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The San Joaquin River Settlement:
Analysis and Implications for Future Negotiations and Funding

by

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Developing Strategies for Collaborative Restoration of the San Joaquin River

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The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

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All analyses and opinions presented in this project are those of the research team and do not necessarily reflect those of the Friant Water Users Authority, its constituents or its affiliates.

Abstract

California's water supply is limited and competing demands have put a strain on the availability of this resource - a strain that may be further compounded by declines or increased variability in water supplies in response to climate change. This juxtaposition of water demands is especially apparent in restoration projects that affect many localities and interests. As a result, it is reasonable to expect that current water allocations will need reapportionment to meet changes in demand across competing interests. Thus, it is necessary to develop efficient, effective, and low-cost approaches to facilitate future reallocations.

Using the San Joaquin River Restoration Settlement as a case study, we analyzed the scientific, economic, and political factors affecting the settlement negotiations, final agreement, and implementation of the agreement. Our analysis allowed us to identify key steps and common negotiation and restoration plan elements that must be addressed in negotiation processes. A negotiation template incorporating these commonalities was created for use in future water reallocation negotiations. Lastly, the ability of restoration participants to obtain sufficient funding can be a barrier to successful restoration. Thus, the negotiation template is accompanied by a funding guide detailing the funding opportunities available and the process by which they may be obtained.

Abbreviations

ADR	Alternative Dispute Resolutions
CEQA	California Environmental Quality Act
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DFG	California Department of Fish and Game
DOI	United States Department of the Interior
DWR	California Department of Water Resources
ESA	Endangered Species Act
FWUA	Friant Water Users Authority
LAO	California Legislative Analyst's Office
NEA	Northwest Economic Associates
NEPA	National Environmental Policy Act
NRDC	Natural Resources Defense Council
PAYGO	Pay as you Go (Federal Funding)
PCM	Parallel Climate Model
SJR	San Joaquin River
SWRCB	State Water Resources Control Board
USBR	United States Bureau of Reclamation
USCBO	United States Congressional Budget Office
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGAO	United States General Accounting Office
USGS	United States Geological Survey

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Executive Summary

History of the San Joaquin River and Settlement

California's Central Valley contains a multitude of rivers and streams, including the San Joaquin River, which supports diverse and abundant wildlife populations and provides support for a variety of industries, including fishing and farming. By the 1860s the agricultural industry of the Central Valley began to thrive, resulting in the rise of a number of powerful agriculture firms, such as the Miller and Lux Company (Autobee, 1994). As these companies rapidly diverted water from the San Joaquin River, the amount of water remaining in the river began to decline (Autobee, 1994). As a result, large sections of the river began to dry up and salmon populations in the region were decimated. Agriculture too was affected by the growing demands placed on a limited water supply. In order to protect this valuable industry, the United States Bureau of Reclamation (USBR) constructed Friant Dam as part of the Central Valley Project (CVP) (Autobee, 1994; Wood, 1938). Friant Dam became operational in 1944, and water was diverted into the Madera and Friant-Kern Canals to be delivered to farms up and down the east side of the Central Valley. In order to more efficiently service water users, the Friant Water Users Authority (FWUA), a Joint Powers Authority, was created to manage operation and maintenance of the Friant-Kern Canal, while the USBR retained responsibility for operation of the dam. Once again, agriculture began to grow. However, this reallocation of water eliminated the river's remaining Chinook salmon population, and it was not long before citizens took notice and expressed reservations (Cody and Sheikh, 2006).

In 1947, concerned citizens, including some riparian landowners, filed a lawsuit against the federal government under California Department of Fish and Game (DFG) code §5937 requiring the dam to release sufficient flows to maintain the salmon fishery below the dam (Autobee, 1994; California Fish and Game Commission, 2006). The suit was dismissed with the state asserting that agriculture was a top priority and water release was not required for sustaining salmon populations. Despite this ruling, the issue was reintroduced in 1958 when DFG filed a formal protest with state, alleging that the operation of Friant Dam was in violation of DFG code §5937. After months of testimony and expert presentations, the State Water Rights Board concluded that maintaining Chinook salmon below Friant Dam was "not in the public interest" (Lufkin, 1990).

The issue remained dormant for nearly 30 years, until the FWUA's water supply contracts for some of FWUA's member districts came up for renewal in the 1980s. In 1988, the Natural Resources Defense Council (NRDC), The Sierra Club, a fishermen's group and other environmental and fishing organizations filed a lawsuit against USBR and other federal agencies alleging violation of the National Environmental Policy Act (NEPA) and the Endangered Species Act

(ESA). The FWUA and a number of its member districts joined in the case as defendant-intervenors. The complaint was later amended to allege that Friant Dam was operating in violation of DFG code §5937 (URS, 2002). Litigation would continue for the next 18 years, until a settlement was announced on September 13, 2006.

The San Joaquin River Settlement ("Settlement") is one of the largest restoration agreements of its kind, encompassing a 153 mile stretch of river between Friant Dam and the Merced River. The Settlement revolves around two main goals: a restored river with continuous flows to the Sacramento-San Joaquin River Delta and naturally reproducing population of fall and spring-run Chinook salmon, as well as a water management program to minimize or eliminate water supply impacts to water users (San Joaquin River Restoration Program, 2007). A phased approach was used in the restoration, which encompasses five reaches – only parts of which currently maintain water flow. The restoration plan includes plans for the construction of a bypass channel as well as modification of current channels and structures to increase flow capacity and allow fish passage.

Project Significance and Objectives

The San Joaquin River is only one example of a growing problem. With an ever-increasing population in the Central Valley and elsewhere across the United States, conflicts of this nature are expected to intensify (USCBO, 1997). These conflicts may be exacerbated by the effects of climate change on water supply. Accordingly, such strains necessitate the development of an efficient, low-cost approach to facilitate future water reallocation efforts. Research and analysis of the San Joaquin River Settlement allows for the possibility of drawing conclusions about its design and development of a template for future water reallocation negotiations, as well as provide guidance on funding such projects. As such, our project focused on four main objectives, including: (1) examination of the San Joaquin River Settlement process, (2) assessment of the restoration plan feasibility, (3) development of a template to be used in similar reallocation negotiations, and (4) creation of a funding guide for the San Joaquin River and similar restoration cases.

To accomplish these objectives, we examined the scientific literature to gather information on the San Joaquin River and Settlement, as well as numerous other cases, including the Columbia and Klamath River basins, for comparison. Additionally, we analyzed historical temperature and flow data, as well as regional climate models. We also elicited information from experts in relevant fields, including fisheries management and water law/policy, and conducted informational surveys to gather data on individual opinions on the issue.

Restoration Plan Analysis

Our analysis of the restoration plan focused on three main aspects of the restoration: Chinook salmon reestablishment, climate change implications, and economic concerns. We examined factors affecting the prospect of successful salmon reintroduction, and identified 3 key factors that will contribute significantly to the likelihood of salmon survival. These included water quality, temperature, and flow rate. Several pollutants have been found in the lower San Joaquin River, many of which have been linked to increased mortality rates, deformities and/or swimming impairments in salmon. Agricultural runoff has been identified as the primary source for many of the pollutants of concern. This raises concerns regarding the potential water quality in the restoration reaches, which are border by agricultural lands. However, an assessment of the impacts cannot be completed until flows have been reestablished along these reaches.

Of more immediate concern is the ability of operators to meet the temperature and flow requirements. Examination of historical temperature data reveals that the temperatures in the lower San Joaquin River, below the Merced River confluence, routinely exceed the maximum temperature objective of 18ºC from the preliminary restoration analysis (McBain & Trush Inc., 2002). A more in depth analysis reveals that salmon have different temperature requirements for different life stages; however the historical data shows that the average daily temperatures routinely fall within the temperature range of decline for all life stages for both fall and spring runs. This indicates that salmon survival is unlikely unless suitable temperatures can be maintained.

Flow rates are a factor in water temperature. The Settlement presents a seasonally variable flow regime (San Joaquin River Restoration Program, 2007). However, the ability of operators to release adequate flows, particularly for fall run Chinook salmon, may be in jeopardy as a result of climate change. While climate change is not currently considered in the Settlement, regional climate models indicate that the Sierra Nevada snowpack that supplies the region with water is expected to decline by approximately 50% by 2090 (VanRheenan *et al.*, 2004). Additionally, an analysis of the regional runoff data reveals that runoff from snowmelt has been decreasing since the 1950s (Roos, 1989). Furthermore, the peak runoff discharge, which historically occurred from late May to early June, has been occurring early in the year with the peak now occurring typically in April to May.

Given these concerns, it will be a challenge for Chinook salmon to survive. However, the Settlement provides several tools, including flexibility in timing of releases, the purchase of additional water to augment the releases, and the reassessment of flow regimes, that can be used to address changes in the environment and increase the ability of operators to meet the salmons' needs.

Lastly, the Settlement does not examine the potential economic impacts that may result from the implementation of the restoration plan, including impacts to the local and regional agriculture, recreation, and hydropower industries. Of these impacts, the most prominent is the potential impact to the agricultural industry serviced by Friant Dam, which generated $2.5 billion in 2002 alone (USDA, 2007a; FWUA, 2006a). An analysis of the water supply, given the implementation of the restoration agreement, indicates that Friant users could experience on average a 19% decrease in their water supplies (FWUA, 2006c). This decrease in supply is expected to translate into decreased crop production, and, as a result, potentially a loss in agricultural jobs. However, these impacts will be analyzed during the preparation of environmental documents under National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) as part of the implementation of the Settlement.

Negotiation Template and Funding Guide

Through our analysis of the Settlement development process, as well as, an examination of similar restoration cases, we were able to develop a template for future water reallocation negotiations. The basic premise of the template is to avoid litigation whenever possible to increase the efficiency of the process, while decreasing the overall cost. The template details a 3-step process which is specific in direction, yet flexible in application so that it may be applied to a variety of restoration cases. These 3 steps include: (1) identify process participants, (2) determine restoration and stakeholder requirements that must be addressed in the restoration plan, and (3) utilize working groups to create one or more restoration plan options, from which a final plan will be created. In order for this process to be successful, we recommend that participants hire one or more outside consultants to oversee the process and determine the restoration and stakeholder needs. Additionally, in an effort to avoid litigation stemming from the negotiation process, we recommend that process participants sign a memorandum of understanding or other agreement that binds each participant to the restoration plan and to a participant-determined cost sharing plan.

Even if the negotiation process is successful, the success of the restoration plan is largely dependent of the availability of funding to carryout the plan. As seen in the case of the San Joaquin River, restoration cases are typically dependent on federal and state government funding. Furthermore, the process of obtaining government funds is often arduous and highly uncertain. Subsequently, restoration efforts could be greatly aided by the use of private funding sources; however, in a majority of states, agencies are unable to obtain private funding, despite the willingness of private donors to contribute, due to legislative barriers and/or a lack of understanding of the process. As such, we have created a funding guide, which details a variety of funding sources available from corporations to foundations, and includes a procedural flowchart to guide participants through the steps necessary to obtain private funding for government projects.

Introduction

Problem Statement

The lengthy, high-cost litigation process in the on-going San Joaquin River Settlement highlights the need for the creation of a more efficient way to negotiate restoration agreements. The solution should be collaborative, cost effective, and have a designated timeframe. Also, the ability to identify and secure funding is vital to the success of any restoration plan.

Project Significance

Human population growth in the Central Valley has increased dramatically in recent years, intensifying the already high demand for water. Additionally, water supplies are limited and rising demands have put a strain on the availability of this resource (Weinberg, 2002). Climate change effects may further complicate water allocation endeavors. With these changes in supply, it is reasonable to expect that historical water allocations will need to be reassessed to meet changes in demand across competing interests (Weinberg, 2002). An example of this is shown in the case of the San Joaquin River Settlement.

The San Joaquin River Settlement was the result of an almost 20 year legal battle between stakeholders over the river's water. The result was an unprecedented agreement with projected costs, including litigation and implementation, of over $500 million. Expanding populations and a heightened awareness of environmental issues make it likely that more reallocation disputes of this nature will occur in the future. Devising an efficient, low-cost approach may help to facilitate future efforts to reallocate water in these situations. By researching and analyzing the San Joaquin River Settlement, it may be possible to draw conclusions about its design and develop a template for future water reallocation negotiations that will minimize costs and time expenditure. Additionally, for the San Joaquin River Settlement, obtaining funds to cover the restoration plan is an important aspect of the project's success. As such, a funding guide provides possibilities for obtaining funds.

Project Objectives

The project includes four main objectives: (1) to analyze the current Settlement, (2) to assess the feasibility of the restoration plan, (3) to develop a template for future water reallocation negotiations, and (4) to design a guide for funding sources for the San Joaquin River Settlement.

Analysis of the current Settlement was a multidisciplinary approach, involving physical sciences, economics, sociology, and political science. We examined the following:

- The parties involved, including, but not limited to, their positions on the issues involved, objectives/desired outcome(s), and satisfaction with the end product.
- The process of the negotiation and why it was so contentious
- The results of the Settlement
- The effectiveness of the process including a comparison of alternative strategies (e.g. collaborative approaches)
- Comparison of the current agreement with similar case studies

Assessing the feasibility of the restoration plan was also multidisciplinary in approach, involving an examination of the challenges to and implementation of the Settlement. We investigated:

- Habitat restoration objectives in comparison with requirements noted in the literature
- Necessary goals to create salmon habitat
- The availability of water to adequately meet both restoration and agricultural demands, incorporating the possible effects of climate change
- The cost impacts of implementation

After the current agreement was analyzed, the data and information generated was used to develop a template that may be applied to future water reallocation negotiations. The template incorporated factors such as:

- Essential scientific aspects
- Economic considerations for water allocation
- Procedural recommendations

Additionally, in order to complete any restoration project, adequate funds must be obtained. To aid in the search for funding sources for the San Joaquin River Settlement, a funding guide was created, incorporating elements such as:

- Federal and state grant opportunities
- Recreation fees
- Private funding options

Methodology

Analysis of the Current Agreement

The study performed an analysis of the current agreement to determine the efficiency and effectiveness of the negotiation process and agreement implementation. This analysis was multidisciplinary in approach and included the following: a review of the relevant literature, an analysis of the negotiation process and settlement agreement, and an assessment of the current and future water supply. The first portion of the analysis, the literature review, involved a review of the relevant literature and research pertaining to the history of San Joaquin River, Chinook salmon, and the Settlement. This research included the history of the region (including the development, historical water allocations, etc.), the legal issues involved (including federal, state, and local statues, court cases, etc.), expert studies (pertaining to Chinook salmon, habitat restoration, climate change, cost analyses, etc.), and the issues that separated the negotiating parties. This information was used to generate a summary of the key elements to be considered in the Settlement analysis and template formation.

The analysis of the Settlement's negotiation process and agreement included an assessment of the negotiation process based on expert opinion, an economic analysis of relevant factors, a scientific analysis of the restoration plan, and an analysis of the current and predicted water supply. As part of this analysis, the group members conducted surveys and interviews of the parties involved in the negotiation process, as well as experts in relevant fields such as agriculture, policy, and natural resource management. These surveys and interviews were used to determine the key issues involved, objectives of the parties, satisfaction with the end product, and the feasibility of and challenges to implementing the Settlement. Additionally, an economic assessment was completed, including an impact analysis to the current water users and the identification of potentially significant economic factors that were either not considered and/or are lacking the necessary data in order to be analyzed. In particular, the impact analysis examined the potential financial impacts on agriculture, recreation, and local hydropower generation facilities. Lastly, a review of the funding options currently being utilized was completed and additional funding sources were identified.

In order to analyze the restoration plan, we examined the habitat requirements of Chinook salmon including, but not limited to, water flow requirements, channel structure, and the effects of pollutants on the reproduction and survival of salmon. We also interviewed parties directly involved in the restoration and other experts in the field to determine the feasibility of implementing the agreement. The feasibility of the restoration plan and salmon reintroduction goals was ascertained using these results. Additionally, the impacts of climate change on regional water availability were analyzed using previous work by Dettinger and Cayan (1995) on climate change effects in the region as a guideline. The historical flow data for the San Joaquin River and Friant Dam were also considered through statistical analysis and compared with trends seen in climate change models. An Ordinary Least Squares regression analysis was used to determine statistically significant trends. This data was used to determine the potential effects of climate change on the timing and regularity of flow in the San Joaquin River basin, and subsequently, the implications of climate change on habitat restoration efforts and the availability of water necessary to fulfill water contracts.

