ATTACHMENT A

Project Description

1 PURPOSE AND NEED

1.1 INTRODUCTION

Water quality conditions in the Sacramento-San Joaquin River Delta (Delta) are declining as a result of persistent drought conditions, putting municipal and agricultural water supplies at risk. The declining water quality conditions also are degrading habitat for threatened and endangered fish dependent on the Delta. In response to these conditions, the U.S. Department of Agriculture identified 54 counties in California as eligible for natural disaster assistance, including funding for emergency watershed protection and water assistance for rural communities following President Obama's announcement of an administration-wide drought response in February 2014.

Additionally, on January 17, 2014, California's Governor Edmund G. Brown Jr. signed a proclamation declaring a State of Emergency, prompted by record dry conditions and projections that 2014 will be the driest year on record (see http://gov.ca.gov/news.php?id=18368). In his proclamation, he found that the lack of precipitation is beyond the ability of local authorities to address and has placed the safety of people and property existing within California in peril due to water shortage from persistent drought conditions. Governor Brown issued a number of directives calling for immediate action to implement conservation programs, to secure water supplies for at risk communities, and to protect critical environmental resources.

Many of these actions would be undertaken by the California Department of Water Resources (DWR) and its various federal, state, and local partners. These actions include temporary modifications of requirements included in the State Water Resources Control Board's Revised Decision 1641 (D-1641) to meet water quality objectives in the Water Quality Control Plan for the Bay-Delta, including increased flexibility for water transfers, diversions, and Delta Cross Channel (DCC) gate operations. The drought proclamation also directed DWR to take other necessary actions to protect water quality and water supply in the Delta, including installation of temporary barriers or temporary water supply connections as needed, and coordination with the California Department of Fish and Wildlife (DFW) to minimize impacts on affected aquatic species.

DWR's proposed 2014 Emergency Drought Barriers Project (EDB) seeks to protect the quality of water for users that rely on Delta water. The EDB would include installation of temporary rock barriers near the heads of Sutter and Steamboat sloughs in order to keep more flow in the Sacramento River, thereby facilitating a greater flow of freshwater through Georgiana Slough and the DCC in order to repel salinity from the central/south Delta and maintain water quality. An additional barrier in West False River near its confluence with the San Joaquin River would be installed to limit salinity intrusion along the lower San Joaquin River and the channels leading from it. The barriers are intended to specifically benefit:

- Communities and farmers in and adjacent to the Delta that rely exclusively on this source for drinkable water and irrigation.
- Upstream resources and communities, because once installed, the barriers would reduce demand on reservoir releases to maintain salinity levels in the Delta, leaving more water upstream for both fishery and community needs.
- The State Water Project (SWP) and Central Valley Project (CVP), as they attempt to maintain access to water supplies for human health and safety.

There is precedent for the EDB. Several rock barriers were installed at Delta locations during 1976 and 1977 to help mitigate for drought conditions. In 1976, one barrier was installed at Sutter Slough to help meet water quality criteria, to conserve water during the drought, and to enable increased SWP and CVP pumping, and the second barrier was installed at Old River at its divergence from the San Joaquin River (often referred to as head of Old River) to protect fishery resources in the Delta. In 1977, as drought conditions continued, barriers were installed at six different locations in the Delta. In addition, control facilities were built at two additional locations. The six barrier locations constructed in 1977 included Old River east of Clifton Court, San Joaquin River near Mossdale, Rock Slough, Indian Slough, Dutch Slough, and the head of Old River.

1.2 PURPOSE OF AND NEED FOR THE EMERGENCY DROUGHT BARRIERS PROJECT

The purpose of the EDB is to prevent the intrusion of saltwater into the Delta, which would render the water undrinkable by 25 million Californians and unusable by the farms that are reliant upon this source, as well as to protect habitat for sensitive aquatic species in the Delta.

The Project is needed because the water supply for all those dependent on the water in the Delta is at risk as water quality conditions in the Delta decline due to the severe drought conditions[1]. In January of this year, unusual amounts of saltwater began intruding into the Delta. The resulting water quality approached human health criteria at many locations in the south Delta and spread as far south as the SWP and CVP intakes near Tracy, putting several communities and local water purveyors dependent on that water supply at risk. The bromide levels also are increasing along with salinity (bromide concentrations are typically low in freshwater and higher in seawater). This is important because bromide plays a role in the formation of disinfection by-products (trihalomethanes and bromate), which are carcinogens and difficult to treat with existing drinking water purification processes.

The Delta is a complex system of interconnecting channels that provide numerous pathways for the tides to push saltwater inland. Normally, outflow is sufficient to prevent San Francisco Bay’s saline water from migrating eastward into the Delta with each tidal pulse, but the record dry January experienced dramatically lower outflow levels. Subsequent storms in February temporarily increased freshwater flow into the Delta, stabilizing salinity levels in the Delta during late February through March. However, precipitation has been low in March, and the National Oceanic and Atmospheric Administration’s seasonal drought outlook predicts drought conditions will persist or intensify through May 31. Sierra snowpack and most reservoirs are below or about at normal levels for this time of year. Currently, Lakes Shasta and Oroville are at 45 percent capacity, and Folsom Lake is at 41 percent capacity (Special Committee on Bay Delta 2014). More significantly, the snowpack that would typically refill them is about 24 percent of average (DWR 2014a), reducing the amount of runoff that will occur later this spring. Thus, there will be insufficient water in the natural runoff or stored in reservoirs that can be released to keep salinity out of the Delta without exhausting stored water before the end of the year. Given current reservoir storage and expected runoff, projections indicate that low river inflows will allow salinity intrusion to the extent that interior portions of the Delta will exceed water quality objectives by May (Resource Management Associates 2014).

The maximum mean daily salinity objective for municipal and industrial use in all water year types established by State Water Resources Control Board in D-1641 is approximately 415 milligrams per liter (mg/L) (Table 1, Water

[1] Calendar year 2013 was the driest year in recorded history for many areas of California, and current conditions suggest no change in sight for 2014 (DWR 2014a).

Quality Objectives for Municipal and Industrial Beneficial Uses). However, in August 2014, salinity is projected to peak and exceed 3,100 mg/L at the SWP intake (Resource Management Associates 2014). Such high salinity levels (with associated bromide levels) could preclude pumping and/or compromise municipal water supplies. This would be particularly devastating for communities without alternative water supplies, including the Contra Costa Water District, which serves approximately 500,000 people and is almost entirely dependent on the Delta for its water supply (Contra Costa Water District 2011).

Once salinity intrudes into the Delta, moving it back toward San Francisco Bay is difficult; thus, high salinity could persist for an extended period if high winter and spring freshwater flows are not available to dislodge it. This would effectively eliminate the Delta as a water supply for the Californians who depend on it, as well as for 3 million acres of farmland. This condition would exist, perhaps for many months, until sizeable storms could provide the necessary outflow to flush out the saline waters. In addition to being critical for the health and safety of those who depend on it, water flowing through the Delta is essential to the agricultural industry and businesses that drive the state's economy; it sustains $400 billion of California's statewide economy (DWR 2014b). Consequently, increased salinity levels would have a profound detrimental effect throughout the state.

Increased salinity levels also have an adverse effect on the sensitive aquatic resources that live in and pass through the Delta. This is both due to exceedance of water quality objectives and because the already limited water supplies stored in the upstream reservoirs would need to be released in order to meet objectives. As a result, cool water resources would be insufficient in late spring and summer to protect salmon eggs incubating in the gravels, and rearing habitat for juvenile salmon below Keswick, Oroville, and other dams would be depleted. Construction of the barriers would allow the retention of additional amounts of cool water to protect natural resource values later in the year because less water would need to be released from the reservoirs for water quality earlier in the year. Additionally, more water also would be available for community needs in upstream areas.

