry Barrier (HFB) is a type of resistance weir commonly used to exclude or trap anadromous fish in rivers. This barrier consists of panels aligned perpendicular to the flow of the river with evenly spaced pipes that allow water, small fish, and particles to pass, while preventing larger fish, such as Chinook salmon, from passing upstream. The main purpose of the barrier is to redirect upstream-migrating adult fall-run Chinook salmon into suitable spawning habitat in the Merced River and prevent migration into the mainstem San Joaquin River upstream of the site, where conditions are currently unsuitable for salmonids. The HFB is currently only operated September – December, so additional weir sites upstream would be needed to assess the migration of steelhead into the study area or HFB would need to operate under much more significant design revisions including extending the timing of operation. This alternative could include installing the HFB for the spring flow period as the first detection location, but historically the barrier has not performed well under high fall flow conditions as similar high flows occur during the spring interim flow period.

The protocols provided in The Salmonid Field Protocols Handbook (SFPH; Johnson et al. 2007) chapter on weirs (Zimmerman and Zabkar 2007) are proposed for use in this alternative as these protocols were developed by leading salmonid experts from the Pacific Northwest. This resource is attached as Appendix A of this proposal.

Key Locations for placement of weir/traps to detect *O. mykiss* include upstream of the confluence of the Merced River, the mouths of Mud, slough, Salt slough, and Newman Wasteway, and the placement of a trap in the existing structure at Sack Dam as the upstream extent of monitoring.

Weir trapping is the preferred method for assessing adult migration in salmonids as it gives an actual count. Constraints of this method are the same as are experienced at the currently operated Hills Ferry Barrier and include: erosion around the base of weir structures due to the easily mobilized sand substrate ubiquitous to the study area; stability under high winter and spring flows; cost and time for construction; staffing resources; and permitting issues for creating in-channel structures. These constraints make this alternative less feasible than alternatives 1 and 2 for implementation in the 2011 spring interim flow period. While this method is constrained for immediate consideration, it would provide a long-term monitoring infrastructure and potentially provide a means to block entrainment risks into the canal system for salmonids migrating into the San Joaquin River in the future..

Other Data Sources

Along with scheduled monitoring for the detection of *O. mykiss* in the study area, existing monitoring and reporting mechanisms can provide information to this monitoring effort. The Grassland Bypass Project has conducted monitoring in Mud and Salt sloughs and Reach 5 of the Restoration Area since the mid 90's. Monitoring coincides with the interim flow periods for their March sampling only. While *O. mykiss* have not been detected under this monitoring program in the past, requesting notification of any *O. mykiss* encountered could add to the value of the proposed plan, or requesting additional sampling be conducted under the permitted activities for this project. Currently, the California Department of Fish and Game issues commercial collecting permits for fisheries in the Restoration Area and the canal system. As a new requirement of permit applicants, DFG has requested notification of any salmonids captured (including but not limited to *O. mykiss* (Eric Guzman, pers. comm, 2/2/2011). Anecdotal information on fish presence in the canal and bypass systems is periodically reported to DFG staff (Matt Bigelow, pers. comm., 2/2/2011); follow up verification to these reports could provide additional knowledge.

Fish Handling/Transporting/Reporting

For all alternatives above, fish will be subject to standard handling and transporting procedures. All captured steelhead will be enumerated, measured (fork length), sexed (if possible), sampled for scales, sampled for genetic tissues, checked for injuries, and checked for the presence of tags. All captured steelhead will be tagged with an external t-bar anchor tag (floy tag) with a unique ID number to document any recaptures that may occur in the study area. Captured steelhead would be transported downstream of the mouth of the Merced River in transport tanks following proposed transport protocols. The transport tank(s) will be filled with stream water immediately prior to transport using a portable, screened water pump. When possible, fish will be moved in and out of the transport truck using a water-filled vessel (i.e., water to water transfer) with minimized netting to reduce stress and loss of slime. Oxygen gas will be supplied to the transport tank(s) using compress oxygen gas cylinders and micro-bubble diffusers. Dissolved oxygen levels will be monitored and maintained near saturation during transport. Transport water will be supplemented with sodium chloride to provide a physiologically isotonic concentration to minimize ionic disturbances. The truck will be stopped after 30 minutes of transportation and each hour thereafter for visual inspection of the life-support system and fish health and wellbeing. Water will be tempered to the receiving water at the predetermined release location before transferring fish, by pumping receiving water directly into the transport tank until the temperature difference is within two degrees Celsius (methods following Transportation Appendix of the SJRRP Reintroduction Strategy Draft).

All captured *O. mykiss* will be reported under the CDFG 4(d) reporting requirements, and appropriate NMFS staff will be consulted as well.

Timing

2011 spring interim flows should reach the Merced River confluence by roughly February 14th. Increased releases from the San Joaquin River tributaries for the Vernalis Adaptive Monitoring Program (VAMP) will occur March 15th through April 30th. The addition of these flows may negate any attraction to adult steelhead provided by the interim flows releases. Following cessation of VAMP flows on April 30th, temperatures may be limiting for *O. mykiss* upstream migration. These factors narrow the critical timeframe for monitoring to the February 14th through March 15th time period. Given this timeframe perhaps the most feasible option is the construction of barrier weirs at the false attraction points (mud slough, salt slough and Newman Wasteway) with the addition of a fish trap at Sack Dam to detect presence of *O. mykiss* in the study area.

Feasibility

The current DFG 4(d) permit application for operation of Hills Ferry Barrier is in review with NMFS and covers operation of the existing barrier with a fish trap. DFG submits a request each year in October for the next calendar year. This request may be modified in the future to include the need to assess both steelhead and/or spring run Chinook salmon above the barrier and relocate them downstream, but the current permit does not cover these activities. The lease for access to the HFB site is specific to the current operations protocol and would need to be revisited for changes in monitoring protocols, including timing of barrier operation. During the spring period it is expected the use of the San Joaquin mainstem by anglers will increase, and the need for further modification of the barrier and its operations would again need to be considered. The Grasslands Bypass Project conducts quarterly electrofishing in the study area. It may be feasible to request additional sampling and adjusted protocols to fit the needs of this study. The use of large fyke traps may be limited by river conditions and access. Reconnaissance of suitable placement and availability of traps and permitting issues would need to be addressed.

Literature Cited

Anderson, J., C. Watry, and A. Gray. 2007. Upstream Fish Passage at a Resistance Board Weir Using Infrared and Digital Technology in the Lower Stanislaus River, California. 2006−2007 Annual Data Report. Cramer Fish Sciences. Prepared for: U.S. Fish and Wildlife Service Anadromous Fish Restoration Program Grant No. 813326G004

Beckon, W.N., PhD., M.C.S. Eacock, and A.G. Gordus., PhD. 2007. Biological Effects on the Grassland Bypass Project. Chapter 7 IN: Grassland Bypass Project annual Report 206-2007. Prepared by the San Francisco Estuary Institute for the GBP Oversight Committee.

Bonar, S.A., W.A. Hubert, and D.W. Willis, eds., 2009. Standard Methods for Sampling North American Freshwater Fishes. American Fisheries Society. Bethesda, Maryland. 335p.

Cousens, N. B. F., G. A. Thomas, C. G. Swann, and M. C. Healey. 1982. A review of salmon escapement techniques. Canadian Technical Report of Fisheries and Aquatic Sciences 1108.

Eilers, C. D. 2008. Review of present steelhead monitoring programs in the California Central Valley. Sacramento, California. Report to California Department of Fish and Game Contract # P0685619. Available at: [http://www.nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=6499]

Eilers, C.D., J. Bergman, and R. Nelson. 2010. A Comprehensive Monitoring Plan for Steelhead in the California Central Valley. The Resources Agency: Department of Fish and Game: Fisheries Branch
Administrative Report Number: 2010-2. R. Bellmer, ed.

Fry, D. H. Jr., 1961. King salmon spawning stocks of the California Central Valley, 1940-1959, California Fish and Game, Vol. 47, pp. 55-71.

FishBio consulting. Unpublished excel data file to U.S. Fish and Wildlife Service Anadromous Fish Restoration Program, Stockton, Ca.

Hallock, R. J., D. H. Fry, Jr., and D. A. LaFaunce. 1957. The use of wire fyke traps to estimate the runs of adult salmon and steelhead in the Sacramento River. California Fish and Game Quarterly 43(4):271-298. U.S. Bureau of Reclamation, Mid-Pacific Region, Sacramento, California.

Hubert, W. A. 1996. Passive capture techniques. Pages 157–181 in B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Johnson, D. H., B. M. Shrier, J. S. O’Neal, J. A. Knutzen, X. Augerot, T. A. O’Neil, and T. N. Pearsons. 2007. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

McBain & Trush, Inc. (eds.), 2002. *San Joaquin River Restoration Study Background Report*, prepared for Friant Water Users Authority, Lindsay, CA, and Natural Resources Defense Council, San Francisco, CA.

McEwan, D. R. 2001. Central Valley Steelhead IN: Contributions to the biology of central valley salmonids. Fish Bulletin 179. R. Brown, ed.

MID/TID. 2009. Draft Tuolumne River 2010 *O. mykiss* Monitoring Summary Report for Don Pedro Project (P-2299).

National Marine Fisheries Service (NMFS). 2000. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act.

National Marine Fisheries Service (NMFS). 2009. Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. Sacramento Protected ResourcesDivision. October 2009.

O'Connell, M. F. 2003. Uncertainty about estimating total returns of Atlantic salmon, *Salmo salar* to the Gander River, Newfoundland, Canada, evaluated using a fish counting fence. Fisheries Management and Ecology 10:23–29.

Snyder, D.E. 2003. Electrofishing and its harmful effects on fish. US Geological Survey, Information and Technology Report USGS/BRD/IRT-2003-0002, Denver, Colorado.

Voight, H.N., and Gale D.B. 1998. Distribution of fish species in tributaries of the lower Klamath
River: an interim report, FY 1996. Technical Report No. 3. Yurok Tribal Fisheries Program, Habitat Assessment and Biological Monitoring Division. 71 p.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle, 1996. Historical and present distribution of Chinook salmon in the Central Valley drainage of California, Sierra Nevada Ecosystem Project: fi nal report to congress, Volume III: Assessments, commissioned reports, and background information, University of California, Center for Water and Wildland Resources, Davis, CA, pp. 309-362.

Zimmerman, C. E., and L. M. Zabkar. 2007. Weirs. Pages 385-398 in D. H. Johnson, B. M. Shrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O'Neil, and T. N. Pearsons. 2007. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

Zimmerman, C. E., G. W. Edwards, and K. Perry. 2008. Maternal origin and migratory history of Oncorhynchus mykiss captured in rivers of the Central Valley, California. Final Report. Prepared for California Department of Fish and Game, Contract P03853006. March 2008. [http://www.delta.dfg.ca.gov/AFRP/documents/Zimmerman_et_al.pdf]

Personal Communications

Don Portz, Fisheries Biologist, US Bureau of Reclamation, Denver Technical Science Center. Phone conversation 2/1/2011.

Matt Bigelow, Environmental Scientist, California Department of Fish and Game, Fresno, Ca. Phone conversation 2/2/2011.

Eric Guzman, Environmental Scientist, California Department of Fish and Game, Fresno, Ca. Phone conversation 2/2/2011.

Weirs

Christian E. Zimmerman and Laura M. Zabkar

Background and Objectives

Weirs—which function as porous barriers built across stream—have long been used to capture migrating fish in flowing waters. For example, the Netsilik peoples of northern Canada used V-shaped weirs constructed of river rocks gathered on-site to capture migrating Arctic char *Salvelinus alpinus* (Balikci 1970). Similarly, fences constructed of stakes and a latticework of willow branches or staves were used by Native Americans to capture migrating salmon in streams along the West Coast of North America (Stewart 1994). In modern times, weirs have also been used in terminal fisheries and to capture brood fish for use in fish culture. Weirs have been used to gather data on age structure, condition, sex ratio, spawning escapement, abundance, and migratory patterns of fish in streams.

One of the critical elements of fisheries management and stock assessment of salmonids is a count of adult fish returning to spawn. Weirs are frequently used to capture or count fish to determine status and trends of populations or direct in-season management of fisheries; generally, weirs are the standard against which other techniques are measured.

To evaluate fishery management actions, the number of fish escaping to spawn is often compared to river-specific target spawning requirements (O'Connell and Dempson 1995). A critical factor in these analyses is the determination of total run size (O'Connell 2003). O'Connell compared methods of run-size estimation against absolute counts from a rigid weir and concluded that, given the uncertainty of estimators, the absolute counts obtained at the weir wer significantly better than modeled estimates, which deviated as much as 50–60% from actual counts. The use of weirs is generally restricted to streams and small rivers because of construction expense, formation of navigation barriers, and the tendency of weirs to clog with debris, which can cause flooding and collapse of the structure (Hubert 1996). When feasible, however, weirs are generally regarded as the most accurate technique available to quantify escapement as the result is supposedly an absolute count (Cousens et al. 1982). Weirs also provide the opportunity to capture fish for observation and sampling of biological characteristics and tissues; they may also serve as recapture sites for basin-wide, mark–recapture population estimates. Temporary weirs are useful in monitoring wild populations of salmonids as well as for capturing broodstock for artificial propagation.

FIGURE 1. — A temporary weir constructed of metal tripods, stringers, and galvanized conduit with both an upstream and downstream trap. Ninilchik River, Alaska.

Rationale

Temporary weirs enable field biologists to quantify the escapement of adult salmonids in streams and rivers. In addition to providing absolute counts of fish migrating through the weir, weirs can be used to capture fish, determine sex ratios and species composition, recapture tagged fish, and collect tissue or scale samples. In locations where management relies on escapement goals, weirs can be used to monitor escapement in order to direct in-season management of commercial or subsistence fisheries.

Objectives

This protocol describes the methods used in counting migrating adult salmonids in streams and rivers using weirs and traps. Generally, weirs and traps are temporarily installed across the stream channel and enable monitoring practitioners to estimate or make an absolute count of fish passing that point in the stream.

FIGURE 2. — A resistance board weir featuring a skiff gate to allow boat passage (in the foreground, marked by pylons), a trap to capture fish in middle of weir, and a passage chute (background), where fish are counted as they pass the weir. Pilgrim River, Alaska. (Photo: Karen Dunmall and Tim Kroeker.)

Temporary weirs may be constructed from a range of materials. Rigid weirs generally consist of a fence and support structure; fences may be constructed from netting (Blair 1956; Noltie 1987) or from rigid material such as pipe or metal pickets (Hill and Matter 1991). These weirs are generally easy to dismantle and transport but are sometimes difficult to maintain during high water or in streams with high debris loads. Weirs constructed of screen or wire panels have a tendency to collect debris such as leaves and algae (Clay 1961). Kristofferson et al. (1986) used a weir constructed of polyethylene (Vexar®) and metal t-posts, similar to that described by Noltie (1987), on an Arctic river but found that clogging by algae and debris led to excessive water pressure that eventually caused the weir to collapse. Noltie (1987), however, reported that the same material could easily be cleaned of leaves using a push broom. Because weirs constructed of these materials are relatively inexpensive, they are probably best used for short-term studies in small shallow streams; practitioners choosing these materials need to take into account the time needed to clean these weirs of debris.

Weirs constructed of metal pickets (which are frequently made of aluminum rods or galvanized conduit) are more resistant to buildup of algae, leaves, and other fine material. In some designs, the pickets can be removed for easy cleaning and to reduce pressure from high flows. The length of the conduit will depend on the depth of the stream and should be long enough that salmon should not be expected to jump over the weir. Anderson and McDonald (1978), Kristofferson et al. (1986), and Hill and Matter (1991) describe construction details for such rigid weirs, which generally consist of structures that support panels of pickets. Supports usually consist of tripods constructed of pipe or wood and support stingers that hold the pickets (see Figure 3). By angling the upstream face of the weir at 120° relative to the stream bottom, the water flows slightly up the pickets before passing through; this movement creates a greater area over which water pressure may dissipate (Anderson and McDonald 1978). To further dissipate water pressure, the weir can be constructed so that the wings of the weir terminate in a 90° angle entering the trap box (see Figure 4). This arrangement allows more water to pass through the weir for a given stream width and guides fish into the trap. Mullins et al. (1991) describe a two-way trap that can be constructed in the apex of two weirs that allows for sampling of both upstream and downstream migrants.

FIGURE 3. — Construction details of tripods and weir panels made of metal stringers and pickets of galvanized electrical conduit.

Rigid weirs work best in rivers that have minimal variation in water flow and depth; these conditions will help avoid, to the greatest extent possible, frequency of washout of the trap and/or weir by increased flows or seasonal freshets. Lake outlets, therefore, are particularly suited to the placement of rigid weirs (Clay 1961). Rigid weirs are also susceptible to damage by large floating debris such as logs or ice. Resistance board weirs were designed to accommodate fluctuation in flow and debris and to allow for inclusion of easy-to-use boat passes (Tobin 1994; Stewart 2002) (see figures 2 and 4). Although not impervious to washout, resistance board weirs can be used in rivers that experience debris-laden high water periods (Tobin 1994). During high water, the resistance board weir will temporarily submerge when pressure created by water and debris loading reaches a point that would typically wash a rigid weir downstream (Tobin 1994). This flexibility requires less maintenance and also reduces the frequency of these occasions when fish cannot be counted.

Resistance board weirs consist of three main components: panels made of capped polyvinyl chloride (PVC) pipe, a rail anchored to the substrate that attaches the panels to the river bottom, and a trap box or chute where fish are captured or counted. Detailed construction and installation manuals for resistance board weirs are available in Tobin (1994) and Stewart (2002, 2003). In summary, a rail is installed across the stream. This rail is anchored to the substrate using steel rod and cables attached to duck-bill anchors placed upstream of the weir. The rail anchors and aligns the cable to which panels are attached. The weir panels are constructed of schedule 40 PVC electrical conduit 6.1 m in length. Electrical conduit is used rather than PVC water pipe because it resists breakdown caused by ultraviolet light. Panels consist of multiple pipes supported by 1.2 m-long stringers that are spaced evenly lengthwise along the panels to provide rigidity to the flexible PVC pipe. Pipe spacing is determined by the desired distance between pipes and is adjusted accordingly based on the size of each target species. A resistance board is attached at the downstream end of the panel to deflect water flow downward, which causes lift and holds the downstream end of the panel above the surface of the water (see Figure 5). Panels are attached to one another and span the width of the stream. At either end of the weir, a short section of fixed weir (similar to the rigid weirs described above) seals the end of the floating weir at either bank (Figure 4). Tobin (1994) and Stewart (2003) describe how to incorporate a skiff gate that allows upstream and downstream passage of boats without opening the weir.

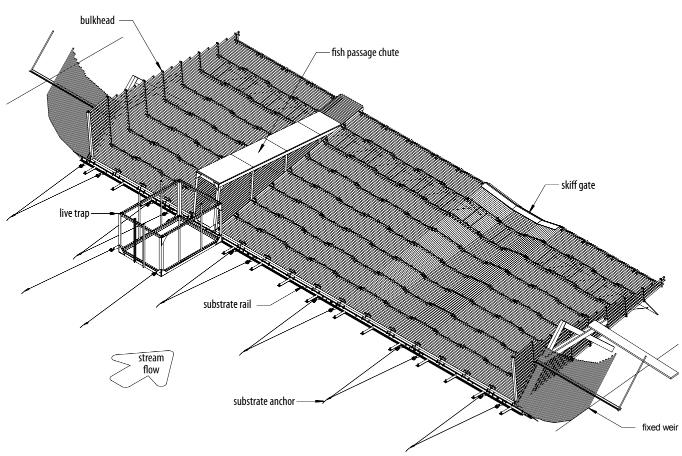


FIGURE 4. — Resistance board weir and major components. (Diagram: Rob Stewart, Alaska Dept. of Fish and Game.)

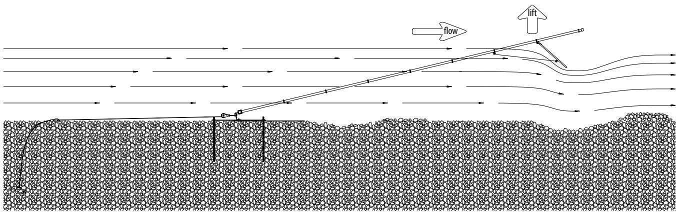


FIGURE 5. — Side view of a resistance board weir panel. The resistance board deflects water at the end of the panel and creates lift to counteract the downward pressure of flow. (Diagram: Rob Stewart, Alaska Dept. of Fish and Game.)

Both rigid and resistance board weirs use fish passage chutes and trap boxes to pass or capture fish. Fish passage chutes allow fish to swim though an opening in the weir and can either attach to a live box for trapping fish or include a counting station where fish are identified and counted. As fish pass through the counting chute they are tallied by observers. In some cases, to minimize personnel costs, automated counters that utilize video technology or resistivity counters are used to quantify fish passing through the fish counting chute (see Figure 6). Trap boxes are used to capture fish for direct examination or for sampling tissues, length, weight, and sex. After having been counted and examined, the fish is passed upstream of the weir. Trap-box designs are presented by Kristofferson et al. (1986), Whelan et al. (1989), and Mullins et al. (1991). In most designs fish enter the trap through a V-shaped passageway (termed a fyke), which inhibits fish from passing back downstream. After fish enter the trap, they either pass through the front gate or counting chute or are trapped for further examination. The trap should be big enough to hold expected numbers of fish comfortably. During the trapping session, the front gate (upstream) is closed and the back gate (downstream) is open to allow fish to enter the trap box. Once the desired number of fish enter the trap, the downstream gate is closed and fish are sampled and released upstream of the weir.

FIGURE 6. — Video monitoring chute, Nikolai Creek, Alaska. Fish passing through the passage chute swim through a video chamber, where they are filmed. Fish can be counted by viewing the video tape in the office.

Sampling design

When creating a sampling design for a weir project, it is important to evaluate the purpose and objectives of each project. In most cases, weirs are used to capture or count all fish passing that point in a stream. For example, if the goal of the project is to determine escapement to a particular river, it is critical that the weir be placed downstream of all spawning habitats and that the weir is operated through the entire migration. In the case of monitoring a stream with small numbers of migrating fish, all fish can be trapped, counted, and passed over the weir without continuous (24-h) counting through the chute. Rather, fish can be examined, counted, and passed at period intervals through the day. A counting chute allows for monitoring larger runs of fish and the counting of each species as they pass uninterrupted through the weir. Counting chutes are fitted with a light-colored floor to facilitate the identification of individual fish; counts are done visually by personnel stationed at the chute, video, or other automated counters. Personnel count fish as long as the counting chute is open to fish passage, which, depending on fish passage rates, may be up to 24 h per day.

Site Selection

Site selection includes two principle considerations. First, the weir must be located at a site that allows sampling and counting of fish to address the objectives of the study. For example, if the objective of the study is to determine escapement of upstream migrating salmonids, the weir must be located downstream of the lowest point of spawning habitat. Second, the location must be conducive to weir construction and maintenance through the range of water flows expected during the operation period.

Site selection is an important consideration in determining the success of weir construction and maintenance. When selecting possible weir sites, substrate, river flow, depth, and width, and timing of high water events should all be considered. Suitable sites for both rigid weirs and resistance board weirs are characterized by wide and shallow areas of stable substrate consisting of gravel or small cobble (Clay 1961). Stable substrates of pebbles or small cobbles allow the weir structure to lie flat on the surface of the substrate and also facilitate secure anchoring using pins or duck-bill anchors. If larger boulders are present, they may impede the structure, act as an obstacle, or create gaps that allow fish to get through the weir. At high water, stream energy is equally distributed across the stream in straight reaches of laminar flow, making it easier to maintain the weir through a range of flows. Water depths less than 1 m during normal flows and water velocity that is slow to moderate are preferred for both rigid and resistance board weirs. If the water is too deep and swift to allow an adult person to wade comfortably at normal flow, the site is not suitable for safe weir operations. At the same time, the weir site should have enough current (especially at passage chutes or traps) to ensure efficient fish passage and attraction flows. Stream width may vary, but practitioners should note that wider locations will require more material in weir construction. Near-vertical stream banks are easier to seal against fish passage but should not contain undercut channels because they are difficult to seal.

Another consideration when choosing weir location and design is the position of a trap or traps on the weir. The recommended number and location of traps depends on the size and morphology of the channel at the weir site. Since fish typically travel in the thalweg (the deepest portions of the river channel), the sampling area or trap should be located in this area. If the river has more than one thalweg or channel, it is recommended that the weir have more than one sampling location for fish to travel through. Trap placement on the weir should account for minimum expected depth. If the trap box is located in a site that is too shallow or too deep, it may be difficult to access the trap and handle fish in the trap, and may lead to excessive stress on fish in the trap. If the system is prone to flooding, it is common to have an alternate sampling location for times when normal operations at the main site are not possible. For example, many systems in Alaska experience flood stages during the rainy months of the summer; by installing a second trap in a different location on a given river, practitioners may avoid sampling delays during flood stages.

Sampling frequency and replication

Weirs are usually used to acquire an absolute count of migrating fish; therefore, sampling considerations need to ensure that weir operations begin before fish migration and continue through the end of migration. In the event that logistic considerations or environmental constraints interrupt weir operation, counts will be incomplete. An important consideration in the development of a fish weir project is replication. Depending on the objectives and goals of the study, many years of data may be needed. Practitioners examining run timing of Pacific salmon will need to monitor the entire run over several years to conduct trends analysis. For example, Korman and Higgins (1997) examined the needed replication of escapement estimates to adequately determine the response of salmon populations to habitat alteration, and they determined that posttreatment monitoring needed to be longer than 10 years.

Stratified sampling designs are a common method for estimating total run abundance and determining overall age, sex, and length composition. In most cases the operational period is stratified into weeks, with escapement determined for each week; and total escapement is simply the sum of weekly escapement. In locations where total fish runs are small, each fish may be handled to gather age, sex, and length data. When run size is too great to allow for sampling of all fish passing the weir, a stratified sampling design is used to estimate sex, age, and length distribution of fish passing the weir. This may be achieved by collecting scales and length from every *n*th fish of a species passed through the trap. The number of fish sampled needs to be determined prior to the season and in consultation with a statistician. On weirs that incorporate both a counting chute and trap, fish can be sampled in the trap for stratified periods of time throughout the run. This technique, also known as a pulse sampling design, is conducted over a 1–3-d time period, followed by a period without sampling (trapping and scale collection/length determination). In most cases, a target sample size for each species is sought for each sampling stratum (e.g., week). These samples are calculated as a subset of the entire escapement and expanded to characterize the age, sex, and length composition of the total annual escapement (see Data Handling, Analysis, and Reporting, page 394, for details).

