Table of Contents

Figures

SECTION 4 Environmental Baseline

The environmental baseline is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species within the Action Area. The environmental baseline "includes the past and present impacts of all Federal, State, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed Federal projects in the Action Area that have already undergone formal or early Section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR § 402.02). The following discussion addresses first the regulatory baseline established by the State of California and recent biological opinions by the USFWS and NMFS which establish constraints of CVP and SWP operations within the Delta, then the ongoing natural and anthropogenic factors leading to the current status of the species under consideration in the BA.

4.1 REGULATORY BASELINE

4.1.1 Water Right Decision 1641

The SWRCB imposes a myriad of water rights terms and conditions on the operations of the CVP and SWP in the Delta. With Water Right Decision 1641(D-1641), the SWRCB implements the objectives set forth in the SWRCB 1995 Bay-Delta Water Quality Control Plan and establishes flow and water quality objectives to assure protection of beneficial uses in the Delta. The SWRCB also grants conditional changes to points of diversion for the Projects within D-1641. The numerous flow and export restraints are designed to protect fisheries. These objectives include specific outflow requirements throughout the year, specific export restraints in the spring and export limit based on a percentage of estuary inflow through the year. The water quality objectives are designed to protect agricultural, municipal, and industrial users in and around the Delta, as well as fishery uses, and they vary through the year and wetness of the year.

4.1.2 USFWS Biological Opinion on Coordinated Operations of the CVP and SWP

On December 15, 2008, the U.S. Fish and Wildlife Service (USFWS) issued a final biological opinion (BO) in response to Reclamation's May 16, 2008 request for formal consultation regarding the continued long term operations of the CVP in coordination with the SWP. Reclamation was the lead agency and the California Department of Water Resources (DWR) was the co-applicant for this consultation. In its opinion, the USFWS concluded that continued long term operations of the CVP and SWP, as proposed, were "likely to jeopardize" the continued existence of delta smelt without further flow conditions in the Delta for their protection and the protection of designated delta smelt critical habitat (USFWS 2008). In order to avoid jeopardizing the continued existence of delta smelt or the destruction or adverse modification of critical habitat, the USFWS developed a Reasonable and Prudent Alternative (RPA) which consists of 5 components aimed at protecting delta smelt, improving and restoring habitat, and monitoring and reporting results. Two of the RPA components are designed to address the protection of different life stages of delta smelt including adults, larvae and juveniles by controlling OMR flows during certain periods when they may be vulnerable. RPA Component 1 is directed at protecting adult delta smelt from entrainment at the pumps and RPA Component 2 is directed at protecting larvae and juvenile delta smelt from entrainment at the pumps. The function and operation of the 2-Gates Project is closely linked to these RPA components.

RPA component 1 addresses high and low entrainment risk periods and actions to protect adult delta smelt under specific conditions during the winter adult migration period. The measure reduces entrainment risk by limiting OMR reverse flows.

RPA Component 2 is implemented upon the completion of RPA component 1 or when Delta water temperatures reach 12ºC, a level that is associated with start of delta smelt spawning, or biological evidence is collected in trawl programs or at the fish facilities that adult smelt have started spawning. OMR flows are also limited under RPA Component 2 depending on the location of the population relative to the proximity of the conveyance channels leading to the pumping facilities in the south Delta.

RPA Component 3 is designed to improve delta smelt habitat during the fall season as related to conditions in the western Delta while RPA Component 4 is directed at habitat restoration in the Delta and Suisun Marsh and RMA Component 5 is directed at Monitoring and Reporting.

4.1.3 DFG 2081 Incidental Take Permit (ITP) for Longfin Smelt

The DFG issued an ITP pursuant to Fish and Game Code section 2081 to the DWR on February 23, 2009 for the on-going and long-term operation of SWP facilities in the Delta for the protection of longfin smelt. Upon review, the DFG found that SWP facilities were within the range of longfin smelt and that they would result in the take[1] of individual longfin smelt and result in temporary or permanent impacts to the species and its habitat. Evidence that longfin smelt would be directly affected by the SWP is provided through salvage records from the Skinner Fish Facility in the south Delta. Adult, sub-adult, larval and juvenile longfin smelt have been recorded in salvage operations from December through June.

Conditions of approval prescribed in the 2081 ITP include OMR flow requirements (Conditions 5.1 and 5.2) and actions to improve survival rates at the Skinner Fish Facility (Condition 6.2.1). The OMR flow requirements are designed to protect adult longfin smelt migration and spawning during the December through February period and larval and juvenile longfin smelt during the January through June period. For the adults (December through February) DFG identified OMR flows no more negative than -5,000 cfs. For the larval/juvenile longfin smelt period, they identified OMR flows no more negative than -1,250 to -5,000 cfs, January through March, no more negative than -2,000 to -5,000, April and May, and no more negative than -5,000 cfs during June. However, these requirements will not be triggered if Sacramento River flows at Rio Vista are greater that 55,000 cfs or San Joaquin River flows at Vernalis are greater than 8,000 cfs. Condition 6.2.1 of the ITP requires DWR to consult with DFG on “projects and actions” to improve survival rates of longfin smelt at the Skinner salvage facility and to produce a plan for implementation by February 2010

