

APPENDIX D

Operations Plan

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2 Operations Plan

D.1 INTRODUCTION

This operations plan characterizes anticipated operations of the 2-Gates Project, describes how these operations complement and coordinate with regulatory requirements imposed by recent USFWS and NMFS Biological Opinions (BOs), and summarizes operational triggers and the decision-making process.

Initial Project operations are based on an understanding of the patterns and relationships of Delta hydrodynamics, water quality parameters (particularly turbidity), delta smelt life cycle and behavioral responses to flow and water quality cues at different life stages, and entrainment by the export facilities. The initial concept for operating the Project was developed and refined using extensive hydrodynamic and delta smelt behavioral modeling by Resource Management Associates (RMA).

The Project goes beyond simply reducing negative flows in Old and Middle Rivers (OMR flows), as specified in the BOs. Entrainment reduction may be accomplished by controlling the distribution and continuity of turbidity and salinity conditions that have been identified as a component of pre-spawning, adult delta smelt habitat (USFWS 2008b). It is anticipated that the Project will enhance the isolation of delta smelt from water management operations at the Central Valley Protect (CVP) and State Water Project (SWP) pumps by limiting the upstream movement of higher concentrations of turbidity in Old and Middle Rivers from December into March. In addition, tidal operation of the 2-Gates Project may also increase dispersive mixing of water in the central or southern Delta seaward toward the western Delta. This has the potential to (1) reduce entrainment risk by dispersing larval/juvenile smelt spawned in the central and southern Delta away from the export pumps, (2) transport juvenile smelt westward toward rearing habitat near Suisun Bay, and (3) enhance export of nutrients and phytoplankton to the west Delta. Water supply benefits can be realized if it is demonstrated that entrainment at the CVP and SWP facilities is reduced or averted by modifying the general distribution of delta smelt north and west of the region of control of the gates.

The Project is designed to be operated in conjunction and coordination with OMR flow restrictions in the USFWS CVP/SWP Operations BO (USFWS 2008b) and the NMFS CVP/SWP Operations BO (NMFS 2009a)¹. Table D-1 illustrates the timing of Project operations and the most relevant Reasonable and Prudent Alternative (RPA) actions. This Operations Plan describes how the Project operations fit into the context of the RPA actions.

The control of water movement from the central Delta into the south Old and Middle Rivers is critical to the control of entrainment of delta smelt (and other pelagic species) by the CVP and SWP export facilities. Since conditions can change rapidly, the Project includes a real-time data gathering and decision framework that evaluates the best course of action for particular hydrodynamic and water quality conditions, delta smelt distributions, and anadromous fish migrations. This Plan describes operational

¹ At this time the Project will not operate during the April 1 to May 31 period to avoid potential adverse effects on emigrating salmon and steelhead. The Project will not change any conditions within the RPAs or operations specified in either the NMFS or USFWS CVP/SWP Operations BOs.

triggers, with further details on the monitoring to detect these triggers provided in the Science Investigation Program & Monitoring Plan (Appendix B).

Table D-1 Summary of RPA Requirements ¹ and Proposed Operations							
Month	2-Gates 1. Pre-spawning Adult Delta Smelt entrainment protection	2-Gates 2. Larval and juvenile delta smelt entrainment protection (dispersive mixing)	USFWS RPA Component 1 Adult delta smelt migration and entrainment		USFWS RPA Component 2 Entrainment protection of larval and juvenile delta smelt	NMFS Action IV. 2.1 Maintain SJR Inflow/Export ratio	NMFS Action IV. 2.3 Reduced exports to limit negative OMR flows depending on presence of salmonids
			Action 1 - High entrainment risk.	Action 2- extended protection			
Dec	December – March		December 1-19	December 20– March			
Jan	Operate gates to maintain low turbidity zone in Old and Middle Rivers, until water temperature ≥12°C or spawning detected.		Limit exports to reduce negative OMR flows (-2,000 cfs) for 14 days.	Limit exports to reduce negative OMR flows ▪ When turbidity & salvage low: -3,500 to -5,000 cfs, ▪ When conditions may increase salvage: -1,250 to -2,000 cfs. End when water temperature ≥12°C or spawning detected.			Jan 1 – June 15 OMR flow (-5,000 to -2,500 cfs) until after June 1 water temperature at Mossdale ≥ 22°C for 7 days.
Feb							
Mar							
		Early-mid March - March 31 Once temperature ≥12°C or spawning detected, operate gates for dispersive mixing.			Early-mid March - June 30 Once temperature ≥12°C or spawning detected, limit exports to reduce negative OMR flows (-1,250 to - 5,000) until June 30 temp ≥25°C.		
April						April 1 – May 31 Maintain Vernalis Inflow/Export ratio depending on water supply parameters (interim 2009-2011) or depending on water year (long term 2012+)	
May							
June		June 1-30 Operate gates for dispersive mixing until temperature ≥ 25°C					

1. Source: USFWS 2008b, NMFS 2009a. All OMR flow requirements are 14-day running average, with simultaneous 5-day average no more than 25 percent more negative than the requirement.

Initial Project operations will be adapted iteratively, based on monitoring and evaluation. This Plan concludes with a description of how the Proposed Action will provide additional information and another management tool to the resource agencies' decision-making process for delta smelt protection.

D.2 OPERATORS AND DECISION-MAKERS

The U.S. Bureau of Reclamation (Reclamation), or its designee, will maintain and operate the Project facilities (e.g., gates, small boat portage ramps) in a manner that is consistent with operations of the OMR flow restrictions under the RPAs established by CVP/SWP Operations BOs. Information from the hydrodynamic and behavioral models will be provided to Reclamation and used to optimize the timing and duration of gate operations.

Decisions will be made via an adaptive process, discussed in more detail at the end of this Operations Plan. Under the USFWS (2008b) CVP/SWP Operations BO, the Smelt Working Group (SWG) meets to consider fish distribution and relative abundance in light of Delta conditions and makes recommendations to USFWS. The USFWS then brings the proposed action (which may be modified from what the SWG has recommended) to Water Operations Management Team (WOMT). Under the NMFS CVP/SWP Operations BO, the Delta Operations for Salmon and Sturgeon Technical Working Group (DOSS) provides recommendations to NMFS, which then brings proposed action to WOMT. The WOMT can either adopt the USFWS's determination or can suggest an alternative action. The USFWS then makes the ultimate decision. The Project operations will fit into this adaptive process. A 2-Gates Study Team will be formed to assess forecast modeling and real-time data on Delta conditions and make recommendations on gate operations to the SWG, DOSS and agencies. In this manner, the Project will provide a new management tool (gate operations) and additional data for the regulatory agencies' decisions.

D.3 FACTORS TO BE CONSIDERED FOR OPERATIONS

Historically, entrainment of delta smelt at the export facilities has occurred primarily during December through June. The scientific understanding of smelt movement, behavior, and entrainment continues to evolve, but it is recognized that the presence of water quality factors in the south Delta and net flow reversals in Old and Middle Rivers can be a significant cause for delta smelt entrainment. The distribution of pre-spawning adult delta smelt is believed to be strongly related to specific ranges of salinity and turbidity. The recently released CVP/SWP Operations BO (USFWS 2008b) strongly supports the linkages between turbidity and delta smelt occurrence and salvage. These water quality factors (electrical conductivity greater than 400 $\mu\text{mhos/cm}$ and turbidity greater than 12 NTU) occur in different parts of the Delta depending on hydrologic conditions and operation of the SWP and CVP facilities. These water quality factors normally occur in the regions of Suisun Marsh and Cache Slough. However, under certain hydrologic and operating conditions, the water quality factors can be substantially moved into the central and south Delta due to reversal of flows on the Old and Middle Rivers.

Adult pre-spawning delta smelt are believed to "seek-out" this turbidity plume by "surfing" the tides and in so doing transport themselves to more inland areas in advance of spawning. The mechanism of pre-spawning delta smelt migration to inland areas has not been verified. Under the current configuration of the south Delta, high exports during these times cause net flow reversals of Old and Middle Rivers, drawing these water quality conditions into the south Delta, which can lead to significant entrainment of pre-spawning adult delta smelt. In addition, delta smelt spawning in the central and south Delta is believed to cause subsequent larval and juvenile smelt entrainment due to the progeny's proximity to the export facilities.

D.4 POTENTIAL MEASURES FOR CONTROLLING ENTRAINMENT

Management strategies to reduce the risk of delta smelt entrainment were evaluated that seek to control adverse hydrodynamic conditions associated with either the movement of turbidity into the central and south Delta or the direct transport of the early life stages of delta smelt into the region of the Delta where they are likely to become entrained by the export facilities. A dual hydrodynamic approach for protecting against delta smelt entrainment is believed to be the most appropriate strategy. The proposed strategy focuses on the operation of a gate system on Old River and Connection Slough to balance negative flows in the Old and Middle River channels and limit development of water quality characteristics that will influence movement of delta smelt habitat into the south Delta. The 2-Gates operation will provide the necessary control on Old and Middle Rivers when used in concert with other actions to manage OMR negative flows. These two actions need to work in concert to provide comprehensive management of entrainment effects at potentially reduced water costs.

D.5 GATE OPERATION PROTOCOLS

The protocols for operating the gates are based on our conceptual understanding of factors affecting smelt entrainment, as described earlier, and refined through hydrodynamic and behavioral modeling. Currently, there are two operational periods, based on delta smelt life-stage-specific objectives and season under the USFWS CVP/SWP Operations BO: (1) pre-spawning adult protection and (2) larval and juvenile protection (Table D-2). Gate operations will begin as early as December each year when smelt distributions are located north and west of the Project facilities as determined by flow, turbidity and salinity, and biological data collected by Project monitoring.