Field/Office Methods

Setup

Before trapping can begin, all weir components need to be purchased, assembled, and constructed. For larger weirs, fabrication can take several weeks and requires use of a workshop with necessary tools and staff expertise. Commercially produced traps are available but can be very expensive. After construction the weir components need to be shipped to the weir location. For remote locations, this may involve the use of helicopters or other means of transportation. Once on-site, the weir can be installed in the stream. In Alaska weirs are frequently installed in early spring when water flow is low. Final panels or trap boxes are installed when trapping begins later in the season. In remote locations a camp must be constructed at the weir site to provide sleeping and eating quarters for all personnel required to maintain the weir. Once the crew is on-site, personnel in the office will need to facilitate grocery shipments and safety of the field crew.

Safety and operational training is an important step in preparing for a field season. Safety training should include first aid appropriate for the location, as remote field locations will require higher proficiency in dealing with injuries while waiting for transportation or medical aid. This training is frequently referred to as wilderness first-aid. Training in operation around water is required, and boat training is needed if the weir will be accessed by boat. Similarly, if helicopters or fixed-wing aircraft are used to access the weir site, training may be needed for proper conduct around aircraft. In remote locations in Alaska, training regarding bear encounters and gun handling is needed. Most agencies have established safety programs and requirements, and weir project planners should check with agency safety personnel when starting a weir project to determine what safety training will be needed and where such training can be acquired. Operational training is also important, and all weir personnel should receive training in weir operation, construction, and project implementation (as well as safety training). Personnel who fully understand the protocol and objectives of the project will be in a better position to make day-to-day decisions concerning project implementation.

Events sequence

Although weir projects may have a field season of a few weeks to months, preparation, analysis, reporting, and maintenance usually require year-round activity. Field crews need to be hired early enough to allow for preseason deployment and training. Creating a preseason task checklist is recommended. Appendix A details the preseason checklist used by the U.S. Fish and Wildlife Service on the Kwethluk River weir project. It includes all tasks that must be completed to initiate the Kwethluk River weir project, including scheduling, hiring, training, shipping, travel, and crew gear distribution. This checklist can be modified for use by other projects.

Another pertinent item to include when preparing for field season is an equipment checklist or inventory list. This should include all the equipment needed to complete the project with associated quantities, quality (i.e., used or new), and storage location. If the field project is located on private, state, or federal land, a land-use agreement or lease will be necessary to occupy and use the land,

and permits may be required. Scientific collecting permits may also be required from state fish and game agencies. Before beginning any project, local fish and wildlife managers should be consulted concerning permit requirements. When preparing for the field season it is important to create a timeline that is associated with the preseason checklist. The timeline should outline deadlines for the preparation, installation, operations, and takeout process.

Measurement details and sample processing

During weir operation, a range of data needs to be collected. These data include the number of fish passing the weir (usually recorded on an hourly basis), length, weight, and scale samples collected, water temperature, and flow (stage height or discharge). Data forms printed on weatherproof paper or notebooks should be developed to organize data gathering and ensure that all data are collected at the appropriate time. All data forms should be easy to understand, with proper headings and space provided to include all the data necessary. Fish passage should be monitored continuously, and fish passage should not be hindered. When operating a weir, it is important to ensure that the weir does not delay fish migration. Fleming and Reynolds (1991) found that Arctic grayling *Thymallus arcticus* delayed at a weir did not migrate as far as control fish and suggested that such delays could cause fish to spawn in suboptimal locations. Fish collected in traps should be sampled as quickly as possible to minimize holding stress and migration delay.

There are two different approaches for weir operation: one utilizes the trap to capture fish and release manually, and the other utilizes the trap as a counting station allowing fish to pass uninterrupted. Typically, the size of the escapement or objectives of the study will determine which technique is suitable for each system. The first method involves trapping fish as they pass through the weir, sampling them for genetics, age, sex, or length information, and releasing them by hand above the weir. This method works well on smaller systems. For larger systems, trap operation may be round-the-clock, and the design would include a counting chute that allows fish to pass uninterrupted. An observer or a video camera would then count each fish as it passes upstream through the weir. In this method, a counting session commences as the counting chute is open, and fish are identified and counted as they pass through the weir. Fish can also be examined by simply allowing the counting chute to remain closed and the downstream gate of the trap to remain open, essentially allowing fish to move into the trap, where they are retained until examined and then released upstream of the weir.

Sample processing may take place in-season or, in most cases, will occur postseason. In-season samples, such as daily escapement estimates, scale samples, or genetic samples, may need to be transported for immediate consideration by fishery managers. In this case, it is important that sampling procedures include a detailed component for quality control. If this element occurs in the field, proper steps should be taken to ensure accurate data collection and proper crew training; one individual needs to be responsible for the oversight and handling of samples.

Data Handling, Analysis, and Reporting

To determine total escapement past the weir, the total number of fish passing the weir each day is summed. In the case of weirs that incorporate a fish counting chute that is open to passage at all times, if fish are only counted during a portion of the day, then the count is expanded to estimate the full day's passage (assuming that passage rates are constant throughout the day). For full days missed because of high water or other events that prevent fish counting, linear interpolation of the counts before and after the missed day(s) can be used to estimate passage for that time period. In cases where fish are passed through a fish trap or where all fish are counted (24-h per day), the resulting number is the absolute number of fish passing the weir.

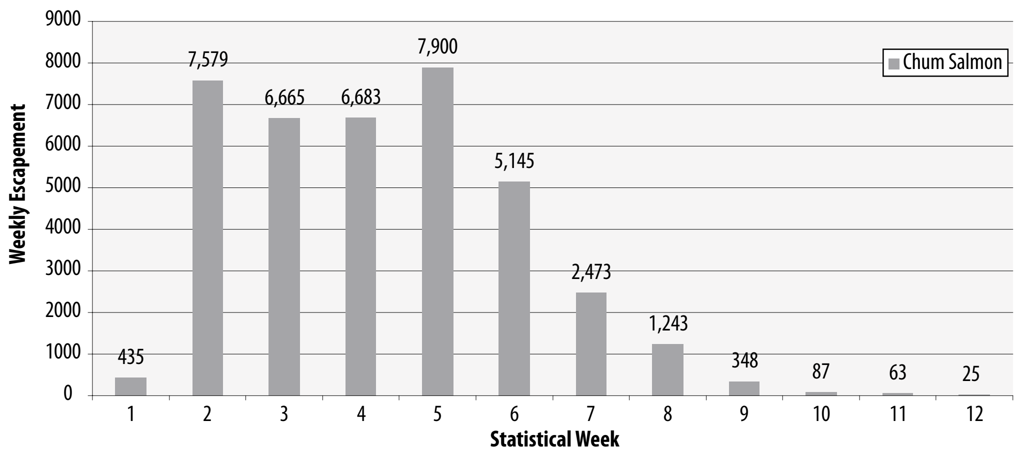


FIGURE 7. — Weekly passage (escapement) of chum salmon *Oncorhynchus keta* at the Kwethluk River weir, 2004 (data from Roettiger et al. [2005]).

When analyzing data from weirs, the sampling period is usually stratified into weekly periods (see Figure 7). Within each stratum (or week), the proportion of fish of a given sex or age (p_{ij}) is calculated as

$$\hat{p}_{ij} = \frac{n_{ij}}{n_j} \qquad \text{(eq 1)}$$

where n_{ij} is the number of fish of sex i or age i sampled in week j, and n_j is the total number of fish sampled in week j. Sex or age composition (p_i) for the total run of a species of sex i or age i is calculated as

$$\hat{p}_{ij} = \sum \left(\frac{N_j}{N} \right) \hat{p}_{ij} \qquad \text{(eq 2)}$$

where N_j equals the total number of fish of a given age or sex passing through the weir during week j, and N is the total number of fish of a given species during the run.

Personnel and Operational Requirements

A successful weir project requires a dedicated and professional staff. Typically, projects will be staffed by a crew leader who is a fishery biologist. The crew leader is responsible for the day-to-day operation of the weir, including determination of crew schedules and daily tasks, quality control of data, and overall project performance. Crew members are responsible for following crew leader's instructions of the and ensuring that tasks are completed in a safe manner that is consistent with project objectives. When possible, project personnel should be hired locally from surrounding communities. Locally hired personnel are likely to have personal experience in the area; such practices are an important step in establishing community support for the project.

The number of personnel required to operate a weir depends on the project. Crew members should always work in pairs to ensure safety. If few fish are encountered, a two- or three-person crew may be sufficient to sample fish and maintain the weir. Projects intended to count large numbers of salmon around the clock may require up to eight people.

Equipment

- Weir and traps
- Boats (if needed to reach weir site)
- Dip nets for collecting fish from trap
- Scales and measuring boards
- Sample containers or cards for scale and genetic samples
- Floodlights (for night work)
- Tools and equipment for maintaining or repairing weir
- Camp equipment, including tents and cooking gear
- Safety equipment (fire extinguishers, personal flotation devices, medical kits, etc.)
- Radio, satellite phone, or other means of communication
- Brooms or rakes for cleaning front of weir

Budget Considerations

Estimated costs

Generally there is a positive correlation between project cost and remoteness of the site. Approximate amounts for two differing kinds of weirs (a picket weir and a floating weir) are shown in the following budget breakdown; costs are in U.S. dollars as of 2005.

Item	Quantity	Cost per weir (USD)
Picket weir with one trap	30 m length	$ 65,000
Floating weir with one trap	60 m length	$100,000
Lighting system for river and camp	Varies by project design	$100–2,000
Field gear for remote site (e.g., tents, sleeping bags, stove, water system)	Per person	$1,000

Literature Cited

Anderson, T. C., and B. P. MacDonald. 1978. A portable weir for counting migrating fishes in rivers. Canada Fisheries and Marine Service Technical Report 733.

Balikci, A. 1970. The Nesilik Eskimo. Natural History Press. New York. 276 p.

Blair, A. A. 1956. Counting fence of netting. Transactions of the American Fisheries Society. 86:199–207.

Clay, C. H. 1961. Fences (or weirs) and barrier dams. Pages157–183 in C. H. Clay, editor. Design of fishways and other fish facilities. Queen's Printer, Ottawa.

Cousens, N. B. F., G. A. Thomas, C. G. Swann, and M. C. Healey. 1982. A review of salmon escapement techniques. Canadian Technical Report of Fisheries and Aquatic Sciences 1108.

Fleming, D. F., and J. B. Reynolds. 1991. Effects of spawning-run delay on spawning migration of Arctic grayling. Pages 299–305 in J. Colt and R. J. White, editors. Fisheries bioengineering symposium. American Fisheries Society, Symposium 10, Bethesda, Maryland.

Hill, J. P., and W. J. Matter. 1991. A low-cost weir for salmon and steelhead. The Progressive Fish-Culturist. 53:255–258.

Hubert, W. A. 1996. Passive capture techniques. Pages 157–181 in B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Korman, J., and P. Higgins. 1997. Utility of escapement time series data for monitoring the response of salmon populations to habitat alteration. Canadian Journal of Fisheries and Aquatic Sciences. 54:2058-2067.

Kristofferson, A. H., D. K. McGowan, and W. J. Ward. 1986. Fish weirs for the commercial harvest of searun Arctic charr in the Northwest Territories. Canadian Industry Report of Fisheries and Aquatic Sciences 174.

Mullins, C. C., P. L. Caines, D. Caines, and J. L. Peppar. 1991. A two-compartment fish trap for simultaneously counting downstream and upstream migrants in small rivers. North American Journal of Fisheries Management 11:358–363.

Noltie, D. B. 1987. Fencing material and methods for effectively trapping and holding pink salmon. North American Journal of Fisheries Management 7:159–161.

O'Connell, M. F. 2003. Uncertainty about estimating total returns of Atlantic salmon, *Salmo salar* to the Gander River, Newfoundland, Canada, evaluated using a fish counting fence. Fisheries Management and Ecology 10:23–29.

O'Connell, M. F., and J. B. Dempson. 1995. Target spawning requirements for Atlantic salmon, *Salmo salar L.*, in Newfoundland rivers. Fisheries Management and Ecology 2:161–170.

Roettiger, T. G., F. Harris, and K. C. Harper. 2005. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2004. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2005-7, Kenai, Alaska.

Stewart, H. 1994. Indian fishing: early methods on the Northwest coast. University of Washington Press, Seattle.

Stewart, R. 2002. Resistance board weir panel construction manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Arctic–Yukon–Kuskokwim Region, Regional Information Report No. 3A02-21, Anchorage.

Stewart, R. 2003. Techniques for installing a resistance board fish weir. Alaska Department of Fish and Game, Division of Commercial Fisheries, Arctic-Yukon-Kuskokwim Region, Regional Information Report No. 3A02-21, Anchorage.

Tobin, J. H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 22, Kenai, Alaska.

Whelan, W. G., M. F. O'Connell, and R. N. Hefford. 1989. Improved trap design for counting migrating fish in rivers. North American Journal of Fisheries Management 9:245–248.

Appendix A: Pre-season checklist used to prepare the Kwethluk River weir project, U.S. Fish and Wildlife Service, Kenai, Alaska\

- ❑ Determine Field Schedule ____________
- ❑ Set-up Contract Funding ____________
- ❑ Build New & Replacement Parts ____________
- ❑ Hire Local Crew (see below) ____________
- ❑ Hire USFWS Crew (see below) ____________
- ❑ Coordinate Short-Term Volunteers (see below) ____________
- ❑ Train Crew ____________
- ❑ Issue gear to Crew ____________
- ❑ Crew Schedules to Kwethluk ____________
- ❑ Update Supplies According to Inventory List ____________
- ❑ Initiate Satellite Phone Account ____________
- ❑ Initiate grocery Accounts ____________
- ❑ Initiate Fuel Account ____________
- ❑ Ship Supplies (Consider HazMat Lead-Time) ____________
- ❑ Update Field Procedures ____________
- ❑ Update Emergency Procedures & Acquire Signatures ____________
- ❑ Brief Crew on Emergency Procedures ____________
- ❑ Set-Up Field Computer ____________
- ❑ Make Travel Arrangements ____________
- ❑ Refuge for Bunkhouse arrangements ____________
- ❑ Ship Vehicle, ____________
- ❑ Ship Boat ____________
- ❑ Vehicle Key ____________

Hire Local Crew:	Position	Contact #
❑ 1. ____________	____________	____________
❑ 2. ____________	____________	____________
❑ 3. ____________	____________	____________

Hire USFWS Crew:		
❑ 1. ____________	____________	____________
❑ 2. ____________	____________	____________

Coordinate Short-Term Volunteers:		
❑ 1. ____________	____________	____________
❑ 2. ____________	____________	____________
❑ 3. ____________	____________	____________
❑ 4. ____________	____________	____________

Train Crew:	1st Aid/CPR	Watercraft	Bear/Firearms
❑ 1. ____________	________	________	________
❑ 2. ____________	________	________	________
❑ 3. ____________	________	________	________
❑ 4. ____________	________	________	________
❑ 5. ____________	________	________	________
❑ 6. ____________	________	________	________
❑ 7. ____________	________	________	________

Issue Gear to Crew:	Hip Waders	Chest Waders	Rain Gear	Sleeping Bag	Other
❑ 1. ____________	❑	❑	❑	❑	________
❑ 2. ____________	❑	❑	❑	❑	________
❑ 3. ____________	❑	❑	❑	❑	________
❑ 4. ____________	❑	❑	❑	❑	________
❑ 5. ____________	❑	❑	❑	❑	________
❑ 6. ____________	❑	❑	❑	❑	________

Appendix E – 2009-2013 Interim Flow Release Program, Water Quality Monitoring Plan

This page intentionally left blank

2009 – 2013 Interim Flow Release Program, Water Quality Monitoring Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM

Rev. 11 Feb 2010

Contents

Appendices

Tables

Figures

List of Abbreviations and Acronyms

ºC	degrees Celsius
ºF	degrees Fahrenheit
COC	chain of custody
CVP	Central Valley Project
Delta	Sacramento-San Joaquin Delta
DFG	California Department of Fish and Game
DMO	data management organization
DO	dissolved oxygen
DWR	California Department of Water Resources
EC	Electrical conductance
mg/L	milligrams per liter, equivalent to parts per million
NRDC	Natural Resources Defense Council
PEIS/R	Program Environmental Impact Statement/Report
PMT	Program Management Team
ppb	parts per billion
ppm	parts per million
QA	Quality Assurance
QC	Quality Control
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Regional Board	Central Valley Regional Water Quality Board
SJRRP	San Joaquin River Restoration Program
SOP	standard operating procedure
SWAMP	Surface Water Ambient Monitoring Program
TAC	Technical Advisory Committee
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service

1.0 Summary

The purpose of this document is to describe a program to monitor water quality changes that may occur with the 2010 – 2013 Interim Flow Release Program of the San Joaquin River Restoration Program (SJRRP). This document was prepared by the Flow and Water Quality Monitoring Technical Subgroup[1]. The San Joaquin River Restoration 2009-2013 Interim Flow Release Program Water Quality Monitoring Plan (Monitoring Plan), as proposed, will be conducted by staff of SJRRP Implementing Agencies[2] and will complement independent monitoring by other Federal, State, and private agencies.

This Monitoring Plan is intended to measure the quality of water as it travels from Friant Dam down the San Joaquin River. The flow modifications at Friant Dam are specified in the Stipulation of Settlement[3]. The implementation of the Settlement is authorized under Section 3406(c)(1) of the Central Valley Project Improvement Act (CVPIA) Title 34 (Public Law 102-575) and the San Joaquin River Restoration Settlement Act, included in Public Law 111-11. Publicly available, high quality data are critical for demonstrating compliance with the provisions of the Settlement and determining the impacts that Interim Flows may have on water quality conditions in the river between Friant Dam and the confluence with the Merced River.

The California State Water Resources Control Board issued a Water Rights Order[4] (Order) that authorizes changes to water rights permits needed to implement the Interim Flow Release Program. The Order requires Reclamation to develop a plan for monitoring water quality and sediments at several locations along the river. In June 2009, a draft Fish Management Plan was prepared by the Fishery Management Technical Workgroup[5] that included many recommendations for monitoring water quality for (1) cold, freshwater habitat, (2) migration of aquatic organisms, and (3) spawning, reproduction, and early development. This Monitoring Plan has been designed to meet the requirements of the Water Rights Order and compliment the adaptive management design of the Fish Management Plan.

Several sampling techniques will be used to collect samples of water, including real-time, grab, and composite using autosamplers. The core of the program will be a series of sensors along the river that will make continuous measurements of physical conditions, including flow, depth, temperature, specific conductance (salinity), pH, dissolved oxygen (DO), turbidity, and

[1] U.S. Department of the Interior, Bureau of Reclamation (Reclamation), Fish and Wildlife Service (USFWS), U.S Department of Commerce, National Marine Fisheries Service (NMFS), the California Departments of Water Resources (DWR) and Fish and Game (DFG), and the California Environmental Protection Agency.

[2] Reclamation, USFWS, NMFS, DWR, and DFG

[3] Natural Resources Defense Council, et al. v. Kirk Rodgers, as Director of the Mid-Pacific Region of the U. S. Bureau of Reclamation, et al. September 13, 2006. Stipulation of Settlement. U. S. District Court, Eastern District of California (Sacramento Division).

[3] California Environmental Protection Agency, State Water Resources Control Board, September 30, 2009. Order WR 2009-0058-DWR Temporary transfer of Water and Change Pursuant to Water Code Sections 1725 and 1707.

[4] SJRRP, June 2009. Draft Fisheries Management Plan: A Framework for Adaptive Management in the San Joaquin River Restoration Program

chlorophyll. The locations of these real-time sites are listed in Table 1. The data will be averaged every 15 minutes and then sent via satellite to the Internet as preliminary data. Raw data will be posted by the California Data Exchange Center (*www.cdec.water.ca.gov*) and linked to the SJRRP website.

Grab samples of water and bed sediments will be collected at the sites listed in Tables 2 and 3 of this Monitoring Plan. The proposed schedule for collecting these samples is shown in Table 4. The proposed list of parameters to be measured at each site are listed in Table 5.

Note: the location and frequency of sampling and the list of parameters are proposed and are subject to revision according the needs of the Implementing Agencies. For example, water samples may be collected at other places of importance for fish passage and survival. Such changes will occur as needed with guidance from the Fishery Management Work Group.

We recommend that monitoring data be compiled and published by an independent data management organization. Annual synthesis reports will be written by staff of the Implementing Agencies.

2.0 Title

San Joaquin River Restoration Program

2010 – 2013 Interim Flow Release Water Quality Monitoring Plan

3.0 Background

Friant Dam is located on the San Joaquin River near Fresno, California. The United States Bureau of Reclamation (Reclamation) has diverted water from the river below the dam since 1952 to irrigate more than a million acres of farmland that produce a variety of crops worth over $2.5 billion annually. Numerous communities depend on Friant water, such as the City of Fresno, and it is the sole source of water for the small communities of Friant, Orange Cove, Lindsay, Strathmore and Terra Bella. These diversions have removed most of the water from the river, and many times the river has been dry at Gravelly Ford, about 40 miles below the dam.

Degraded water quality in various segments of the San Joaquin River has been a serious problem for several decades due to low river flows and discharges from agricultural areas, wildlife refuges, and municipal waste water treatment plants. Degraded water quality has been identified as a potential limiting factor for Chinook salmon and other native fishes. Constituents such as pesticides and other urban and agricultural wastes may affect water quality parameters such as DO and turbidity, creating habitat unsuitable for Chinook salmon.

In 1998, the Central Valley Regional Water Quality Control Board (Regional Board) adopted a Water Quality Control Plan[6] for the Sacramento and San Joaquin River basins (Basin Plan) as the regulatory reference for meeting Federal and State requirements. Specific water quality standards associated with the lower San Joaquin River apply to boron, molybdenum, selenium, dissolved oxygen, pH, pesticides, and salinity, as measured at Vernalis and other locations along the San Joaquin River as it enters the Delta. One of the high priority issues of the Basin Plan review is the regulatory guidance for total maximum daily load (TMDL) standards at locations along the San Joaquin River. Mud and Salt Sloughs, which flow into the San Joaquin River upstream from the Merced River, and the San Joaquin River from Mendota Pool downstream to Vernalis are listed as impaired water bodies.

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 administered by Reclamation 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 settlement was reached[7]. 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 planning and environmental review necessary to implement the Settlement is authorized under Section 3406(c)(1) of the Central Valley Project Improvement Act (CVPIA) Title 34, (Public Law 102-575) and the San Joaquin River Restoration Settlement Act, included in Public Law 111-11. The Secretary of the Interior is authorized and directed to implement the terms and conditions of the Settlement through the Act.

The San Joaquin River Restoration Program (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 and restore a self-sustaining Chinook salmon fishery in the river while reducing or avoiding adverse water supply from the restoration flows. The SJRRP will be implemented by Reclamation, the California Department of Water Resources (DWR), the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), and the California Department of Fish and Game (DFG), known as the Implementing Agencies..

The Settlement has two primary goals:

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

[6] California Regional Water Quality Control Board, Central Valley Region, Revised February 2007. The Water Quality Control Plan (Basin Plan) for the Central Valley Region, Fourth Edition. The Sacramento River Basin and the San Joaquin River Basin.

[7] Natural Resources Defense Council, et al. v. Kirk Rodgers, as Director of the Mid-Pacific Region of the U. S. Bureau of Reclamation, et al. September 13, 2006. Stipulation of Settlement. U. S. District Court, Eastern District of California (Sacramento Division).

- 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.

Increasing flows in the San Joaquin River from Friant Dam to the Merced River and downstream reaches could improve water quality conditions under various hydrologic conditions in some reaches of the river. Opportunities to improve water quality in the San Joaquin River will be identified and evaluated to the extent that they are consistent with actions that address the Restoration and Water Management goals.

Sources of adverse water-quality conditions and whether or not SJRRP releases will improve water quality are unknown. Evaluating and taking management actions for these conditions may be necessary to successfully meet the Restoration Goal. All life stages of Chinook salmon could be affected.

It is expected that the monitoring framework described below will enable the collection of information required for real-time decision making and evaluate the success of the SJRRP and its objectives.

Figure 4 is an organizational chart for the SJRRP. This monitoring plan has been developed and will be implemented by members of the Flow and Water Quality Monitoring Subgroup. Technical issues will be resolved by the Fishery Management Workgroup. Policy issues will be resolved by the Program Manager with guidance from the Program Management Team (PMT) and independent Technical Advisory Committee (TAC). The roles and responsibilities are described in Paragraph 18 of the Settlement and the 2007 Program Management Plan[8]. To facilitate real-time management decisions by the Program Manager, the Implementing Agencies will compile and assess current information regarding water operations, Chinook salmon and other fish condition, such as stages of reproductive development, geographic distribution, relative abundance, and physical habitat conditions.

The SJRRP will coordinate with land owners, irrigation districts, and other relevant entities to identify water quality improvement opportunities associated with implementing the SJRRP.

3.1 Beneficial Uses

The data collection and analysis performed for the release of the Interim Flows Program has the potential to provide a broad range of beneficial uses including fisheries. Fisheries resources in the area associated with existing native species and proposed reintroduction of Chinook salmon stand to benefit from the knowledge of general trends in water quality, flow and temperature. Specific information has the ability to tell fisheries experts what environmental conditions are present and allow them to make more informed decisions to manage fish species.

[8] San Joaquin River Restoration Program, May 1, 2007. Program Management Plan.

3.2 Study Area

The Study Area for this Monitoring Plan (Figure 1) encompasses over 152 miles of the San Joaquin River from Millerton Lake to the Merced River confluence. This Monitoring Plan will also incorporate data from other agencies involved with planning and implementation efforts along the San Joaquin River to evaluate regional effects of the restoration effort.

The river is divided in the five reaches between Friant Dam and the confluence with the Merced River (Figures 4 to 8) with different hydrologic features:

Reach 1	River Miles 268 – 225	Friant Dam to Gravelly Ford
Reach 2	River Miles 225 – 205	Gravelly Ford to Mendota Dam
Reach 3	River Miles 205 – 182	Mendota Dam to Sack Dam
Reach 4	River Miles 182 – 136	Sack Dam to Bear Creek
Reach 5	River Miles 136 – 118	Bear Creek to Merced River

Figure 2 is a diagram that shows the locations of the real-time monitoring stations with respect to major tributaries to and diversions from the San Joaquin River. The real-time monitoring stations are summarized in Table 1.

Figure 3 is a diagram showing the locations of water and sediment monitoring sites, listed in Tables 2 and 3.