Development of a Template and Funding Guide

Based on the research conducted above, key steps in the negotiation process were identified, along with common negotiation and restoration plan elements that must be addressed. These common elements were compared to other restoration case studies, including the Colorado, Russian, and Trinity Rivers to name a few, to determine commonality among the various restoration efforts. The commonly identified elements were used to develop a template for future water reallocation negotiations. The template details the procedural steps that may be used to facilitate an efficient process, including the use of consultants and working groups. Additionally, the template identifies key points that must be addressed during the process, including the identification of process participants, critical scientific factors, and relevant economic considerations. To compliment the negotiation template, an informational funding guide was created, detailing a variety of funding sources available for restoration projects, as well as the process by which parties may secure private funding.

History of the San Joaquin River and the Settlement

Water in the West

The American West has long been seen as a land of opportunity. The Central Valley in particular contained a multitude of rivers and streams, including the San Joaquin River, which supported diverse wildlife populations (Autobee, 1994). One of the most abundant fish species was the Chinook salmon (McBain & Trush Inc., 2002). The extensive fish runs were not what attracted settlers to the region though. The famous gold rush of the mid 1800s drew prospectors and settlers across the Rockies and into the Central Valley. By 1850 the rivers of the region were lined with small diversions and prospectors hoping to "strike it rich" (Autobee, 1994). However, the true value of the Central Valley did not lie in the gold found in the water, but rather the water itself.

The temperate climate of the Central Valley and the abundance of water in the local rivers and aquifers created an ideal environment for growing crops and soon gave rise to a lucrative agricultural industry (FWUA, 2005). The San Joaquin River became a source of irrigation as residents diverted the water throughout the arid region to support crops. By the 1860s the Central Valley was dominated by wheat growers who had successfully harnessed the Central Valley's water supply (Autobee, 1994; FWUA, 2005). As a result of the agricultural boom a number of powerful agriculture firms arose, such as the Miller and Lux Company (Autobee, 1994). These companies soon found themselves fighting to maintain their water rights as an ever-growing group of small farmers established themselves in the Central Valley. Seeing the unique water needs of the region, investors formed hundreds of irrigation companies in the 1870s and 1880s, most of which perished soon after their birth. By the 1920s, surface and groundwater supplies were pushed to their limits and the growth of California's agricultural industry had come to a standstill.

Friant Dam

With the reduction in groundwater aquifers and an inability to divert more water from rivers, including the San Joaquin, the future of approximately 3.6 million acres of irrigated land was at stake. Farmers and state authorities turned to the USBR for support (Autobee, 1994).[1] The USBR responded with the Central Valley Project, which included plans for the construction of Friant Dam, a 319 foot tall gravity dam that could retain upwards of 500,000 acre-feet of water in Millerton Lake (Autobee, 1994; URS, 2002). Construction of the dam was completed in 1942 and operation began in 1943. Upon completion, water released from the dam flowed through two canals, the Madera and Friant-Kern Canals, delivering water to over 15,000 farms (Autobee, 1994). In order to manage the regional water contracts the Friant Division was formed.

Currently, the Friant Division includes cities, irrigation and water utility districts along the east side of the San Joaquin Valley of California. The division services approximately 15,000 mostly small family farms, encompassing approximately one million acres of irrigable farmland from Merced to Kern Counties. In total, the area annually produces approximately $2.5 billion in gross agricultural production. As a result, many communities are either directly or indirectly dependent on Friant water supplies (FWUA, 2006a). Along with agriculture and municipal water service, the dam is operated for flood control purposes and provides an incidental, yet important, recreation benefit. In order to meet their needs, some users have also acquired groundwater and local surface supplies from the Tule, Kings, Kaweah and Kern Rivers. In addition, some areas have access to useable groundwater supplies. However, the intense use of groundwater has increased pumping costs and led to aquifer overdraft (Nakagawa, 2004).[2] While groundwater pumping has historically provided water for the economic growth of the Central Valley, the overdraft has also resulted in severe detriment to the area's ecological profile.

[1] The USBR, formed as part of the Reclamation Service under the Reclamation Act of 1902, was tasked with recapturing land from the desert to make it useful to Americans (USBR, 2007a).

[2] Additional problems associated with overdraft are land subsidence and a decrease in the quality of remaining groundwater (Nakagawa, 2004).

Ecological Impacts

Before settlement of the San Joaquin River Basin, Chinook salmon (*Oncorhynchus tshawytscha*) populations were said to rival populations in southern Alaska, with runs of up to 500,000 individuals a year. These populations thrived despite naturally high water temperatures, and even continued to survive after portions of the San Joaquin River were diverted for agricultural use. Despite changes throughout the Central Valley, populations persisted as more diversions occurred and dams were constructed. It wasn't until around 1910 when significant initial declines in numbers occurred, as well as a noted reduction in the average size and age of individuals caught. Fishery managers took note of this, and by 1957 commercial fishing was no longer permitted. While pollution and introduced predators contributed to the decline of fish stocks, the main cause was found to be habitat alterations. These alterations included a reduction in the number, size, and accessibility of spawning grounds and the destruction of habitat as a result of decreases in or elimination of the water supply and channel modifications. These effects were the result of water diversions from the San Joaquin River, as well as the construction and operation of the Kerckhoff and Friant Dams, which left only two percent of the available water for river flow.[3] As a consequence of these occurrences, Chinook salmon runs in the San Joaquin River were essentially extinct by the late 1940s (Autobee, 1994). Presently, nearly 60 miles of the SJR, between Friant Dam and the Merced River confluence, remain dry through much of the year (FWUA, 2006b).

Political and Legal Implications

With environmental awareness growing since the 1970s, new values and demands for water arose. These demands naturally conflict with those of agricultural production and recreation, creating further tension between the many water users in the Central Valley region, including contracted users, recreational users, and environmentalists. This tension has been present since construction of the Friant Dam began. Such tensions are inherent in any public good, often making government intervention necessary via legislation or litigation. As public attitudes change and needs shift, issues relating to water allocation will be revisited. As stated by former California Attorney General Bill Lockyer, "water is a public resource, and its use is always subject to review and reconsideration if new information demonstrates a need to protect fisheries or other public trust values" (Stroshane, 2004).

While the current San Joaquin River case has been on-going since 1988, the issue of salmon survival was first brought to the courts in 1947. At this time, a group

[3] The Kerckhoff Dam was built in 1916 about 25 miles above the Friant Dam site. This dam blocked migration of salmon into spawning areas in the higher Sierra Nevada Mountains (FWUA, 2006b).

of landowners filed a lawsuit against the federal government claiming a violation of the California Department of Fish and Game code §5937, which requires a dam to release a sufficient amount of water to maintain flows for downstream fish populations (Autobee, 1994). A California court ruled that the demand for agricultural water supplies was superior to the need to maintain a salmon fishery and the case was dismissed. The plight of the salmon did not end here though. In 1958, DFG filed a formal protest with the State Water Rights Board, stating once again that the operation of Friant Dam failed to maintain the salmon fishery below the dam and subsequently, was operating in violation of DFG code §5937. For the second time, it was concluded that agriculture presented a superior water demand, and maintaining a salmon fishery was "not in the public interest." After this ruling the issue of Chinook salmon in the San Joaquin River remained dormant for nearly 30 years.

It was not until some of the Friant water users' contracts came up for renewal in the 1980's that the issue rose again. In 1988, the NRDC, The Sierra Club, a fishermen's group and other environmental and fishing organizations filed a lawsuit against USBR and other federal agencies alleging violation of NEPA and the Endangered Species Act (ESA). The FWUA and a number of its member districts joined in the case as defendant-intervenors. The complaint was later amended to allege that Friant Dam was operating in violation of DFG code §5937 in diverting natural flows of the San Joaquin River, resulting in the extinction of annual runs of Chinook salmon (Autobee, 1994; URS, 2002). After years of litigation and negotiation, of considerable expense in time and legal fees, the parties to the suit began to actively pursue a settlement in 1999. This type of negotiation illustrated a desire to move away from costly courtroom action and toward a consensus to both protect the area's economy and restore the river. The final compromise was a settlement outlining the restoration of historic river flows, while mitigating or eliminating impacts to current water users.

The San Joaquin River Settlement

The San Joaquin River Settlement names two goals: "to restore and maintain fish populations in 'good condition'," and to "reduce or avoid adverse supply impacts to all Friant Division long-term contractors" (NRDC v. Rodgers, 2006). To restore the salmon populations along their historic range will require the rewatering of the SJR, including reaches of the river that have been dry for decades (Cody and Sheikh, 2006; URS, 2002). It will also require restoration of riparian habitat to provide a suitable environment for the salmon. The area of focus on the San Joaquin River is a 153 mile section extending from Friant Dam to the San Joaquin River's confluence with the Merced River (Figure 1). The efforts involved will occur in phases, transitioning from the planning process to implementation of identified techniques. Substantial improvements in the channel and structure of the river are projected to begin in 2009 and continue over the next few years. However, before restoration efforts can begin, information must be

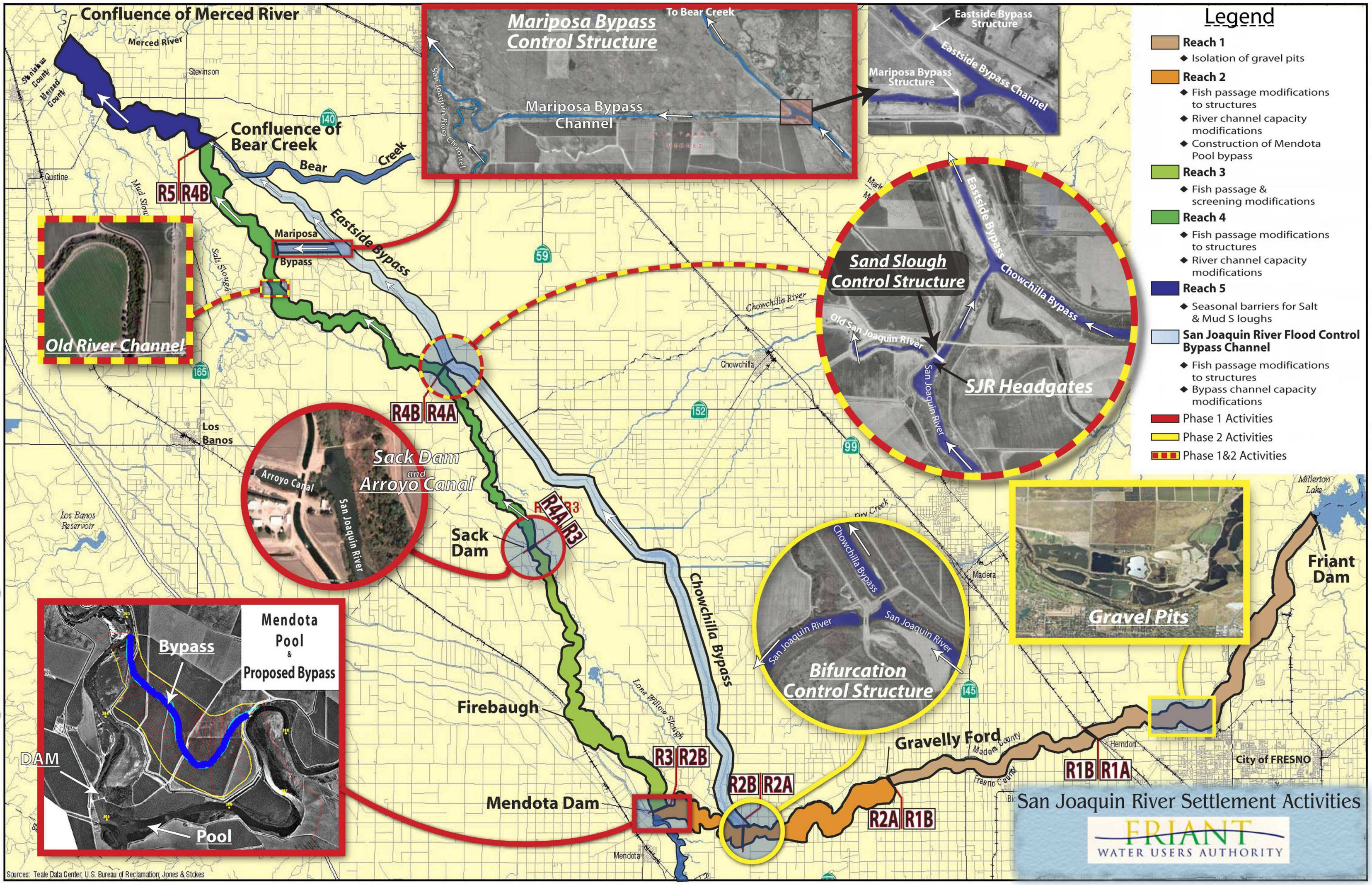

Figure 1. Map of the proposed restoration sites along the San Joaquin River (Courtesy of FWUA).

gathered to determine what will be necessary to supply required water releases as outlined in the Settlement and make other manipulations for salmon habitat.

Subsequent to the start of channel improvements and installation of fish screens, Chinook salmon are slated to be reintroduced prior to December 31, 2012. Potential for success of this reintroduction is an issue under debate. Previous efforts to restore salmon in San Joaquin tributaries encountered problems with low dissolved oxygen levels and water contamination issues, which is of particular concern given the close proximity of agricultural lands to the river. The exact timeframe for the salmon to recover and establish self-sustaining populations is uncertain and will depend on water quality, habitat suitability, ocean conditions, and climate change effects. Global warming from climate change will result in increased water temperature in the San Joaquin River, impacting the growth rate of salmonids like the Chinook salmon. Initially, the growth rate will increase with temperature, resulting in increased survivorship of young salmon, as larger smolts are less susceptible to predation (Myrich and Cech, 2004). However, once the temperature exceeds the optimum range, growth rates rapidly decrease and survivorship plummets (Brett *et al.*, 1969).

The Settlement focuses directly on the hydrologic and ecological systems in the Central Valley of California. It does not explicitly address possible impacts of future climate change projections in its restoration planning and water allocation issues. Some current global climate change projections show significant effects on water supply in the Central Valley, including a reduction in snow pack of approximately 50% by 2090 for the San Joaquin River basin (VanRheenan *et al.*, 2004). This will greatly affect flows, as the Sierra Nevada snowpack is the main source of water for the San Joaquin River and Millerton Lake. Furthermore, historical records reveal trends since the 1950s that show the proportion of total annual runoff received from snowmelt has decreased (Roos, 1989). This loss in snowpack corresponds to a loss in water storage, possibly requiring the creation of additional reservoirs (Roos, 1989). Also, with shifting climate comes a change in the timing of flows throughout the year, which has been shown to have seasonal effects that are more pronounced in the southern San Joaquin basin (VanRheenan *et al.*, 2004). Changes in the timing and amount of flow combined with an increase in the precipitation ratio of rain to snow, creates optimal conditions for floods and droughts. All of these effects have significant implications for the SJR and surrounding environment, including biota, dam function, recreation, and overall water availability. These factors control the management practices and economics of the river, all of which were effectively changed by the outcome of the Settlement.

Funding allocation plans focus on specified “priority processes” which take precedence over other plans and will receive the strongest focus and monetary support, including increasing channel capacity, strengthening levees, and modifying channel structure to allow fish passage. Total costs are expected to range between $250 million and $800 million (DWR, 2006). These costs will be covered by income from a variety of sources, including funds that are currently coming from Friant Dam beneficiaries, such as farmers and cities, as well as state bond initiatives and federal appropriations (FWUA, 2006b).