The anticipated operations planned for the initial year are discussed below. Operations in subsequent years or within the initial operational year could be adjusted, based on monitoring data, to improve project effectiveness and to refine hypotheses. A multi-year schedule of the Proposed Action's gate operating periods and experimental periods, along with relevant RPA periods and Interagency Ecological Program (IEP) monitoring programs, is presented for December 2009-July 2011 (Figure D-1) and December 2011-July 2015 (Figure D-2).

Table D-2 Planned Operational Periods

Operational Period	Season	Operational Schedule	Triggers, Off-ramps, and Notes
Pre-spawning Adult Protection	Approximately December 1 to 15 – early March	Gates closed 0.5-2.5 hours daily.	<ul style="list-style-type: none"> Gates would be operated to balance flows between Old and Middle rivers and maintain a low turbidity zone in these rivers. Trigger for Operations - Turbidity \geq 12 NTU at San Joaquin River at Jersey Point. Off-ramp - Water temperatures \geq 12°C or a "spent" female smelt detected in Spring Kodiak trawl (SKT) or salvage.
Larvae and Juvenile Protection	Early March - March 31	Old River gate closed on flood tide (twice daily, about 10 hours total daily) and open on ebb and slack tides (~14 hours daily). Connection Slough gate closed about 20 hours daily and open during slack tide (~4 hours daily).	<ul style="list-style-type: none"> Gates would be operated to maximize dispersive mixing. Trigger for operations - Water temperatures \geq 12°C or a "spent" female smelt detected in SKT or salvage. Old River gates periodically opened during daylight hours for 15-20 minutes when there is boating demand.
	April 1 - May 31	Gates open at all times, including Memorial Day weekend.	<ul style="list-style-type: none"> Gates would not be operated during this period (Ref NMFS RPA IV 2.1)

2-Gates Fish Protection Demonstration Project

	June 1 - June 30	Old River gate closed on flood tide (twice daily, about 10 hours total daily) and open on ebb and slack tides (~14 hours daily). Connection Slough gate closed about 20 hours daily and open during slack tide (~4 hours daily).	<ul style="list-style-type: none"> • Trigger for operations – Commence gate operations June 1 • Off-ramp - June 30 or when Delta water temperatures \geq 25°C. Gates open continuously until trigger monitoring commences in December. • Old River gates periodically opened during daylight hours for 15-20 minutes when there is boating demand.
No Operations	July – November	Gates open at all times.	<ul style="list-style-type: none"> • Gates open continuously to allow fish movement and navigation. • Monitoring for triggers for adult operations resumes in December.

Year	Ops Year		Month												
			Dec	Jan	Feb	Mar	Apr	May	June						
2009-10 and 2010-2011	0 & 1	USFWS RPA* Component 1 Adults	RPA Comp. 1, Action 1 -2,000 OMR	RPA Component 1 Action 2 When turbidity & salvage low, then OMR -3,500 to -5,000 cfs. When turbidity and flow conditions may increase salvage, then OMR -3,000 to -5,000 cfs. Cease when water temperature reaches 12°C or spent female found											
		Component 2 Larvae/Juveniles							RPA Component 2 - When water temperature reaches 12°C or spent female found, then OMR flows -1,250 to -5,000 cfs.						
		NMFS BO RPA*		NMFS Action IV 2.3 OMR flows -2,500 to -5,000 cfs (Salvage trigger: 1st stage then -3,500 cfs for at least 5 days; 2nd stage trigger, then -2,500 cfs for at least 5 days)											
		VAMP							NMFS Action IV.2.1 San Joaquin River flows at Vernalis, OR a ratio of San Joaquin River flow at Vernalis and combined exports						
		IEP Sampling	Kodiak trawling				20-mm survey				Tow-net survey				
2009-10	0	2-Gates Studies & monitoring	2-Gates Technical Team refines experimental design and monitoring elements and establishes baseline water quality conditions						Salmon survival through Old & Middle rivers with gates (tagged release)						
			Predators in Old & Middle rivers without gates, Maybe Sturgeon movements through Old & Middle rivers without gates (tagged salvage fish)												
			2-Gates Project Operations			Gate Operations for Adult Delta Smelt						Juvenile Gate Ops	Juvenile Gate Ops		
2010-2011	1	2-Gates Studies & monitoring	H1 Flow balance	H2 Maintain a low-turbidity zone in Old & Middle rivers Reduced adult smelt entrainment						H4	H5 Dispersive Mix			H5 Dispersive Mix	
				H3 Fixed station trawl of turbidity-adult delta smelt migration											
											Salmon survival through Old & Middle rivers with gates (tagged release)				
				Predators in Old & Middle rivers with gates Sturgeon movements through Old & Middle rivers with gates (tagged salvage fish)											

* USFWS BO RPA OMR flow requirements must be met on a 14-day running average, and a simultaneous 5-day running average within 25% of 14-day OMR flow requirement
H = Hypothesis to be tested (5 hypotheses total)

Figure D-1 Annual Schedule of 2-Gates Project Operations and Relevant RPA Requirements, and IEP Monitoring for December 2009 – June 2011

2-Gates Fish Protection Demonstration Project

Year	Ops Year		Month												
			Dec	Jan	Feb	Mar	Apr	May	June						
All years starting Dec 2011	2 to 5	USFWS RPA * Component 1 Adults	RPA Comp. 1, Action 1 -2,000 OMR			RPA Component 1 Action 2 When turbidity & salvage low, then OMR -3,500 to -5,000 cfs. When turbidity and flow conditions may increase salvage, then OMR -3,000 to -5,000 cfs. Cease when water temperature reaches 12°C or spent female found									
		Component 2 Larvae/Juveniles					RPA Component 2 - When water temperature reaches 12°C or spent female found, then OMR flows -1,250 to -5,000 cfs								
		NMFS BO RPA *		NMFS Action IV 2.3 OMR flows -2,500 to -5,000 cfs (Salvage trigger: 1st stage then -3,500 cfs for at least 5 days; 2nd stage trigger, then -2,500 cfs for at least 5 days)						NMFS Action IV.2.1 Ratio of SJR flow @ Vernalis and Combined exports					
		IEP Sampling	Kodiak trawling						20-mm survey						Tow-net survey
2011-12 and 2012-13	2 & 3	2-Gates Project Operations	Gate Operations for Adult Delta Smelt						Juvenile Gate Ops					Juvenile Gate Ops	
		2-Gates Studies & Monitoring	H2 Turbidity gap ops, H4 Reduced adult smelt entrainment						H5 Dispersive Mx					H5 Dispersive Mx	
								Salmon survival through Old & Middle rivers with gates (tagged release)							
					Predators in Old & Middle rivers with gates Sturgeon movements through Old & Middle rivers with gates (tagged salvage fish)										
2013-14 and 2014-15	4 & 5	2-Gates Project Operations	Gate Operations for Adult Delta Smelt						Juvenile Gate Ops					Juvenile Gate Ops	
		2-Gates Studies & Monitoring (reevaluate continuing tagged fish and predator studies)	H2 Turbidity gap ops, H4 Reduced adult smelt entrainment						H5 Dispersive Mx					H5 Dispersive Mx	
								REEVALUATE - Salmon survival through Old & Middle rivers with gates (tagged release)							
					REEVALUATE - Predators in Old & Middle River at gates, Sturgeon movements through Old & Middle rivers with gates (tagged salvage fish)										

* USFWS BO RPA OMR flow requirements must be met on a 14-day running average, and a simultaneous 5-day running average within 25% of 14-day OMR flow requirement
H = Hypothesis to be tested (5 hypotheses total)

Figure D-2 Annual Schedule of 2-Gates Project Operations and Relevant RPA Requirements, and IEP Monitoring for December 2011 – June 2015.

D.5.1 Operational Triggers and Off-Ramps

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 (Figure D-3) and the larval and juvenile operational period (Figure D-4).

Turbidity (≥ 12 NTU) is the trigger for initiating adult protective measures for both the Proposed Action and USFWS's RPA Component 1 established by the CVP/SWP Operations BO (USFWS 2008b). The USFWS RPA Component 1 is triggered when the three-day-average turbidity from three stations (Prisoner's Point, Holland Cut, and Victoria Canal) is ≥ 12 NTU. The Proposed Action uses turbidity data from a different location, namely when turbidity reaches 12 NTU at the San Joaquin River at Jersey Point. Modeling indicates that this would occur 3 to 21 days earlier than the three-station trigger to initiate USFWS RPA Component 1. Using Jersey Point data provides more advance warning of conditions that are expected to trigger pre-spawning adult smelt migration, and thus allows more time to formulate decisions regarding gate operations. Water temperature and initiation of delta smelt spawning are used as the triggers for measures to protect larval and juvenile delta smelt. The USFWS RPA Component 1 is suspended and RPA Component 2 is triggered when (1) mean daily water temperatures at Mossdale, Antioch, and Rio Vista are $\geq 12^{\circ}$ C, or (2) delta smelt have begun spawning (spent female delta smelt are detected in Spring Kodiak Trawl [SKT] or salvage). The RPA Component 2 is suspended June 30 or when daily average water temperatures reach 25° C for three consecutive days at Clifton Court Forebay. The Proposed Action utilizes these same triggers. (The RPA Component 2 can also be suspended any time the three-day average flow on Sacramento River at Rio Vista is $\geq 90,000$ cfs and the three-day average flow on the San Joaquin River at Vernalis is $\geq 10,000$ cfs.)

Data on physical triggers (turbidity, temperature, average daily flow) will be provided from fixed monitoring stations in the Delta, as described in the Science Investigation Program and Monitoring Plan (Appendix B). If an information gap occurs during real-time monitoring of a particular trigger, such as turbidity at Jersey Point, data from surrounding stations and sources will be used to provide information for decision-making. These include turbidity at other stations, especially upstream of Old and Middle Rivers, flow information for the Sacramento River and other incoming tributaries (indicating conditions that would result in a first flush event or a pulse of rising turbidity and flow), and storm forecasts.