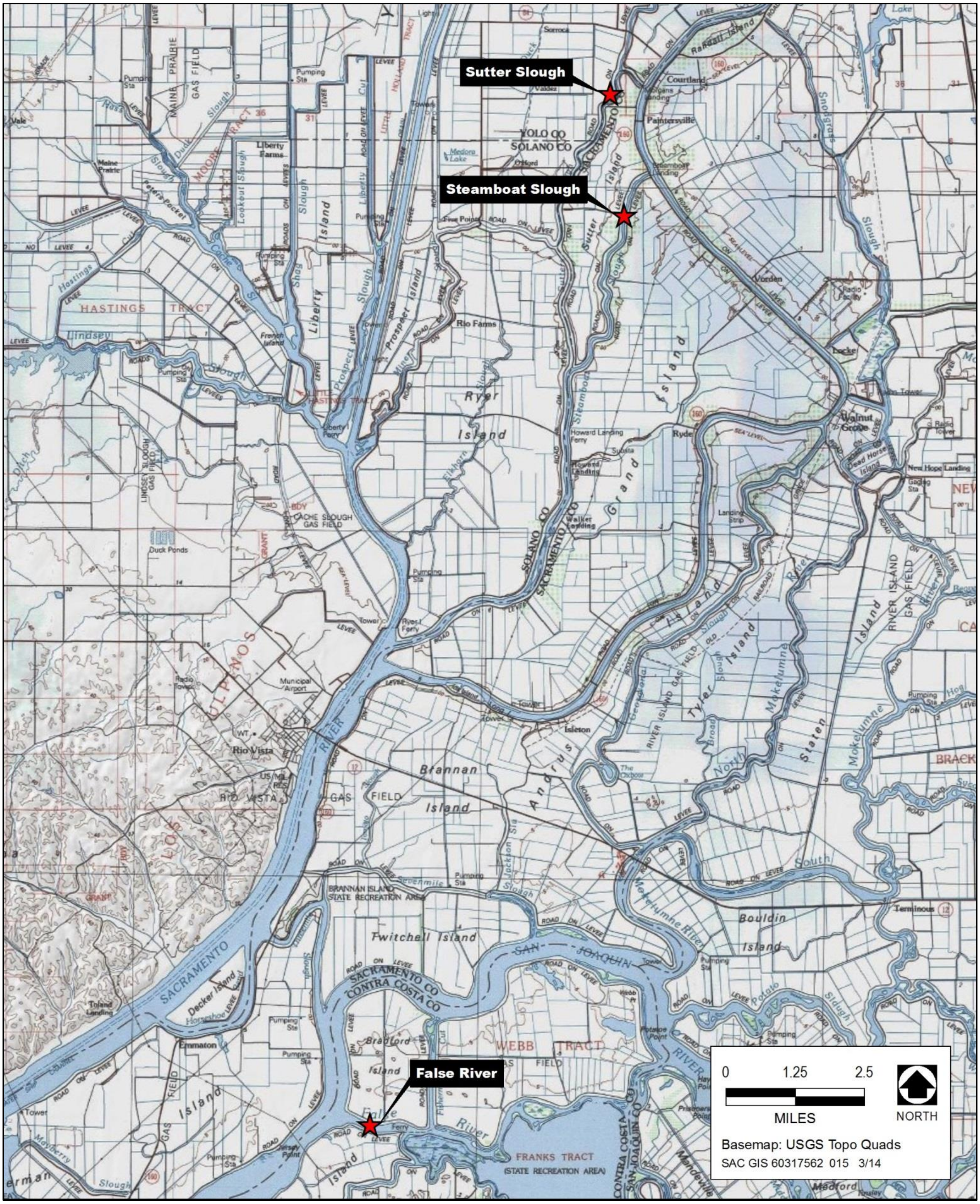
If implemented quickly, the EDB could impede the intrusion of saltwater into the central and south Delta and optimize the use of fresh water flows to maintain water quality that meets human health criteria through the spring and summer. Modeling of salinity intrusion with variable installation dates demonstrated the greatest benefits are gained if the barriers are installed as soon as possible. For example, installation of the barriers in combination with modest changes to operation of the DCC by May 1 provides a substantial benefit compared to a later installation in June or July. Modeling data show that by June, electrical conductivity (EC) levels are already exceeding 1,500 Siemens per centimeter (µS/cm) at the Old River at Holland Tract site (approximately 960 mg/L), whereas a May 1 effective date for operation of the barriers and DCC would keep the EC levels near or below 1,000 µS/cm (approximately 640 mg/L) (Resource Management Associates 2014).

2 PROJECT LOCATION

The barriers would be located at three locations in the north and central Delta:

- Sutter Slough,
- Steamboat Slough, and
- West False River

The general locations of these sites are shown in Figures 1 and 2, and their specific locations are in Figures 3-5.

