APPENDIX C

Monitoring Plan

Monitoring Approach

BACKGROUND

The proposed 2-Gates Project is designed to reduce entrainment of delta smelt by the State Water Project (SWP) and Central Valley Project (CVP) water export facilities. The design and anticipated benefits of the Project are predicated on observations about factors that appear to lead to episodes of high CVP and SWP delta smelt entrainment. Specifically, it has been observed that reductions in salinity and increases in turbidity in the Delta associated with early winter river "flushes" trigger the upstream dispersion (migration) of pre-spawning adult delta smelt. To the extent these turbidity and salinity conditions develop in the lower San Joaquin River and south-central delta, delta smelt may be encouraged to migrate to this area to spawn. Under this scenario, spawning smelt and their larval offspring would be vulnerable to entrainment in the pumping-related reverse flows in lower Old and Middle rivers, and ultimately entrainment at the CVP and SWP export facilities. Placement and operation of flow control gates in Old River and Connection Slough will balance the upstream movement of water in these channels, and potentially levels of CVP and SWP smelt entrainment. It is anticipated that by keeping spawning delta smelt away from the influence of export pumping smelt entrainment will be reduced and annual population recruitment increased.

This Monitoring Plan is designed to collect water quality and biological data regarding the effects of the 2-Gates Project operations on delta smelt, salmon, steelhead, green sturgeon and longfin smelt. It is guided by the principles of adaptive management, which uses science tools to improve management decisions. Monitoring will provide data essential for Project evaluation, which will allow for refining the concepts the Project, is premised on and adapting Project operations. It is intended that monitoring occur over a five-year period to fully evaluate the effectiveness and effects of the 2-Gates Project, although this plan focuses on the monitoring that will occur during the first year of operations. Also, this monitoring plan is intended to be a starting framework, with future efforts substantially influenced from what is learned from the results of the monitoring during the initial Project operations season and by technological advances in monitoring tools.

A robust field monitoring program is essential for fully assessing the response of delta smelt, salmon, steelhead, green sturgeon and longfin smelt to the operation of the 2-Gates Project. Delta smelt move into the interior Delta in mid-winter prior to spawning. Salmon and steelhead use the Delta for migration and rearing habitat. The effects of gate closures and changed hydrodynamics on delta smelt and on migrating parr and smolt salmon and steelhead from the Sacramento, Mokelumne and San Joaquin river systems needs to documented and assessed. The 2-Gates Project operations may also affect green sturgeon and longfin smelt using this area of the Delta. Gate installation and operation may increase or attract predators to these locations. The assessment needs to evaluate the effects of changed hydrodynamics, the affects of blocked temporarily blocked migration routes and any affects from concentrated predators at the gate structures.

Project monitoring also needs to provide real-time monitoring to determine triggering conditions for project operations and documenting resultant hydrodynamic, water quality and biological responses. Real-time monitoring results may also be useful for refining operations to minimize detrimental effects on water quality and sensitive species, and for documenting other Delta factors that may be important when considering the overall efficacy of project operations. The monitoring program builds on ongoing monitoring efforts conducted through the Interagency Ecological Program (IEP) and other Delta area programs. Because the Delta is a complex and variable system, multiple parallel approaches are often necessary to develop useful monitoring information, and the proposed monitoring program reflects this need.

PURPOSE & OBJECTIVES

– This monitoring plan for the 2-Gates Project was developed to accomplish three general objectives. The first general objective is to provide real-time information about the Delta environment to support

project operations decision making, particularly regarding forecasting and triggering initial seasonal operations. Secondly, the monitoring described in the plan will provide information essential to evaluating the Project's effectiveness in achieving its primary purpose of reducing SWP and CVP delta smelt entrainment. Finally the proposed monitoring will identify effects on other species and describe any unintended negative consequences resulting from Project operations. The 2-Gates Project Monitoring Plan will meet these general these general objectives will be addressing a series of specific monitoring questions listed and annotated below.

Monitoring Methods

This section of the 2-Gates Project Monitoring Plan describes the specific types of monitoring and information the types of information, and associated monitoring methods that will be employed both to guide Project gate operations and to evaluate Project effects on fish and water quality, as expressed by the key monitoring questions. The proposed monitoring approach relies substantially on data from existing monitoring programs, with enhancements to provide finer resolution data (e.g., additional sites or increased sampling frequency for fish monitoring). Some of the key questions will be addressed through entirely new monitoring efforts (e.g., predatory fish occurrence at gate structures). The overall monitoring approach is summarized in Tables C-1 to C-3.

MONITORING NEEDS

Monitoring to Detect Triggering Conditions

Gate operations will be triggered by water quality conditions and distribution of delta smelt. The monitoring elements are detailed below and summarized in Table C-2.

WATER QUALITY

Existing sites for water quality monitoring occur at USGS and DWR supported sites around the Delta (Table C-4). The main water quality parameters measured at existing sites include turbidity (NTU), electrical conductivity (µmhos/cm.), and water temperature (°C). Some sites also provide a flow. According to the USFWS OCAP Biological Opinion (USFWS 2008), conditions that initiate delta smelt movement in advance of spawning are associated with those storms that generate sufficient runoff in the Sacramento River to affect water quality in the Delta beginning in late December. Delta smelt salvage occurs at the CVP Tracy Fish Collection Facility (TFCF) and at the SWP Skinner Fish Protective Facility (SFF) following these water quality events (USFWS 2008). Ongoing water quality monitoring for turbidity, electrical conductivity and temperature at Jersey Point and Prisoners Point will be used to determine triggering conditions for operating the gates.

DELTA SMELT PRESENCE

Delta smelt occurrence in the vicinity of the gate structure will be determined by using a Kodiak Trawl deployment earlier in the season (December instead of January) at an expanded number of monitoring sites in the area leading up to the gates and in Middle River and the San Joaquin River. Frequent sampling at multiple stations in the central delta will be necessary to determine the proximity of migrating delta smelt to the gates. Also, close monitoring of salvage at the TFCF and SFF will identify the occurrence of pre-spawning adult delta smelt in the southern Delta.

Table C-1 Monitoring of Triggers for Gate Operations

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

Monitoring to Detect Gate Installation and Operations Effects

Installation and operation of the 2-Gates Project will alter the hydrodynamics in portions of the Delta ecosystem, potentially influencing delta water quality and fishery resources. The proposed monitoring plan contains elements to address each of these five aspects of the ecosystem (Tables C-2 and C-3).

HYDRODYNAMICS

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

WATER QUALITY

Gate closure will reduce or attenuate tidal flows in and out of Old River between Franks Tract and Railroad Cut and in Connection Slough. Gate closure may have a measurably affect water quality conditions in these channels and possibly cause minor water quality changes throughout the south and central Delta. Levels of dissolved oxygen, turbidity, temperature, and chlorophyll A will need to be monitored in the area in close proximity to the gates and in the channels on either side to develop information on water quality conditions. Furthermore, the network of existing monitoring stations run by CDWR, USGS, and USBR will need to be utilized as well as enhanced in some locations in order to generate a comprehensive database of real-time data that can be used to assess Project effects on the Delta as a whole.