Analysis of the Settlement Agreement

Salmon Life History and Habitat Requirements

Chinook salmon progress along the following life-stages process: eggs, alevins (hatchlings), frys, smolts, and lastly, adults (Baker and Morhardt, 2001). In looking at Chinook salmon survival, the critical time periods to focus on are spring and fall flows, which are the key run periods for Chinook salmon in the San Joaquin River. In assessing where to focus habitat restoration efforts for the San Joaquin, it is important to note which life stages exist most often in the SJR. Such observations are important in determining the most suitable conditions to implement for particular times of the year, based on the requirements for the most common life stages. Chinook salmon have different temperature, pH, and other requirements due to variation in sensitivity based on their life stage (Baker and Morhardt 2006). During the fall run, adult spawners, yearlings, fry, and smolts are the observed life stages present in the river, while tributaries also include eggs and alevins. Adults and juveniles exist solely in the ocean in the fall (Baker and Morhardt, 2001).

Spawning

Flow and habitat restoration is particularly important since Chinook salmon enter the river for the sole purpose of reproduction. Salmon must spawn in fresh or brackish water, and use gravelly sediment to create nests called redds, where they bury eggs for incubation (Williams, 2006). Some salmon will stay in the river for a longer period of time before emigrating to the ocean; these are known as stream-based, whereas earlier emigrants are labeled as ocean-based. Salmon will spend anywhere between one and six years in the ocean before migrating back up to their spawning grounds on the San Joaquin River to reproduce and subsequently die. Given such individual differences in timing, it may take up to 6 years to realize the success of the restoration through the return of spawned individuals.

Consistently, studies have shown that Chinook salmon most commonly use areas with mean depths of 0.3 to 0.55m (Williams, 2006), though one study showed spawning occurring from 0.12 to 1.22 m with half of the observations occurring from 0.49 to 0.79m (Sommer *et al.*, 2007). Depth preference changes with flow rate, with higher flows increasing the depth at which redds are constructed (Sommer *et al.*, 2007). The bulk of studies have documented mean velocities of

0.4 to 0.6 m/s for Chinook salmon spawning but velocities used have ranged from 0.12 -1.46m/s (Williams, 2006; Sommer *et al.*, 2007). The range of depths and velocities is widely varying however, suggesting that these two factors may not be limiting. Depth will vary widely in the restoration area and, in addition to velocity, will vary depending on the amount of flow going through the area (McBain & Trush Inc., 2002). Some scientists hold the belief that neither of these factors play a role in the success of a redd, and that the main issue is having a good sub-gravel flow (Williams, 2006). Finer gravel sizes result in lower sub-gravel flow rates, and these flows influence emergence time and size of the fry. Low velocities reduce the size of the fry, with a previous study documenting a 3-10cm/h having a major impact on fry sizes (Shumway et al 1964). Low dissolved oxygen also delays hatching, and the combination of the two can result in decreased reproduction rates amongst salmon runs

River substrate is important to the successful establishment and production of redds. Salmon require specific gravel size and composition to accommodate eggs and allow sufficient water flow. In Feather River, a watershed north of the Sacramento-San Joaquin River Delta (the terminus of the SJR), salmon were observed to spawn in gravel size classes that ranged up to the 6- to 9-inch class. The bulk of redds were located in 3-6 inch gravel size class and no redds had more than 50% fines (Sommer *et al.*, 2007). Other studies on Central Valley salmon have shown a range from 0.4-3 inches, and the suggested rule of thumb is that the median grain size urns about 1/10th the length of the fish (Williams, 2006). Current efforts to examine geomorphic aspects of the restoration site have mainly looked at channel alteration, though sediment for redd establishment has been looked at. Lack of water flow affected sediment flow and a few recent estimates of spawning gravel has shown that there is significant salmon habitat with one study estimating 773,000 square feet of spawning habitat for salmon between Friant Dam and Skaggs Bridge of which 408,000 square feet contained less than 40% fines (McBain & Trush Inc., 2002). Increased water flow should aid in sediment movement, and actual effects on habitat suitability will be seen.

Fall Run

Before Friant Dam and water diversions transformed the physiology of the San Joaquin River, Chinook salmon were regularly seen in its waters, probably most abundantly in the fall (Williams, 2006). Arriving from late summer through fall, the salmon travel upstream and spawn through December (Williams, 2006). Chinook salmon are influenced by environmental conditions; temperature in particular, which dictates the onset of spawning as well as fry emergence. Temperatures of around 14 or 15ºC trigger the onset of spawning, and fry emerge between December and April, depending on water temperatures during incubation as well as when spawning occurred (Williams, 2006). Higher temperatures increase the rate of embryo development, but fall run embryos begin to exhibit increasing mortality at 12 ºC, and temperatures above 13.9ºC are typically lethal (Myrick and Cech, 2004; Williams, 2006).

Spring Run

Spring run Chinook salmon migrate into freshwater through the winter and spring season, staying in pools through the summer (Williams, 2006). The salmon actually spawn in late summer after they have taken time to sexually mature during the early and mid summer months (Williams, 2006). The adults do not survive well in temperatures over 21ºC, and therefore spring run Chinook salmon migrate upstream until they are able to find cool enough habitats (Williams, 2006). Unlike other Central Valley rivers, the SJR has more area in higher elevations, which have lower air temperatures and receive more runoff as snowmelt, affording more cool water habitat. In the past, spring run salmon probably were highest in number in the SJR because of the abundant habitat at these high elevations and the corresponding snowmelt flows (Williams, 2006). The spring run Chinook salmon travel farther upstream and into higher elevations than fall run salmon do, probably due to the earlier time at which cooler temperatures occur in these areas (Williams, 2006). Just like fall runs, spawning does not begin until the water cools down to temperatures around 14 or 15ºC, which typically occur by September (Williams, 2006). Additionally, some of the fry migrate immediately while others will remain for several months. Early migraters leave the SJR in the winter, whereas those that remain behind may stay until late spring or remain and travel downstream from fall through spring of the next year (Williams, 2006).

Effects of Temperature

Temperature requirements are particularly dissimilar between the northern, more studied populations, and Central Valley populations of Chinook salmon. The Central Valley is the most southerly extent of Chinook salmon range, and seldom has issues with low temperatures affecting salmon growth and survival (Myrick and Cech, 2004). On the contrary, high temperatures occur far more often, both in acute and chronic episodes, and have a major impact on the ability of Chinook to persist. The predicted flow reduction and subsequent higher temperatures due to climate change will likely exacerbate this situation. Historically, water temperatures rose well over 70º F at Friant Dam during the time when runoff flowed unimpaired to the delta, late summer and early fall (McBain & Trush Inc., 2002). Younger life stages, such as eggs and alevins, require lower temperature ranges, whereas juveniles and older salmon can survive in warmer waters (Table 1) (Myrick and Cech, 2004).

Table 1. Temperature requirements for various life stages of Chinook Salmon in the SJR. Temperatures are listed as values at which mortality is high. Upper number is maximum for survival. Fall and spring run actual values are recorded for the SJR at Vernalis for the years 1961-1997 (McBain & Trush Inc., 2002).

	Temperature Range of Decline (ºC)	**Fall Run Historical Temperatures (ºC)**		**Spring Run Historical Temperatures (ºC)**	
		Maximums	**Averages**	**Maximums**	**Averages**
Migration	12-21	16-22	13-16	16-24	12-17
Holding	14-21	---	---	16-31	12-24
Eggs	12-16	14-17	10-12	12-27	9-23
Juveniles	18-24	15-20	11-15	12-24	10-17

Growth is a key indicator of health in Chinook salmon and is a critical factor to the smoltification and general survival of salmon. Higher growth rates indicate better living conditions and improved health and fitness. Thus, growth rates are a good indicator of restoration success. Additionally, good conditions within the SJR will better equip the fish for survival in the ocean, given that larger fish are better able to survive in poorer conditions and have an advantage over smaller fish in the smoltification process (Myrick and Cech, 2004). Smoltification involves the acquisition of saltwater tolerance, which makes outmigration into ocean environments possible. Achieving a suitable smoltification size is therefore critical to salmon survival. Chinook salmon growth is affected by many different aspects of individual physiology and environmental factors, including water temperature. Growth effects can be considered only slightly less important than the direct effects that water temperature has on salmon survival (Myrick and Cech, 2004). Growth generally increases with increased temperature for all life stages, and cold water temperatures result in slower embryonic and larval growth (Williams, 2006). As shown by temperature range of decline in Table 1, higher temperatures only increase growth to a certain point, after which high temperatures result in increased mortality. Some of the fry migrate straight to the ocean, while others will remain in the river as smolts and grow to a larger size before migration. Cold winter waters will result in stream-based salmon, which leave in the spring or summer, as opposed to ocean-based salmon which generally emigrate during the first three months of their life (Williams, 2006). Remaining in the river allows these young salmon to grow to a larger size before proceeding out to the ocean, and this increased body size gives them the advantage of a higher survival rate (Williams, 2006). Lower water temperatures make the juveniles more likely to stay near the spawning grounds, and high flows from the dam generally result in these lower water temperatures (Williams, 2006).

High temperatures impede migration, and though there is evidence of survival in a 21ºC daily average, studies indicate that values around 19ºC have shown to inhibit fall-run migration and 21ºC blocked migrating salmon entirely (Table 1)

(Williams, 2006; Bjornn and Reiser, 1991). While studies have shown that increased temperatures on the lower San Joaquin River inhibit the survival of salmon, previous studies of salmon on the San Joaquin River indicate that the now-extirpated spring runs in the upper SJR were actually tolerant of warmer water (Williams, 2006).

The optimum temperature range for eggs and alevins in the San Joaquin River basin is between 6 and 12ºC (Myrick and Cech, 2004). Eggs and larvae require a minimum of 1.7ºC in order to survive, but low temperatures are generally not an issue for the San Joaquin River (Myrick and Cech, 2004). Eggs and larvae cannot survive temperatures above 16.7ºC, and waters approaching this temperature generally have high death rates (Myrick and Cech, 2004). Temperatures between 12 and 13ºC show some mortality, and approaching 14 and 15ºC mortality greatly increases (Williams 2006). Winter run salmon eggs have exhibited a tolerance for slightly lower temperatures, showing increasing mortality around13.3ºC, but a similar maximum tolerance (Myrick and Cech, 2004). Table 1 demonstrates historical temperature values in the San Joaquin River, at which these temperatures threaten various salmon life stages.

Whereas eggs and alevins are sensitive to high temperatures, juveniles flourish in higher temperatures. Research on juvenile salmon is limited; however studies indicate that juveniles are able to survive in temperatures ranging from 7 to 25ºC. However, much of the thermal tolerance of salmon depends on the acclimation of the salmon (Myrick and Cech, 2004).

Aside from temperature, the availability of food has been shown to influence the optimal growth temperatures for salmon. Lab experiments show that fewer food sources lowers the metabolic function of salmon and subsequently, the temperature demand for optimal growth; resulting in slower growth (Myrick and Cech, 2004). The preferential temperature for Chinook salmon growth in laboratory environments is between 17 and 20ºC if salmon eat until they are full (Myrick and Cech, 2004). In natural environments, however, salmon eat less and are impacted by other factors, and thus growth rates are lower, and 15ºC has been suggested as a more appropriate optimum temperature (Myrick and Cech, 2004; Williams, 2006). However, a study on salmon in an environmentally similar habitat in the Columbia River showed that reducing temperatures from 18.5 to 15ºC had limited growth benefit (Williams, 2006). Treatments of 13-16ºC and 17-20ºC with 60-80% rations showed no growth rate difference in one study and environments with water above 22ºC show a rapid drop off in growth. Additionally, experiments showed that 97% of the population were able to survive at 24ºC, whereas at 25ºC survival is reduced to 36% (Williams, 2006). Another study showed no survivors at 24ºC, which is most likely due to variations in lab conditions.

Water Quality

Water quality is a main component of maintaining a healthy ecosystem. There are many factors that influence water quality, and with the plethora of surrounding farmlands, irrigation runoff can result in high amounts of a variety of water pollutants that can decrease or even eliminate salmon survival. Contaminants in the SJR that pose a threat at high levels include salinity, nutrients, organic carbon, and other toxic contaminants (Table 2) (Monsen *et al.*, 2007). Salinity and temperature are the two largest issues for the SJR basin, whereas dissolved oxygen has been noted to not be a significant concern in the SJR. Nutrients, trace elements, pesticides and herbicides are all pollutants of concern in the lower SJR and may have impacts on restoration efforts (Monsen *et al.*, 2007). With agriculture as the major industry in the surrounding area, the SJR experiences a high load of pesticides and herbicides. Since agriculture is a non-point source, water quality is not well-regulated and may continue to affect the basin. Although the Central Valley Regional Water Quality Control Board addresses irrigated lands, urban runoff may still play a large role in pollutant influx in coming years (Cal-EPA, 2005). No recent data exists for the upper SJR as it has been dry for the past few decades, and thus it remains to be seen what the water quality will be like once flows are re-established in these areas. Due to concerns regarding impacts to salmon, water quality should be extensively monitored, and significant threats, such as pollutants from runoff, should be minimized. Special attention should be paid to salinity, nutrients, organic carbon, trace elements, pesticides and herbicides.

Table 2. Water quality values in the San Joaquin River at Vernalis for 1999-2001.

Water Quality Parameter	Values
Specific Conductance (mmhos cm^{-1})	621 ± 183
pH	8.0 ± 0.4
Alkalinity (mg CaCO3 L^{-1})	85 ± 24
Dissolved Oxygen (mg L^{-1})	9.6 ± 1.4
Nitrite+Nitrate (mg N L^{-1})	1.62 ± 0.59
Orthophosphate (mg P L^{-1})	0.107 ± 0.054
Dissolved Organic Carbon (mg C L^{-1})	2.83 ± 0.47
Total Dissolved Selenium (nmol L^{-1})	8.6 ± 2.5

Flow

Stream flow is particularly influential for salmon survival, as flow levels can have a large impact on different salmon life stages. As previously discussed, temperature change is one of the important effects in which flow plays a significant role. Temperature rises more quickly with low flows since there is a smaller body of water to heat up, and less mixing between upper and lower water layers can occur (Jager and Rose, 2003). Studies on flow requirements abound; however, the bulk of knowledge available is on spring flows, while the rest of the year, including critical fall flows, are less understood.

In the San Joaquin River basin, 60% of natural flows occur between April and June (Jager and Rose, 2003). This is due to the domination of spring snowmelt, the main source of water influx. Any flow management plan must take this into account and coordinate for high spring flow rates. Historical data indicate that the high flows provided from snowmelt permitted salmon in the SJR to travel up to higher elevations than other rivers' runs, up to 1,000m above sea level, but actual distribution and main areas of spawning are not known (Williams, 2006).

Flow Requirements

Tradeoffs exist between benefits and consequences of having higher or lower flows during salmon runs. According to Jager and Rose, restrictions on annual flow result affect fall flows more severely than spring flows. Elevated spring flows are more enduring and remain higher as overall annual flow decreases, and are the last flows to disappear. Elevated fall flows, however, are the first to go as annual flow drops. Studies show that there is a minimum level of winter flow that must be met to ensure success, but values above this level provide no additional benefit for fall Chinook salmon recruitment (Jager and Rose, 2003). For the Tuolumne River specifically, an annual flow of up to 489 hm^3 presented increasing recruitment, but flows above this value demonstrated decreased incremental recruitment. Since values above this minimum are not particularly beneficial, but are useful in the spring, management must allocate water appropriately between seasons. The best plan for dam management in allocating flow values would be to assess and apportion the minimum water flow needs for the winter, and then allocate additional flows during spring.

Chinook salmon have the highest survival rates when smolt emigration coincides with naturally high flow events (Jager and Rose, 2003). The smolt have the highest survival in flood conditions, where flows are over 18,000cfs. Below 10,000cfs, smolt appear to have lower survival with increasing flows. Examination of Chinook salmon populations in the SJR has revealed that spring flow rates are the main influence for fall-run population abundance, whereas other influences have little to no effect (DFG, 2005). Magnitude, duration, and frequency are the major aspects of flow as they relate to the salmon survival (DFG, 2005).[4] The bulk of studies on Chinook salmon have shown that seasonal flows with peaks in the spring produce the highest benefits (Jager and Rose,

[4] It should be noted that this model has not been finalized and is currently under the peer review process.

2003). Studies show that during spring runs there is lower alevin survival, but higher spring out-migrant survival when flows are high (Jager and Rose, 2003).