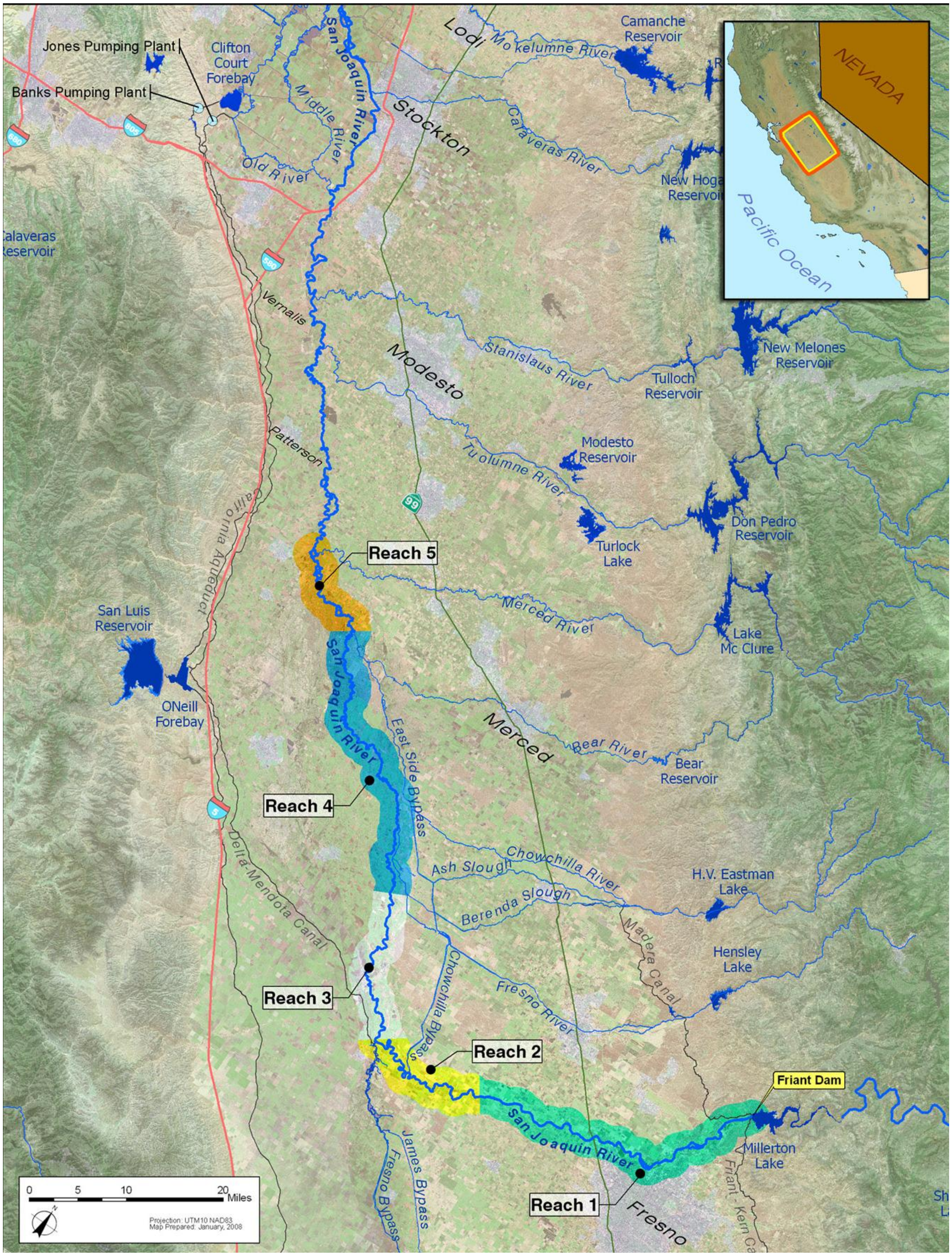


Figure 1.
Location Map – San Joaquin River Restoration Program Showing Five Reaches of the Study Area Between Friant Dam and the Confluence with the Merced River

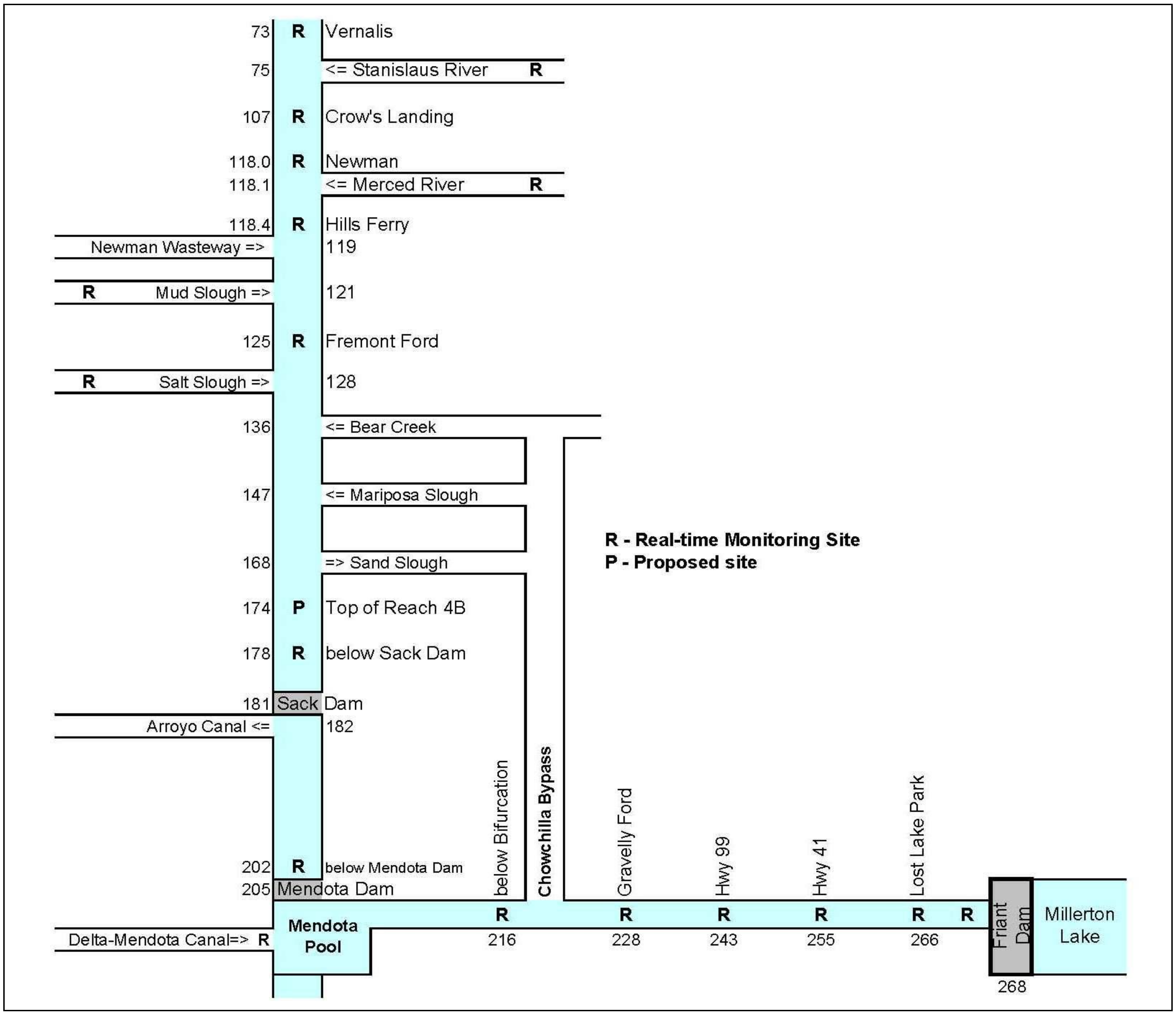


Figure 2.
Diagram of the San Joaquin River from Friant Dam to the Merced River Showing Real-time Monitoring Sites

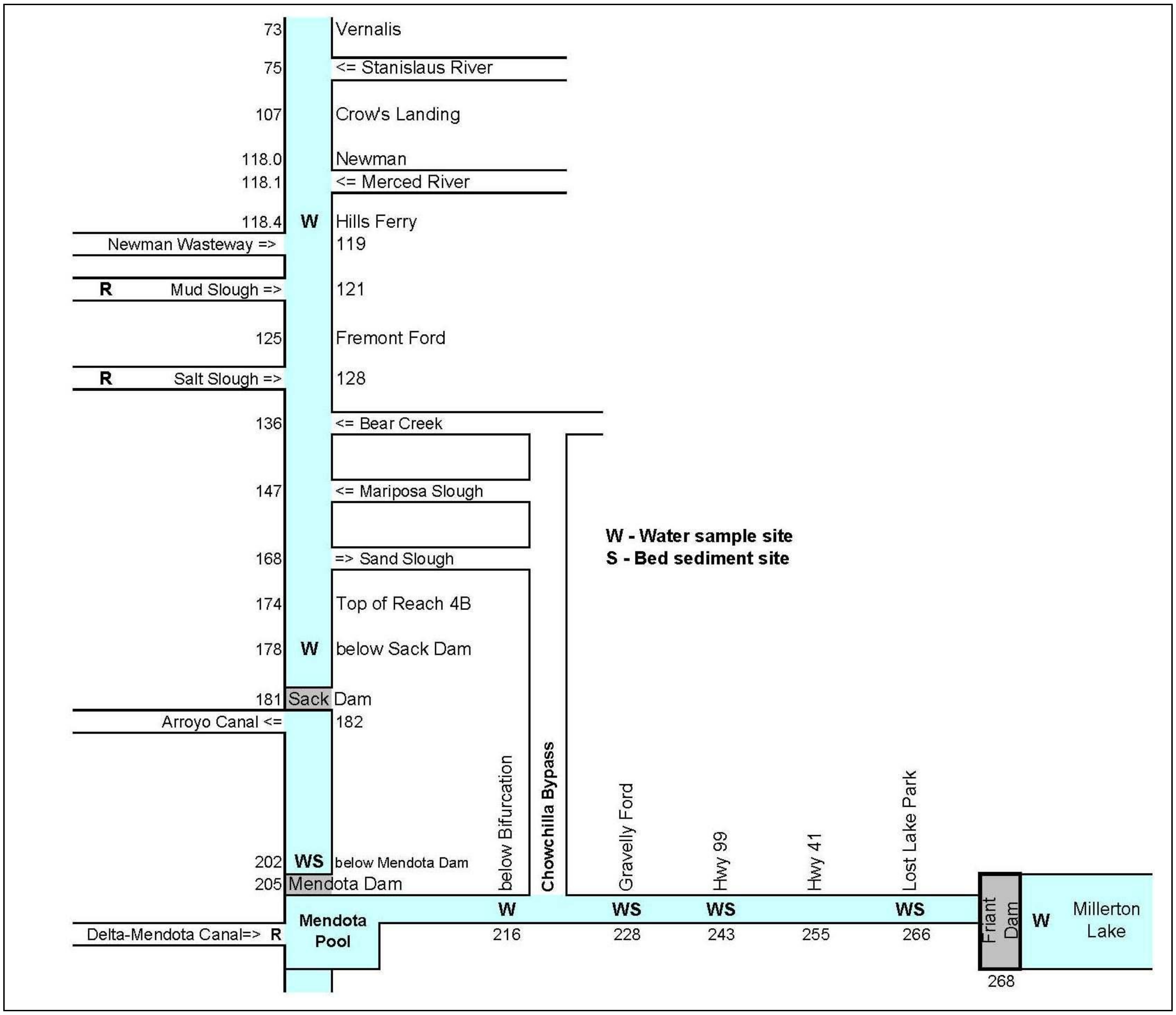


Figure 3.
Diagram of the San Joaquin River from Friant Dam to the Merced River Showing Water and Sediment Monitoring Sites

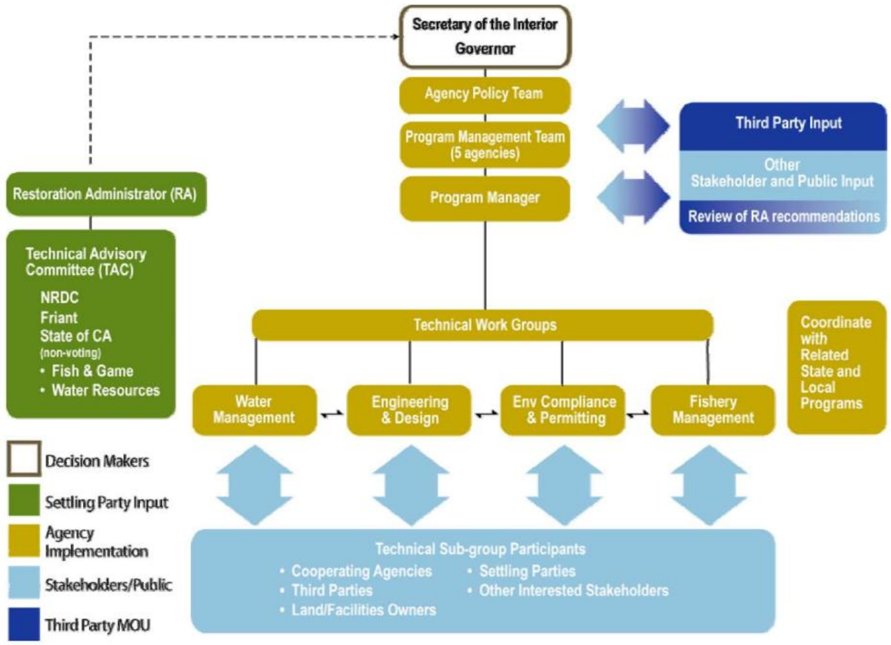


Figure 4.
SJRRP Organization Chart

Table 1. Real-Time Water Quality Monitoring Sites

River Mile	Location	Operating Agency	CDEC	Stage	Flow	EC	Temperature	DO	Turbidity	Chlorophyll
268.0	Millerton Lake	Reclamation	MIL	C	C					
267.6	San Joaquin River at Friant Dam (bottom of spillway)	Reclamation	X			C	C	C	C	C
266.0	San Joaquin River below Friant Dam (Lost Lake Park)	USGS	SJF	C	C	C	C			
255.2	San Joaquin River at Highway 41	Reclamation	H41	C		C	C			
240.7	San Joaquin River at Donny Bridge	Reclamation	DNB	C	C	C	C			
227.6	San Joaquin River at Gravelly Ford	Reclamation	GRF	C	C	C	C	P	P	P
216.0	San Joaquin River below bifurcation	Reclamation	SJB	C	C	C	C	P	P	P
211.8	San Joaquin River at San Mateo Road	Reclamation	P	P	P	P	P			
202.1	San Joaquin River near Mendota (below Mendota Dam)	USGS	MEN	C	C					
181.5	San Joaquin River near Dos Palos (below Sack Dam)	DWR	SDP	C	C	C	C	C	C	C
168.4	San Joaquin River at top of Reach 4B	DWR	P	C	C	C	C	C	C	C
125.1	San Joaquin River at Fremont Ford Bridge	USGS	FFB	C	C	C	C			
118.3	San Joaquin River at Hills Ferry	USGS	P	C	C	C	C	P	P	P
118.0	San Joaquin River near Newman (below Merced River)	USGS	NEW	C	C					
107.2	San Joaquin River near Crows Landing	USGS	SCL	C	C	C	C			

Notes: C- continuous measurements

P – Proposed sites, scheduled to operate in 2010

X – Sonde installed, not linked to CDEC

Table 2. Water Quality Monitoring Sites

River Mile	Monitoring Site	Reach	TSS	Nutrients	TOC/DOC	Bacteria	Anions and cations	Trace Elements	Pesticides
266.0	SJR below Friant Dam (Lost Lake Park)	1A	X	X	X	X	X	X	TBD
243.2	SJR at Highway 99 (Camp Pashayan)	1A	X	X	X	X	X	X	TBD
227.1	SJR at Gravelly Ford	2A	X	X	X	X	X	X	TBD
205.1	SJR below Mendota Dam	3	X	X	X	X	X	X	TBD
173.9	SJR at Highway 152	4A	X	X	X	X	X	X	TBD
125.1	SJR at Fremont Ford	5		X	X	X	X	X	TBD
118.3	SJR at Hills Ferry	5	X	X	X	X	X	X	TBD
107.2	SJR at Crows Landing			X	X	X	X	X	TBD

Sampling Frequency: Weekly during February 2010, Monthly through December 2010
TSS – Total suspended solids
TOC/DOC – Total and dissolved organic carbon
Nutrients: Total nitrogen, ammonia, nitrates, nitrites, total Kjeldal nitrogen, total phosphate, chlorophyll
Bacteria: Total Coliform
Anions: Alkalinity, bicarbonates, carbonates, chloride, sulfates
Cations: Calcium, magnesium, potassium, sodium
Trace elements: Arsenic, boron, copper, chromium, lead, mercury, molybdenum, nickel, selenium, zinc
Pesticides: to be determined

Table 3. Bed Sediment Monitoring Sites

River Mile	Monitoring Site	Reach	TOC	Trace elements	Pesticides	Toxicity
226.0	SJR below Friant Dam (Lost Lake Park)	11	X	X	TBD	TBD
227.1	SJR at Gravelly Ford	2A	X	X	TBD	TBD
211.8	SJR at San Mateo Road	2B	X	X	TBD	TBD
206.0	Mendota Wildlife Management Area	2B	X	X	TBD	TBD
205.5	Mendota Pool (above Mendota Dam)	2B	X	X	TBD	TBD
205.1	SJR below Mendota Dam	3	X	X	TBD	TBD
174.1	SJR at Highway 152	4A	X	X	TBD	TBD
118.3	SJR at Hills Ferry	5	X	X	TBD	TBD

Sampling Frequency: April and October 2010
TOC – Total organic carbon
Trace elements: Arsenic, boron, copper, chromium, lead, mercury, molybdenum, nickel, selenium, zinc
Pesticides: to be determined
Toxicity: to be determined

San Joaquin River Restoration Program
2010 Monitoring Program
Table 4 Sample Schedule

	Millerton Lake	SJR below Friant Dam (Lost Lake Park)	SJR at Gravelly Ford	SJR at San Mateo ford	Mendota WMA	Mendota Pool (above Mendota Dam)	SJR below Mendota Dam	SJR below Sack Dam	SJR at HWY 152	SJR at Fremont Ford	SJR at Hills Ferry	SJR at Crows Landing
Milepost	268	265	227.6	211.9		205.1	204.8	181.9	173.9	125.1	118.3	107.1
Thursday, February 04, 2010		W										
Wednesday, February 10, 2010		W	W							G		G
Wednesday, February 17, 2010		W	W							G		G
Wednesday, February 24, 2010		W	W				W			G		G
Wednesday, March 03, 2010		W	W				W	W		G		G
Wednesday, April 07, 2010		W,S	W,S	S	S	S	W,S		W,S	G	W,S	G
Wednesday, May 05, 2010		W	W				W		W	G	W	G
Wednesday, June 09, 2010		W	W				W		W	G	W	G
Wednesday, July 07, 2010		W	W				W		W	G	W	G
Wednesday, August 04, 2010		W	W				W		W	G	W	G
Wednesday, September 01, 2010		W	W				W		W	G	W	G
Wednesday, October 06, 2010		W,S	W,S	W,S	W,S	W,S	W,S		W,S	G	W,S	G
Wednesday, November 03, 2010		W	W				W		W	G	W	G
Wednesday, December 08, 2010		W	W				W		W	G	W	G

2010 Interim water
No Interim water at this site
Dry
Sample collected
W - water sample
S - sediment sample
G - Grassland Bypass Project

San Joaquin River Restoration Program
2010 Monitoring Program
Table 5 List of Parameters

Media	Analyte		Units
Water		Total Suspended Solids	mg/L
	Nutrients	Ammonia as N	mg/L
		Nitrate as N	mg/L
		Nitrite as N	mg/L
		Phosphates	mg/L
		Phosphorous, total	mg/L
		Total Kjeldal nitrogen	mg/L
		Total nitrogen	mg/L
		Chlorophyll A	mg/L
		Total Organic Carbon	mg/L
		Dissolved Organic Carbon	mg/L
	Bacteria	Total coliform	#/100ml
	Anions	Chloride	mg/L
		Alkalinity	mg/L
		Carbonate	mg/L
		Bicarbonate	mg/L
	Metals	Calcium	mg/L
		Magnesium	mg/L
		Potassium	mg/L
		Sodium	mg/L
		Arsenic, total	µg/L
		Chromium, total	µg/L
		Copper, total	µg/L
		Lead, total	µg/L
		Nickel, total	µg/L
		Zinc, total	µg/L
		Selenium, total	µg/L
		Mercury, total	ng/L
	Pesticides	organochlorine scan	µg/L
		pyrethroid scan	µg/L
		carbamates	µg/L
		organophosphates	µg/L
	Field Measurements	pH	units
		Conductivity	µS/cm
		Turbidity	NTU
		Dissolved oxygen	mg/L
		Temperature	oC

Sediment		Grain Size analysis	
		Total Organic Carbon	mg/L
	Metals	arsenic	mg/L
		chromium	mg/L
		copper	mg/L
		lead	mg/L
		mercury	mg/L
		nickel	mg/L
		Percent moisture	%
		zinc	mg/L
	Pesticides	Organochlorine scan	ug/L
		Pyrethroid scan	ug/L
	Acute toxicity	percent survival	%
		Sample dry weight	mg
		TIE	

4.0 Study Methods and Materials

4.1 Monitoring Design

The objectives of this Monitoring Plan follow the regulatory requirements set forth in the Water Rights Order WR 2009-0058-DWR (Order), which discusses the need for water quality monitoring and Monitoring Plan development (See Appendix B). The primary objective of this Monitoring Plan is to obtain high quality data to support the SJRRP and to meet the terms of the Order.

Reclamation will be responsible for the purchase and use of all materials associated with this Monitoring Plan. Most sampling equipment will be owned and operated by Reclamation staff. Reclamation's Quality Assurance Officer will be responsible for training of all field staff and verification of methods and results.

The Monitoring Plan provided in this document is compliant with the Surface Water Ambient Monitoring Quality Assurance Monitoring Program (SWAMP) guidelines.

4.2 Adaptation to Real-Time Conditions

Given the uncertainty associated with restoration of Chinook salmon and native fish populations to the San Joaquin River, and complexity of the SJRRP, a real-time management program is needed to ensure the SJRRP can be flexible, adjusting as new information becomes available. The response of reestablished Chinook salmon and other fishes to physical factors such as temperature, streamflow, climate change, and the impacts of various limiting factors is unknown.[9]

Real-time management will allow decision makers to take advantage of a variety of strategies and techniques that are adjusted, refined, and/or modified based on an improved understanding of system dynamics. SJRRP restoration actions are restricted to the Restoration Area, thus limiting the application of real-time management on an ecosystem-wide basis. Thorough monitoring and evaluation of real-time management actions are critical to successful learning and resolution of scientific uncertainties. Results of monitoring and evaluation will be used to redefine problems, reexamine goals, and/or refine conceptual and quantitative models, to ensure efficient learning and adaptation of management techniques.

By using real-time management, the SSJRP will respond and change the implementation and management strategy as new knowledge is gained. This real-time management approach will (1) maximize the likelihood of success of actions, (2) increase learning opportunities, (3) identify data needs and reduce uncertainties, (4) use the best available information to provide technical

[9] SJRRP, June 2009. Draft Fisheries Management Plan, Page 1-3

support and increase the confidence in future decisions and recommendations, and (5) prioritize management actions.

4.3 Indicators and Measurement Parameters

The following sections describe the parameters for real-time and laboratory measurement of water quality, as well as methods for quality control, data management, and data reporting.

4.3.1 Real-Time Water Quality Monitoring Parameters

Parameters that will be monitored on a real-time basis at the stations discussed above for this Monitoring Plan are described below. Methods of measurement, along with range, resolution, and accuracy of specified sensors are provided in Table 2.

Temperature

Temperature is a physical property of a system measured in degrees Fahrenheit (ºF) or Celsius (ºC). Temperature is a critical parameter for various life stages of salmonids.

Salinity

Salinity is a measure of dissolved elements in water. It is the sum weight of many different elements within a given volume of water, reported in milligrams per liter (mg/L) or parts per million (ppm). Salinity is an ecological factor of considerable importance, influencing the types of organisms, such as plants and fish, that live and grow in a body of water. Salinity can be estimated by measuring the specific conductance (SC) of water.

Dissolved Oxygen

In aquatic environments, DO is a measure of the amount of oxygen (O_2) dissolved in water. Super saturation can sometimes be harmful for organisms and can cause decompression sickness. Lack of dissolved oxygen is also harmful. DO is measured in standard solution units such as millimoles O_2 per liter (mmol/L) or milligrams O_2.

pH

The property of pH is a measure of the acidity or alkalinity of a solution given by the concentration of hydrogen ions. Values of pH in water are commonly in the range 0 to 14 units. Aqueous solutions at 25°C with a pH of less than 7 are considered acidic, while those with a pH of greater than 7 are considered basic (alkaline). When a pH level is 7.0, it is defined as “neutral” at 25°C. The pH reading of a solution is usually obtained by comparing unknown solutions to those of known pH.

Turbidity

Turbidity is the cloudiness or haziness of a fluid, caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality.

Chlorophyll

Chlorophyll, in various forms, is bound within the living cells of algae and other phytoplankton found in surface water. Chlorophyll is a key biochemical component in the molecular apparatus that is responsible for photosynthesis, the critical process in which the energy from sunlight is used to produce life-sustaining oxygen. In the photosynthetic reaction, carbon dioxide is reduced by water, and chlorophyll assists this transfer.

Algae refer to simple aquatic organisms, such as seaweed, pond scum, and plankton, that are plantlike and contain chlorophyll. For *in-situ* monitoring, the measured parameter is the chlorophyll contained within the phytoplankton.

Monitoring chlorophyll levels is a direct way of tracking algal growth as an indicator organism for the health of a particular body of water.

When algae populations bloom, then crash and die in response to changing environmental conditions, they deplete DO levels – a primary cause of most fish kills. High levels of nitrogen and phosphorus can be indicators of pollution from manmade sources, such as septic system leakage, poorly functioning wastewater treatment plants, or fertilizer runoff. Thus, chlorophyll measurement can be used as an indirect indicator of nutrient levels.

The most widely used measure of phytoplankton biomass is chlorophyll a. It has several advantages as a measure of phytoplankton biomass, including (1) the measurement is relatively simple and direct, (2) it integrates cell types and ages, (3) it accounts to some extent for cell viability, and (4) it can be quantitatively coupled to important optical characteristics of water.

Table 6. Real-Time Monitoring Physical Parameters

Temperature	
Method	Digital thermometer (YSI 6600 sonde)
Range	-5 to +45 ºC
Resolution	0.01 ºC
Accuracy	± 0.15 ºC
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
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
pH	
Method	Digital probe (YSI 6600 sonde)
Range	0 to 14 units
Resolution	0.01 unit
Accuracy	± 0.2% unit
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
Chlorophyll	
Method	Digital sensor (YSI 6600 sonde)
Range	0 to 400 µg/L
Resolution	0.1 µg/L Chlorophyll; 0.1% FS
Depth	200 feet

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

4.3.2 Sampling For Laboratory Analyses 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. Reclamation will execute contracts with select laboratories that have met its standards of quality assurance and data validity.

Constituents

The complete list of constituents to be measured at various sites along the SJRRP study area will be determined as needed by relevant scientific personnel for fish and water management purposes. Parameters may include selenium, mercury, boron, nutrients, and other compounds that cannot be measured with field sensors.

