**Responses to**
**CALFED Science Program**
**Science Review of the Two-Gates Project**
**Submitted by the Metropolitan Water District of Southern California**
**November 15, 2009**

The 2-Gates Fish Protection Demonstration Project proponents would like to thank the CALFED Science Program and the Independent Science Review Panel (Panel) for your complimentary and useful comments, as presented in the report "Science Review of the Two Gates Project", September 29, 2009. You aptly determined the potential positive adaptive management aspects of the project and repeatedly reinforced the importance of our commitment to science.

We appreciate this opportunity to respond to specific comments in that report. In the time since we produced the summary document (July 16, 2009) and presented to the Panel on August 6, 2009, we have further refined the Project and its scientific investigation program and monitoring plan. Many of the Panel's recommendations have been incorporated in the updated Project, as will be detailed below. We would be pleased to collaborate with the CALFED Science Program and the panel reviewers during implementation of the Project to improve modeling techniques, monitoring protocols, and other aspects of the Scientific Investigation Program.

To set the context for our comments, it is worth recapitulating the scientific rationale for the 2-Gates Fish Protection Demonstration Project (Project). Many factors have been implicated in the decline of delta smelt, such as loss to entrainment in water diversions (including but not limited to the CVP and SWP export facilities), habitat alteration from physical and flow changes in the Delta, extremely low population levels that affect recruitment, food web alteration due to non-native invasive species, increased predation from non-native species, and contaminants. The 2008 USFWS Biological Opinion focused on entrainment at the CVP/SWP exports as a serious factor for decline. Consequently, the Project has been designed to minimize this threat. The current regulatory framework to protect delta smelt is focused largely on the reduction of exports in order to restrict negative OMR flows (USFWS 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. 2009).

The Project design is based on our best available understanding of how environmental factors and delta smelt biology interact to affect entrainment and enhance survival. For the adult phase, the focus is on the pre-spawning migration in winter and spring, which is a period of high entrainment. The best available empirical data points to a relationship between mean flows, increased turbidity, and entrainment of adults that are presumably following physical cues on their migration following winter flush events. 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. For the weak-swimming larval and juvenile phase, the focus is on enhancing transport flows away from the south Delta export facilities and toward rearing habitat in the west. Keeping adults substantially out of the south Delta may also reduce potential entrainment of their progeny.

Extensive hydrodynamic modeling and particle tracking model simulations have been performed to test these assumptions and refine the design of Project structures and operating protocols. These efforts have been continually refined throughout the Project's development, with input from the Science Panel and various agencies. We have applied expertise to address uncertainties in testing methods and quantitative performance measures as they relate to modeling, physical surrogates and field monitoring. For example, power analyses and bootstrapping techniques by Dr. Bryan Manly have been extended to estimate uncertainty levels and field sampling intensities to answer questions from agencies. In the following sections, we respond to specific comments and recommendations from the Science Panel. Our responses are based on recent revisions and enhancement of modeling runs, effects analyses, environmental documents, and the scientific investigation program and monitoring plan. Where appropriate, we cite relevant sections of the "Draft Environmental Assessment for the 2-Gates Fish Protection Demonstration Project" (EA), released by the U.S. Bureau of Reclamation on October 19, 2009 (http://www.usbr.gov/mp/nepa/nepa_projdetails.cfm?Project_ID=4472). We also cite where information will be provided in the Biological Assessment (BA) to be submitted by the U.S. Bureau of Reclamation.

**Comment 3.1 - Goals poorly defined**

The purpose, as stated in the EA (Section 2.1.1), "is to construct and operate two operable gates placed in Old River and Connection Slough to:

- Test hypotheses of RMA's delta smelt behavioral model.
- Test hypotheses of RMA's turbidity model.
- Provide entrainment protection for delta smelt.
- Avoid additional impacts on other listed species."

The Project will comply with the required RPAs, including OMR flows, described in the USFWS and NMFS SWP/CVP Operation Biological Opinions (BOs) (USFWS 2008, NMFS 2009) and other water management requirements (e.g., State water rights decisions D-1485, D-1641). Compliance with the required RPAs applies to the test and, if effective, RPAs also apply to subsequent periods of potential increased deliveries. There is no statement or intent to seek operations beyond existing requirements in the BOs or water rights decisions.