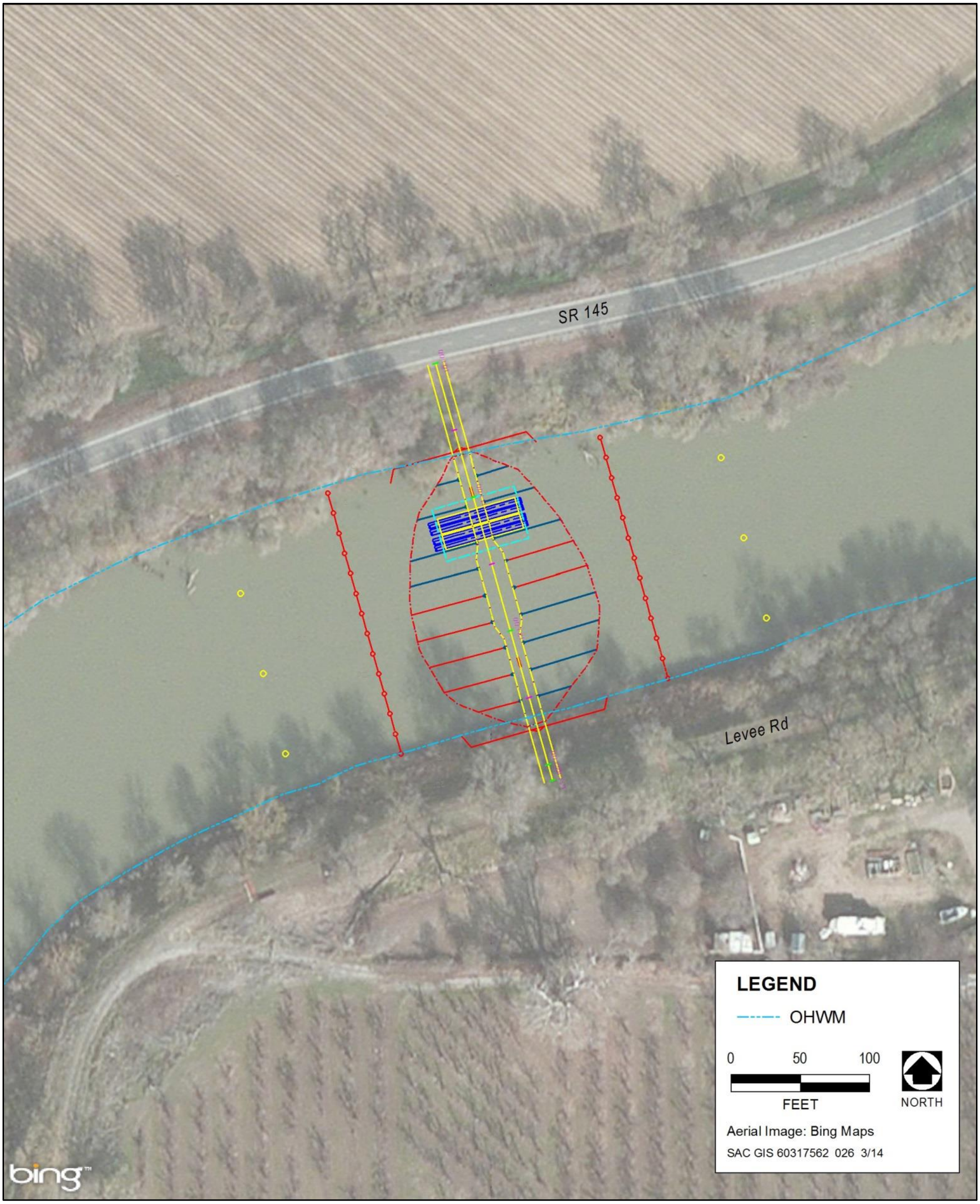


Source: Moffatt & Nichol 2014, AECOM 2014

Figure 1 **Regional Location**

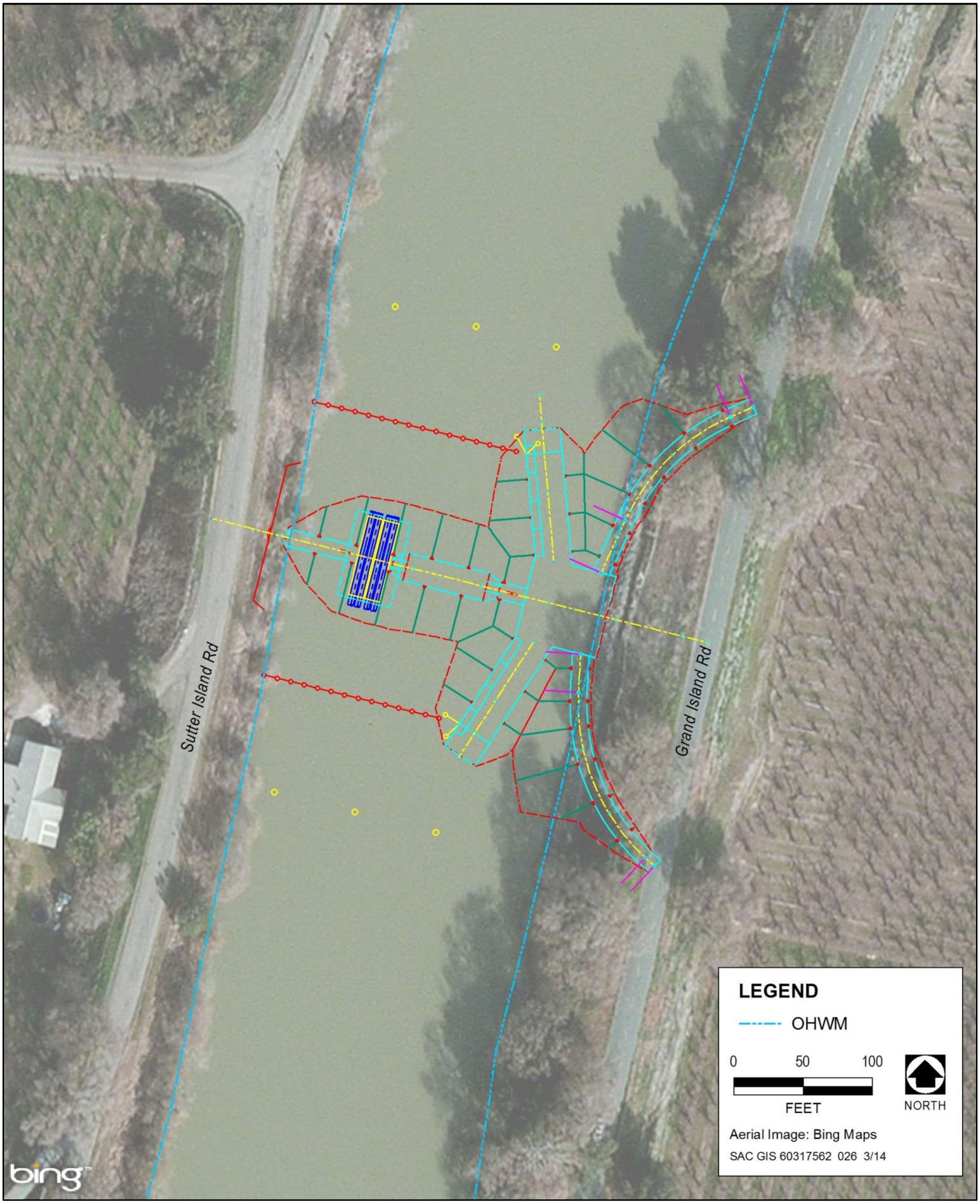
Source: Moffatt & Nichol 2014, AECOM 2014

Figure 2 **Project Sites – Overview**



Source: Moffatt & Nichol 2014, AECOM 2014

Figure 3 **Project Site – Sutter Slough**



Source: Moffatt & Nichol 2014, AECOM 2014

Figure 4 **Project Site – Steamboat Slough**

Source: Moffatt & Nichol 2014, AECOM 2014

Figure 5 **Project Site – West False River**

The Sutter Slough site is located in the north Delta about 0.6 miles directly west of the Sacramento River at the northwest end of Sutter Island. This site is approximately 1 mile southwest of the community of Courtland and 7 miles northwest of Walnut Grove and is on the border between Yolo and Sacramento counties. The barrier site is located about 1.25 miles downstream from the confluence of Sutter Slough and the Sacramento River.

The Steamboat Slough site is approximately 2.1 miles south-southeast of the Sutter Slough site, on the east side of Sutter Island, and approximately 1.0 mile southwest of the Sacramento River in Sacramento County. The Steamboat Slough barrier site is located about 0.95 mile downstream from the confluence of Steamboat Slough and the Sacramento River and is between Sutter and Grand Islands.

The West False River site is located approximately 0.4 mile east of the confluence with the San Joaquin River, between Jersey and Bradford Islands in Contra Costa County, and is about 4.75 miles northeast of Oakley.

3 GENERAL DESIGN AND INSTALLATION CONCEPTS

Rock (rip-rap) barrier weir structures would be installed at all three sites. All structures would be trapezoid-shaped rock barriers with a wide base tapering up to a 12-foot-wide top width set perpendicular to the channel alignment. Rock fill would be placed along the base of the levees for support at the Sutter Slough and Steamboat Slough sites. The West False River site would have transitions to the levees with 75-foot-long sheet pile walls supported by king piles and buttressed with rock because the levees are weaker in this area than at the northerly sites due to peat soil foundations. Design drawings for each location are included in Supplemental Information, Attachment D.

The rock barriers would be installed at each of the sites in spring 2014 (beginning around May 1st) and removed in November 2014, prior to the rainy season when freshwater runoff would occur and during the period that fall-run Chinook salmon would pass through the Delta. If drought conditions persist, the barriers could be reinstalled and removed in subsequent years during the same timeframes. Depending on location, the barriers would serve two important drought management purposes: the Sutter and Steamboat Slough barriers would redirect freshwater flows into the central Delta, and create a hydrologic barrier to repel higher saline water; and the West False River barrier would be a physical barrier at a key location that would reduce the intrusion of high-salinity water from Suisun Bay into the central and south Delta.

