APPENDIX C

Science & Monitoring Plan

August 2, 2009

Introduction

This Science & Monitoring Plan (Plan) has been prepared as an accompaniment to the proposed 2-Gates Fish Protection Demonstration Project (2-Gates Project and/or Project) in California's Sacramento – San Joaquin River Delta (Delta). The Plan describes a suite of scientific investigations designed to assess the effectiveness of the Project in achieving its delta smelt protection objectives, while improving understanding of the delta smelt responses to habitat conditions that underlie Project design. The Plan also describes monitoring efforts essential for assessing Project effects on other Delta species, particularly those listed under the federal and California Endangered Species acts.

Background

PROJECT PURPOSE

The 2-Gates Project proposes an alternative management strategy to achieve protection of the delta smelt (*Hypomesus transpacificus*). The Central Valley Project (CVP) and State Water Project (SWP) operate under the Operations and Criteria Plan (OCAP) and other water rights and water quality requirements. These operations comply with the Reasonable and Prudent Alternatives (RPAs) in the recent Biological Opinions (BOs) for the OCAP from the U.S. Fish and Wildlife Service (FWS 2008) and National Marine Fisheries Service (NMFS 2009). The RPAs include actions to limit reverse flows in Old and Middle Rivers to reduce entrainment of fish at the CVP and SWP export facilities.

The Project seeks to provide equal or improved protection to delta smelt (reduced entrainment at the export pumps) with higher than the minimum allowed water exports described in the OCAP BO RPAs while operating within the other water management requirement (D-1641). In particular, the Project is intended to demonstrate that operable barriers, strategically placed in the central Delta and managed in conjunction with some restrictions on OMR negative flows, can provide equal or greater protection for delta smelt than restrictions on OMR negative flows alone. The proposed 2-Gates Project is designed as a demonstration project to test this premise and to improve understanding of the key physical and biological processes needed to restore a sustainable ecosystem.

The 2-Gates Project proposes to install and operate temporary, removable gates in two channels in the central Delta at Old River and Connection Slough (Figure 1). The gates will be used to manipulate flows and key water quality components of delta smelt habitat in order to reduce entrainment of delta smelt at the export facilities.

PROJECT GOALS AND OBJECTIVES

The 2-Gates Project goals are:

- Goal 1 (overarching goal) - To provide equal or improved protection of delta smelt with higher than the minimum allowed water exports described in the OCAP BO RPAs while operating within the other water management requirements.

    - Reduce adult delta smelt entrainment in the export facilities by operating the gates to manipulate the turbidity flux in the central and western Delta to create a zone of lower turbidity in advance of the south Delta export facilities.

- Reduce juvenile delta smelt entrainment in the facilities by transporting that portion of the population in the south and central Delta into the western Delta, through gate operations that enhance dispersive mixing.

- Goal 2 – To minimize adverse effects to other listed species or other resources in the Delta, including Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawaytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*), North American green sturgeon (*Acipenser medirostris*), and longfin smelt (*Spirinchus thaleichthys*).

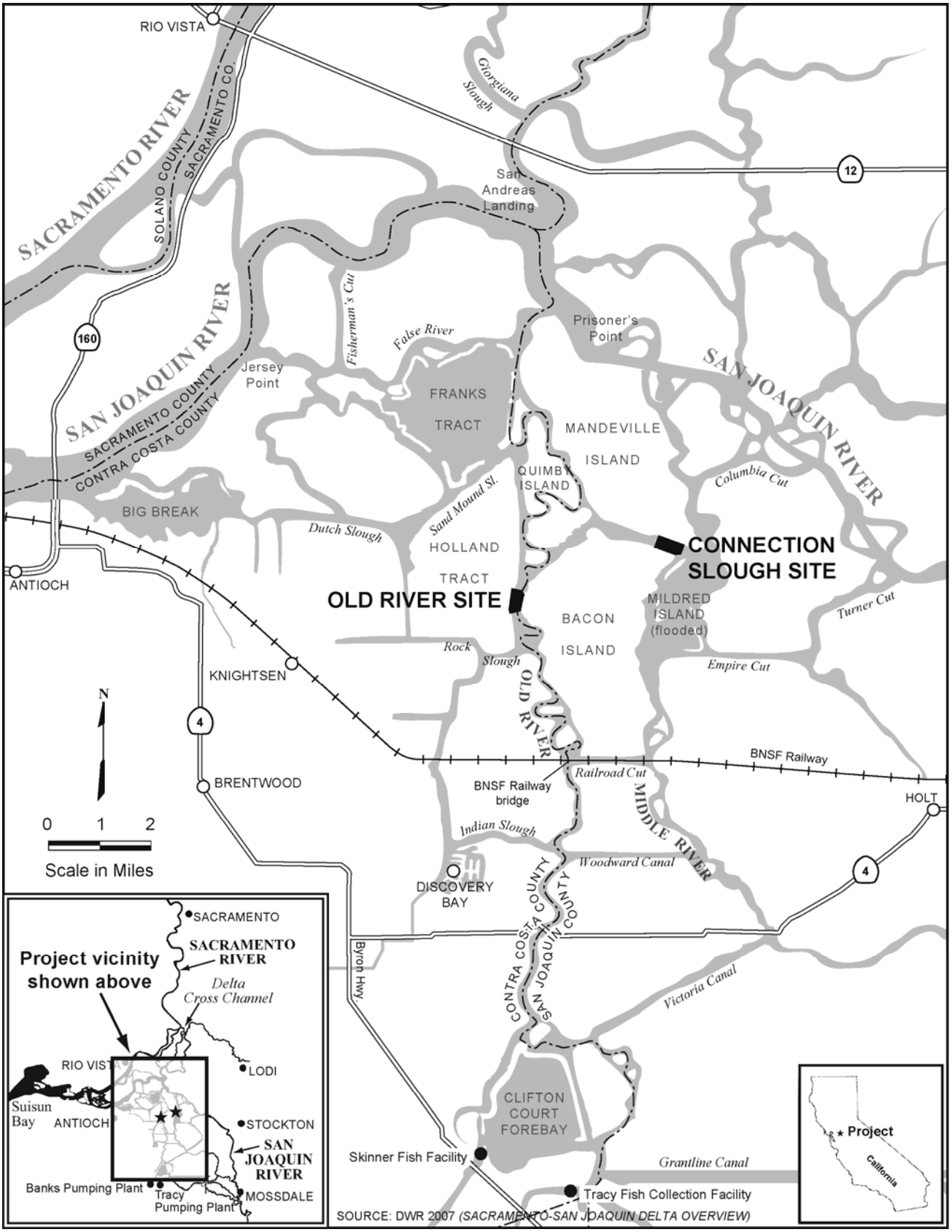

Figure 1. Regional location of 2-Gates Project

ADAPTIVE MANAGEMENT FRAMEWORK

A Project adaptive management framework has been developed consistent with Project goals to test key hypotheses and monitor effects in order to refine understanding, modify hypotheses and improve operations (Figure 2). The concept of this project was developed through extensive modeling of hydrodynamic conditions, turbidity, and the effects on biological models. The Project is designed as an experiment to test hypotheses regarding the relationship of flows, water quality (turbidity) and delta smelt behavior and distribution. Tests would be conducted through iterative field operations. The multi-parameter Science & Monitoring Plan provides information for hypothesis testing and adaptive management. While it is the expectation that the experiment will demonstrate and provide higher than the minimum allowed water exports described in the OCAP BO RPAs, the experiment will operate fully within the flow requirements of the RPAs for the OCAP BO and other water management requirements.

The hypotheses testing and monitoring program described in this Plan will provide data to:

- Guide efficient operation of the Project (triggering conditions for gate operations).
- Assess Project effects on changes in local flow, turbidity, and salinity under different scenarios.
- Allow verification and testing of the models for future evaluation of operational changes and Delta improvements.
- Improve understanding of delta smelt biology and behavior in the Delta.

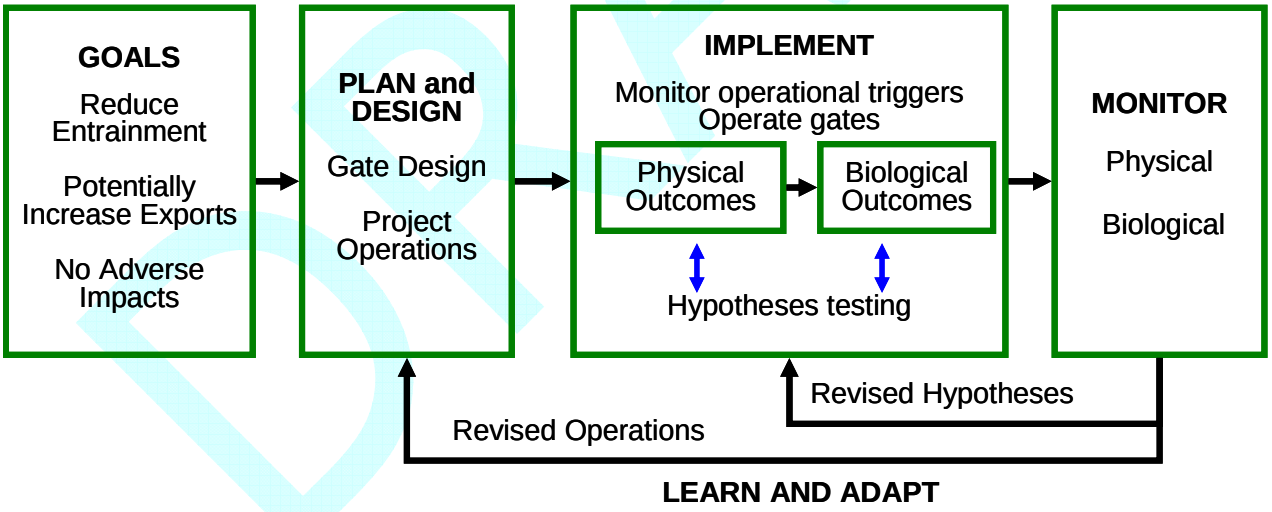

Figure 2. Adaptive management framework for the 2-Gates Fish Protection Demonstration Project

As stated above, the overarching goal of the proposed 2-Gates Project is to enhance protection of delta smelt (i.e. reduce entrainment by the State Water Project (SWP) and Central Valley Project (CVP) water export facilities) while maintaining water supply benefits. The 2-Gates Project is designed to use operable barriers in Old River and Connection Slough in conjunction with restriction of lower negative Old and Middle river (OMR) flows to provide equal or greater protection for delta smelt than the application of OMR negative flow restrictions alone.

The 2-Gates Project will install and operate removable gates in two key channels in the central Delta (Old River and Connection Slough) in order to control flows and thereby help reduce entrainment of delta smelt at the export facilities without adversely affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley Steelhead, North American green sturgeon and longfin smelt The 2-Gates Project is designed to have the flexibility to be operated to test alternative water management and fish protection strategies. The 2-Gates Project includes a monitoring program, outlined in this Monitoring Plan, to evaluate the effectiveness of the gates, provide information for timely gate operation decisions and to acquire related information on a broad range of aquatic ecosystem effects.

Figure 3 presents a conceptual model of how the Project would affect OMR flows and turbidity, which in turn would affect delta smelt and other species.

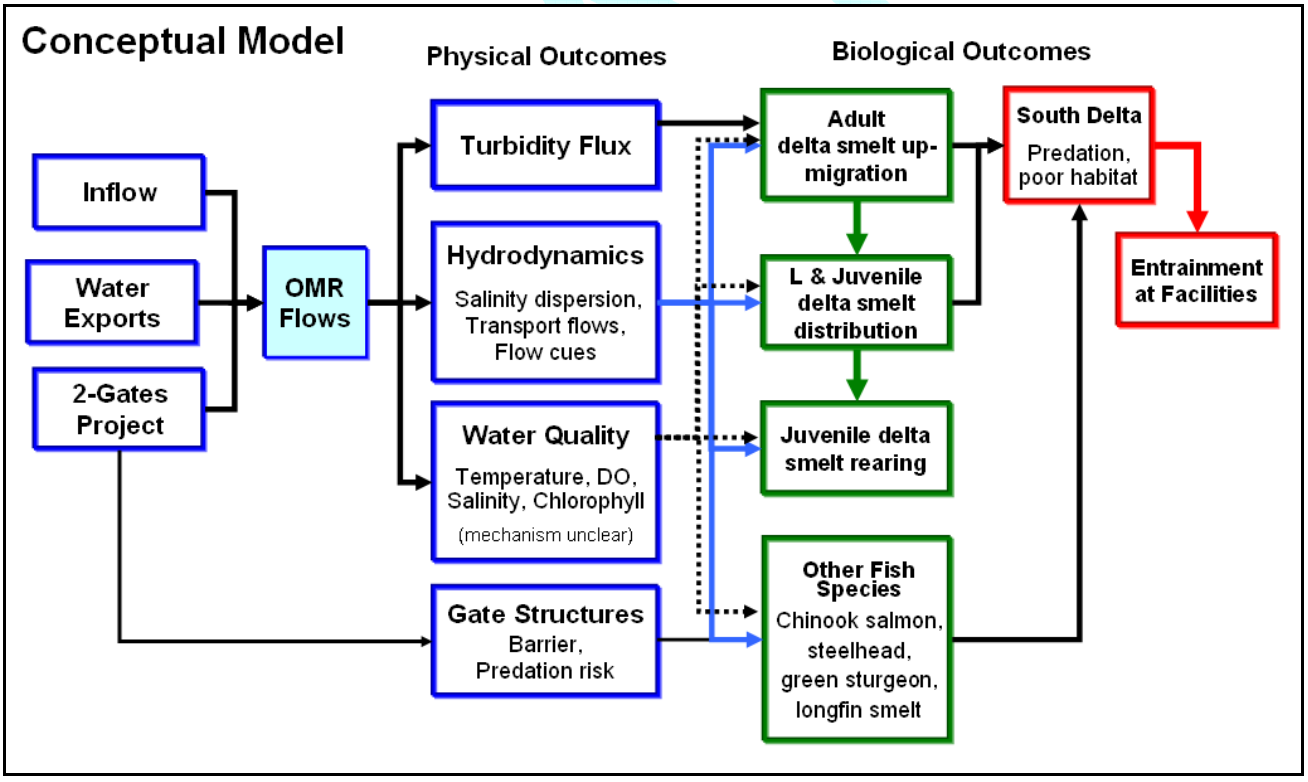

Figure 3. Conceptual Model of 2-Gates Project

The operable gates will be used to adjust OMR flows in order to affect turbidity flux. This in turn is expected to affect the distribution of pre-spawning adult delta smelt migrating into the Delta and

their subsequent progeny, and consequently their risk of entrainment. The 2-Gates Project may also affect other protected fish species, through changes in hydrodynamics (e.g. flow cues for outmigrating smolts), turbidity (upstream migrating longfin smelt), and the physical gate structures (e.g. movement barrier when closed, increased predation risk from non-native fishes).

SCIENCE & MONITORING FRAMEWORK

The 2-Gates Project is by design a limited-term demonstration project proposed for up to a five year trial period. Integral to the Project is a comprehensive monitoring and special studies program that serves multiple roles:

- To provide information for efficient Project gate operation decisions.
- To provide data to test hypotheses which should reduce uncertainties regarding delta smelt responses to Project gate operations, behavior, preferred habitat, and life histories.
- To provide data to allow verification and testing of the models for future evaluation of Project operational changes.
- To provide data on the changes in flow, turbidity and other variables to evaluate the physical effects of the Project operations.
- To provide data to evaluate potential Project effects on other species of interest, such as increased predation risk at gate structures, or impediments to movement of salmonids and sturgeon through the Delta.
- To provide guidance for adaptive modifications of project operations and structures.

In order to understand the effects of 2-Gates Project operations on hydrodynamic processes, a network of fixed-site sampling stations would be placed at key locations throughout the Delta. These stations either coincide with or will augment the network of existing Delta monitoring stations. These stations would monitor time-series of various constituents such as flow, temperature, salt, turbidity, and chlorophyll (Chl-a) at these locations, would also measure the flux (or load) of these constituents. By co-locating constituent and discharge measurements and making these flux calculations, information will be gained as to how constituents vary in time at key locations in response to 2-Gate operations, and a record will be gained of how 2-Gates operations alter exchanges between regions in the Delta through these key channels.

These above studies will be part of the larger monitoring and scientific investigations program described in this plan, which is intended to provide a comprehensive picture of Project effects and effectiveness, particularly in regard to possible impacts on other listed species. It is expected that the overall Plan will be further developed in collaboration with regulatory agency representatives (e.g. NMFS and USFWS) and system monitoring entities, such as the Interagency Ecological Program (IEP). It is expected that the ultimate comprehensive science and monitoring program will include:

- Identification of key potential Project impacts on other species that will be addressed by the Monitoring Program.

- Expansion of acoustic tag based investigations of the survival and pathways of juvenile salmon emigrating through the Delta to address occurrence and survival in areas influenced by the Project.

- Expansion of the principal existing adult delta smelt abundance and distribution monitoring effort, IEP's Spring Kodiak Trawl Survey, to cover the full season of Project adult operations and to intensify sampling in the area of the Delta affected by the Project.

- Temporal and geographical intensification of the principal juvenile delta smelt abundance and distribution monitoring effort, IEP's 20mm Survey, to better assess juvenile smelt responses to Project operations.

- New large-fish acoustic camera monitoring at gate locations to assess gate effects on adult sturgeon and salmon migration, and to assess the abundance and behavior of fish predators in the vicinity of the gates.

- Compilation of data from all relevant existing, expanded, and new monitoring programs, such that it is easily available for use by Project staff and collaborators.

- Establishment of data synthesis and information dissemination infrastructures to feed adaptive management decision making regarding Project operations. It is expected that existing decision making bodies, such as the Smelt Working Group and Water Operations Management Team will be the principle recipients of monitoring information related to the Project.

Because the Delta is complex and always changing, controlled experiments are generally not possible. It is the intent to use the full body of information gathered through hydrodynamic modeling, and Project monitoring, and field testing programs to draw inferences and conclusions about Project effects and effectiveness and expand our knowledge about how the Delta works.