4.1.4 NMFS Biological Opinion on Coordinated Operations of the CVP and SWP

On June 4, 2009, the NMFS released a final biological opinion (BO) which concluded that continued long term operations of the CVP and SWP are “likely to jeopardize” the continued existence of Sacramento River winter run Chinook salmon, Central Valley spring run Chinook salmon, Central Valley steelhead, and the southern DPS of North American green sturgeon (NMFS 2009). They also concluded that continued operations of the CVP and SWP were “likely to destroy or adversely modify” designated critical habitat of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead and proposed critical habitat for the southern DPS of North American green sturgeon. In order for CVP and SWP operations to continue in compliance with the ESA, the NMFS developed an RPA which consists of a number of actions which are listed by division: Sacramento Division; American River Division; East Side Division; Delta Division; and, Fish Passage Program. These actions are aimed at protecting listed salmon, steelhead and green sturgeon and improving or restoring habitat. Within the Delta Division, where the 2-Gates Project is located, the NMFS BO includes six RPA actions which they anticipate will reduce the diversion of emigrating juvenile salmonids from the Sacramento River system into the central and southern Delta and which are expected to reduce the

[1] The Fish and Game Code defines “Take” as to “hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture or kill.”

entrainment and salvage of juvenile salmonids emigrating through the Delta at the CVP and SWP pumping facilities in the south Delta. These actions are based on the premise that "a properly functioning Delta is critical to migration pathways and rearing habitat, both of which are primary constituent elements of critical habitat" for listed salmonids and green sturgeon (NMFS 2009). The six actions described by the NMFS to be taken in the Delta are:

Action IV.1: Modify Delta Cross Channel (DCC) gate operations and evaluate methods of controlling access to Georgiana Slough and the Interior Delta.

Action IV.2: Control net negative flows toward the CVP and SWP export pumps through Old and Middle Rivers.

Action IV.3: Curtail export pumping when listed salmonids and sturgeon are observed near the CVP and SWP delta pumping facilities.

Action IV.4: Improve fish screening and salvage operations at the CVP and SWP pumping facilities.

Action IV.5: Establish a technical group to assist in real-time operations

Action IV.6: Do not implement the South Delta Barriers Improvement Program.

4.2 ENVIRONMENTAL BASELINE

4.2.1 Factors Affecting the Species and Critical Habitat in the Action Area

Water exports at the CVP and SWP Delta Pumping Facilities has long been recognized to have multiple effects on the Delta ecosystem upon which species such as delta smelt depend (Stevens and Miller 1983, Arthur et al. 1996, Bennett and Moyle 1996, USFWS 2008). In general, water is conveyed to the Jones Pumping Plant for the CVP and the Banks Pumping Plant for the SWP via the Old River and Middle River (OMR) channels, often resulting in a net (over a tidal cycle or tidal cycles) flow south, through the Action Area, towards these facilities (these are generally referred to as "negative" or "reverse" flows). When combined CVP/SWP water export exceeds San Joaquin River inflows, additional water is drawn from the Sacramento River through the Delta Cross Channel, Georgina Slough, and Three-Mile Slough. At high pumping rates, net San Joaquin River flow is toward Banks and Jones (Arthur et al. 1996). Combined flow in Old River and Middle River is measured as "OMR" flows. Flow towards the pumps (in a southerly direction) is generally characterized as "negative" or "reverse" flow for both measurements. Additionally, OMR flow towards the pumps is increased seasonally by installation of the South Delta Temporary Barriers. In particular, the Head of Old River barrier, when allowed, reduces flow from the San Joaquin River downstream into Old River so more water is drafted from the San Joaquin River through Turner and Columbia cuts adding to OMR flows from the Central Delta

4.2.2 Delta Flow Management

Studies have indicated that in general the CVP and SWP export pumps create a "zone of entrainment" and that flow management can increase the survival of fish residing in or migrating through the Delta. Delta hydrodynamics can be indexed by tidally averaging net flows through Old and Middle Rivers (OMR) that integrate changes in inflow, exports, and barrier operations (Monsen et al. 2007, Peter Smith, USGS, unpublished data). Several analyses have revealed strong, non-linear inverse relationships between net OMR flow and winter salvage of delta smelt at the fish facilities (Reclamation 2008; Peter Smith, USGS, unpublished data; Grimaldo et al accepted manuscript; Kimmerer 2008). Similar relationships have also been observed for listed salmonids, whether from the Sacramento, Mokelumne, or San Joaquin River systems. While the specific details of these relationships vary by species and life stage, net OMR flow generally works very well as a binary switch: negative OMR (net flow south or towards the pumping facilities) is associated with some degree of entrainment, while positive OMR (net flow north or away from the pumping facilities) is usually associated with no, or very low, entrainment. While the mechanism is unknown, OMR flows may interfere or compete with normal tidally driven flows that species would ride or follow into or out of the estuary. Particle tracking modeling (PTM) also shows that entrainment of particles and residence time is highly related to the absolute magnitude of negative OMR flows, and that the zone of influence of the pumps increases as OMR becomes more negative. The rapid increase in the extent of the zone of entrainment at high negative OMR flows likely accounts for the faster-than-linear increase in entrainment as OMR becomes more negative. However, Adult delta smelt do not behave entirely as passive particles, but use tidal flows to seek suitable staging habitats, generally where turbidity levels are greater the 12 NTU's, prior to spawning. When the water being exported is suitable staging habitat, (when turbidity is > 12 NTU), delta smelt do not have a reason to avoid net southward transport toward the pumps so the OMR/entrainment relationship reinforces that tidally averaged net flow is an important determinant of the migratory outcome for delta smelt. The entrainment risk to juvenile salmonids also increases, regardless of their origin, as negative OMR flows increase (NMFS 2009). Consequently, both the USFWS and NMFS have established RPA's in their most recent BO's regarding CVP and SWP long-term operations that limit OMR flows when certain conditions of turbidity, salvage, and water temperature are met between December 1 and June 30 each year (USFWS 2008, RPA Actions 1, 2 and 3; NMFS 2009, RPA IV.2.3)