FISH RESPONSE

Proposed Project operations are intended to reduce the vulnerability to entrainment of delta smelt, juvenile salmon, and other small pelagic up Old River or into Middle River from the Franks Tract area by the CVP and SWP water export facilities.

The intended outcome of Project operations is that pre-spawning adult smelt will not be attracted to migrate from the vicinity of Franks Tract or other areas in the Delta to waters where they would be subject to entrainment. However, there is an undesirable possibility that adult delta smelt blocked by Project operations from entering Old and Middle Rivers directly would move into Middle River around the north side of Mandeville Island and become entrained through project-related increased reverse flows in these channels. This occurrence is managed by Project operations through Old and Middle River flow balancing. Frequent, direct sampling of fish density at sites throughout the south and central Delta, including close monitoring of CVP and SWP fish salvage will be needed to assess whether the effects of Project gate operations on migrating adult delta smelt are desirable or undesirable during the December–March spawning period.

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

The effects of gate operations on juvenile salmon and steelhead could be positive or negative depending on the river of origin and the general Delta hydrodynamic conditions during emigration. In order to evaluate Project effects on juvenile salmon and steelhead emigrating from Central Valley watersheds, direct sampling and tracking of tagged juvenile salmon and steelhead will be conducted. In combination, these methods will allow for the evaluation of the effects of expected increased reverse flows in Middle River and decreased flow in Old River.

SALVAGE

Reducing entrainment of delta smelt at the CVP and SWP water export facilities is the primary objective of the Two-Gates Project. Because fish salvage at the SFPF and TFCF is a available indicator of juvenile and adult fish entrainment, close monitoring of salvage will be crucial to assessing the effectiveness of the Project in achieving its primary objective and assessing its effects on other species. Salvage data from periods of Project gate operations will be compared to historic data of average salvage rates under comparable water year type and OMR flow conditions. In season salvage responses and these statistical comparisons with historical salvage data should provide reasonable indications of whether gate operations are succeeding in the goal of reducing entrainment or having unintended consequences on entrainment of certain species, life stages, or runs. Existing salvage monitoring includes examination of salvaged juvenile salmonids to detect fish with coded-wire tags. The origins of these salvaged fish from various release locations throughout the Central Valley could potentially provide insights into how Project operations are influencing juvenile migrations through the Delta.

PREDATION

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

Table C-2 Monitoring to Evaluate of Gate Operations on Fish

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

Table C-3 Monitoring to Evaluate Effects of Gate Operations on Water Quality

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

KEY MONITORING QUESTIONS

The following is an annotated list of the key questions the Monitoring Plan is intended to address. Several of the key questions are associated with addressing the primary goal of the Project, reducing entrainment of pre-spawning adult delta smelt and the vulnerability of their offspring. Other questions are associated with assessing potential effects on other fish species and the aquatic habitats within the area of the Project's influence. The annotations provided under each question below briefly describe the monitoring elements directed at each question. The details of each Monitoring Plan element can be found in the subsequent 'Monitoring Methods' section of the Plan.

Question 1:
Do Project gate operations reduce negative flows from the Franks Tract area via Old River and Connection Slough to the CVP and SWP south Delta pumping facilities?

Monitoring Elements: Real-time flow monitoring using existing flow monitoring sites and Acoustic Doppler Channel Profilers (ADCPs) in Old River south of the gate location and north of Railroad Cut, north of the Gate Location and south of Connection Slough, in Connection Slough west of the gate and in Middle River south of Connection Slough and north of Railroad Cut. Remotely operated ADCPs will be deployed elsewhere in the zone of control to validate hydrodynamic changes from gate installation and operation.

Question 2:
To what extent do Project gate operations reduce entrainment of pre-spawning adult delta smelt at CVP and SWP south Delta water export facilities?

Monitoring Elements: Real-time salvage monitoring at TFCF and SFPF will be the best indicator of Project effects on entrainment. Kodiak trawl sampling will be expanded to include additional sites in Old River upstream and downstream of the gates and in Middle River, and the San Joaquin River between Old and Middle Rivers, and the addition of sites between existing monitoring sites to increase detection of smelt in Old and Middle rivers to better asses the migratory fate of smelt within the Projects area of influence. The project-related sampling will begin in December of each season and last through June 30.

Question 3:
To what extent do Project gate operations reduce spawning of adult delta smelt in the south Delta, thereby reducing the risk of entrainment for larva and juveniles?

Monitoring Elements: Data from existing Smelt Larva and 20mm surveys from sites in the southern Delta will provide basic information on the presence of larva and juveniles.

Question 4:
Do Project-related gate operations negatively affect Sacramento, Mokelumne, or San Joaquin river juvenile salmon/steelhead take at the CVP/SWP export facilities?

Monitoring Elements: Salvage monitoring at TFCF and SFF December through June for uniquely tagged or marked salmon released in these rivers. Acoustic tagged salmon will provide real time Project affects data when combined with an array of existing and new detection stations. External tags or marks could be processed in near real time to evaluate and modify Project operations, while any sampled coded wire tagged (CWT) fish will not provide real-time data, the release locations of CWT tagged fish could be used to assess Project effects after the end of each operations season. Monitoring related to addressing Question "4" will involve extensive coordination other ongoing and new acoustic tagging studies on juvenile salmon/steelhead on the Sacramento, Mokelumne and San Joaquin rivers, including coordination with VAMP studies. Project-related additions to acoustic tagging capacity of existing programs, and increases in detection sites at key junctions and channel segments in the central and southern Delta will be made. New detection stations at the gate sites will document the movement/delay of individual fish in south and central Delta channels.

Question 5:
Do Project gate operations effect through-Delta survival of emigrating Sacramento, Mokelumne, or San Joaquin river juvenile salmon and steelhead?

Acoustic tag detection stations will be established up and downstream of each Project gate to assess juvenile salmon passage times, behavior, and predation mortality. Acoustic tag data from gate sites will be compared with data from an enhance array of detection sites in the southern and central Delta to assess the degree of Project exposure experienced by emigrating juvenile salmonids.

Question 6:
Do Project gate operations delay the migration of adult salmon to upstream spawning habitats in the Sacramento, /Mokelumne, and San Joaquin river watersheds?

Monitoring Elements: Real time evaluation of data from acoustic-tagged Sacramento, San Joaquin and Mokelumne River adult salmon and steelhead captured, tagged and released in the western Delta. Recording sites will be deployed at key Delta junctions and on both sides of the gates to detect tags passing in real time. Also DIDSON cameras will be deployed on both sides of each Project Gate to detect migrating salmon and evidence of migration delay. Monitoring will occur from early December through April 15 for steelhead and winter-run and spring-run Chinook and during August through December for fall-run and late fall run Chinook.