PROJECT CONCEPTUAL FOUNDATION AND HYPOTHESES

Conceptual Foundation

The 2-Gates Project design and operations are based on our conceptual understanding of patterns and relationships of Delta hydrodynamics, fluxes in water quality parameters, delta smelt life cycle and behavioral responses to flow and water quality cues at different life stages, and entrainment at the export facilities.

ENTRAINMENT OF ADULT DELTA SMELT

Entrainment in water diversions and exports has been highlighted as one of several factors in the decline of delta smelt (FWS 2008)[1]. Large numbers of fish including delta smelt are entrained at the CVP and SWP export facilities, as indicated by salvage numbers (Brown et al. 1996). Delta smelt

[1] Although it is beyond the scope of this Project, it is worth noting that other factors, alone or in combination, likely contribute to the decline of delta smelt. Abundances of delta smelt and several other pelagic species have declined significantly since 2000 (Sommer et al. 2007, Feyrer et al. 2007). The Pelagic Organism Decline (POD) outlined several possible mechanisms including: (1) prior fish abundance, which posits that continued low abundance of adults leads to reduced juvenile production (i.e., stock-recruit effects); (2) habitat, which posits that estuarine water quality variables, disease, and toxic algal blooms in the estuary affect survival and reproduction; (3) top-down effects, which posits that predation and water project entrainment affect mortality rates; and (4) bottom-up effects, which posits that food web interactions affect survival and reproduction (Sommer et al. 2007, Baxter et al. 2008).

occur in salvage in December-March as adults, and May-June as juveniles (>20 mm) (Kimmerer 2008). Substantial numbers of larvae are presumed entrained as well (Bennett 2005, Kimmerer 2008), although levels of larval entrainment are unknown because the fish screening facilities cannot effectively sample fish smaller than 20mm (Baxter et al. 2008).

Entrainment risk for delta smelt depends on their geographic distribution, with the greatest risk being in close proximity to the south Delta and water export facilities (Kimmerer 2008). The movement and distribution of adult delta smelt is affected by a variety of factors. These include Delta inflow, tidal flows, pumping at CVP and SWP export facilities, complex channel configurations and connections; along with salinity, temperature, and turbidity gradients (Grimaldo et al. in press). The southward movement of water influenced by pumping at the CVP and SWP water export facilities, increases vulnerability to entrainment (FWS 2008). A significant inverse relationship has been observed between net Old and Middle River flow and winter salvage of delta smelt (P. Smith 2009) and other pelagic fishes (Grimaldo et al. in press) at the SWP and CVP. The general pattern is that pelagic species entrainment (salvage) is low when Old and Middle Rivers flow are positive (Baxter et al. 2008). However, the biological mechanisms for these relationships are not well understood.

The current regulatory framework to protect delta smelt is focused largely on the reduction of exports in order to restrict negative OMR flows (FWS 2008, NMFS 2009). However, because other factors (e.g. turbidity) may influence delta smelt distribution and movement, understanding the relationships among hydrodynamics, water quality and delta smelt behavior may reveal another mechanism for managing entrainment loss (Grimaldo et al. in press).

TURBIDITY RELATIONSHIPS

Recent evidence suggests low water transparency is a key characteristic of delta smelt habitat (Bennett 2005, Feyrer et al. 2007, and Nobriga et al. 2008). This relationship has been observed for adults (Spring Kodiak Trawl data, Bennett 2009) and juveniles (20 mm survey, Bennett 2009; Fall Midwater Trawl, Feyrer et al. 2007). The mechanisms causing the negative associations between water clarity and delta smelt occurrences are unknown. One hypothesis is that turbidity may function as a trigger for upstream migration by adult delta smelt (Grimaldo et al. in press). Another hypothesis, based on studies at the Skinner Facility delta smelt hatchery, is that turbidity is necessary to enable larval smelt to detect their food (Joan Lindberg, pers. comm., Nobriga et al. 2008) hypothesized that higher water clarity increases predation risk for delta smelt and other fishes typically associated with turbid water. The 2-Gates Project focuses on the correlation between turbidity, flows, and adult delta smelt distribution and entrainment.

Upstream migration of pre-spawning adults appears to be triggered by abrupt changes in flow and turbidity associated with the first large precipitation event of the season in the basin (“first flush”) (Grimaldo et al. in press). Review of salvage trends found a correlation in several years between elevated turbidity, high exports, and increased salvage (FWS 2008).

It appears that turbidity in excess of 12-15 NTU is correlated with and may be a functional cue for the annual spawning migration by delta smelt from Suisun Bay to the Delta. We hypothesize that the distribution pattern of turbidity will influence the distribution of pre-spawning adult delta smelt in the central and western Delta. The adult distribution presumably may affect the location of spawning and the spatial distribution of their progeny. This would affect the entrainment risk of larvae and juveniles in the Delta until they move downstream to rearing habitat near Suisun Bay.

The location and structure of the turbidity field is affected by freshwater inflow, tidal flows and other Delta hydrodynamics, as revealed by recent hydrodynamic modeling of turbidity and flow conditions with and without 2-Gates Project operations. During high river flow periods, turbidity enters the western Delta from the Sacramento River and the central Delta via Georgiana Slough, and then enters the south Delta through Old River and Middle Rivers. Inflow from the San Joaquin River also contributes a pulse of turbidity, although the timing typically lags from the Sacramento River. When these two water bodies meet, they form a turbidity "bridge" from the central and west Delta to the south Delta (Figure 4 - Historic Condition). This continuous high turbidity zone allows smelt to move south toward the pumps. This pattern is illustrated in modeling of historic conditions and conditions under OCAP and OCAP with 2-Gates (Figures 4 and 6). Under historic conditions, turbidity levels exceed 15 NTU throughout the central and south Delta (Figure 4). High turbidity conditions (>35 NTU) exist continuously along the Old River channel (approximately 17 miles) from Franks Tract in the central Delta to the export intake at Clifton Court Forebay in the south Delta (Figure 5).

Water management actions (operation of the SWP and CVP export pumps) consistent with the OCAP RPA actions (FWS 2008) prevent or delay the "turbidity bridge" from forming in the south Delta channels by reducing negative OMR flows. Hydrodynamic modeling of turbidity distributions under OMR flow requirements indicates a reduction in turbidity in the central Delta (Figure 5), and along the Old River channel (Figure 4), although levels may still be above 15 NTU. The proposed gates, when operated in conjunction with OMR flow requirements, may provide greater control and more flexibility in keeping turbidity away from the pumps (Figures 4 and 6). A low turbidity region (< 15 NTU) is maintained for approximately 6 miles of Old River with gate operations in conjunction with OMR flow requirements (Figure 6).

Thus, entrainment reduction may be accomplished by controlling the distribution and continuity of turbidity and salinity conditions that appear to be a component of pre-spawning, adult delta smelt habitat. Preliminary results from the newly developed adult delta smelt behavioral model applications suggest that the distribution and density of adults could be modified to reduce the potential for entrainment at the CVP and SWP facilities through the combination of pumping restrictions (FWS 2008) and the Project gate operations (Figure 4). Keeping pre-spawning adult delta smelt substantially out of the south Delta may also reduce potential entrainment of their progeny (larval and juvenile life stages).

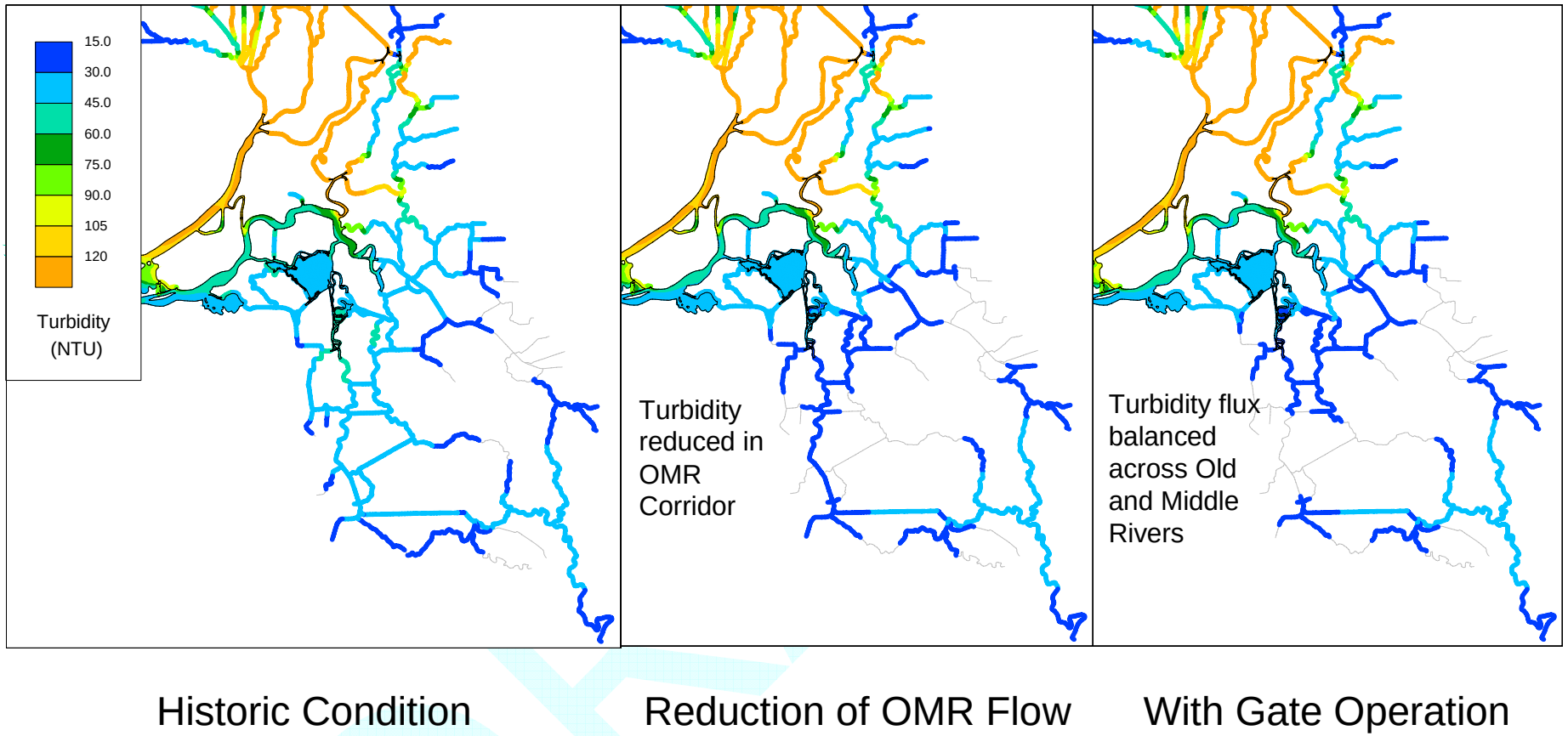

Figure 4. Operation of 2-Gates Project to Reduce Adult Delta Smelt Entrainment by Balancing Turbidity Flux along Old and Middle Rivers.

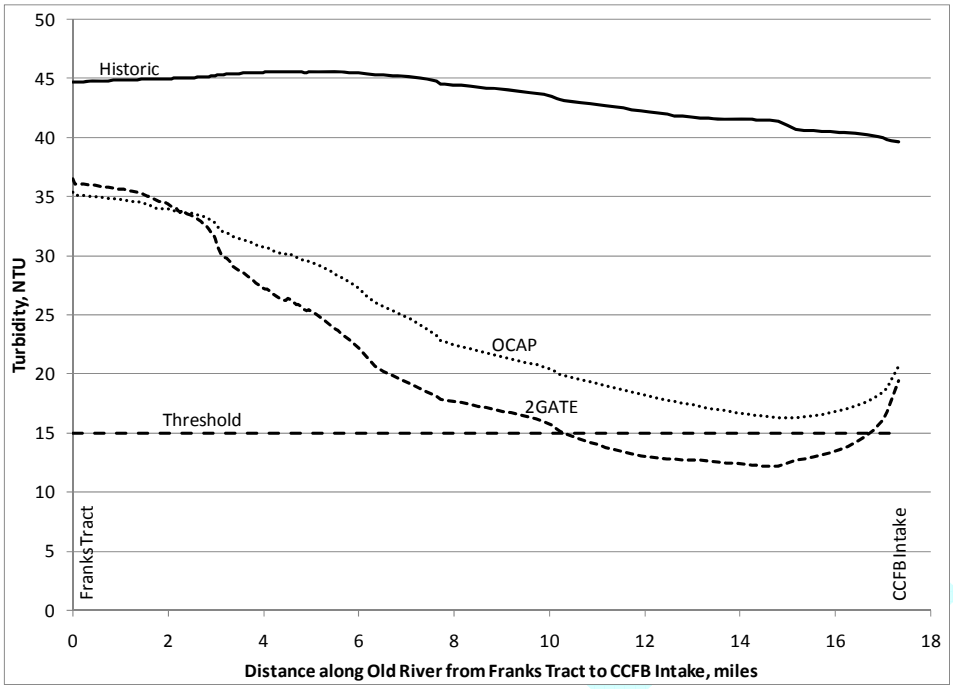

Figure 5. Longitudinal Profile of Modeled Turbidity along Old River from Franks Tract to Clifton Court Forebay

DISPERSIVE MIXING

The Project gates may also be operated to enhance the transport of larval and juvenile delta smelt and organic carbon towards the western Delta and to reduce salinities at the export facilities. Larval delta smelt presumably drift with the predominant tidal currents, perhaps exercising some control through vertical migrations in the water column (Bennett 2005). They move downstream until they reach favorable rearing habitat, typically in the Suisun Bay region. Hydrodynamic modeling suggests that opening the gates on ebb tides can enhance mixing of water in the central Delta and can disperse flows seaward toward the western Delta (Figure 6). This has the potential to benefit delta smelt by (1) dispersing larvae and juveniles which are hatched in the central Delta away from the export pumps, thereby reducing entrainment risk of those fish, and (2) enhancing transport of central Delta juveniles westward toward rearing habitat near Suisun Bay. Particle tracking modeling of different water management scenarios suggest that entrainment of juveniles could be potentially reduced except for a very small percentage of those fish that hatch in the Mokelumne Rivers, Georgiana Slough or on the Sacramento River north of the Georgiana Slough confluence (Figure 7).

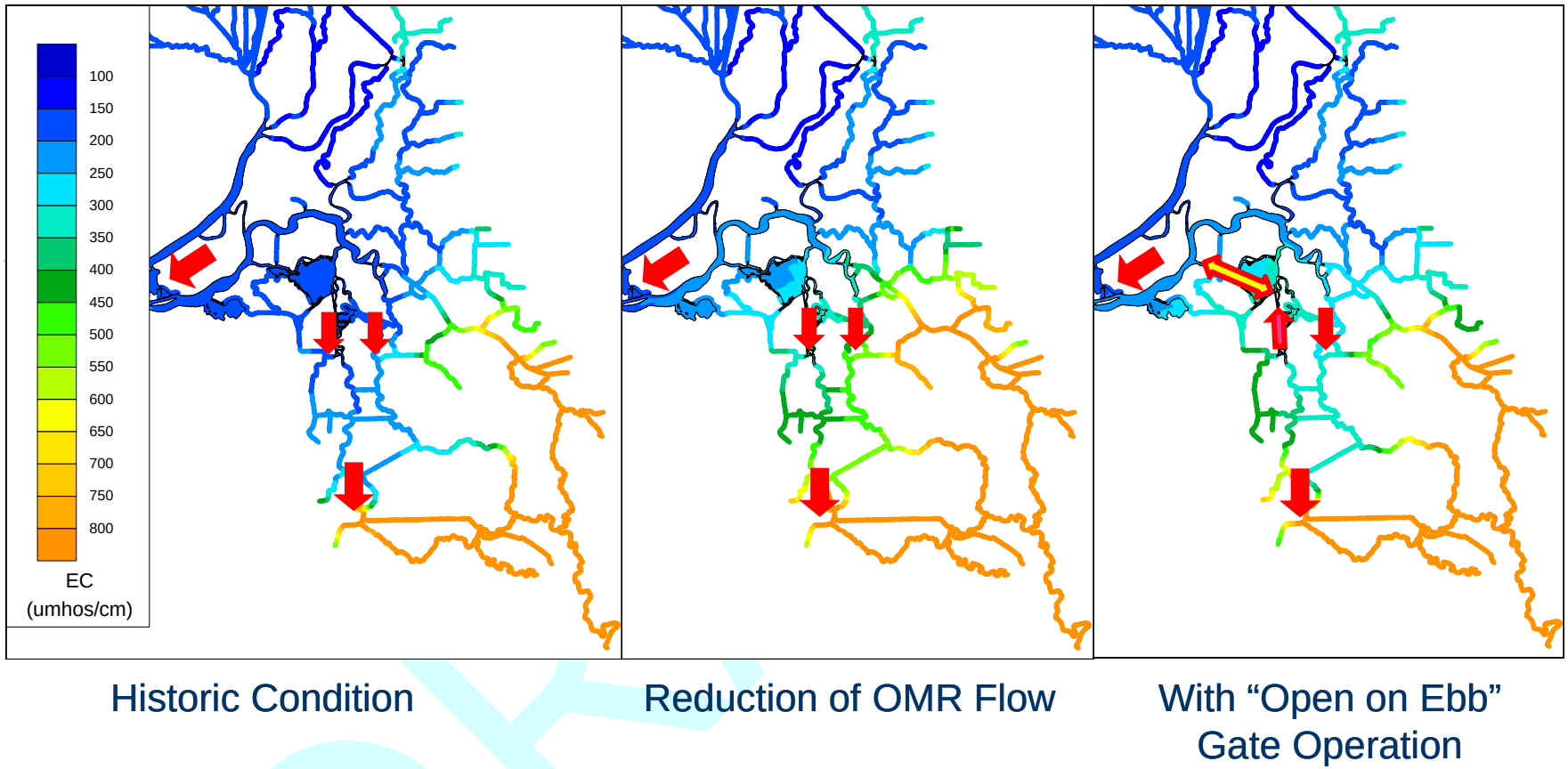

Figure 6. Operation of 2-Gates Project to Reduce Larval/Juvenile Delta Smelt Entrainment.