The NMFS has also noted that numerous studies indicate that increased flows through the Delta are positively correlated to increased survival of emigrating juvenile salmonids through the Delta towards the ocean regardless of whether they originate in the Sacramento, Mokelumne, or San Joaquin River systems. Most at risk are those juvenile salmonids emigrating from the San Joaquin River, Calaveras River and Mokelumne River basins. These fish are particularly vulnerable to entrainment at the CVP and SWP pumping facilities when high export levels draw water through the many channels leading west and south between the confluence of the San Joaquin River and Old River near Vernalis and Jersey Point, on Jersey Island at the confluence of the San Joaquin River and False River. To reduce the vulnerability of juvenile salmonids emigrating from the lower San Joaquin River system to entrainment at the CVP and SWP delta pumping facilities, the NMFS OCAP BO has established an RPA which requires minimum San Joaquin River flows, measured at Vernalis, of 1,500 to 6,000 cfs from April 1 through May 31, annually, depending on water year type. In addition, the NMFS BO established a San Joaquin River inflow to CVP/SWP export ratio of 1:1 to 4:1 between April 1 and May 31 each year, depending on water year type (See NMFS 2009, RPA IV.2.1). It is felt that this requirement will create more favorable hydrologic conditions, including greater net downstream flows, in the main stem of the San Joaquin River for emigrating salmonids. These increased flows through the San Joaquin portion of the Delta are also expected to enhance the survival of Sacramento River salmonids which have been diverted through the DCC or Georgiana Slough to the interior Delta.

4.2.3 Tracy Fish Collection Facility (TFCT) and Skinner Fish Collection Facility

The CVP and SWP south Delta water export facilities are known to entrain all species of fish inhabiting the Delta (Brown et al. 1996) and are of particular concern in dry years, when the distribution of young striped bass, delta smelt, and longfin smelt shift upstream, closer to the diversions (Stevens et al. 1985; Sommer et al. 1997). Delta smelt, juvenile salmon, steelhead, and green sturgeon are all susceptible to entrainment at the CVP and SWP Delta pumping facilities as they migrate through the Delta. Adult salmon, steelhead and sturgeon are not considered as susceptible because of their increased swimming ability allowing them to avoid entrainment.

The Tracy Fish Collection Facility (TFCF) was developed and built by Reclamation in the 1950's as part of the CVP with the initial purpose of rescuing (salvaging) juvenile striped bass and Chinook salmon caught up in the incoming flows at the intake of the Delta Mendota Channel (DMC) by way of the Tracy Pumping Plant (TPP). The best available technology at the time proved to be a set of vertical louvers angled into the inflows that directed fish towards recessed collection tanks. Changes over time redirected to rescue/salvage operations at the TFCF to focus primarily of delta smelt, Chinook salmon, steelhead, green sturgeon and other State or Federal listed species or species of concern. Under current operations, fish are removed from the collection tanks several times each day, transferred to fish trucks, and transported to lower San Joaquin and Sacramento River sites for release back into the Delta.

The Skinner Fish Protection Facility (SFPF) was constructed in the late 1960's and is designed as a "behavioral barrier", using a complex system of louvers and pipes to divert water into holding tanks where entrained fish (characterized as "salvage") are collected and trucked to western Delta locations and released in a effort to reduce the adverse effects of fish loss due to operations of the Banks Pumping Plant. Unfortunately, the louver system is relatively inefficient at protecting fish less than 20 mm in length (DFG 2009).

The magnitude of entrainment effects caused by the SWP's Banks Pumping Plant and the CVP Jones Pumping Plant is indicated by the approximately 110 million fish salvaged at the SWP's Skinner Fish Collection Facility, located just downstream of the Banks Pumping Plant, and returned to the Delta over a 15-year period (Brown et al. 1996). This number greatly underestimates the actual number of fish entrained and does not include losses through the guidance louvers at either facility. For Banks in particular, it does not account for high rates of predation in the Clifton Court Forebay which separates the Old River diversion point from the Skinner and Banks facilities (Gingras 1997).