Impact on Temperature

As one of several influences on water temperature, flow rate is directly related to temperature change and, as a result, the high spring flows lower the rate of temperature increase. Consequently, overall temperature is lower during late spring and early summer. The lower temperatures increase the likelihood of egg and alevin survival since the range of tolerance for these young life stages is lower. When flow levels are high during the fall, the number of spawners waiting to migrate upstream increases (Jager and Rose, 2003). Theories for why this is include flow levels assisting in barrier avoidance or functioning as a migration cue.

It has been noted that annual flow affects have an effect on salmon survival. The optimal temperature for Chinook salmon egg incubation is 8ºC, while more advanced life stages can endure higher temperatures (Jager and Rose, 2003). The upper lethal temperature for juveniles, for example, is 25ºC (Jager and Rose, 2003). In terms of overall success, the Jager and Rose study noted that higher annual flow allowances produced a longer duration of successful spawning, with the highest flow yielding the longest period of successful spawning (120 days) (Jager and Rose, 2003). Therefore, high flow rates are not likely to be an issue, since high rates will ultimately increase spawning success, and feasibility suggests that flows are unlikely to reach rates high enough to have negative consequences on survivorship, given high water demands and future climate change impacts.

In addition to mortality, high temperatures can also influence salmon survival through secondary effects of threats such as predation. Flow can influence predation in a number of ways, such as affecting predator efficiency or salmon migration speed and aggregation. With higher flow comes higher turbidity and velocity, which diminish the ability of predators to pursue their prey. In addition, salmon are more likely to form aggregations in high flow conditions, as well as move downstream through the river more quickly; lessening the time they are vulnerable to predation (Jager and Rose, 2003).

The goal of restoration is to make habitat suitable for native species, namely Chinook salmon. Invasive species are unwelcome and any access that may be provided should be avoided. Migrating young may be exposed to predation by non-native fishes, such as black bass. Competition for redd establishment and food may be an issue, but in the past SJR production was high enough that this was not an issue (McBain and Trush Inc., 2002). To avoid infiltration of non-natives, lower river flow and high temperatures should be avoided, as such conditions are detrimental to Chinook salmon survival, but encourage non-native penetration (Feyrer and Healey, 2002). The majority of non-natives have been identified in areas that have these conditions, and agriculture drainage sites are also observed to contribute to non-native abundance (Feyrer and Healey, 2002; May and Brown, 2002).

Geomorphic Aspects

As part of the restoration plan, many sections of the San Joaquin river channel will be altered in order to make it more suitable for salmon spawning, as well as to improve degraded conditions. In making such alterations, geomorphic aspects of the project must be taken into account, particularly since failure to address geomorphology is often a reason why habitat restoration endeavors fail (Kondolf, 2000). Geomorphology is the study of landscape functioning, and geomorphic considerations should include examination of changes in the following four factors: flow regime, sediment regime, effects of riparian vegetation, and effects of human modification (Kondolf, 2000). Flow is crucial in examining geomorphology, and changes in velocity distribution as well as channel form and functioning are items that must be addressed. Channel form and dimension are particularly important for water flow as well as habitat. Appropriate sediment composition, particularly gravel quality and mobilization are key for establishment of redds and success of eggs (Kondolf, 2000). Any changes in these items must be explored on a smaller, reach specific level in addition to assessment of the broader basin. Subsequent monitoring of post-restoration performance should be quantifiable to pre-project baseline data.

Water Supply

Water Releases for Salmon

Due to the influence of flow on the migration and general survivability of the salmon, the centerpiece of the restoration agreement is the operation of Friant Dam to release sufficient flows to meet the needs of the salmon in each life stage.

A recent study focused on Chinook salmon survival in the Tuolumne River, a tributary of the San Joaquin River. The study is an excellent reference to use for salmon efforts in the San Joaquin River, given its close proximity, similar conditions and inclusion of a nearby dam. The study concluded, amongst other things, that the presence of a dam restricts natural flow in an area, and so flow must be monitored and controlled to provide for adequate salmon survival conditions.

Water-flow year (wet or dry) is a major factor of water flow needs. Table 3 lists the water flow recommendations specified by the California Department of Fish and Game for Chinook salmon population success (DFG, 2005). The values are specific for Vernalis, a city downstream of the SJR restoration stretch. Given the proximity and connectivity of the site to the SJR restoration area, restoration efforts should strive to achieve these downstream flow rates to ensure salmon survival.

Table 3. Flow requirements in the SJR at Vernalis, as specified by the DFG for Chinook salmon, based on water year types (DFG, 2005).

Year	**Flow (cfs)**	**Window (days)**
Wet	20000	90
Above Normal	15000	75
Below Normal	10000	60
Dry	7000	45
Critical	5000	30

Tradeoffs exist between benefits and consequences of having higher or lower flows during salmon runs. According to Jager and Rose, reducing the overall annual flow has more deleterious effects for assuring adequate fall flow rates as opposed to spring flow rates. Elevated spring flows are more enduring and remain higher as overall annual flow decreases, and are the last flows to disappear. Elevated fall flows, however, are the first to go as annual flow drops. Studies show that there is a minimum level of winter flow that must be met to ensure success, but values above this level resulted in decreased incremental recruitment for fall Chinook salmon (Jager and Rose, 2003). Since values above a minimum are not particularly beneficial to fall run Chinook salmon, but are useful in the spring, management must allocate water appropriately between seasons. The best plan in allocating flow values would be to assess and apportion the minimum water flow needs for the winter, and then allocate additional flows during spring.

Currently flow capacities throughout the SJR vary widely, and future flow rates based on the restoration will depend on the year, reach, and channel form (Table 4). The Settlement includes an average block of 4,000 cfs in mid to late April and flushing flows with a several-hour peak as close to 8,000 cfs as possible (NRDC v. Rodgers, 2006). Reasons behind this requirement include geomorphic aspects and salmon bed mobilization. Parties to the settlement did not, however, consider climate change in their examination of the feasibility of meeting flow requirements.

Table 4. Restoration Hydrograph Year Types and Annual Releases at Friant Dam (United States District Court, 2006).

Year Type	Assumed Riparian Release (acre-feet)	Restoration Release (acre-feet)	Total Annual Release (acre-feet)
Critical-Low	116,662	0	116,662
Critical-High	116,662	70,795	187,457
Dry	116,741	184,021	300,762
Normal-Dry	116,741	247,876	364,617
Normal-Wet	116,741	356,281	473,022
Wet	116,741	555,568	672,309

In addition to regular seasonal flows, management must take pulse flows into account. These flows provide short-term benefits in trigger salmon emigration, proving to be more influential than high flows (Jager and Rose, 2003). Pulse flows probably serve as a cue for out-migration, which in turn results in the synchronization of the salmon, affording them better protection from predators as they travel collectively downstream.

Dry versus wet hydrologic years affect seasonal flow allocation requirements for maximizing recruitment. Seasonal water flow requirements for maximizing recruitment depend on how much water is available annually. Flow requirement for success varies from one year to the next, and thus optimal management of flows to ensure salmon survival requires consideration of timing. The best flow management plan, as suggested by Jager and Rose, would be to allocate flows first for winter, spring, and lastly fall (Jager and Rose, 2003). Jager and Rose present recommendations for allocating flows for the use of the water. Such recommendations could be examined and incorporated into similar future cases in water allocations, and include a requirement to provide for the minimum winter flow must be provided for all hydrologic years. Supplementary flows above this minimum are not necessary given the minimal benefits produced, as discussed earlier. In future cases high spring flows could be ensured through the acquisition of additional flows, with the exception of extremely dry years. During extremely wet years, excess flows should be allocated to the fall for attracting additional fish numbers.

Potential Impacts of Climate Change

The Settlement focuses directly on the hydrologic and ecological systems in the Central Valley of California, but lacks the inclusion of future climate change projections for its restoration planning and water allocation assessment. However, climate change has the potential to significantly impact hydrological system, including the timing and variability of flow, of the San Joaquin River basin, its past and projected future impacts must be analyzed.

Global warming occurs when greenhouse gases build up in the atmosphere. This leads to increases in the amount of radiation that enters and becomes trapped in the earth's atmosphere, causing temperature change and climate pattern shifts. Carbon dioxide, a major greenhouse gas, has increased by over 30% since the industrial revolution, leading to an average increase in global temperature of approximately 0.7ºC over the past century (Rowland, 2001). Regional climate change models show predictions of 1-2.5ºC average temperature increases by 2050 for the San Joaquin River basin (Leung and Qian, 2004). Such an increase is projected to have many effects on the current hydrological regime of the San Joaquin River-Friant Dam region.

Since the 1950s runoff data shows that the proportion of total annual runoff received from snowmelt has decreased in the San Joaquin region (Roos, 1989). Parallel Climate Model (PCM) projections reveal reduction in snowpack of about 50% by 2090 for the San Joaquin basin (VanRheenan *et al.*, 2004). The loss in snowpack corresponds to a loss in water storage, which could require the construction of additional reservoirs to maintain current operations (Roos, 1989). However current restoration requirements make reservoir construction impossible, implying definite effects will be seen in future supply. With the shifting climate also comes a change in the timing of flow throughout the year. Reduced stream flow was shown to have seasonal effects visible in spring, summer, and winter, which are more pronounced in the southern San Joaquin River basin (VanRheenan *et al.*, 2004). The amount of flow has implications for the entire environment of the river including its biota, dam function, recreation, and overall water availability. These factors control the economics and management practices of the river and all were effectively changed by the outcome of the Settlement.

Other impacts of global warming on hydrology involve the flood and drought regimes, which are regionally specific. The San Joaquin River receives its water from the Southern Sierra Nevada Mountains. With changes in the timing and amount of flow, combined with an increase in the precipitation ratio of rain to snow, conditions are set for floods and droughts. In the winter, heavy flows have the potential for floods, as the increase in temperature raises the geographic elevation where snow falls as rain (Howat and Tulaczyk, 2005). For rivers fed by the Sierra Nevada Mountains, variability in winter runoff has increased since the 1960s (Pupacko, 1993). A continuation of this increased variability will change the reliability of flow predictions, which will impact planning regarding required flows for environmental purposes and may have economic impacts on the agricultural industry of the San Joaquin River basin, as well as other Friant water users.

Regional Climate Change Models

As the main source for runoff throughout the year, snowmelt is a significant factor when considering water supply impacts for regions such as the Central Valley. For rivers originating at high altitudes, such as the San Joaquin River, winter snow at high elevations supplies water in the spring and summer (Howat and Tulaczyk, 2005). Warming during winter results in a higher fraction of precipitation falling as rain rather than snow, which would be immediately discharged into the river instead of staying in snowpack until melting. The decrease in snowpack would in turn decrease the summer water supply and increase the likelihood of floods in winter and spring (Miller *et al.*, 2003). Snowpack in the Sierra Nevada region shows increased sensitivity with decreasing elevation, which means rivers sourcing from lower elevations should expect larger impacts (Howat and Tulaczyk, 2005). The San Joaquin River, which originates in the high southern Sierra Nevadas, was the least sensitive in a case study where 17 drainages in the region were analyzed (Howat and Tulaczyk, 2005). However, impacts should not be disregarded as a modeled 3ºC increase results in a 13-22 % loss in the basin's snow-water equivalent (Howat and Tulaczyk, 2005).[5] Such a loss would have huge impacts on water supply of the San Joaquin River, with implications on the availability of flows for environmental, agricultural, and other purposes.

Historical Data Analysis

Stream flow data from the United States Geological Survey (USGS) Hydro-climatic Data Network for the San Joaquin River was used to determine historical trends and the potential effects of climate change on the San Joaquin River.[6] Monthly stream flow data for water years 1922-1928 and 1952-1988 allowed for the creation of hydrographs showing decadal averages (Figure 2).[7] Additionally, average monthly stream flow data was used to create seasonal timelines for the continuous data set from 1952-1988 (Figure 3).

The resulting hydrograph shows the rise in stream flow in March, with continued increases throughout spring, before peaking in May to June (Figure 2). Seasonal decadal flow shows slightly increasing winter flow through time, accompanied by a slight decrease in spring flow percentage (Table 5). This is indicative of earlier annual snowmelt, a predicted result of global warming. Summer, like winter,

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[5] Snow-water equivalent is the amount of water contained in the snowpack (Howat and Tulaczyk, 2005).

[6] The San Joaquin River station, number 11226500, is located at Miller Crossing.

[7] The time periods of 1922-1928 and 1952-1988 were used as it was the available dataset for that monitoring station, which is located above the dam.

shows a slight increase in flow through time, which indicates a delay in snowmelt. Although the percentages of annual flow have a slim range, with actual annual flow ranging from 1,845 to 15,631 cfs, a shift by even one percent could correspond to changes of over 150 cfs in flow.

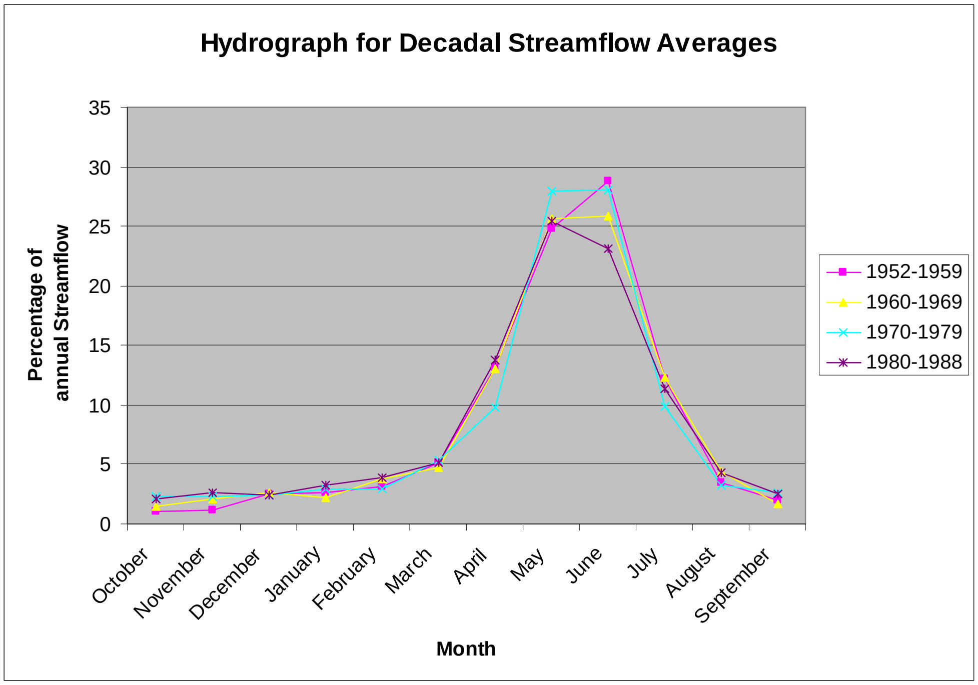

Figure 2. The hydrograph for decadal averages displays the average decadal percentage of total annual flow for the continuous available data.

Table 5. Seasonal percentages of annual stream flow.