The 2-Gates Project is a five-year test only, and separate from any follow-on project (EA Sec 2.1.1):

> "The results of the Proposed Action are needed to enhance the knowledge of delta smelt behavior through data collection and monitoring that is expected to inform the future development and implementation of a plan to reduce entrainment of delta

smelt at the CVP export facility. Should a permanent project be implemented in the future, it would be subject to separate environmental review and permitting processes. The Proposed Action has independent utility, and is not dependent upon the implementation of any longer-term plan, including the Bay-Delta Conservation Plan (BDCP). It would not result in a long-term commitment to permitting or constructing permanent gate structures in Old River and Connection Slough. The Proposed Action includes removal of the gate facilities at the end of the five-year demonstration period."

**Comment 3.2 - Smelt behavioral model poorly formulated**

3.2.1. The reviews are correct in describing the Adult Delta Smelt Behavior Model (SBM) as taking a top down approach. The SBM was developed based on two primary observations. First that adult delta smelt move upstream in the winter to spawn, and second that there appears to be correlation between the presence of adult delta smelt and turbidity. The model relies on the hypothesis that fish are able to determine the upstream direction and the direction of increasing turbidity relative to the direction of tidal flows in order to deliberately utilize tidal flows (by vertical or lateral motion) to move through the system. The salinity (EC) field is used as an indication of the upstream direction with recognition that the fish may actually be using some factor to determine the upstream direction. The reviewers comment that the model requires fish to sense subtle, km-scale gradients. Because the tidal excursion is very large in the western Delta, on the order of 10-15 km, if the fish are able to approximately maintain their spatial position they will experience the subtle spatial gradients as relatively large temporal gradients with each tidal cycle.

3.2.2. Particle tracking results using the SBM provide a more realistic distribution of adult delta smelt during the winter upstream migration and spawning period than simple passive particle tracking. This is not conclusive evidence that the SBM is mechanistically correct. Other behavior models should be implemented and tested, and as the reviewers suggest, it is important to test behavior models that begin with the best available understanding as to how fish respond to their immediate environment. The Alternate Behavior Model (ABM) suggested in Appendix II is one example. The mechanisms suggested for the ABM may provide a much more realistic distribution of fish (particles) in the Suisun Bay region during low flow periods when the primary turbidity is resuspension from the bed and moderate salinity stratification is present. It is not clear that the ABM would induce upstream migration during high flow periods when vertical gradients are very small and the primary turbidity source is the freshwater inflow. The ABM should be first implemented with a 3D particle tracking model such as the one developed by Dr. Edward Gross for use with the UnTRIM3D model of the Delta.

3.2.3. A critical component of on-going work is to develop a set of clear metrics that will make it possible to evaluate alternate behavior models and model parameter calibration. These metrics should consider both salvage patterns and in-Delta fish distribution.

3.2.4. Regarding the flow field asymmetries noted in the Panel's Appendix II, these will certainly be intermittently present in the Suisun Bay region, particularly during low flow periods. There is very little if any stratification farther east in the Delta during high flow periods. There will be water quality and flow monitoring concurrent with the slack water trawl experiment. It will be possible to look for evidence of subtle stratification or flow asymmetries that may be biologically relevant.

**Comment 3.3 - The turbidity/behavior linkage is weakly statistical, not mechanistic**

The slack water sampling is directly focused on refining the understanding of the link between turbidity and upstream migration behavior. If field conditions are appropriate (the winter period is neither too dry nor too wet), the sampling may be able to identify if migration is tightly correlated with the first flush turbidity plume and whether other factors such as day-night cycles or lunar phase play an important role. Preparation of the detailed sampling plan is underway now.

**Comment 3.4 - The hydrodynamic model needs better substantiation and quantification of uncertainty/reliability**

3.4.1. As noted in the turbidity modeling report and at the science review, the turbidity model is a first attempt with an effort to make the best use of available data. To date there is insufficient observed data to fully specify the boundary conditions, and there are insufficient observations in the interior of the Delta to fully test the validity of the model. The data that is available is a mixture of turbidity, suspended sediment, and secchi disk observations.

3.4.2. A key component of the 2-Gates science program is a much more robust monitoring network for turbidity in the Delta. New data will be provided through an initial year of updating the turbidity model calibration, which may yield insights to allow better estimates of turbidity distribution for previous years from available data.