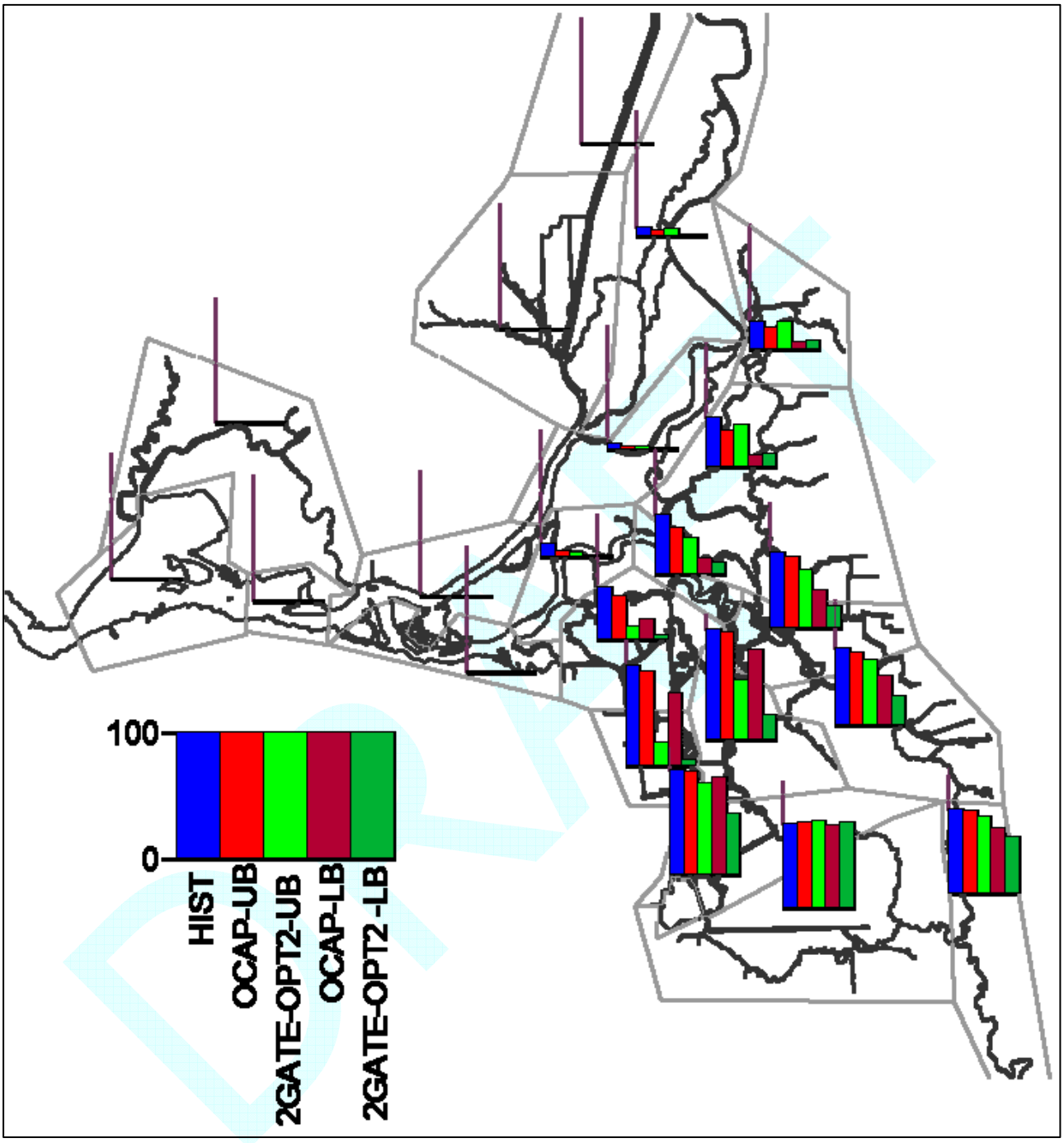

Figure 7. Percent of Particles Entrained at CVP+SWP by Region during the Modeled Period

Finally, this dispersive mixing process could also be used to improve habitat in the Sacramento-San Joaquin confluence area by facilitating westward transport of nutrients and plankton originating in the upper San Joaquin River and southern Delta. The POD studies have hypothesized that "bottom up" factors, such as the quality and availability of food, may have important consequences for pelagic fishes including delta smelt. Low and declining primary productivity in the estuary is likely a principal cause for the long-term pattern of relatively low and declining biomass of pelagic fishes (Baxter et al. 2008). There has been a significant long-term decline in phytoplankton biomass (chlorophyll *a*) and primary productivity to very low levels in the Suisun Bay region and the lower Delta (Jassby et al 2002). Mueller-Solger et al. (2006) concluded that areas rich in high-quality phytoplankton and other nutritious food sources such as the southern Delta and small tidal marsh sloughs may be critical "source areas" for important Delta smelt prey organisms such as *Pseudodiaptomus forbesi* and *Eurytemora affinis* (Bennett 2005). This is consistent with results by Durand et al. (unpublished data in Baxter et al. 2008) that showed that transport from upstream was essential for maintaining the *P. forbesi* population in Suisun Bay.

CONCEPTUAL MODEL

Based on the current state of Delta science and our focused hydrodynamic modeling, we developed a simplified conceptual model to present the Project's chain of logic (Figure 8).

Our premise is that OMR flows are affected by several factors, including gate operations. OMR flows are expected to affect physical factors, such as local hydrodynamics and turbidity flux. These changes are in turn expected to affect the movement of adult smelt, their distribution, and consequently the distribution of their offspring. The risk of entrainment is increased if delta smelt are located in the south Delta in close proximity to the export facilities and where habitat conditions may be less favorable for juvenile rearing.

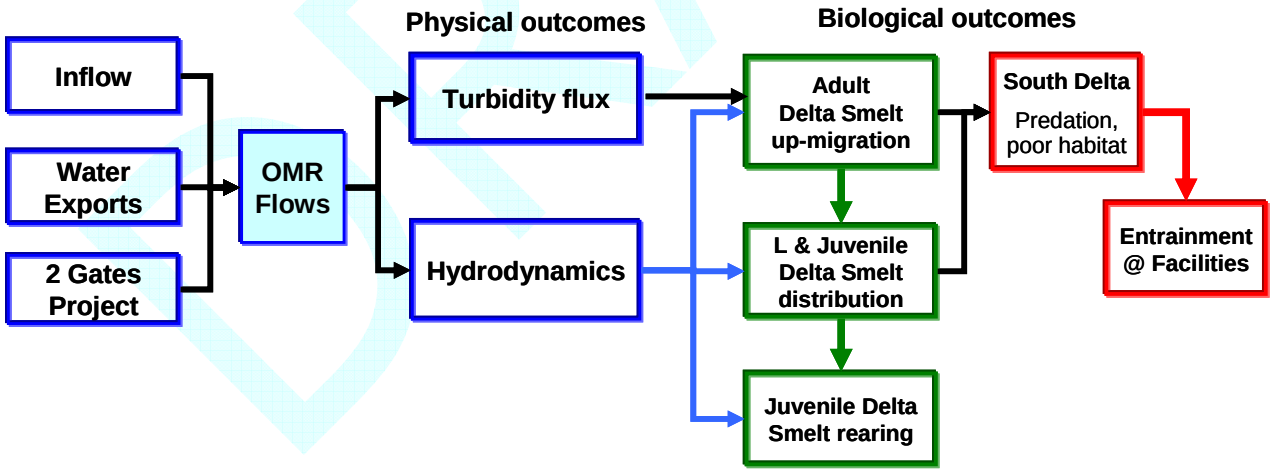

Figure 8. Conceptual Model of 2-Gates Project Inputs and Outcomes.

Key Questions & Hypotheses Testing

The Project is designed as a five-year demonstration project to evaluate the effectiveness of operable gate structures in managing Old and Middle River flows, turbidity and entrainment; and to test hypotheses of relationships among flows, turbidity levels and delta smelt distribution. The Project-related monitoring will also address questions about gate and gate operation effects on other species.

Hydrodynamic processes have been identified as important drivers affecting delta smelt habitat, movement, distribution, and vulnerability to entrainment by the export facilities (Bennett 2005, Grimaldo et al. in press, Kimmerer 2008, and FWS 2008). The Project includes two life-stage-specific sets of operations to protect pre-spawning adults and juveniles. The key questions underlying the Project are:

- Can the Project reduce pre-spawning adult delta smelt entrainment in the CVP and SWP export facilities by maintaining a zone of low turbidity between the export facilities and the central and western Delta?
- Can the Project reduce juvenile delta smelt entrainment in the facilities by enhancing dispersive mixing to transport them from the south and central Delta into the western Delta?

The following sections present several generally-stated hypotheses regarding physical outcomes of gate operations and biological response of delta smelt (Table 1). These hypotheses are designed to test specific questions and underlying assumptions, refine understanding of processes that influence entrainment of delta smelt, and evaluate Project performance. This knowledge will be used to refine the Project design and operation to protect delta smelt and to guide regulatory decision-making. Because of the physical changes in the central Delta likely to result from the Project, other species could be affected. Table 2 lists the potential issues for other listed species resulting from the Project, along with identification of the metrics and monitoring data sources to be used in examining these issues. The data sources and related analysis approaches are described in more detail in later sections of the Monitoring Plan.

Assessment of the 2-Gates Project provides a unique opportunity to gain insights into Delta processes and point the way towards follow-up investigations. However, there are significant challenges in attempting to conduct a quantitative, testable program in a natural, uncontrolled "experiment." The Delta is a complex environment and is subject to substantial fluctuations on daily, seasonal, annual, and multi-year time scales that are not necessarily predictable in spatial, magnitude, duration, or directional scales. In addition to these sources of variation, which may be derived by natural and/or anthropogenic forces, the assessment program may be influenced by the assessment program itself. For example, low densities of delta smelt may result in small sample sizes and reduced statistical power. The ability to conduct sampling may be constrained by endangered species take limits or other logistical constraints. Other factors such as Delta hydrology, temperature regimes, or predation may obscure the magnitude of project effects and make it impractical to obtain sufficient data to tease out the relative weights of the effects. Collectively, the elements of the broad monitoring program proposed here will provide the necessary information to identify confounding factors and their magnitude to assist in the interpretation of test results.

As a result, traditional controlled experiments are generally not possible in the Delta. Our experimental design recognizes these challenges. For example, the principles of the BACI (Before-After-Control-Impact) design are applied to reduce environmental variability between treatments.

Another approach is to explicitly measure confidence intervals. These approaches will be applied as needed in specific studies used to test hypotheses. Some of the inferences or conclusions will be subject to substantial variability and uncertainty. This will undoubtedly require additional study and refinement of the monitoring program and modeling.

Table 1. Hypotheses/Questions for concept-testing the proposed 2-Gates Fish Protection Demonstration Project.

No.	Hypotheses and Questions	Metrics [1]	Data sources	Test
Balanced Flows and Turbidity				
1	2-Gates Project operations can control net flows in Old River to achieve a predictable balance of flows in both Old and Middle Rivers.	▪ Flows in Old and Middle Rivers	▪ Existing and new flow monitoring stations. ▪ RMA modeled flows [2].	▪ A BACI experiment using modeled flows: test time series of flows with and without 2-Gates operations. [3] ▪ Compare observed flows to those predicted by the RMA model.
2	2-Gates Project operations, can balance net flows between Old and Middle rivers, as indicated in 1, to maintain a low turbidity region in Old and Middle Rivers.	▪ Flows in Old and Middle Rivers ▪ Turbidity (observed) down Old and Middle Rivers and into Franks Tract and lower San Joaquin River. ▪ Model results for flows and turbidity from forecasting and from concurrent conditions.	▪ Existing and new flow monitoring stations. ▪ Existing and new water quality stations (turbidity, EC, temperature and chlorophyll a). ▪ RMA modeled flows and turbidities [2].	▪ BACI experiment of model: test time series of flows and turbidities with and without gate operations. [3] ▪ Compare observed turbidity fluxes to those predicted by the RMA model.
Delta Smelt Migration and Salvage				
3	Migration of pre-spawning adult delta smelt from the Suisun Bay into the Delta and freshwater habitats occurs when initial winter storm events increase Sacramento River turbidity in the Delta to above a threshold of 12-15 NTU.	▪ Storm event (1st of season) ▪ Delta inflow ▪ Sacramento River flows ▪ Turbidity ▪ Delta smelt catch at fixed stations, one each in the Sacramento and San Joaquin rivers.	▪ Existing and new flow monitoring sites. ▪ New turbidity, EC and water temperature stations. ▪ Daytime fish catches in a stationary Kodiak or Midwater trawl over a ~12-hr tide cycle (Appendix D).	▪ Time series at fixed sites. Single field event monitored over tidal cycle.

1. Additional discussions are planned at the science panel.
2. RMA hydrodynamic model will run trials run over 1-2 weeks with controllable and stable net flows and exports. Test on same tide phase for both. Neap and spring >=twice each, learning as we go. First measure with gates open, then a few days with the gates operating (closed for all or some portion of 24 hours). This is not a pulse flow test.
3. Test is for no difference in mean flow for model runs with gates open and a difference when Project is operating, with multiple model runs. Do mean observed flows fall in range of predicted net flows, i.e., predictions are correct? Assume that the distribution of random variation under historic conditions applies to the test conditions. Use appropriate tests taking into account autocorrelation if necessary.

Table 1. Hypotheses/Questions for the proposed 2-Gates Fish Protection Demonstration Project (continued)

No.	Hypotheses and Questions	Metrics [1]	Data sources	Test
Balanced Flows and Turbidity				
4	Maintaining a low turbidity region in Old and Middle Rivers reduces adult delta smelt salvage.[2]	▪ Turbidity ▪ Observed Salvage ▪ Model results for salvage	▪ Existing and new flow stations ▪ Existing and new water quality stations. ▪ Vessel-based turbidity monitoring down the Old and Middle Rivers ▪ Salvage	▪ A BACI experiment using modeled flows, turbidity and salvage: test time series of flows, turbidity and salvage with and without 2-Gates Project operations. ▪ Compare observed flows, turbidity and salvage to those predicted by the RMA model.
Dispersive Mixing				
5	Open-on-ebb operations increase dispersive mixing between the south-central Delta and lower San Joaquin River through Franks Tract-False River.	▪ Net flows in Old and Middle Rivers ▪ Calculate salt flux decomposition in False River west of Franks Tract or possibly measure bromide time series (Appendix E) ▪ Salinity and salts gradients from OR –FT-FR-SJR. ▪ Fingerprinting estimates based on bromide time series.	▪ Existing and new flow monitoring stations. ▪ Additional field data to fingerprint water source (e.g. bromide sensor)	▪ A BACI experiment using modeled flows: test time series of flows and salinity with and without 2-Gates Project operations. [3] ▪ Compare observed flow and salinity values with those predicted by the RMA model.

What follows below are presentations of the concepts underlying the hypotheses listed in Table 1, along with descriptions of the experimental designs proposed for testing the hypotheses. The key sources of data and information to support these designs are described in Attachments (A, B, and C) to this Plan, or in some cases are described in later sections of the Plan.

ADULT DELTA SMELT PROTECTION

Concept

Pre-spawning adult delta smelt migrate upstream from Suisun Bay into the Delta when initial storm events increase Sacramento River turbidity in the Delta. Recent study (Grimaldo et al. in press) suggests that turbidity plumes associated with the Sacramento River inflow are a likely trigger for upstream movement into the western Delta, including the lower San Joaquin River. If these initial plumes expand from the western Delta into the Old and Middle River corridor, adult delta smelt may track these turbidity cues southward to the pumps, resulting in entrainment losses.

Entrainment of adult delta smelt at the export facilities is correlated with negative OMR flows and high turbidity (Kimmerer 2008, Grimaldo et al. in press, FWS 2008). The relationship of flow and turbidity can be quantified simply as the turbidity flux (Tf) or the product of turbidity, C, and the discharge (or mass flux) in Old and Middle Rivers (Q: Tf=QC). Recent modeling results suggest that the total turbidity flux at the facilities can be minimized by balancing the turbidity flux between Old and Middle Rivers (Figure 4).

Based on these data, it may be possible to reduce entrainment at the export facilities by manipulating flows and turbidity. The RMA models predict that the 2-Gates Project can establish a low turbidity zone in Old and Middle rivers that could, in coordination with less negative OMR flows, reduce entrainment of adult delta smelt. This would involve both (1) strategically-timed reduction of exports to reduce negative OMR flows, and (2) operation of the 2-Gates Project to balance the turbidity flux between the Old and Middle Rivers.

Balanced Flows and Turbidity

Hypotheses

Balanced flow and turbidity hypotheses have been developed with regard to the principle mechanisms influencing adult delta smelt movement. The ability to influence this movement further away from and less at risk of export facilities is expected to influence the regions of spawning and distribution of larva and juvenile delta smelt. Two hypotheses have been developed regarding flow and turbidity effects of gate operations (Table 1):

1. 2-Gates Project operations, coordinated with allowable changes in export levels, can control net flows in Old River to achieve a predictable balance of flows in both Old and Middle Rivers.

2. 2-Gates Project operations, coordinated with allowable changes in export levels, can balance net flows between Old and Middle Rivers to maintain a low turbidity region in Old and Middle Rivers.

Experimental Design

Modeled flow and turbidity will be compared with and without gates operations with actual measured flow and turbidity distribution to evaluate the project's performance in balancing flows and maintaining a turbidity gap in Old and Middle rivers. Fixed-site water quality monitoring (described in Attachment A) and modeling results (See Attachment B) are the key sources of supporting this design.