Sampling Methods

Grab samples may be collected using a stainless steel sampling device. This device is a cage on a pole that holds the sampling bottle. Grab samples may also 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. Reclamation will specify the sampling details in a Quality Assurance Project Plan to be prepared for the SJRRP. Details will include sample volume, correct container, preservative, and handling. Some samples will require immediate delivery to the analytical lab. Reclamation will train field staff to collect samples.

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. Reclamation will train field staff to conduct this sampling method.

Time composite samples, if needed, will be collected using an autosampler. Daily composite samples typically consist of two 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 Regional Water Quality Control Board (Central Valley RWQCB) currently use autosamplers to collect daily composite samples from the Delta-Mendota Canal, San Luis Drain, and San Joaquin River at Crows Landing. Reclamation staff will be available to deploy and operate autosamplers as needed to support the SJRRP.

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. Reclamation will train field staff to complete COC forms.

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.

4.4 Data Analysis and Assessment

The SJRRP Streamflow and Water Quality Monitoring Subgroup will have regular conference calls to discuss updates and data related to the release of flows from Friant Dam and the related information collected from the San Joaquin River as water moves through the existing channel. Compilations of data will be reviewed by the Subgroup to identify trends and justify changes to the Monitoring Plan and implement real-time management strategies.

An annual meeting will occur with Interagency staff to review collected water quality monitoring data, to analyze the general trends, and to write an annual report that summarizes the findings.

4.5 Data Collection and Frequency of Sampling

Interim Flow water will be tracked and sampled at several sites along the river as specified in the Water Rights Order and for the benefit of fishery management. The foundation of this Monitoring Plan will be a series of sensors located along the study area that will provide real-time measurements of physical conditions (Table 1). The sondes will measure stage (depth), flow, specific conductance, temperature, dissolved oxygen, and pH. The locations of the sensors are listed in Table 1 and are shown on Figure 3.

Routine samples of water will be collected at the sites listed in Table 2 for analyses of various parameters required by the Water Rights Order. Other sites will be added to support fish management research. The frequency of sampling and analytical parameters will be is based on initial findings from the 2009 Interim Flow Water Quality Monitoring, the requirements of the Order, and recommendations from the SJRRP Streamflow and Water Quality Monitoring Subgroup.

Additional water quality monitoring locations may be warranted as new site conditions dictate. Therefore, this list may be revised based upon future data needs.

4.6 Spatial and Temporal Scale

4.6.1 Reach 1

There are five monitoring sites within Reach 1.

River Mile 267.6 San Joaquin River at Friant Dam

Description	**The station is located at the base of Friant Dam.**
Purpose	To measure the initial volume, temperature, and quality of water released from the dam into the river for riparian diversions and the SJRRP.
Responsible Agency	Reclamation, Friant Dam office, is responsible for operation of the dam and will maintain this sonde.
Equipment	Multi-parameter sonde, linked to CDEC via satellite.

Note: The sonde will not be connected to CDEC; used for training Reclamation staff.

River Mile 266.0 San Joaquin River below Friant Dam (Lost Lake Park)

Description	**The station will be located near the existing USGS flow monitoring site in Lost Lake Park.**
Purpose	To measure the quality of water released from the dam into the river for riparian diversions and the SJRRP. Sediment will be collected here.
Operating Agency	USGS will operate the real-time sonde. Reclamation (MP-157) will collect water samples.
Existing Equipment	Stage recorder, linked to CDEC via satellite.
Revision	Candidate site for autosampler for baseline water quality for fish habitat

River Mile 244.2 San Joaquin River at Highway 41

Description	**This site is located about 13 miles downstream from Friant Dam, below sand and gravel pits and urban storm drains.**
Purpose	To measure the quality of water in the river near possible sources of turbidity, nutrient, and pesticide contamination
Operating Agency	Reclamation, Friant
Existing Equipment	Multi-probe sonde
Modifications	Candidate site for water quality monitoring for fish habitat

River Mile 243.1 San Joaquin River at Highway 99 (Camp Pashayan)

Description	**This site is located about 25 miles downstream from Friant Dam, below several golf courses.**
Purpose	To measure the quality of water in the river near possible sources of nutrient and pesticide contamination.
Operating Agency	Reclamation (MP-157) will collect water samples here.
Existing Equipment	None
Modifications	Candidate site for water quality monitoring for fish passage

River Mile 240.7 San Joaquin River at Donny Bridge

Description	**This site is located about 28 miles downstream from Friant Dam, below vineyards urban storm drains.**
Purpose	To measure the quality of water in the river near possible sources of turbidity, nutrient, and pesticide contamination
Operating Agency	Reclamation, Friant
Existing Equipment	Multi-probe sonde
Modifications	Candidate site for water quality monitoring for fish passage

4.6.2 Reach 2

There are three water quality sites within Reach 2.

River Mile 227.6 San Joaquin River at Gravelly Ford

Description	**This site is located about 40 miles downstream from Friant Dam, where the last riparian diversion occurs; from here, the Restoration Flows will sustain the river.**
Purpose	To measure the volume and temperature of water in the river. Sediment will be collected here.
Operating Agency	Reclamation, Friant Dam office.
Existing Equipment	Stage recorder, multiple parameter sonde, linked to CDEC via satellite.

River Mile 216.0 San Joaquin River below Chowchilla Bifurcation

Description	**This site is located about 52 miles downstream from Friant Dam, below the Chowchilla Bypass. This is a flood control channel and inlet to the Mendota Pool.**
Purpose	To measure the volume and temperature of water in the river.
Operating Agency	Reclamation, Friant Dam office.
Existing Equipment	Stage recorder, multiple parameter sonde linked to CDEC via satellite.

River Mile 211.8 San Joaquin River at San Mateo Road

Description	**This site is located about 56 miles downstream from Friant Dam, above the Mendota Pool.**
Purpose	To measure the volume and temperature of SJRRP entering the Mendota Pool. Sediment will be collected here.
Operating Agency	Reclamation, Friant Dam office.
Existing Equipment	Stage recorder, multiple parameter sonde linked to CDEC via satellite.

Note: Proposed site to be installed in 2010.

Sediment sample will be collected from the Mendota Wildlife Management Area and the Mendota Pool above Mendota Dam to measure the changes resulting from the delivery of SJRRP water to the area.

4.6.3 Reach 3

There is two SJRRP monitoring sites in Reach 3. In addition to the station described below, Reclamation will operate two water quality stations that measure the quality of water in the Mendota Pool: Delta-Mendota Canal Check 21, and Central California Irrigation District Main Canal headworks at Bass Avenue. Data from these sites will be integrated into this Monitoring Plan.

River Mile 205.2 San Joaquin River below Mendota Dam

Description	**The Mendota Dam impounds water from the Kings River, San Joaquin River, and Delta-Mendota Canal. The blend of waters varies in volume and quality. Water is delivered to agriculture and wildlife refuges.**
Purpose	To measure the quality of water in the river. Sediment will be collected here.

Operating Agency	Reclamation (MP-157)
Existing Equipment	None
Revision	Candidate site for an autosampler.

River Mile 202.1 San Joaquin River below Mendota Dam

Description	**The water is a blend from the Kings River, San Joaquin River, and Delta-Mendota Canal that varies in volume and quality.**
Purpose	Real-time measurements of volume, temperature, and salinity of water in the river.
Operating Agency	USGS
Existing Equipment	Stage recorder, linked to CDEC.
Revision	Add multiple parameter sonde and autosampler; connect power supply.

4.6.4 Reach 4

The four SJRRP monitoring stations in Reach 4 are described below. In addition, flow and water quality data collected by the USGS and Regional Board at Salt Slough at Lander Avenue may be used by the SJRRP. The USGS measures flow, electrical conductivity (EC), and temperature at this site, and the Regional Board collects water samples each week to analyze selenium and boron. DWR also collects flow data in the river at Lander Avenue (Highway 165).

River Mile 182.0 San Joaquin River below Sack Dam

Description	**This is a major point of diversion of water to agriculture and wildlife refuges. SJRRP flows will sustain the river below this point.**
Purpose	To measure the water quality in the river.
Operating Agency	Reclamation MP-157
Existing Equipment	None

River Mile 181.5 San Joaquin River near Dos Palos

Description	**This is in another portion of the river to be restored with SJRRP flows. The reach is contaminated with agricultural return flows.**
Purpose	Real-time measurements of volume, temperature, and salinity of water in the river.
Operating Agency	DWR
Existing Equipment	Stage recorder, multi-probe sonde, linked to CDEC.

River Mile 173.9 San Joaquin River at Highway 152

Description	**This is in another portion of the river to be restored with SJRRP flows. The reach is contaminated with agricultural return flows.**
Purpose	To measure the water and sediment quality in the river.
Operating Agency	Reclamation MP-157
Existing Equipment	None

River Mile 168.4 San Joaquin River at Top of Reach 4B

Description	**This is in another portion of the river to be restored with SJRRP flows. The reach is contaminated with agricultural return flows.**
Purpose	Real-time measurements of volume, temperature, and salinity of water in the river.
Operating Agency	DWR
Existing Equipment	Stage recorder, multi-probe sonde, linked to CDEC.

4.6.5 Reach 5

There are two monitoring stations for the SJRRP in Reach 5. Water quality data collected by other agencies at tributaries to the San Joaquin River near Reach 5 may be used by the SJRRP. At Mud Slough near Gustine, USGS measures EC and temperature, while Regional Board collects water samples each week to analyze selenium and boron. When water is released from the Delta-Mendota Canal to the San Joaquin River through the Newman Wasteway, Reclamation will monitor water quality and toxicity in the Newman Wasteway and San Joaquin River.

River Mile 125.1 San Joaquin River at Fremont Ford Bridge

Description	**The river at this site receives water from local farms and refuges and Salt Slough (Grassland Bypass Project Station G).**
Purpose	To measure flow and quality of water in Reach 5.
Operating Agency	Flow, EC, temperature: USGS Other parameters: Regional Board (weekly) Biota: DFG (quarterly)
Existing Equipment	GOES station, linked to CDEC.
Revision	Upgrade existing multiple parameter sonde to measure turbidity and dissolved oxygen.

Note: This site is part of the Grassland Bypass Project. Based on available funds, Reclamation will continue to fund monitoring of flow, salinity, temperature, selenium, nutrients, and biota. These data will be incorporated in the SJRRP Monitoring Plan.

River Mile 118.3 San Joaquin River at Hills Ferry

Description	**The site is located at Hills Ferry, about one half-mile upstream from the confluence of the Merced River (Grassland Bypass Project Site H).**
Purpose	This is where the net volume of water attributed to SJJRP Flows will be measured. Many biological and water quality parameters have been measured here for with the Grassland Bypass Project.
Operating Agency	Flow, EC, temperature: USGS Selenium, boron: San Luis & Delta-Mendota Water Authority Biota: DFG (quarterly)
Existing Equipment	GOES station, linked to CDEC; autosampler site

Note: Weekly grab samples for selenium and boron are collected for Grassland Bypass Project. Quarterly biota monitoring.

4.6.6 San Joaquin River Below Merced River

We will compile data from two sites located below the Merced River confluence, downstream from Reach 5.

River Mile 118.1 San Joaquin River at Newman

Description	**The river at this site receives water from the san Joaquin River and Merced River.**
Purpose	To measure flow and quality of water below .
Operating Agency	Flow, EC, temperature: USGS
Existing Equipment	GOES station, linked to CDEC.

River Mile 107.1 San Joaquin River at Crows Landing

Description	**This is a water quality monitoring site for the Grassland Bypass Project.**
Purpose	Assess net benefit to lower San Joaquin River from SJRRP; compare with long history of flow and water quality data.
Operating Agency	Flow, EC, temperature: USGS Water quality: Regional Board
Existing Equipment	GOES station, linked to CDEC, autosampler on dock.

4.7 Data Management

Each Implementing Agency and contractor collecting data for the 2009-2013 Interim Flows Water Quality Monitoring Plan shall be responsible for its own data reduction (analysis), internal data quality control, data storage, and data reporting. Each will provide its data to the independent data management organization (DMO) for compilation, publication, and distribution of printed copies. We recommend that the DMO be a non-profit[10] or academic institution[11].

The 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 will specify formats for final reports. Reclamation will coordinate the Implementing Agencies and the DMO to ensure compliance with suggested data dissemination procedures and formats.

All data collected under this Monitoring Plan will be compatible with the 2005 Surface Water Ambient Monitoring Program (SWAMP) Information Management Plan.

Data will be labeled according to accuracy and degree of verification:

[10] The San Francisco Estuary Institute handles data and reporting for the Grassland Bypass Project under a grant from Reclamation.

[11] I.e., the California Water Institute at CSU Fresno.

- Real-Time – Raw data from in-situ sensors; preliminary and subject to change upon review and calibration by the collecting agency
- Provisional Data - Data that have been reviewed by the collecting agency but still may be changed pending reanalysis or statistical review
- Laboratory Data – Data produced by the laboratory following laboratory QA/QC protocols and verified by the QA Officer.

5.0 Coordination and Review Strategy

5.1 Flow and Water Quality Monitoring Subgroup

The SJRRP Flow and Water Quality Monitoring Subgroup consists of representatives from the following agencies:

- Central Valley Regional Water Quality Board
- U.S. Fish and Wildlife Service
- U.S. Environmental Protection Agency
- California Department of Water Resources
- National Marine Fisheries Service
- California Department of Fish and Game
- U.S. Bureau of Reclamation

The SJRRP Flow and Water Quality Monitoring Subgroup will coordinate and review data, and will provide guidance for real-time management of Interim Flows from Friant Dam. The Subgroup will regular conference calls to discuss data related to the release of flows from Friant Dam and the related information collected from the San Joaquin River as water moves through the existing channel during Interim Flow releases. Compilations of data will be reviewed by the Subgroup to identify trends and justify changes to this Monitoring Plan to allow for real-time management. An annual meeting will occur to review collected water quality monitoring data, to analyze the general trends, and to write an annual report that summarizes the findings.

5.2 Items to be Addressed During Information Collection

As this Monitoring Plan is developed and analysis is completed and disseminated to appropriate agencies, it is anticipated that elements of this Monitoring Plan may change in order to adapt to changing conditions, new policy, and suggested improvements to specific procedures.

Several existing outstanding items that are not addressed specifically in this report, but are anticipated to be developed through coordination with appropriate agencies are the following:

- Assessment questions identified in the SWAMP assessment framework that monitoring will address.
- Determination of a possible link to statewide monitoring framework components,
- Integration of project data into the 305(b)/303(d) reporting cycle

5.3 Revision of this Monitoring Plan

The implementation of this monitoring plan will be subject to review by the Flow and Monitoring Subgroup. The DMO will compile and post all preliminary and verified data for review. Regular meetings will provide opportunities to identify trends or problems with the monitoring plan, make recommendations for changes and improvements, and to evaluate the scientific value of monitoring. Technical recommendations will be directed to the Fishery Management Workgroup and the Project Manager will seek funds to implement the changes. Policy issues will be resolved by the Project manager with guidance from the Technical Advisory Committee. Figure 4 is the organizational chart for the SJRRP.

6.0 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.

Quality assurance (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 this Monitoring Plan. The QAPP will be administered by the Quality Control Officer for Reclamation. QA objectives will be used to validate the data for this project. The data will be accepted, rejected, or qualified based on how sample results compare to established acceptance criteria[12].

The 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.

[12] U.S. Bureau of Reclamation, Mid-Pacific Region. May 2001. Standard Operating Procedures for Environmental Monitoring. Sacramento.

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 3 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. However, the Flow and Water Quality Monitoring Subgroup will continue to evaluate the choice of the sites with respect to their representativeness and will make appropriate recommendations to the Water Quality Monitoring Group given a belief or finding of inadequacy.

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.

7.0 Reporting

Preliminary real-time flow data will be posted on the CDEC. The purpose of this data is to provide an instant estimate of field conditions. Real-time flow data will be posted on the Web site as preliminary, subject to change. We recommend that the DMO compiles this data into an interactive graphic on a web-site to show current conditions along the river.

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. The purpose of these reports is to provide information for analyzing trends and changes in water quality in the river. The DMO will maintain a database for download by interested parties. Reclamation will coordinate with the Implementing Agencies and the DMO to ensure compliance with suggested data dissemination procedures and formats.

Final data will be completely verified by the respective Implementing Agencies and published in the Annual Report. The Flow and Water Quality Monitoring Subgroup will collaborate to prepare information for the Annual 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.

Appendix A
Excerpts from Paragraph 15 of the Settlement Agreement

15. Prior to the commencement of full Restoration Flows pursuant to this Settlement, the Parties agree that the Secretary shall begin a program of interim flows, which will include releases of additional water from Friant Dam commencing no later than October 1, 2009, and continuing until full Restoration Flows begin. Flows released according to the provisions of this Paragraph 15 shall be referred to as "Interim Flows." The Restoration Administrator, in consultation with the Technical Advisory Committee, the Secretary, and other appropriate Federal, State and local agencies, shall develop and recommend to the Secretary implementation of a program of Interim Flows in order to collect relevant data concerning flows, temperatures, fish needs, seepage losses, recirculation, recapture and reuse. Such program shall include releasing the flows identified in Exhibit B for the appropriate year type to the extent that such flows would not impede or delay completion of the measures specified in Paragraph 11(a), or exceed existing downstream channel capacities. To the extent that any gauging locations identified in Paragraph 13(g) are not available to measure flows due to in-channel construction related to Paragraph 11 improvements and until such gauging locations are installed, Interim Flows will be measured by establishing any necessary temporary gauging locations or by manual flow measurements for the purposes of collection of relevant data. The Parties anticipate that a program of Interim Flows would include:

(a) In 2009, release flows from October 1 through November 20 of a timing and magnitude as defined in the appropriate year type hydrograph [flow schedule] specified in Exhibit B, and without exceeding the then existing channel capacities;

(b) In 2010, release flows from February 1 through December 1 of a timing and magnitude as defined by Exhibit B for the appropriate year type, and without exceeding the then existing channel capacities;

(c) In 2011 and 2012, assuming in-channel construction begins May 1, release flows from February 1 through May 1 of a timing and magnitude as defined by Exhibit B for the appropriate year type, and without exceeding the then existing channel capacities. From May 1 through September 1, release flows to wet the channel down to the Chowchilla Bifurcation Structure to collect information regarding infiltration losses; and

(d) In subsequent years, if the highest priority channel improvements identified in Paragraph 11(a) are not completed, release flows for the entire year of a timing and magnitude as defined by Exhibit B for the appropriate year type, without exceeding the then existing channel capacities or interfering with any remaining in-channel construction work on the highest priority Paragraph 11 improvements.

(e) For purposes of implementing the Interim Flows specified in 15(a) through 15(d), the Secretary, in consultation with the Restoration Administrator, shall determine the then existing channel capacity and impact of Interim Flows on channel construction work."

Appendix B
Excerpts from Condition 22 of the Water Rights Order

22. Reclamation shall collect baseline information to evaluate potential impacts to Mendota National Wildlife Refuge and other resources associated with the temporary transfer. For this effort, Reclamation shall collect sediment and water quality information at the locations and for the parameters specified in Table 1. Samples shall be collected at least one week before interim flows reach the respective monitoring station to capture baseline data. If sediment sample concentrations are below criteria identified by the Deputy Director for Water Rights, then no additional sediment, organo-chlorine or pyrethroid sampling shall be required during the fall 2009 interim flow. If samples exceed the proposed criteria, Reclamation shall continue all sampling specified in Table 2 developed by the Central Valley Regional Water Quality Control Board (Central Valley Water Board) and Reclamation. Approximately one week after interim flows reach the respective monitoring station, water samples shall be collected at each location and analyzed for organic and inorganic water quality parameters as specified in Table 2. Reclamation shall compile real-time data from sites listed in Table 3 to monitor flow and physical parameters during the study period.

By January 1, 2010, Reclamation shall develop a monitoring plan, acceptable to the Deputy Director for Water Rights, for the releases beginning after February 1, 2010. Prior to submitting the plan to the Division of Water Rights, Reclamation shall obtain the written comments of the Central Valley Water Board, U.S. Fish and Wildlife Service, and California Department of Fish and Game. The plan is subject to review, modification and approval by the Deputy Director for Water Rights.

Until approval of a final monitoring plan, samples collected as part of this project must include field duplicates at a rate of 5% of the total project sample count at sites that includes all parameters to be analyzed. Additional quality assurance samples may be required by specific analytical methods.

Results from all water quality monitoring must be submitted to the Central Valley Water Board and Division of Water Rights within two months of data collection. Results shall include: laboratory name where results were analyzed, analytical result, analytical method, field duplicate results, and laboratory quality control, including laboratory blanks, reference material, matrix spikes, and laboratory duplicates.

At a minimum, analyses for each parameter group will include the following:

- *TSS =Total suspended solids*
- *Nutrients: TN, NH4, N02, N03, TKN, TP, P04, chlorophyll*
- *TOC/DOC: total and dissolved organic carbon*
- *Bacteria: Fecal coliform and E. coli*
- *Trace Elements/minerals: cations (Ca. Mg, K, Na); anions (CI, C04, HC03); total TE (copper, chromium, lead, nickel, zinc, arsenic, mercury)*
- *Pesticides: water column pre-release scans (carbamates and organophosphates); post-release scans (carbamates, organophosphates, and dependent on sediment results addition of organochlorines and pyrethroids)*
- *Bed Sediment: TOC, Trace elements (copper, chromium, lead, nickel, zinc, arsenic, mercury), organochlorine scan, pyrethroid scan, toxicity*

Appendix C
Excerpts from Page 6 and 7 of the Draft Fishery Management Plan, June 2009

Monitoring Objectives

Provide water-quality conditions suitable for Chinook salmon and other native fishes completing their life cycle without lethal or sublethal effects.

Monitoring Requirements

Constituents such as pesticides and other urban and agricultural wastes may affect water quality parameters such as DO and turbidity, creating habitat unsuitable for Chinook salmon. Sources of adverse water-quality conditions and whether or not discharge conditions will improve water quality are unknown. Evaluating and taking management actions for these conditions may be necessary to successfully meet the Restoration Goal.

Three species toxicity testing (Central Valley Water Board/EPA standards) has not been done, so it is unknown what water quality could be considered a limiting factor in Reaches 1 and 2. Water quality in Reaches 3 through 5 is considered of moderate importance because it experiences a significant amount of agricultural return flows, but effects on Chinook salmon are largely unknown.

Objectives, MCLs

To meet the SJRRP Restoration Goal, water quality should meet minimum standards for protection of aquatic resources. Because of the lack of information on the effects of many water quality constituents on Chinook salmon and other fishes, the water quality objectives for beneficial uses defined by the Central Valley Regional Water Quality Control Board (Central Valley Water Board) are used to establish water-quality goals.

The temperature objectives are based on a DFG proposal to assess temperature impairment (DFG 2007b), U.S. Environmental Protection Agency (EPA) guidelines (EPA 2003) and a report on temperature impacts on fall-run Chinook salmon and steelhead (Rich and Associates 2007).

Water-quality objectives are “the limits or levels of water quality constituents or characteristics established for the reasonable protection of beneficial uses of the water or the prevention of a nuisance in a specific area” (California Water Code Section 13050(h)).Water-quality standards consist of the designated beneficial uses and water quality objectives set forth by the State Water Resources Control Board (SWRCB) and the Central Valley Water Board and are contained in the Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin (Basin Plan). For the San Joaquin River system, including the Restoration Area, SWRCB has set a goal to be free from toxic substances in surface water (Central Valley Water Board 1998).

Selenium, DO, and ammonia objectives are based on the Central Valley Water Board and SWRCB standards described above. Additional water-quality criteria are defined in Exhibit B.

Water temperatures for spring-run Chinook salmon adult migrants should be less than 68 °F in Reaches 3, 4, and 5 during March and April, and less than 64°F in Reaches 1 and 2 during May and June (Exhibit A, Table A-1).

Water temperatures for spring-run Chinook salmon adult holding should be less than 59°F in holding areas between April and September (Exhibit A, Table A-1).

Water temperatures for spring-run Chinook salmon spawners should be less than 57°F in spawning areas during August, September, and October (Exhibit A, Table A-1).

Water temperatures for spring-run Chinook salmon incubation and emergence should be less than 55°F in spawning areas between August and December (Exhibit A, Table A-1).

Water temperatures for spring-run Chinook salmon juveniles should be less than 64°F in the Restoration Area when juveniles are present (Exhibit A, Table A-1).

Selenium levels should not exceed 0.020 milligrams per liter (mg/L) or a 4-day average of 0.005 mg/L in the Restoration Area (Exhibit B, Table B-3).

DO concentrations should not be less than 6.0 mg/L when Chinook salmon are present (Exhibit B, Table B-3).

Total ammonia nitrogen should not exceed 30-day average of 2.43 milligrams nitrogen per liter (mg N/L) when juvenile Chinook salmon are present or exceed a 1-hour average of 5.62 mg N/L when Chinook salmon are present (Exhibit B, Table B-9). (FMP Page 3*-13)

~~~~~~~~~~~~

- Habitat Objective 5 – To provide appropriate flow timing, frequency, duration and magnitude, enabling the viability of 90 percent of all life-history components of spring-run Chinook salmon.

  - Recommended monitoring and evaluation – An analysis of streamflow and fish distribution and survival is recommended. Flow and stage measurement will occur real-time, according to procedures based on the USGS publication *Stream-Gaging Program of the U.S. Geological Survey – U.S. Geological Survey Circular 1123* (Wahl, Thomas, and Hirsch 1995). Population Monitoring Objectives 1, 2, and 6 described above will provide spring-run Chinook salmon viability.

- Habitat Objective 6 – Water temperatures for spring-run Chinook salmon adult migrants should be less than 68°F in Reaches 3, 4, and 5 during March and April and less than 64°F in Reaches 1 and 2 during May and June (Exhibit A, Table A-1).

  - Recommended monitoring and evaluation – Water temperature will be monitored real-time at two locations in Reach 1, two locations in Reach 2, one location in Reach 3, two locations in Reach 4, and two locations in Reach 5.
~~~~~~~~~~~~

- Habitat Objective 7 – Water temperatures for spring-run Chinook salmon holding adults should be less than 59°F in holding areas between April and September (Exhibit A, Table A-1).
  - Recommended monitoring and evaluation – Water temperature will be monitored real-time at two locations in Reach 1, two locations in Reach 2, one location in Reach 3, two locations in Reach 4, and two locations in Reach 5.
- Habitat Objective 8 – Water temperatures for spring-run Chinook salmon spawners should be less than 57°F in spawning areas during August, September, and October (Exhibit A, Table A-1).
  - Recommended monitoring and evaluation – Water temperature will be monitored real-time at two locations in Reach 1, two locations in Reach 2, one location in Reach 3, two locations in Reach 4, and two locations in Reach 5.
- Habitat Objective 9 – Water temperatures for spring-run Chinook salmon incubation and emergence should be less than 55°F in spawning areas between August and September (Exhibit A, Table A-1).
  - Recommended monitoring and evaluation – Water temperature will be monitored real-time at two locations in Reach 1, two locations in Reach 2, one location in Reach 3, two locations in Reach 4, and two locations in Reach 5.
- Habitat Objective 10 – Water temperatures for spring-run Chinook salmon juveniles should be less than 64°F in the Restoration Area when juveniles are present (Exhibit A, Table A-1).
  - Recommended monitoring and evaluation – Water temperature will be monitored real-time at two locations in Reach 1, two locations in Reach 2, one location in Reach 3, two locations in Reach 4, and two locations in Reach 5.
- Habitat Objective 11 – Selenium levels should not exceed 0.020 mg/L or a 4-day average of 0.005 mg/L in the Restoration Area (Exhibit B, Table B-3).
  - Recommended monitoring and evaluation – Selenium levels will periodically be monitored in 5 locations as part of a short list of water quality parameters using laboratory analysis.
- Habitat Objective 12 – DO concentration should not be less than 5.0 mg/L when Chinook salmon are present (Exhibit B, Table B-3).
  - Recommended monitoring and evaluation – DO will be monitored real-time at the same locations as water temperature: two locations in Reach 1, two locations in Reach 2, one location in Reach 3, two locations in Reach 4, and two locations in Reach 5. Additional sampling sites for DO may be added, as needed.