Question 7:
Does Project gate installation and operation interfere with movement of sturgeon through Old River and Connection Slough channels?.

Monitoring Elements: Utilize mobile DIDSON acoustic camera systems on the upstream and downstream side of each gate to detect the presence of migrating adult sturgeon and assess delays during gate passage.

Question 8:
How does installation and operation of the 2-Gates Project structures effect predator density and activity at the gates and in the channels leading to and from the gates?

Monitoring Elements: Use DIDSON camera systems on the upstream and downstream side of each gate before and after gate installation, and during gate operations to assess predator densities, behavior, and habitat use. Also, compare predator populations in the vicinity of the gates to similar ungated sites in near by similar channels. Capture, tag, release and track acoustic-tagged predatory fish to determine residence time/movement and habitat use in proximity of the gates. Finally, use methods employed by the DFG Resident Fish Study at added sites nearby and at the gates to detect predator abundance and distribution changes following gate installation and operation.

Question 9:
How does installation and operation of the 2-Gates Project structures affect water quality (turbidity, DO levels, temperature) in the vicinity of the Project?

Monitoring Elements: Water quality monitoring stations will be added in the channels within 1000 feet up and downstream of each gate structure. Near-gate water quality conditions will be compared with data from established southern and central Delta stations.

Existing Monitoring Programs: Much of the data to satisfy the monitoring needs described above can be gathered from existing monitoring programs conducted by the IEP and other entities. These programs have been proven to generate reliable data. Furthermore, utilizing these existing sources of data allows project assessment data to be easily compared with historical databases. Many of these programs sample widely distributed sites over long sampling periods and will generate monitoring data that allows for a 'big picture' analysis of project effects. In this section of the Monitoring Plan the elements of existing monitoring programs that will be used in Project assessment are identified and described. Existing monitoring programs and how they will integrate into the 2-Gates Monitoring Plan are provided in Tables C-1, C-2, C-3, and C-4.

Fish Monitoring

FALL MIDWATER TRAWL AND SUMMER TOWNET SURVEY

The Fall Midwater Trawl (FMWT) and the Summer Townet Survey (TNS) are the two longest running fish monitoring programs used to index adult and juvenile delta smelt abundance. They were designed to target mid-water age-0 species and are used to develop annual indices of abundance, and characterize distribution throughout the Delta. The FMWT is conducted monthly at nearly 50 sites throughout the region from upper San Francisco Bay through the delta from September through December. The TNS is conducted during the summer at 32 stations spread from upper San Pablo Bay through the Delta (Figure C-1). The TNS survey occurs at slightly different times each year that depending upon conditions related to juvenile striped bass recruitment, but a minimum of two surveys are conducted each year with start and ending dates ranging from early June to late August, respectively. These two monitoring programs occur outside of the period of potential gate operations and will not be employed as real-time monitoring tools. However, if the Project is successful in significantly reducing the entrainment of pre-spawning adults and or improving the survival of spawned delta smelt, then abundance indices developed from these surveys should reflect an increase in delta smelt production relative to expected levels.

SPRING KODIAK TRAWL (SKT)

The existing SKT Survey samples every other week at 39 stations distributed from lower Napa River through the Delta starting in January or February and running through March. The Delta-wide surveys are supplemented by intermediate surveys focused on areas of highest adult delta smelt concentration. This trawl survey provides very useful monitoring tool for sampling the anticipated period of gate operations. The gear has proven to be effective for sampling adult delta smelt, adult longfin smelt, and juvenile salmonids. Data from the existing SKT Survey program will be used to assess the proximity of the delta smelt population to the gates and areas of high entrainment vulnerability. Four of the SKT Survey sites (812, 815, 906, and 902) are in the area clearly influenced by Project operations. The sampling frequency at these sites will need to be increased to provide the additional information needs associated with monitoring the 2-Gates operational effects (Figure C-1). Also, the SKT Survey will need to begin earlier (in December) to be useful for the entire 2-Gates operational period.

20 MM SURVEY

The purpose of the existing 20mm Survey is to monitor the annual and seasonal abundance and distribution of post-larval and juvenile delta smelt. Eight to 10 individual fortnightly surveys are conducted each year from March to July covering nearly 50 sites distributed from upper San Pablo Bay through the Delta and lower rivers. Eight of the sites (sites 809, 812, 815, and 906 in the San Joaquin River; site 901 in Franks Tract; sites 902 and 915 in Old River; and site 915 in Middle River) are located in the area influenced by the project (Figure C-1). Data from individual surveys is available in near-real-time (within 72 hours) to generally

characterize the distribution of smelt relative to the project area and areas of high entrainment risk. However, the frequency of individual surveys and the density of stations in the project area are insufficient to provide for responsive management of Project operations, nor to provide detailed assessments of Project effects and effectiveness. The next section of this Monitoring Plan describes 20mm Survey enhancements designed to facilitate better assessment of the 2-Gates Project. Comparison of post-project survey data to pre-project survey data for south delta sites will useful in determining the effects of operations on delta smelt spawning distribution and evaluating the success of the operations in preventing spawning in the south delta.