3.4.3. The turbidity modeling to date suggests that boundary inflows are the dominate turbidity source during the high flow periods. Wind resuspension does create important local turbidity spikes although it is not clear if it is important to the regional distribution. The current model is not accurately predicting the low turbidity prior to storm events which may result from resuspension in channels with tidal flows or local sources of turbidity such as Delta island return flows. As additional data is collected it will be determined if a full sediment transport model should be implemented. As noted by the reviewers, it will be important to consider the importance of organic matter and flocculation of cohesive sediments with respect to turbidity in the system.

3.4.4 The simulated turbidity field is a primary driver for the SBM particle simulations. Dr. Bryan Manly is working with RMA to implement a methodology to carry through the uncertainty in the turbidity model to the SBM particle simulations using a bootstrap error analysis. Using this method, confidence intervals with respect to potential error in the turbidity field can be produced around the SBM estimates of salvage and in-Delta distribution.

**Comment 3.5 - Fish-turbidity studies are not clearly designed**

3.5.1. Earlier investigations have worked out the appropriate logistics and design for assessing the mechanisms underlying fish vertical movements. The findings of this three-year study are detailed in three peer-reviewed publications:

- Kimmerer, W.J., J. Burau, and W.A. Bennett. 1998. Tidally-oriented migration and position maintenance of zooplankton in northern San Francisco Bay. Limnology and Oceanography 43: 1697-1709.
- Bennett, W.A., W.J. Kimmerer, and J.R. Burau. 2002. Plasticity in vertical migration by native and exotic estuarine fishes in a dynamic low-salinity zone. Limnology and Oceanography 47: 1496- 1507.
- Kimmerer, W.J., J. Burau, and W.A. Bennett. 2002. Persistence of tidally-oriented vertical migration by zooplankton in a temperate estuary. Estuaries 25:359-371.

The Project will be increasing the number of turbidity sensors in the Delta at key locations to improve resolution of this key physical attribute. Assessing delta smelt response to turbidity is more challenging, largely because the fish has become so rare and the system is dynamic.

3.5.2. Integrated hydrodynamic and fish sampling studies are proposed to evaluate the role of water transparency in determining the timing and migration of delta smelt upstream into the Delta region (EA Appendix B Scientific Investigation Program and Monitoring Plan, Key Questions & Hypotheses; and forthcoming BA and Appendices by the U.S. Bureau of Reclamation). These studies will evaluate hydrodynamic conditions and conduct non-destructive fish sampling, using a standard trawl and a high technology camera near the back end of the net by concurrently monitoring the complete tidal cycle (about 12 h) over a representative depth of the water column on the Sacramento and San Joaquin Rivers. The fixed location sampling will let the tidal currents bring the fish and turbidity past the trawl for the duration of a tidal excursion (approximately 8 miles each way), allowing effective sampling of 16 miles of river channel. Further refinements in this experimental design are being prepared to address complex behavioral characteristics of delta smelt.

3.5.3. The RMA particle tracking model has also been enhanced to simulate multiple particle model realizations driven by a single run of the RMA Bay-Delta model with bootstrap errors applied to the predicted time dependent turbidity field (results to be included in forthcoming BA and Appendices). The output from the set of realizations has been used to estimate confidence intervals about the mean predicted entrainment for several sample simulation conditions. Results from the example simulations suggest that the methodology may provide useful insights for the uncertainty in entrainment related to uncertainty in the turbidity model.

3.5.4. See response 3.6.5. for description of (1) specifications and methods for Before-After-Control-Impact (BACI) design for both modeled and observed conditions and (2) simulations to determine whether changes in the distribution of larval and juvenile delta smelt due to gate operations can be detected from intensive fish sampling or alternative surrogate salinity test methods (EA Appendix B, Scientific Investigation Program and Monitoring Plan, Key Questions and Hypothesis Testing; and forthcoming BA and Appendices).

3.5.5. The flow field asymmetries noted in Appendix II will certainly be intermittently present in the Suisun Bay region, particularly during low flow periods. There is very little if any stratification farther east in the Delta during high flow periods. There will be water quality and flow monitoring concurrent with the slack water trawl experiment. It will be possible to look for evidence of subtle stratification or flow asymmetries that may be biologically relevant.