The entrainment of adult delta smelt at the CVP and SWP Pumping facilities occurs mainly during their upstream spawning migration between December and April. Entrainment risk depends on the location of the fish relative to the export facilities and the level of exports (Grimaldo et al. accepted manuscript). The spawning distribution of adult delta smelt varies widely among years. In some years a large proportion of the adult population migrates to the Central and South Delta, placing both spawners and their progeny in relatively close proximity to the export pumps and increasing entrainment risk. In other years, the bulk of adults migrate to the North Delta, reducing entrainment risk. In very wet periods, some spawning occurs west of the Delta.

The CVP and SWP water operations are thought to have a minor impact on delta smelt eggs because they remain attached to substrates or at least are strongly negatively buoyant due to attached sand grains (USFWS 2008). However, shortly after hatching, larvae become subject to flow-mediated transport, and are vulnerable to entrainment although they generally do not show up in salvage counts until they reach 20-25 mm in length. Most salvage of juvenile delta smelt occurs from April-July with a peak in May-June (Grimaldo et al. accepted manuscript, as referenced in USFWS 2008).

Delta smelt and other fish are not officially counted at the fish facilities unless they are 20 mm or greater in total length and transitioning to the juvenile stage. Juvenile delta smelt are vulnerable to entrainment and are counted in salvage operations once they reach 20-25 mm in length, but the fish facilities only capture a portion of the fish passing the louvers and screens until they surpass 30 mm in length (Kimmerer 2008). Most salvage of juvenile delta smelt occurs from April-July with a peak in May-June (Grimaldo et al. accepted manuscript). High winter entrainment has been suspected as a contributing cause of both the early 1980s (Moyle et al. 1992a) and the POD-era declines of delta smelt (Baxter et al. 2008).

4.2.4 Contra Costa Water District

Contra Costa Water District (CCWD) diverts water from the Delta for irrigation and municipal and industrial uses in central and eastern Contra Costa County, California (between the Delta and San Francisco Bay). CCWD's system includes intake facilities in the Delta at Mallard Slough, Rock Slough, and Old River near SR 4. Water can be sent directly to treatment plants for use or to the Los Vaqueros Reservoir for storage. The total diversion by CCWD is approximately 127 TAF per year. Most CCWD diversions are made through facilities that are screened; the Old River (80 percent of CCWD diversions) and Mallard Slough (3 percent of CCWD diversions) facilities have fish screens to protect delta smelt. However, the fish screens on these facilities may not protect larval fish from becoming entrained. For that reason, in part, there are also no-fill and no diversion periods at the CCWD facilities. Before 1998, the Rock Slough Intake was CCWD's primary diversion point. It has been used less since

1998 when Los Vaqueros Reservoir and the Old River Pumping Plant began operating and now only accounts for 17 percent of CCWD's diversions. To date, the Rock Slough Intake is not screened. Reclamation is responsible for constructing a fish screen at this facility under the authority of the CVPIA. Reclamation has received an extension for construction of the screen until 2008 and is seeking a further extension until 2013. The diversion at the Rock Slough Intake head works structure is currently sampled with a sieve net three times per week from January through June and twice per week from July through December. A plankton net is fished at the head works structure twice per week during times when larval delta smelt could be present in the area (generally March through June). A sieve net is fished at Pumping Plant #1 two times per week from the time the first Sacramento River winter-run Chinook salmon is collected at the TFCF and SFF (generally January or February) through June. The numbers of delta smelt entrained by the facility since 1998 have been extremely low, with only a single fish observed in February 2005 (Reclamation 2008).

4.2.5 Delta Cross Channel (DCC)

The Delta Cross Channel (DCC) is a component of the CVP and was built to convey water from the Sacramento River to the lower Mokleumne River to improve water quality conditions in the central Delta. When gates at the head of the DCC are open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the Central Delta.

As reported by the NMFS, studies have shown that emigrating salmonids and green sturgeon, which are diverted through the DCC into the Mokelumne River system and the central Delta, experience much higher mortality rates than those which stay in the lower Sacramento River. Longer emigration time through the Delta, combined with increased exposure to predation and the indirect effects of contamination, along with an increased risk of entrainment into the CVP and SWP pumping facilities are all stressors to salmonid and sturgeon as a result of opening the DCC gates (NMFS 2009). As a result, the NMFS has established a RPA action in their OCAP BO which specifically addresses DCC operations (NMFS 2009 RPA Action IV.1.2.). Based on certain triggers, the NMFS BO requires DCC gate closure between October 1 and June 15 each year in accordance with the following general criteria:

- **October 1 through December 14:** Gates closed when water quality criteria per D-1641 are met and the Knights Landing Catch Index (KLCI) or Sacramento Catch Index (SCI) for salmon is greater than 3 fish per day;
- **December 15 through January 31:** Gates closed, but may be opened for up to 5 days to conduct NMFS approved experiments or up to 3 days (from one hour after sunset to one hour before sunrise) when necessary to maintain Delta water quality;
- **February 1 through May 15:** Gates closed (as required by D-1641);
- **May 16 through June 15:** Gates closed for up to 14 days for fisheries protection if determined necessary by NMFS;
- **June 16 through September 30:** Gates generally open, with intermittent closures for hydrodynamic and fishery experiments as necessary.