MOSSDALE KODIAK TRAWL SURVEY

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

LONGFIN SMELT LARVA SURVEY

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

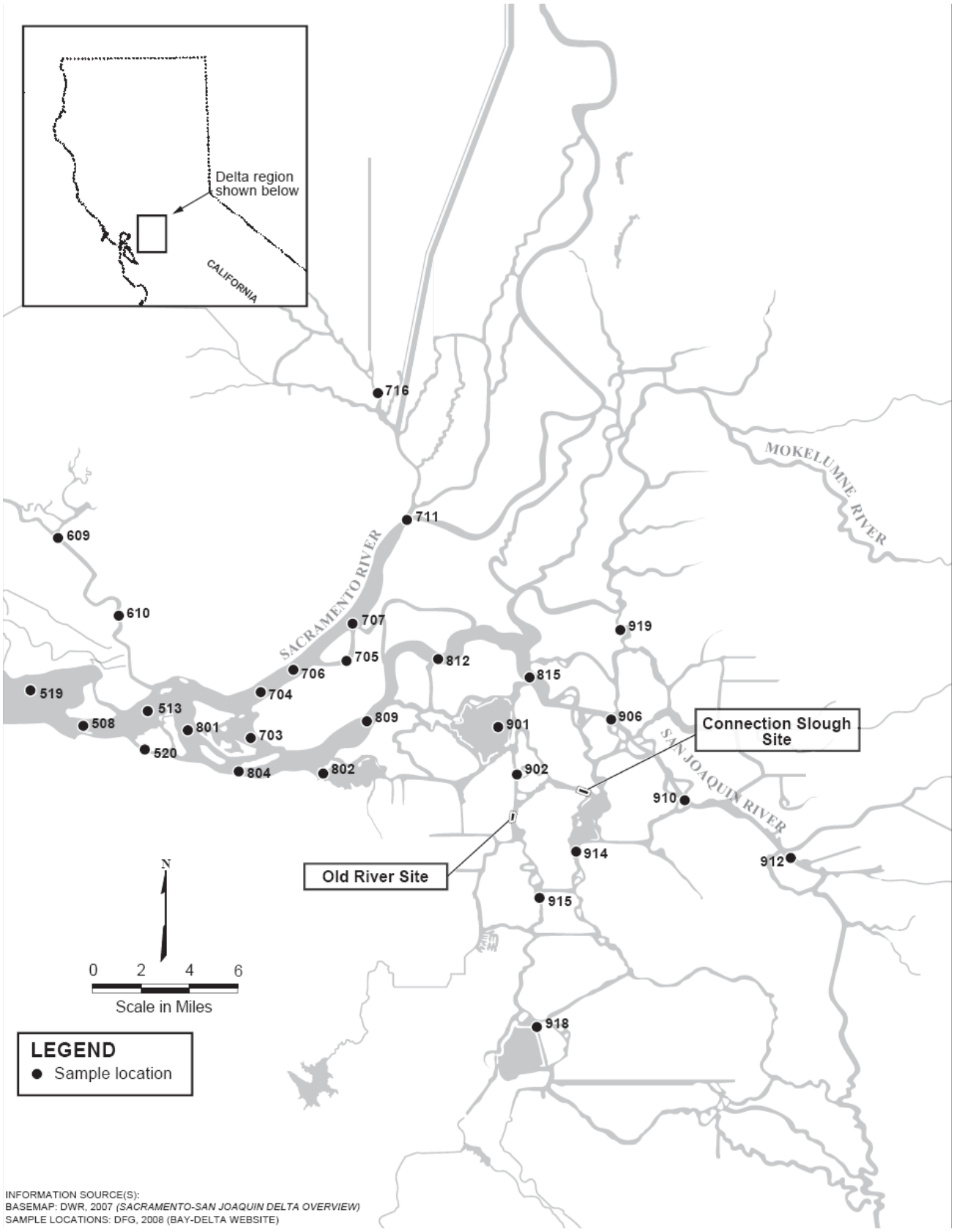

Figure C-1 Map of Bay Delta Estuary Sampling Locations for the SKT, TNS, and 20-mm Survey

SALVAGE MONITORING

Existing salvage monitoring will be sufficient for evaluating the effectiveness of gate operations at preventing entrainment of adult and juvenile delta smelt. Salvage densities during project operations will be compared to pre-project densities, and evaluated in-season, to determine if gate closure is successful at reducing entrainment of smelt and if the salvage densities of any other species are affected by gate operations. Under existing salvage protocols salvaged salmonids are routinely examined for coded-wire tags. The occurrence of tagged hatchery origin fish released in various Central Valley stream locations may provide some indication of how Project operations are effecting migration through the Delta. The number and timing of occurrences during Project operations could be compared to historical occurrences under similar hydrological conditions. Existing salvage monitoring programs report salvage indices on a daily basis in order to inform management decisions. Rapid daily reporting will be essential to the 2-Gates monitoring program and could be further supported by the 2-Gates monitoring program if necessary. No enhancements to the existing salvage sampling and reporting protocol are required to tailor it to Project assessment needs.

Water Quality and Flow Monitoring

Ongoing monitoring of water quality conditions occur at key Delta sites for agricultural use, municipal and industrial use and fish and wildlife. There are numerous stations in the vicinity of the Project that can be used to monitor flow or water quality (Table C-4). Permanent flow monitoring sites are also available. Established USGS, DWR, CCWD monitoring sites and additional sites, as needed by hydrodynamic modelers, will be used to monitor water quality conditions. New sensors will be installed on existing stations at locations where additional parameters will be needed.

HYDRODYNAMICS

Flow conditions in the Sacramento and San Joaquin Delta are monitored at 19 existing sites from the Sacramento River at Freeport and the San Joaquin River at Mossdale to Collinsville (Table C-4). The stations are maintained by DWR, USGS, and Reclamation. Five new sites will be added including one on the San Joaquin River at Oulton Point, and sites at either side of each gate (Table C-4, Figure C-2).

ELECTRICAL CONDUCTIVITY

EC in the Sacramento and San Joaquin Delta is monitored at 15 existing sites from the Sacramento River at Freeport and the San Joaquin River at Mossdale to Collinsville (Table C-4). The stations are maintained by DWR, USGS, and Reclamation. EC will be added to the existing Victoria Canal site and to five new sites as noted in the Hydrodynamics paragraph above (Table C-4, Figure C-2).

TURBIDITY

Turbidity in the Sacramento and San Joaquin Delta is monitored at four existing sites from the Sacramento River at Freeport and Hood and at Jersey Point and Prisoner's Point on the San Joaquin River (Table C-4). The stations are maintained by DWR, USGS, and Reclamation. Turbidity will be added to eleven existing stations and to the five new sites as noted in the Hydrodynamics paragraph above (See Table C-4, Figure C-2).

WATER TEMPERATURE

Water Temperature in the Sacramento and San Joaquin Delta is monitored at five existing sites in the Central Delta (Table C-4). The stations are maintained by USGS and Reclamation. Water temperature will be added to eight existing stations and to the five new sites as noted in the Hydrodynamics paragraph above (Table C-4, Figure C-2).

DISSOLVED OXYGEN

Dissolved Oxygen in the Sacramento and San Joaquin Delta is monitored at one existing site in the Victoria Canal (Table C-4). This station is maintained by USGS. Dissolved Oxygen will be added to twelve existing stations and to the five new sites as noted in the Hydrodynamics paragraph above (See Table C-4, Figure C-2).

CHLOROPHYLL-A

Chlorophyll-a in the Sacramento and San Joaquin Delta is monitored at one existing site at the San Joaquin River at Mossdale (Table C-4). This station is maintained by DWR. Chlorophyll-a will be added to twelve existing stations and to the five new sites as noted in the Hydrodynamics paragraph above (See Table C-1, Figure C-2).