Although salvage is a trigger for USFWS RPA requirements, it will not be used as a trigger to commence adult gate operations. Salvage data does provide valuable feedback for guiding gate operations and exports, testing hypotheses, and adaptive management. Salvage will be used as a warning sign for evaluating and adjusting operations as necessary.

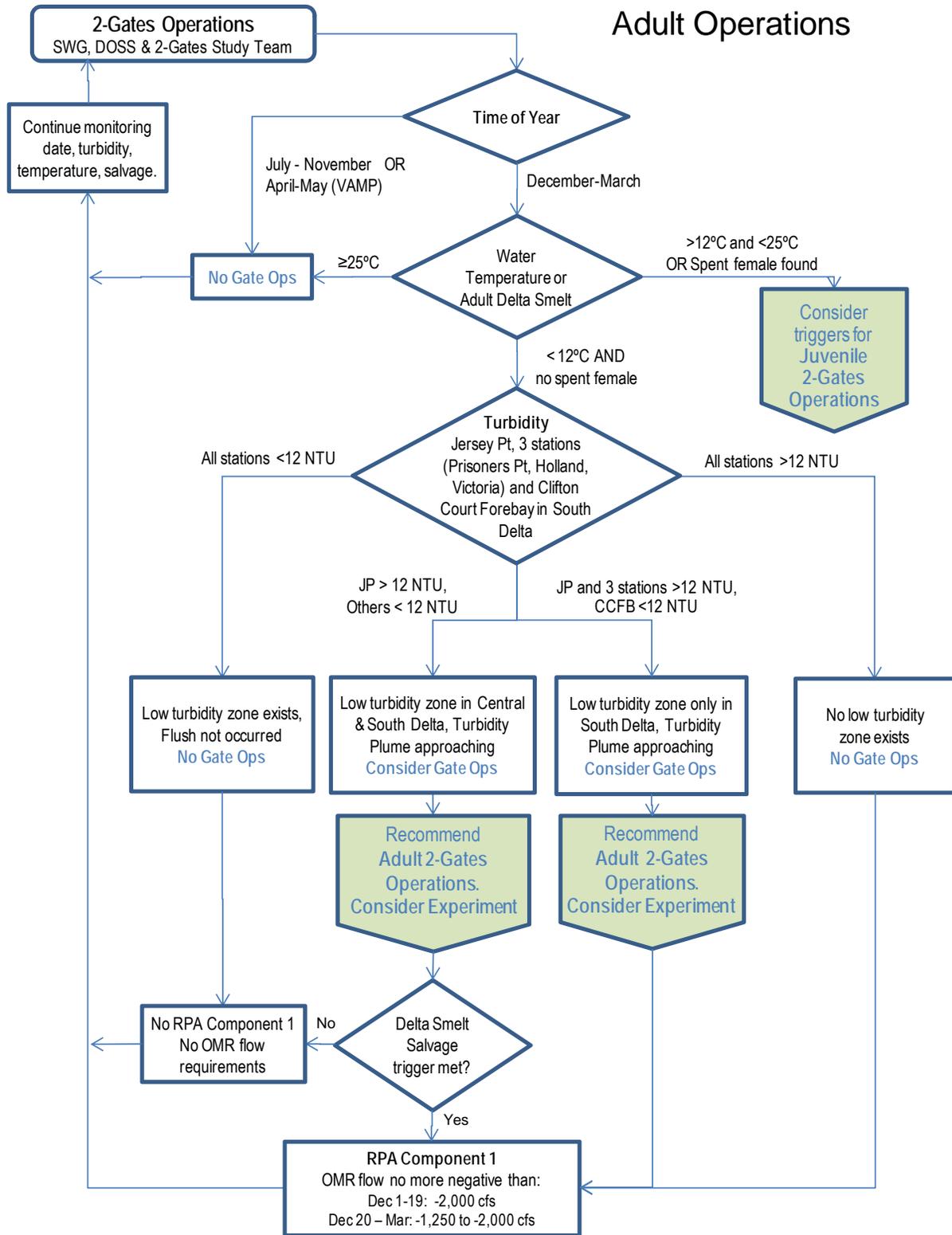


Figure D-3 Decision Tree and Triggers for Adult 2-Gates Operation Period

Larval/Juvenile Operations

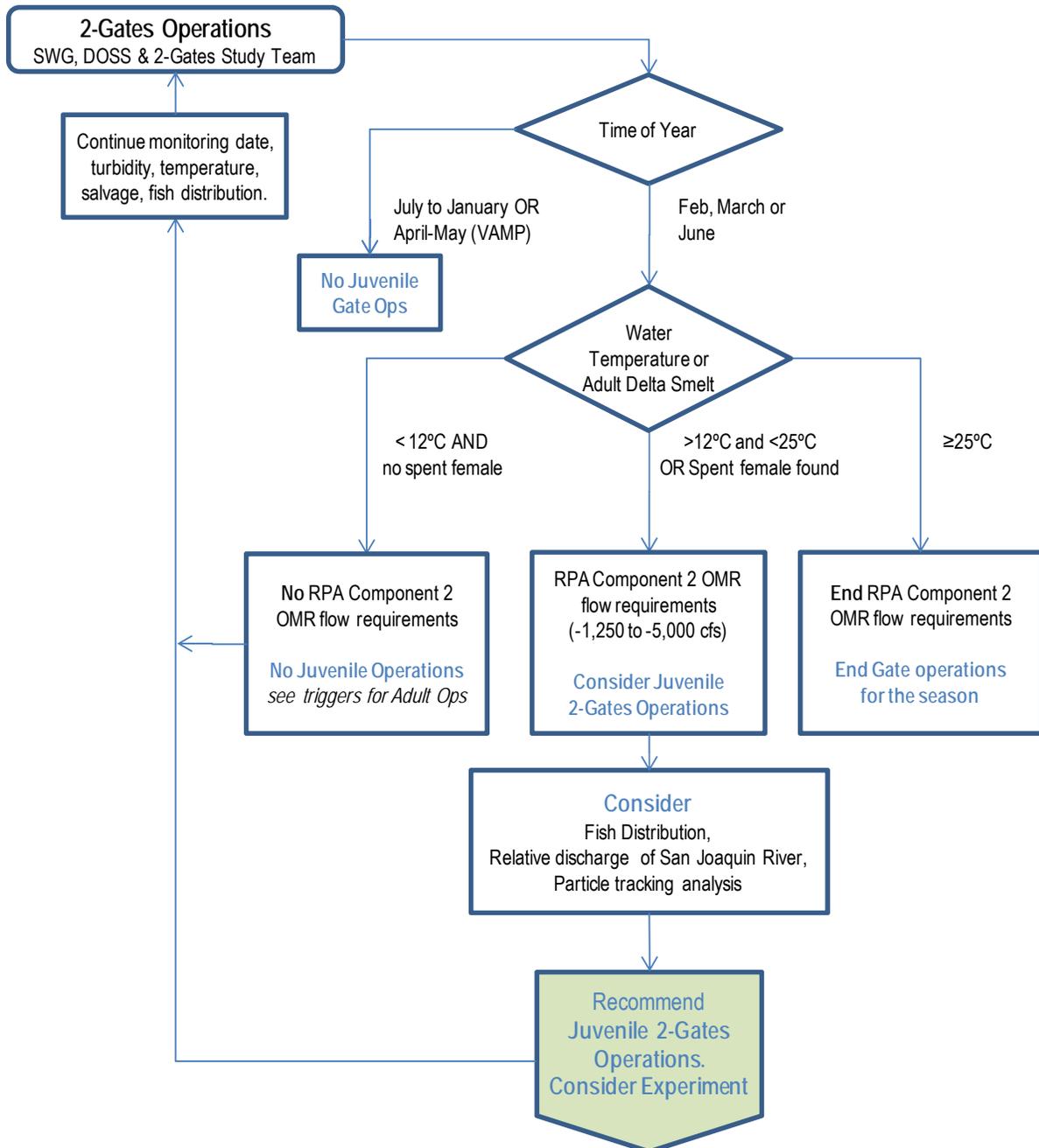


Figure D-4 Decision Tree and Triggers for Larval and Juvenile 2-Gates Operation Period

D.5.2 Adult Delta Smelt (December through March)

OBJECTIVE

To provide equal or improved protection of pre-spawning adult delta smelt from entrainment with early operation of the Project facilities and early implementation of RPA Component 1 Action 1 and, once demonstrated to be an effective tool for the protection of delta smelt, to allow SWP and CVP water exports to increase while operating within the required OMR flow range established by the CVP/SWP Operations BOs (USFWS 2008b) and all other water management requirements.

ACTION

To protect pre-spawning adult delta smelt as they migrate inland, the gates will be operated from the onset of the higher turbidity conditions from December into March. After December 1, gates would be operated in Old River and Connection Slough to balance flows in Old River and Middle River either before or in conjunction with RPA Component 1 Action 1 in order to maintain a low turbidity zone (<12-15 NTU) in Old River and Middle River between the central Delta and the south Delta export facilities (Hypothesis 2). The gates will be closed 0.5-2.5 hours daily in advance of a forecast high turbidity event.

Gate operations would occur while OMR flow requirements are in place during this period². When turbidity or salvage reach trigger levels during December 1-19, USFWS RPA Component 1 Action 1 would be implemented, which requires average daily OMR flow³ no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent). RPA Component 1 Action 2 would be implemented after Action 1 (after December 19) or when determined by the SWG. When turbidity and salvage are low during this period, average daily OMR flow would be no more negative than -3,500 cfs to -5,000 cfs (14-day running average), with a 5-day running average within 25 percent. When conditions occur that may result in increased salvage (i.e., turbidity or salvage triggers met), average daily OMR flow would be no more negative than -1,250 cfs to -2,000 cfs (14-day running average), with a 5-day running average within 25 percent. Forecast model simulations will be rerun in response to real-time turbidity data as needed to detect upcoming high turbidity events.