A BACI (Before-After-Control-Impact) experimental design will be used to compare the RMA predictions of flow with and without 2-Gates Project operations. Conducting a true BACI designed field experiment is not possible in the Delta because there is no suitable control site. For the Impact conditions, the RMA model will be run for a period of time (e.g., a week) without the 2-Gates Project operations (the Before period), and then for a similar period of time with 2-Gates Project operations (the After period). This will be repeated n times to obtain n sets of flow output time series differing because of the random variation in the RMA model. There will also be n runs of the RMA model for the Control conditions, where in this case the 2-Gates Project operations will not occur for both the Before and After period. This will provide n sets of flow output series, again differing because of the random variation in the RMA model. The value to be used for n will be determined based on trial runs of the RMA model with uncertainty incorporated. It needs to be a balance between having a sufficient number of runs to estimate mean predicted flow rates with reasonable accuracy and the need to keep the computing time to a reasonable level.

There are various analyses possible for the results of this BACI experiment. Initially a simple analysis involves calculating the mean flow on Day 1 of the Before period for the n Impact runs of the RMA model, and comparing this with the mean flow on the same day for the n Control runs of the RMA model. This comparison can be done for each day in the Before period and for each recorded flow variable. If the data are approximately normally distributed then a t-test can be used to compare the Impact and Control means, otherwise a randomization test can be used. Because the 2-Gates Project operations are not used in the Before period it should be found that only about 5% of the Impact – Control mean differences are significant at the 5% level. This then provides a test that the model results are behaving appropriately.

The mean flows on Day 1 in the After period can also be calculated for a flow variable from the n RMA model runs under Impact conditions, and the n runs under Control conditions. The difference between these means can then be tested for significance using a t-test or randomization test. In this case it is anticipated that most of the differences will be significant at the 5% level because the 2-Gates Project operations do change the flow rates in the RMA model. Confidence limits for the true mean differences can also be calculated to show the estimated effects of the 2-Gates Project operations and the level of sampling error involved with these estimated effects.

As well as the RMA model results there will be observed daily flow rates at sampling stations in the Old and Middle Rivers for the Before period (when the 2-Gates Project are not operating) and the After period (when the 2-Gates are operating) because the Impact Before and After conditions will be applied in the Delta as well as in the RMA model runs. These observed flow rates can be compared with the mean flow rates for the RMA Impact model runs to see whether the observed flow rates are within the range expected based on the n repeated runs of the model with random variation. If the differences between observed flows and mean model predicted flows are within the range expected from the random variation in the model then this confirms the validity of the model. If the observed flow rates are not within the ranges expected based on the random variation in the

RMA model then the differences between the observed and predicted flows may suggest ways to improve the RMA model.

Adult Delta Smelt Migration and Salvage

Hypotheses

Hypotheses have been developed regarding the physical migration cues for pre-spawning adult delta smelt and the effectiveness of the project in reducing adult delta smelt entrainment (Table 1):

3. Migration of pre-spawning adult delta smelt from the Suisun Bay into the Delta and freshwater habitats occurs when initial winter storm events increase Sacramento River turbidity in the Delta to above a threshold of 12-15 NTU.

4. Maintaining a low turbidity region in Old and Middle Rivers reduces adult delta smelt salvage at the export facilities.

Experimental Design

Hypothesis 3 - Adult Migration and Turbidity

A set of integrated hydrodynamic and fish sampling studies are proposed to evaluate the role of water transparency (i.e. turbidity) in determining the timing and migration of delta smelt upstream into the Delta region (detailed in Attachment C). We propose to concurrently monitor hydrodynamic conditions and conduct fish sampling over a complete tidal cycle (about 12 h) at two locations (near Decker Island in the Sacramento River and near Jersey Point in the San Joaquin River). Fixed location sampling will let the tidal currents bring the fish and turbidity past us for the duration of a tidal excursion (approximately 8 miles each way), allowing us to effectively sample a total of 16 miles of river channel.

Sampling would occur in late December to early January at low Sacramento River discharge and then immediately following the first large precipitation event of the season in the basin ("first flush"). Previous work suggests that delta smelt typically arrive at the fish salvage facilities within about three days following a sharp increase in turbidity (Grimaldo et al. in press), suggesting a rapid response by delta smelt to elevated turbidity. We anticipate that few, if any, delta smelt will be detected during the pre-turbid period, and more delta smelt will be detected as they move past our sampling location once a turbidity "bridge" forms between the low salinity zone and the western Delta (Appendix D).

The data from this experiment will be used to (1) tighten the linkage between observed delta smelt distributions (fall midwater trawl, Spring Kodiak Trawl, or salvage), (2) enhance, calibrate and verify the delta smelt behavior model described in Attachment A, and, (3) provide a real-time early warning system that would alert the water project operators to the onset of delta smelt migration into the central Delta.

Hypothesis 3 is supported if the migration of pre-spawning adults is observed to occur when an initial winter storm event increases the Sacramento River turbidity to above the stated threshold. This requires that there are few if any adult delta smelt observed in samples in the Delta before the storm event, but an increasing number after the storm event. If a sufficient number of adult delta

smelt are observed a test for an impact of the storm event will be possible based on the time series of catches of the fish.

Hypothesis 4 - Adult Entrainment

We will compare modeled salvage with and without gates operations with actual observed salvage to evaluate the project's performance in reducing adult delta smelt entrainment. The salvage of fish at the CVP and SWP export facility fish screens provides an index of entrainment. The salvage process, collection of salvage data, and estimation of salvage rates is described in later sections of this Plan. We would expect to observe no salvage if there is a turbidity gap (<12 NTU) in Old and Middle Rivers. There may be other outcomes depending on field conditions. For example, if there is (1) high turbidity measured at the export facilities due solely to high turbidity in San Joaquin River inflow to the Delta that is pulled across at Grant Line Canal, but (2) low turbidity at Franks Tract, then the turbidity gap is present and we would expect no salvage. If there is a sufficiently high San Joaquin River inflow that produces a strong turbidity gradient from the south Delta, the turbidity gap will not be maintained. This project is not designed to control flows originating from the San Joaquin side. Therefore, we would expect salvage to occur.

Testing hypothesis 4 follows the same BACI design procedure as for hypotheses 1 and 2. There will be n runs of the RMA model with a Before period with no 2-Gates Project operation, followed by an After period with 2-Gates Project operations. This gives n Impact runs. There will also be n control runs of the model with no 2-Gates Project operations in both the Before and After periods. Comparison between the daily modeled values for flow rates, turbidity and salvage should then show similar mean values for the Control and Impact runs in the Before period, but significantly different means are expected in the After period. Confidence limits for the mean differences in the After period then indicate the magnitude of the 2-Gates Project effects and the sampling errors in determining these effects. In addition the Impact conditions will apply in the Delta so that a comparison of the modeled mean flow, turbidity and salvage values with the observed values at sampling stations will indicate whether the model predictions are correct. If the observed values are within the range expected based on the RMA model including randomness then this will confirm the accuracy of the RMA model. If the observed values are outside the range expected with randomness in the RMA model then this may suggest how the RMA model can be improved.

Testing of hypothesis 4 may be inhibited by high variability in the salvage variable. Fish salvage at the CVP and SWP Delta fish screening facilities is often used as an index for entrainment at the CVP and SWP intakes. However, the relationship between entrainment and salvage can vary considerably over short periods of time due variations in pre-screen mortality (caused by variation in factors such as predator activity and Clifton Court Forebay habitat conditions) and screening efficiency (due to variation in export rates or fish size). Also, the number of delta smelt observed during salvage sampling may be very low. It may be possible to reduce the confidence limits around estimates of salvage by increasing the level of sampling during test periods or maintaining relatively steady water project operations (e.g. export rates and Forebay gate operations).

DISPERSIVE MIXING

Concept

The distribution of larval and juvenile delta smelt depends on spawning locality (distribution of spawning adults) and Delta hydrodynamics (FWS 1994). Adequate flows are necessary to transport

larvae and juveniles downstream to productive rearing habitat in Suisun Bay and to prevent entrainment by the export facilities. Tidal operation of the 2-Gates Project may increase dispersive mixing of water in the central or southern Delta seaward toward the western Delta. This has the potential to (1) disperse larval/juvenile smelt spawned in the central and southern Delta away from the export pumps, thereby reducing entrainment risk, (2) enhance juvenile transport westward toward rearing habitat near Suisun Bay, and (3) enhance export of nutrients and phytoplankton to the west Delta. Preliminary modeling illustrates the tidal pumping through Franks Tract that could occur with Project operations.

The hypothesized dispersive mixing process could also be used to improve habitat in the Sacramento-San Joaquin river confluence area by facilitating westward transport of nutrients and organic carbon (e.g. phytoplankton and zooplankton) originating in the upper San Joaquin River and southern Delta. This expected effect would be confirmed with water quality parameters (e.g. chemical fingerprinting of water to differentiate San Joaquin River and Sacramento River waters within False River and the western Delta). Modeling results suggest that the Project would achieve greater reduction of cumulative entrainment of larval/juvenile delta smelt than OMR flow restrictions alone (Figure 7).

Hypothesis

We developed the following hypothesis to examine Project effects on a hydrodynamic process for juvenile delta smelt transport:

5. Opening the Old River gate on ebb-tide and closing it on flood creates net circulation downstream on Old River and upstream on Middle River that increases mixing between Franks Tract and western San Joaquin River.

Experimental Design

The dispersive mixing hypothesis will be tested through a specific enhancement of water quality and hydrodynamics monitoring described in Attachment A. We intend to use changes in the salt (and perhaps *chlorophyll a* (Cl-a)) flux in False River to test the "dispersive mixing mechanism" behind 2-Gates Project operations designed to reduce entrainment of larval and juvenile delta smelt that are hatched in a broad region of the central and southern Delta. If 2-Gates Project operations do increase dispersive exchange of water (and hopefully larval and juvenile delta smelt) from the central and southern Delta into the western delta and salinities are elevated in the San Joaquin, then San Joaquin River salt could be used as a conservative tracer. If the "dispersive mixing mechanism" is working as planned, then an increase in dispersive flux in False River should be detected, which would be directed from Franks Tract into the western San Joaquin Delta – a direct measure of the effectiveness of 2-Gates Project operations in creating this transport mechanism. Moreover, if 2-Gates Project operations facilitate westward transport of organic carbon (e.g. phytoplankton) originating in the upper San Joaquin River and southern Delta, then an increase in Chl-a flux should be observed through False River (presuming it is not completely grazed down by the benthos). These are but a handful of examples of how fluxes will be used in this project to inform real time operations and evaluate performance.

The testing of hypothesis 5 again involves a BACI design. There will be n Impact runs of the RMA model with a Before period with no 2-Gates Project operations, followed by an After period with the 2-Gates Project operations. There will also be n Control runs of the model with no 2-Gates Project operations in either the Before of After period. Comparisons between daily mean values for flows and salinity should show that that these are similar for the Impact and Control conditions in the Before period but differ in the After period. The estimated mean differences with confidence limits then indicate the magnitude of the 2-Gates Project effects and the likely sampling error in the estimated effects. In addition because the impact conditions will be applied in the Delta a comparison between the observed daily values for river flows and salinity with the values observed at field stations will show whether the observed values are within the range expected from the RMA model with randomness. If the observed values are within the expected range then this will confirm the accuracy of the RMA model. If observed values are outside the range expected from the RMA model then this may indicate ways in which the RMA model can be improved.

MONITORING CONSIDERATIONS FOR OTHER SPECIES

The focus of the 2-Gates Project is reducing entrainment of delta smelt at the CVP & SWP water export facilities. The objectives and associated hypotheses presented in Table 1 and discussed above address that focus. Because of the physical changes in the central Delta likely to result from the Project, other species could be affected. Table 2 lists the potential issues for other listed species resulting from the Project, along with identification of the metrics and monitoring data sources to be used in examining these issues. The data sources and related analysis approaches are described in more detail in later sections of the Monitoring Plan.

1

Table 2. 2-Gates Project Monitoring Issues for Species Other than Delta Smelt (DS)				
Species/Run	Issue #	Issue/Consideration	Metrics	Programs/Data Sources
1. Chinook salmon emigrants (CS)				
	1.1	Project operations have the potential to increase or decrease CVP/SWP entrainment rates of emigrating juvenile San Joaquin CS	• CVP/SWP salvage	• Ongoing CVP/SWP fish salvage reporting • Mossdale Trawl Survey outmigrant sampling
	1.2	Project gate operations have the potential to affect through-Delta migration duration, routes, and survival rates of emigrating juvenile San Joaquin CS.	• Through-Delta migration rates of acoustic-tagged juvenile SJ salmon • Through-Delta migration routes of acoustic-tagged juvenile SJ salmon • Through-Delta survival rates of acoustic-tagged juvenile SJ salmon	• Project-enhanced VAMP acoustic tagging studies
	1.3	Project operations have the potential to increase or decrease CVP/SWP entrainment rates of juvenile Sacramento and Mokelumne river salmon emigrating through central Delta channels	• CVP/SWP salvage	• Ongoing CVP/SWP fish salvage reporting • Chipps Island Trawl Survey outmigrant sampling
	1.4	Project gate operations have the potential to affect through-Delta migration duration, routes, and survival rates of juvenile Sacramento and Mokelumne river salmon emigrating through central Delta channels	• Through-Delta migration rates of acoustic-tagged juvenile Sac. salmon • Through-Delta migration routes of acoustic-tagged juvenile Sac. salmon • Through-Delta survival rates of acoustic-tagged juvenile Sac. salmon	• Project-specific releases of acoustic-tagged juvenile Sac. salmon, monitored by Project-enhanced Delta receiver array • Ongoing East Bay MUD acoustic-tagged juvenile salmonid migration studies
	1.5	Project gate structures and operations have the potential to affect predator densities and efficiency at gate locations, and potentially localized juvenile salmon mortality rates.	• Predator densities and behaviors at gate locations	• New large-fish imaging and sonar monitoring at gate structures • Project-enhanced VAMP acoustic tagging studies
2. Steelhead emigrants (STH)				
	2.1	Project operations have the potential to increase or decrease CVP/SWP entrainment rates of emigrating juvenile San Joaquin STH	• CVP/SWP salvage	• Ongoing CVP/SWP fish salvage reporting
	2.2	Project gate operations have the potential to affect through-Delta migration duration, routes, and survival rates of emigrating juvenile San Joaquin STH.	• Through-Delta migration rates of acoustic-tagged juvenile SJ STH • Through-Delta	• Project-enhanced VAMP-like acoustic tagging studies for STH as called for June 4, 2009 NMFS OCAP

Table 2. 2-Gates Project Monitoring Issues for Species Other than Delta Smelt (DS)				
Species/Run	Issue #	Issue/Consideration	Metrics	Programs/Data Sources
			migration routes of acoustic-tagged juvenile SJ STH • Through-Delta survival rates of acoustic-tagged juvenile SJ STH	
	2.3	Project operations have the potential to increase or decrease CVP/SWP entrainment rates of juvenile Sacramento and Mokelumne river STH emigrating through central Delta channels	• CVP/SWP salvage	• Ongoing CVP/SWP fish salvage reporting
	2.4	Project gate operations have the potential to affect through-Delta migration duration, routes, and survival rates of juvenile Sacramento and Mokelumne river STH emigrating through central Delta channels	• Through-Delta migration rates of acoustic-tagged juvenile Sac. & Mok. river CS and STH • Through-Delta migration routes of acoustic-tagged juvenile Sac. and Mok. river CS and STH • Through-Delta survival rates of acoustic-tagged juvenile Sac. & Mok. River CS & STH	• Project-specific releases of acoustic-tagged juvenile Sac. salmon, monitored by Project-enhanced Delta receiver array • Ongoing East Bay MUD acoustic-tagged juvenile salmonid migration studies
	2.5	Project gate structures and operations have the potential to affect predator densities and efficiency at gate locations, and potentially localized juvenile STH mortality rates.	• Predator densities and behaviors at gate locations	• New large-fish sonar monitoring at gate structures • Project-enhanced VAMP and VAMP-like acoustic tagging studies
3. Green Sturgeon (GS)				
	2.1	Gate structure and operations have the potential to impede sturgeon movement in Delta channels	• Sturgeon presence and passage rates at Project structures.	• New large-fish imaging and sonar monitoring at gate structures • New acoustically tagged and released salvaged juvenile sturgeon
4. Longfin Smelt (LFS)				
	4.1	Project has the potential to reduce adult and juvenile LFS entrainment through mechanisms similar to those for DS	• CVP/SWP LFS salvage rates	• Ongoing CVP/SWP fish salvage reporting
	4.2	Project has the potential to reduce adult LFS occurrence and spawning in OMR	• Spawning season adult distribution • Spawning season larvae distribution	• Enhanced IEP Kodiak Trawl Survey • Ongoing IEP Fall Mid-water Trawl Survey results • Ongoing IEP LFS Larva Survey

GENERAL PROJECT EFFECTS MONITORING METHODS

In the preceding section of the 2-Gates Project Science & Monitoring Plan we described the conceptual bases for the proposed design and operation of the Project, identified the key hypotheses and questions underlying the Project concept that will be tested or addressed during the five-year Project, and described the experimental approach and methods to be used in hypothesis testing. In this section of the Plan we describe the broad environmental and fisheries monitoring program intended to generally assess Project effects. In addition to supporting the interpretation experiments described in the preceding Plan section, the broad monitoring program monitors conditions for triggering Project operations, and monitors effects on the general Delta environment and species other than delta smelt (particularly other ESA-listed species).

This latter "other species" aspect of Project monitoring is critical to the Project achieving its goals and objectives. The project has been designed to achieve its delta smelt protection objectives, while minimizing negative on, and even benefiting, other species. Collectively, the elements of the overall Plan are intended to provide the information necessary to assess the Project's effectiveness, allow for adaptive decisions regarding Project design and operations, and provide a real-time warning of unintended Project negative impacts so that appropriate remedial actions can be taken.

The proposed monitoring approach relies substantially on data from existing monitoring programs, with enhancements to provide finer resolution data (e.g., additional sites or increased sampling frequency for fish monitoring). Some of the key questions will be addressed through entirely new monitoring efforts (e.g., predatory fish occurrence at gate structures). The overall monitoring approach is summarized in Table 3. A schematic display of how the various elements of the proposed monitoring program address the components of the 2-Gates Project conceptual model is illustrated in Figure 3.