4.2.6 South Delta Temporary Barriers (SDTB)

The South Delta Temporary Barriers (SDTB) project was initiated by DWR in 1991 in partial response to a 1982 lawsuit filed by the South Delta Water Agency. The projects objective is to ensure that south delta agricultural diverters do not experience adverse water level and circulation conditions as a result of SWP and CVP operations. The project consists of four rock barriers across south Delta channels, three "agricultural" barriers (one on Old River near Tracy, one on Middle River, and one on Grant Line Canal) and one "fish" barrier, located at the Head of Old River (HORB). The three agricultural barriers are generally installed between April 15 and September 30 each year. The HORB has been installed in most years in the fall, between September 15 and November 30, and during the spring, between April 15 and May 30 to protect migrating salmon in the San Joaquin River. However, under the terms of the FWS 2008 OCAP BO installation of the HORB is only allowed when delta smelt "entrainment" at the confluence of the Mokelumne River and the San Joaquin River (Station 815) is predicted by the particle tracking model (PTM) to be less than 1% (USFWS 2008, RPA Action 5). High flows on the San Joaquin River can also prohibit installation of the HORB. The U.S. Army Corps of Engineers (Corps) issued a 404 permit to DWR for annual installation and operation of the SDTBs. Both the USFWS and NMFS have issued biological opinions on SDTB program permits through 2007 and have included continued operations of the SDTB program through 2010 in their 2008 BO's on the continued coordinated operation of the SWP and CVP (USFWS 2008, NMFS 2008). The NMFS has determined that the proposed replacement of these temporary barriers with permanent operable gates will adversely modify critical habitat and has directed DWR not to implement the South Delta Improvement Program, which includes permanent operable gates in Phase I (NMFS 2009, RPA IV.6).

Installation and operation of the SDTBs does not change total Delta outflow or the location of X2 but does cause changes in the hydraulics of the southern and central Delta that affect fish. The spring, installation of the HORB is designed to reduce the number of emigrating salmon smolts from the San Joaquin River basin from entering the south Delta via Old River. During the fall, this barrier is designed to improve flow and dissolved oxygen (DO) conditions in the San Joaquin River for the immigration of adult fall-run Chinook salmon. When the HORB is in place, San Joaquin River flow is effectively blocked from entering Old River. This, in turn, increases westerly flow from the San Joaquin River via Turner and Columbia cuts, two major Central Delta channels that flow toward the Banks and Jones pumping plants. In years when sizable numbers of delta smelt move into the central Delta, increases in negative OMR caused by installation of the SDTBs can also increase their entrainment at the SWP and CVP pumps (USFWS 2008). At this time it is not certain if the SDTB program will continue beyond 2010.

4.2.7 Vernalis Adaptive Management Plan (VAMP)

The Vernalis Adaptive Management Plan (VAMP) was initiated in 2000 as part of the SWRCB D-1641and is a large-scale, 12 year, experimental-management program designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta and to determine their survival rates in response to changes in San Joaquin River flows and CVP and SWP exports and the installation of a temporary barrier at the head of Old River (currently limited by the USFWS 2008 BO, RPA Action 5). Managed by the San Joaquin River Technical Committee (SJRTC), the VAMP program schedules and maintains pulse flows from the San Joaquin River system (as measured at Vernalis), combined with reduced exports at the CVP and SWP pumping plants for one month during the spring salmon smolt emigration period, typically from April 15- May 15, although this time period may change from year to year based on water year conditions. Tagged salmon smolts released in the San Joaquin River are monitored as they move through the Delta in order to determine their fate. While VAMP-related studies attempt to limit CVP and SWP impacts to San Joaquin River juvenile salmonids, the associated reduction in exports reduces the upstream flows (also referred to as "negative" or "reverse" flows) that occur in the South and Central Delta. This reduction limits the southward draw of water from the Central Delta, reducing the entrainment of delta smelt (USFWS 2008) along with Sacramento and Mokelumne River salmon and steelhead.

Under terms of the 2009 NMFS OCAP BO, minimum San Joaquin River flows at Vernalis are required from April 1 through May 31 annually, beginning in 2010 (NMFS 2009, RPA Action IV.2.1). This requirement establishes minimum San Joaquin River flows, measured at Vernalis, of 1,500 to 6,000 cfs depending on water year type, between April 1 and May 31 each year. In addition, the NMFS has established a San Joaquin inflow to CVP/SWP export ratio for the April 1 to May 31 period annually of 1:1 to 4:1, depending on water year type. It is felt that this requirement will create more favorable hydrologic conditions, including greater net downstream flows, in the main stem of the San Joaquin River for emigrating salmonids. At this time it is uncertain how the new NMFS requirement will affect experimental-management program design for the duration of the VAMP program.