**Comment 3.6 - Any actual adaptive management plan is vague and undefined**

3.6.1. The Project has made great strides in developing the conceptual model, operational structure and process of adaptive management. As seen in the EA, the Project description now includes decision trees for adult and larval/juvenile operating periods with explicit indicators, triggers and management decisions.

3.6.2. 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 (EA Scientific Investigation Program and Monitoring Plan, Appendix B, Figure 3). The premise is that OMR flows are affected by gate operations, which influence 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 the distribution of their offspring and risk of entrainment. The Conceptual Model underlies the experimental design and Operations Plan gate operation under different protocols to protect pre-spawning adults and larval and juvenile delta smelt (EA Operations Plan, Appendix D). A multi-year schedule of the Project's gate operations, experimental studies, relevant periods for RPA requirements for OMR flows (USFWS 2008, NMFS 2009), and IEP fish monitoring programs is provided for December 2009-July 2011 (EA, Figure 2-13) and December 2011-July 2015 (EA, Figure 2-14).

3.6.3. The start and conclusion of each operational period are triggered by specific water quality conditions (turbidity, temperature), date, and/or natural history (evidence of spawning). Decision Trees depicting triggers for gate operations and OMR flow requirements are presented for the adult operational period and the larval and juvenile operational period (EA, Figures 2-15 and 2-16). A likely sequence for gate operations and experimental periods shows how the Scientific Investigation Program may be conducted within the context of the current operational constraints, including the testing of the various hypotheses (EA, Appendix C, Figure 11).

3.6.4. Studies have been conducted to assess testing methods and quantitative performance measures of gates performance based on modelled and observed conditions (results to be included in forthcoming BA and Appendices). The intensity of sampling requirements have been evaluated to provide statistical validity of fish sampling and surrogate water constituent methods and quantitative measures. Intensive sampling simulation has been performed to see whether changes in the distribution of larval and juvenile delta smelt due to gate operations can be detected from this sampling. Detection of changes appears possible within three days of gate operations starting, providing that the catch-per-unit effort (CPUE) is not too low. Related to the detection of larval and juvenile delta smelt distributions due to gate operations, further studies are evaluating the use of salinity as a surrogate through bootstrap analyses.

3.6.5. An adaptive management framework has been developed to test key hypotheses and monitor effects in order to refine understanding, implement alternative hypotheses and improve operations. Specifications and implementation methods for monitoring project performance have been provided (EA Appendix B, Scientific Investigation Program and Monitoring Plan, Key Questions and Hypothesis Testing). Here specifications and methods for Before-After-Control-Impact (BACI) design are defined for both modeled and observed conditions. Sampling methods and quantitative measures for integrated hydrodynamic and fish sampling studies are also 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 (refinements to be included in forthcoming BA and Appendices).

3.6.6. A new 2-Gates Technical Team has been formed responsible for project management, convened by Reclamation and including representatives from regulatory agencies, CALFED Science Program, and other experts as necessary. The Project, via the Technical Team, would be integrated within the agencies' existing monitoring and decision-making processes through the Smelt Working Group (SWG) and Delta Operations for Salmon and Steelhead (DOSS).

3.6.7. In the coming months, the adaptive management framework and experimental program will continue to be refined with the agencies. Specific criteria and thresholds will be developed further with agencies' input. Alternative hypotheses will be considered as our understanding improves, and the Technical Team will be responsible for adjusting the 2-Gates investigation and monitoring program as appropriate. As such, we intend to take full advantage of the experimental aspects that have been carefully designed into the Project.

3.6.8. A comprehensive project biological monitoring budget has now been developed which includes a 5-year period to address all sampling and monitoring needs, and adaptive management protocols. The budget is currently under review with Reclamation and the project proponents. This includes a commitment for monitoring, analysis and synthesis of results, and a reasonable contingency funding to allow for budgetary uncertainties. Should the project successfully demonstrate operations that reduce delta smelt entrainment and potentially improve water exports within current discretionary flow ranges of the OCAP BOs, a long-term program may be considered, based on a separate environmental documentation and permitting process.