The decision process for adult gate operations according to trigger conditions is illustrated in Figure D-3.

TIMING

The adult operations will occur December into March. A typical sequence for gate operations and experimental periods is illustrated in Figure D-5. This illustrates how the Scientific Investigation Program may be conducted within the context of the CVP/SWP Operations BO RPAs, including the testing of the various hypotheses during the monitored “before” condition with gates open and the “after” condition with gates in operation. The 2-Gate adult operations will occur concurrently with the USFWS CVP/SWP Operations BO RPA Component 1.

² RPA Component 1 Action 2 OMR flow requirements do not apply whenever a three day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, OMR flow requirements of the Action are again in place (USFWS 2008b).

³ OMR flows for this and all relevant actions would be measured at the Old River at Bacon Island and Middle River at Middle River stations, as has been established already by the Interim Order. OMR flow requirements are generally measured as 14-day running average, with a simultaneous 5-day running average within 25 percent of the 14-day flow requirement.

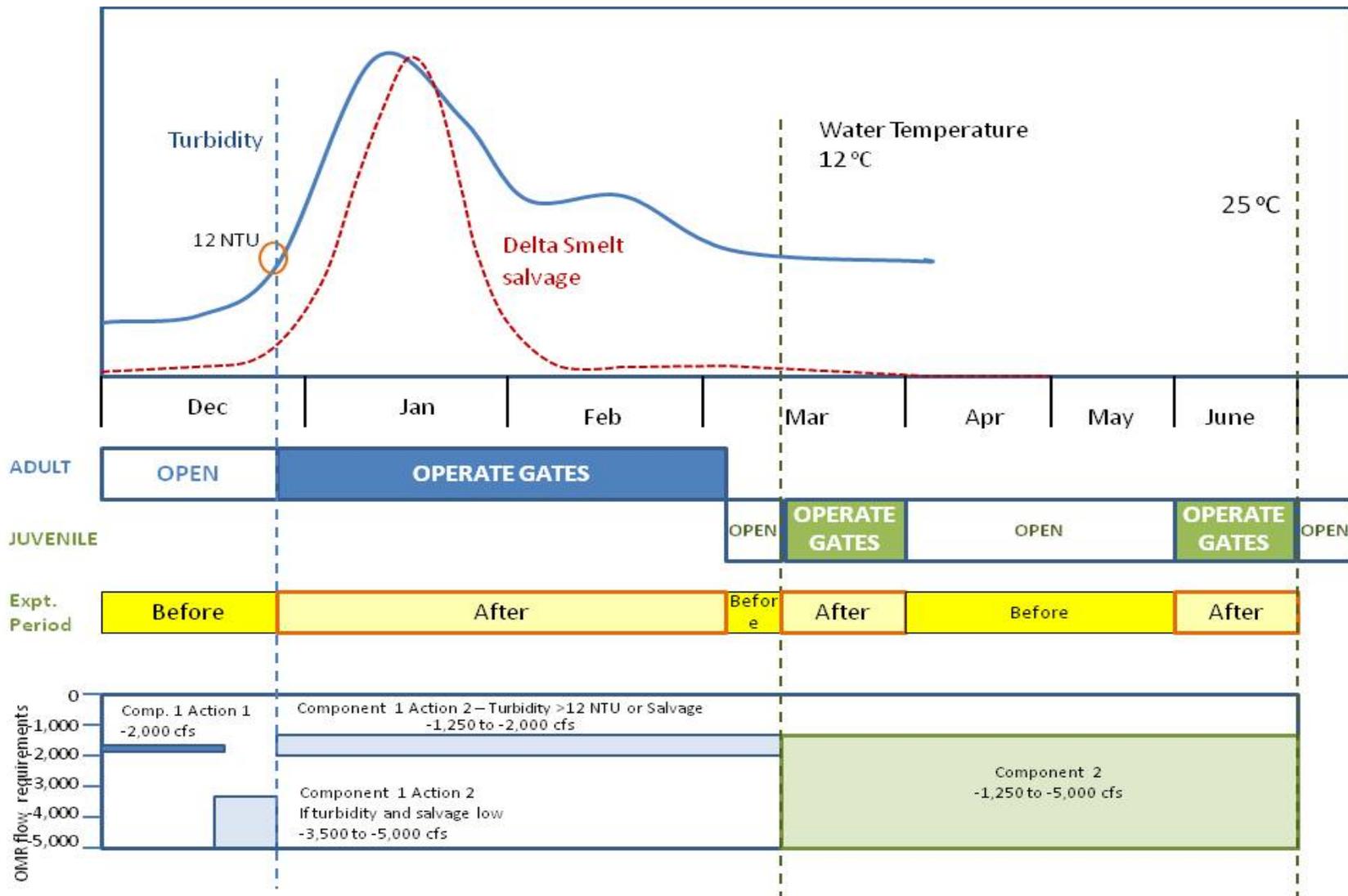


Figure D-5 Typical Sequence of 2-Gates Operations, Experimental Periods, and OMR Flow Restrictions.

TRIGGERS

The triggers for gate operations are described in Table D-3:

- **Turbidity.** Commence gate operations when turbidity ≥ 12 NTU at the San Joaquin River at Jersey Point station. Monitor turbidity at stations along Old and Middle Rivers to determine how far the more turbid water extends toward the south Delta. Suspend gate operations when a low turbidity zone (<12 NTU) no longer exists on Old and Middle rivers before the export facilities (i.e., turbidity ≥ 12 NTU at Holland Cut, Victoria Canal, any other station south of the Old River gate, and Clifton Court Forebay). If turbidity dissipates and drops below 12 NTU along Old and Middle Rivers, resume turbidity monitoring to detect a possible secondary flush that would recommence gate operations.
- **Salvage.** Cease gate operations if three days of delta smelt salvage occur after December 20 at either facility or cumulative daily salvage count is above a risk threshold, based upon the “daily salvage index” approach reflected in a daily salvage index value ≥ 0.5 (daily delta smelt salvage $>$ one-half prior year Fall Midwater Trawl [FMWT] index value).

Table D-3 Triggers for Adult Operational Period (December-March).

Trigger	Description	Threshold	Action
Turbidity	Turbidity (NTU) at various stations (1)	< 12 NTU @ JP	Monitor for trigger, no gate operations
		> 12 NTU @ JP AND <12 NTU in Old and Middle R	Commence gate operations
		> 12 NTU throughout Old and Middle River and central Delta	Cease gate operations, wait for turbidity to drop and equilibrate, recommence trigger monitoring.
Salvage	Delta smelt Salvage index -Calculated ratio of adult salvage to FMWT index (2)	Delta smelt salvage < salvage trigger	Continue with gate operations plan
		Delta smelt salvage > salvage trigger AND Turbidity > 12 NTU @ JP and <12 NTU @ OMR	Cease gate operations, consult with SWG, evaluate actions
	Salmonid catch index (3)	>10 fish/day Nov-Feb >15 fish/day Mar-April	Consult with DOSS, evaluate actions
	Condition of female delta smelt	Spent female found in salvage	Cease adult gate operations, and
Temperature	Water temperature at 3 stations (4)	Temperature >12°C	Shift to juvenile gate operations
Spring Kodiak Trawl	Condition of female delta smelt	Spent female detected in SKT	

SWG – Smelt Working Group, DOSS – Delta Operations for Salmon and Sturgeon Technical Group
 1. Turbidity measured at JP (San Joaquin River at Jersey Point) and several stations in Old and Middle Rivers
 2. Delta smelt salvage trigger from USFWS CVP/SWP Operations BO, Attachment A (USFWS 2008b).
 3. Salvage index for juvenile salmon from NMFS CVP/SWP Operations BO, RPA Action IV.3, p. 652-3 (NMFS 2009a)
 4. Water temperature three station daily mean at Mossdale, Antioch, and Rio Vista.

SCENARIOS AND ALERTS:

- If turbidity levels drop below 12 NTU along Old and Middle River stations for three days following a high turbidity event, this would indicate that turbidity has settled out and water is clearer. Cease gate operations and leave gates open, but continue to monitor turbidity at Jersey Point for a potential additional pulse of turbidity and any additional migrating adult delta smelt.

- If turbidity levels increase above 15 NTU throughout Old and Middle Rivers, as measured at several stationary monitoring sites⁴, this would indicate that the high turbidity plume as extended down to the South Delta and there is no low-turbidity zone that delta smelt would avoid. Cease gate operations but continue to monitor turbidity at Jersey Point and along Old and Middle River to see if turbidity levels drop below 12 NTU. If this occurs, resume monitoring for turbidity (≥ 12 NTU at Jersey Point) to trigger gate operations for adults.
- If salvage or SKT surveys document adult delta smelt in the south Delta or at the export facilities, this would indicate that the low turbidity zone was not maintained or was ineffective at reducing delta smelt movement toward the export facilities. Gate operations would cease and the gates would remain open until another triggering event occurred.

OFF-RAMPS:

Temperature. Water temperature reaches 12°C based on a three station daily mean at Mossdale, Antioch, and Rio Vista. Most successful delta smelt spawning occurs in the temperature range of 12-18°C (USFWS 2008b). The water temperature threshold ($\geq 12^\circ\text{C}$) signals a transition from adult to larvae/juvenile delta smelt management actions.

Biological. Onset of spawning indicated by presence of spent females in SKT or salvage facilities.

Adult gate operations will be continued until these triggers are met or until hydrodynamic forecast modeling indicates that Project operations will not benefit adult delta smelt distribution relative to potential entrainment by the SWP and CVP pumping facilities.