Monitoring to Detect Operations Triggering Conditions

Delta smelt spawning season (winter) gate operations will be triggered by water quality conditions and distribution of pre-spawning adult delta smelt. The necessary monitoring elements are detailed below and summarized in Table 3 and depicted conceptually in Figure 8.

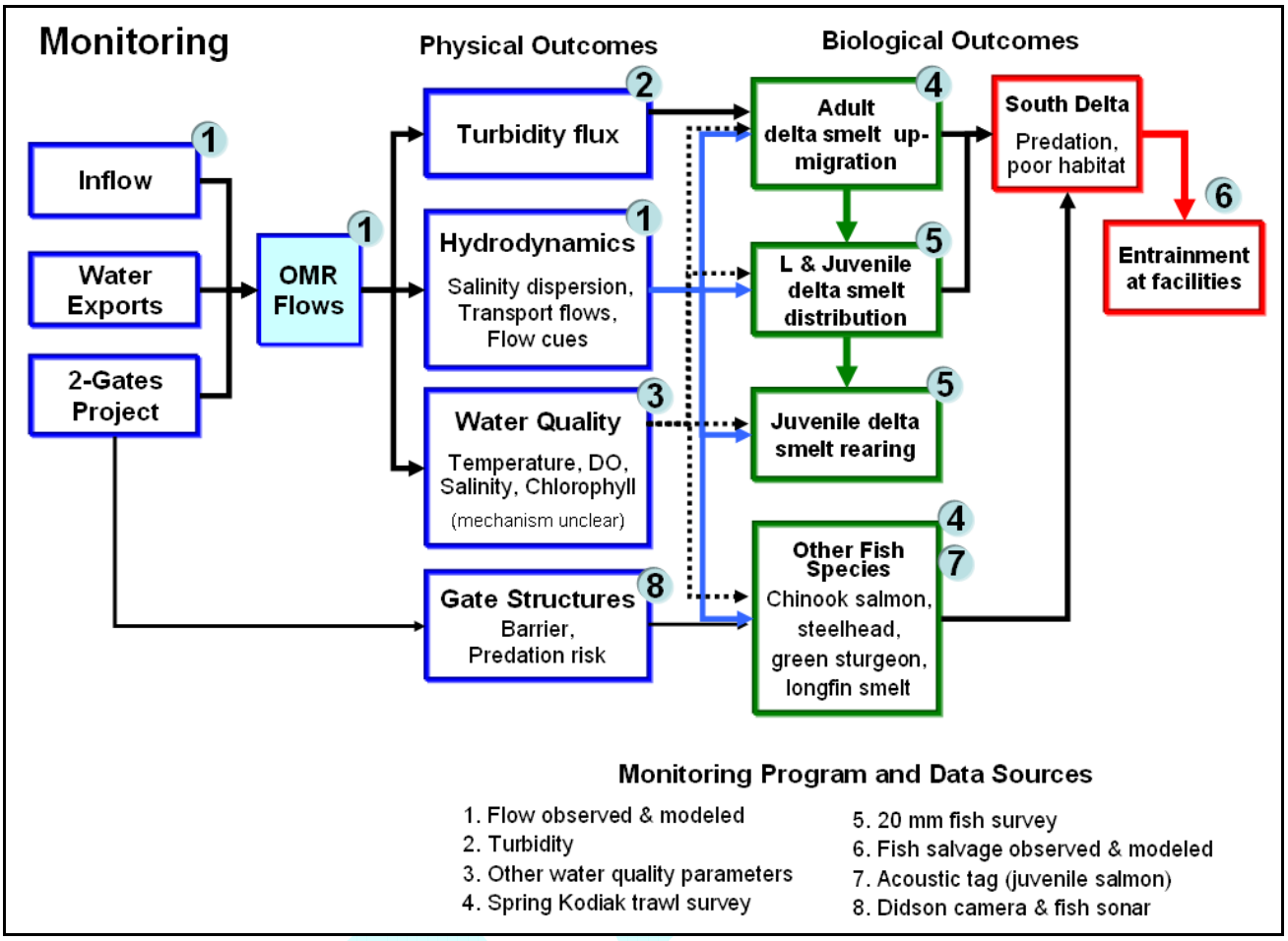

Figure 9. Programs to provide data for Project effects monitoring and hypothesis testing for the 2-Gates Project

Water Quality

Existing sites for water quality monitoring occur at USGS and DWR supported sites around the Delta (Table 6). The main water quality parameters measured at existing sites include turbidity (NTU), electrical conductivity (µmhos/cm.), and water temperature (°C). Some sites also provide channel flow data. According to the USFWS OCAP Biological Opinion (USFWS 2008) and analyses conducted in developing the Project, conditions that initiate upstream delta smelt movement in advance of spawning are associated with storms that generate sufficient runoff in the Sacramento River to affect water quality in the Delta beginning in late December. High levels of delta smelt salvage occurs at the CVP Tracy Fish Collection Facility (TFCF) and at the SWP Skinner Fish Protective Facility (SFF) following these water quality events (USFWS 2008). Ongoing water quality monitoring for turbidity, electrical conductivity and temperature at Jersey Point will be the primary tool used to determine triggering conditions for initiating spawning season gate operations.

Delta Smelt Presence

Delta smelt abundance and distribution in the region of the Delta north and west of the gate structure will be determined by using data from the IEP's Kodiak Trawl Survey (KTS). To meet the specific

information needs of the 2-Gates Project, we propose initiating the KTS earlier in the season (December instead of January) at an expanded number of monitoring sites in the lower Old and Middle Rivers and the lower San Joaquin River. Frequent sampling at multiple stations in the central delta will be necessary to determine the proximity of migrating delta smelt to the gates. Also, close monitoring of salvage at the TFCF and SFF will identify the occurrence of pre-spawning adult delta smelt in the southern Delta.

Table 3. Monitoring of triggers for seasonal gate operations

Indicators	Method	Location	Frequency	Duration	Monitoring Enhancements
Instantaneous Flow, Net Flow, Stage	Flow Monitoring	Existing stations	Real-Time (hourly)	December –June	No adjustments to this existing program
Turbidity, Electrical Conductivity, Temperature	Automated Water Quality Monitoring	Jersey Pt.., Prisoners Pt.	Real-Time (hourly)	December –June	No adjustments to this existing program
Delta smelt density and distribution	Spring Kodiak Trawl (adult ops. season)	Existing stations	Every other week	January - March	Increase sampling frequency at stations in the central and south Delta to twice per week during December-March.
	20 mm Survey (juv. ops season)	Existing stations	Monthly to bi-weekly	March-June	Increase sampling frequency at stations in the central and south Delta to twice per week during December-March.
	Salvage Monitoring	Skinner Fish Facilities	Daily	March-June	No adjustments to this existing program

MONITORING EFFECTS OF GATE INSTALLATION AND OPERATIONS

Installation and operation of the 2-Gates Project will alter the hydrodynamics in portions of the Delta ecosystem throughout the annual operations season (December through June), potentially influencing delta water quality and fishery resources. The proposed monitoring plan contains elements to address all of these aspects of the Delta ecosystem (Tables 3, 4 and 5) during both the delta smelt spawning season and larval/juvenile operations periods.

Hydrodynamics

Real-time monitoring of flow in key Delta channels will be necessary to document hydrodynamic changes caused by gate operations, which can affect both water quality and fish distribution. Real-time flow monitoring data will be essential to correctly interpreting the results of water quality and biological monitoring. The 2-Gates Project monitoring team will need to utilize a combination of existing flow stations managed by agencies such as USGS, USBR, and CDWR. In addition manually and remotely operated ADCPs will be necessary at strategic locations where no existing flow gauges are present. Real-time flow data will be compared to modeled flows to determine the difference between actual and predicted Project hydrodynamic effects in Old, Middle and False rivers, Fisherman's Cut, the San Joaquin River, and possibly other channels (e.g. Rock Slough, Dutch Slough) that may have altered flow regimes due to Project gate operations.

Water Quality

Gate operations will modulate tidal flows in Old River between Franks Tract and Railroad Cut and in Connection Slough. Gate operations may have a measurable effect on water quality conditions in these channels during both operating periods and possibly cause minor water quality changes throughout the south and central Delta. Levels of dissolved oxygen, turbidity, temperature, and chlorophyll A will need to be monitored in the area in close proximity to the gates and in the channels on either side to develop information on water quality and habitat conditions. The network of existing monitoring stations run by CDWR, USGS, and USBR will need to be utilized as well, and enhanced in some locations in order to generate a comprehensive database that can be used to assess Project effects on the Delta as a whole.

Fish Response

Proposed Project operations are expected to reduce the vulnerability to entrainment of delta smelt, juvenile salmon, and other small pelagic up Old River or into Middle River from the Franks Tract area by the CVP and SWP water export facilities. In the case of adult smelt the expected outcome of Project operations is that pre-spawning adult smelt will be discouraged by a Project-created low turbidity zone from migrating from the vicinity of Franks Tract or other areas in the western Delta into lower Old and Middle rivers where they would be particularly vulnerable to transport to the export facilities. A possible undesirable Project outcome would be that adult delta smelt blocked by Project operations from entering Old and Middle Rivers directly would move into Middle River around the north side of Mandeville Island and become entrained through Project-related increased reverse flows in these channels. A second anticipated Project outcome is reduced entrainment of larval and juvenile delta smelt. A reduction in larval and juvenile smelt entrainment is expected, because 1) winter project operations should reduce delta smelt spawning in the southern Delta, and 2) the spring Project operations in combination with OCAP actions (FWS 2008) will restrict OMR negative flows. Frequent, direct sampling of fish density at sites throughout the south and central Delta, including close monitoring of CVP and SWP fish salvage will be needed to assess whether the effects of Project gate operations on migrating adult and larval/juvenile delta smelt are desirable or undesirable during the December–March spawning period.

Particle tracking and delta smelt behavioral modeling indicate that Project operations will benefit adult and larval delta smelt by reducing CVP and SWP entrainment. Direct sampling of the larval fish community at sites in the central and south delta, including at the CVP and SWP export facilities will be used to verify the results of the modeling.

The effects of gate operations on juvenile salmon and steelhead could be positive or negative depending on the river of origin and the general Delta hydrodynamic conditions during emigration. In order to evaluate Project effects on juvenile salmon and steelhead emigrating from Central Valley watersheds, direct sampling of migrants and tracking of coded wire tagged (CWT), passive integrated transponder (PIT) PIT-tagged, and acoustic-tagged juvenile salmon and steelhead is proposed.

Fish Salvage

Reducing entrainment of delta smelt at the CVP and SWP water export facilities is the primary objective of the 2-Gates Project. Because fish salvage at the SFPF and TFCF is the principal indicator of juvenile and adult fish entrainment, close monitoring of salvage will be crucial to assessing the effectiveness of the Project in achieving its primary objective and assessing its effects

on other species. In season salvage responses and statistical comparisons with historical salvage data should provide reasonable indications of whether gate operations are succeeding in the goal of reducing entrainment or having unintended consequences on entrainment of various species, life stages, or runs.

Predation

Increased predation on migrating smelt and juvenile salmonids is a potential undesirable consequence of Project gate placement and operations. Increased predation rates at gate locations could occur if predatory fishes are able to effectively utilize flow conditions or cover to increase foraging success, or if the structures concentrate predators. Non-quantitative and quantitative assessments of large predator density and behavior are needed to assess predator effects and inform possible control measures.

Table 4. Monitoring to Evaluate Effects of Gate Operations on Fish

Indicators	Method	Location	Frequency	Duration	Monitoring Enhancements
Density and location of smelt and salmonids	Spring Kodiak Trawl	Existing stations	Every other week	January - March	Increase sampling frequency at stations in central and south Delta to weekly during December-March
Density and location of larval longfin and delta smelt	Longfin smelt Larva Trawl	Existing stations	Every other week	January-June	No adjustments to this existing program
Population index of adult smelt	Fall Midwater Trawl	Existing stations	Monthly	September-December	No adjustments to this existing program
Population index of juvenile delta smelt	Summer Townet Survey	Existing stations	Twice annually	June - August	No adjustments to this existing program
Entrainment indices	Salvage Monitoring	Skinner Fish Facilities	Daily	All year	No adjustments to this existing program
Location and movement of tagged salmon in relation to gate operations	Salmon Tagging & movement Study	Releases in lower Sacramento and Mokelumne Rivers	Once annually	March – May	New sampling program
Timing of outmigrating S.J. River salmonids	Mossdale Trawl	S.J. River at Mossdale	3-5 days per week	January -May	No adjustments to this existing program
Presence of large predators, adult sturgeon or adult salmon	Didson Camera/Fish Finder Monitoring	Immediately upstream and downstream of gates, and control sites in central Delta channels	Daily during gate closure	December – mid May	New sampling program

Table 5. Monitoring to evaluate effects of Project gate operations on Delta water quality

Indicators	Method	Location	Frequency	Duration	Monitoring Enhancements
Turbidity, Electrical Conductivity, Temperature,	Automated Water Quality Monitoring	Multiple from Western Delta to South Delta	Real-Time (hourly)	All year	No adjustments to this existing program.
Temperature, Electrical Conductivity, Turbidity, Dissolved oxygen concentration	Automated Water Quality Monitoring	¼ mile downstream and upstream of each gate.	Real-Time (hourly)	During prolonged gate closure	New sampling program adding five monitoring stations near the gates, and roving crew for profiles

EXISTING MONITORING PROGRAMS AND DATA SOURCES

Much of the data to satisfy the monitoring needs described above can be gathered from existing monitoring programs conducted by the IEP and other entities. Furthermore, utilizing these existing sources of data allows Project assessment data to be easily compared with historical databases. Many of these programs sample widely distributed sites over long sampling periods and will generate monitoring data that allows for a 'big picture' analysis of Project effects. In this section of the Monitoring Plan the elements of existing monitoring programs that will be used in Project assessment are identified and described. Where noted, enhancements to existing programs are needed to meet Project assessment needs. These enhancements are discussed in detail in the next section of the Plan. Existing monitoring programs and how they will integrate into the 2-Gates Monitoring Plan are provided in Table 3.

Water Quality and Flow Monitoring

Ongoing monitoring of water quality conditions occur at key Delta sites for agricultural use, municipal and industrial use and fish and wildlife. There are numerous stations in the vicinity of the Project that can be used to monitor flow or water quality (Table 6). Permanent flow monitoring sites are also available. Established USGS, DWR, CCWD monitoring sites and additional sites, as needed by hydrodynamic modelers, will be used to monitor water quality conditions. New sensors will be installed on existing stations at locations where additional parameters will be needed.

Hydrodynamics

Flow conditions in the Sacramento and San Joaquin Delta are monitored at 19 existing sites from the Sacramento River at Freeport and the San Joaquin River at Mossdale to Collinsville (Table 6). The stations are maintained by DWR, USGS, and Reclamation. Five new sites will be added including one on the San Joaquin River at Oulton Point, and sites at either side of each gate (Table 6 and Figure 10).

Turbidity

Turbidity in the Sacramento and San Joaquin Delta is monitored at four existing sites from the Sacramento River at Freeport and Hood and at Jersey Point and Prisoner's Point on the San Joaquin River (Table 6). The stations are maintained by DWR, USGS, and Reclamation. Turbidity will be added to eleven existing stations and to the five new sites as noted in the Hydrodynamics paragraph above (Table 6, Figure 10).

Electrical Conductivity

Electrical Conductivity (EC) in the Sacramento and San Joaquin Delta is monitored at 15 existing sites from the Sacramento River at Freeport and the San Joaquin River at Mossdale to Collinsville (Table 6). The stations are maintained by DWR, USGS, and Reclamation. EC will be added to the existing Victoria Canal site and to five new sites as noted in the Hydrodynamics paragraph above (Table 6, Figure 10).

Water Temperature

Water Temperature in the Sacramento and San Joaquin Delta is monitored at five existing sites in the Central Delta (Table 6). The stations are maintained by USGS and Reclamation. Water temperature will be added to eight existing stations and to the five new sites as noted in the Hydrodynamics paragraph above (Table 6, Figure 10).

Dissolved Oxygen

Dissolved Oxygen in the Sacramento and San Joaquin Delta is monitored at one existing site in the Victoria Canal (Table 6). This station is maintained by USGS. Dissolved Oxygen will be added to twelve existing stations and to the five new sites as noted in the Hydrodynamics paragraph above (Table 6, Figure 10).

Chlorophyll-a

Chlorophyll-a in the Sacramento and San Joaquin Delta is monitored at one existing site at the San Joaquin River at Mossdale (Table 6). This station is maintained by DWR. Chlorophyll-a will be added to twelve existing stations and to the five new sites as noted in the Hydrodynamics paragraph above (Table 6, Figure 10).

Table 6. Locations and Capabilities of Monitoring Stations Supporting Operations of the 2-Gates Project

	Agency			Measures					
Existing or New Monitoring Locations	USBR	DWR	USGS	Flow	Electrical Conductivity	Turbidity	Water Temp	Dissolved Oxygen	Chlorophyll -a
Existing Monitoring Stations									
Sacramento River at Rio Vista (RIO)			●	E	E				
Sacramento River at Freeport (FPT)		●		E		E			
Sacramento River at Hood (HOO)		●	●	E	E	E			
Sacramento River at Collinsville (COL)	●		●	E	E	N	N	N	N
Delta Cross Channel (DCC)			●	E	E				
Georgiana Slough (GEO)			●	E					
San Joaquin River at Jersey Point (JPT)		●	●	E	E	E	N	N	N
San Joaquin River at Prisoners Point (PRI)	●		●	E	E	E	E	N	N
False River (FAL)			●	E	E	N	E	N	N
Holland Cut (HOL)			●	E	E	N	E	N	N
Old River at Franks Tract (OSJ)			●	E	E	N	E	N	N
Old River at Quimby Island (ORQ)			●	E	E	N	E	N	N
Old River at Bacon Island (OLD)		●	●	E	E	N	N	N	N
Middle River at Bacon Island (MID)		●	●	E	E	N	N	N	N
Middle River at Columbia Cut (MRC)			●	E	E	N	N	N	N
Victoria Canal (VIC)			●	E	N	N	N	E	N
Clifton Court Gates (CCG)			●	E	E	N	N	N	N
San Joaquin River at Mossdale (MOS)		●		E	E	N	N	N	E
Mokelumne River at Andrus Island (MOK)			●	E					
New Monitoring Stations									
San Joaquin River at Oulton Point (OUL)					N	N	N	N	N
N of Old River Gate (ORN)					N	N	N	N	N
S of Old River Gate (ORS)					N	N	N	N	N
W of Connection Slough Gate (CSW)					N	N	N	N	N
E of Connection Slough Gate (CSE)					N	N	N	N	N

NOTE: "E" refers to existing monitoring activity; "N" refers to new monitoring activity.