Table C-4 Locations and Capabilities of Monitoring Stations Supporting Operations of the 2-Gates Project

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

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

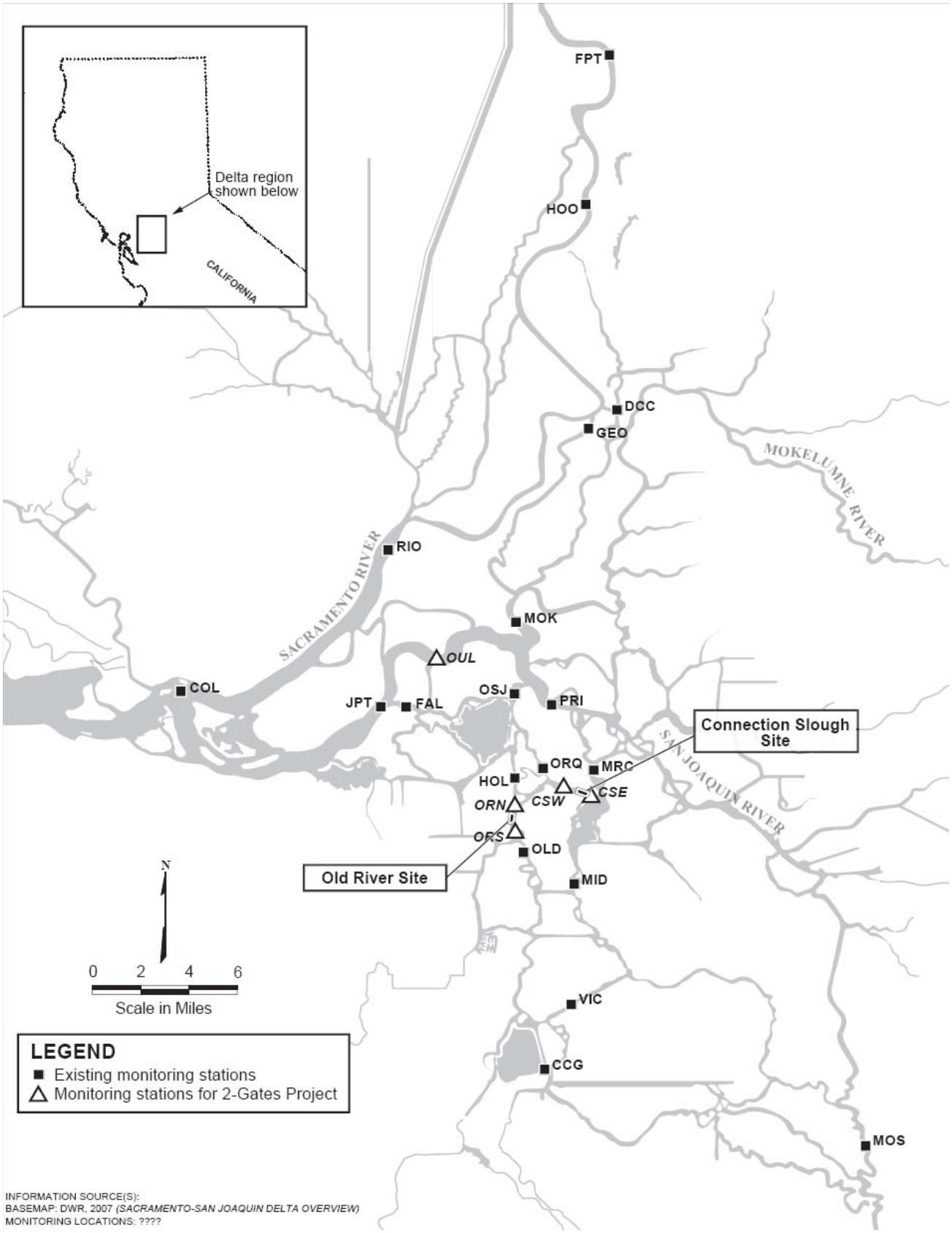

Figure C-2 Locations of Existing DWR, Reclamation, and USGS Monitoring Stations in the Delta and Stations added for the Project

NEW / ADDED MONITORING PROGRAMS TO EVALUATE EFFECTS OF GATE OPERATIONS

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

SPRING KODIAK TRAWL (SKT)

The existing SKT Survey will be useful for annually characterizing the distribution of smelt populations relative to the Project gates and areas of high entrainment risk during the January through March period, however the existing SKT Survey protocol presently begins after delta and longfin smelt spawning migrations have begun and gate operations will have started. Therefore, for the purposes of 2-Gates Project assessment the duration of the SKT Survey will be expanded to include the month of December. The existing SKT Survey includes several sites within the influence of the Project (San Joaquin River sites 809, 812, 815 and 906; in Old River at sites 901, 902, and 918; and in Middle River at Site 914) (Figure C-1). The sampling frequency these sites in the immediate Project area will be increased to weekly to allow for improved assessment and adaptive management of the Project. Kodiak trawl data will allow project managers to evaluate how the distribution of migrating smelt is changed by gate closure or if adult smelt migrate around the gates into the south Delta through the lower San Joaquin River.

20mm Survey

As indicated in the previous section of this Monitoring Plan, the 20mm Survey in its current form is inadequate to responsively inform Project gate operations, or to clearly understand how the Project is affecting juvenile smelt in the vicinity of the Project. To facilitate these information needs, the frequency of sampling at existing 20mm Survey sites within the area of influence of the Project gates San Joaquin River sites 809, 812, 815 and 906; in Old River at sites 901, 902, and 918; and in Middle River at Site 914) will be increased from fortnightly to weekly (Figure C-1).

SALMON/STEELHEAD STUDIES

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

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

inefficiencies associated with the use of incompatible equipment technologies by different investigators working in the same region.

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

The conduct of acoustic tag-based salmonid migration research and monitoring in the Delta is presently very dynamic, with several studies currently underway. These include general assessments of migration duration and mortality from various parts of the watershed, detailed examination of migration behavior at key channel junctions in the northern Delta, and assessments of emigration success under the VAMP program. Some studies are soon ending, some just beginning, and others ongoing. The investigations conducted to date have established a robust array of receivers in the central and southern Delta that is expected to be in place during the 2-Gates Project operation period (Figure C-3). The Project Monitoring Plan proposes adding several receivers to the array to address questions specific to the Project (Figure C-3). The key to ensuring that Project-related questions can be cost-effectively addressed by acoustic tag investigations is for Project representatives to join the existing community of investigators already collaborating on this type of work. This participation will provide the project with the opportunity to support key parts of the existing acoustic array required for Project assessment, to contribute additional tagged fish to studies in various parts of the system that help address Project-related questions, and ensure that tagging efforts related to the Project are technologically up-to-date and compatible with other efforts.