**Recommendation 4.1– Clarify the goal of the Project**
See response 3.1 to this comment.

**Recommendation 4.2 – Adaptive Management Plan**
See responses 3.6.5 and 3.6.6 to this comment.

**Recommendation 4.3 - Commitment for monitoring, analysis and synthesis of results**

The 2-Gates Project is based on an adaptive management approach that includes a commitment to monitoring, analysis, and synthesis of results. We have outlined an adaptive management framework, both for real-time decision-making of gate operations (decision trees and integration into decision-making process) and on an annual review schedule (2-Gates Technical Team review). The Scientific Investigation Program and Monitoring Plan (EA Appendix B) provides more details of existing and enhanced monitoring efforts. The Project will rely on and supplement existing IEP programs, and where necessary the Project proponents will augment funding to maintain necessary monitoring stations and programs. Focused studies to address key uncertainties and evaluate project effects on other species are outlined, which include new studies (predator effects at gates) and augmentations of existing programs (Delta salmon tagging studies).

**Recommendation 4.4 – Testing of mechanistic linkage is key and must be strengthened**
See response 3.3 to this comment.

**Recommendation 4.5 – Consequences to other species**

The consequences of the 2-Gates Project to other species are evaluated in the environmental documents prepared for the Project. The EA evaluates effects on aquatic and terrestrial biological resources, while the Biological Assessment evaluates effects on other listed species.

The methods of evaluating effects involve a variety of quantitative modeling analyses of operations effects on hydrodynamics, water quality, entrainment, habitat and distribution and migration pathways.  The assessment includes qualitative descriptions of other effects such as disturbance from construction, predation risk at the structures, and includes increased or new monitoring efforts.  Also addressed are direct injury or mortality and food web effects.

Supporting hydrodynamic and turbidity modeling utilize the RMA finite element models for surface waters, which are generalized two-dimensional hydrodynamic models used to compute depth-averaged velocity and water surface elevation (RMA2) and temporal and spatial description of water quality parameters (RMA11). RMA TRK particle tracking model results were was used to assess passively transported particles such as larval and juvenile delta smelt, and as an indicator of entrainment risk for migrating salmonid smolts. For adult delta smelt, the model employs a behavior algorithm to simulate the pre-spawning behavioral element.

Salmonid smolt survival through the Delta to Chipps Island with and without the Project installed and operating was assessed using the Delta Passage Model (DPM) developed by Cramer Fish Sciences (EA Appendix A, Attachment 1; and forthcoming BA and Appendices). Although the DPM is primarily based on studies of late fall-run Chinook salmon (as surrogates for Sacramento River winter-run Chinook salmon) it can be applicable to salmon and steelhead smolts with similar emigration timing. Even though the DPM does not include predation mortality occurring at the gate locations, it provides a useful tool to assess likely Delta-wide effects for the 2-Gates project on salmonid smolts. While the south Delta component of the DPM is not fully developed, this analysis includes a description of anticipated changes in tidally averaged flows at five key salmonid smolt migration junctions along the San Joaquin River through the Delta.

A comprehensive description of effects to other species such as juvenile salmon, splittail and tule perch, and their habitats can be found in the U.S. Bureau of Reclamation EA Section, Section 3.4; in EA Appendix A, Attachment 1, Salmonids Smolt Migration Analyses; and in EA Appendix B Scientific Investigation Program and Monitoring Plan. These effects will also be addressed in the forthcoming BA and Appendices to be issued through USBR.

**Recommendation 4.6 – Involve the CALFED Science Program in the project**

We appreciate the feedback from the Science Review Panel and the CALFED Science program and welcome their continued involvement. As described in the EA, the 2-Gates Technical Team is expected to engage the CALFED Science Program and relevant experts for data review and evaluation, hypothesis testing, refinement of hypotheses and management actions in the course of this five-year demonstration project.

In closing, we appreciate the Science Review Panel’s conclusion that the 2-Gates Project “is a carefully prepared initiative that represents large-scale innovative thinking to provide greater flexibility in managing the Delta that is founded on an adaptive management framework with a solid scientific basis that can evolve over time as the monitoring program generates a better knowledge of the current conditions and induced changes by the gates.” We are confident the collaboration with the CALFED Science Program and its independent scientific expertise will improve the Scientific Investigation Program. The Project has been and will continue to be refined and improved, thanks to your input.