The Sutter Slough and Steamboat Slough sites would be designed to allow fish passage and manage water quality on the downstream side of the barriers using a combination of a an overflow weir designed to be inundated in the event of a very high tide or high river discharge and the installation of four 48-inch culverts with slide gates. The West False River barrier does not include these features. Tidal flows would be the main factor influencing water quality conditions at this barrier. Fish movement can occur through the adjacent San Joaquin River and through other channels, including Fisherman’s Cut, East False River, and Dutch Slough during the West False River closure.

Vessel traffic would be blocked at each barrier site. Boat ramps would be provided on either side of the Steamboat Slough barrier. Vessels up to 24 feet and 10,000 pounds would be moved around the barrier by equipment and an operator provided by the State. Boats heading into Sutter Slough would be directed by signage to Steamboat Slough for passage. Larger vessels would have to transit the Sacramento River channel instead of passing through Sutter or Steamboat sloughs between Courtland and Rio Vista. Boat access would not be provided at the West False River site since alternative routes are available via the Stockton Deep Water Ship Channel in the San Joaquin River between Antioch and eastern Delta locations, or via Fisherman's Cut or East False River to south Delta destinations.

Solar-powered monitoring instruments would be placed at appropriate locations upstream and downstream at each site and would monitor parameters like dissolved oxygen, turbidity, salinity (EC), river stage, and flow velocity (see EDB Water Quality/Flow Monitoring Plan). Additional monitoring, including using DIDSON cameras, would be used to assess the Sutter Slough and Steamboat Slough sites for interaction with and passage of migratory fish through the culverts. One 48-inch culvert would remain fully open at all times at the Sutter Slough and Steamboat Slough barriers primarily for fish passage.

Appropriate navigation signage would be installed at each of the sites and would comply with navigation requirements established by the U.S. Aids to Navigation System and the California Waterway Marker system, as appropriate. Signs would be posted at upstream and downstream entrances to each waterway or other key locations, informing boaters of the restricted access. A Notice to Mariners would include information on the location, date, and duration of channel closures. Signs would be posted on each side of each barrier, float lines with orange ball floats would be located across the width of the channels to deter boaters from approaching the barriers, and solar-powered warning buoys with flashing lights would be present on the barrier crest, as well, in order to prevent accidents during nighttime hours. Additional information regarding navigational issues at each of the sites is provided below.

4 STRUCTURAL COMPONENTS

4.1 SUTTER SLOUGH SITE

The Sutter Slough rock barrier would be 200 feet long and up to143 feet wide at the base and 12 feet wide at the top. The top of the barrier would be set at an elevation of 9.50 feet across the crest and would include about a 50-foot overflow weir 20 feet wide at the top, set at 7.50 feet elevation[2]. The weir would allow overflows at high stage, keep flow in the middle of the channel, minimizing the potential for erosion of the river banks. The barrier would include a submerged structure placed on a bed of crushed rock consisting of two steel frames with four 48-inch corrugated metal culverts set at an invert elevation of -2.0 feet. The culverts would be operated to allow fish passage and to regulate water levels and water quality on the downstream side of the barrier. One culvert would remain open at all times for fish passage, and the other culvert slide gates would be operated such that the culverts are fully open, fully closed, or at least 50% open as needed to improve water quality and/or stage downstream of the bariers.

The monitoring equipment and culvert slide gates would be accessed by the levee road on the north or via SR 145. The site is navigable and is used primarily by recreational traffic, but signs would be posted at both entrances to the slough, informing boaters that Steamboat Slough provides boat passage for vessels up to 24 feet long and up to 10,000 pounds.

2 Vertical elevations are based on the North American Vertical Datum of 1988 (NAVD 88).

4.2 STEAMBOAT SLOUGH SITE

The Steamboat Slough rock barrier would be 220 feet long, up to 110 wide at the base, and 12 feet wide at the top. The top of the structure would be at elevation 9.50 feet and would include about a 50-foot overflow weir 20 feet wide at the top, set at 7.50 feet and is designed to operate similar to the weir in Sutter Slough. Like the Sutter Slough site, it would include a submerged steel frame set at an invert elevation of -2.0 feet with four 48-inch corrugated metal culverts to allow fish passage and management of downstream water surface elevation and quality. One culvert would remain open at all times for fish passage, and the other culvert slide gates would be operated such that the culverts are fully open, fully closed, or at least 50% open as needed to improve water quality and/or stage downstream of the barriers.

This site is navigable by commercial and recreational traffic, and boat ramps on each side of the barrier would be provided on the east side of the channel. Two 12-foot-wide gravel roads would connect to Grand Island Road. The west access road would be about 150 feet long, and the east access road would be about 250 feet long. A State-provided boat tender would be present on the apron during daytime hours with a pickup truck and trailer. When a boat approaches, the trailer would be backed into the water, the boat would be placed on the trailer, and it would be driven to the boat ramp on the other side, where it would be placed back in the river. Boats up to 24 feet and 10,000 pounds could be accommodated. The site would not be available for launching boats from the land. The ramps would be approximately 6 feet by 20 feet and would be placed on rock fill with a 15 percent slope. Dock anchors (comparable to mooring lines) would be used to stabilize the boat ramps.

Workers would access the boat ramps via Grand Island Road, and the monitoring equipment and operable slide gates would be accessed via Sutter Island Road, both of which are public roads, or by boat.

4.3 WEST FALSE RIVER SITE

The West False River barrier would be approximately 800 feet long and up to 150 feet wide at the base and 12 feet wide at the top. The top of the structure would be at an elevation of 7.00 feet across the entire crest. The barrier would include two king pile-supported sheet pile walls extending out from each levee into the channel for a distance of 75 feet. The sheet piles/king piles would be required because the levees are weaker at this location since they sit on peat, and placing a large volume of rock directly on the levees would cause too much stress. The walls would be buttressed with some rock on both sides, however. After barrier removal, rock would be used to make smooth transitions around the sheet pile abutments which would remain in place for possible future use.

No boat passage is provided around this barrier because alternative routes (Fisherman's Cut or False River east for vessel traffic between the south Delta to the San Joaquin River; and the Main San Joaquin River for vessel traffic between the Antioch and the eastern Delta) are available. No fish passage has been provided because migrating fish would use the adjacent San Joaquin River, Fisherman's Cut or Dutch Slough and their access would not be restricted.

To monitor water quality in the central Delta and the associated changes in water quality and flow resulting from the False River barrier site, DWR proposes to install up to four permanent water quality and/or flow monitoring stations at Fisherman's Cut, Frank's Tract, Sherman Lake, and one additional site. The stations, which will be able to monitor several constituents including electrical conductivity (EC), would be installed on 12-inch-diameter steel pipe piles. DWR would place navigational aids as needed around the stations.

5 PROJECT CONSTRUCTION

5.1 CONSTRUCTION PRACTICES

Notices of construction would be posted at local marinas and in the Local Notice to Mariners. Navigational markers would be used to prevent boaters from entering the immediate construction area, and speed limits would be posted. Safe vessel passage procedures would be coordinated with the Sector Waterways Management Division (U.S. Coast Guard Station Yerba Buena Island) and California Department of Parks and Recreation Division of Boating and Waterways (Cal Boating). An educational program would be implemented to inform boaters of the purpose of the Project and the expected duration of installation activities. The program would include notices in local newspapers and boater publications as appropriate; notices also would be posted at local marinas and boat launches and on the Project website.