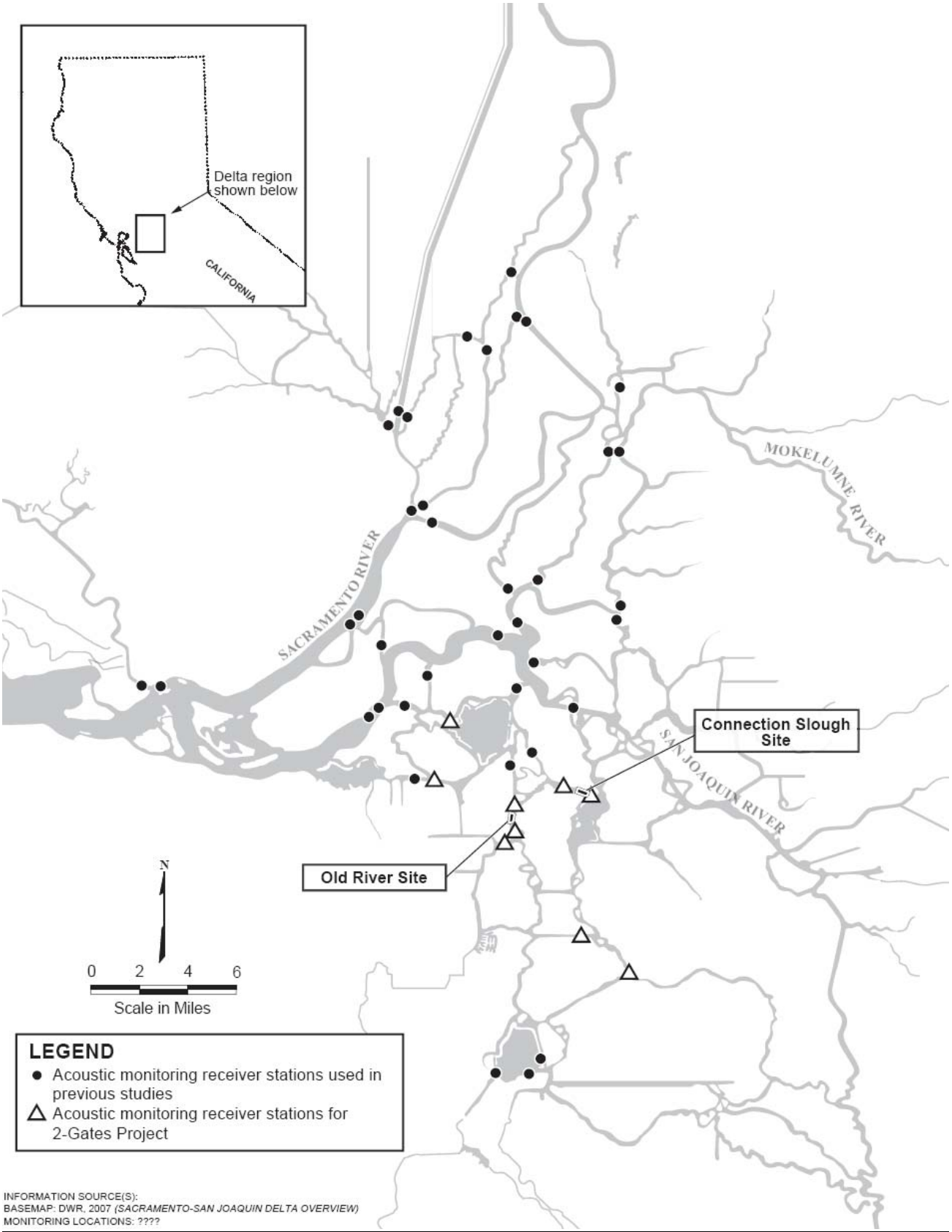

Figure C-3 Acoustic Fish Tracking Sites from Previous Studies and New Sites needed for the Monitoring Plan

CAMERA MONITORING FOR PREDATORS AND FISH MOVEMENT

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

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

DIDSON acoustic cameras are capable of detecting fish up to 12 meters away in turbid water (Maxwell & Gove 2002). Acoustic cameras will be mounted on an adjustable pole attached to the side of a small boat. The boat will be positioned along the bank with the acoustic camera pointing toward the channel thalwag at the monitoring and control sites pictured in Figures C-4 and C-5. Beam settings will be adjusted to detect predators such as striped bass greater than 12 inches in length or adult sturgeon holding near the gates. Two pole mounted DIDSON cameras will be utilized for monitoring. The DIDSON camera operators will move and position the camera boats between and within the monitoring and control sites. These methods will be similar to those tested by the CDWR Fish Facilities Section (2003).

In the case that predator accumulation near the gates is observed by DIDSON cameras, electrofishing boats will be utilized for sampling and thinning the predator assemblage (Figures C-4 and -5 show location of cameras).

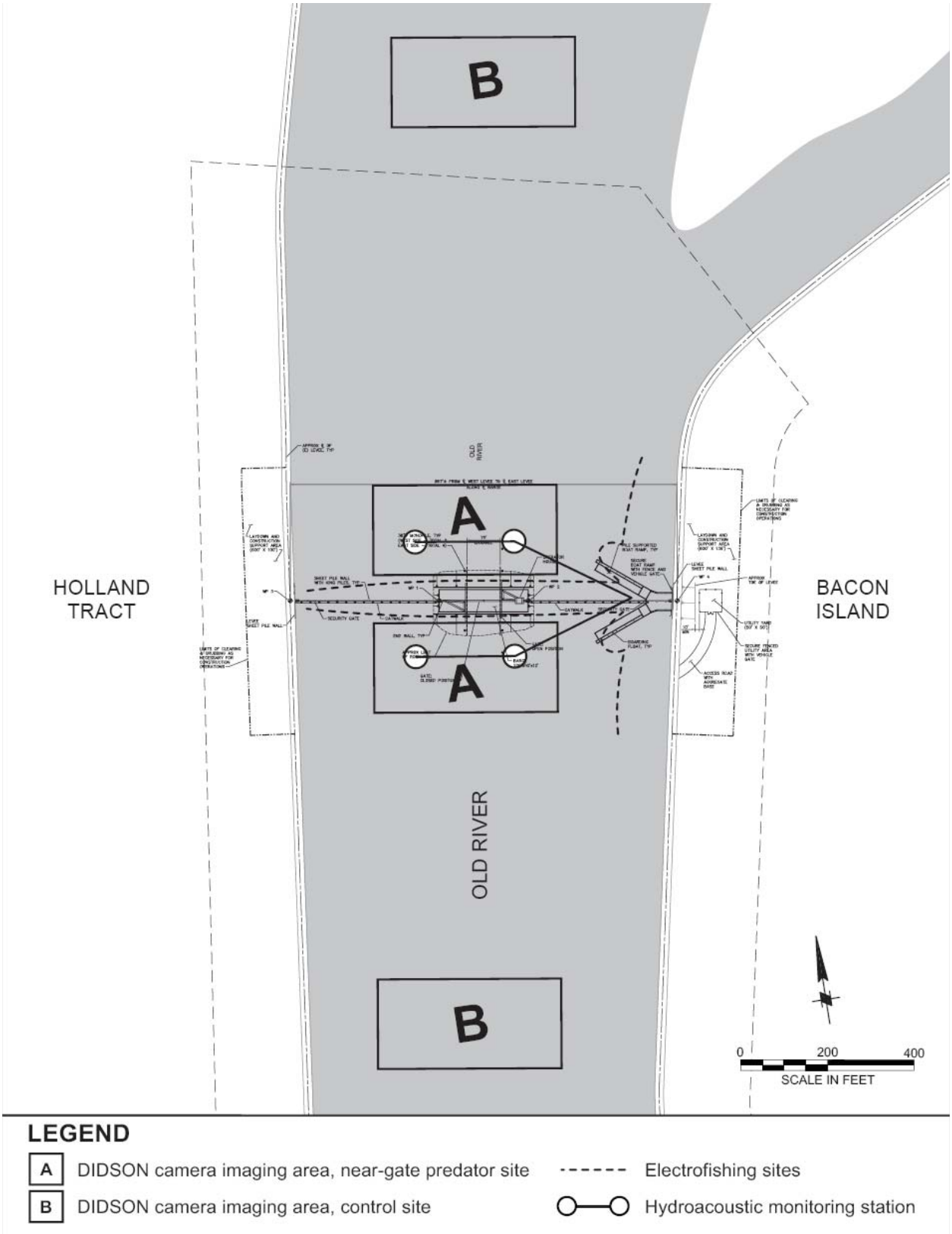

Figure C-4 Old River Gate Area showing location of continuously recording hydrophone array, monitoring areas for boat-based DIDSON imaging and electrofishing sites.