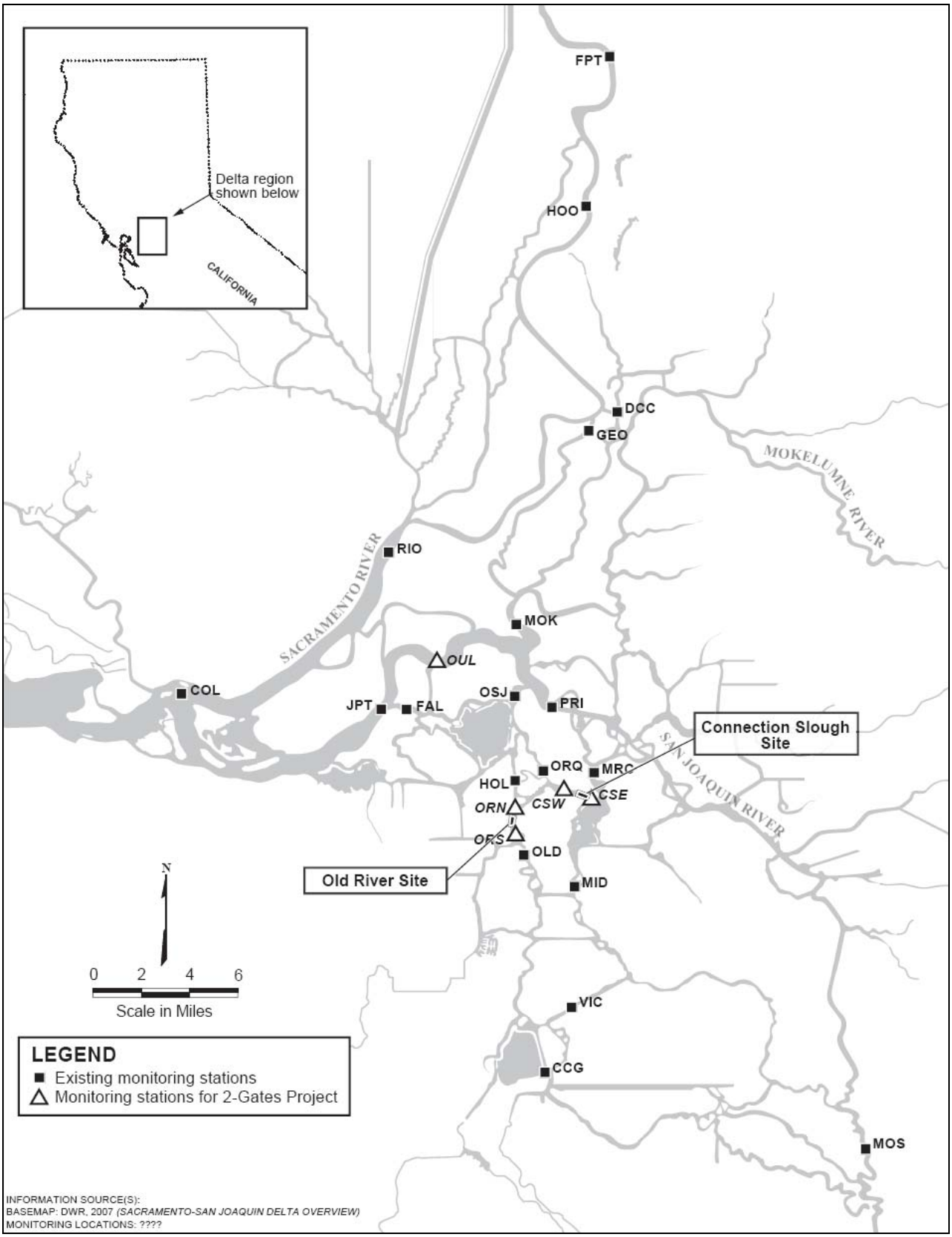

Figure 10. Locations of Existing DWR, Reclamation, and USGS Monitoring Stations in the Delta and Stations added for the Project

FISH MONITORING

Fall Midwater Trawl and Summer Townet Survey

The Fall Midwater Trawl (FMWT) and the Summer Townet Survey (TNS) are the two longest running fish monitoring programs used to index adult and juvenile delta smelt abundance. They were designed to target mid-water age-0 species and are used to develop annual indices of abundance, and characterize distribution throughout the Delta. The FMWT is conducted monthly at nearly 50 sites throughout the region from upper San Francisco Bay through the delta from September through December. The TNS is conducted during the summer at 32 stations spread from upper San Pablo Bay through the Delta (Figure 10). The TNS survey occurs at slightly different times each year that depending upon conditions related to juvenile striped bass recruitment, but a minimum of two surveys are conducted each year with start and ending dates ranging from early June to late August, respectively. These two monitoring programs occur outside of the period of potential gate operations and will not be employed as real-time monitoring tools. However, if the Project is successful in significantly reducing the entrainment of pre-spawning adults (through reduced salvage at the export pumps) and or improving the survival of spawned delta smelt (through dispersive mixing of larval and juvenile delta smelt), then abundance indices developed from these surveys should reflect an increase in delta smelt production relative to expected levels. Also, growth rates of smelt sampled from areas influenced by the Project (particularly north and west of the gates) will provide insights into how general habitat conditions have been affected by enhanced dispersive mixing resulting from the Project.

Spring Kodiak Trawl (SKT)

The existing SKT Survey samples every other week at 39 stations distributed from lower Napa River through the Delta starting in January or February and running through March. The Delta-wide surveys are supplemented by intermediate surveys focused on areas of highest adult delta smelt concentration. This trawl survey provides very useful monitoring tool for sampling the anticipated period of gate operations. The gear has proven to be effective for sampling adult delta smelt, adult longfin smelt, and juvenile salmonids. Data from the existing SKT Survey program will be used to assess the proximity of the delta smelt population to the gates and areas of high entrainment vulnerability. Four of the SKT Survey sites (809, 901, 918, 914, 812, 815, 906, and 902) are in the area clearly influenced by Project operations. The sampling frequency at these sites will need to be increased to provide the additional information needs associated with monitoring the 2-Gates operational effects (Figure 11). Also, the SKT Survey will need to begin earlier (in December) to be useful for the entire 2-Gates operational period.

20mm Survey

The purpose of the existing 20mm Survey is to monitor the annual and seasonal abundance and distribution of post-larval and juvenile delta smelt. Eight to 10 individual fortnightly surveys are conducted each year from March to July covering nearly 50 sites distributed from upper San Pablo Bay through the Delta and lower rivers. Eight of the sites (sites 809, 812, 815, and 906 in the San Joaquin River; site 901 in Franks Tract; sites 902 and 915 in Old River; and site 914 in Middle River) are located in the area influenced by the Project (Figure 10). Data from individual surveys is available in near-real-time (within 72 hours) to generally characterize the distribution of smelt relative to the Project area and areas of high entrainment risk. However, the frequency of individual surveys and the density of stations in the Project area are insufficient to provide for responsive

management of Project operations, or to provide detailed assessments of Project effects and effectiveness. The next section of this Monitoring Plan describes 20mm Survey enhancements designed to facilitate better assessment of the 2-Gates Project. Comparison of post-project survey data to pre-project survey data for south delta sites will useful in determining the effects of operations on delta smelt spawning distribution and evaluating the success of the operations in preventing spawning in the south delta. As with the FMWT Survey and TNS, growth rates of smelt sampled by the 20mm Survey should provide information about how habitat quality in areas influenced by Project operations.

Mossdale Kodiak Trawl Survey

The Mossdale Kodiak Trawl Survey is conducted on the San Joaquin River at Mossdale (just upstream of the Old River channel bifurcation) and is used to monitor the outmigration of juvenile fall-run Chinook salmon and steelhead from the San Joaquin River system, as well as to monitor the abundance of other fishes in the San Joaquin River. Frequency of sampling has ranged from 3 to 5 days a week and sampling occurs throughout the year. Daily catch is based on a series of ten-minute tows occurring within each sampling day. For the purposes of the 2-Gates Monitoring Plan, the Mossdale Trawl data is important for determining the timing of the salmon outmigration from the San Joaquin River. The Head of Old River Barrier (HORB) is installed and operated during VAMP to prevent salmon from moving into Old River. When the barrier is closed, very fish move into Old River, but continue into the Delta down the San Joaquin River past Stockton. When the barrier is open, or not installed, fish can move into Old River, then down the Grant Line Canal toward the CVP and SWP intakes. The form of the HOR "barrier" has varied over time. Most recently sound and light behavioral barriers have been installed. Both past physical barriers, and the more recent behavioral barrier, have been effective in reducing the movement of juvenile salmon into upper Old River. Knowing the timing of the outmigration and the dates of installation and closing and opening of the HORB provides useful information to interpret the salvage of San Joaquin salmon and steelhead at the fish facilities related to the 2-Gates operations. The current frequency of sampling is adequate for interpreting salvage results.

Longfin Smelt Larva Survey

This survey was initiated in January 2009 and runs every other week from January to mid-March. Thirty-five sites covering the area from Benicia through the Delta are sampled using a sled-mounted, obliquely-towed 505 micron mesh ichtyoplankton net. The gear is effective at sampling larval delta and longfin smelt and will therefore be useful (assuming adequate fish density and sample size) for monitoring the distribution of larvae in the south and central Delta during the gate operations period. Data from this survey (evaluated using DWR data analysis protocols) will be compared to the results of the particle tracking model to determine whether the modeled gate operations effects are representative of the actual effects. This comparison will be important in determining the success of the Project in reducing larval entrainment as there is no measure of larval entrainment at the CWP and SWP. No enhancements to the existing survey protocol are required to tailor it to Project assessment needs.

Fish Salvage Monitoring

Existing salvage monitoring will be sufficient for evaluating the effectiveness of gate operations at reducing entrainment of adult and juvenile delta smelt without augmentation or change. Salvage densities during Project operations will be compared to pre-project densities, and evaluated in-season, to determine if gate operations are successful at reducing entrainment of smelt and if the

salvage densities of any other species are affected by gate operations. The occurrence of tagged hatchery origin fish released in various Central Valley stream locations may provide some indication of how Project operations are effecting juvenile salmonid migration through the Delta. The number and timing of occurrences during Project operations could be compared to historical occurrences under similar hydrological conditions. Existing salvage monitoring programs report salvage indices on a daily basis in order to inform management decisions. Rapid daily reporting will be essential to the 2-Gates monitoring program and could be further supported by the 2-Gates monitoring program if necessary. No enhancements to the existing salvage sampling and reporting protocol are required to tailor it to Project assessment needs.

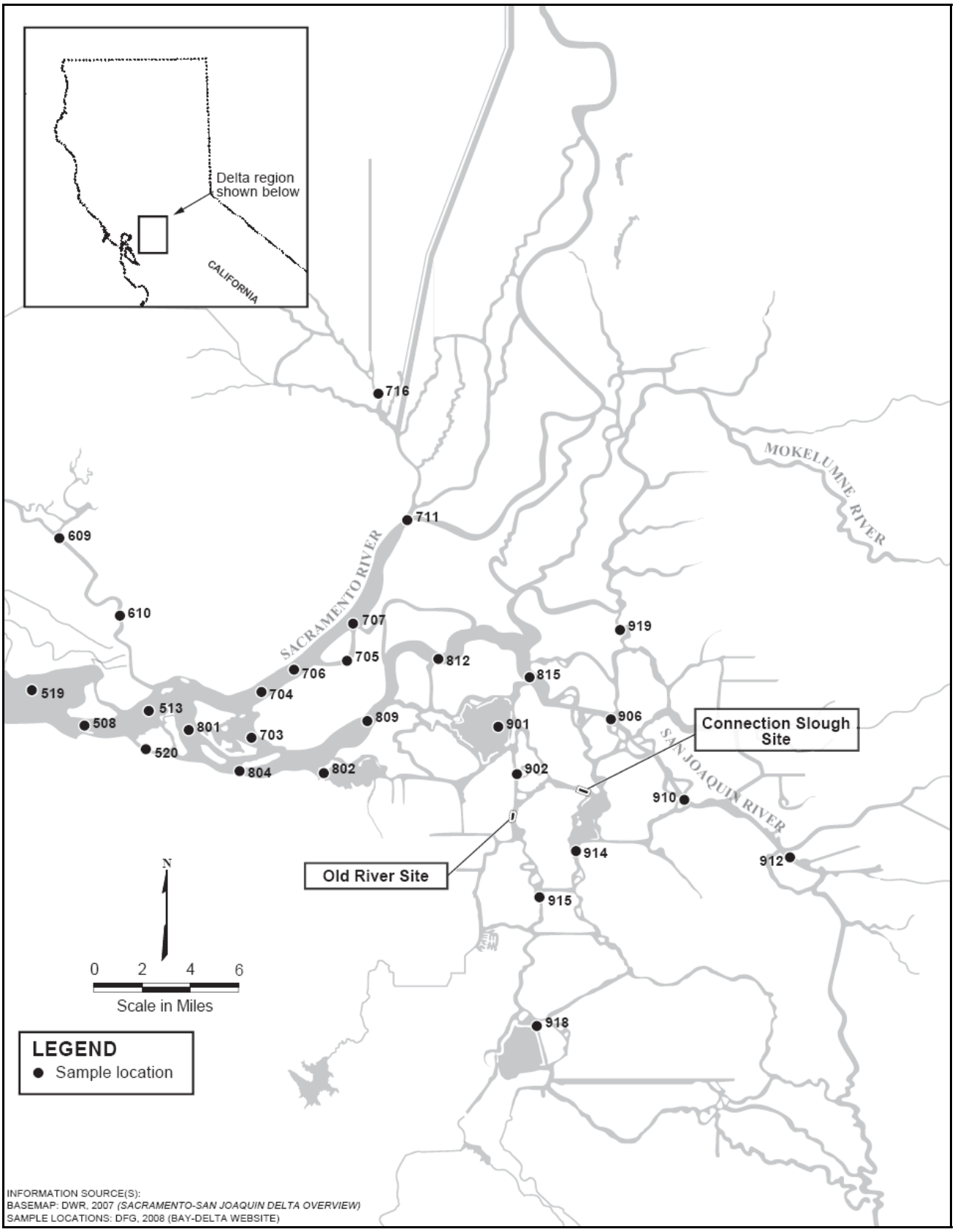

Figure 11. Map of upper estuary sampling locations for the Spring Kodiak Trawl, Townet, and 20-mm surveys.

MONITORING PROGRAMS AND DATA SOURCES (ENHANCED AND NEW)

Existing monitoring programs in their present form can provide much, but not all, of the data needed to operate and evaluate the effects of the Project. New monitoring efforts will be needed to fill the gaps. New monitoring may be a new program specifically for the 2-Gates Project or an expansion of the sampling regimen of an existing program. Additional sites will be added to some monitoring programs or the frequency of sampling may be increased. The following paragraphs describe additions to existing programs, and new programs, to be added to monitor the effects of the 2-Gates Project.

Water Quality Monitoring

Monitoring at new water quality stations (Table 6, Figure 10) will occur with automated multiparameter sensors (such as a Hydrolab Datasonde®, or YSI 6600 sonde). Automated multiparameter sensors will be deployed during gate operations (December through June). These stations will be outfitted with web-enabled remote monitoring and control allowing real-time data to be accessed remotely on a daily basis. The stations and probes will be inspected, cleaned, and serviced weekly by trained technicians. A roving water quality crew using a boat and a portable multiprobe sensor on a 30 foot cable to obtain water profile data will be utilized as needed to supplement automated sampling. All water quality instruments will be inspected, cleaned, and calibrated weekly. Real-time water quality monitoring at new sites will allow Project managers to take action to open the gates if closures resulted in near-gate elevated water temperatures (exceeding 18 °C for smelt spawning, or 24°C for smelt survival), or if dissolved oxygen levels approach 5.0 ppm (below DO requirements for salmon).

Fish Monitoring

Spring Kodiak Trawl (SKT)

The existing SKT Survey will be useful for annually characterizing the distribution of smelt populations relative to the Project gates and areas of high entrainment risk during the January through March period, however the existing SKT Survey protocol presently begins after delta and longfin smelt spawning migrations have begun and gate operations will have started. Therefore, for the purposes of 2-Gates Project assessment the duration of the SKT Survey will be expanded to include the month of December. The existing SKT Survey includes several sites within the influence of the Project (San Joaquin River sites 809, 812, 815 and 906; in Old River at sites 901, 902, and 918; and in Middle River at Site 914) (Figure 11). The sampling frequency of these sites in the immediate Project area will be increased to weekly (or some other sampling period to accurately detect the presence of delta smelt) to allow for improved assessment and adaptive management of the Project, and to better understand how turbidity influences delta smelt distribution. Kodiak trawl data will allow Project managers to evaluate how the distribution of migrating smelt is changed by gate closure or if adult smelt migrate around the gates into the south Delta through the lower San Joaquin River.

20mm Survey

As indicated in the previous section of this Monitoring Plan, the 20mm Survey in its current form is inadequate to responsively inform Project gate operations, or to clearly understand how the Project is affecting juvenile smelt in the vicinity of the Project. To facilitate meeting these information needs, the frequency of sampling at existing 20mm Survey sites within the area of influence of the Project

gates San Joaquin River sites 809, 812, 815 and 906; in Old River at sites 901, 902, and 918; and in Middle River at Site 914) will be increased from fortnightly to weekly (Figure 11). Also, adding the examination of growth rates and other measures of health and condition of smelt sampled from the western Delta may reveal whether dispersive mixing in this region from Project gate operations has improved habitat conditions.