RATIONALE

Hydrodynamic modeling results indicate that the gates should be closed about an hour per day, to balance flows between Old and Middle Rivers in order to manage the turbidity plume and presumably adult delta smelt distributions. Behavioral modeling has shown that the 2-Gates Project, in conjunction with OMR flow restrictions (RPA Component 1 Actions 1 and 2) may be effective in preventing the formation of turbid conditions that are linked to pre-spawning movement of delta smelt generally within the central Delta, thereby reducing the entrainment of delta smelt at the CVP and SWP pumps. These early actions may also control the initial distribution of larval and juvenile delta smelt in locations that reduce the probability of entrainment at the CVP and SWP export pumps. Hydrodynamic forecast modeling will inform the decision regarding initiation and conclusion of this operation period.

There are real-world limitations to successfully managing turbidity distribution in the Delta, including the occurrence of infrequent and unplanned events occur at unpredictable times. For example, turbidity associated with very large San Joaquin outflow that does not coincide with a similar event on the Sacramento watershed may overwhelm the ability to maintain a low turbidity region in the Old and Middle River corridor. Also, when Delta outflows are high, adult delta smelt are located far west of the central Delta and entrainment vulnerability is low.

⁴ Monitoring sites for turbidity distribution along Old and Middle Rivers include existing stations (OR at Franks Tract, Holland Cut, OR at Bacon Island, MR at Columbia Cut, MR at Bacon Island, and Victoria Canal), and new stations that will be established (OR at Old River gate, OR at Woodward Island, OR at Victoria Island, MR at Connection Slough gate, MR at Woodward Island, MR at Victoria Island).

D.5.3 Larvae/Juvenile Delta Smelt (March through June)

OBJECTIVE

To provide equal or improved protection of larval and juvenile delta smelt from entrainment by increasing dispersive mixing to enhance downstream transport, and, once demonstrated to be an effective tool for the protection of delta smelt, to allow SWP and CVP water exports to increase while operating within the required OMR flow range established by the CVP/SWP Operations BOs (USFWS 2008b, NMFS 2009a) and all other water management requirements.

ACTION

The gates will be operated tidally to increase dispersive mixing from the central and south Delta toward the western Delta. The Old River gate will be closed on flood tide (twice daily, about 10 hours total daily) and open on ebb and slack tides (~14 hours daily). Connection Slough gate will be closed about 20 hours and open during slack tide (~ 4 hours daily). Net daily OMR flow, according to the USFWS RPA Component 2, will be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR. A real-time hydrodynamic and delta smelt distribution forecasting system for juvenile and larval delta smelt will be used to forecast optimum Project operations for dispersive mixing as a means of protecting juvenile and larval delta smelt. Monitoring of salinity (EC) and flow at different stations will be used to calculate and measure fluxes that are indicative of hydrodynamic mixing processes.

The decision process for adult gate operations according to trigger conditions is illustrated in Figure D-4.

TIMING

The larval and juvenile operations begin in March immediately after pre-spawning adult operations likely in March. A typical sequence for gate operations and experimental periods is illustrated in Figure D-5. This gate operation schedule will be suspended for April and May, and the gates will be open continuously April 1 through May 31 to coincide with the San Joaquin salmon and steelhead outmigration period as defined in the NMFS CVP/SWP Operations BO (RPA Action IV.2.1) (NMFS 2009a). Gate operations will resume for the month of June. Based upon daily salvage data, the SWG may recommend an earlier start to RPA Component 2, which may lead to an earlier start of 2-Gates larval and juvenile operations. USFWS will make the final determination.

TRIGGERS FOR GATE OPERATIONS

The triggers for larval and juvenile gate operations are described in Table D-4:

- **Temperature.** Daily mean water temperatures $\geq 12^{\circ}\text{C}$ at three stations (Mossdale, Antioch and Rio Vista).
- **Biological.** Onset of spawning indicated by presence of spent females in SKT or in salvage at either facility.

SCENARIOS AND ALERTS:

- If the distribution of larval or juvenile delta smelt (20mm survey) or juvenile salmon (SKT) were more in the eastern Delta or Middle River than central Delta, then the SWG and DOSS would be informed. Under the juvenile operations scenario, flows from this region of the Delta would trend toward the south and the export pumps. The technical groups would review data on fish distribution, relative discharge of the San Joaquin River, and particle tracking, and then make a recommendation

on whether gate operations for dispersive mixing should continue, or should be suspended and the gates left open.

- If juvenile salmonids from the Mokelumne River (acoustic tagging) were found in the south Delta (acoustic tagging, SKT) or in salvage, then consult with DOSS, cease gate operations and evaluate.
- If salvage reaches the CVP/SWP Operations BO RPA trigger levels for delta smelt or salmonids, then consult SWG and DOSS and evaluate whether to continue, adjust, or suspend gate operations and leave the gates open.

OFF-RAMPS:

Temperature. Water temperature reaches a daily average of 25°C for three consecutive days at Clifton Court Forebay. This is close to the thermal maxima for delta smelt (Swanson et al. 2000).

Temporal. June 30. Gates will be open continuously July 1 through November 30 to allow fish movement and navigation.

RATIONALE

To provide added protection to larvae/juvenile delta smelt, the gates will be operated to enhance dispersive mixing for downstream transport. Gate operations for larvae/juvenile smelt will take place during March and June. During this period, the OMR flow requirements are -1,250 cfs to -5,000 cfs (RPA 2 from the USFWS CVP/SWP Operations BO). From April 1 through May 31, the gates will not be operated, and will remain in a fully open position, to coincide with the San Joaquin salmon and steelhead outmigration period as defined in the NMFS CVP/SWP Operations BO (NMFS 2009a, RPA IV.2.1). In some years, conditions may occur when very large San Joaquin River inflow may overwhelm tidal flows in the Old and Middle river channels. This large inflow will mask the effects of the Project.

Table D-4 Triggers for Larval and Juvenile Operational Period (March and June)

Trigger	Definition	Threshold	Action
Temperature	Water temperature at 3 stations (3)	Temperature >12°C	Start gate operations for dispersive mixing
		Temperature >25°C	End operations for the year, Leave gates open
Dates	Period for juvenile operations	April 1-May 31	Suspend juvenile gate operations, Open gates for salmonid outmigration
		June 30	End operations for the year, Leave gates open
Salvage	Delta smelt Salvage index -Calculated ratio of adult salvage to FMWT index (1)	March: Adult concern level June: 0 (zero)	Consult with SWG, review ops, evaluate actions
	Salmonid catch index (2)	>15 fish/day Mar-April	Consult with DOSS, review gate ops, evaluate
20 mm survey	Distribution of delta smelt	Delta smelt # in East Delta elevated	Consult with SWG, evaluate whether hydrodynamics will carry out or to south
Acoustic tagging	Distribution of juvenile salmonids	Mokelumne salmon in south delta	Consult with DOSS, review gate ops, evaluate actions

SWG – Smelt Working Group, DOSS – Delta Operations for Salmon and Sturgeon Technical Group
 1. Delta smelt salvage trigger from USFWS CVP/SWP Operations BO, Attachment A (USFWS 2008b).
 2. Salvage index for juvenile salmon from NMFS CVP/SWP Operations BO,RPA Action IV.3, p. 652-3 (NMFS 2009a)
 3. Water temperature three station daily mean at Mossdale, Antioch, and Rio Vista.

D.5.4 July through November

The gates will not be operated from July through November and will remain in a fully open position.

D.6 FORECASTED OPERATIONS – ADULT AND LARVAE/JUVENILE BEHAVIOR MODELS

D.6.1 Forecasting Process

Computer simulation modeling output of Delta hydrodynamics, water quality and the distribution of delta smelt will be provided for consideration in the determination of Project facilities operations. Effective real-time forecasting requires establishment of initial conditions using historic simulations; gathering and validation of data for real-time boundary conditions; timely agency interaction to determine inflow, quality, and operations forecasts; acquiring and interpreting smelt survey and salvage data; generating output forecasting products; field testing; and documentation.

Forecasts will be performed when requested and/or approximately every two weeks. Forecasts will utilize the most recent field observations of delta smelt density; and forecasted estimates of inflow, inflow water quality, and operations from system operators and data collection groups. For each forecast period, several simulations may be performed using alternative estimates of future conditions. An initial set of forecast simulations will be performed using best estimates of future operations provided by Reclamation and the California Department of Water Resources (DWR) system operators. Upon review of simulated delta smelt distribution and entrainment estimates by the SWG a second set of forecast simulations may be performed with revised future operations with the objective of identifying operations that protect delta smelt from entrainment.

D.6.2 Adult Smelt Model

A real-time hydrodynamic and adult delta smelt behavioral forecasting system will be refined based on the existing RMA Bay-Delta Model used in the development of the Project. The forecasting system will use the delta smelt behavioral model and will address scientific postulations that the adult smelt may be “surfing” the tides as a means of staying within their desirable habitat range. Additionally, patterns of salinity and turbidity habitat may correlate with smelt abundance, such that the smelt behavior model will impart habitat seeking behavior on the particles. Further descriptions of the existing modeling systems are described in Appendix A.

D.6.3 Juvenile and Larvae Model

A real-time hydrodynamic and delta smelt distribution forecasting system for juvenile and larval delta smelt will be developed based on the existing RMA Bay-Delta Model used in the development of the Project. Passive RMA particle tracking and water quality computer modules will be used to forecast optimum Project operations for dispersive mixing as a means of protecting juvenile and larval delta smelt. The model will address unique aspects of the larval stage, including observed behaviors associated with turbidity and light.

D.7 MONITORING FOR OPERATIONAL TRIGGERS

The 2-Gates Project will obtain real-time information for operational triggers from programs monitoring hydrodynamics (flow), water quality (turbidity, temperature), and fish (salvage at fish facilities, surveys in Delta, acoustic tagging for salmonids). In most cases the data is available from existing monitoring

programs. The Project will augment existing monitoring where necessary. For example, additional sensors will be added for water quality, especially in Old and Middle Rivers and at the gate facilities, to provide greater spatial resolution and/or more frequent monitoring triggers. The individual monitoring programs are described in further detail in the Science Investigation Program & Monitoring Plan (Attachment C).