The rock would come from one or more quarries, and structures such as the steel frames used to support culverts that allow fish passage and articulated concrete mats for boat ramps would be prefabricated. Most materials and construction equipment (e.g., cranes and clamshells and the vibratory pile driver used at the West False River site) would be brought to the site by barges, and most construction would take place from the water. The exceptions would be construction of the gravel roads used to access the boat ramps at the Steamboat Slough, the transport of road materials and boat ramps to this site, and perhaps the installation of portions of the king piles and sheet piles at the West False River site. Additionally, minimal vegetation and clearing would be required on the levees prior to placement of rock or the installation of sheet piles. This would be accomplished by a dozer or backhoe and hand clearing. The gravel access roads at the Steamboat Slough site also would be cleared and grubbed of trees and other vegetation and would be hauled off site and disposed of in an appropriate location. Any levee access roads that are damaged as a result of construction equipment or truck use would be restored to pre-construction conditions or better once construction is completed.

The rock barriers would be constructed by using a barge-mounted crane and clamshell to place the rock in the channel at the Sutter Slough and Steamboat Slough sites. Because of the greater width of the channel at the West False River site, a dump scow may be used to transport the rock and place it in the channel. Some rock placement at this site would require the use of a barge-mounted crane and bucket. Although some rock slope protection may need to be temporarily moved out of the sheet pile abutments alignments at False River no channel dredging or excavation in the levee profiles would be required.

The sheet and king piles are anticipated to be installed by an appropriately-sized vibratory hammer, which appears to be feasible given the anticipated ground conditions and modest pile penetration of 20 feet to 50 feet in the ground. Vibratory penetration rates are normally limited to 20 inches per minute (per North American Sheet Piling Associations – Best Practices, www.nasspa.com), which would result in the following vibration times per pile assuming normal driving conditions:

- 20-ft ground penetration: 12 minutes
- 50-ft ground penetration: 30 minutes

Due to uncertainties of the ground conditions and the possibility of encountering dense soil layers and/or obstructions such as left-in-place rip-rap on the existing levee side slopes, a larger impact hammer will be available as a contingency measure, in the event unexpected harder driving is encountered. The impact hammer will only be used if the vibratory hammer cannot reach design tip elevation of the pilings. If piles are driven by impact hammers in water deeper than one meter, a bubble curtain would be employed if underwater noise exceeds pre-established levels (peak pressure levels or cumulative sound exposure level) that would indicate potential injury to fish.

5.2 CONSTRUCTION SCHEDULE

Construction would occur during regular daytime hours. Construction may occur concurrently at more than one EDB site, if adequate equipment is available. The overall construction schedule is estimated to be 30 to 60 days. The barriers would be installed in the spring and removed in the fall. Removal would take approximately 30 to 45 days.

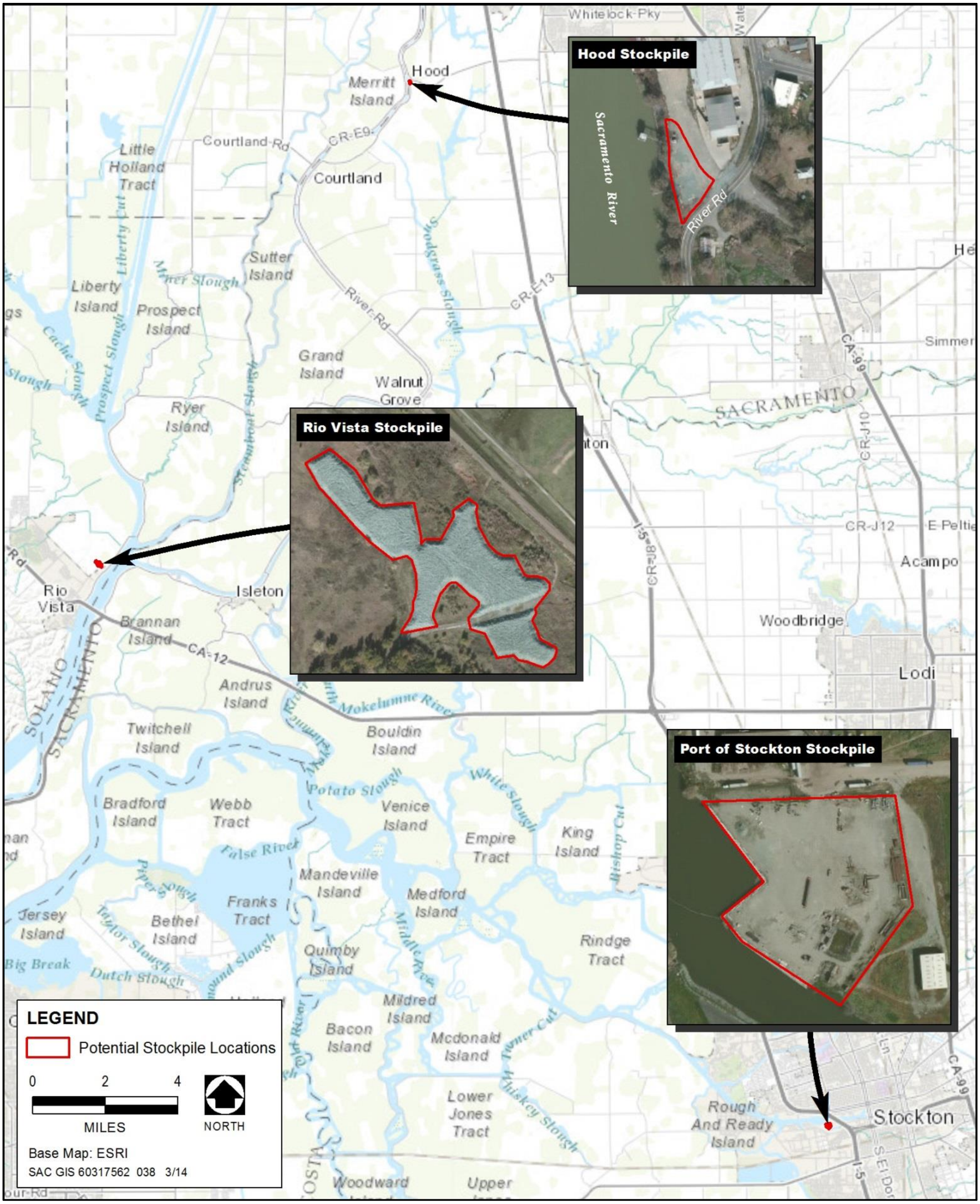
5.2.1 FACILITIES REMOVAL

All rock, gravel, and structures would be removed from the Project sites in the fall, with the exception of the sheet pile abutments at the West False River site. Bathymetric surveys would be completed after rock fill removal to confirm that the rock is removed. The materials would be transported from the area, primarily on barges. Materials would be stored at a nearby DWR storage facility, likely located in Hood, Rio Vista, or the Port of Stockton. These potential material storage locations are depicted in Figure 6. If lease arrangements can be made with local landowners near the barrier sites, rock may be stored close to the barrier sites for use in future drought conditions if needed.

5.2.2 SITE RESTORATION

Disturbed areas would be restored after initial construction and after Project structures are removed. The affected areas would be restored to meet local land use and resource agency requirements as soon as the barriers are no longer needed.

A restoration plan would be developed, as required by applicable regulatory agencies, and would be completed prior to the onset of construction. The restoration plan would identify areas that would be restored and restoration methods. Seed mixes, schedules, success criteria, and success monitoring for restoration of wetlands, streams, and drainages would be identified. The restoration plan would be included in the contract specifications. The restoration plan would also consider the need for reinstallation of the barriers the following year if drought conditions continue.