4.2.8 In-Delta Diversions

There are 2,209 known agricultural diversions in the Delta (Herren and Kawasaki 2001). The vast majority of these diversions do not have fish screens to protect fish from entrainment. It has been recognized for many years that delta smelt are entrained in these diversions (Hallock and Van Woert 1959). Determining the effect of this entrainment has been limited because previous studies either (1) did not quantify the volumes of water diverted (Hallock and Van Woert 1959), or (2) did not sample at times when, or locations where, delta smelt were abundant (Spaar 1994, Cook and Buffaloe 1998). Delta smelt primarily occur in large open-water habitats, but early life stages move downstream through Delta channels where irrigation diversions are concentrated (Herren and Kawasaki 2001). At smaller spatial scales, delta smelt distribution can be influenced by tidal and diel cycles (Bennett et al. 2002), which also may influence vulnerability to shore-based diversions.

In the early 1980s, delta smelt were commonly entrained in the Roaring River diversion in Suisun Marsh (Pickard et al. 1982), suggesting that it and similar diversions can adversely affect delta smelt. However, delta smelt may not be especially vulnerable to many Delta agricultural diversions for several reasons. First, adult delta smelt move into the Delta to spawn during winter-early spring when agricultural diversion operations are at a minimum. Second, larval delta smelt only occur briefly in most of the Delta and not usually during the summer months when diversion demand is high. Third, Nobriga et al. (2004) examined delta smelt entrainment at an agricultural diversion in Horseshoe Bend during July 2000 and 2001, when much of the YOY population was rearing within one tidal excursion of the diversion. Delta smelt entrainment was an order of magnitude lower than density estimates from the DFG 20-mm Survey. Low entrainment was attributed to the offshore distribution of delta smelt, and the extremely small hydrodynamic influence of the diversion relative to the channel it was in. Because Delta agricultural diversions are typically close to shore and take small amounts of water relative to what is in the channels they draw water from, delta smelt vulnerability is generally thought to be low, despite their small size and their poor performance near simulated fish screens in laboratory settings (Swanson et al. 1998; White et al. 2007). The impact on fish populations of individual diversions is likely highly variable and depends upon size, location, and operations (Moyle and Israel 2005). Given that few studies have evaluated the effectiveness of screens in preventing losses of fish, much less declines in fish populations, further research is needed to examine the likely population level effects of delta smelt mortality attributed to agricultural diversions (Nobriga et al. 2004; Moyle and Israel 2005). Note however, that most of the irrigation diversions are in the Delta, so low flow conditions that compel delta smelt to rear in the Delta fundamentally mediate loss to these irrigation diversions. PTM evidence for this covariation of Delta hydrodynamics and cumulative loss to irrigation diversions was provided by Kimmerer and Nobriga (2008).

4.2.9 Invasive Species

Invasive species greatly impact the growth and survival of juvenile salmonids, and likely adult and juvenile delta and longfin smelt within the Delta, including the Action Area. Non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and other sunfish species (*Lepomis* and *Pomoxis* spp) present an additional risk to the survival of listed fish species migrating through, spawning, and/or rearing in the Delta that was not historically present prior to their introduction. These introduced species are often better suited to the changes that have occurred in the Delta habitat than are the native species. The presence of the Asian clam (*Potamocorbula amurensis)* has led to alterations in the levels of phyto- and zooplankton found in water column samples taken in the Delta. This species of clam efficiently filters out and feeds upon a significant number of these planktonic organisms, thus reducing the populations of potential forage species for listed fish species.

Likewise, introductions of invasive plant species such as the water hyacinth (*Eichhornia crassipes*) and *Egeria densa* have diminished access of listed fish species to critical habitat. *Egeria densa* forms thick “walls” along the margins of channels in the Delta. This growth prevents listed fish species from accessing their preferred shallow water habitat along the channel's edge. In addition, the thick cover of *Egeria* provides excellent habitat for ambush predators, such as sunfish and bass, which can then prey on juvenile salmonids swimming along their margins. Water hyacinth creates dense floating mats that can impede river flows and alter the aquatic environment beneath the mats. DO levels beneath the mats often drop below sustainable levels for fish due to the increased amount of decaying vegetative matter produced from the overlying mat. Like *Egeria*, water hyacinth is often associated with the margins of the Delta waterways in its initial colonization, but can eventually cover the entire channel if conditions permit. This level of infestation can produce barriers to fish movement within the Delta. The introduction and spread of *Egeria* and water hyacinth have created the need for aquatic weed control programs that utilize herbicides targeting these species. Even in dilute concentrations, these compounds are thought to have indirect effects, such as reduced reproductive output or ability to avoid predators, on listed salmonids, and likely smelt, in the Action Area. However, increased regulation generally is expected to improve the water quality in the Delta.