Decade	Fall	Winter	Spring	Summer
1922-1928	6.7	10.7	67.4	15.2
1952-1959	4.8	11.0	66.7	17.6
1960-1969	6.2	10.8	64.6	18.4
1970-1979	7.0	11.3	65.8	15.8
1980-1988	7.2	12.4	62.4	18.1

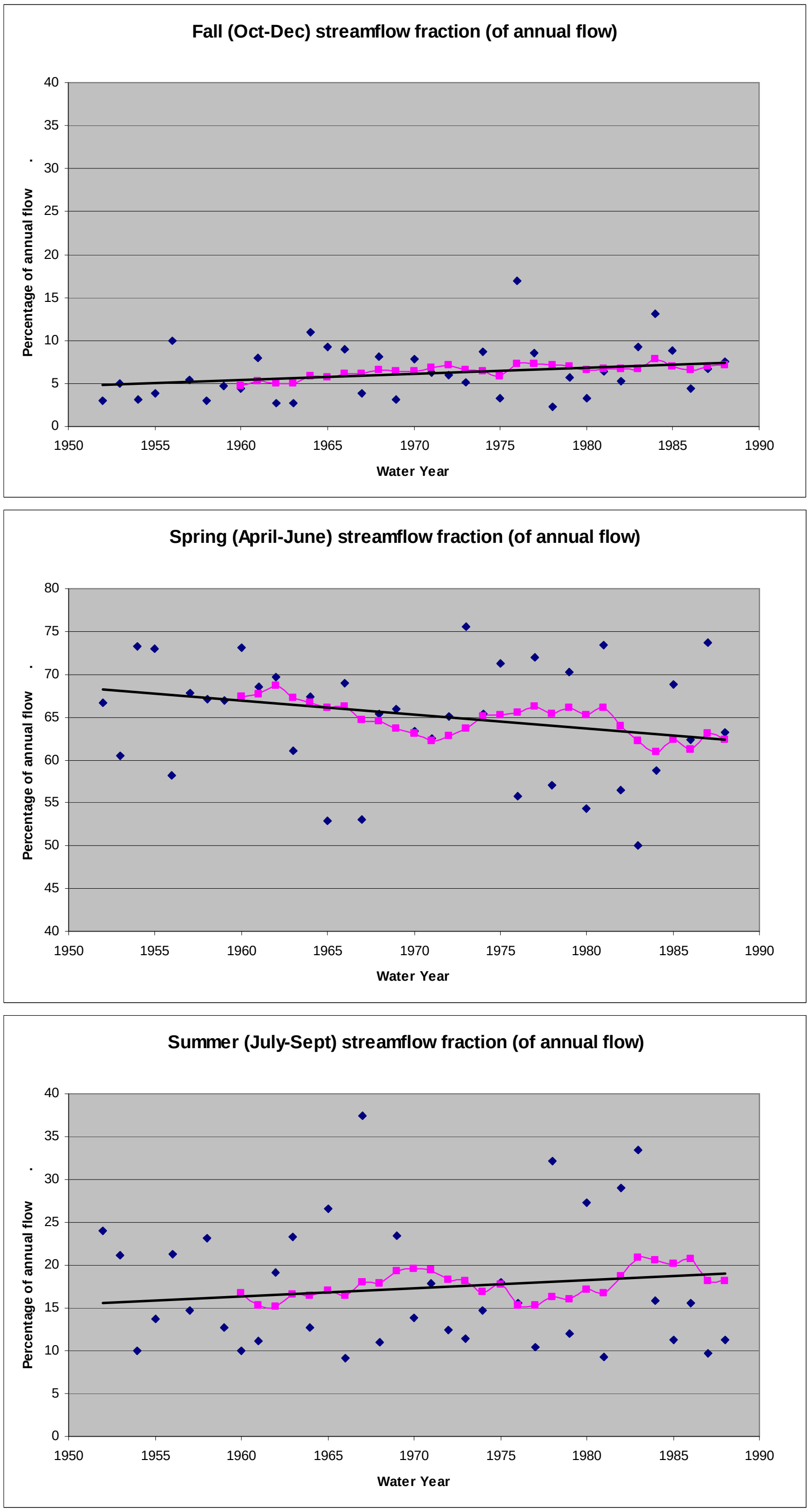

Figure 3. Seasonal fraction of annual streamflow data for 1952-1988 for fall, spring, and summer. For each graph the nine year moving average is shown in pink, while the regression line is shown in black.

Seasonal stream flow fraction hydrographs split the annual flow into the four seasons, defined as the following:

- Fall: October, November, and December
- Winter: January, February, and March
- Spring: April, May, and June
- Summer: July, August, and September

Nine-year moving averages show the overall trend in flow over time for data that can vary widely on an annual scale for flashy systems such as the San Joaquin (Figure 3). Fall and winter hydrographs reveal fairly constant nine-year moving averages indicating little change of annual percentage of streamflow through time (Figure 3). Spring and summer hydrographs show much more variance in their nine-year moving averages. The spring hydrograph shows a decrease in fraction of flow for the nine-year moving average; while summer shows a corresponding increase (Figure 3). Figure 4 shows the shifts in summer and spring together to express the direct relationship between these seasons: years when spring increases, summer has a corresponding decrease and vice versa.

The results of our analysis are consistent with other regional climate change studies of the area. Table 6 shows statistically significant trends in fall, spring, and summer. Previous studies show the San Joaquin River has experienced significant trends in flows beginning in the late 1940s (Dettinger and Cayan, 1995). The upper San Joaquin River shows statistically significant increases in monthly fractional flow for October, November, and March corresponding to a close to significant decrease in June (Dettinger and Cayan, 1995). These modeled streamflow trends were conducted with the inclusion of factors such as precipitation, temperature, and elevation on the regional basin scale. From 1949 to 1990, a trend toward warmer winters (by a nearly 2ºC increase) coinciding with significant decreases in spring runoff, demonstrates the correlation between the two variables (Dettinger and Cayan, 1995). With global warming expected to increase temperatures further, it can be assumed that spring runoff will be affected.

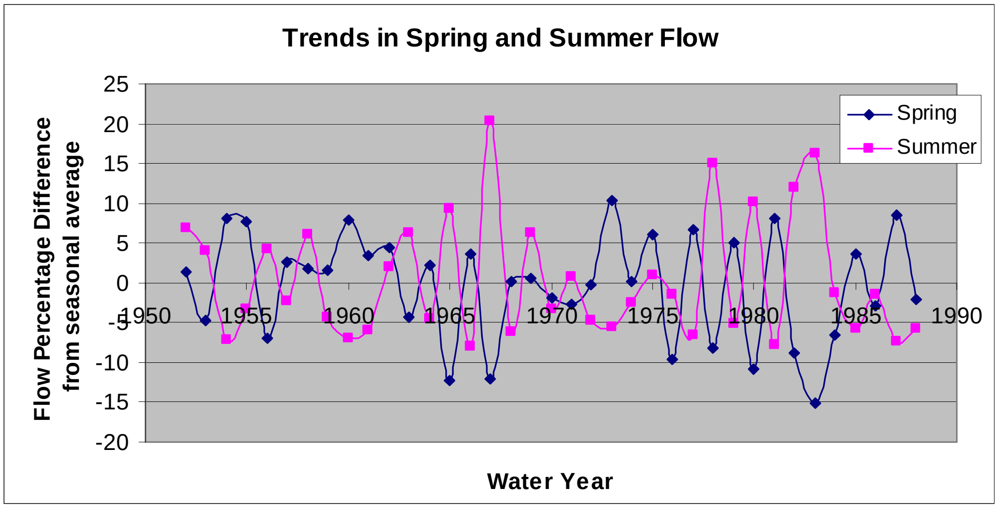

Figure 4. The annual spring difference from seasonal average (blue) is offset by the annual summer difference from seasonal average (pink), displaying the close relationship between the two seasons.

Table 6. Seasonal trends and their statistical significance (p-value<.05).

Season	Trend	p-value	Statistically significant?
Fall	increasing	5.6E-07	Yes
Winter	decreasing	0.706	No
Spring	decreasing	5.7E-05	Yes
Summer	increasing	0.008	Yes

Predicted Impacts to Current Users

Many conflicts result from the past and future trends in climate change where opposite effects occur. Several examples can be directly related to the Settlement. For instance, climate change forces a necessity of increased reservoirs due to loss of snowpack, but the requirement of sustainable river flow for endangered salmon and other water demands potentially prevent such storage. Also, if salmon species continue to decline, suits similar to *NRDC, et al. v. Rodgers, et al.* are expected to continue to occur. Additionally, the effects of global warming will need thorough consideration. Rivers, deltas, and other waterways are critical habitat for declining aquatic species, requiring the maintenance of specific flow levels, as seen for salmon in this case. Consequently, increasing temperatures from climate change may decrease water flow or alter the timing of flow; making it difficult to meet required criteria. This may ultimately result in operational changes for many dams, and in the most extreme cases, dam removal. These predictions show how important climate change is in the determination of critical settlements such as the San Joaquin River Settlement. Overall, although no one can be certain about the exact impacts of climate change in the future, models incorporating predicted trends show significant impacts on susceptible factors, especially hydrological aspects.

In addition to the expected changes in flow from climate change impacts, significant decreases in supply to water users are required in order to reach the restoration goals and maintain flow for salmon survival. An analysis of the water supply, given implementation of the Settlement, indicates that Friant users could experience, on average, a 19% decrease in their water supplies in normal water years and potentially 23% decrease in dry years (FWUA, 2006c). These reductions may translate into the loss of Class 2 water rights for FWUA users.[8] This correlates to a reduction of 242,000 acre-feet, displaying the need for mitigation strategies. For the Friant Water Users Authority, these strategies include a Recovered Water Account and a plan for recapture, reuse, and exchange of water (FWUA, 2006c). However, these plans for mitigation do not incorporate the intensified effects on supply resulting from climate change. Also, the reduction in reliability of flow as a result of climate change could exacerbate the ability of Friant to meet the needs of its municipal, agricultural, and environmental users.

The Economics of the Settlement: Impacts and Funding

Economic Impacts of the Settlement

The Settlement currently does not address the potential economic impacts, which may result from the implementation of the Settlement. These impacts, stemming mainly from a reduction in water supplies to current users, are predicted to affect both agricultural and urban interests in the cities of Orange Cover, Lindsay, and Fresno.

Agriculture

The state of California boasts a $29.6 billion dollar agricultural industry of which $2.5 billion is from the Friant Division service area, (USDA, 2007a; Friant, 2006a). In this area, there are approximately 15,000 relatively small family farms (200 to 300 acres) (USDA, 2007a). Primary crops include table grapes, tree fruit, nut crops, citrus and alfalfa (Valley Water Alliance, 2006). These farms are dependent on the availability of water during the growing season. The source of that water can have large impacts on expenses as pumping groundwater and

[8] Class 1 water supplies, known as the “firm” water supplies, are the primary contracted supplies delivered in any given year (Valley Water Alliance, 2005). Class 2 supplies are “non-firm” supplies and are considered to be “soft” supplies that are only delivered in years after all Class 1 demands have been met.

importing water from other areas is much more costly than utilizing contracted surface supplies.

San Joaquin Valley Agricultural Water Committee retained Northwest Economic Associates (NEA), a natural resources and consulting firm, to analyze the effects of drought and regulatory reductions to water on the region's economy (NEA, 2002a and b). Their study showed total water usage in the San Joaquin Valley decreased by 800,000 acre-feet in 1991 (the fifth of six consecutive drought years), which is six percent less than normal usage (NEA, 2002a). Although surface water supplies were 57% lower than normal during the drought year, ground water supplies were 127% higher. Using ground water for irrigation is more expensive than using surface water due to pumping related costs, and on-farm water costs in the Valley increased $163 million. Additionally, the idling of 253,000 acres of cropland coupled with reduced yields from a further 125,000 acres created on-farm losses of $281 million. Direct on-farm and off-farm losses totaled $200 million. Secondary effects included reduced sales of farm machinery, fertilizer and other inputs, resulting in an additional $264 million reduction in regional economic activity in 1991 (NEA, 2002a).

Surface water deliveries during the sixth consecutive drought year were below normal by 53%. (NEA, 2002a) Groundwater supplies were 152% above normal, which was more than the prior year despite the higher surface water deliveries. On-farm water costs rose $259 million, primarily due to increases in energy and water costs. In addition to cropland idled in 1991, a further 172,000 acres of cropland were not utilized and 33,000 acres suffered reduced yields. In 1992, losses to on-farm revenues were $157 million while regional economic activities suffered an additional $145 million in lost revenues (NEA, 2002a).

Friant Water Users Authority also utilized NEA to assess the local and regional economic impacts of reduced surface water deliveries on the agency's service area (NEA, 2002b). The study analyzed effects on cropping patterns, irrigation technologies and crop idling using an optimization model at reductions of 200,000 acre feet and 500,000 acre feet (10% and 25% reductions below contracted amounts for that water year). Per the analysis, the 200,000 acre foot reduction would result in idling 173,000 acres of cropland, creating a revenue reduction of as much as $180 million. Due to secondary effects, regionally, over 2,000 jobs would disappear and personal income would fall by $75 million annually by the seventh year. The 500,000 acre foot reduction would result in the idling of 372,000 acres of crop land and cause a revenue reduction of as much as $383 million. Regionally, employment would be reduced by more than $3,500 jobs resulting in a drop in personal income of $129 million per year by the seventh year (NEA, 2002b).

Clearly, reductions in surface water delivery, regardless the impetus, will have a negative effect on the local and regional economy. Some estimate that farmers will see their water deliveries drop by about 170,000 acre feet (approximately 15%) per year under the Settlement (Grossi & Scultz, 2006). In 2005, the Friant Division allocated 100% of its contracted Class 1 water. In 2007, only 50% of contracted Class 1 water was allocated, and 0% of Class 2 water (USDA, 2007b). Forecasts for reduced snowpack and stream flows may result in continued allocation reductions. In the future, the area's economy may need alternative revenue sources to remain healthy.

Urban

The Friant Division's long term contractors include the urban service areas of the cities of Orange Cove, Lindsay, and Fresno. Two of these cities, Orange Cove and Lindsay, are largely dependent on agriculture with more than a third of the population existing below poverty level (Table 7). The third, Fresno, employs much of its far larger population in educational, health and social services or retail and about a quarter of the population existing below poverty level (Table 7).

Table 7. Selected demographic characteristics for Cities of Orange Cove, Lindsay and Fresno (United States Census Bureau, 2000).

	City of Orange Cove	City of Lindsay	City of Fresno
Population	7,772	10,297	427,652
Hispanic origin	91%	45%	50%
Employment			
Agriculture	43%	33%	3%
Management, professional	9%	13%	27%
Median household income	$22,357	$24,305	$32,236
Average per capita income	$7,126	$8,230	$15,010
Population below poverty line	45%	40%	26%
Education (of population 25 years and older):			
Less than 9th grade education	59%	44%	16%
High school diploma or equivalent	13%	15%	20%
Any education past high school	12%	23%	49%
College degree	4%	9%	26%
Speak English "very well" (of population 5 years and older)	52%	40%	20%

Reductions to water supplies in communities where workers are largely dependent on agriculture for their income will yield larger impacts to households in those areas. In Orange Cove and Lindsay, where the median household income is less than 60% of the national average, even small quantitative effects in income will have larger proportional effects on the welfare of those households. Prisons and alternative industries have been proposed in the area, and may provide a means of combating reductions to income and employment in those areas that may be affected adversely by reductions in water allocations, but water remains a delicate issue for residents of these cities (Westlands Water District, 2004).

Unemployment

Impacts of reduced water deliveries have a more noticeable effect on small communities in where farming is the primary or only employer (NEA, 2002a). Unemployment rates rose during a drought in the early 1990s and have remained at more than double their pre-drought levels (NEA, 2002b; United States Census Bureau, 2000). The cities of Orange Cove and Lindsay are more dependent on agriculture for their livelihood, and thus, their economies are more sensitive to issues of water allocation than is the economy of Fresno. This gives rise to great sensitivity about water allocation in the area. Additionally, lower education levels limit the types of jobs that residents of these areas may shift to should their unskilled positions disappear (Table 7). The higher education level in Fresno gives those residents more mobility across job markets.

Measures to abate possible effects on the employment level in these areas generally involve the creation of new unskilled jobs. Options, such as the installment of a prison near the area in Mendota, have been discussed as solutions to possible job reductions should decreases in water allocations affect agricultural jobs in these areas (Westland Water District, 2004). Such solutions would create unskilled, non-agricultural jobs, but may also increase water demands for these cities, as the new facilities would require water to run.

Another option may be to create unskilled jobs around the recreation industry as it relates to the river. Maintenance of parks along the river and in the general vicinity may utilize some of the other abilities obtained by unskilled laborers while working in the agricultural industry. Other unskilled positions may arise as well. Although this solution would not place further burden on the issue of water allocation, barriers of language and transportation may come into play. With a large percentage of affected towns consisting of people not fluent in English, it may prove difficult to place them in jobs that interface these workers with human relations/customer service jobs such as in new restaurants or hotels that might accompany the increase in recreation (Table 7). Additionally, the rising cost of operating motor vehicles may limit the distances individuals will be able to travel to a job.