- Habitat Objective 13 – Total ammonia nitrogen should not exceed 30-day average of 2.43 mg N/L when juvenile Chinook salmon are present or exceed a 1-hour average of 5.62 mg N/L when Chinook salmon are present (Exhibit B, Table B-9).
  - Recommended monitoring and evaluation – Total ammonia nitrogen will be monitored weekly to every other week in two locations in cooperation with the Grassland Bypass Project. Additional sampling sites for ammonia nitrogen may be added, as needed.

Appendix C
Proposed Water Quality Standards and Objectives

Water Quality Standards – Overview

Surface water quality (WQ) is evaluated in the United States through standards that are designed to protect "present or probable future beneficial [water] uses". Standards are composed of two parts: objectives, which are designed to protect specified aspects of a particular beneficial use, and numeric limits, which are used to implement the objectives.

Beneficial water uses may be protected by one or more objectives. Many different criteria are needed because objectives can address different aspects of a protection. For example, drinking water protections range from Taste and Odor Thresholds, which address nuisance conditions, to California State Response Levels, which target cancer risks. Other objectives diverge because they are founded on different principles. While California Public Health Goals (CPHGs) and Maximum Contaminant Levels (MCLs) both address cancer and toxicity risks, CPHGs are purely health-based while MCLs are management-based, balancing health benefits, economic constraints, and technological feasibility.

CVP Water Quality Objectives

From over fifty available objectives, fifteen were chosen for the protection of CVP beneficial uses (Table 1). These objectives were identified following guidelines published in Marshack (2000):

1) Priority was placed on health-based objectives that reflect current scientific research
2) California objectives were prioritized over National objectives
3) Objectives with provisional or draft limits (those not based on peer reviewed science) were not considered
4) California Safe Harbor Levels (Proposition 65) were excluded. Though promulgated, "Proposition 65 limits are in conflict with other health-based limits for drinking water in California" (Marshack, 2000).

Although recommended by Marshack, advisory objectives such as the California Public Health Goals and California Potency Factors were not considered. Use of advisory objectives typically requires analytical methods that are cost-prohibitive and/or under development.

Table 1. Water quality objectives for the protection of designated CVP beneficial uses

Water Quality Objectives for the Protection of Human Health (Beneficial Use: Domestic and Municipal Water Supply) 1. California and National Toxics Rule - consumption of water plus organisms 2. National Recommended Ambient Water Quality Criteria - consumption of water plus organisms 3. California Primary Maximum Contaminant Level 4. California Secondary Maximum Contaminant Level 5. National Primary Maximum Contaminant Level 6. California State Notification and Response Level
Water Quality Objectives for the Protection of Fresh Water Aquatic Life (Beneficial Use: Fish and Wildlife Habitat) California and National Toxics Rule

Table 1. Water quality objectives for the protection of designated CVP beneficial uses
1. Continuous exposure (4-day average) 2. Maximum concentration (1-hour average) 3. Instantaneous maximum concentration National Recommended Ambient Water Quality Criteria 4. Continuous exposure (4-day average) 5. 24-hr average 6. Maximum concentration (1-hour average) 7. Instantaneous maximum concentration
Water Quality Objectives for the Protection of Agriculture (Beneficial Use: Agriculture) 1. Agricultural Limits (includes protections for all agricultural uses)
Water Quality Objectives for the Protection of Inland Surface Waters (Beneficial Use: All Uses Unless Specified) 1. Sacramento River and San Joaquin River Basin Plan Objectives

CVP Water Quality Evaluation
For this project, CVP water quality was evaluated following protocol below:

1) For each CVP monitoring site (water body), identify applicable beneficial uses and corresponding WQ objectives (Table 1)
2) For each site, select physical, chemical and biological constituents-of-concern
3) For every constituent, select a single WQ standard to protect each applicable beneficial use (choose one standard per constituent per beneficial use). Follow the algorithm outlined below.
4) Identify the most-restrictive WQ limit for all water uses in order to determine required reporting limits. Based on the required reporting limit, choose an appropriate method for analyzing each constituent. If the most restrictive WQ limit is a maximum, select a reporting limit that is three to five times lower than the WQ limit. If the most restrictive WQ limit is a minimum, select a reporting limit three to five times greater than the WQ limit.
5) Analyze sample water for constituents-of-concern, using methods selected in Step 4.
6) For each constituent, compare analytical results to the most restrictive WQ limit for that constituent (chosen in Step 4). If results meet the standard, then water at that site is of sufficient quality for all beneficial uses. If results do not meet the most restrictive standard, continue to Step 7.
7) Assess water quality for each beneficial use separately by comparing sample results with standards chosen in Step 3. If concentrations are within limits, WQ is considered suitable for the evaluated use. If concentrations exceed limits, WQ is "polluted" and unsuitable for the evaluated use.
8) Make recommendations as needed.

Algorithm for Choosing CVP Water Quality Standards

For every constituent, an algorithm based on Marshack's guidelines was used to select a single water quality standard for each beneficial water use. Use of this protocol ensures that appropriate water quality standards were chosen in a consistent manner.

1) For each constituent of concern, independently choose WQ standards for each applicable beneficial use. For all standards selections, consult Appendix WQ.
2) Select standards for the protection of municipal and domestic water consumption.
   - If a Toxics Rule (CTR/NTR) standard exists, choose it. Toxics Rule standards trump all save BP standards.
   - If there is no CTR/NTR standard, choose the most restrictive of the remaining five standards for the protection of human health (AWQ, CA-PMCL, CA-SMCL, US-PMCL, NRL).
3) Select standards for the protection of fresh water aquatic life.
   - If a Toxics Rule (CTR/NTR) standard exists, choose it. If more than one CTR/NTR standard exists, choose the one that is the most restrictive.
   - If there is no CTR/NTR standard, choose the AWQ criteria. If more than one AWQ exists, choose the one that is most restrictive.
4) Select standards for the protection of agricultural use.
5) Select Basin Plan (BP) standards. Note that BP standards supersede other standards that protect the same beneficial use. For example, the BP Fluoride standard for the protection of human health supersedes all other human health standards for Fluoride.
   - If the BP contains a standard applicable to the monitoring site, apply the standard as indicated in the Plan. For example, to protect fish habitat in certain reaches of the Sacramento River, the BP contains standards for water temperature that apply certain weeks of the year.
   - If a BP standard exists for a particular water use but no water body is specified (as in the case of BP metals standards for the protection of human health), apply the standard to all waters in the Sacramento and San Joaquin River Basins.

Insert wq stds ms excel

Appendix E
Proposed Sediment Standards

Proposed Sediment Quality Targets for Monitoring of the San Joaquin River Restoration Project

While the Central Valley Regional Board does not provide specific guidelines for monitoring sediment quality in their Basin Plan it is important to establish targets for levels of pollutants in the sediment to remain under. Table 1 shows the proposed sediment quality targets for pyrethroids. These targets were produced by measuring the concentrations causing acute toxicity and growth impairment in *Hyalella azteca* (Amweg 2005). Table 2 shows the proposed sediment quality targets for Metals/Elements. Table 3 shows the proposed sediment quality targets for Total Polycyclic Aromatic Hydrocarbons (Total PAH), Total Polychlorinated Biphenyls (Total PCBs), and Organochlorine Pesticides (OC Pesticides). The proposed targets for metals/elements, Total PAH, Total PCBs, and OC Pesticides were obtained from several different sources including both studies and government standards.

Table 1. Sediment Quality Targets for Pyrethroids

Analytical Group	Parameter	Amweg Erratum 10-d Hyalella azteca LC50 values (ug/g)
Pyrethroids	lambda-cyhalothrin	0.45
	bifenthrin	0.52
	deltamethrin	0.79
	cyfluthrin	1.08
	esfenvalerate	1.54
	permethrin	10.83

Table 2. Sediment Quality Targets for Metals/Elements

Analytical Group	Parameter	Means for Geologic Backgrounds (ppm)			MacDonald et al. Consensus Based PEC (mg/kg)	NOAA ERL (mg/kg)	NOAA ERM (mg/kg)	SWRCB SQG (Ritter et al.) Guidelines		
		Western U.S. (Schacklette, et al., 1984)	California means (Pettygrove and Asano, 1984)	Kesteron Reservoir Pond 2 (Fujii, 1988)				Low Toxicity (mg/kg)	Moderate Toxicity (mg/kg)	High Toxicity (mg/kg)
Metals/Elements	Arsenic	5.5 (<.01 - 97)		<10	33	8.2	70			
	Cadmium	0.45 (<1.0 - 4.0)	0.34	<2	4.98	1.2	9.6	0.09	0.22	1.66
	Chromium	39.3 (7.52 - 246)	15.4	45	111	81	370			
	Copper	18 (2.28 - 50/4)	14.6	9	149	34	270	52.8	96.5	406
	Lead	8.57 (<5.00 - 473)	16.6	20	128	46.7	218	26.4	60.8	154
	Mercury	0.03 (<0.05 - 0.50)			1.06	0.15	0.17	0.09	0.45	2.18
	Nickel	25.7 (3.75 - 114)	14.1	32	48.6	20.9	51.6			
	Selenium	0.52 (0.05 - 15)		5.2						
	Zinc	48.1 (7.05 - 176)	60.4	39	459	150	410	112	200	629
	% Total Organic Carbon	0.67 (0.07 - 4.80)								

PEC=probable effect concentration

ERL=Effects Range-Low

ERM=Effects Range-Median
SQG=Sediment Quality Goals
LC50=Lethal Concentration 50

Table 3. Sediment Quality Targets for PAH, PCBs, and Organochlorine Pesticides

Analytical Group	Parameter	MacDonald et al. Consensus Based PEC (mg/kg)	NOAA ERL (mg/kg)	NOAA ERM (mg/kg)	SWRCB SQG (Ritter et al.) Guidelines		
					Low Toxicity (mg/kg)	Moderate Toxicity (mg/kg)	High Toxicity (mg/kg)
	Total PAH	22.8	4.022	44792	0.312	1.325	9.32
	Total PCBs	0.676	0.0227	180	0.0119	0.0247	0.288
Organochlorine Pesticides	Chlordane	0.0176			0.00054	0.00145	0.0145
	Dieldrin	0.0618					
	Sum DDD	0.028					
	Sum DDE	0.0313					
	Sum DDT	0.0629					
	Total DDT	0.572	0.00158	46.1	0.00042	0.00152	0.0893
	Endrin	0.207					
	Heptachlor epoxide	0.016					
	Lindane	0.00499					

PEC=probable effect concentration
ERL=Effects Range-Low
ERM=Effects Range-Median
SQG=Sediment Quality Goals

References

Amweg EL, Weston DP, Ureda NM. 2005. Use and toxicity of pyrethroid pesticides in the Central Valley, California, USA. *Environ Toxicol Chem* 24:966–972.

Fujii, Roger. 1988. Water Quality and Sediment Chemistry Data of Drain Water and Evaporation Ponds from Tulare Lake Drainage District, Kings County, California, March 1985 to March 1986. U.S. Geological Survey. Open File Report 87-700. 19 pages

Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder. 1995. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. *Environmental Management* 19(1): 81-97.

MacDonald, D. D., C. G. Ingersoll, and T. A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. *Environ Toxicol Chem* 39:20-31.

NOAA. 1999. Sediment Quality Guidelines Developed for the National Status and Trends Program. Online <http://response.restoration.noaa.gov/book_shelf/121_sedi_qual_guide.pdf> 14 September 2009

Pettygrove, G.X. and Asano, T. (editors), 1984. Irrigation with Reclaimed Municipal Wastewater--A Guidance Manual. Lewis Publishers, Chelsea, Michigan (Appendix I).

Ritter, Kerry J., Steven M. Bay, Rober W. Smith, Doris E. Vidal-Dorsch, and L. Jay Field. 2008. Development and Evaluation of Sediment Quality Guidelines Based on Benthic Macrofauna Responses. Southern California Coastal Water Research Project Annual Report 91-105.

Shacklette, H.T. and Boerngen, J.G. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States: U.S. Geological Survey Professional Paper 1270, 105 p.

Appendix F – 2010 Annual Technical Report

This page intentionally left blank

2010 Annual Technical Report

SAN JOAQUIN RIVER
RESTORATION PROGRAM

April 2011

Table of Contents

Figures and Tables

Attachment

Appendices

Abbreviations and Acronyms

ADCP	Acoustic Doppler Current Profiler
ATR	Annual Technical Report
CCID	Central California Irrigation District
CDEC	California Data Exchange Center
CDFG	California Department of Fish and Game
cfs	cubic feet per second
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project
Delta	Sacramento-San Joaquin Delta
DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
EC	electrical conductivity
FMP	Fisheries Management Plan
FMWG	Fisheries Management Work Group
NMFS	National Marine Fisheries Service
PG&E	Pacific Gas and Electric Company
RA	Restoration Administrator
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RM	River Mile
RWQCB	Regional Water Quality Control Board
Settlement	Stipulation of Settlement in *NRDC, et al. v. Kirk Rodgers, et al.*
SJRRP	San Joaquin River Restoration Program
SMN	San Joaquin River above Merced River near Newman
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TAF	thousand acre-feet
TSC	Technical Services Center
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Services
USGS	U.S. Geological Survey
WR	Water Right
WY	water year

1.0 Introduction

The San Joaquin River Restoration Program (SJRRP) is a comprehensive long-term effort to restore flows and a self-sustaining Chinook salmon fishery to the San Joaquin River from Friant Dam to the confluence of Merced River, while reducing or avoiding adverse water supply impacts. More information on the SJRRP is available at http://www.restoresjr.net.

This Annual Technical Report (ATR) presents an incremental update for monitoring and analysis results from 2010 and builds on a draft released in August 2010 which reported on the first half of 2010. The ATR along with the Monitoring and Analysis Plan (formerly known as Agency Plan) are SJRRP annual reporting and planning documents. These documents play a role in the development of SJRRP adaptive management, which links monitoring and analysis efforts to the decision making processes they are designed to support, forming the scientific basis for San Joaquin River operations downstream from Friant Dam. The ATR tracks long-term strategies for SJRRP implementation in problem statements and identifies information needs as uncertainties to be resolved in order to implement the Stipulation of Settlement in *NRDC, et al., v. Kirk Rodgers, et al.* (Settlement). The ATR allows the Implementing Agencies to present to stakeholders the status and results of technical work to address SJRRP needs.

1.1 Report Organization

The main body of the ATR summarizes monitoring and analysis results from the past year of SJRRP. The ATR is supported by three types of appendices: problem statements/information needs, reports, and data. Some appendices include data atlases as attachments. Appendix A introduces problem statements, which track long-term implementation approaches and are supported by information needs describing specific knowledge gaps to be addressed through studies. The modular format of Appendix A allows technical challenges to be addressed as new information becomes available, and removed from further analysis when they have been resolved. Data reports present raw data from monitoring activities. Reports are stand-alone documents providing updated monitoring and analysis results. Atlases provide monitoring results and the monitoring network for a particular resource area. A brief description of the document organization is presented in the bullets below.

- **Section 1.0 Introduction** – the purpose and structure of the Annual Technical Report.
- **Section 2.0 2010 Summary** – key monitoring and analysis results from 2010.
- **Section 3.0 Monitoring Network** – a description of the components monitored and presentation of monitoring locations.

- **Section 4.0 Models and Analytical Tools** – a description of available numerical models for analysis.
- **Section 5.0 Conclusions** – a description of results and revised understanding of physical and biological systems based upon monitoring data.
- **Appendix A. Problem Statements and Information Needs** –problem statements and information needs for 2010 including:
    - Gravelly Ford Flow Targets,
    - Unexpected Seepage Losses Downstream from Gravelly Ford
    - Seepage Management
    - San Joaquin River Channel Capacity Management
    - Mature Spawners
    - Healthy Fry Production
    - Smolt Outmigrants
    - Smolt Survival
    - Adult Recruits
    - Adult Passage.
- **Appendix B. Reports** – describing 2010 monitoring and analysis results.
- **Appendix C. Surface Water Stage and Flow** – a description of monitoring methodology and presentation of surface water stage and flow data (15-min./hourly stream gage data and periodic manual measurements).
- **Appendix D. Surface Water Quality** – a description of monitoring methodology and presentation of surface water quality data (15-min./hourly sensor data and periodic manual measurements).
- **Appendix E. Sediment** – a description of monitoring methodology and presentation of suspended sediment data, and bed mobility data.
- **Appendix F. Groundwater** – a description of monitoring methodology, groundwater levels, record of hotline calls, daily seepage evaluations, and flow bench evaluations.
- **Appendix G. Surveys** – a description of methodology and survey data.
    - Bathymetric Surveys

    - Monitoring Sections
        - Topographic Surveys
        - Sample Lines and Section Views
    - Water Surface Profiling
        - Water Surface Elevations
        - Discharge Measurements
        - Bed Profile Surveys
    - Habitat Mapping
    - Aerial Photos [placeholder, atlas development in progress]
    - Vegetation Surveys [placeholder]
- **Appendix F. Fisheries Data**– [placeholder]

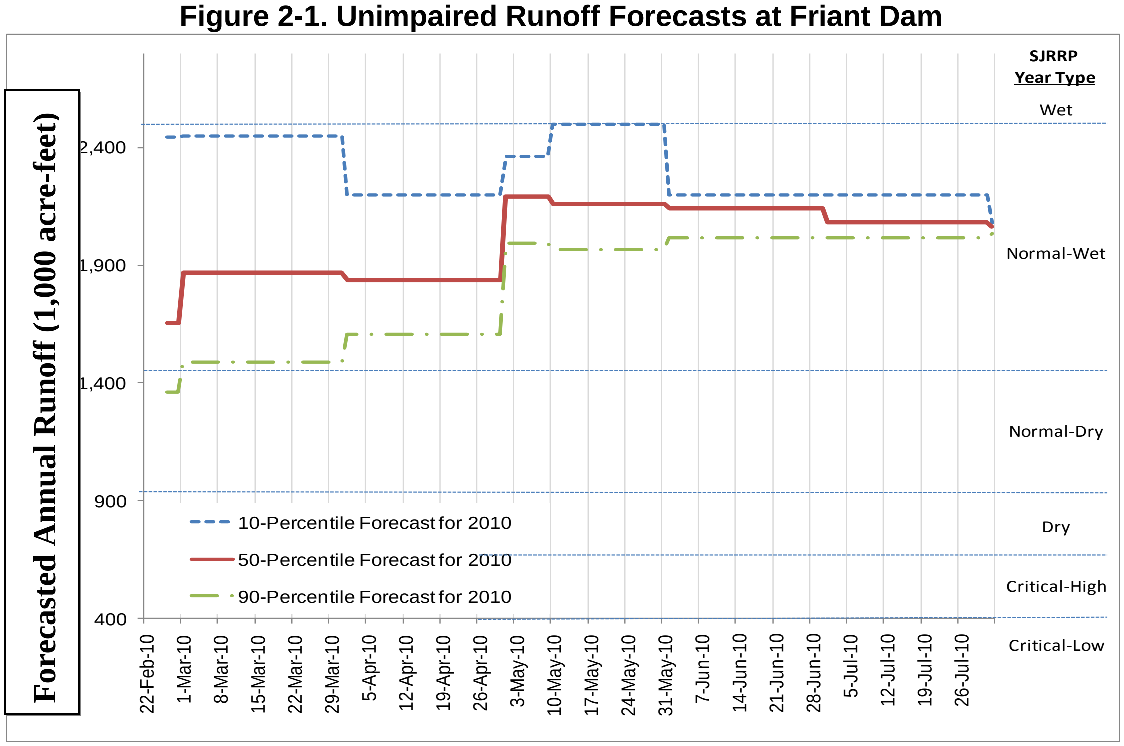
2.0 2010 Summary

The Settlement requires a period of Interim Flows prior to full Restoration Flows in order to collect relevant data concerning flows, temperatures, fish needs, seepage losses, recirculation, recapture and reuse. Results from monitoring during Interim Flows contribute to the scientific basis for San Joaquin River operations downstream of Friant Dam, and support decisions on implementation.

2.1 Allocation

The flow schedule for Interim Flows depends on the annual unimpaired runoff at Friant Dam. At the start of the restoration year on March 1, the water supply is unknown and requires forecasting. U.S. Department of the Interior, Bureau of Reclamation (Reclamation) water supply forecasts include 10 percent, 50 percent, and 90 percent exceedance estimates for total unimpaired runoff at Friant Dam. Reclamation may declare a water supply between the 50 and 90 percent probability for use in scheduling flows. The February forecast resulted in a Normal-Dry year-type, increased to a Normal-Wet year-type by March, and remained Normal-Wet through June as illustrated in **Figure 2-1**. Channel capacity constraints limit the amount of water released for the SJRRP. The final WY2010 water supply allocation for SJRRP was on June 1, 2010 for a total of 377 thousand acre-feet.

Figure 2-1. Unimpaired Runoff Forecasts at Friant Dam



2.2 Flow

SJRRP releases Interim Flows based on Settlement flow targets and consistent with SJRRP environmental documents. The SJRRP Restoration Administer (RA) issued 2010 Interim Flow Recommendations for flow release rates and durations February 1 – December 1, 2010. Before changing releases from Friant Dam, Reclamation conducted flow bench evaluations to determine if downstream constraints permitted releases according to the RA Recommendations. Constraints to 2010 Interim Flows included channel capacities, groundwater elevations, Mendota Pool water quality, and Mendota Pool water user demand. Friant Dam flow changes during 2010 Interim Flows are displayed in **Table 2-1** below.

Table 2-1 2010 Interim Flow Releases

Release Date	Friant Dam Release (cfs)	Comment
February 1	350	Begin Calendar Year 2010 Interim Flows
February 11	400	Adjusted to meet Gravelly Ford flow target due to prior riparian demands
February 26	350	Adjusted to meet Gravelly Ford flow target, due to inflows from Little Dry Creek and Cottonwood Creek
March 1	500	Adjusted to meet RA flow target
March 16	800	Adjusted to meet RA flow target
March 29	1,100	Adjusted to meet RA flow target
April 12	1,500	Adjusted to meet RA flow target
April 13	1,250	Adjusted to meet target of 700 cfs downstream of Sack Dam, and Mendota Pool Demand
April 17	1,350	Adjusted to meet target of 700 cfs downstream of Sack Dam, and Mendota Pool Demand
April 19	1,100	Adjusted because of water quality concerns in Mendota Pool
April 23	1,350	Adjusted to meet RA flow target and not to exceed 700 cfs downstream of Sack Dam
May 1	1,550	Adjusted to meet RA flow target and Mendota Pool Demand
May 28	800	Adjusted to meet RA flow

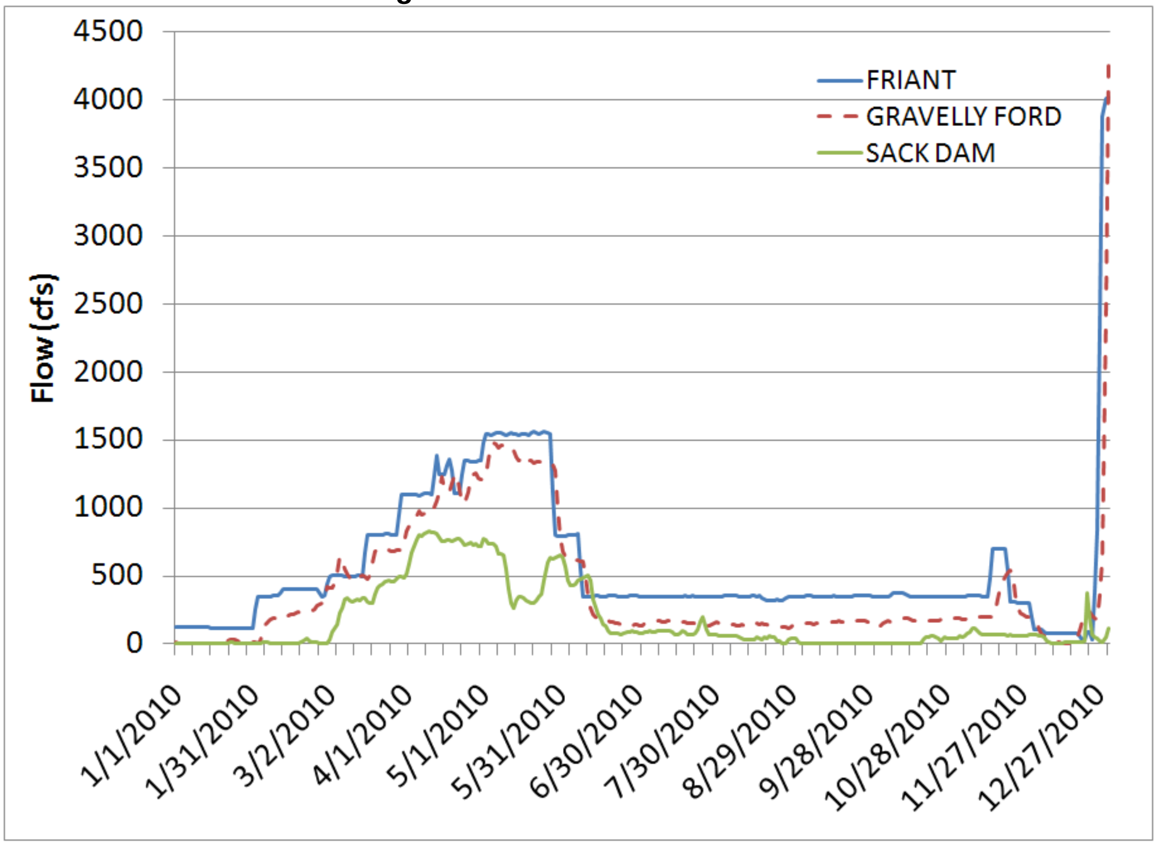
Release Date	Friant Dam Release (cfs)	Comment
		target
June 8	350	Adjusted to meet RA flow target
August 19	325	Reduced flows for Gravelly Ford compliance following a period of exceeding flow targets
August 28	350	Resumed 350 cfs releases from Friant after August 19 reduction for Gravelly Ford compliance
November 15	700	WY 2011 Fall Pulse
November 22	300	No Interim Flows released between November 22, 2010 and February 1, 2011.