Source: DWR adapted by AECOM 2014

Figure 6 **Potential Stockpile Locations**

6 REFERENCES

California Department of Water Resources (DWR). 2014a. Breaking Drought News. Website (http://www.water.ca.gov/waterconditions/) accessed March 2014.

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ATTACHMENT B

Permit Application Continuation

ATACHMENT B PERMIT APPLICATION CONTINUATION

BOX 11. PROJECT IMPACTS

DWR proposes to install rock (rip-rap) barrier dike structures at all three sites. All structures would be trapezoid-shaped rock barriers with a wide base tapering up to a 12-foot-wide top width set perpendicular to the channel alignment. Rock fill would be placed along the base of the levees for support at the Sutter Slough and Steamboat Slough sites. The False River site would have transitions to the levees with 75-foot long sheet piles walls supported by king piles and buttressed with rock because the levees are weaker in this area than at the northerly sites. Design drawings for each location are included in Supplemental Information, Attachment D. Additionally, minimal vegetation and clearing would be required on the levees prior to placement of rock or the installation of sheet piles. This would be accomplished by a dozer or backhoe and hand clearing. The gravel roads access roads at the Steamboat Slough site also would be cleared and grubbed of trees and other vegetation and would be hauled off site and disposed of in an appropriate location. Tree removal may be required; however, DWR has not identified specific trees. Prior to tree removal, DWR will conduct a tree inventory identifying the species, size (in diameter breast height) and number of tree to be removed.

CDFW's jurisdiction under Fish and Game Code Section 1602 includes the streambed and associated riparian vegetation or top-of-bank, whichever is greater. The streambed is delineated by the ordinary high-water mark (OHWM). On a levee system, CDFW takes jurisdiction to the waterside hinge-point of the levee. Since all three watercourses are within a levee system, CDFW's jurisdiction extends to the hinge-point. The habitat between the OHWM and hinge-point at Sutter and Steamboat sloughs is considered to be mixed riparian. False River lacks riparian vegetation due to rock rip-rap; however, there are no impacts at False River above OHWM.

The total temporary impact area to waters is approximately 3.14 acres and the total volume of rock fill in waters is approximately 95,363 cubic yards. Temporarily disturbed areas would be restored after initial construction and after Project structures were removed. The affected areas would be restored to meet local land use and resource agency requirements as soon as they are no longer needed. After restoration was completed, the channel bed would be restored to grade with clean sand.

All rock, gravel, and structures would be removed from the Project sites in fall 2014, with the exception of the sheet pile abutments and adjacent rock feathering at False River. The sheet pile abutments would extend out from each levee into the channel for a distance of 75 feet. Therefore, the sheet pile abutments and adjacent rock feathering are considered to be a permanent impact to waters. The total permanent impact area to waters is approximately 0.75 acres and the total permanent volume of rock fill in the waters is approximately 20,804 cubic yards. Table 1 summarizes and Figures 1-4 show the impacts to waters.[1]

[1] A portion of the temporary fill will be placed on top of the permanent fill. Where this overlap occurs, the area is considered to be a permanent impact only (i.e., to avoid double counting). Figures1-4 do not distinguish between the temporary and permanent impact areas because of the two-dimensional nature of the maps.

Table 1 Summary of Temporary and Permanent Impact to Waters			
Location	**Area (Acres) of Fill**	**Linear Feet**	**Volume (Cubic Yards) of Fill**
Temporary			
Sutter Slough	0.45	143	11,996
Steamboat Slough	0.81	310	11,506
False River	1.88	130	71,861
Sub-Total	**3.14**	**583**	**95,363**
Permanent			
Sutter Slough	0.00	0	0
Steamboat Slough	0.00	0	0
False River	0.75	20	20,804
Sub-Total	**0.75**	**20**	**20,804**
Total–Temporary and Permanent			
Sutter Slough	0.45	143	11,996
Steamboat Slough	0.81	310	11,506
False River	2.63	150	92,665
Total	**3.89**	**603**	**116,167**

The total temporary impact area to mixed riparian vegetation is approximately 0.172 acres[2] and the total volume of rock fill in mixed riparian vegetation is approximately 5,596 cubic yards. Table 2 summarizes and Figures 1-4 show these temporary impacts to mixed riparian vegetation.

Table 2 Summary of Temporary Impacts to Mixed Riparian			
Location	**Area (Acres)**	**Linear Feet**	**Volume (Cubic Yards) of Fill**
Sutter Slough	0.003	143	413
Steamboat Slough	0.169	350	5,183
False River	0.000	0	0
Total	**0.172**	**493***	**5,596**

Note:

* For Sutter and Steamboat sloughs, the linear feet in Table 1 are not in addition to the linear feet provided in Table 2. In other words, the linear feet in Table 2 encompass the linear feet in Table 1.

[2] The area of impacts to mixed riparian vegetation (unlike waters) is rounded to the nearest thousandth in order to show the minimal impacts associated with Sutter Slough.

BOX 13. LIST OF LOCAL, STATE, AND FEDERAL PERMITS REQUIRED FOR THE PROJECT

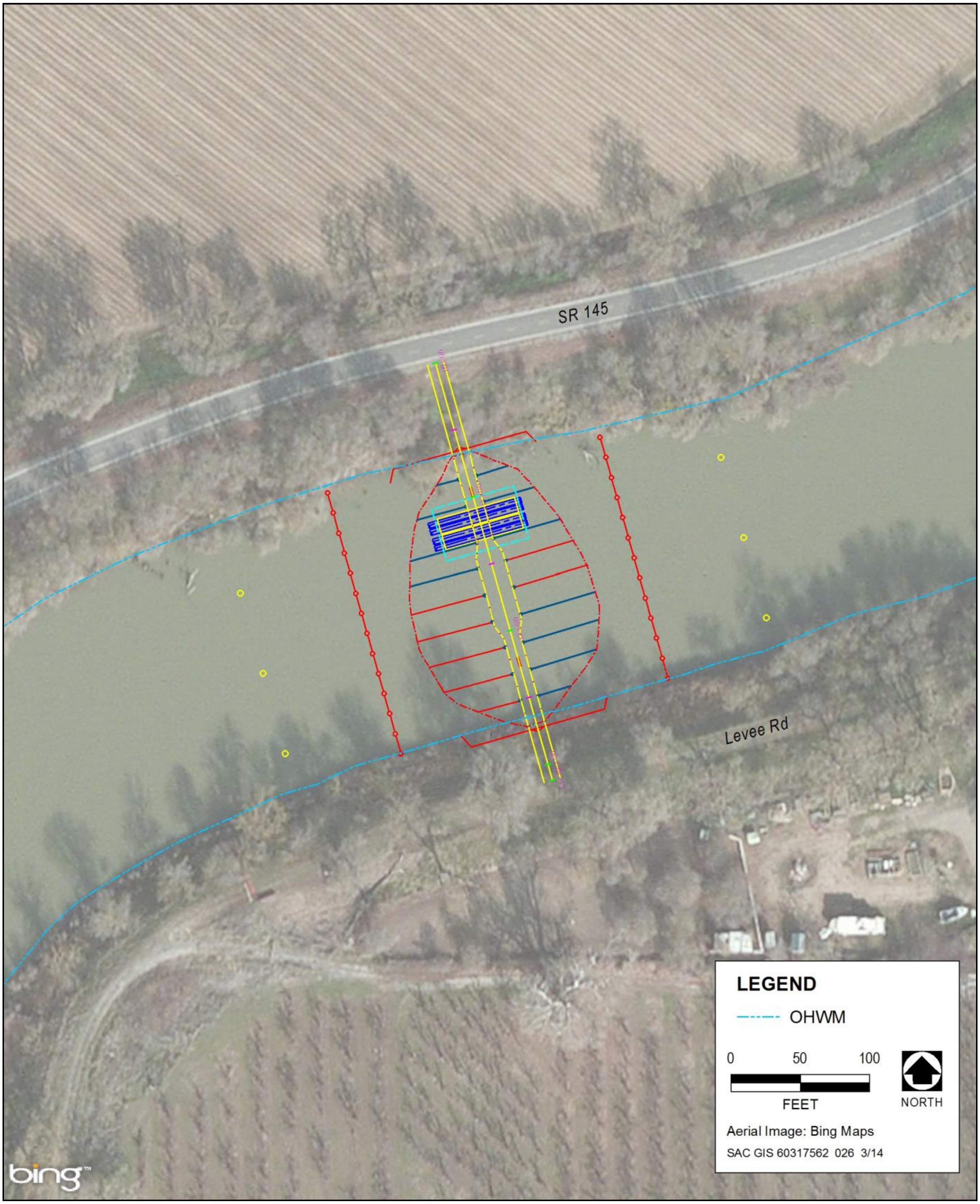
Table 3 lists the local, state, and federal permits required for the Project.