Lastly, it is unclear whether the river restoration would create a significant number of jobs, or whether these jobs might be offset or even overcome by decreases in recreational demand at Millerton Lake due to lower reservoir levels. Further research will be necessary to discern whether the recreation industry as it relates to the river will yield possible employment.

Hydro-power

One of the twelve electric power generation plants in Fresno-Madera County is the Friant Power Plant, which produces 31 megawatts (MW) of power annually for the Friant Power Authority (ENTRIX, 2005). The Friant plant consists of three generators, one on each the Madera and Friant-Kern Canals as well as one on the San Joaquin River release outlets. The river outlet produces up to 2 MW of the total power produced at this plant. Power from this plant is sold to PG&E (ENTRIX, 2005).

Per a 2005 study, power was sold at $77 per megawatt-hour (MWh) May through October and $71/MWh November through April (ENTRIX, 2005). This is $2.8 million less than an "average" year, and would result not only in lower revenues for the Friant Power Authority, but reduced regional income of $907,000 annually with a reduction of less than 10 jobs directly and less than 15 indirectly through the region. (ENTRIX, 2005)

These losses may not be affected by terms of the Settlement as power generation is dependent on flow levels and not necessarily on which generator produces that power. However, power generation may be reduced due to diminished flows predicted by climate change, but if flows are diverted from one generator to another, this will not necessarily change the output of power at the plant. As flow regimes are dictated by exhibit B of the Settlement, power output could be predicted for any flow scenario addressed by the hydrograph within the Settlement.

Recreation

Recreation has increased since the 1950s. This was predominantly a function of three factors: leisure time, mobility and income (Thompson, 1999). Studies have shown that leisure time increased through the 1970s, but has decreased somewhat since then (Zinser, 1995). With the spreading of vehicle ownership, Americans have increased their mobility to grant them access to a broader geography. Higher income brackets may also enjoy more recreational activities. One type of recreation is water based.

Other factors that have increased recreational use of water are physical geography, technology and demographics. Physical geography relates to climate, landforms and vegetation which create natural-resources regions having inherent physical limitations and recreation opportunities (Thompson, 1995). Southern states have more warm days, creating more opportunities to participate in water based recreation activities. In western states, weather is warm but water is scarce, and so water based recreation tends to concentrate in fewer sites. This places more pressure on those areas that offer opportunities for water based recreation activities.

Technology also expands opportunities for recreational use of water as it allows recreationists to use the water in ever varying ways. At one time, water based recreation was restricted to swimming, fishing, and boating. With technology, recreationists may now water ski, jet ski, or participate in other activities which technology has allowed. Additionally, the advent of vehicular transportation and four-wheel drive vehicles generates access to water spots that were previously inaccessible.

Demographic characteristics impact recreational water use as well. As population grows, more individuals will want access to water spots. This may actually diminish the recreational experience of water recreation at a given site due to overcrowding. Even though "…the presence of water enhances other recreation activities from camping to hiking of picnicking," (Thompson, 1995) overuse of a recreation site may impede the utility derived by individual users.

Behind Friant Dam lies Millerton Lake. With a capacity of 520,528 acre-feet, 600,000 people visit the lake annually to swim, fish, hike, and enjoy many other outdoor activities (USBR 2007; USEPA, 2003). During winter, the park runs boat tours to view bald eagles and other wildlife (USBR, 2007B). Several recreation areas line the river below Friant Dam. These sites are frequented by recreationists and school children year round, who may use the areas for picnicking, hiking, swimming, fishing, camping and educational activities. Currently, fees for these facilities range from three to ten dollars for vehicle and boat entry.

Restoration Funding

The California Department of Water Resources (DWR) has reviewed the Settlement and assesses the costs to be between $363 million and $580 million (DWR, 2006). However, this cost assessment only includes the cost of the channel restoration and does not include the costs related to the impacts on downstream users or the mitigation of water supply impacts of current Friant users (DWR, 2006). In total, the restoration is projected to cost between $250 million and $800 million, dependent largely on the type and extent of levee work to be undertaken in conjunction with these projects (FWUA, 2006b; LAO, 2007). Given the uncertainties surrounding the restoration plan it is impossible to know the total cost of the restoration project as a whole. As such, more precise cost estimates will be arrived at during various project-specific planning activities as part of implementation of the Settlement.

Funding for the restoration plan is expected to come from a variety of sources including, USBR, DFG, DWR, and those served by Friant Dam (Table 8). However, additional funding must still be acquired. Per the Settlement, federal appropriations and state bond initiatives will provide the bulk of the funding for the restoration (San Joaquin River Restoration Program, 2007). Federal funds of up to $250 million may be made available through PAYGO appropriation. An additional $17 million may be made available from a surcharge to Friant contractors under the Central Valley Project Improvement Act (CVPIA) of $7 per acre foot (approximately $8 million per annum) and the Friant Capital Repayment (FCP) plan (approximately $9 million). However, the CVPIA, FCP, and PAYGO funds require federal congressional approval. House of Representatives bill, formerly H.R. 24, now H.R. 4074, authorizing the approval of these funds was proposed in January of 2007. Currently, H.R. 4074 has been approved by the House of Representatives Natural Resources Committee and is scheduled for debate, yet House action on the bill has been delayed until the PAYGO offsets are resolved (see discussion on PAYGO below) (HR 4074, 2007).

On the state level additional funds of up to $200 million may be available under Propositions 84 and 1E, both of which were passed by voters in the November 2006 elections (Attorney General 2006a and b). Up to $2 million may also be made available from the Restoration Fund established under CVPIA (San Joaquin River Restoration Program, 2007).

The PAYGO, or pay-as-you-go, rules reinstated by the House of Representatives in 2007 require that legislative proposals which require new funding to be offset by reductions in other programs or increased federal revenues in order to neutralize impacts on the overall federal budget (Crawford, 2007). Original legislation for the agreement necessitated nearly $250 million in offsets over a ten year period; however, House of Representatives committees have only been able to identify $170 million in offsets. The $170 million is currently earmarked to come from a nuclear power plant tax fund that is designated for use in the cleanup and decommissioning of nuclear power plants; however, revisions are on-going and this may change (HR 4074, 2007). While the $170 million identified thus far is not the full amount needed for the restoration, it is over half of the necessary amount, and is subsequently sufficient to allow the bill to move forward.

Efforts have been made to reduce the PAYGO "score" by including such provisions as accelerated capital repayment by Friant's water contractors for water facilities constructed and funded by the federal government. Such repayments would be cost neutral to water contractors, and would replace bonding provisions currently provided for in the legislation for timely funding of Settlement. Friant water contractors would receive water contracts providing more certainty along with relief from certain provisions of Reclamation law as an incentive for making these advance payments (Western Farm Press, 2007).

While the current Settlement Agreement anticipates that those sources described above will provide the necessary restoration funding, it is clear that there is a large amount of uncertainty regarding the federal appropriations. As such, it may be necessary to identify and acquire additional financial support in order to proceed with the restoration plan.

Table 8. The current SJR restoration funding sources (San Joaquin River Restoration Program, 2007).

	Funding Source	**Amount (millions of dollars)**	**Annual Amount (millions of dollars)**
"Federal"	CVPIA Friant Surcharge	--	8
	Friant Capital Repayments	--	9
	CVPIA Restoration Funds	--	2
	Federal Appropriation	250	--
State	Prop 84	140	--
	Prop 1E	60	--
Total		**450**	**19**

Negotiation Template

Given the multitude of scientific and economic factors that influence any restoration plan, it is easy to see that there are no simple, one-size-fits-all solutions. Similarly there are no simple negotiations. With each new situation there are new parties with unique needs and goals. Subsequently, to develop a universal negotiation template it is necessary to identify the commonalities, including both process and plan requirements and obstacles, among previous river restoration case studies. Through our analysis of the San Joaquin River Settlement and other restoration examples, including the Colorado, Columbia, Eel, Russian, and Trinity Rivers, we identified the following commonalities:

- Litigation results in negotiation
- Much of the time spent in litigation and negotiation is taken up by competing expert opinions
- More than one restoration plan should be considered

Negotiation Template

Step 1. Determine Participants

a. Stakeholders will identify and appoint representatives to comprise the Plan Development Team; which will:
   i. Determine a restoration plan development timeline
   ii. Create a binding Memorandum of Understanding with each stakeholder group agreeing to:
      - Engage actively in the restoration plan development and implementation processes
      - Abide by the restoration requirements determined by the Advisory Panel (Step 2)
      - Adhere to the finalized plan (Step 3)
      - Share costs of the project

b. Plan Development Team will identify the outside parties, including at least one mediator, to makeup the Advisory Panel which will:
   i. Collectively determine the restoration and stakeholder requirements that must be addressed in the restoration plan (Step 2)
   ii. Oversee the working groups and plan development process (Step 3)

Step 2. Gather and Analyze Data

a. Advisory Panel will identify and assess the restoration requirements which must include, but are not limited to:
   i. Flow (necessary for migration and growth/development)
   ii. Temperature
   iii. Food Availability
   iv. Geomorphology
   v. Fish Passage
   vi. Climate Change

b. Advisory Panel will identify and assess the stakeholder requirements and potential impacts; which must include, but are not limited to:
   i. Water Demand
   ii. Socioeconomic Impacts (local and regional)

c. Advisory Panel will collectively determine the requirements that must be addressed and/or met by the restoration plan

d. Advisory Panel will report its findings (Step 2c) to the Plan Development Team

Step 3. Creation and Approval of a Restoration Plan

a. Working Groups will be created, which will:
   i. Meet simultaneously
   ii. Develop a basic restoration plan, including:
      - Restoration processes to meet the restoration requirements (Step 2), utilizing modifiable planning techniques
      - Mitigation strategies
      - Timeline, including reassessment points
      - Funding options

b. Working groups will present plan options to the Plan Development Team and Advisory Panel

c. Plan Development Team and Advisory Panel will create a finalized plan, including a timeline, by either:
   i. Voting for the best restoration plan presented, or;
   ii. Creating a hybrid restoration plan from those presented

d. Advisory Panel will assess the created restoration plan to ensure the requirements (Step 2) are met. If approved, the restoration plan will proceed to the implementation process. If not approved, the Advisory Panel will present a report of the plan deficiencies to the Plan Development Team, which will return to Step 3c.

The basic premise of the template is to avoid litigation and employ an open, collaborative negotiation strategy. Negotiations are one form of alternative dispute resolution (McDowell and Sussman, 1996).[9] Alternative dispute resolution (ADR) has been employed in fields such as business, finance, and water conflict resolution, as a strategy to avoid litigation (Zantell, 2001). Using negotiation rather than litigation has been shown to decrease the time is takes to achieve a resolution, legal fees (both attorney and court fees), and the adversarial nature of the process by encouraging open communication and collaboration among participants (Colby 2000; Leach, 2002; McDowell and Sussman, 1996). Additionally, by avoiding a formal legal process, participants have more flexibility in addressing all concerns, including economic and water supply concerns, and, ultimately, arriving at a solution (Zantell, 2001). While we acknowledge that there may be situations which require legal action to be taken in order to achieve results, history tells us that litigation often only ends with negotiation (Colby, 2000). In the case of the San Joaquin River, the current lawsuit was filed in 1988; however it was not until 1999 that the parties involved first came to the table to negotiate. The litigation was stayed throughout the negotiation, but the negotiations failed. Ultimately, both parties realized it would take a settlement to get what they wanted, or to limit their losses. Subsequently, it fell to the parties involved to develop a solution. While time consuming, the negotiations did result in a settlement. Similarly, the state of Montana filed suit against Atlantic Richfield Co. (ARCO) in 1983 for pollution of several water bodies, including the Clark River, resulting in significant species and ecological impacts (State of Montana, 2004). However, it wasn't until 1997 that the case went to trial after years of opposing legal briefs and motions. However, two years later it was a series of intense negotiations that allowed the parties to reach a final settlement in 1999.

The second premise of the template is that neutral, outside parties should be used to determine the restoration and stakeholder requirements, as well as any negotiation obstacles (Shamir and Kutner, 2003; Snyder, 2003). These outside parties should include mediators and consultants from relevant fields (Snyder 2003). Using neutral parties to identify points of agreement and contention allows all parties to differentiate between perceived and actual needs (Colby, 2000; Jonsson, 2005; Shamir and Kutner, 2003; Snyder, 2003). Additionally, the use of third parties and consultants reduces and/or eliminates the need for opposing expert testimony (Snyder, 2003). This is also a potential cost saving tool because it allows the parties involved to hire one consultant group as opposed

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[9] ADR is used to describe a host of non-litigative techniques to resolve conflicts, including mediation and moderated negotiations (Shamir and Kutner, 2003; Zantell, 2001). These techniques were officially endorsed and encouraged by the federal government in 1998 as a means of reducing litigation and increasing the efficiency of conflict resolution involving government agencies (Colby, 2000).

to one or more for each party (Colby, 2000). In the case of the Columbia River basin, which included the restoration of the Columbia and Snake Rivers, an "independent scientific group," consisting of experts in the fields of ecology, fisheries, population dynamics and statistics, was created (ISAB, 1996). This group was tasked with developing a set of scientific standards by which restoration goals could be measured and achieved. Additionally, the group was tasked with evaluation the restoration efforts on a periodic basis to ensure, to the extent possible, the success of the restoration plan.

According to the guidelines set forth in the template, the outside parties will be used to determine the restoration and stakeholder requirements that must be addressed. While we expect that the number and breadth of these requirements will change with each unique situation, we have provided a basic list of requirements that we feel are universal across restoration agreements. The universal restoration requirements include: flow, temperature, food availability, geomorphology of the restoration area, fish passage opportunities and barriers, and climate change (Berhardt *et al.*, 2005; Pejchar and Warner, 2001; Russian River Watershed Council, 2002; Standford *et al.* 1996). In addition to the restoration requirements, we believe that for a successful negotiation to be achieved the needs of the stakeholders must be considered as well (Jonsson, 2005). In terms of water reallocation negotiations the critical stakeholder needs that must be addressed are the potential socioeconomic impacts to current users and the surrounding communities, as well as the water demand and potential mitigation measures (King and Maitland, 2003; Lui, Christiansen, and Jaksch, 1980; Wallace, Acreman, and Sullivan, 2003). It should be noted that it is often unrealistic to assume that stakeholder impacts can be fully mitigated or compensated for; however, at the very least these impacts must be identified in order to provide the opportunity for mitigation (Snyder, 2003).

Due to the complex and interactive nature of the restoration and stakeholder requirements, it is often a good idea to have multiple plan options to choose from as each will typically result in a different outcome (Standford *et al.*, 1996). In order to create these plan options, we recommend the use of small working groups composed of representatives of each stakeholder group, as well as one or more neutral parties to oversee the process (Jonsson, 2005; Richter *et al.*, 2003).[10] As previously discussed, each restoration case is unique in terms of the number of stakeholders, etc., so we have not made any recommendations as to the specific make up of each working group. From the plans created by the working groups,

[10] In many cases working groups are utilized, but referred to by other titles, including, but not limited to, task force, (sub)committee, and (blue-ribbon) panel; however, the basis function premise is one and the same (USGAO, 2002).

a final restoration plan will be generated by either choosing the best plan or combination of plan elements (USGAO, 2002).

In creating both the plan options and the finalized plan, we recommended the use of adaptive management. As can be seen with the San Joaquin River there are many unknowns in the restoration plan. What flows will be necessary to achieve the temperature objectives? Will agriculture runoff need to be managed to ensure salmon survival? These questions cannot be answered until the restoration plan has been implemented; however, the use of modifiable planning, or adaptive management, techniques allows the participants to reassess the restoration efforts as time progresses and adjust the course of action as necessary in order to achieve their goals (DOI, 2000; Richter *et al.*, 2003). Adaptive management is not without opposition though. In fact, it can be considered a rather controversial point in the template because in conflicts such as the San Joaquin River in which users are losing access to a historical water right there is a desire for a concrete outcome that ensures their water supply will only be affected by a stipulated amount. When adaptive management is used there is a sense of inherent uncertainty stemming from the notion that the restoration strategy may change upon reassessment; which could result in additional impacts to users. However, with the growing number of restoration cases we can clearly see the benefits of adaptive management techniques in ensuring that restoration goals are met and that money is not wasted on a rigid plan that ultimately fails to meet these goals (DOI, 2000; Richter *et al.*, 2003). Of the restoration case studies examined, all included adaptive management strategies in their plan (DOI, 2000; Richter *et al.*, 2003; Russian River Watershed Council, 2002).