D.8 COORDINATION OF DECISION-MAKING FOR OPERATIONS

D.8.1 Teams and Technical Groups

As described in the CVP/SWP Operations BOs, Reclamation and DWR work closely with the USFWS, NMFS, and DFG to coordinate the operation of the CVP and SWP with fishery needs. This coordination is facilitated through several forums in a cooperative management process that allows for modifying operations based on real-time data that includes current fish surveys, flow and temperature information, and salvage or loss at the project facilities, (hereinafter “triggering event”). Key teams and technical groups participating in the decision-making process:

- The WOMT is comprised of representatives from Reclamation, DWR, USFWS, NMFS, and DFG. This management-level team was established to facilitate timely decision-support and decision-making at the appropriate level. Although the goal of WOMT is to achieve consensus on decisions, the participating agencies retain their authorized roles and responsibilities.
- The SWG evaluates biological and technical issues regarding delta smelt and develops recommendations for consideration by USFWS. The SWG consists of representatives from USFWS (chair), DFG, DWR, EPA, and Reclamation. The SWG compiles and interprets the latest near real-time information regarding state- and federally-listed smelt. The SWG may meet at any time at the request of USFWS, but generally meets weekly during the months of December through June, when smelt salvage at the salvage facilities has occurred historically. The SWG will submit their recommendations in writing to USFWS and DFG. The SWG will employ a delta smelt risk assessment matrix (DSRAM) to assist in evaluating the need for operational modifications of SWP and CVP to protect delta smelt. This document will be a product and tool of the SWG and will be modified by the SWG with the approval of USFWS, in consultation with Reclamation, DWR and DFG, as new knowledge becomes available. The currently approved DSRAM is shown in Tables E-9 and E-10 (Attachment A of the USFWS CVP/SWP Operations BO). Additional triggers and management tools anticipated from 2-Gates Project are indicated at the bottom of these tables.
- The Delta Operations for Salmon and Sturgeon (DOSS) Technical Working Group provides recommendations to WOMT and NMFS on measures to reduce adverse effects of Delta operations of the CVP and SWP to salmonids and green sturgeon. The DOSS group is comprised of staff from Reclamation, DWR, DFG, USFWS, and NMFS. The DOSS group and WOMT will use information from monitoring to make decisions regarding Delta Cross Channel gate closures and export pumping. The team will coordinate with the SWG to maximize benefits to all listed species; and coordinate with the other technical teams to ensure consistent implementation of the NMFS CVP/SWP Operations BO RPA. Monitoring data related to triggers in the decision tree will be reported on DAT calls and evaluated by DOSS. Reclamation/DWR shall take actions within 24 hours of a triggered condition occurring. If the decision tree requires an evaluation of data or provides options, then DOSS shall convene within one day of the trigger being met. DOSS shall provide advice to NMFS, and the action shall be vetted through WOMT standard operating procedures.

The Project will coordinate with this decision-making process through another team established for this purpose:

- The 2-Gates Analysis and Synthesis Team makes recommendations to the SWG and DOSS on Project operations to protect delta smelt. Reclamation will convene a 2-Gates Scientific Investigation Team for the purpose of refining the study design for the experiments. The experiments will be developed to ensure that results are statistically robust and uncertainties due to experimental design have been minimized to the fullest extent possible. Additional expertise may be included in the workgroup, at the discretion of the agencies. The 2-Gates Analysis and Synthesis Team reviews and evaluates monitoring data and forecast modeling in order to guide operations of the gates in Old River and Connection Slough.

D.8.2 Operations Coordination and Timely Interface with Smelt Working Group

Project operations are intended to be informed by forecasts based on simulation modeling and in-field monitoring. Applicable in-field monitored data will be incorporated into the forecast modeling system and forecast updates produced. It is anticipated that it will require one day to gather new observed data, perform data validation, perform historic simulation with latest available data, gather best estimate future operations from delta operators, and prepare and run initial outputs. These computer outputs will then be post-processed and results (forecast products) will be available for review by Reclamation and the SWG.

It is anticipated that these forecasts and ‘proposed short-term operations’ will be reviewed by the SWG, the WOMT and other applicable review and approval organizations as a part of their normal activities. Following this review, approved operations will be described and implemented by Reclamation or its designee.

It is anticipated that the following detailed monitoring data and forecast predictions will be provided:

- **Turbidity concentrations** (triggering operations at > 12 NTU) at the region of control of the 2-Gates Project, defined here as San Joaquin River at Jersey Point. As noted above, forecasting of these conditions will be accomplished through a real-time network of stations from which measurements of turbidity and salinity concentrations and other constituents can take place. Other turbidity measurements will be supported by the Project at locations specified in the Science Investigation Program & Monitoring Plan (Appendix B) and as required by the USFWS CVP/SWP Operations BO.
- **Average Daily Flow.** Supplemental monitored information (as described in Appendix B) and modeled forecasts will be provided by the Project in addition to the information need to evaluate restriction of OMR negative flow rates under the USFWS CVP/SWP Operations BO will be demonstrated.
- **Daily Mean Water Temperatures.** Supplemental monitored information (as described in Appendix B) and modeled forecasts will be provided by the Project in addition to the information needed to implement the conditions listed in the USFWS CVP/SWP Operations BO (at Mossdale, Antioch, and Rio Vista $\geq 12^{\circ}\text{C}$).

D.8.3 Real Time Decision-Making Process for RPA Components 1 and 2

The Project will coordinate with the decision-making process described in the 2008 USFWS CVP/SWP Operations BO and presented in Figure D-6:

- Within one day after the SWG recommends an action should be initiated, changed, suspended or terminated, the SWG shall provide to USFWS a written recommendation and a biological justification. USFWS shall determine whether the proposed action should be implemented, modified, or terminated; and the OMR flow needed to achieve the protection. USFWS shall present this information to the WOMT.

- The WOMT shall either concur with the recommendation or provide a written alternative to the recommendation to USFWS within one calendar day. USFWS shall then make a final determination on the proposed action to be implemented, which shall be documented and posted on the Sacramento Fish and Wildlife Service’s webpage.
- Once USFWS by Reclamation and DWR, and shall remain in effect until the need for the action ends or the OMR flow is changed, as determined by USFWS, consistent with the RPA and described within Attachment B. Data demonstrating the implementation of the action shall be provided by Reclamation to USFWS on a weekly basis.
- If USFWS determines that an OMR flow change is required while an action is ongoing, Reclamation and DWR shall adjust operations to manage to the new OMR flow within two days of receipt of USFWS’s determination. This new OMR flow shall be used until it is adjusted or the action is changed or terminated based on new information, as described in the RPA and Attachment B (USFWS 2008b).

The USFWS identified a suite of triggers (Table D-9) and responses or “tools for change” (Table D-10) in their BO (Attachment A) to guide decision-making. The Project will expand the options for response available to the SWG, WOMT, DOSS and the agencies. We provide a new functional trigger for a key process (turbidity, which is hypothesized to cue adult spawning migration) and another tool for management (operable gates to allow manipulations of hydrodynamics and turbidity distribution).

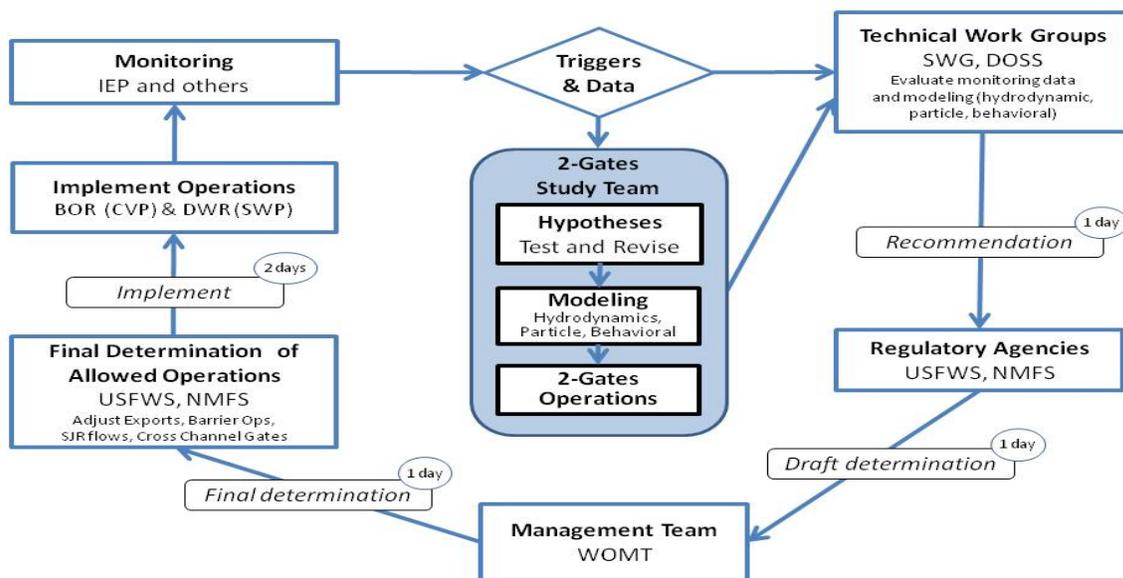


Figure D-6 Framework for Decision Making, Operations and Monitoring

Table D-5 Delta Smelt Risk Assessment Matrix (DSRAM) – Triggers for USFWS CVP/SWP Operations BO RPA* and for 2-Gates Project