During 2010 Reclamation tested releases from Friant Dam and the resulting ability to meet targets at Gravelly Ford. Downstream of San Mateo Avenue the San Joaquin River channel is again used to convey both water deliveries (from the Delta Mendota Canal) and Interim Flows. Mendota Dam is a second point of flow control in the Restoration Area and is operated by Central California Irrigation District for water deliveries to Arroyo Canal and Interim Flows targets at Sack Dam. **Figure 2-2** below displays flow records for Friant Dam, Gravelly Ford, and Sack Dam.

Shallow groundwater near the Sand Slough Control Structure on the south side of Reach 4A, as well as the adjacent north side of the Eastside Bypass, limited flows below Sack Dam because of potential impacts to downstream lands. For two weeks during May 2010, SJRRP studied surface-groundwater interactions in this key area by reducing and holding Sack Dam flow targets to 300 cfs before increasing back to the prior 700 cfs flow target. During June 2010, SJRRP responded to landowner input by limiting flows below Sack Dam to 80 cfs. **Section 2.4** below contains discussion of groundwater monitoring results.

The addition of Interim Flows to the San Joaquin River led to increased operational complexity at Mendota Pool. Recapture of a portion of Interim Flows by water users at Mendota Pool enabled Reclamation to release Interim Flows up to the full channel capacity in Reach 2 without exceeding the Sack Dam flow limits. During April 2010 operators decreased DMC deliveries to Mendota Pool to accommodate recapture of Interim Flows. Without dilution from DMC flows, water quality in Fresno Slough declined to the point where it was no longer acceptable for irrigation deliveries. Reclamation responded by reducing the Friant Dam release to 1,100 cfs while local agencies sent water through the Firebaugh Wasteway into Reach 3 to restore Fresno Slough water quality.

Figure 2-2 2010 Interim Flows



Source: QA/QC flow records
CDEC codes: Friant (Reclamation)= MIL; Gravelly Ford (Reclamation)= GRF; Sack Dam (DWR)= SDP

The SJRRP continued and expanded monitoring during spring 2010 with several stage and flow monitoring efforts. The U.S. Geological Survey (USGS), Reclamation, and the California Department of Water Resources (DWR) took manual streamflow measurements to support development of continuous flow records at stream gage sites, including the development of rating curves at the Sack Dam and Washington Road gages. Additional manual streamflow measurements were made at certain sites that do not have stream gages. Reclamation conducted water surface and bathymetric surveys in Reaches 3 – 5. DWR installed stage recorders, conducted water surface profile and cross-section surveys, and made manual streamflow measurements. Methods and data from these monitoring efforts are presented in Reports and Data Appendices.

2.3 Channel Capacity

2.3.1 Water Surface Elevation

The Department of Water Resources (DWR) continued several monitoring efforts during 2010 in support of the Channel Capacity Problem Statement. DWR conducted water surface profile surveys at an average spacing of approximately 0.5-mile in Reaches 1-3, and discharge measurements throughout the restoration reaches (refer to **Table 2-2**).

Water levels were recorded at the top and bottom of hydraulic controls, at upstream and downstream of discharge sites, and at every half foot of drop. The number, spacing and exact location of the points were prioritized based on hydraulic conditions, resources, access, and GPS coverage.

A preliminary comparison of the surveyed and computed water surface profiles based on the current 1-D HEC-RAS model indicates that the majority of significant hydraulic controls were sufficiently characterized by the survey data, and that noticeable gaps in the data do not exist. Preliminary comparisons of the survey data and current model results also indicate that additional model calibration is necessary and can now be performed in numerous locations where previous calibration data didn't exist. **Table 2-2** shows the number of discharge sites in each reach and the flows being released from Friant Dam during the discharge measurement. The eleven sites in Reach 1A included runoff from a spring storm. Additional details including the split flow measurements and duplication of D11 are in the Report 6.0 **Discharge Measurements** in **Appendix B**. Recorded flow measurements generally indicate a decrease in total discharge in the downstream direction.

Table 2-2. 2010 DWR Discharge Measurement Site Distribution

Reach	Friant Dam (cfs)	Discharge Measurements
1A	1100	11*
1B	1100	2
2A	1350	2
2B	1350	2
3	1350	5

*** sites include spring storm runoff**
Discharge measurements made with Acoustic Doppler Current Profiler (ADCP)
Refer to Appendix B, Section 6.0 Discharge Measurements Report

2.3.2 Water Level Recorders

Six additional water level recorders (WLRs) were installed at key locations in Reaches 1A and 1B from September 2009 through January 2010 in order to provide additional data to calibrate the hydraulic and flow-routing models (see 2009 ATR for more information). Water stage data are being collected by the recorders at 15 minute intervals and saved in the data logger from the date of installation. These data are periodically downloaded and processed for reporting.

The stage data were converted to water surface elevations using survey information and are displayed in the **Additional Water Level Recorders Report** in **Appendix B**. Generally, the water level recorder results correlated well with the water surface profile survey.

2.3.3 Effects of Sand Mobilization on Water Surface Elevation

DWR monitored scour chains and conducted bed profile surveys during five interim flow release benches from Friant Dam that ranged from 800 to 1,550 cfs. Two monitoring sites in Reach 2A (M6.5 and M10) were selected and one cross section per each site was monumented for monitoring activities.

Four scour chains at each site were installed in fall 2009 and monitored after each seasonal interim flow release. The selected sites have been visited and changes recorded after each seasonal flow release from Friant Dam since fall 2009 flows began.

During spring 2010 interim flow releases, total deposition observed ranged from 0.08 to 1.31 feet at Site M6.5 and from 0.98 to 1.96 feet at Site M10. However, there was not much local scour in the vicinity of chains at both sites. Please refer to the **Scour Chains** report in **Appendix B**.

Cross sectional and longitudinal profiles at the sites were repeatedly surveyed using a cataraft-mounted echo sounder linked to survey-grade GPS rover during the Interim Flow release benches. Each bed profile survey includes a corresponding discharge measurement using Acoustic Doppler Current Profiler (ADCP) and multiple water surface elevation measurements using an Auto Level.

Cross-section and longitudinal profiles collected at both selected sites during various flow release benches were compared and the results presented in the **Bed Profile Surveys Report** in **Appendix B** and data in **Appendix E**. General scour was not observed over the range of survey flows. Local man-made influences at the two sites make it very difficult to measure general scour.

2.3.4 Sand Storage Assessment

DWR conducted a sand storage assessment by locating primary supply sand storage, and performing topographic surveys of four in-channel pits (refer to **Appendix B**, report 10.0 **Sand Storage in Reach 1** and **Attachment 1: Evaluation of Sand Supply, Storage, and Transport in Reaches 1A and 1B**.

Reach 1, from Friant Dam to Hwy 145, was visited three times, once in November 2009 (700cfs), a second time in March 2010 (600cfs) and a third time in July 2010 (350cfs). The field visits were done by boat. During the visits, numerous sand sources were identified. Pictures were taken of the sources and depths were measured with a 10-foot long piece of quarter inch rebar. At some sites, sand samples were gathered for later processing to determine gradations.

Four gravel mining pits were selected as having the potential to inhibit sand transport and were surveyed in April 2010 and again in June 2010. From April 2010 to June 2010 Reach 1 experienced at least 30 days of 1600cfs flows. Sand deposition was calculated through comparison of April and June surveys in the four pits.

2.3.5 Monitoring Cross-Section Re-surveys

In July 2009, DWR conducted monitoring cross-section surveys at 12 sites in Reach 1B and Reach 2A. Monitoring included performing a topographic survey patch that was as wide as the river from levee to levee and about 75 feet long, and collecting at least one sand bed sample at each site. In January 2010, those 12 sites were re-surveyed and three additional sites (one being in Reach 2B) were added. In October 2010, the 15 sites were re-surveyed for a second time.

DWR calculated net scour or deposition at each location by comparing surfaces generated from the topography surveys. From the surfaces, we were able to calculate volume changes. From July 2009 to January 2010, seven sites showed net deposition, and five sites showed a net scour. The largest scour was at M6 with a cut of 197 cubic yards. The largest deposition was at M8 with a fill of 524 cubic yards. From January 2010 to October 2010, six sites showed a net deposition and nine sites showed a net scour. The largest deposition was at M9 with a fill of 1,123 cubic yards. The largest scour was at M2 with a cut of 637 cubic yards. Please refer to the **Topographic Surveys Report**.

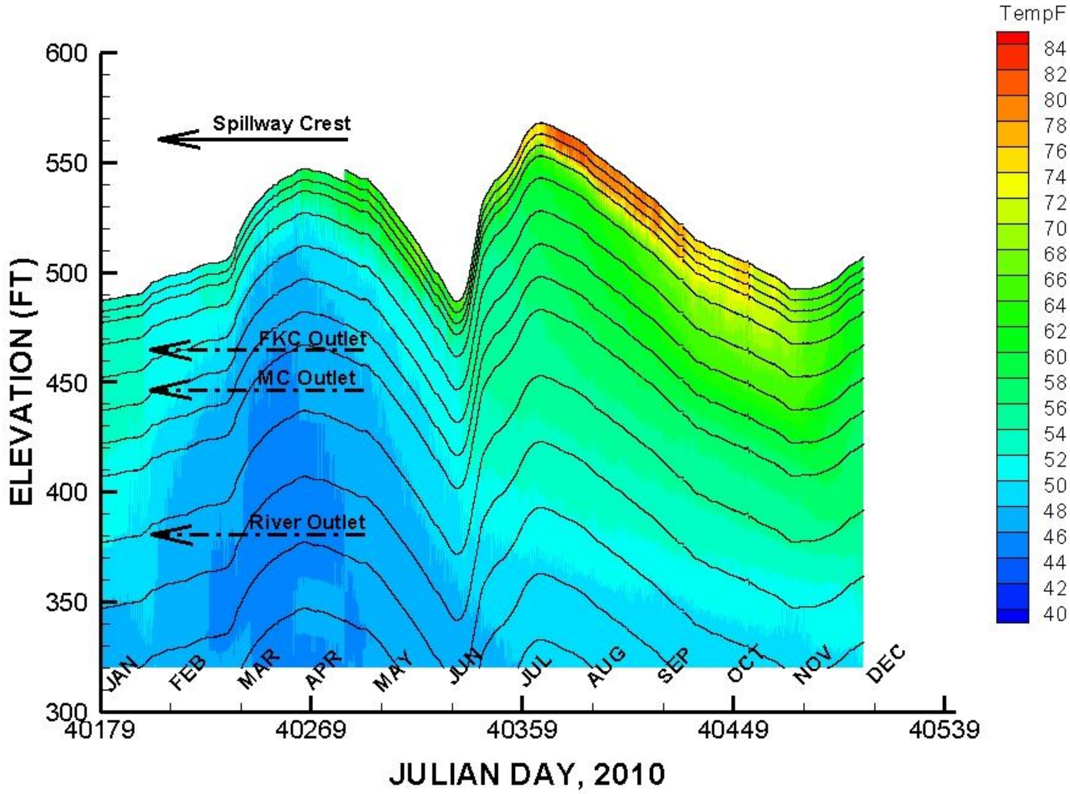
2.3.6 Bed Material Sampling

DWR collected bed material samples in January and October 2010 during topographic surveys (see above). The results were compared with earlier samples and presented in the **Bed Sampling Report**. The comparison showed that some sites exhibited significant changes in material size while others showed slight or no change. No general patterns in change of material size were observed between each seasonal interim flow release.

2.4 Temperature

Reclamation collected temperature data at several Millerton Lake locations during 2010. **Figure 2-3** below displays 2010 temperature profile results from the monitoring string deployed upstream from Friant Dam. The Friant Dam release temperature to the San Joaquin River varied from 45-55°F during 2010. The **Millerton Lake Temperature Monitoring Report 2005-2010** in **Appendix B** provides an update on temperature string results, and the **Temperature Monitoring Atlas** attached to **Appendix D** includes results from this study.

Figure 2-3. 2010 Friant Dam Forebay Temperature Profiles

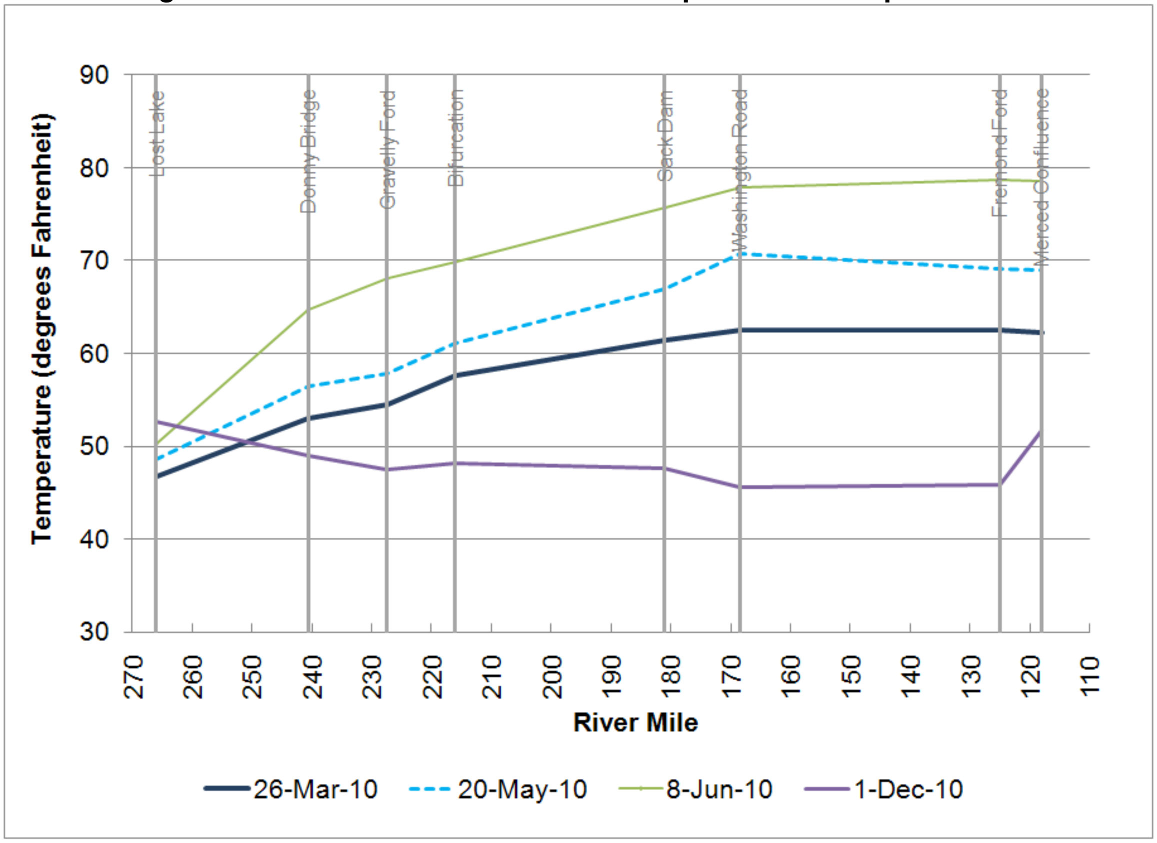


Temperature profile results indicate a relationship between high flow years (2005, 2006, 2010 Interim Flows) and the hypolimnetic temperatures in Millerton Reservoir. When flood releases are made through the river outlets (El. 380 ft) the coldest water is released and it is replaced by SJR inflows to Millerton Reservoir. During 2010 Interim Flow releases the river outlet releases temperature exceeded 50 deg F on June 8.

Water Year 2010 was a Normal-Wet year type with late spring rains, an above-average and persistent snow pack, and low air temperatures. **Figure 2-4** displays San Joaquin River temperatures for key time periods during 2010.

The California Department of Fish and Game (CDFG) continued to manage a network of temperature sensors in Reaches 1 – 5 during 2010 Interim Flows to support fisheries studies. Please refer to the **Temperature Monitoring Atlas** attached to **Appendix D**.

Figure 2-4. 2010 Interim Flows San Joaquin River Temperatures



Temperature monitoring allows SJRRP to improve understanding of factors that influence river temperatures, including Friant Dam release temperature and rate, and ambient air temperature. Refer to **Appendix D** for spring 2010 air temperature data near Firebaugh. On May 28 when Interim Flows reduced from 1,550 cfs to 800 cfs at Friant Dam, the river temperature at Gravelly Ford was below 60 degrees. During the following 10 days, the Friant Dam release temperature reached approximately 50°F, but river temperature at Gravelly Ford reached nearly 70°F. River temperature at Gravelly Ford continued to climb with and follow ambient air temperature in excess of 80°F during summer flows (350 cfs) while the Friant Dam release temperature increased to approximately 55°F.

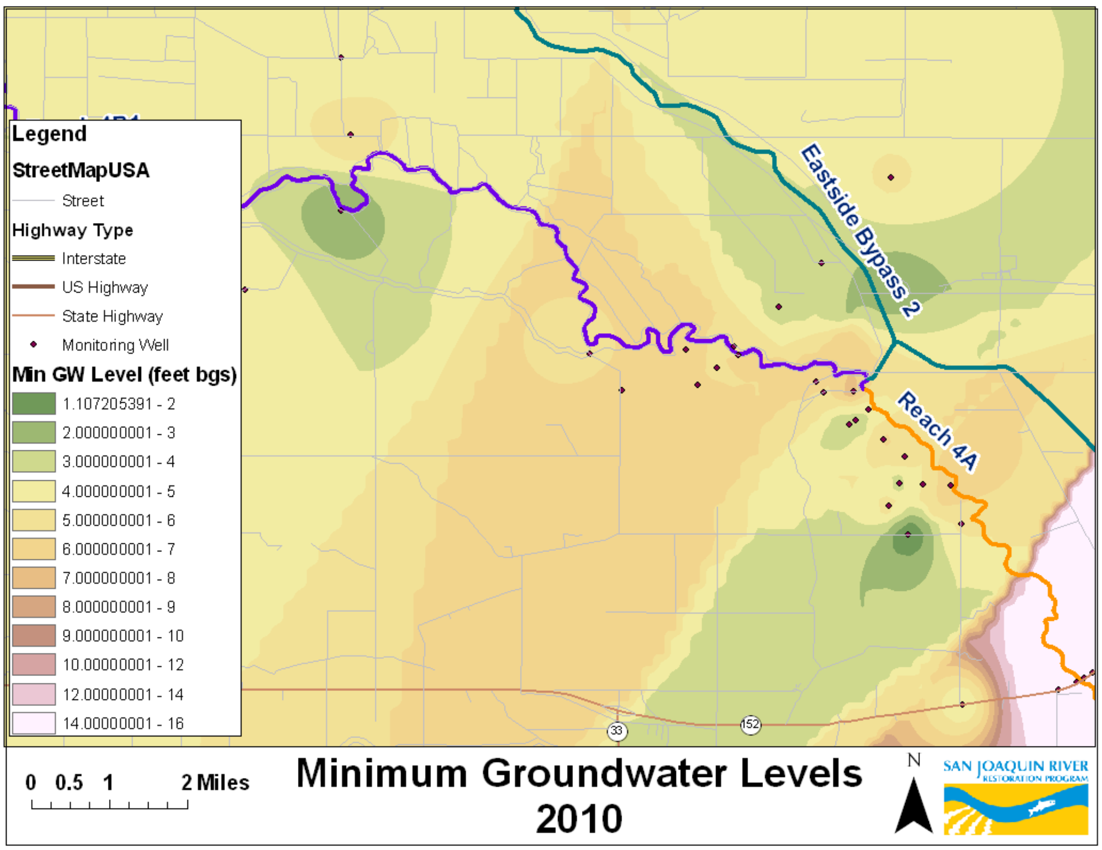
2.5 Seepage

SJRRP continued to implement the Seepage Monitoring and Management Plan to reduce or avoid material adverse seepage impacts during 2010. Reclamation expanded the monitoring well network to 123 wells and collaborated with Central California Irrigation District to produce a single atlas that reports groundwater levels for 245 wells (refer to the **Monitoring Well Atlas**). SJRRP monitors key wells weekly and conducts daily evaluations when flows exceed 475 cfs in Reaches 2A and 3 to make sure groundwater levels do not exceed thresholds designed to prevent encroachment into crop root zones. A Seepage Hotline allows landowners to provide input in real-time to supplement information from the monitoring well network. Hotline calls prompt a site visit to inform flow management decisions.

Approximately 50 soil salinity surveys conducted during spring 2010 established baseline salinity levels and improved understanding of the influence of Interim Flows on soil salinity levels. The availability of soil salinity data is pending a complete analysis.

Seepage management includes identification of projects to address seepage issues which constrain Interim and Restoration Flow releases. During 2010 SJRRP began evaluating a site near River Mile 170 for factors that could influence groundwater levels and crop yields. **Figure 2-5** displays minimum groundwater depths near Reach 4A. **Appendix F** includes a compilation of seepage data, including a monitoring well atlas, a record of hotline calls, daily seepage evaluations, and flow bench evaluations.

Figure 2-5. 2010 Minimum Depth to Groundwater near Reach 4A



2.6 Water Quality

The water quality monitoring program for the 2010 SJRRP Interim Flows included 16 real-time monitoring stations and seven sites where water samples are measured monthly for total suspended solids, nutrients, total and dissolved carbon, bacteria, trace elements, and pesticides based on recommendations by the Regional Water Quality Control Board

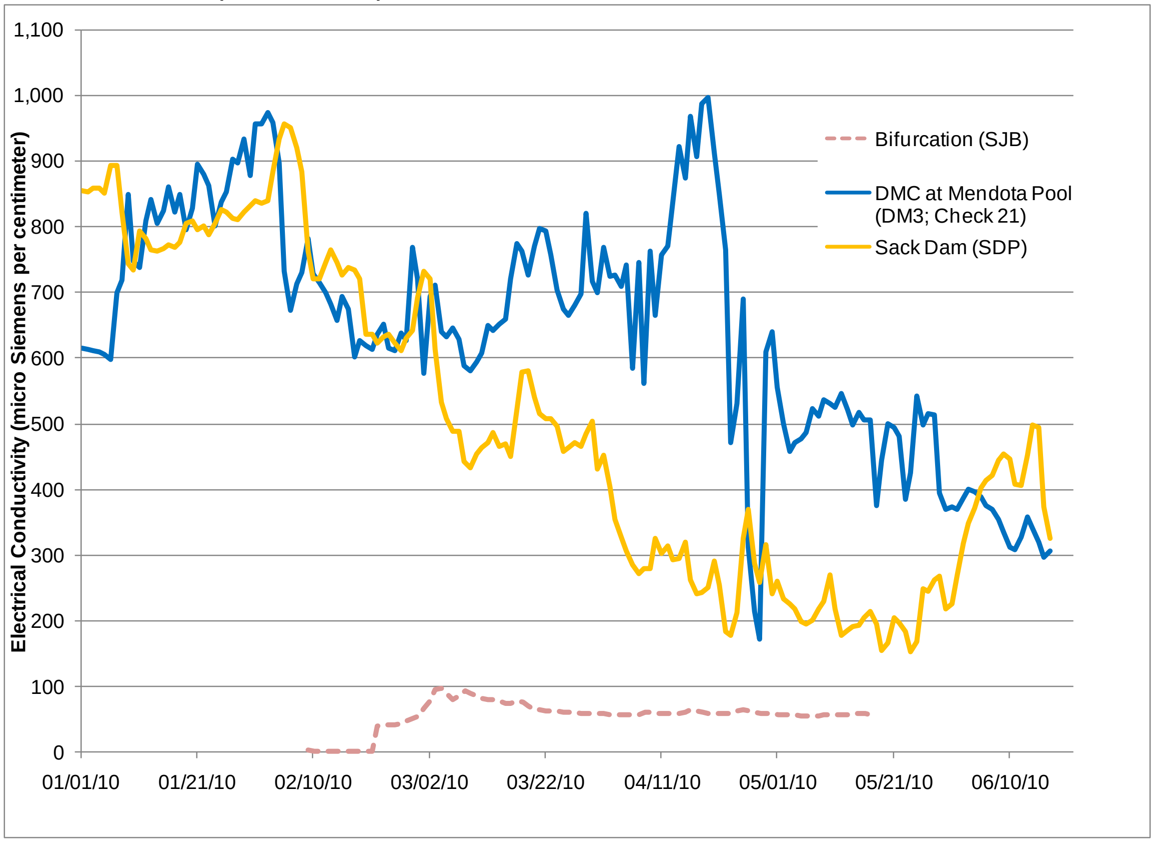
(RWQCB) and the SJRRP FMWG. **Appendix D** provides a complete list of parameters, constituents, and results for 2010.

Figure 2-6 illustrates measurements of electrical conductivity (EC) measured during the spring 2010 Interim Flows. The California Data Exchange (CDEC) electrical conductivity sensor at stream gage DM3 recorded a spike in Mendota Pool salinity because of the introduction of Sacramento-San Joaquin Delta (Delta) water from the Delta-Mendota Canal (DMC) that has higher salinity water than Friant Dam. From April 22 through 28, recaptured SJRRP flows and low irrigation demands at Mendota Pool reduced Delta deliveries. Seepage drainage water returned to the DMC resulted in EC levels that would not permit the Mendota Pool pump-in program. The water delivered to the Mendota Pool from the DMC did not thoroughly mix with low-salinity releases from Friant Dam and resulted in higher salinity water in Fresno Slough and the irrigation canal headworks, than desired by irrigators. Reclamation, the San Luis and Delta-Mendota Water Authority, and the San Joaquin River Exchange Contractors Water Authority adjusted operations to close the DMC at Check 21, meet Arroyo Canal demands through the Firebaugh Wasteway, and dilute high salinity in Mendota Pool/Fresno Slough with low-salinity San Joaquin River water. Reclamation met demands at Mendota Pool with deliveries from Friant Dam. Water quality monitoring included telemetered EC readings and grab samples, as reported in **Appendix D**.

FMWG developed the **Water Quality and Fish Report** as an assessment of SJRRP water quality monitoring in terms of sampling frequency, sampling locations, sampling methods, and detection levels. This review interprets water quality monitoring results for possible effects to Chinook salmon and other fish native to the San Joaquin River. Some notable findings and recommendations thus far include:

- Bifenthrin in sediment samples at concentrations with potential to cause mortality in certain organisms and transfer up the food web via bioaccumulation.
- A total of 42 water quality samples with copper exceeding the EPA aquatic-life chronic benchmark for invertebrates, and 30 samples exceeding the acute benchmark for invertebrates.
- Storm inflow monitoring could potentially reveal toxic concentrations from surface runoff.
- Tissue samples or semi-permeable membranes could help address uncertainty regarding bioaccumulation and food web transfer.
- Some laboratory detection limits are above concentrations of sub-lethal effects (parts per trillion range), which have been shown to affect growth, swimming behavior, reproduction, and immune system response in aquatic fish and invertebrates.