4.2.10 Existing Monitoring Programs

Most research and monitoring of fish populations in the Bay-Delta estuary are coordinated through the Interagency Ecological Program (IEP). The IEP is a cooperative effort, funded primarily by Reclamations and DWR and led by state and federal resource agencies with university and private partners. There are currently 16 fish monitoring programs that are implemented year-round across the entire Bay-Delta system (Honey et al. 2004). Figure 2-1 illustrates existing monitoring stations that are sampled regularly in the Bay-Delta estuary under different programs and which capture delta smelt, longfin smelt, salmon, and other fish species. Sturgeon are rarely collected at these stations. The Fall Midwater Trawl Survey (FMWT) and the Summer Townet Survey (TNS) are the two longest running IEP fish monitoring programs that are used to index the abundance of delta smelt and other fish species. They work well because they were originally designed to target age-0 striped bass, which have similar habitat requirements to delta smelt. Two more recent programs, the 20-mm Survey and the Spring Kodiak Trawl (SKT) Survey, were designed specifically to sample delta smelt and are also commonly used to evaluate relative abundance and distribution.

Each of these four sampling programs mentioned above targets different life stages and encompasses the entire distribution of delta smelt for the given life stage and time of year. The efficiency of sampling gears used for delta smelt is unknown. However, they were all designed to target open-water pelagic fishes and data from these programs have been used extensively in prior studies of delta smelt abundance and distribution (e.g., Stevens and Miller 1983; Moyle et al. 1992a; Jassby et al. 1995; Dege and Brown 2004; Bennett 2005; Feyrer et al. 2007).

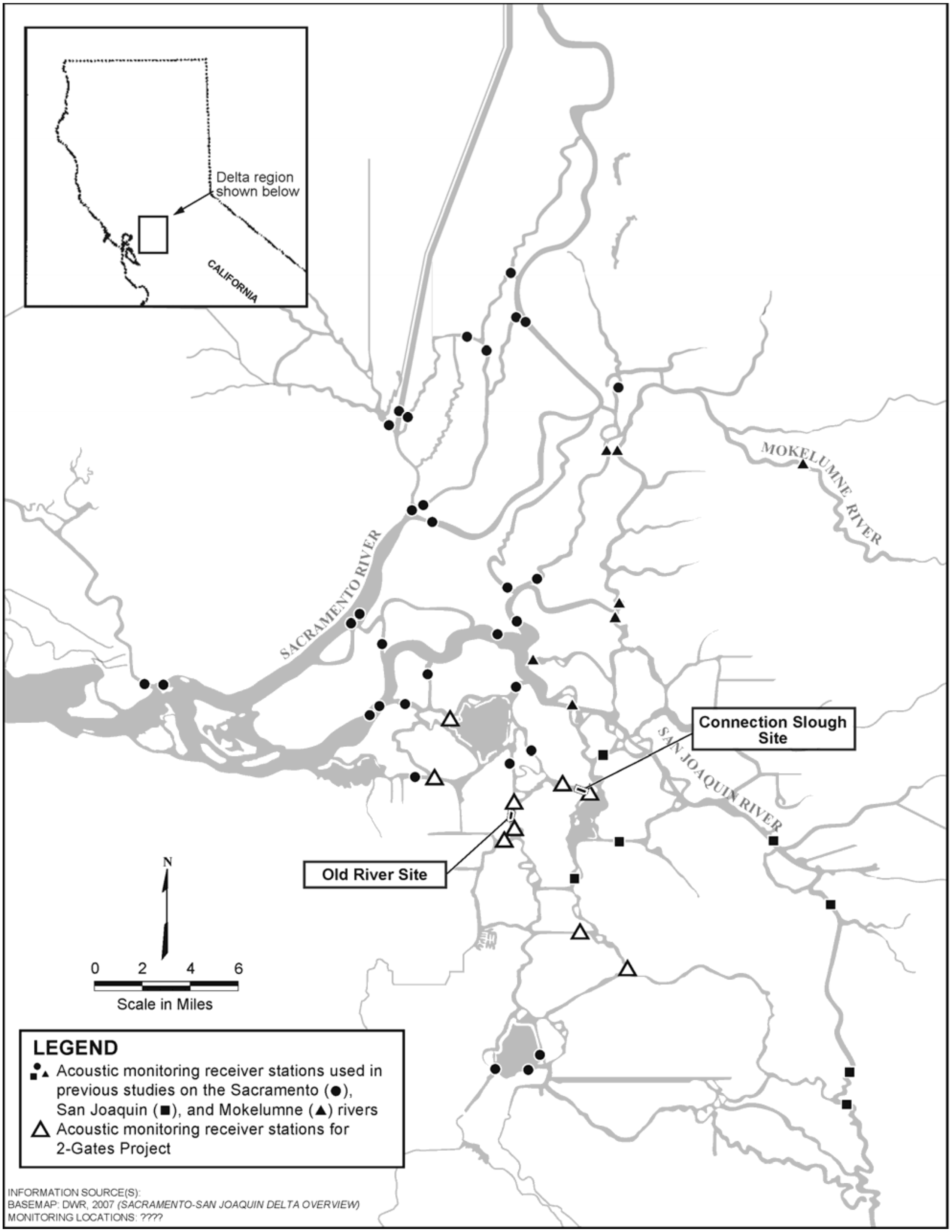

Figure 2-1 Locations of existing monitoring stations that are sampled regularly in the Bay-Delta estuary under different programs and the 2-Gates acoustic monitoring receiver stations.