Triggers	December	January	February	March	April	May	June	July
Life Stage	Adults	Adults	Adults	Adults and Larvae	Adults and Larvae	Larvae and Juveniles	Larvae and Juveniles	Juveniles
Previous Year's FMWT Recovery Index	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74
Risk of Entrainment				X2 upstream of Chipps Island and temps are $\geq 12^\circ$	X2 upstream of Chipps Island and temps are between 12° and 18°C	X2 upstream of Chipps Island and mean delta-wide temps $< 18^\circ\text{C}$ and south delta temps below 28°C	X2 upstream of Chipps Island and temps are below 28°C	X2 upstream of Chipps Island and temps are below 28°C
Duration of Spawning period (number of days temperatures are between 12° and 18°C)					39 days or less by April 15	50 days or less by May 1		
Spawning Stage as determined by SKT and/or salvage			Presence of Adults at spawning stage ≥ 4	Adult spawning stage ≥ 4	Adult spawning stage ≥ 4			
Smelt distribution (SKT)	SKT	SKT	SKT	See footnote #5 or negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm/summer townet centroid or low juvenile abundance	Negative 20mm/summer townet centroid or low juvenile abundance
Salvage Trigger (Dec-Mar = ratio of adult salvage) (FMWT)	Adult concern level calculation	Adult concern level calculation	Adult concern level calculation	Adult concern level calculation		If salvage is above zero	If salvage is above zero	
Triggers for 2-Gates Project								
Turbidity	>12 NTU @ Jersey Point	>12 NTU @ Jersey Point	>12 NTU @ Jersey Point					
Larval and Juvenile (Temperature)				Temps $\geq 12^\circ\text{C}$			Temps $12^\circ\text{C} - 25^\circ\text{C}$	
* From Appendix A of USFWS CVP/SWP Operations BO (USFWS 2008b)								

Table D-6 Delta Smelt Risk Assessment Matrix (DSRAM) – Tools for Change for USFWS CVP/SWP Operations BO RPA* and for 2-Gates Project

Tools for Change*	December	January	February	March	April	May	June	July
Export reduction at one or both facilities	X	X	X	X	X	X	X	X
Change in barrier operations						X	X	X
Change in San Joaquin River flows				X	X	X	X	X
Change in position of cross channel gates						X	X	
NEW for 2-Gates Project								
Change in gate operations on Old and/or Connection Slough/Middle Rivers	X	X	X	X			X	

*Tools for change are actions that the SWG can recommend to the DATA and WOMT to help protect delta smelt. Adapted from USFWS 2008 CVP/SWP Operations BO, Attachment A

D.9 CONSISTENCY BETWEEN CVP/SWP OPERATIONS BO RPAS AND PLANNED 2-GATES OPERATIONS

The 2-Gates Project is designed to be operated in a manner that is consistent with operations of the OMR flow restrictions under the CVP/SWP Operations BO RPAs. The RPAs most relevant to the Project include:

USFWS CVP/SWP OPERATIONS BO

- RPA 1 Component 1 Action 1: Adult Migration and Entrainment (First Flush) (Table D-5)
- RPA 1 Component 1 Action 2: Adult Migration And Entrainment (Table D-6)
- RPA 2 Component 2: Entrainment Protection Of Larval Smelt (Table D-7)

NMFS CVP/SWP OPERATIONS BO

- RPA IV Action 2.1 San Joaquin River Inflow to Export Ratio (Table D-8)
- RPA IV Action 2.3 Reduced exports to limit negative flows in OMR depending on presence of salmonids (Table D-8)

The objectives, actions, timing, triggers and off-ramps for the delta smelt RPAs are directly compared to the Project operations in Tables 4-6. The actions and timing of the salmonid RPAs are presented in Table D-7, including notes on how the Project operations relate to these RPAs. In all cases, the Project operates within the OMR flow requirements.

Table D-7 Comparison between Adult Delta Smelt Protections in USFWS CVP/SWP Operations BOs RPA Component 1 and 2-Gates Operations

	CVP/SWP Operations BO RPA (USFWS 2008b) Component 1, Action 1: Adult Migration and Entrainment (First Flush)	2-GATES DEMONSTRATION PROJECT Operation 1: Pre-Spawning Adult Delta Smelt (Hypotheses 1, 2, 3 & 4)
Objective	A fixed duration action to protect pre-spawning adult delta smelt from entrainment during the first flush, and to provide advantageous hydrodynamic conditions early in the migration period.	To provide equal or improved protection of pre-spawning adult delta smelt from entrainment with early operation of the Project facilities and early implementation of RPA Action 1, and to allow SWP and CVP water exports to increase while operating within the required OMR flows established by the CVP/SWP Operations BOs and all other water management requirements.
Action	Limit exports so that the average daily OMR flow* is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent).	Operate gates in Old River and Connection Slough to balance flows in Old River and Middle River (Hypothesis 1) in conjunction with RPA Action 1 in order to maintain a low turbidity zone (<12-15 NTU) in Old River and Middle River between the central Delta and the south Delta export facilities (Hypothesis 2). Gates closed 0.5-2.5 hours daily in advance of a forecast high turbidity event. Average daily OMR flow* is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent). Perform 2-Gates "before" and "after" conditions testing during RPA Action 1 (Parts A and B). "After" conditions will be performed as necessary to maintain the low turbidity zone described above.
Timing	Action 1: December 1 to December 20 – Based upon an examination of turbidity data from Prisoner’s Point, Holland Cut, and Victoria Canal and salvage data from CVP/SWP (see below), and other parameters important to the protection of delta smelt including, but not limited to, preceding conditions of X2, FMWT, and river flows; the SWG may recommend a start date to USFWS. The Service will make the final determination. Action 2: After December 20 – The action will begin if the 3 day average turbidity at Prisoner’s Point, Holland Cut, and Victoria Canal exceeds 12 NTU. However the SWG can recommend a delayed start or interruption based on other conditions such as Delta inflow that may affect vulnerability to entrainment.	November 15 – Complete forecast model (new computer simulation model of Delta hydrodynamics, water quality and delta smelt distribution) output and review available data including but not limited to preceding conditions of delta smelt distribution (FMWT) and river flows. The SWG will review modeling and observed data and make recommendations as appropriate for additional simulations, a start date for gate operations and/or conducting an early December Kodiak trawl. December 1- Update forecast. Make decision whether to do early December Kodiak trawl. Forecast modeling will be performed starting December 1 and repeated when requested and/or approximately every two weeks. Forecasts will use most recent field observations of delta smelt density (FMWT, early Kodiak trawl if available); and forecasted estimates of inflow, inflow water quality, and operations. For each forecast period, several simulations may be performed using alternative estimates of future conditions. Upon review of simulated delta smelt distribution and entrainment estimates by the SWG, a request may be made by the SWG or WOMT for a second set of forecast simulations. After December 15 – Gate operations and RPA Action 1 will begin when turbidity at Jersey Point exceeds 12 NTU. This is an earlier triggering of OMR flow control and other Project facilities. Gates closed 0.5-2.5 hours daily in advance of a forecast high turbidity event. Forecast model simulations will be rerun in response to real-time turbidity data as needed to detect upcoming high turbidity events. However, the SWG can recommend an earlier start or interruption based on other conditions such as Delta inflow that may affect vulnerability to entrainment.

Table D-7 Comparison between Adult Delta Smelt Protections in USFWS CVP/SWP Operations BOs RPA Component 1 and 2-Gates Operations

	CVP/SWP Operations BO RPA (USFWS 2008b) Component 1, Action 1: Adult Migration and Entrainment (First Flush)	2-GATES DEMONSTRATION PROJECT Operation 1: Pre-Spawning Adult Delta Smelt (Hypotheses 1, 2, 3 & 4)
Triggers (Part B only)	Turbidity: 3-day average of 12 NTU or greater @ all three stations (Prisoner's Point, Holland Cut, Victoria Canal) OR Salvage: Three days of delta smelt salvage after December 20 at either facility or cumulative daily salvage count that is above a risk threshold based upon the "daily salvage index" approach reflected in a daily salvage index value ≥ 0.5 (daily delta smelt salvage > one-half prior year FMWT index value).	Turbidity: 12 NTU or greater @ Jersey Point. Following first flush event: If turbidity levels drops below 12 NTU at Old and Middle River monitoring stations** for 3 days following a high turbidity event, then cease gate operations (gates remain open) and reinitiate monitoring for turbidity triggering event for adult operations. If turbidity once again reaches or exceeds 12NTU at Jersey Point, then reinitiate adult gate operations (RPA Action 1 will still be in place) until turbidity drops below 12 NTU OR off-ramps triggers are reached (see below).
	The window for triggering Action 1 concludes when either offramp condition described below is met. These offramp conditions may occur without Action 1 ever being triggered. If this occurs, then Action 3 is triggered***, unless USFWS concludes on the basis of the totality of available information that Action 2 should be implemented instead.	Water supply trigger: If there is a clear-water low turbidity zone on Old and Middle Rivers (<12 NTU at OLD and MID stations**) AND salvage rates are at an acceptably low level for the last 3 days (as defined by the SWG), THEN The SWG will consider allowing exports to increase while still remaining within RPA 1 limits on negative OMR flows (from the operation of the export pumps). The SWG will make a recommendation to the USFWS, which will make the final determination regarding timing and level of OMR flow.
Suspension of Action	Flow: OMR flow requirements do not apply whenever a three day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, OMR flow requirements of the Action are again in place.	Salvage or SKT fish surveys: Gate operations will be suspended if salvage or SKT surveys indicate that adult delta smelt have already entered the south Delta.
Off-ramps***	Temperature: Water temperature reaches 12°C based on a three station daily mean at Mossdale, Antioch, and Rio Vista OR Biological: Onset of spawning (presence of spent females in SKT or at Banks or Jones).	Turbidity – Turbidity throughout Old and Middle Rivers** exceeds 12-15 NTU (i.e., no low-turbidity zone exists), then open the gates and cease 2-Gates Adult Operations until (1) low turbidity conditions return or (2) triggers are reached for Gate Operations 2: Larval and Juvenile Protection (Dispersive Mixing). Temperature: Water temperature reaches 12°C based on a three station daily mean at Mossdale, Antioch, and Rio Vista OR Biological: Onset of spawning (presence of spent females in SKT or at Banks or Jones).
<p>* OMR Flows for this and all relevant actions will be measured at the Old River at Bacon Island and Middle River at Middle River stations, as has been established already by the Interim Order.</p> <p>** Monitoring of the turbidity plume will include Old River (OR at Franks Tract, Holland Cut, OR at the 2-Gates structure, and OR at Bacon Island) and Middle River stations (OR at Quimby Island, Connection Slough gates, Middle River at Bacon Island, and Victoria Canal).</p> <p>*** The off-ramp criteria for Actions 1 and 2 to protect adults from entrainment are identical to the initiation triggers for Action 3 to protect larval/juveniles from entrainment</p>		