Figure 2-6. Electrical Conductivity of Surface Water at the Chowchilla Bifurcation station, Sack Dam, and the Delta Mendota Canal at Mendota Pool

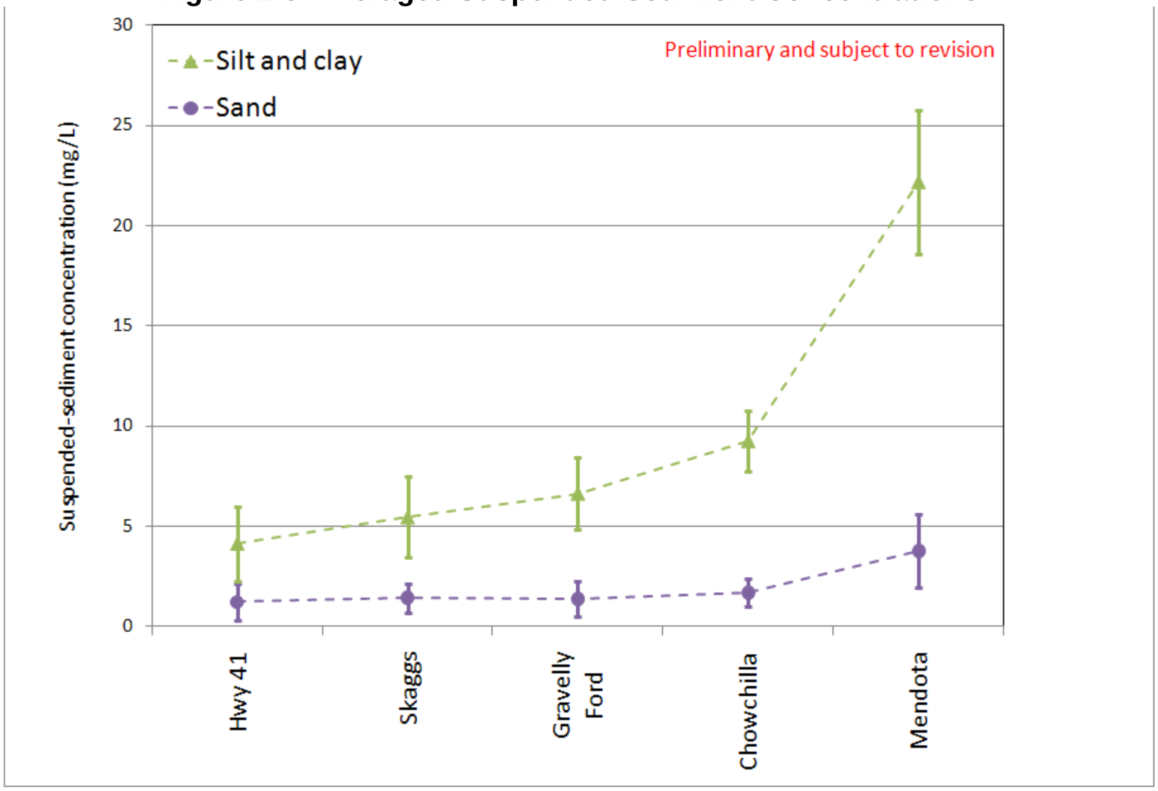


2.7 Sediment

SJRRP collected sediment data for channel capacity and fisheries studies. Please refer to ATR **Section 2.3** for a summary of the California Department and Water Resources sediment monitoring. During March-May 2010 USGS collected suspended sediment, bedload, and discharge data eight times at five locations: Highway 41, Skaggs Bridge, Gravelly Ford, Chowchilla Bifurcation Structure, and below Mendota Dam. Friant Dam releases ranged from 500 to 1,550 cfs during sediment sampling (refer to **Appendix C**).

At upstream sites, suspended-sediment concentrations were low (<10 mg/L) and as flow increased, suspended-sediment concentration decreased, which indicates a sediment supply limitation. At lower sites, suspended-sediment concentrations increased or were nearly constant with flow; thus, sediment supply appears to increase with distance downstream from Friant Dam, as expected. Increasing sediment supply led to increasing suspended-sediment concentrations, for both silt/clay and sand fractions, in the downstream direction (refer to **Figure 2-8**).

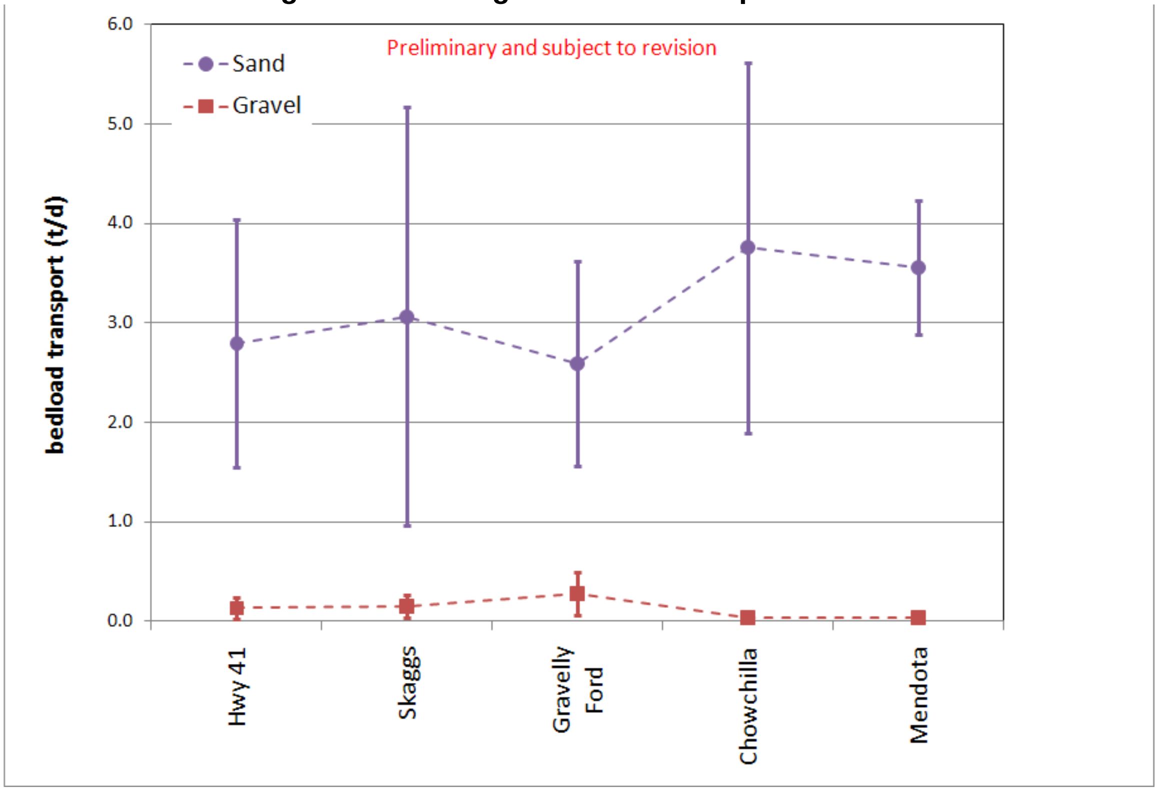
Figure 2-8. Averaged Suspended Sediment Concentrations[1]



1. Suspended sediment concentrations averaged over the entire period at the USGS sampling sites. Vertical bars denote ± one standard deviation in the measurements at each site (i.e. they are not error bars but rather represent the range in concentration measured at each site).

Bedload measurements also suggest that sediment supply increases downstream, though the trends are not as clear as for suspended sediment. Average bedload transport rates increased downstream for sand; whereas gravel bedload transport rates were small at all sites indicating that flows were not high enough to entrain very much gravel (refer to **Figure 2-9**). The median grain size of bedload decreased from about 0.7 mm at Hwy 41 to about 0.4 mm at Mendota, again indicating that the supply of fine sand increases downstream with distance away from Friant Dam.

Figure 2-9. Average Bedload Transport Rates[1]



1. Bedload transport rates averaged over the entire period at the USGS sampling sites. Vertical bars denote ± one standard deviation in the measurements at each site (i.e. they are not error bars but rather represent the range in concentration measured at each site).

SJRRP continues to collect data in order to manage channel capacity through development of an annual sediment hydrograph for the Restoration Area. Next steps for this effort include regular monitoring at the five established locations, addition of a bed material component as part of the regular monitoring, and investigation of sediment contributions from tributaries in Reach 1A to the San Joaquin River.

2.8 Aerials Analysis and Inundation Modeling

SJRRP conducted five aerial flights during 2010 Interim Flows to collect 2-foot color-infrared imagery of the Restoration Area. The flights acquired information for vegetation mapping during phenological periods optimal for species identification, and information for fisheries habitat studies at different flow rates (see **Table 2-3**).

Table 2-3. San Joaquin River Flows (cfs) on Aerial Flight Dates

Flight	Date	Friant Dam	Donny Bridge	Skaggs Bridge	Gravelly Ford	Bifurcation	Sack Dam	Washington Road
1	3/22/2010	804	760	735	707	495	426	(no data)
2	4/7/2010	1,100	1,056	1,003	952	805	789	693
3	4/24/2010	1,352	1,144	1,223	1,035	950	730	700
4	5/6/2010	1,552	1,463	1,365	1,468	1,271	724	798
5	6/25/2010	351	241	224	135	76	78	42

Key
cfs = cubic feet per second

Analysis of 2010 aerial imagery to produce waterlines provides contiguous inundated area estimates for assessment of current San Joaquin River fisheries habitat conditions (refer to **Table 2-4**).

Table 2-4. San Joaquin River Preliminary Contiguous Inundated Acres from Aerial Imagery

Flight	Date	Friant Dam (cfs)	Reach 1A	Reach 1B	Reach 2A	Reach 2B	Reach 3	Reach 4A	Reach 4B1	Eastside Bypass 2	Eastside Bypass 3	Mariposa Bypass	Reach 5
1	3/22/2010	804	514	269	319	312	320	232	81	366	120	4	386
2	4/7/2010	1,100	Analysis in progress.										
3	4/24/2010	1,352											
4	5/6/2010	1,552											
5	6/25/2010	351											

Vegetation maps produced from this imagery will include elderberry (*Sambucus sp.*) to establish a baseline for future consultation with the U.S. Fish and Wildlife Service (USFWS); the presence of five invasive species, including giant reed (*Arundo donax*), sponge plant (*Limnobium spongia*), Chinese tallow (*Sapium sebiferum*), red sesbania (*Sesbania punicea*), salt cedar (*Tamarix sp.)* with potential to compromise successful implementation of SJRRP; and a base vegetation-type map of the Restoration Area.

Analysis of one-dimensional HEC-RAS inundation modeling results is in progress. Complete results from the aerial imagery will allow for further validation of modeled results.

2.9 Fisheries

The Fisheries Management Plan describes life-history strategies and requirements within each stage for both spring and fall-run Chinook salmon. **Attachment 1** displays life stages, life stage outcomes, and existing and future SJRRP monitoring to address fisheries problem statements.

2.9.1 Spawning Environment (in the Hyporheic Zone)

Invertebrates that might impact salmon eggs or alevins were not detected in gravels sampled with hyporheic pots. Dissolved oxygen concentrations at various possible redd locations measured at the 30 cm depth indicated that seven out of nine potential redd sites experienced at least one DO reading below 8 mg/L (criterion for protection of early life stages) with most (six of nine) below 6 mg/L. Percent sand (2 mm particle size) collected from hyporheic samplers averaged 4.76 % in September 2010 and 6.68 % in December 2010, and was less than the 13% above which negative impacts may occur. Predicted Chinook salmon emergence success from a regression using gravel sizes from collected samples averaged 46%. Early results indicate that there are a few redd sites suitable for egg and alevin survival in this section of the San Joaquin River. It also appears that intragravel DO may be a limiting factor in this portion of the river.

2.9.2 Hills Ferry Barrier Evaluation

Hills Ferry Barrier is designed to inhibit passage of migrating adult, fall-run Chinook salmon into the currently unsuitable habitat of the San Joaquin River upstream of the San Joaquin-Merced River confluence. The Hills Ferry Barrier is a hybrid Alaskan-Sliding Pipe weir design used to exclude and/or trap large migrating fish from swimming upstream while allowing water and other smaller species to pass. The soft, sandy river substrate was observed to erode around the support structures and base of the conduit bars, resulting in scouring holes underneath the barrier footings and along the shoreline.

The evaluation included surveys under high turbidities with a DIDSON acoustic camera to locate and observe scouring, missing pickets, and gaps in the barrier. The near-video quality images of the DIDSON allow detailed underwater inspections of the barrier and substrate; however the angle of the weir and the surface reflection posed some difficulties on the downstream side of the barrier. Carp, catfish, striped bass, threadfin shad, and Chinook salmon were identified, especially on the downstream side were the barrier was inhibiting their movement up-river or providing structure. Chinook salmon and carp were observed to move along the barrier looking for holes in the barrier and passage opportunity. The DIDSON provided an interesting observation of an unidentifiable species (most likely a carp), using its body to attempt to burrow under the conduit pickets in the substrate at the barrier’s base, accelerating the erosion process.

Sonic telemetry was employed to monitor adult Chinook salmon behavior, primarily on the downstream side of the Hills Ferry Barrier to assist in determining the effectiveness of the barrier at inhibiting passage and movement patterns in the proximity of the Hills Ferry Barrier and San Joaquin-Merced River Confluence. In addition, fish at Sack Dam, Mendota Pool, and the base of Friant Dam were caught and esophageally implanted with sonic tags. The fish trap at Hills Ferry Barrier proved to be ineffective at catching Chinook salmon but did capture carp and catfish. The trap captured only two salmon during the study duration which were immediately released without a sonic tag due to fish condition and logistical restrictions. In November 2010, two male Chinook were captured upstream of the barrier that had apparently bypassed the barrier during cleaning (excessive water hyacinth loads and vegetative debris become lodged against the sliding pipes and require their removal for a short period to allow the plant matter to travel downstream), through scour holes at the base, or barrier gaps along the shore, and traveled upstream. These fish were netted while swimming along the upstream side of the barrier looking for passage back downstream, tagged with a sonic transmitter, and released downstream of the barrier. Fish were tracked with five pre-positioned receivers placed at strategic locations and a hand-held mobile receiver to provide details on local movements. These two fish were detected only on receivers below the weir and confluence and did not re-ascend the San Joaquin or the Merced Rivers.

Fishermen and San Luis Canal Company (SLCC) staff alerted Reclamation and Department of Fish and Game (CDFG) staff to approximately four fish below Sack Dam where one female was later tagged with a sonic transmitter and released upstream of the dam. This fish was later tracked downstream of Mendota Pool. CDFG biologists, along with the San Luis Canal Company (SLCC) staff, reconfigured the stop logs in the Sack Dam fish ladder to allow passage of other fish that had made it past the Hills Ferry Barrier. Biologists from Implementing Agencies collaborated in trap and haul operations to relocate salmon from several locations. Biologists later observed several salmon (~12) below the base of Mendota Dam and CDFG sonically tagged a few females and released them into Mendota Pool. Two other males were captured in an irrigation canal, tagged, and transported to the base of Friant Dam and released. Fish observed on the upstream side of the barrier, below Sack and Mendota Dams, and in irrigation canals successfully bypassed Hills Ferry Barrier. Erosion of the unstable substrate will remain a problem until the temporary barrier is redesigned with significant changes to restrict salmon passage.

2.9.3 Fish Passage Evaluation

The Department of Water Resources (DWR) conducted Fish Passage Evaluations along the San Joaquin River and flood bypasses from Friant Dam to the Merced River confluence to identify passage impediments to migration of juvenile and adult salmon and other native fish. Initial assessments (First Pass) in July and August 2010 of structures included identification of potential fish passage impediments, field evaluations of these structures, and development of passage criteria. Each structure is rated as a barrier, not a barrier, or an impediment to fish passage. 45 of 68 potential barriers were surveyed. Structures along the Chowchilla Bypass and upper Eastside Bypass were not surveyed.

First Pass surveys included measurement of the structure length, outlet drop, slope, elevation of the tailwater control relative to structure inlet, outlet, pool invert, ratio of structure width to channel width, and channel substrate continuity over or through the structure. Fish Passage Inventory Data collected at all locations included a description of the type and condition of each structure, structure dimensions, stream habitat, GPS waypoints, a site sketch, and photographs.

Stream crossing evaluations relied on criteria developed by the California Department of Fish and Game (CDFG) and the National Marine Fisheries Service (NMFS). These criteria were generally based on the flow velocities within the structure, jump height to enter a structure, drop distance at the exit of a structure, and pool depths upstream and downstream of a structure. The initial evaluation of each structure categorizes each structure as Green/Gray/Red as it relates to fish passage:

- Green – The location is assumed adequate for passage of all salmonid species throughout all salmonid life stages and stream flows.

- Gray – The location may not be adequate for all salmonid species at all their life stages and stream flows. More information is needed to evaluate the structure.
- Red – The location will likely fail to meet CDFG and NMFS passage criteria at all flows for strongest swimming species presumed present.

Further fish passage evaluation (Second Pass) of Gray sites will include topographic surveys and hydraulic modeling. Red sites require no additional analysis and will be placed onto the list of structures to be removed or modified. Cumulative effects of each structure on fish migration were not evaluated during this study. The First Pass identified 28 structures as Green, 13 structures as Gray, and 8 structures as Red. The First Pass data collection and fish passage assessments are included in a draft Technical Memorandum currently in review.

2.9.4 Habitat Mapping

The Department of Fish and Game completed habitat mapping in Reaches 1B, 2, and 4A. Please refer to **Appendix G**.

2.9.5 Reach 1A Bed Mobility

This study includes several measurement components to assess the ability of flows to mobilize the stream bed in Reach 1A, targeting anticipated Chinook salmon spawning areas. At two sites monitoring of the bed provides information that will assist in calibrating and validating a model to predict Reach 1A flow and sediment transport conditions. At each site 5 cross-sections were monumented for monitoring over time. The individual measurement components of this task include channel topography, bed material sampling, bed photography, gravel tracer, force gauge, and flow profiling surveys. All of these components were measured at both study sites and all but one was used at each site’s 5 cross-sections. Force gauge surveys were not performed along the downstream most cross-section at either site.

There is measureable variability in the ability of the bed to become mobilized between the two sites, between cross-sections, and along cross-sections. Tracer results demonstrate that mobility occurs at 700 cfs flows at one site while at the same flow levels the other site remains immobile. Tracer movement during 700 cfs flows suggests mobility is limited to portions of the channel close to the thalweg within the riffle and absent in the upstream pool/glide tail and downstream pool head. During the monitoring period a 1,700 cfs flow occurred. Survey results suggest that approximately 20% more tracers were mobilized as compared to the 700 cfs flow. Comparing travel distance measurements between the two flow levels are inconclusive due to difficulty in deciphering between cumulative distances versus event specific distances.

Channel alteration was observed to result from the 1,700 cfs flow. Measurements recorded bed scour by as much as 1.5 ft, deposition by as much as 1 ft, and at least 6 ft of bank erosion. The same flow induced erosion of bank material and drift of large woody debris into the channel. The result of which was a local addition of approximately 4,000 ft^3 of sand, gravel, and cobble sediment to the channel. Future monitoring efforts will investigate (1) the role of the sediment supplied to alter local bed mobility as well as (2) trends in channel geometry. The consequences of these will be applied to predict flow variables such as velocity and depth and proactively assess their impact to aquatic habitat needs.

3.0 Monitoring Network

The monitoring network for the SJRRP was developed to address problem statements presented in Appendix A, and to refine or strengthen conceptual models and assumptions. The monitoring network shown in Figure 3-1 includes sites currently monitored. The number of sites currently monitored, are presented by physical parameter in Table 3-1. The locations included in bathymetric, water surface profile, and cross section surveys are shown in figures presented in Appendices D and F. Additional information regarding the locations for aerial and biological surveys is not currently available.

Appendices B through F describe the monitoring methodology used for each of the physical parameters that were monitored and surveys that were conducted during the spring 2010 Interim Flows.

Table 3-1. Number of Monitoring Locations by Reach

Reach	Flow and Stage	Groundwater Levels and Temperature	Surface Water Temperature	Surface Water Quality	Sediment
1A	6	4	20	3	3
1B	2	11	3	1	1
2A	5	20	4	2	13
2B	2	10	3	1	1
3	1	13	4	2	1
4A	1	21	5	2	2
4B1	2	15	2	1	0
4B2	0	0	3		0
5	3	4	7	4	1
Bypasses	1	0	11	0	2
Tributaries				3	

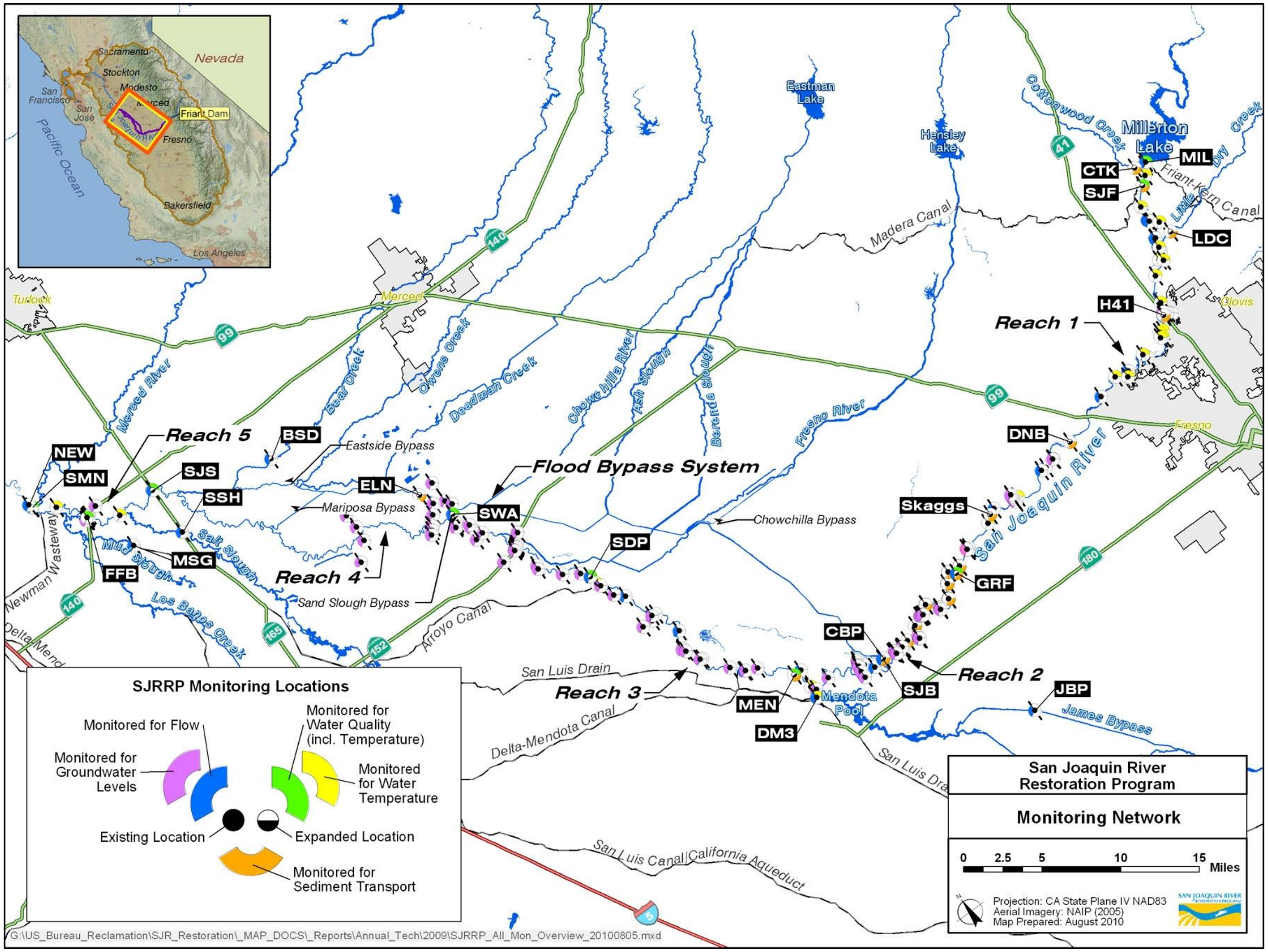


Figure 3-1. Monitoring Locations in Reaches 1 Through 5

4.0 Models and Analytical Tools

Modeling provides a numerical representation of conceptual models to assist in understanding and predicting conditions that may help formulate operations as well as other studies and plans. Improving models of the physical conditions in and around the San Joaquin River may support in resolving problem statements identified in **Appendix A**.

Table 4-1. Analytical Tools for SJRRP

Model	Type	Purpose	Status	Model Application
HEC-RAS	Hydraulic (1D)	Water surface (Inundation mapping)		Terrain updates
SRH-2D	Hydraulic	Depth/velocity/habitat mapping		
SRH-2D	Sediment	Transport/habitat mapping		
SRH-2D	Temperature	Habitat mapping		
SRH-1D	1D mobile boundary sediment	Transport		Update based on new terrain data.
HEC-5Q	1D hydraulic routing, temperature	San Joaquin River temperature		Validation using 2010 monitoring data. Modeling for proposed hydrographs to aid flow scheduling.
CE-QUAL-W2	Temperature (vertical 2D)	Millerton cold water pool	Complete	
SRH-1DV	Cross section vegetation	Vegetation response to flow and sediment conditions		Support for design work on Reach 2B and Reach 4B site-specific projects
CVHM	Groundwater	Groundwater flow	CVHM has 1-mile-square grids for Central Valley	Preliminary simulations related to Reach 2B proposed alignments right now, using current version and input from HEC-RAS model
EDT	Fisheries	Population response to habitat conditions	Under development	

5.0 Conclusions

2010 was a Normal-Wet year which provided an opportunity to release Interim Flows to collect monitoring data, begin analysis efforts, and develop some conclusions. During this first year of Interim Flows SJRRP gained insight into operation of Friant Dam to achieve downstream flow targets. Friant Dam was operated responsive to seepage constraints, Mendota Pool demand, and water quality near Mendota Pool. Flow benches of approximately 14 days appeared to allow sufficient time for conditions in the Restoration Area to stabilize.

During fall 2009, water quality monitoring resulted in non-detection or concentrations below maximum contaminant levels for all parameters of concern to the SWRCB and SJRRP. The current water quality monitoring program is based on the 2009-2013 Water Quality Monitoring Plan, which may be refined to adjust frequency of measurements or adjust the number of required monitoring sites with input from SWRCB and FMWG.

Results from stream gage temperature monitoring indicate that ambient air temperature is an important factor influencing river temperature downstream to the Merced River confluence. Further study may be required to support this conclusion and to study the temperature influences on upstream San Joaquin River temperatures.