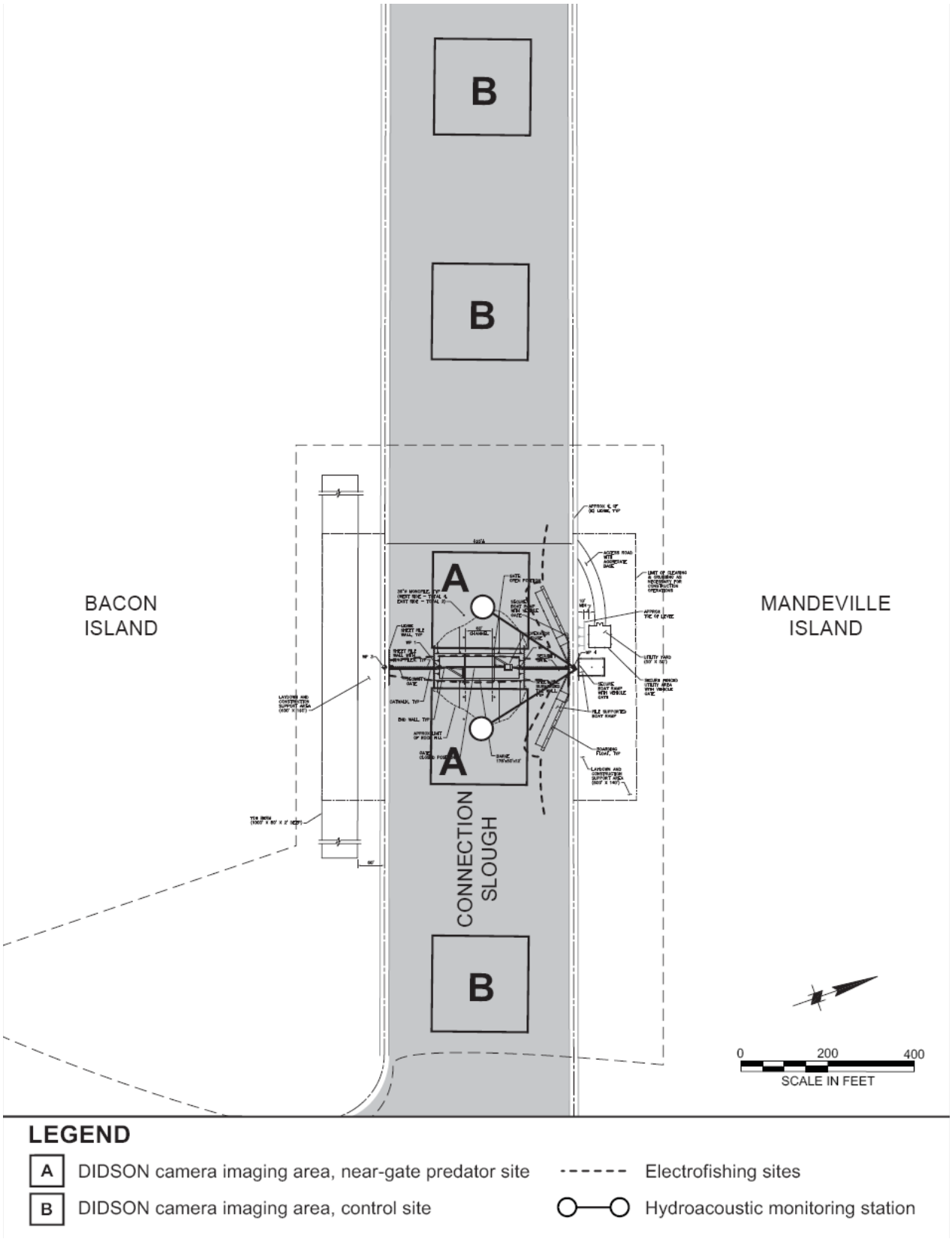

Figure C-5 Connection Slough Gate Area showing location of continuously recording hydrophone stations, areas for boat-based DIDSON imaging and electrofishing sites.

Monitoring at new water quality stations (Table C-4, Figure C-2) will occur with automated multiparameter sensors (such as a Hydrolab Datasonde®, or YSI 6600 sonde). Automated multiparameter sensors will be deployed during gate operations (December through March). These stations will be outfitted with web-enabled remote monitoring and control allowing real-time data to be accessed remotely on a daily basis. The stations and probes will be inspected, cleaned, and serviced weekly by trained technicians. A roving water quality crew using a boat and a portable multiprobe sensor on a 30 foot cord to obtain water profile data will be utilized as needed to supplement automated sampling. All water quality instruments will be inspected, cleaned, and calibrated weekly. Real-time water quality monitoring at new sites will allow Project managers to take action to open the gates if closures resulted in elevated water temperatures (exceeding 18 °C for smelt spawning, or 24°C for smelt survival), or if dissolved oxygen levels approach 5.0 ppm (below DO requirements for salmon).

Data Collection, Handling, Storage, and Disposition

All data will be collected in accordance with established, standardized sampling protocols. Existing sampling programs will utilize existing written sampling protocols when conducting sampling at new locations or times. New written protocols will be developed for new monitoring programs, such as DIDSON camera monitoring. All written protocols will be refined for project needs and provided to MWD for review and comment. All data will be collected to the highest standard of accuracy.

All data will be carefully entered and stored in specifically designed Access databases. These databases will include both existing agency databases and a new 2-Gates monitoring team database. Data will be pulled from agency databases and the 2-Gates monitoring team database by the 2-Gates analysis and synthesis team (Figure C-6).

QUALITY ASSURANCE/QUALITY CONTROL

All data pulled from agency and project team databases will be subject to 2-Gates monitoring team QA/QC procedures. These procedures will include written protocols, staff training, data checks, fish identification verification, and peer-review procedures. Written protocols will be developed for all sampling and monitoring, and provided during staff trainings to ensure all data are collected according to established standards. Field data will be checked at collection. All monitoring data will be tagged as preliminary, provisional, or final prior to use in updates and reports by the analysis and synthesis team.