Table 3
Local, State, and Federal Permits Required for the Project

Agency	Approval Type	Identification Number	Date Applied	Date Approved	Date Denied
USFWS	BO	T.B.D.	March 2014	T.B.D.	N.A.
NMFS	BO	T.B.D.	March 2014	T.B.D.	N.A.
SHPO	MOU	T.B.D.	March 2014	T.B.D.	N.A.
SWRCB	CWA Section 401 WQC	T.B.D.	March 2014	T.B.D.	N.A.
USACE	CWA Section 404	T.B.D.	March 2014	T.B.D.	N.A.
USACE	RHA Section 10 and 408	T.B.D.	March 2014	T.B.D.	N.A.
USCG	Private Navigation Aids	T.B.D.	March 2014	T.B.D.	N.A.
CVFPB	Encroachment Permit	T.B.D.	March 2014	T.B.D.	N.A.
CDFW	CESA Section 2081 ITP	T.B.D.	March 2014	T.B.D.	N.A.
RWQCB	NDPES	T.B.D.	T.B.D.	T.B.D.	N.A.
SLC	MOU	T.B.D.	March 2014	T.B.D.	N.A.

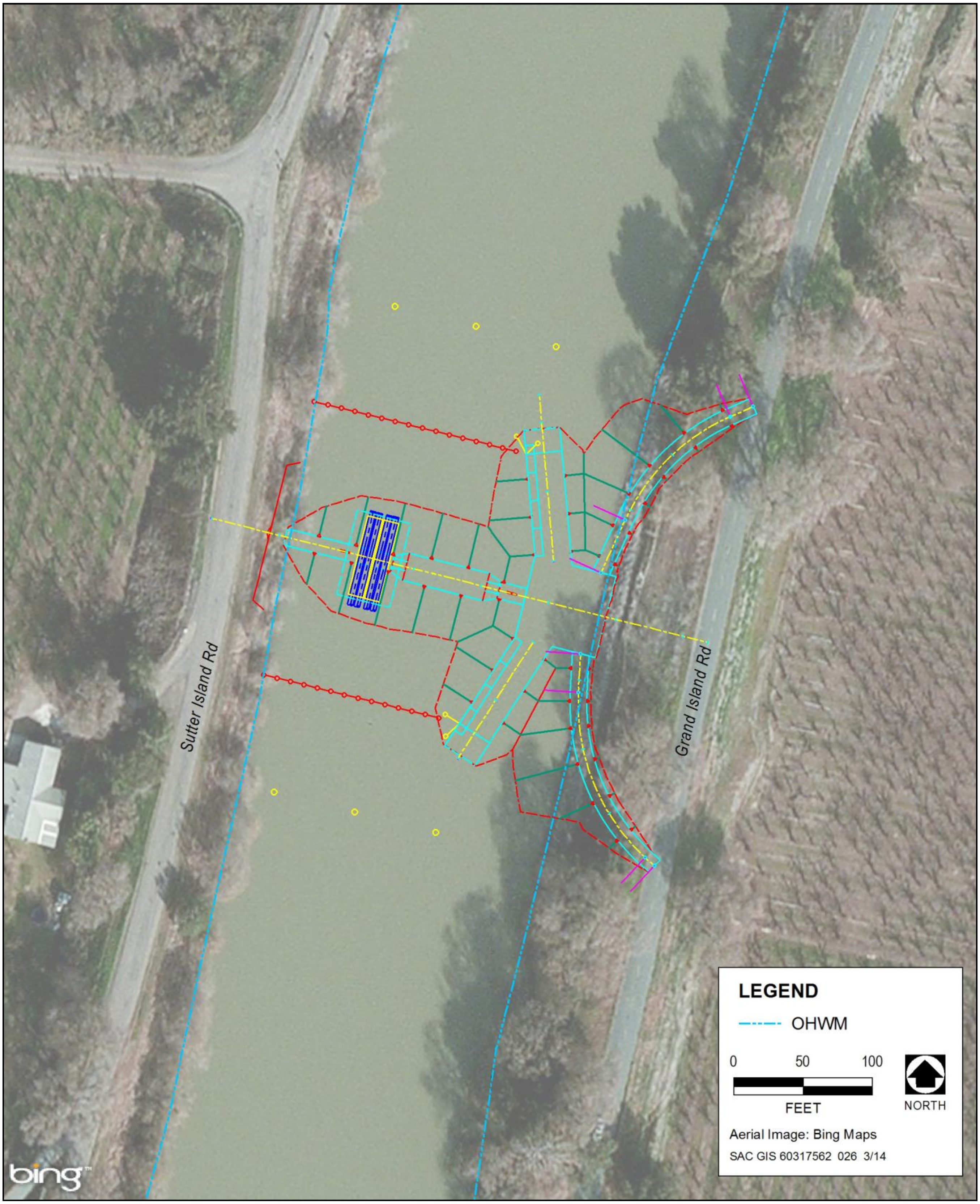
Source: Moffatt & Nichol 2014, AECOM 2014

Figure 1 **Impact Map–Overview**



Source: Moffatt & Nichol 2014, AECOM 2014

Figure 2 **Impact Map–Sutter Slough**



Source: Moffatt & Nichol 2014, AECOM 2014

Figure 3 **Impact Map–Steamboat Slough**

Source: Moffatt & Nichol 2014, AECOM 2014

Figure 4 **Impact Map–False River**

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ATTACHMENT C

Aquatic and Terrestrial Biological Assessments

Biological Assessment of Potential Effects on Listed Fishes from the Emergency Drought Barriers Project