2010 monitoring identified several areas of shallow groundwater near the river. Analysis to understand the factors affecting shallow groundwater near the river will continue. Thresholds may be refined based on lateral groundwater gradients below fields. Data collected during 2010 may be used to calibrate models.

Analysis of data collected by the 2010 Interim Flows monitoring network is ongoing and results will continue to appear in future reports.

6.0 References

Central Valley Operations Office (CVOO). 2010. 2009 Reservoir Operations Reports. Available at < http://www.usbr.gov/mp/cvo/rpt_09.html>.

San Joaquin River Restoration Program (SJRRP). 2009a. Draft Fisheries Management Plan: A Framework for Adaptive Management in the San Joaquin River Restoration Program. Available at <http://restoresjr.net/>.

San Joaquin River Restoration Program (SJRRP). 2009b. Draft Seepage Management Plan.

San Joaquin River Restoration Program (SJRRP). 2011. Restoration Flow Guidelines.

Appendix G – Seepage Monitoring and Management Plan

This page intentionally left blank

DRAFT

Seepage Management Plan

SAN JOAQUIN RIVER RESTORATION PROGRAM

March 28, 2011

1. Introduction

This Seepage Management Plan (Plan) for the San Joaquin River Restoration Program (SJRRP) describes the monitoring and operating guidelines for reducing Interim or Restoration Flows to the extent necessary to address any material adverse impacts caused by Interim and Restoration Flows in the San Joaquin River identified by the SJRRP groundwater monitoring program. The geographic scope of this Plan, referred to as the Restoration Area, is the area within five miles of the San Joaquin River and associated bypass system along the 150-mile reach from Friant Dam to the confluence with the Merced River. This 150-mile reach and associated defined sub-reaches are shown in Figure 1.

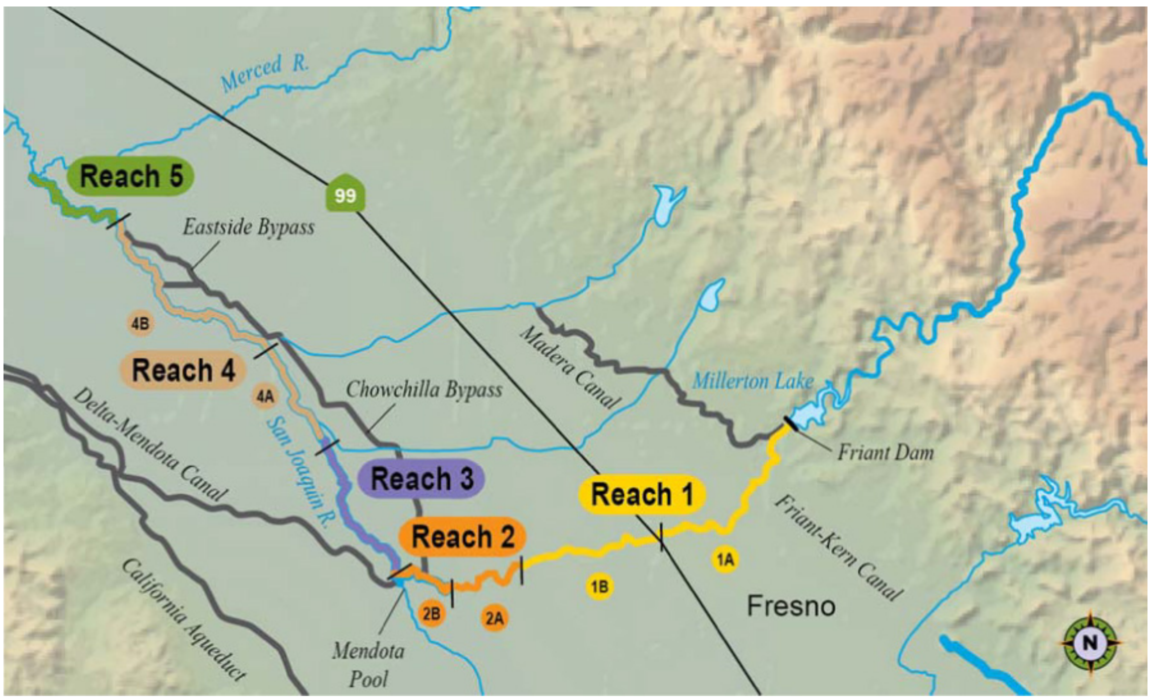


Figure 1. Restoration Area

This Plan is meant to be a dynamic, adaptive plan. Implementation of SJRRP activities over time will result in new information and subsequent revisions of the Plan. The Plan provides the framework to facilitate this adaptive process. Stakeholder input and feedback has helped to shape this plan and will continue to improve the process.

The seepage-related effects considered in this Plan are related to lateral flow through levees and associated seeps, and rising of the water table in areas where it is shallow. The former is straightforward in concept, but the latter requires some explanation. Two mechanisms may cause the water table to rise in association with Restoration Flows. Along losing reaches, where river water surface elevation is above groundwater level, increased seepage from the river/bypass system may result in increased groundwater recharge. Along gaining reaches, where river water surface elevation is below groundwater level, groundwater discharge to surface water may be impeded by an increase in surface-water stage. In response, the water table will rise until equilibrium with surface water, or the discharge to surface water is established, or evapotranspiration and/or other forms of discharge increase to regain the previous rate of discharge. In this document, all impacts caused by groundwater rise associated with changes in river/bypass stage, regardless of mechanism, are referred to as *seepage impacts*.

The Plan provides a means to reduce or avoid risk of seepage impacts through a combination of monitoring and analyses to better understand and predict system response to Restoration activities, and development of thresholds and response actions designed to reduce or avoid undesirable outcomes. Components of the Plan include:

- Purpose and Objectives: the purpose and intended outcomes of the Plan;
- Seepage Effects: description of undesirable outcomes and the processes that contribute to seepage.
- Locations of Known Risks: areas identified as at risk for seepage effects through landowner identified parcels, historical groundwater levels, the Central Valley Hydrologic Model (CVHM), and the current monitoring program.
- Operations Plan: procedures for assessing flow rates and responding to real-time concerns identified by monitoring and landowner feedback through making changes in flow releases.
- Monitoring Program: the data collection program including a series of telemetry, logged, and manually measured monitoring well transects and staff gages spaced roughly 8-10 miles apart with additional wells at locations identified by the SJRRP and landowners to document the hydrologic response to Interim and Restoration Flows, inform analyses, constrain modeling, and identify potential or actual seepage impacts.
- Thresholds, Triggers, and Operational Criteria: groundwater levels that identify the potential for seepage effects, and events that result in increased scrutiny and provide operational criteria to restrict the magnitude, timing, or duration of flows.
- Site Visits and Response Actions: specific actions or alternative actions that will be implemented as necessary to meet operational criteria and avoid or reduce seepage impacts;
- Projects: potential modifications to reduce seepage effects and allow for higher flows that require independent, supplemental environmental documentation and regulatory review; and
- Revision Process: process for modifying and/or updating the Plan on the basis of information obtained during implementation of the Plan.

Data and tools to support the Plan include historical measurements, anecdotal evidence, hydrologic models, and analytical computations. The release of Interim Flows allows the SJRRP to study groundwater and seepage effects and remove conveyance constraints prior to the release of full Restoration Flows. Implementation requires a number of site-specific tasks to determine monitoring locations, install monitoring systems, establish thresholds, and prescribe response actions for various levels of SJRRP-induced changes. Local landowners can provide information to improve the effectiveness of the program including continued input through the Seepage and Conveyance Technical Feedback Group meetings. The main body of the Plan describes the components and interactions of operations to reduce or avoid seepage impacts. The following appendixes contain supporting technical information:

A. Seepage Effects
B. Areas Potentially Vulnerable to Seepage Effects
C. Historic Groundwater Levels and Surface-Water Flow
D. Sediment Texture and Other Data
E. Operations
F. Monitoring Well Network Plan and Other Seepage-Related Monitoring
G. Development of Soil Salinity Thresholds
H. Development of Groundwater-Level Thresholds
I. Landowner Claims Process
J. Modeling
K. References Cited

This Plan is part of the project description for the SJRRP and the expected environmental impacts of implementing the Plan must comply with NEPA and CEQA criteria.

2. Purpose and Objectives

The Plan will convey Interim and Restoration Flows while reducing or avoiding SJRRP-induced seepage impacts along the San Joaquin River and the Eastside and Mariposa Bypasses from Friant Dam to the Merced Confluence. This Plan addresses several components of the San Joaquin River Restoration Settlement Act, H.R. 146, which requires the Secretary of the Interior to:

(1) prepare an analysis that includes channel conveyance capacities and the potential for levee or groundwater seepage;

(2) describe a seepage monitoring program; and

(3) evaluate possible impacts associated with the release of Interim Flows.

3. Seepage Effects

This plan identifies and evaluates a physical impact by describing the measurable impact mechanisms, processes, and thresholds where actual or pending seepage could cause damage. Impact mechanisms under the Plan include:

1. **Waterlogging of crops –** inundation of the root zone resulting in mortality or reduced crop yields.
2. **Root-zone salinization –** salinity increases resulting in mortality or reduced crop yields.
3. **Levee instability –** boils or piping (seeps) that may compromise the short- or long-term integrity of the levee.

4. Locations of Known Risks

This plan represents potential risks by sites and areas of likely or known vulnerability to seepage effects on the basis of (1) mapped depth to the water table using measured water levels; (2) problematic areas identified by landowners; (3) analysis of flow, precipitation, and water-level data; and (4) simulation results using a regional hydrologic model, particularly in areas where water-level data are sparse. Appendix B: Areas Potentially Vulnerable to Seepage Effects includes documentation of these data and analyses.

The analysis of potential risks documents local knowledge, assists in siting monitoring stations, and scopes additional studies. Data and analyses that support baseline seepage conditions are included in Appendixes B: Areas Potentially Vulnerable to Seepage Effects and Appendix C: Historic Groundwater Levels and Surface-Water Flow.

5. Monitoring Program

Reclamation monitors the effects of SJRRP activities which informs identification of when, where, what, and how potential response actions may be implemented. Thresholds, discussed in Section 6, indicate potential for seepage effects and inform response actions and/or additional data collection needs. The monitoring program informs modeling and analysis to evaluate strategies for implementing response actions. See Appendix F: Monitoring Well Network Plan and Other Seepage-Related Monitoring for details on the existing Monitoring Plan and future directions.

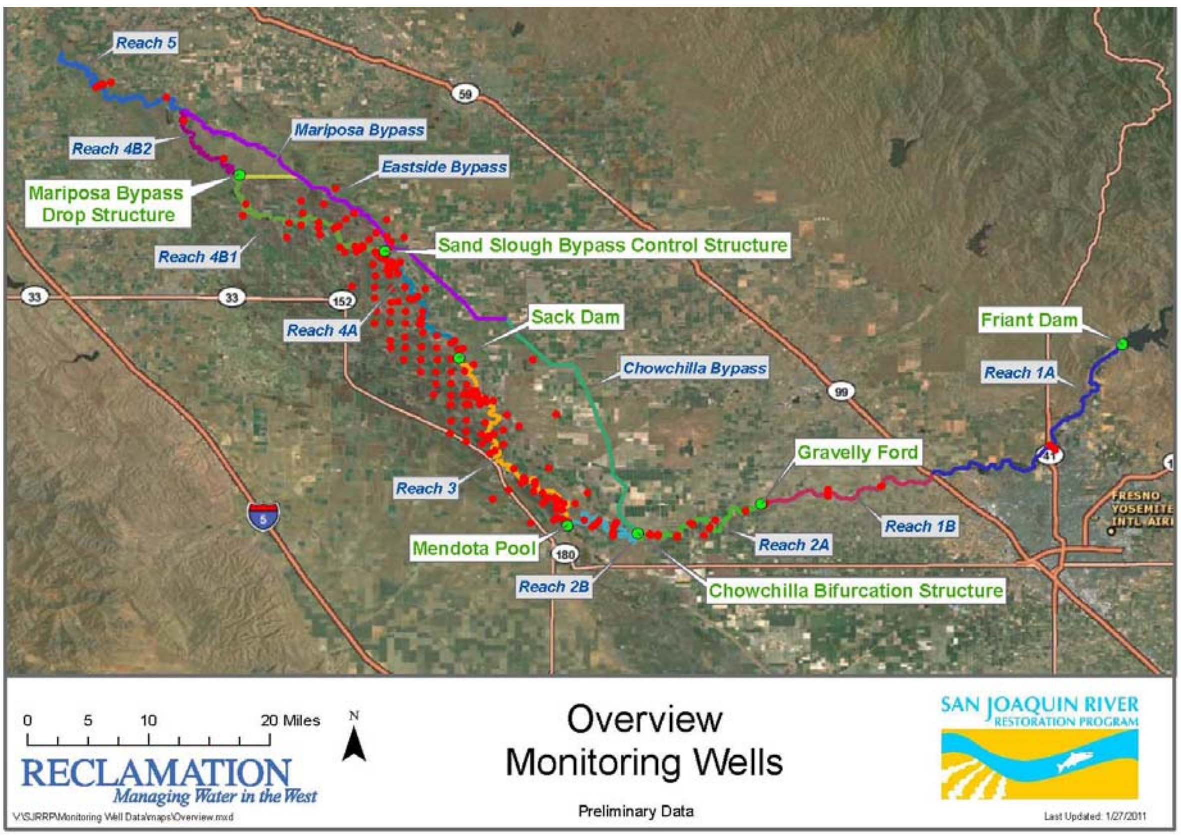


Figure 2. Cover of SJRRP Monitoring Well Atlas showing SJRRP monitoring well network including stakeholder wells

Areas underlain by a shallow water table, herein referred to as shallow groundwater areas, are of particular interest in the monitoring program. The SJRRP currently takes measurements in 111 monitoring wells as of February 21, 2011. The monitoring program includes:

1. Well transects spaced at roughly every 8–10 miles with 4–6 shallow monitoring wells (indicative of the water table aquifer), a staff gage measuring river stage, and 1–2 deeper monitoring wells (potentially indicative of the underlying semiconfined or confined aquifer) at each transect;
2. Additional shallow wells located in known shallow groundwater areas that may be affected by seepage, in collaboration with local landowners and the Central California Irrigation District (CCID);
3. Soil sampling and soil salinity surveys using electromagnetic (EM) methodology, in collaboration with local landowners;
4. Reporting from local landowners on visual crop health, levee seeps, and other observations through phone and email with established SJRRP-designated points of contact.

Information from monitoring, analysis, and local landowners will be used to determine well locations, subject to potential access limitations. New information may indicate that wells should be added, decommissioned, excluded from particular cross-sections or otherwise modified in the future. The Monitoring Well Atlas, available on the SJRRP website, contains details of the monitoring well network and will be updated periodically as additional information is gained and wells are installed or modified.

6. Thresholds

Thresholds identify transition points where seepage effects cross into a range that may cause damages. Thresholds also collect information before an impact occurs and provide time to initiate a response. Thresholds may take the following forms:

1. **Water surface elevation** – measured elevation of the water surface in a well relative to a vertical datum.
2. **Depth to water** – measured vertical distance to the water surface in a well relative to the land surface.
3. **Root-zone salinity** – measured (using direct or indirect methods) salinity in the plow or root zone and/or distribution of salinity in soil profiles.

A groundwater levels shallower than a threshold indicates the potential for impacts in the absence of actions to avoid, minimize, rectify, reduce, or compensate for seepage impacts. Site-specific customization of specific thresholds will continue to be enhanced by coordination with local landowners and may depend upon characteristics such as:

1. Local geology;
2. Presence, design considerations, and state/condition of the levee system;
3. Historical experience and areas of known historical seepage problems;
4. Structures and operations;
5. Soil salinity profile;
6. Crop type; or
7. Intent of threshold.

Draft thresholds associated with the water table and monitoring thresholds for soil salinity in farmed shallow groundwater areas are shown in Table 1. The salinity thresholds apply only where current conditions are more favorable than the threshold values. If current conditions exceed threshold values, thresholds will be a specified change from current conditions.

Table 1. Draft thresholds for groundwater and soil salinity underlying agricultural lands

Impact indicator	Threshold	Basis
Plow layer soil salinity (0-12 inches below land surface)	ECe[1] = 2.0 deciSiemens/m (ds/m) (See Appendix G)	Salinity affects germination or emergence of vegetable and other crops
Active root zone soil salinity (0-30 inches below land surface)	River-reach-specific; e.g., ECe[1] = 1.5 ds/m for reach 2B (See Appendix G)	Known salt tolerance for crops
Minimum depth to water table	Variable, depending on crop type, historical water levels, and local conditions (see Appendix H)	Waterlogging affects crop yields and increases soil salinity

[1] ECe is electrical conductivity of soil-water extract (saturation extract)

The SJRRP has identified specific groundwater thresholds for each well and priority wells for measuring groundwater thresholds in areas of known risk. There are three methods for determining the groundwater threshold. These include:

- Agricultural Practices
- Historical Groundwater
- Drainage

The thresholds are generalized, and adjustments may be required to account for on-site and/or seasonal conditions. Crop health can be affected by conditions unrelated to SJRRP activities, including various climatic conditions and other factors such as plant diseases. The procedures used for establishing thresholds are described in Appendix G: Development of Soil-Salinity Thresholds and Appendix H: Development of Groundwater-Level Thresholds.

7. Operations Plan

The approach to operations is a conservative, iterative one. The SJRRP will estimate a release from Friant Dam and Mendota Dam that avoids seepage impacts. The release will estimate non-damaging flows by establishing groundwater thresholds, as described in Section 6 and Appendix H, and linking thresholds to river stage through a conceptual model. The conceptual model initially assumes one foot of increase in river stage causes one foot of increase in groundwater. If the monitoring program identifies areas where the conceptual model predicts overly conservative flow limits, the SJRRP may update flow releases based on site specific information. When the SJRRP cannot estimate a higher release that will not exceed a threshold, the stage or flow rate in the river becomes an operational criterion. An operational criterion is a specific measurable or observable criterion (such as a river stage) that indicates impending impacts, is established based on site-specific analysis, and will limit flow releases.

Prior to an increase in the targeted Friant Dam release, the SJRRP conducts a Flow Bench Evaluation. The purpose of the Flow Bench Evaluation is to avoid seepage impacts through checking factors and reducing or eliminating the proposed increase accordingly. Flow Bench Evaluations verify:

1) Conveyance Capacity:

   Avoid levee instability by limiting flows to the rated conveyance capacity of the channel.

2) Flow Stability:

   Account for travel time and potential changes that may not have materialized since the prior change in releases by allowing flows to stabilize before the next change in releases.

3) Groundwater Projections:

   Avoid seepage impacts by predicting groundwater level rise from the proposed increase assuming a one foot increase in river stage equates to a one foot increase in groundwater level. If groundwater levels are predicted to rise above thresholds, this triggers a site visit as described in Section 8, prior to the change in flow.

4) Groundwater Telemetry:

   Avoid seepage impacts by monitoring real-time groundwater wells and conducting a site visit if levels are near thresholds.

5) Groundwater Manual Measurements:

   Avoid seepage impacts by measuring groundwater wells weekly and conducting a site visit if levels are near thresholds.

6) Mendota Pool Operations:

   Avoid infeasible operations through the Mendota Pool operations calls including exchangeable demand, water quality, and Central Valley Project South of the Delta operations.

7) Landowner Feedback (Seepage Hotline):

   Avoid potential seepage impacts by gathering data from Seepage Hotline calls and subsequent site visits.

8) Operations Feedback:

   Avoid infeasible operations and levee instability through coordination with the Central California Irrigation District, San Luis Canal Company, and Lower San Joaquin Levee District on potential concerns with the proposed flow increase.

In addition to Flow Bench Evaluations, the SJRRP conducts Daily Flow Evaluations when flows are above 475 cfs. Daily Flow Evaluations include documentation of the checks on conveyance capacity, Mendota Pool operations, and landowner feedback as described above. Daily Flow Evaluations also trigger site visits if real-time or measured groundwater levels are near thresholds.

Flow Bench Evaluations and Daily Flow Evaluations help the SJRRP avoid seepage impacts and document decisions to increase flows. These evaluations also trigger site visits and response actions based on SJRRP's monitoring network.

See Appendix E: Operations for example forms.

8. Triggers

Triggers describe when the SJRRP will take action through site visits and flow management. There are three different types of triggers. Two of these are SJRRP actions, and the last one allows landowners observations to trigger SJRRP action. These triggers include:

1. Flow Bench Evaluations: A site visit and response action is triggered when groundwater levels are predicted to rise above thresholds
2. Daily Flow Evaluations: A site visit and response action is triggered when measured groundwater levels are near thresholds
3. Seepage Hotline Call: A site visit and response action is triggered when landowners observe seepage-related issues

Following a trigger, the SJRRP will initiate a site visit. The SJRRP may re-evaluate the estimated flow rate and/or the threshold as a result of information collected at a site visit.

9. Site Visits and Response Actions

Site visits, triggered by flow bench evaluations, daily flow evaluations, or seepage hotline calls, collect a variety of information to inform management response decisions. Site visits provide an initial assessment to determine the type of impact, description of the seepage, the relationship to interim flows, the immediacy of the response, a recommended real-time response action, and any needed follow-up regarding projects. Site visits may include monitoring and conversation with the landowner to gather the following types of data:

1. Landowner Input on Seepage Effects
2. River Stage
3. Soil Texture
4. Hand Auger Groundwater Levels (allows rapid response rather than waiting for backhoe or well installation)
5. Drive Point Installation
6. Soil Salinity
7. Infrastructure

8. Crop Health
9. Photos

The operations for releasing Interim and Restoration Flows are designed to safely convey flows without triggering the need for response actions. If site visits are triggered, response actions will be evaluated and implemented as soon as practicable to avoid or reduce seepage impacts. Flood operations supersede SJRRP releases and may occur irrespective of groundwater monitoring. Potential response actions include:

1. **Planned releases can occur** – no seepage impacts are anticipated at the site based on the planned release schedule. Anticipated releases can occur.
2. **Increased monitoring** – no seepage impacts are anticipated at the site for the near-term anticipated releases, however, an increased monitoring frequency will gather additional information to assist in evaluating the potential seepage impacts of future releases.
3. **Adjustment to local flow rate** – the conceptual model linking thresholds to river stage may be adjusted at this site based on information gathered at the site visit. This may or may not create a new restriction on maximum release.
4. **Adjustment to threshold** – information gathered at the site visits regarding crops, historical groundwater, or drainage will adjust the threshold at the site. This adjustment will be done in collaboration with the landowner.
5. **Flow Response Actions** – an immediate or future change in flows is needed to prevent material adverse seepage impacts. Potential flow response actions include:
    a. **Restrictions on maximum release** – flow rates in each reach will be established below documented historical rates known to cause seepage impacts, to be accomplished through a combination of releases from Friant Dam, infiltration, and agreements with diverters.
    b. **Restrictions on ramping rates and duration** – limits on the incremental increases in flow rates provide the ability to evaluate the system response through the monitoring program while limiting the volume of upstream water if an impending impact is observed, measured, or predicted through simulation.
    c. **Reduction of Restoration Flow releases at Friant Dam** – reductions in Restoration Flows released from Friant Dam will limit the amount of water available to cause seepage impacts. Reductions at Friant Dam will need to consider travel time and the associated delay in response.
    d. **Redirection of flows at Chowchilla Bifurcation Structure** – directing flow into the bypass system at the Chowchilla Bifurcation Structure will provide a faster response for downstream reaches compared to Friant Dam operational changes. This response requires coordination with the Lower San Joaquin River Levee District for such operations.
    e. **Delivery of flows to Exchange Contractors and Refuges at Mendota Pool** – delivery of water to Mendota Pool will reduce flows in Reach 3 and downstream. Use of diversion into Mendota Pool to reduce downstream flows will require

coordination with the Central California Irrigation District and the San Luis Delta-Mendota Water Authority.

f. **Delivery of flows to Exchange Contractors and refuges at Sack Dam –** at times when the San Luis Canal Company has canal conveyance capacity, additional water diversions at Sack Dam can assist with reducing potential seepage impacts in Reach 4A and downstream. Use of the Sack Dam response will require coordination with the San Luis Canal Company.

g. **Redirection of flows at Sand Slough Control Structure –** during Interim Flows water will not be directed into Reach 4B. In subsequent years, water causing concerns in Reach 4B may be diverted into the Eastside Bypass. Use of the Eastside Bypass will require coordination with the Lower San Joaquin River Levee District.

10. Projects

Potential future actions may be needed if meeting Settlement goals through specified Restoration Flows is sufficiently compromised by seepage-related constraints. Such actions may include real estate actions or structural additions. These actions likely would require landowner agreements and initiation of project-specific environmental documentation to comply with NEPA, CEQA, and other regulatory requirements. Potential future actions may include:

1. Easements and/or compensation for seepage effects;
2. Acquisition of lands;
3. Slurry walls between the river/bypass and seepage-impacted lands to reduce water-table response to increased surface-water stage;
4. Seepage berms to protect against levee failure;
5. Drainage interceptor ditches to lower the water table;
6. Tile drains to lower the water table;
7. Operate new drainage and/or existing irrigation wells to lower the water table; and/or
8. Conveyance improvements such as sand removal.

The Plan will not result in planning, design, environmental compliance or construction of potential projects, but will assist in identifying such actions.

11. Revisions

Updates to the Plan may include changes derived from data obtained through the monitoring program, results from improved modeling and analysis tools, modified objectives or thresholds, and/or identification of additional concerns that arise through Plan implementation. The policy for revising the Plan includes:

1. Stakeholders may submit recommendations to the Program Manager at any time;
2. The Program Manager will acknowledge and respond to recommendations; and

3. A periodic review of the Plan through the Seepage and Conveyance Technical Feedback Group meetings may incorporate changes, including any new information such as the findings of a peer review panel.

The revision process sets the expectations for stakeholder and management participation. The SJRRP may not be able to commit to specific recommended actions, but all comments and recommendations will be considered.

Seepage Management Plan Appendices

Please click on the link below to be taken to the appropriate Appendix.

Appendix A: Seepage Effects
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppA.pdf

Appendix B: Areas Potentially Vulnerable to Seepage Effects
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppB.pdf

Appendix C: Historic Groundwater Levels and Surface-Water Flow
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppC.pdf

Appendix D: Sediment Texture and Other Data
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppD.pdf

Appendix E: Operations
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppE.pdf

Appendix F: Monitoring Well Network Plan and Other Seepage-Related Monitoring
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppF.pdf

Appendix G: Development of Soil Salinity Thresholds
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppG.pdf

Appendix H: Development of Groundwater Thresholds
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppH.pdf

Appendix H, Attachment 1: Responses to Threshold Comments
http://www.restoresjr.net/flows/Groundwater/SMP20110221AppHAtt1.pdf

Appendix I: Landowner Claims Process
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppI.pdf

Appendix J: Modeling
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppJ.pdf

Appendix K: References Cited
http://www.restoresjr.net/flows/Groundwater/SMP20110328AppK.pdf