Lastly, the process by which a final plan is chosen allows the parties involved to select either one of the plan options created by the working groups or create a hybrid plan by selecting elements from multiple options. While this process ideally allows for the creation of a plan that encompasses the best options available, it runs the risk of creating a "cherry-picked" plan that may no longer adequately address the restoration and stakeholder requirements. To avoid falling victim to this, we have included a final plan approval procedure by which the outside advisors are tasked with analyzing the final plan to ensure that it adequately addresses the requirements and goals previously set forth.

Alternative Funding

Funding Options

The San Joaquin River Restoration Settlement is being heralded as a historically significant restoration agreement. However, questions about funding lend uncertainty to the future of restoration efforts. As previously discussed, a large portion of the funds are to be acquired through federal appropriations. However, the bill authorizing PAYGO funding, and the restoration work, has yet to be passed. Additionally, the upcoming elections may affect the bill's outcome. The shroud of uncertainty surrounding the Settlement's funding is not uncommon, and with governments citing increasingly tight budgets it is likely that future restoration projects will encounter these same problems. Thus, it is necessary to find alternative funding sources. While there are numerous alternative funding sources that may be available for large scale restoration projects, we believe that the most promising of these are federal and state government grants, recreation fee changes, and private sector donors (Poff, 2003).

Grants

There are numerous federal and state grant opportunities for restoration projects. Federal agencies, including the National Oceanic and Atmospheric Administration, United States Fish and Wildlife Service, and the Bureau of Land Management, have consistently awarded river restoration grants over the last decade. In 2007 and 2008, over $50 million in grants were awarded from these three agencies alone, with individual awards ranging from $5,000 to upwards of $5,000,000. While individual awards would represent only a small portion of the total cost of a project such as the San Joaquin River, they do significantly contribute to the overall success of a restoration program's funding and should not be ignored. Conveniently, almost all federal and state grants can be found online at http://www.grants.gov.

Recreation Fees

Additional funding sources may be available in the form of recreation fees, if properly set up and managed. Generally, recreation fees cover the operation expenses of the facility for which they are charged. If properly framed, an additional "restoration and maintenance fee" may help bolster funding for restoration and mitigation efforts.

In the National Forest System, recreationists predominantly participate in mechanized travel and viewing scenery (37.4%), camping, picnicking, and swimming (24.9%). To a lesser extent, recreationists participate in hiking (5.9%) and fishing (5.2%). Table 9 shows the percentage of people using National Forest System lands by activity type (Hammit, 1987). The recreation at Millerton Lake is consistent with these activities (USBR, 2004). As popularity of these activities and use of facilities increase, it may be necessary to limit use of the sites. In 1950, only 9 visitors floated or rafted down the Colorado River. By 1972, that number had increased to 16,432, causing the National Parks Service to limit future passage to 14,253 visitors per year (Hammit, 1987). If similar limitations on entry were imposed at recreation sites along the San Joaquin, the limited supply may create a demand, thus substantiating a fee for use, which may help generate funds for restoration as well as create jobs. Additionally, research indicates that recreationists not only desire participation in recreational activities, but seek specific settings in order to enjoy a special kind of recreation experience and subsequent benefits (USBR, 2004). Even land based activities are augmented by the presence of water (Thompson, 1999). It may therefore be appropriate to charge fees for the upkeep of recreation areas, which may create additional funds and/or further job demand.

Table 9. Percentage of people using National Forest System lands by activity type (Hammit, 1987).

Activity	Percent
Nature Studies	0.9
Other	5.8
Fishing	5.2
Resort Cabins	5.1
Hunting	5.5
Winter Sports	5.9
Hiking, Horseback, Water Travel	9.4
Camping, Picnicking, Swimming	24.9
Mechanized Travel & Viewing Scenery	37.4

However, user fees can be hard to apply to something that has traditionally been free. Generally, user fees should be charged on the cost for producing recreational opportunities (Loomis and Walsh, 1997). This makes sense for private entities so that they may cover costs, but public agencies may be expected to provide services at a discounted price or for free on public lands. Some view charges by public entities as "double taxation," as taxpayer dollars go to support public services (Reiling & Kotchen, 1996).

This may be surmounted by partnering with external organization, an option that has become more popular in providing recreation on public lands (Lapage, 1994). The idea is not entirely new. The United States Department of Agriculture (USDA) Forest Service contracts with private businesses to help maintain many of its recreation sites across the United States, and the National Parks Service has worked with private entities as concessionaires to manage gift shops, lodges and restaurants. For example, Fred Harvey Company has provided visitor services at the Grand Canyon National Park since the early 1900s, and continues to be a primary concessionaire on the South Rim today (Loomis and Walsh, 1997).

Partnering is not the perfect solution, however. Agency personnel may feel they will lose power and control over a particular area should private parties be brought in (Vask, Donnelly, and LaPage, 1995). Still, recreationists may feel more willing to pay for services provided by private parties who specialize in a service than they would be for services provided by the public entity if they perceive that the service should be provided for free where the public entity is concerned. Additionally, fees may be paid to the public entity for the right to do service on the public land, which may provide another funding source for restoration efforts. The private entity may also be more efficient in the performance of its duties since it will be able to specialize in that service, and may be better able to provide jobs for the area.

Private Donors

Historically, private donations to environmental causes, such as restoration cases, have been thought of as strictly personal contributions. These contributions are typically in the form of small financial donations or volunteer work with non-profit organizations. However, in reality private funding can be obtained from a variety of sources, including:

1. Private individuals
2. Family foundations
3. Corporate foundations
4. National foundations

Private individuals are simply people who have money to give. Family foundations are organizations are run by a family that considers formal requests for funding. Many of these foundations have a requirement to grant 5% of their corpus per annum to charitable causes in order to maintain their tax status.[11] Corporate foundations generally give funds in one of two ways: matching and direct gift. For matching funds programs, a corporation encourages its employees and/or members of the general public to donate money to one or more charitable endeavors; a contribution of equal value is then donated by the corporation. The second mechanism, direct gifts, tends to be a structured process. Typically this includes a formal application process during which applicants are asked to substantiate their need and demonstrate that their project is inline with the goals and stipulations of the corporation. Lastly, national foundations, such as the Ford Foundation or the Doris Duke Foundation, are funded by private family funds; however, unlike a family foundation, a national foundation is run by an organization and the family has relinquished control of the funds to a governing board, which considers requests for funding.

While money from several private individuals or small foundation donations could amass to larger amounts, it is more efficient to target those with the ability to make single, large donations (J. Deacon, personal communication, January 17, 2008). Thus, for large restoration projects, we recommend that large foundations,

[11] The "corpus" of any investment or endowment is the principle investment, not including interest earned.

particularly corporate foundations, are concentrated on as primary funding sources.

While obtaining corporate funding may have been difficult in the past, it has become much easier as the willingness of corporations to contribute to environmental causes has increased in recent years. For example, large companies, including Coca-Cola, Ben and Jerry's, and Patagonia, have all donated funds, in the form of matching funds or direct gifts, to environmental causes. One innovative example of bridging the private-public sector gap can be seen in the Corporate Wetlands Restoration Partnership (Coastal America, 2007). This unique program elicits the help of private organizations in the form of financial contributions or in-kind services to complete wetland restoration projects nationwide. The success of this program, which is reflective of the willingness of corporations to donate both their time and money, has been so great that it has given rise to the creation of the International Corporate Wetlands Restoration Project (International Corporate Wetlands Restoration Project, 2007).

Funding Guide

Currently, the process by which a private citizens or organizations (both for and not for profit) may assist in funding a public projects is ambiguous at best. In fact, for most of the United States, donation of private funds directly to public projects is legislatively prohibited. Currently, only the federal government and 6 states allow the donation of private funds to public coffers (these funds are typically referred to as "tax me more" funds); however, once donated these funds become part of the general coffers and may not be earmarked for specific projects ("Tax Me More Fund Program", 2007). As a result of these barriers and general ambiguity surrounding the process, we have created a funding guide to streamline the process by providing project participants with a general procedure for obtaining private funding for public projects (Figure 5).

The first step to obtaining privates funds for a government project is to determine whether, or not, a policy or procedure for doing so is already in place. If such a mechanism does exist, the project should simply follow the existing procedure. However, our research indicates that most states, including California, lack such a procedure. As result it is necessary to determine if the use of private funds is legislatively prohibited. In most states, legal barriers do exist, and often these legal barriers may not be bypassed. As such, for most projects it will be necessary to enact legislative changes. Failure to enact the necessary changes at this step in the process will prohibit use of private funding, and cause the project to rely on traditional funding sources.

Once any legal impediment has been surmounted, the project may proceed to the creation of a 501(c)3 (not-for-profit organization, or NPO). The creation of an NPO would mean that donations to the project through this organization would be tax deductible to donors, ultimately making it a more attractive funding option. Once collected, the NPO would be responsible for transferring the funds to the appropriate government entity for use on the specified project.

Lastly, we recommend the NPO develop a recognition standard for donors. Such recognition standards may include, but are not limited to:

- Signs along river reaches, parks, or other high visibility areas
- Educational kiosks or pamphlets in parks
- Displays in visitor centers

The development of a recognition standard would not only praise past contributions, but would encourage additional contributions as it would carry the added benefit of public recognition and positive association for donors.

Funding Guide

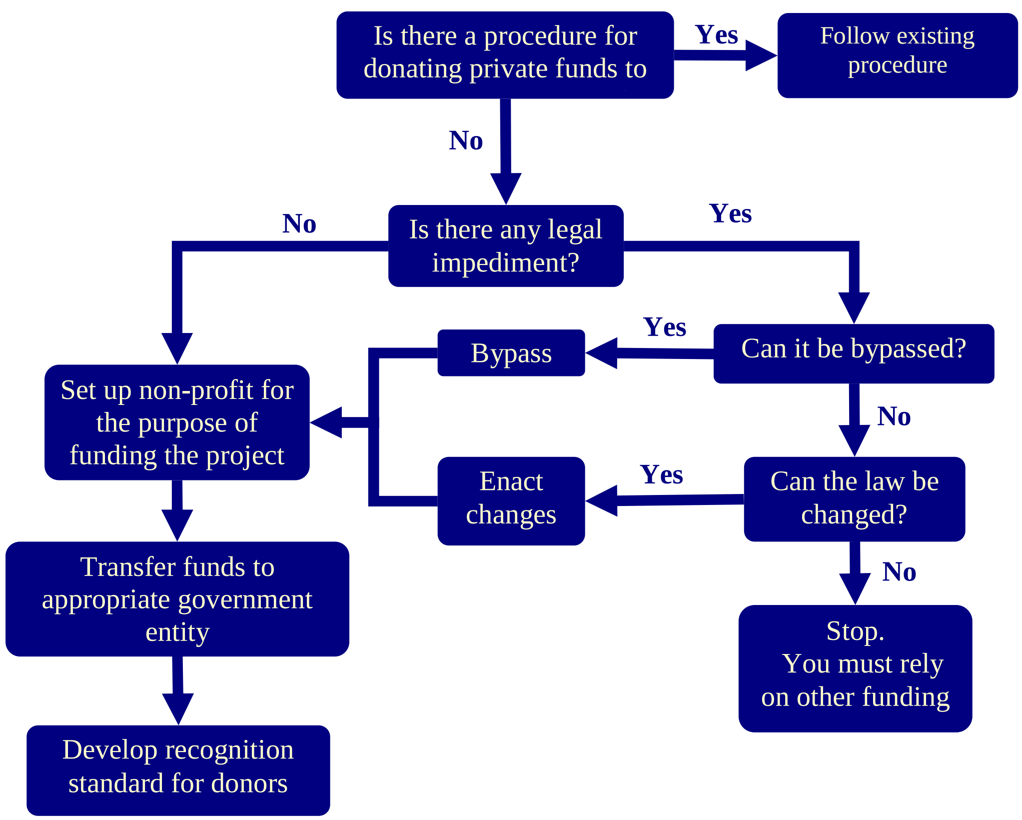

Figure 5. The procedure for obtaining private funding for government projects

Future Research

While analysis of the San Joaquin River Restoration Settlement can teach us much about the elements of restoration efforts and water allocation, as well as some of the processes to reach functional agreements. Applying these lessons to other cases in an effective manner will be complimented by future research efforts.

Restoration Research

Very little research has been conducted regarding Chinook salmon in the Central Valley region and even less so on the San Joaquin River. In fact, the majority of studies have focused on northern populations, specifically in Alaska, Oregon, Washington, and British Columbia. Consequently, the salmon restoration goals for the San Joaquin River Settlement were based upon these studies, and, given the heavily northern bias, such values may not be appropriate reference points. The habitats that Chinook salmon occupy in these studied areas are often quite different from conditions within the San Joaquin River, posing reservations as far as the appropriateness of the stated goals (McBain & Trush Inc., 2002). Maximum temperature goals, for example, were based on the literature, but conditions in tributaries of the San Joaquin River have exceeded these temperatures without resulting in the mortality of the salmon that run in these locations. While the Settlement provides a limited opportunity for research during the release of Interim Flows, the hydrographs and other conditions specified in the Settlement were based on work performed by the various experts hired by the Settling Parties, not site-specific research. This lack of site specific information demonstrates the need for additional research into the San Joaquin River and its ability to support Chinook salmon.

Climate Change

As shown in historical trends and model predictions, climate change impacts play an important role in water resource management (Jackson *et al.*, 2001; Pimentel *et al.*, 1997). This includes projects such as restoration plans which require certain flows for environmental purposes. Climate change models show increased variation in flow which makes flow predictions difficult for water managers (Jackson *et al.*, 2001). Decreased reliability in timing and amount of flow has impacts throughout the year to municipal and industrial water users, salmon, and, in areas such as the Central Valley, agricultural users. All categories of water users have corresponding negative economic impacts associated with climate change. Such impacts make climate change a vital consideration when creating restoration plans and establishing flow regimes. Regional models provide a good estimate for climate change effects and should be considered for the location in question.

Water supply mitigation

Throughout the Western United States water is allocated to a variety of users, including municipalities, industry, and environmental uses. As a result, obtaining the water necessary for restoration projects may be difficult and costly. In the case of the San Joaquin River, restoration efforts will result in water being reallocated from current users, decreasing the water supply many of these users rely upon for their livelihood. As such, it is necessary to develop water supply mitigation measures. Currently, assessment of potential water supply mitigation measures is underway, and environmental impacts from implementations will be studied during the NEPA/CEQA process. The primary options for mitigation water supply impacts are: (1) to obtain alternative water supplies in the form of increase exports from the Sacramento-San Joaquin Delta ("Delta"), water transfers from non-Friant users, and/or increased groundwater pumping or (2) decrease the water demand by shifting crop type and/or a reduction in planted acreage.

Given the current legal restrictions on Delta pumping, it is unlikely that additional supplies will be able to be obtained from this source with any kind of regularity. An alternative option to supplement water supplies may be the increased extraction of groundwater. Currently, the Friant service area and the east side of the San Joaquin Valley are in a state of overdraft, and further pumping may prove problematic (Nakagawa, 2004). However, this state of overdraft provides an option for aquifers to be recharged with recaptured and/or reclaimed water, as well as with excess water during flood years. Aside from the potential negative side effects associated with overdraft, an increase in groundwater pumping requires more energy, making it a more costly option (Jackson *et al.*, 2001). This would further increase costs to users. As science advances, cleaner, more cost effective energy sources may help alleviate these issues. Additionally, for areas in which groundwater is not already well-mapped and/or adjudicated, legal disputes may arise as a result of competing groundwater interests. As such, further study as to defining property rights to aquifers and other common resources will be necessary to develop effective methods for avoiding litigation and facilitating compromise in this area.