Juvenile Salmon/Steelhead Emigration Studies

Because the proposed 2-Gates Project will modify hydrodynamic conditions in the central and southern Delta, and the Project gates are potential impediments to fish migration, the Project Monitoring Plan addresses the important topic of Project effects on the survival, and migration duration and routes, of juvenile salmon emigrating through the Delta from Central Valley watersheds.

The effects of water development on emigrating Central Valley juvenile salmonids have long been the subject of extensive monitoring and research. Until recently these investigations have relied heavily on the release and subsequent recapture of fish tagged with coded-wire tags. More recently, juvenile salmonid migration investigations have evolved towards the use of acoustic tag technology. The great advantage of the acoustic tag approach is that it allows the investigator to "recapture' a tagged fish at any desired location along a migration route by positioning one or more recording receivers in the water at that location. In general, this allows for much more refined characterizations of fish migrations and responses to conditions along the migration route. The acoustic tag approach does have it disadvantages and limitations, including the cost of individual tags, which can limit an investigators sample size, and the relatively large size of tags, which can prevent their use in smaller-sized fish typical of emigrants in some situations, and tag battery life, which can limit the time and distance an individual fish can be tracked. There are also potential problems and inefficiencies associated with the use of incompatible equipment technologies by different investigators working in the same region.

Despite some potential limitations, acoustic tagging appears very well suited to addressing questions about Project effects on juvenile salmonids emigrating through the Delta. For example, acoustic receivers positioned at the Project gate sites can readily detect migration delays or mortality occurring at these sites. Also, acoustic tags and appropriately positioned receivers can directly measure the routes taken by fish emigrating from various watershed sources when encountering Delta hydrodynamic conditions influenced by Project operations.

The conduct of acoustic tag-based salmonid migration research and monitoring in the Delta is presently very dynamic, with several studies recently completed. These include general assessments of migration duration and mortality from various parts of the watershed, detailed examination of migration behavior at key channel junctions in the northern Delta, and assessments of emigration success under the VAMP program (SRGA 2009). Some studies are ending, some just beginning, and others ongoing. NMFS' June 4, 2009 OCAP relating to Central Valley water project operations (NMFS 2009) calls specifically for continuation of juvenile salmonid migration investigations in the southern and central Delta for six years during the April – May emigration period. Planning for this six-year program will begin in September, 2009.

The investigations conducted to date have established a robust array of receivers in the central and southern Delta that is expected to be in place during the 2-Gates Project operation period (Figure

11). The Project Monitoring Plan proposes adding several receivers to the array to address questions specific to the Project (Figure 12). The key to ensuring that Project-related questions can be cost-effectively addressed by acoustic tag investigations is for Project representatives to join the existing community of investigators already collaborating on this type of work. This participation will provide the Project with the opportunity to support key parts of the existing acoustic array required for Project assessment, to contribute additional tagged fish to studies in various parts of the system that help address Project-related questions, and ensure that tagging efforts related to the Project are technologically up-to-date and compatible with other efforts. The six-year program called for in the 2009 NMFS OCAP provides a particularly timely and relevant collaboration opportunity for assessing Project effects on juvenile salmonid emigration.

Planning for 2010 VAMP-related juvenile salmonid migration studies will begin during the summer of 2009 (Pat Brandes (USFWS Stockton) personal communication). It is anticipated that the objectives and protocols of the 2010 investigations will be similar to those for the 2008 and 2009 investigations. The San Joaquin River Group Authority website (www.sjrg.org) includes a link to the final 2008 VAMP technical report (SJRG 2009). During 2008 a total of approximately 900 acoustic-tagged Chinook salmon smolts were released to investigate through Delta survival. For their study VAMP biologists employ Hydroacoustic Technology, Incorporated (HTI) tag/receiver system. Approximately one half of the smolts were released on two dates (April 29 and May 6) in the San Joaquin River at Durham Ferry and the other half on two dates (May 1 and May 8) at Stockton. The passage of smolts through the southern and central Delta was monitored at 16 acoustic signal receiver monitoring sites. The distribution of these sites was established through a collaborative effort by agency and VAMP biologists to provide smolt survival data for key reaches of the system. In combination with a survival model developed for the Project it is hoped the data can examine the effect that key migration pathways have on overall smolt survival through the system. It is expected that by adding acoustic monitoring stations near the 2-Gates Project gates in 2010 and future years, the effect of gate operations on pathway and overall survival can be ascertained.

A specific proposal has been developed in connection with the 2-Gates Project to assess Project effects on juvenile salmonids emigrating through the Delta from the Mokelumne River watershed (See Attachment D). Project effects on Mokelumne River Chinook salmon parr will be assessed by releasing two groups of ~150,000 hatchery-reared, coded-wire-tagged (CWT) parr in the New Hope Landing area coinciding with periods of gate operation and non-operation. Differences between test periods in the rates of recovery of these CWT parr in Trawl sampling at Chipps Island (western Delta) and at the CVP/SWP fish salvage facilities will provide inferences about Project operations influences on parr migration survival rates and pathways. Efforts are also proposed to capture naturally emigrating parr at the Woodbridge Irrigation District Dam near Lodi, implant these natural parr with CWTs, and release them. Variations in occurrence of these fish during the February through April season at Chipps Island associated with changes in Project operations will allow for inferences about Project effects. The proposal suggests assessing Project effects on larger (>140mm) emigrating Mokelumne River Chinook salmon smolts by implanting ~400 hatchery-reared and ~100 captured naturally migrating smolts with VEMCO acoustic tags. Observation of these acoustic-tagged fish after release in the April through June period at the many extant, new Project-related, receiver stations (Figure 12) will be used to assess Project effects on smolt migration and pathways. Comparisons will also be made with results of similar acoustic tag studies conducted in recent years in the northern Delta in the absence of the Project. A similar acoustic-tag approach is proposed to examine Project effects on juvenile and kelt steelhead. Finally, the Mokelumne River

salmonid proposal includes a pilot investigation of the feasibility of field deployed, open cod end trawling gear fitted with PIT tag detection equipment to detect PIT-tagged juvenile salmonids. If successful, this pilot study could provide a tool for sampling tagged and released salmonids without risking "take" of listed species.

During the summer of 2009 there will be a general review of the ongoing "Delta Action 8" investigations. These studies have been successfully documenting juvenile salmonid migration routes and survival through the northern Delta, but are not funded past the 2009-10 emigration season. Participation in the review will provide the opportunity to consider how continued investigations might address Project assessment objectives, and how funding from the Project could allow continuation of the investigations through the five year Project duration.

Figure 12 displays both previously established acoustic tag receiver stations and proposed stations specific to the assessment of 2-Gates Project effects on salmonid emigration. The Project-related receiver stations include stations on either side of both gates. The purpose of the stations near the gates is to identify emigrants encountering the gates and document the direction and duration of gate passage. For the purposes of Project assessment two receiver stations are also proposed for the Middle River east of the gate sites. The purpose of the Middle River stations is detect emigrants that are moving towards the water export facilities from the lower San Joaquin River and lower Mokelumne River.

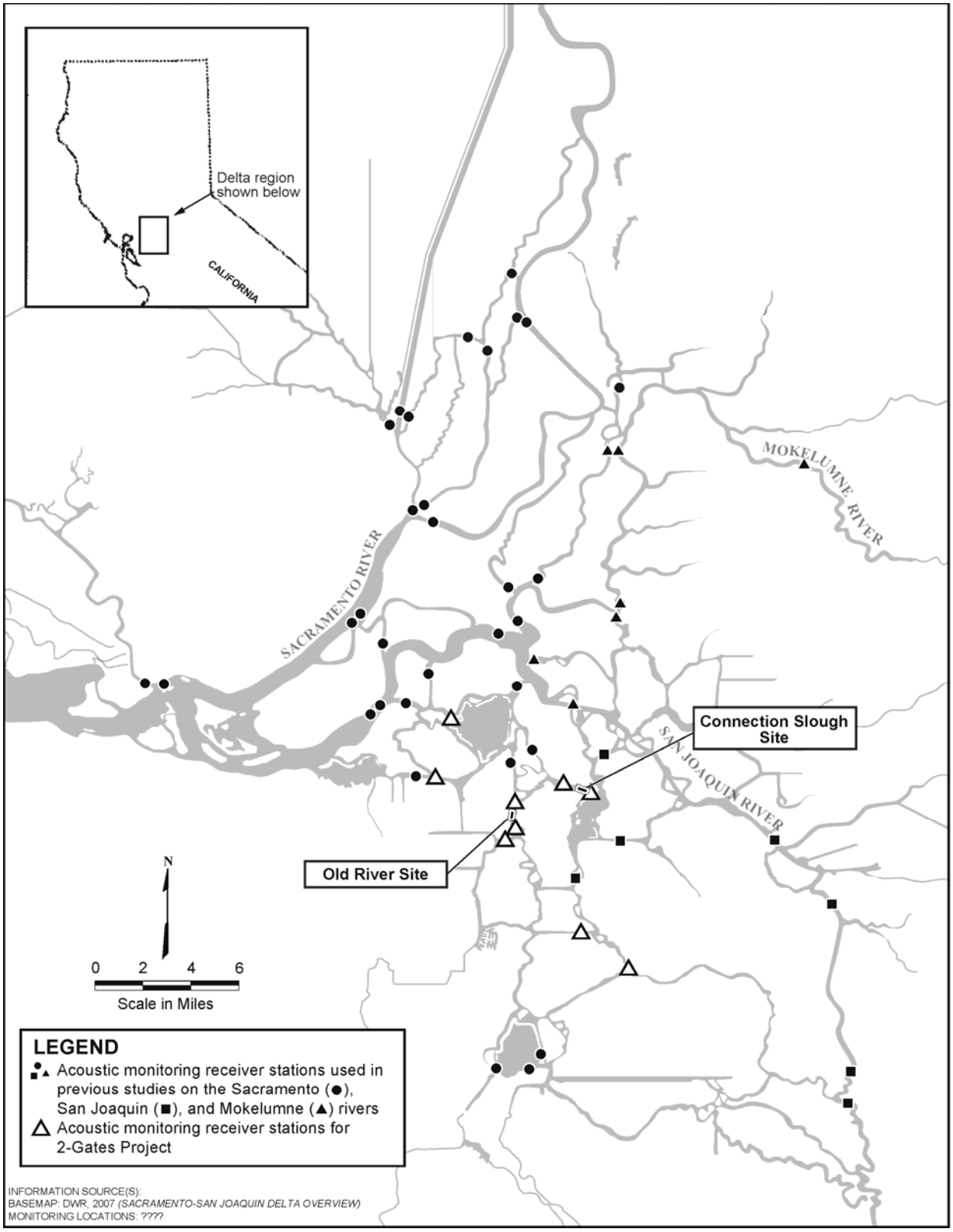

Figure 12. Integration of the 2-Gates monitoring with other potential salmon outmigration studies in the Delta using acoustic tagging methods (Sacramento, Mokelumne, and San Joaquin River (VAMP).

Camera and Sonar Monitoring for Predators and Large Fish Movement

DIDSON acoustic cameras will be used in combination with sonar ("fish finder") technology to monitor large fish movement in the river channel near the gates, the level of predator populations in the area surveyed, and how fish distribution or habitat use changes with gate operations in order to determine:

- Whether sturgeon or other large migratory fish are delayed at the gate when open or approach when closed, and if they persist when a gate is closed.
- Predator fish accumulation near the gates or along the gate abutments or barges.

DIDSON acoustic cameras are capable of detecting fish up to 12 meters away in turbid water (Maxwell & Gove 2002). Acoustic cameras will be mounted on an adjustable pole attached to the side of a small boat. The boat will be positioned along the bank with the acoustic camera pointing toward the channel thalwag at the monitoring and control sites pictured in Figures 10 and 11. Beam settings will be adjusted to detect predators such as striped bass greater than 12 inches in length or adult sturgeon holding near the gates. Two pole mounted DIDSON cameras will be utilized for monitoring. The DIDSON camera operators will move and position the camera boats between and within the monitoring and control sites. These methods will be similar to those tested by the CDWR Fish Facilities Section (2003).

In the case that predator accumulation near the gates is observed by DIDSON cameras, predator reduction efforts could be initiated. For example, electrofishing boats, large-mesh gill nets or angling, could be utilized for sampling and thinning the predator assemblage (Figures 13 and 14 show proposed locations of cameras). Recording catch per unit effort during predator thinning efforts will provide a metric of thinning success.

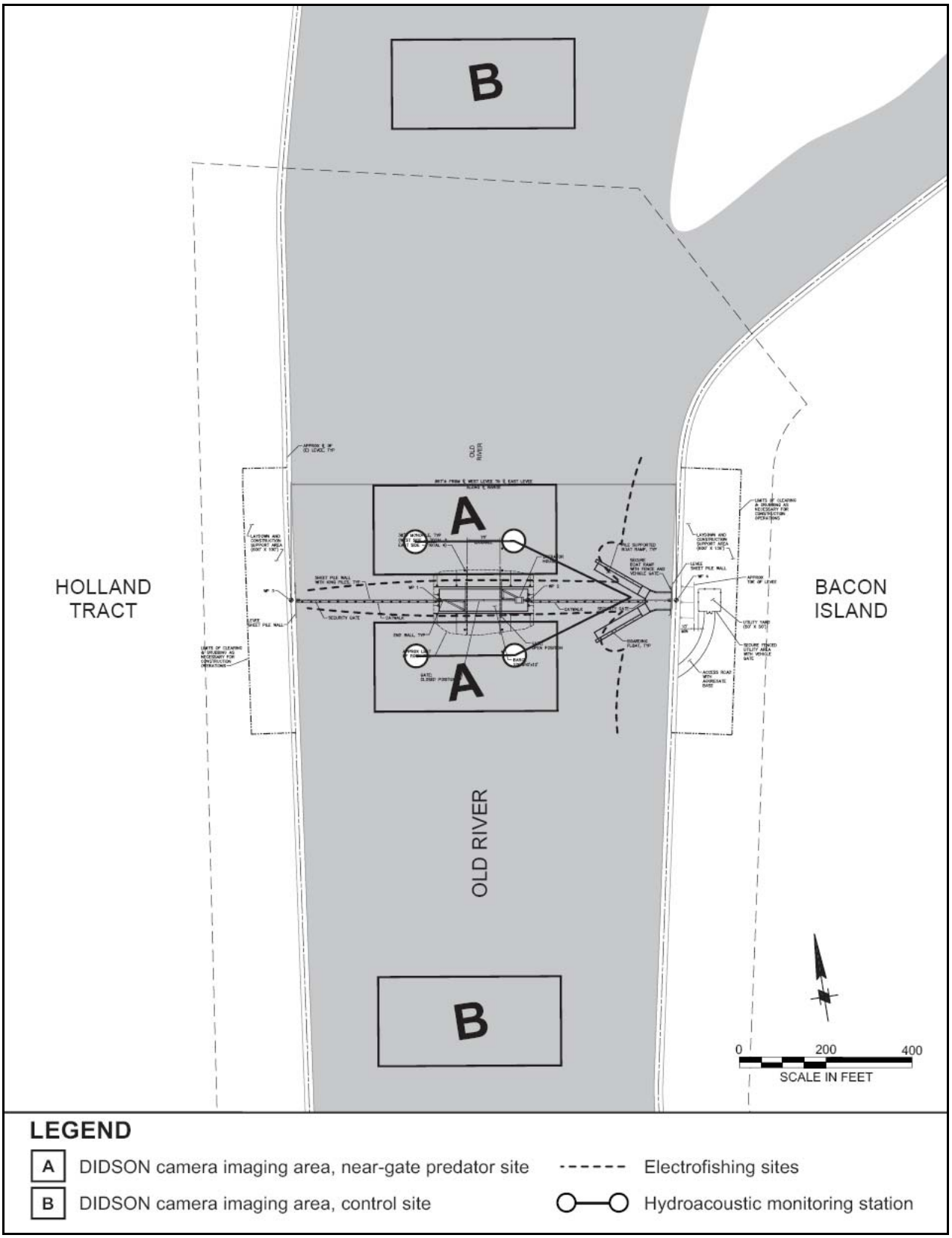

Figure 13. Old River Gate Area showing location of continuously recording hydrophone array, monitoring areas for boat-based DIDSON imaging and electrofishing sites

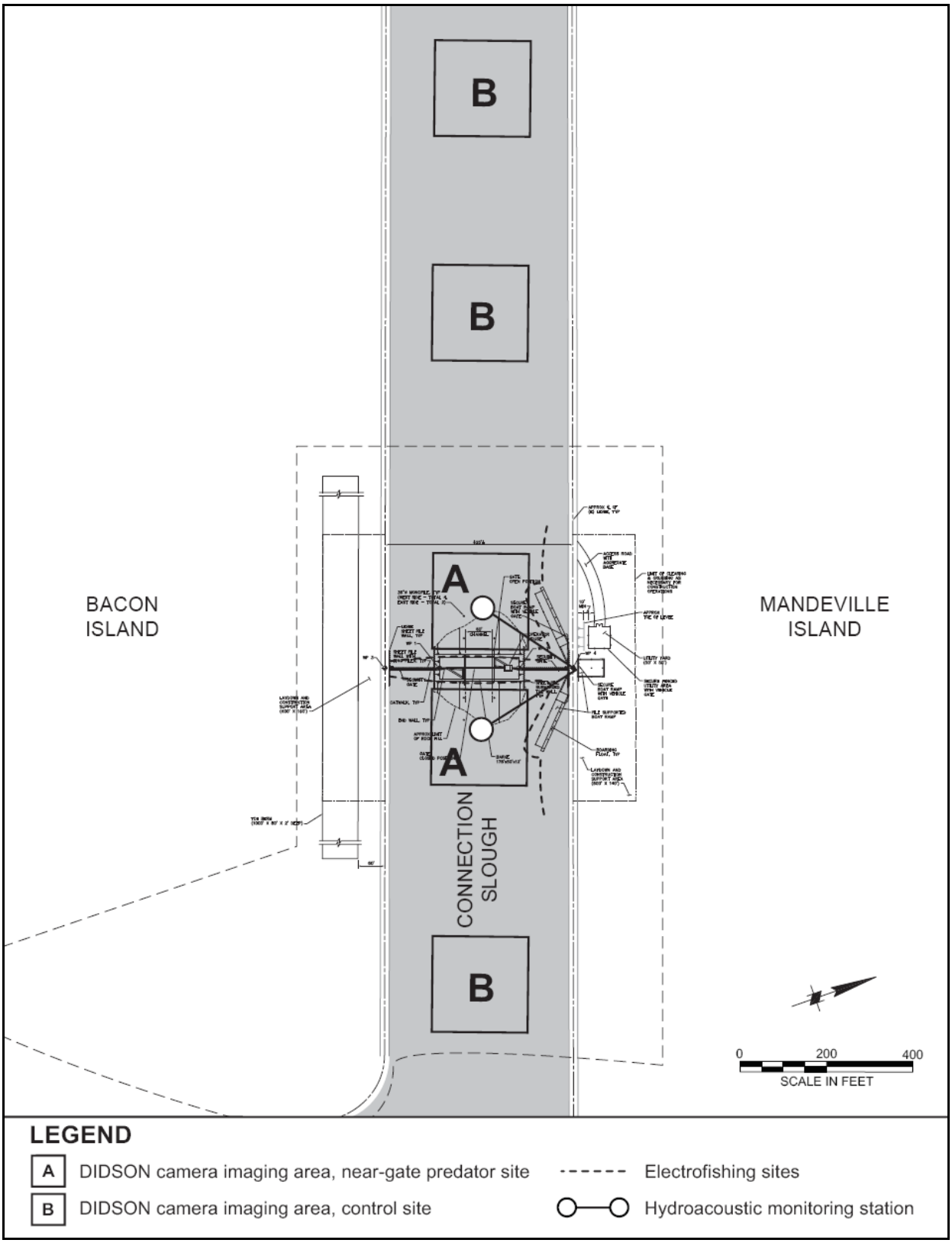

Figure 14. Connection Slough Gate Area showing location of continuously recording hydrophone stations, areas for boat-based DIDSON imaging and electrofishing sites.