Data from the FMWT are used to calculate indices of relative abundance for delta smelt. The program has been conducted each year since 1967, except that no sampling was done in 1974 or 1979. Samples (10-minute tows) are collected at 116 sites each month from September to December throughout the Bay-Delta. Detailed descriptions of the sampling program are available from Stevens and Miller (1983) and Feyrer et al. (2007). The delta smelt recovery index includes distribution and abundance components and is calculated from a subset of the September and October FMWT sampling (http://www.delta.dfg.ca.gov/). The details on the calculation of the recovery index can be found in the Delta Native Fishes Recovery Plan (USFWS 1995b). Data from the TNS are used to calculate indices of abundance for young-of-year delta smelt during the summer. The TNS has been conducted annually since 1959 (Turner and Chadwick 1972). It involves sampling at up to 32 stations with three replicate tows to complete a survey. A minimum of two surveys is conducted each year. The delta smelt index is generated from the first two TNS surveys (Moyle et al. 1992a). The TNS sampling has had an average survey starting date of July 13, but surveys have been conducted as early as June 4 and as late as August 28 in some years (Nobriga et al. 2008). Data from the 20-mm survey are used to examine the abundance and distribution of young post-larval/early juvenile delta smelt during the spring (Dege and Brown 2004). The survey has been conducted each year since 1995, and involves the collection of three replicate samples at up to 48 sites; additional sites have been added in recent years. A complete set of samples from each site is termed a survey and 5-9 surveys are completed each year from approximately March though June. This survey also simultaneously samples zooplankton with a Clarke-Bumpus net during one of the three sampling tows at each site. Data from the SKT are used to monitor and provide information on the pre-spawning and spawning distributions of delta smelt. The survey also quantifies the reproductive maturity status of all adult delta smelt collected. SKT sampling has been done since 2002 at approximately 39 stations. Sampling at each station is completed five or more times per year from January to May. Supplemental surveys are often completed when additional information is requested by managers to assist with decisions relating to water project. An additional source of information on delta smelt comes from salvage operations at the Banks and Jones pumping plant fish collection facilities. Both pumping facilities are screened with fish-behavioral louvers designed to salvage young Chinook salmon and striped bass before they enter the pumps (Brown et al. 1996).

In general, the salvage process consists of fish capture, handling, transport, and ultimately release at locations where they are presumed safe from further influence of the CVP and SWP delta pumps. However, unlike some species, it is commonly recognized that delta smelt often do not survive the salvage process. Data on the salvage of delta smelt is typically used to provide an index of entrainment into the diversion pumps, but not as an index of general population abundance. However, there are a number of caveats with these data including unknown sampling efficiency, unknown pre-screen mortality in Clifton Court Forebay, and no sampling of fish smaller than 20 mm (Kimmerer 2008). Fortunately, some of this information may become available in the future because of targeted studies on efficiency and pre-screen mortality being conducted by the IEP and Reclamation. Although monitoring at the Banks and Jones pumping plants is limited in geographic range compared to the other surveys, they sample substantially larger volumes of water, and therefore may have a greater likelihood to detect low densities of delta smelt larger than 20 mm. Delta smelt entrainment is presently estimated (or indexed) by extrapolating data from periodic samples of salvaged fish (≥ 20 mm). Fish are counted from a sub-sample of water from the facility holding tanks and numbers are extrapolated based on the volume of water diverted during collection of that sample to estimate the number of fish entrained into the Banks and Jones pumping plants. Intervals typically range from 1-24 hours depending on time of year, debris loads, etc.

4.2.11 Levee Construction, Maintenance and Bank Protection

Levee construction, maintenance and bank protection activities have affected aquatic habitat availability and the processes that develop and maintain preferred habitat by reducing floodplain connectivity, changing riverbank substrate size, and decreasing riparian habitat and shaded riverine aquatic cover. Levee construction, maintenance and bank protection activities generally result in two levels of impacts to the environment: (1) site-level impacts which affect the basic physical habitat structure at individual bank protection sites; and (2) reach-level impacts which are the cumulative impacts to ecosystem functions and processes that accrue from multiple bank protection sites within a given river reach. Revetted embankments result in loss of sinuosity and braiding and reduce the amount of aquatic habitat. Impacts at the reach level result primarily from halting erosion and controlling riparian vegetation. Reach-level impacts which cause significant impacts to fish are reductions in new habitats of various kinds, changes to sediment and organic material storage and transport, reductions of lower food-chain production, and reduction in aquatic cover provided by root-wads and large woody debris within the river channel.

4.2.12 Research and Monitoring Programs

Research and monitoring programs within the Delta, including potentially the Action Area, are expected to continue into the future. These include DFG monitoring programs, DWR studies and sampling, IEP studies, and various fish sampling programs conducted by academics and private consulting firms. Both lethal and non-lethal take of various fish species, including listed species, is associated with these programs. If listed populations are reduced to very low abundance levels, incidental take associated with these monitoring can have an effect on the survival and recovery of listed species.