ANALYSES FRAMEWORK

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

- Determining the effectiveness of OCAP and 2-Gates triggers for gate operations including the 12 NTU turbidity threshold and Old River/Middle River reverse flow ratios.
- Defining desired water quality conditions and fish abundance indices in order to gauge project effectiveness over short and long time scales
- Defining thresholds for considering and implementing operational changes
- Defining the types of operational changes that could feasibly be implemented
- Obtaining baseline data from existing or additional monitoring programs

- Refining existing water quality and fish behavior models to better define the relationship between hydrodynamics, turbidity, and fish response based on new data

Statistical analyses may be performed with several programs (i.e., S+, R, Origin, PRIMER, JMP and Excel). Daily and weekly memorandums, as well as monthly reports, will be written by the analysis and synthesis team and provided to the Smelt Working Group (SWG). The SWG may make additional data requests to the analysis and synthesis team. After analyzing the memorandums and reports the SWG will provide operational recommendations to the Water Operations Management Team (WOMT). The WOMT will make major decisions on operational changes related to the Project. The WOMT may request additional information and analysis from the SWG or the Project analysis and synthesis team (Figure C-6).

PRODUCTS AND DISPOSITION OF RESULTS

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

FEEDBACK TO PROJECT TEAM

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

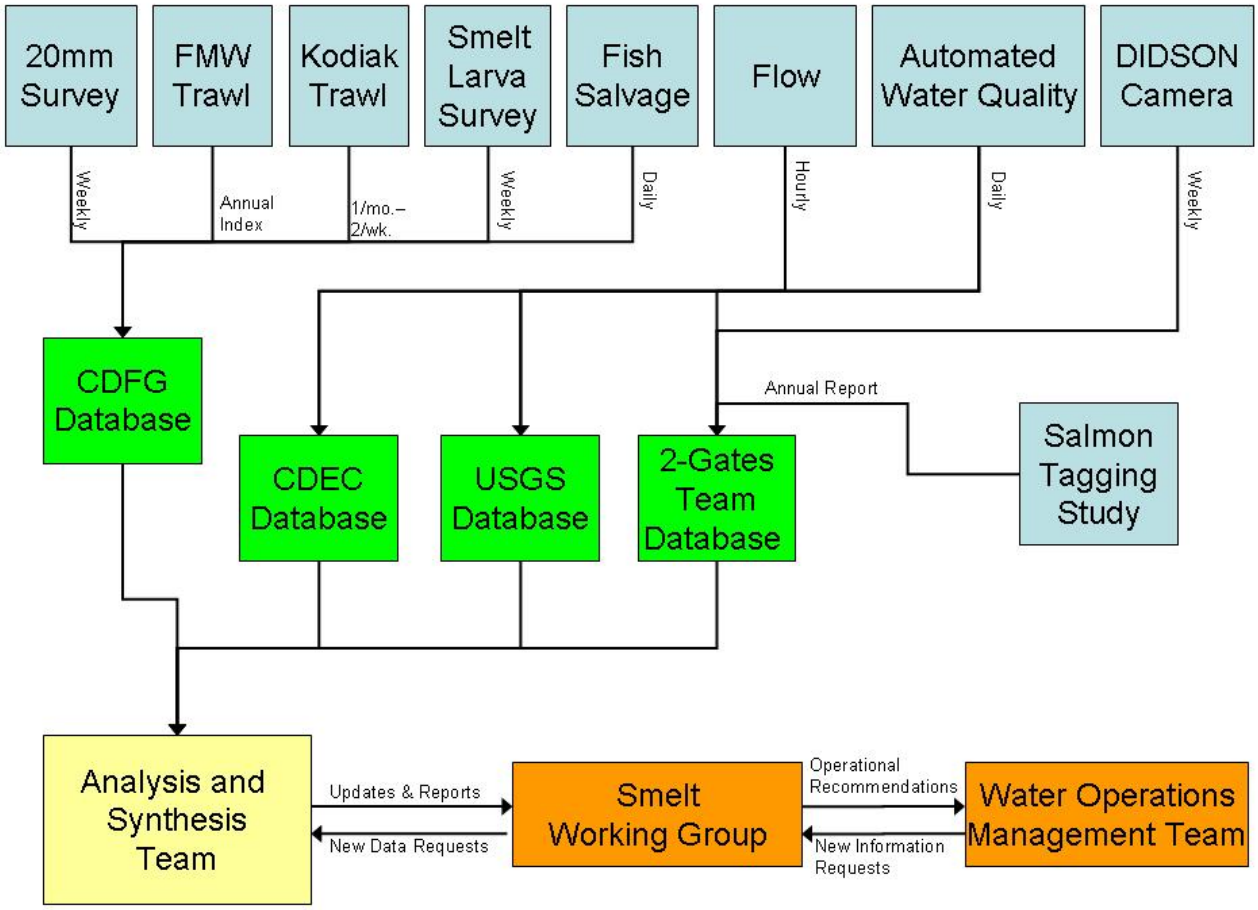

Figure C-6 Proposed Information Management Structure for the 2-Gates Monitoring Program

FEASIBILITY ISSUES

Study Elements

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

Fish Capture Probability: Densities of delta smelt, longfin smelt, and steelhead are currently at record low levels making monitoring indices less reliable for these species. There is a high probability that no individuals of any species will be caught at a specific location and time even though the species may be present in the area. This presents a problem for statistical interpretation of monitoring results and may introduce increased variability into calculated population and density estimates. Problems with low capture probability will mostly affect the Kodiak, 20 mm, and fall mid-water trawls as well as the smelt larval survey. While delta-wide annual population indices are likely to be comparable to recent annual indices and statistically robust, specific density estimates for areas affected by the gates may be difficult to calculate.

Salmon Tracking: Each experimental release of tagged salmon or steelhead fish is an extremely intensive effort and, in order to be successful, has to be closely coordinated with numerous other monitoring programs

from various organizations (IEP sampling programs, CDFG Hatchery Operations, VAMP, Sacramento River salmon migration studies, Mokelumne River salmon studies, and state and federal screen operation programs). Some elements of the proposed project are feasible and similar projects have occurred with success in other Central Valley rivers and areas of the Delta. These include past tagging and tracking projects performed by the USGS, VAMP, and EBMUD (see Workman et al. 2008).

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

Permits and Agreements

All necessary permits for the Project plan and associated activities will need to be acquired. Time lines for federal ESA Section 10(A)(1)(a) permits is approximately 9 months from initial application. Initial application will need to follow issuance of a Biological Opinion in support of the Project. A second approach would be to have the study overseen by a Principal Investigators already holding permits to handle and study these species. Typically, an existing permit would need to be modified for the 2-Gates Project studies. Permitting could initially be covered by Section 7 of the Endangered Species Act (16 U.S.C. 1531 et seq.) and CDFG Scientific Collecting Permits.

ESTIMATED BUDGET AND SCHEDULE

To be provided under separate cover.