Table D-8 Comparison between Adult Delta Smelt Protection in USFWS CVP/SWP Operations BOs RPA Component 1 Action 2 and 2-Gates Operations 1

	USFWS CVP/SWP Operations BOs RPA Component 1 Action 2: Adult Migration and Entrainment	2-GATES DEMONSTRATION PROJECT Operations 1: Pre-Spawning Adult Smelt (Hypotheses 1, 2, 3 & 4)
Objective	An action implemented using an adaptive process to tailor protection to changing environmental conditions after Action 1. As in Action 1, the intent is to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions.	To provide equal or improved protection of pre-spawning adult delta smelt from entrainment and to allow SWP and CVP water exports to increase while operating within the required OMR flows established by the CVP/SWP Operations BOs and all other water management requirements.
Action	The range of net daily OMR flows will be no more negative than -1,250 to - 5,000 cfs*. Depending on extant conditions (and the general guidelines below) specific OMR flows within this range are recommended by the SWG from the onset of Action 2 through its termination (see Adaptive Process in Introduction). The SWG would provide weekly recommendations based upon review of the sampling data, from real-time salvage data at the CVP and SWP, and utilizing most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The Service will make the final determination.	Operate gates in Old River and Connection Slough to balance flows in Old River and Middle River in order to maintain a low turbidity zone (<12-15 NTU) in Old River and Middle River between the central Delta and the south Delta export facilities. Gates closed 0.5-2.5 hours daily in advance of a forecast high turbidity event. The range of net daily OMR flows will be no more negative than -1,250 to - 5,000 cfs.
Timing	Beginning immediately after Action 1. Before this date (in time for operators to implement the flow requirement) the SWG will recommend specific requirement OMR flows based on salvage and on physical and biological data on an ongoing basis. If Action 1 is not implemented, the SWG may recommend a start date for the implementation of Action 2 to protect adult delta smelt.	Gate operations will begin when turbidity at Jersey Point exceeds 12 NTU and be maintained until the monitored turbidity is below the amount and there is a low turbidity zone (<12-15 NTU) in Old River and Middle River between the central Delta and the south Delta export facilities**. Forecast model simulations will be rerun every two weeks or as needed to detect changes in turbidity, delta smelt distribution and salvage events.
Suspension of Action	Flow: OMR flow requirements do not apply whenever a three day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, the OMR flow requirements of the Action are again in place.	Salvage or SKT fish surveys: Gate operations will be suspended if salvage or SKT surveys indicate that adult delta smelt have already entered the south Delta.
Off-ramps***	Temperature: Water temperature reaches 12°C based on a three station daily average (Rio Vista, Antioch, Mossdale) or Biological: Onset of spawning (presence of spent females in SKT or at either facility)	Temperature: Water temperature reaches 12°C based on a three station daily average (Rio Vista, Antioch, Mossdale) or Biological: Onset of spawning (presence of spent females in SKT or at either facility)
* OMR Flows for this and all relevant actions will be measured at the Old River at Bacon Island and Middle River at Middle River stations, as has been established already by the Interim Order.		
** Monitoring of the turbidity plume will include Old River (OR at Franks Tract, Holland Cut, OR at the 2-Gates structure, and OR at Bacon Island) and Middle River stations (OR at Quimby Island, Connection Slough gates, Middle River at Bacon Island, and Victoria Canal).		
*** The off-ramp criteria for Actions 1 and 2 to protect adults from entrainment are identical to the initiation triggers for Action 3 to protect larval/juveniles from entrainment		

Table D-9 Comparison between Larval and Juvenile Delta Smelt Protection in USFWS CVP/SWP Operations BOs RPA Component 2 and 2-Gates Operations 2

	USFWS CVP/SWP Operations BOs RPA Component 2: Entrainment Protection of Larval Smelt	2-GATES DEMONSTRATION PROJECT Operations 2: Larval and Juvenile Smelt (Dispersive Mixing) (Hypothesis 5)
Objective:	Minimize the number of larval delta smelt entrained at the facilities by managing the hydrodynamics in the Central Delta flow levels pumping rates spanning a time sufficient for protection of larval delta smelt, e.g., by using a VAMP-like action. Because protective OMR flow requirements vary over time (especially between years), the action is adaptive and flexible within appropriate constraints.	To provide equal or improved protection of larval and juvenile delta smelt from entrainment, with higher than minimum allowed water exports under CVP/SWP Operations BO RPAs and other requirements, by increasing dispersive mixing to enhance downstream transport.
Action:	<p>Net daily OMR flow will be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR*.</p> <p>Depending on extant conditions (and general guidelines below) specific OMR flows within this range are recommended by the SWG from the onset of Action 3 through its termination.**</p> <p>The SWG would provide these recommendations based upon weekly review of sampling data, from real-time salvage data at the CVP/SWP, and expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The Service will make the final determination.</p>	<p>Old River gate closed on flood tide (twice daily, about 10 hours total daily) and open on ebb and slack tides (~14 hours daily). Connection Slough gate closed except during slack tide (~4 hours daily).</p> <p>Gates will be operated to maximize dispersive mixing in the central Delta toward the west Delta. Before and after field testing of hypothesis 5 will be performed.</p> <p>Net daily OMR flow will be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR*.</p> <p>Forecast modeling - A real-time hydrodynamic and delta smelt distribution forecasting system for larval and juvenile delta smelt will be used to forecast optimum Project operations for dispersive mixing.</p>
Timing:	Initiate the action after reaching the triggers below, which are indicative of spawning activity and the probable presence of larval delta smelt in the South and Central Delta. Based upon daily salvage data, the SWG may recommend an earlier start to Action 3. The Service will make the final determination.	<p>2-Gates Operations 2 beginning immediately after 2-Gates Operations 1 (likely in March) and continuing until March 31. Gate operations cease April 1 – May 31 (gates remain open), and recommence June 1 through June 30.</p> <p>Based upon daily salvage data, the SWG may recommend an earlier start to Action 3. The Service will make the final determination.</p>
Triggers:	<p>Temperature: When temperature reaches 12°C based on a three station average at Mossdale, Antioch, and Rio Vista. or</p> <p>Biological: Onset of spawning (spent females in SKT or at either facility).</p>	<p>Temperature: When the 3-station daily mean water temperatures at Mossdale, Antioch and Rio Vista $\geq 12^{\circ}\text{C}$. or</p> <p>Biological: Onset of spawning (presence of spent females in SKT or at either facility).</p>
Suspension of Action:		Gate will be open continuously April 1 - May 31 to coincide with the San Joaquin salmon and steelhead outmigration period (NMFS 2009a, RPA IV.2.1). Gates will be open continuously July 1 - November 30 to allow fish movement and navigation.
Offramps:	<p>Temporal: June 30; or</p> <p>Temperature: Water temperature reaches a daily average of 25°C for three consecutive days at Clifton Court Forebay.</p>	<p>Temporal: June 30; or</p> <p>Temperature: Water temperature reaches a daily average of 25°C for three consecutive days at Clifton Court Forebay.</p>
<p>* Both the 14-day and the 5-day running averages will be computed using the "tidally filtered" daily average OMR flows reported by U.S. Geological Survey.</p> <p>** Maximum negative OMR flows will range between -2000 and -3500. During certain years of higher or lower predicted entrainment risk, requirements as low as -1,250 or -5,000 will be recommended to USFWS by the SWG.</p>		

Table D-10 Operations Plan for NMFS CVP/SWP Operations BOs RPA IV. Actions 2.1 and 2.3

NMFS CVP/SWP Operations BOs RPA IV. Action 2.1: San Joaquin River Inflow to Export Ratio.		NMFS CVP/SWP Operations BOs RPA IV. Action 2.3: Reduced exports to limit negative flows in OMR depending on presence of salmonids.
Objective:	To reduce the vulnerability of emigrating CV steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta, by increasing the inflow to export ratio. To enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable Table B-hydraulic conditions in the main stem of the San Joaquin River for emigrating fish, including greater net downstream flows.	Reduce the vulnerability of emigrating juvenile winter-run, yearling spring-run, and CV steelhead within the lower Sacramento and San Joaquin rivers to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta. Enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable Table B-hydraulic conditions in the main stem of the San Joaquin River for emigrating fish, including greater net downstream flows.
Action:	Make releases as necessary from New Melones and/or reduce exports to maintain San Joaquin River flows at Vernalis at target levels (details in NMFS 2009a, p.641-645)	From January 1 through June 15, reduce exports, as necessary, to limit negative flows to -2,500 to -5,000 cfs in Old and Middle Rivers, depending on the presence of salmonids. The reverse flow will be managed within this range to reduce flows toward the pumps during periods of increased salmonid presence.
Timing:	April 1 – May 31 (VAMP period)	January 1 – June 15
Triggers:	April 1 – May 31	January 1 – June 15 Daily salvage of salmonids
Relevance to 2-Gates Project	2-Gates Project will not be operated during VAMP period, gates will remain open	OMR flow restrictions will be coordinated with USFWS RPAs. 2-Gates Project will operate within the OMR flow requirements of both BOs