An additional option for increasing water supplies is to import it from other areas where water supplies are in surplus. This has long been a strategy in California (Quinn, 1968).[12] This may provide opportunity to tap into resources that may not be utilized in other, water rich regions. This solution would require either infrastructure such as canals and aqueducts or other transportation such as

[12] The development of Los Angeles was made possible by transferring water from the Owens Valley and other regions (Quinn, 1968). Water is also transported from Northern California to Southern California via the California Aqueduct.

trucking. Either form would require a great deal of energy to move the water from its source to its user, which would be costly and have impacts to the environment, making it a less desirable option.

Non-traditional sources may also help increase water supplies. Technological advances have made reclaimed gray-water an economically viable source for many functions, such as landscape irrigation and flushing of toilets. These functions require only secondary treatment of water (to non-potable quality). Irrigation of agriculture and other uses requiring tertiary treatment are generally not palatable to the public, and may require not only education campaigns, but legislative measures to allow for the use of properly treated reclaimed water. Presently, measures to encourage, or even require the use of reclaimed water for activities where use of secondarily treated water is allowable will help displace demand for fresh water sources. As reclaimed water cannot presently be used to irrigate crop lands, it may be more appropriate to focus these activities in urban areas, such as business court, parks and residential districts.

Even if supplies can be increased, decreasing demand for those supplies will further minimize impacts to users. A primary way to decrease demand for water is via conservation efforts. Encouraging use of low flow faucets and promoting water efficient landscaping have long been a trend in California (California Code of Regulations, 2007). These regulations even include requirements for the use of low flow toilets. Since conservation measures have long been in effect in these areas as a condition of water service contracts with Reclamation, further efforts alone may not yield much more relief on water demand. However, continued efforts coupled with studies illustrating monetary savings to be had as a result of efficient water use may further water conservations efforts, and ultimately reduce the demand for new freshwater supplies.

An additional method of reducing demand for water is a shift to more water efficient crops. This has already happened in some areas. Draw backs to this solution include that changing to these crops is capital intensive to the agricultural producers, and that less water intensive crops are also often less labor intensive, which has negative impacts to the communities dependent on agriculture for their wellbeing (United States Census Bureau, 2000). Detailed study of the primary and secondary impacts of these types of crop shifts as well as determination of measures to counter any negative effects associated with such shifts should be undertaken.

Regardless of efforts to avoid impacts, issues such as climate change and population growth may necessitate adaptation measures. Many measures that might be adopted to prevent impacts to users may also be applied to adapt to changes in water supplies. Further study of these measures may indicate whether implementation may be more effective as impacts materialize than to implement them in anticipation of impacts.

Economics

There is very little economic analysis of what kinds of economic effects may come of restoration efforts (Lui, Christiansen, and Jaksch, 1980). Prior studies, such as the NEA studies discussed in this paper, concentrate on effects of water reduction to agriculture and dependent industries based on drought years (NEA 2002a and b). What is missing is an analysis of impacts from allocating water to the restoration.

While studies regarding people's willingness to pay for access to large national parks, such as Yosemite, exist, little indicates how the public may value smaller areas, such as riverside parks that may be developed with restoration of the San Joaquin River. Fees for access to restored areas may be used to compensate current users for reductions in water supplies. Further studies regarding what revenues may be generated from recreation and what current users are willing to accept as compensation should be undertaken.

Additionally, with growing populations, real estate development could be affected by restoration of the San Joaquin River. It has been said that the three most important things in real estate are location, location and location. Proximity to the restored river and resulting recreation areas may affect real estate values in the area. Study will be necessary to isolate the effect of recreation areas on real estate values as well as the possible effects of flooding or other negative impacts of river proximity.

A full cost analysis of the litigation process involved in arriving at the Settlement should be undertaken to facilitate comparison to other methods of resolving conflicts of this type. Due to the sensitivity of the situation and the timing of our study, this information was not readily available. Future analysis of this information will be useful in comparing the cost effectiveness of each option.

Additionally, the existing hydro-power facility at Friant Dam may benefit from improved technologies. Implementation of low head hydro may allow increased power generation even if flows decrease (Paish, 2002). This power may be used beneficially to mitigate user impacts financially or just to displace less efficient power sources. Further investigation of costs and benefits of low head hydro use in this area will be needed.

Policy

In addition to the many scientific and economic considerations that remain to be examined, there are a significant number of policy options that require further research. From our research of the Settlement and other restoration examples, we have identified three main policy areas that require additional research, including: species protection, legal system reform, and legislative reform of private funding options.

Habitat Protection

In many restoration cases, the parties involved are attempting to revive a struggling population of salmon, steelhead, etc. In the case of the San Joaquin River the parties are attempting to restore what some consider to be an extinct population to an ecosystem that has not existed for over 60 years. While there are many viable salmon populations in northern rivers from which a stock population can be drawn, the survivability of these salmon in the San Joaquin River is uncertain. As such, it may be a more effective strategy to look at multiple indicators when assessing the potential of proposed restoration projects rather than focusing on a single species (Lucas *et al.*, 2002). In many instances, such as the Colorado River restoration, restoration participants have actively pursued a plan that incorporates ecosystem and/or multispecies management (Cohn, 2001).

Yet much of the guiding legislation regarding the protection of species stems from the Endangered Species Act, which is designed to create protection plans for a single specie. In these instances the legal policy dictates that the greater ecosystem function, including impacts to the other species it may support, are secondary to the survival of the specie in question (Baron *et al.*, 2002). This policy approach creates a disparity in conservation and environmental protection values (Baron *et al.*, 2002). Furthermore, many have argued that the standard approach to specie restoration and/or protection does not take into consideration the specie specific impacts that may result from natural adaptation and climate change; opting instead to focus on the restoration of historical conditions (Baron *et al.*, 2002).

Subsequently, we believe that research should be conducted into reshaping our environmental legislation to provide habitat or ecosystem protection, rather than focusing on single specie protection. In order to bring about this kind of change, we believe that a set of restoration or protection standards, by which the success of a project could be assessed, would need to be developed. Furthermore, we believe that these standards would most likely need to be adapted to the uniqueness of each case, and that no single solution will exist.

Changing the Legal System

In creating our negotiation template, we sought to move away from the costly and time consuming litigation process and into a more collaborative negotiation process. While our research clearly supports this recommendation, we have no legal imperative to require participants of water reallocation negotiations to pursue negotiations over litigation. As such, we recommend that additional research be conducted into how to best to shape environmental regulations to require collaborative negotiations as part of the process.

Preliminary research into this topic, suggests that there is a historical legal precedent for requiring mediation. In the United States, 17 states require some form of alternative dispute resolution, typically in the form of negotiations, for a variety of legal conflicts (McDowell and Sussman, 1996). Most notably, California law requires divorcing couples to attend mandatory mediation in an effort to reach a more amicable settlement. It is believed that this saves both time and money for participants and shortens the legal process. When examining restoration cases, we previously discussed that litigation often resulted in negotiations. Thus, by applying the same legal standard to environmental policy, we find the potential to save substantial time and millions of dollars in each case (McDowell and Sussman, 1996).

Furthermore, we have acknowledged that not all restoration cases may be solved through negotiations, and that litigation may still be necessary in some cases. As such, we recommend that research be conduct to determine the viability of creating statewide environmental and/or water court system, particularly in the western United States. Much of the time spent in litigation is essentially spent educating the courts on the legal and scientific background of the environmental policy and restoration case at hand. We believe that much of the time spent in this process could potentially be avoided by dedicating several judges statewide for this purpose. By having judges who are well-versed in the legal and scientific aspects that are common among restoration cases, costly delays could potentially be avoided. While specialty courts, such as family law courts, have existed for decades, the question of environmental courts is a relatively new for most states, but not unheard of concept. Most notably, the state of Colorado created a water court system in the 1960s (The Water Information Program, 2008). This court is dedicated to resolving disputes surrounding a complicated system of water rights. While there is not sufficient data to draw any quantitative conclusions about the efficacy of this system, a qualitative assessment indicates that it has been a successful system, and that other states may benefit from a similar arrangement.

Funding Reform

Currently, a major stumbling block for large-scale restoration cases, including the San Joaquin River, is the ability to obtain sufficient funding. Through the creation of our funding guide we have detailed a variety of funding sources aside from budget allocations and bond measures which may be useful. Of these funding sources, we believe that private donations could potentially have the greatest impact; however, with the exception of six states, there is no means by which private funds may be transferred to public coffers. Additionally, for those states that do allow the donation of private funds, and for the federal government, all private donations (typically referred to as "tax me more" funds) are simply added to the general budget and cannot be earmarked for specific projects (Tax Me More Fund Program, 2007). As such, we recommend that research be conducted into how best to reshape each state's legislation to allow for private funds to not only be donated to public coffers, but be earmarked for specific projects.

Conclusions

After nearly 20 years of litigation, the San Joaquin River Settlement was reached in 2006. This historical settlement, boldly attempts to restore a river that has been dry for decades and salmon population that has not existed since the 1950s. The management plan created for the San Joaquin River makes every effort to provide the most suitable salmon habitat, including a variety of channel modifications and a seasonal flow regime. However, there are several questions surrounding the survivability of salmon in the San Joaquin River. In particular, water quality, temperature, and even climate change are predicted to have significant impacts on the overall survival of salmon in all life stages. Thus, even with a fully restored habitat, climate change and water quality concerns may preclude salmon from thriving in the San Joaquin River. The best mechanisms by which to combat these concerns will require significant additional research, some of which is on-going, regarding the San Joaquin River and regional climate change.

Additionally, if the San Joaquin River restoration is to be successful, there needs to be adequate funding in order to carry out the necessary channel modifications. Currently, the most significant funding source, a federal spending bill, has been stalled in congress. As such we have created a funding guide that details a variety of alternative funding sources, including private donations, that may be acquired by project participants. While private funding could potentially be obtained to cover these costs, and eliminate the need for federal spending, California, like a majority of the United States, does not allow private funds to be donated to public coffers. As such, we recommend that research into financial policy reform be conducted.

As a result of our research into the San Joaquin River Settlement and numerous other restoration cases, we have concluded that participation in a collaborative negotiation process, rather than litigation, provides numerous benefits to the parties involved. In particular, negotiation has the potential to save significant amounts of time and money. Furthermore, by avoiding litigation participants are not restricted to the legislative language, and are able to consider a broader range of restoration and stakeholder requirements that may have otherwise been precluded from the process. Thus, we have developed a negotiation template, which details a 3-step process which is specific in direction, yet flexible in application so that it may be applied to a variety of restoration cases. These three steps include the identification of process participants, restoration and stakeholder requirements, as well as the utilization of working groups to create a restoration plan.

Lastly, restoration negotiations and implementations are unnecessarily complicated and restricted by federal and state policies. As such, significant policy reform is needed. We recommend that environmental policy be reshaped to include habitat and ecosystem protection, rather than single specie protection. Additionally, we recommend legislation be adopted to require a mandatory negotiation process, and allow litigation only as a last resort.

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APPENDICES

Appendix A: Negotiation Template

Negotiation Template

(See the glossary below for definitions of the terms in bold.)

Step 1. Determine Participants

a. **Stakeholders** will identify and appoint representatives to comprise the **Plan Development Team**; which will:
    i. Determine a restoration plan development timeline
    ii. Create a binding **Memorandum of Understanding** with each stakeholder group agreeing to:
        - Engage actively in the restoration plan development and implementation processes
        - Abide by the restoration requirements determined by the **Advisory Panel** (Step 2)
        - Adhere to the finalized plan (Step 3)
        - Share the costs of the project, as defined by the project participants to include any limitations of financial contributions from each participant

b. Plan Development Team will identify the **outside parties**, including at least one **mediator**, to makeup the **Advisory Panel** which will:
    i. Collectively determine the restoration and stakeholder requirements that must be addressed in the restoration plan (Step 2)
    ii. Oversee the working groups and plan development (Step 3)

Step 2. Gather and Analyze Data

a. Advisory Panel will identify and assess the **restoration requirements** which must include, but are not limited to:
    i. **Flow** (necessary for migration and growth/development)
    ii. **Temperature**
    iii. **Food Availability**
    iv. **Geomorphology**
    v. **Fish Passage**
    vi. **Climate Change**

b. Advisory Panel will identify and assess the **stakeholder requirements** and potential impacts; which must include, but are not limited to:
    i. **Water Demand**
    ii. **Socioeconomic Impacts** (local and regional)

c. Advisory Panel will collectively determine the requirements that must be addressed and/or met by the restoration plan

d. Advisory Panel will report its findings (Step 2c) to the Plan Development Team

Step 3. Creation and Approval of a Restoration Plan

a. **Working Groups** will be created, which will:
   i. Meet simultaneously
   ii. Develop a basic restoration plan, including:
      - Restoration processes to meet the restoration requirements (Step 2), utilizing **modifiable planning** techniques
      - **Mitigation strategies**
      - **Timeline**, including **reassessment points**
      - Funding options

b. Working groups will present plan options to the Plan Development Team and Advisory Panel

c. Plan Development Team and Advisory Panel will create a finalized plan, including a timeline, by either:
   i. Voting for the best restoration plan presented, or;
   ii. Creating a hybrid restoration plan from those presented

d. Advisory Panel will assess the created restoration plan to ensure the requirements (Step 2) are met. If approved, the restoration plan will proceed to the implementation process. If not approved, the Advisory Panel will present a report of the plan deficiencies to the Plan Development Team, which will return to Step 3c.

Glossary

Advisory Panel: an advisory group consisting of outside parties who determines the restoration requirements through site assessment

Memorandum of Understanding: a binding document that must be signed by all members or represented groups outlining the terms and details of the project, including any funding responsibilities for each participant

Outside Parties: Non-vested groups or individuals contracted to establish restoration and stakeholder requirements, as well as oversee all negotiation processes. The outside parties are the consultants and mediators who will make up the **Advisory Panel**.

- **Consultants**: The consultants may be either individuals or consulting firms. The consultants should experts in the fields of fisheries management, hydrology, and economics, to name a few.
- **Mediators**: At least on professionally mediator should be hired to oversee the process to avoid and or reduce conflicts.

Plan Development Team: a group of stakeholder representatives tasked with designing and selecting the optimal restoration plan

- All stakeholders should be represented

Restoration Plan Elements:

Restoration Requirements[13]: the set of biotic and abiotic conditions needed for survival of target species

- **Flow:** determine flow necessary for spawning conditions, growth/development, and migratory needs of restoration species
- **Temperature:** determine the water temperature ranges, including the range of decline, for each life stage of the target specie
- **Food Availability:** examination of available food sources with considerations of the abundance of food and inter-specie competition for food
- **Geomorphology:** past and current channel structure, makeup (substrate, hydrology, etc.), and function, as well as, restoration goals
- **Fish Passage:** examination of the migratory capabilities and potential migration barriers (including temperature, flow, physical structures, etc.) of the target species
- **Climate Change:** analysis and consideration of climatic trends, when possible, to aid in decision-making regarding restoration goals

[13] This is by no means a complete list of restoration requirements that must be considered. This is meant to represent a list of basic considerations.

Stakeholder Requirements: the needs of and potential impacts to stakeholders, including:

- **Water Demand:** consideration of the individual and total water demand for users, including the volume of water needed, as well as the economic impacts from the potential loss of water or shift to new water sources
- **Socioeconomic:** economic analysis of the potential impacts on related industries such as agriculture, recreation, hydropower, etc., including an assessment of potential unemployment impacts

Modifiable Planning: a management approach that allows users to adapt and respond to new information, emerging concerns, etc. in order to increase the likelihood of a successfully meeting the agreed upon goals of the restoration project (also known as adaptive management)

Mitigation: the offset of or compensation for impacts to stakeholders, other species, etc.

Reassessment points: periodic reassessment of the implementation process in order to examine the progress toward achieving the project goals
Timeline: the perceived timeline goals for the project which should be adapted to coincide with findings of reassessment points

Working Groups: smaller groups created from the members of the Plan Development Team. Each group should consist of stakeholder representatives, consultants, and at least one mediator

- The actual number of stakeholder representatives and consultants should be determined by the Plan Development Team and the Advisory Panel.

Appendix B: Funding Guide

The following flowchart is meant to guide restoration project participants through the process of obtaining private funding.