DATA COMPILATION, ANALYSIS, AND REPORTING

The science and monitoring program implemented in connection with the 2-Gates Project will necessarily require a broad collaboration. The key participants in that collaboration will likely be:

- 2-Gates Project biologists provided by MWD and/or assigned from the Project-implementing agencies (e.g. DWR or USBR) to lead 2-Gates Project monitoring and assessment.
- The Interagency Ecological Program, whose ongoing monitoring programs provide the base for much of the 2-Gates Project assessment.
- Principle Investigators from individual IEP and non-IEP monitoring and research efforts that can contribute to 2-Gates Project assessment.

A broad collaboration of this sort will require a strong monitoring leadership team made of representatives from the key collaborators to provide overarching management of the multi-year effort, including:

- Ensuring participant coordination
- Managing budgets and contracts
- Keeping agency managers informed about monitoring progress and results
- Encouraging timely reporting and publication of monitoring results by program participants

Strong, independent technical oversight of the monitoring program is essential for ensuring that program results are credible and accepted by decision makers and the public. Ongoing monitoring programs will include structured periodic consultation with and guidance by regional experts including staff in the University of California at Davis Center for Watershed Sciences. University-level scientific review and strategy development would be provided in response to periodic updates by the 2-Gates monitoring leadership team. Consultation will be specifically focused toward the proposed hypotheses, monitoring, evaluation and re-hypothesizing process.

Testing strategies and implementation protocols, along with ongoing monitoring and data collection will be systematically implemented and documented to seek input and guidance to more effectively implement the monitoring program. This is expected to generate improved protection to delta smelt and potentially improved water supply benefits, while minimizing effects on other fish species.

One of the earliest steps in 2-Gates Project implementation will be establishment by the monitoring leadership team of a Data Analysis and Synthesis Team. This team will play the critical role in compiling data and information from throughout the collaboration, and synthesizing that information for decision makers and the public. An important tool for compiling and making widely available data and information related to the 2-Gates Project will be the Bay Delta Live website (www.baydeltalive.com), which has been developed as an efficient, transparent common source tool for data collection and exchange of information for the monitoring/real time operational and implementation efforts in the Delta. The site provides quick access to all ongoing data collection and dissemination programs in the Delta, including CDEC, USGS, and CDFG.

All monitoring data will be collected in accordance with established, standardized sampling protocols. In cases where existing monitoring programs are being enhanced to accommodate 2Gates project information needs, existing written sampling protocols will be refined and employed. New

written protocols developed for new Project-related monitoring programs, such as DIDSON camera monitoring, will be peer reviewed, and provided to key agencies for review and comment.

- Monitoring results will be utilized to drive an adaptive management feedback loop in which the Project team and agency representatives will analyze the data that is collected, communicate the results, and make decisions to adapt operations and monitoring. Key elements that will be considered include:

Daily and weekly memorandums, as well as monthly reports, will be written by the analysis and synthesis team and provided to the Smelt Working Group (SWG). The SWG may make additional data requests to the analysis and synthesis team. After analyzing the memorandums and reports the SWG will provide operational recommendations to the Water Operations Management Team (WOMT). The WOMT will make major decisions on operational changes related to the Project. The WOMT may request additional information and analysis from the SWG or the Project analysis and synthesis team (Figure 12).

HYPOTHESIS-SPECIFIC ANAYTICAL APPROACHES

Delta Smelt

To Be Provided: (The previous "Key Hypotheses & Question Testing" lists the key delta smelt protection hypotheses related to the Project, and the experimental designs and analytical approaches to be used in evaluating the Project.)

Other Listed Species

Table 2 provides a list of 2-Gates Project effect considerations for species other than delta smelt that the Monitoring Plan seeks to address. What follows here are general descriptions of proposed analytical approaches for addressing the various potential effects.

CVP/SWP Entrainment Rates

Fish entrainment rates for listed species are key indicators of how the Project is influencing Delta fish habitat and survival. Entrainment rates provide 1) a measure of the direct loss (mortality) of fish to the CVP/SWP water export facilities, and 2) an indication of changes in fish migration pathways through the Delta. Although it is generally not feasible to directly measure CVP/SWP fish entrainment rates, the salvage of juvenile and adult fish at the screening facilities associated with the water intakes provide indices of actual entrainment. On an ongoing basis semi-hourly estimates are made of species salvage rates. These estimates can be compiled into daily, weekly, and annual estimates of species-specific salvage. With varying degrees of accuracy (depending on the species) the semi-hourly salvage estimates can be converted to estimates of actual entrainment based on available data on screening efficiency, pre-screen loss, and other factors. Other time-averaged periods (daily or monthly) may be more appropriate for species with low densities.

In order to assess how the Project is influencing CVP/SWP entrainment and habitat conditions, available estimated rates of salvage and entrainment during periods of Project gate operations will be compared to seasonal historical rates. Of course, such comparisons can be problematic given the

high variability in Delta physical conditions, and fish distribution and abundance. To reduce the impact of variability, comparisons can be limited to years or periods of similar Delta physical conditions. High short-term (daily) variability may necessitate aggregating data into monthly estimates to make useful comparisons. Also, attempts will be made to normalize observed salvage rates against measures of seasonal and annual species abundance and distribution derived from ongoing Delta-wide fish surveys. It will be possible to report the results of these comparisons in near-real time, because preliminary daily salvage estimates are routinely made available within 24-hours.

For some species or salmonid runs it may be possible to develop new, or adapt existing, statistical models, that can predicted expected "no project" rates of entrainment or salvage. The delta smelt BO (FWS 2008) uses such a model to inform protective actions. Examples of factors that might be useful in building such models include:

- Annual or seasonal species abundance based on surveys such as the Spring Kodiak Trawl or 20mm surveys
- Species distribution metrics based on surveys
- Water quality conditions
- Hydrological factors (e.g. river inflow or Delta outflow)

In the context of the 2-Gates Project, attempts to build statistical models would be made prior to Gate installation and operation for continuous use as operations proceed. Where models can be developed with reasonably strong predictive capability, actual salvage or entrainment rates during periods of Project operation will be compared to predicted "no-Project" rates to assess Project effects.

Through-Delta Salmonid Migration Survival

Juvenile salmonids emigrating through the Delta experience highly variable rates of survival depending on general conditions in the Delta and the migration pathways. Ongoing studies involving the release and monitoring of acoustic-tagged juvenile salmonids provide detailed information about the pathways taken by individual fish emigrating through the Delta, and survival rates associated with those pathways. Based on the survival and pathway data from individual fish, statistical models have been developed to allow for estimation of overall salmonid race or species survival depending on the proportion of fish taking various pathways through the Delta.

The Monitoring Plan proposes the addition of acoustic tag monitoring sites at Project gates and elsewhere in channels influenced by gate operations. Fish occurrence data at the Project-related sites will indicate 1) the proportion of emigrants encountering Project facilities or passing through affected channels, 2) the survival rate and fate of fish passing through Project-effected portions of the Delta, and 3) the effect of Project gates and gate operations on passage time through Project-effected channels. In analyzing Project effects, the proportion (by species or race) of fish using various pathways through the Delta will be compared for periods of Project gate operations and non-operations. Also, survival data for fish emigrating through Project-effected channels will be incorporated into extant survival models, so Project effects on overall survival rates can be estimated.

Ongoing, and newly proposed (see Attachment D), large-scale programs involving the release and recapture of CWT juvenile salmonids can also potentially contribute to 2-Gates Project effects on

migration and survival. CWT juveniles are routinely released at a variety of Central Valley watershed locations, including the Delta. The occurrence of these CWT fish at the SWP/CVP fish salvage facilities and in trawl sampling at Chipps Island provide measures of through-Delta survival rates and fate. Survival and entrainment (salvage) rates for fish released during periods of Project gate operation and non-operation can be statistically compared assess Project effects. During the 5-year Project period CWT fish releases could be deliberately made to coincide with different Project operation scenarios. Comparisons of fate and survival could also be made between periods of gate operation and historical results from the many years of CWT investigations.

Near-gate Predation

It is not feasible to directly measure rates of entrainment at the Project gate structures, so the assessment of predation impacts will be inferred from observed levels of predator abundance and composition. The Monitoring Plan calls for observing predators and their behavior at gate structures during periods of both gate operation and non-operation. The Monitoring Plan also calls for predator monitoring at reference sites away from the gates. Predator monitoring, which will be accomplished using acoustic camera and fish sonar technologies, will provide images of individual large fish in areas surveyed. Predator densities (e.g. fish per m^3) will be compared between gate and reference sites, and between operation and non-operation periods at the gates. Qualitative comparisons will be made of predator behavior during periods of gate operation and non-operation.

Products and Disposition of Results

Deliverables will include monthly progress reports with invoices, brief daily and weekly memorandums, e-mail status updates, alerts and meetings on potential problems or surprises affecting operations or deliveries, presentations at science conferences, and annual drafts and final reports. All deliverables and results from the 2-Gates monitoring effort will be provided to the Water Operations Management Team (WOMT) and the Smelt Working Group (SWG) for incorporation into the decision making process for operation of the SWP and CVP facilities and to the entity responsible for operating the gates. Under a follow-on assignment, report sections may be developed and submitted for peer-reviewed publications to broadly disseminate the findings of the 2-Gates monitoring team, so other Central Valley projects may benefit from lessons learned here.

Feedback to Project Monitoring Team

The SWG and the WOMT will provide the Project analysis and synthesis team with feedback in a variety of forms. The SWG and WOMT may need additional data and analysis, an answer to a specific question, or clarification on a statement made in an analysis document. Furthermore, the SWG and WOMT will make annual assessments of whether Project monitoring protocols were meeting the needs of Project decision makers. An open line of communication between the SWG, the WOMT, and the Project analysis and synthesis team will be essential to the success of the monitoring program.

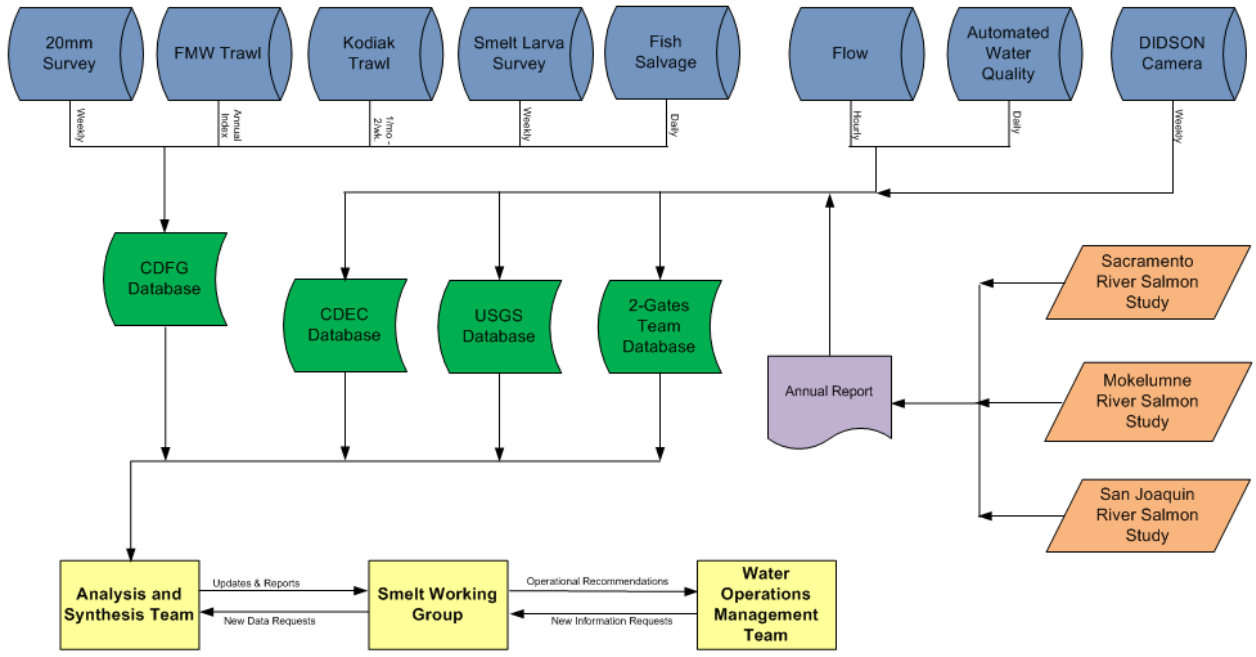

Figure 15. Proposed Information Management Structure for the 2-Gates Monitoring Program

IMPLEMENTATION ISSUES

Feasibility Issues

Study Elements

The 2-Gates monitoring program will be conducted with the most appropriate techniques and methods available but this does not guarantee definitive findings concerning Project effects on delta smelt, salmon, steelhead, green sturgeon or longfin smelt. There may be some feasibility issues associated with key elements of the monitoring plan.

Fish Capture Probability

Densities of delta smelt, longfin smelt, and steelhead are currently at record low levels making monitoring indices less reliable for these species. There is a high probability that few or no individuals of a particular species will be caught at a specific location and time even though the species may be present in the area. This presents a problem for statistical interpretation of monitoring results and may introduce increased variability into calculated population and density estimates, making temporal and geographical density comparisons difficult. Problems with low capture probability will mostly affect the Kodiak, 20 mm, and fall mid-water trawls as well as the smelt larval survey. While delta-wide annual population indices are likely to be comparable to recent annual indices and statistically robust, specific density estimates for areas affected by the gates may be difficult to calculate. Low densities also create a "detection" problem for recognizing unexpected negative Project outcomes that may require quick action to remediate.

Salmon Tracking

Each experimental release of tagged salmon or steelhead fish is an extremely intensive effort and, in order to be successful, has to be closely coordinated with numerous other monitoring programs from various organizations (IEP sampling programs, CDFG Hatchery Operations, VAMP, Sacramento River salmon migration studies, Mokelumne River salmon studies, and state and federal screen operation programs). Some elements of the proposed Project are feasible and similar projects have occurred with success in other Central Valley rivers and areas of the Delta. These include past tagging and tracking projects performed by the USGS, VAMP, and EBMUD (see Workman et al. 2008).

Environmental Variability

Conditions beyond the control of the any of the experiments include water project operations, natural events or disasters, such as a levee break. Large changes in Delta inflow conditions or in export activity may obscure effects resulting from 2-Gates Project operations. Studies in subsequent years will require revisiting the tasks, a new design effort and proposal, schedule and budget.

Permits and Agreements

All necessary ESA Take permits for the Project and associated new monitoring activities will need to be acquired. Time lines for federal ESA Section 10(A)(1)(a) permits is approximately 9 months from initial application. Initial application will need to follow issuance of a Biological Opinion in support of the Project. An alternative approach would be to have the study overseen or conducted by Principal Investigators already holding permits (e.g. the Interagency Ecological Program). Typically, an existing permit would need to be modified for the 2-Gates Project studies. Permitting could

initially be covered by Section 7 of the Endangered Species Act (16 U.S.C. 1531 et seq.) and CDFG Scientific Collecting Permits. It may be possible to obtain take authorization for new and enhanced monitoring elements by treating them as an integral part of the Project. The Plan proposes significant increases in field fisheries sampling, both in the form of new surveys and expansion of existing surveys. However, the proposed increase in sampling is not expected to result in a large increase in listed species 'take'. This expectation is based on the fact that in many cases increased sampling will occur in areas and periods of low listed species density.

ESTIMATED SCHEDULE

TBD.

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ATTACHMENTS – PROVIDED UNDER SEPARATE COVER

Attachment A. Sacramento-San Joaquin Delta Turbidity Modeling

Attachment B. Fixed-Site Monitoring Associated with the 2-Gates Fish Protection Demonstration Project Operations

Attachment C. Monitoring and Analysis to Determine if Elevated Turbities from the Sacramento River Trigger Movement of Adult Delta Smelt

Attachment D. Mokelumne Salmonid Monitoring Plan for 2-Gates Proposal