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Acronyms and Abbreviations

BA	Biological Assessment
BMP	best management practices
BO	Biological Opinion
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
CRR	cohort replacement rates
CU	consumptive use
CVP	Central Valley Project
CVTRT	Central Valley Technical Review Team
CWT	coded-wire tag
dB	decibels
DCC	Delta Cross Channel
DFW	California Department of Fish and Wildlife
DO	dissolved oxygen
DPS	distinct population segment
DWR	California Department of Water Resources
EDB	Emergency Drought Barriers Project
EFH	essential fish habitat
E/I	export to inflow ratio
ESA	federal Endangered Species Act
FFGS	Floating Fish Guidance Structure
FMP	Fishery Management Plans
FRFH	Feather River Fish Hatchery
ft/s	feet per second
GCID	Glenn Colusa Irrigation District
HMMP	Hazardous Materials Management Program
IEP	Interagency Ecological Program
ITP	Incidental Take Permit
JPE	Juvenile Production Estimate
JPI	Juvenile Production Index

km/day	kilometers per day
LSZ	low salinity zone
mm	millimeters
mph	miles per hour
MSDS	Material Safety Data Sheets
NAS	National Academy of Sciences
NMFS	National Marine Fisheries Service
OCAP	Operations Criteria and Plan
OMR	Old and Middle River
PAH	poly aromatic hydrocarbons
PCE	primary constituent elements
PFMC	Pacific Fishery Management Council
ppt	parts per thousand
PVA	population viability analysis
RBDD	Red Bluff Diversion Dam
RMS	root mean squared
RST	rotary screw traps
RTDOMT	Real-Time Drought Operations Management Team
SEL	sound exposure level
SJR	San Joaquin River
SKT	Spring Kodiak Trawl
SOP	Standard Operating Procedures
SRA	shaded riverine aquatic
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TBP	Temporary Barriers Project
TUCP	Temporary Urgency Change Petition
USACE	US Army Corps of Engineers
USFWS	US Fish and Wildlife Service

Biological Assessment Of Potential Effects On Listed Fishes From The 2014 Emergency Drought Barriers Project

Introduction

Water quality conditions in the Sacramento-San Joaquin River Delta (Delta) are declining as a result of persistent drought conditions, putting municipal and agricultural water supplies at risk. The declining water quality conditions also are degrading habitat for threatened and endangered fish dependent on the Delta. In response to these conditions, the U.S. Department of Agriculture identified 54 counties in California as eligible for natural disaster assistance, including funding for emergency watershed protection and water assistance for rural communities following President Obama's announcement of an administration-wide drought response in February 2014.

Additionally, on January 17, 2014, California's Governor Edmund G. Brown Jr. signed a proclamation declaring a State of Emergency, prompted by record dry conditions and projections that 2014 will be the driest year on record (see http://gov.ca.gov/news.php?id=18368). In his proclamation, he found that the lack of precipitation is beyond the ability of local authorities to address and has placed the safety of people and property existing within California in peril due to water shortage from persistent drought conditions. Governor Brown issued a number of directives calling for immediate action to implement conservation programs, to secure water supplies for at risk communities, and to protect critical environmental resources.

Many of these actions would be undertaken by the California Department of Water Resources (DWR) and its various federal, state, and local partners. These actions include temporary modifications of requirements included in the State Water Resources Control Board's Revised Decision 1641 (D-1641) to meet water quality objectives in the Water Quality Control Plan for the Bay-Delta, including increased flexibility for water transfers, regulating diversions, and Delta Cross Channel (DCC) gate operations. The drought proclamation also directed DWR to take other necessary actions to protect water quality and water supply in the Delta, including installation of temporary barriers or temporary water supply connections as needed, and coordination with the California Department of Fish and Wildlife (DFW) to minimize impacts on affected aquatic species.

DWR's proposed 2014 Emergency Drought Barriers Project (EDB) seeks to protect the quality of water for users that rely on Delta water. The EDB would include installation of temporary rock barriers near the heads of Sutter and Steamboat sloughs in order to keep more flow in the Sacramento River, thereby facilitating a greater flow of freshwater through Georgiana Slough and the DCC in order to repel salinity from the central/south Delta and maintain water quality. An additional barrier in West False River near its confluence with the San Joaquin River would be installed to limit salinity intrusion along the lower San Joaquin River and the channels leading from it. The barriers are intended to specifically benefit:

- Communities and farmers in and adjacent to the Delta that rely exclusively on this source for drinkable water and irrigation.

- Upstream resources and communities, because once installed, the barriers would reduce demand on reservoir releases to maintain salinity levels in the Delta, leaving more water upstream for both fishery and community needs.
- The State Water Project (SWP) and Central Valley Project (CVP), as they attempt to maintain access to water supplies for human health and safety.

There is precedent for the EDB. Several rock barriers were installed at Delta locations during 1976 and 1977 to help mitigate for drought conditions. In 1976, one barrier was installed at Sutter Slough to help meet water quality criteria, to conserve water during the drought, and to enable increased SWP and CVP pumping, and the second barrier was installed at Old River at its divergence from the San Joaquin River (often referred to as head of Old River) to protect fishery resources in the Delta. In 1977, as drought conditions continued, barriers were installed at six different locations in the Delta. In addition, control facilities were built at two additional locations. The six barrier locations constructed in 1977 included Old River east of Clifton Court, San Joaquin River near Mossdale, Rock Slough, Indian Slough, Dutch Slough, and the head of Old River.

This document is a Biological Assessment (BA) that assesses the effects of the EDB on federally listed fish species (some of which are also state listed). The document is divided into the following main sections:

- Introduction;
- Consultation History;
- Purpose and Scope of this Biological Assessment;
- Emergency Drought Barriers Project Description;
- Action Area;
- Life Histories;
- Critical Habitat;
- Environmental Baseline;
- Effects Assessment;
- Cumulative Effects;
- Conclusions;
- References.

The Effects Assessment of this BA includes Construction Effects and Operations Effects. Note that the latter only considers effects related to the EDB within the Action Area (e.g., hydrodynamics, water quality, and near-field predation effects); the potential operations effects of contingency planning for drought conditions (e.g., quantity of cold water storage in upstream reservoirs that may be available under different Delta salinity management strategies) are not included in this BA.

A number of different sources were used in preparing this document. Because of the similarity of a number of aspects of the EDB to the South Delta Temporary Barriers Project (TBP), some of the information found in this document was adapted from the most recent TBP consultation materials, i.e., Biological Assessments by DWR (2012a,b) and Biological Opinions (BOs) by the National Marine Fisheries Service (NMFS) (2013) and U.S. Fish and Wildlife Service (USFWS) (2014a). In addition, useful information was obtained from the recent BOs by NMFS (2014) and USFWS (2014b) on the 2014 Georgiana Slough Floating Fish Guidance Structure Study.

Consultation History

The consultation history for the EDB includes the following:

- March 5, 2014: Representatives from NMFS and USFWS attended an EDB coordination meeting hosted by DWR, which also included representatives from the U.S. Bureau of Reclamation (Reclamation), U.S. Army Corps of Engineers (USACE), SWRCB, and the AECOM-led consulting team;
- March 12, 2014: Representatives from NMFS and USFWS attended an EDB coordination meeting hosted by DWR, which also included representatives from Reclamation, USACE, SWRCB, DFW, and the AECOM-led consulting team;
- March 19, 2014: Representatives from NMFS and USFWS attended an EDB coordination meeting hosted by DWR, which also included representatives from Reclamation, USACE, SWRCB, DFW, and the AECOM-led consulting team.

Purpose and Scope of this Biological Assessment

This BA is intended to satisfy the Section 7 consultation requirements of the federal Endangered Species Act (ESA) for species managed by USFWS and NMFS, and also includes information for consultation regarding essential fish habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act. As such, this BA describes the potential effects on federally-listed and state-listed fish species, critical habitat, and EFH that may result from the implementation of the EDB.

The following species and habitats are addressed in this BA, based on the potential for occurrence in the action area.

- Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*).
- Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*).
- Central Valley steelhead (*Oncorhynchus mykiss*).
- North American green sturgeon (*Acipenser medirostris*), southern distinct population segment (DPS).
- Delta smelt (*Hypomesus transpacificus*).
- Central Valley spring-run Chinook salmon designated critical habitat.
- Central Valley steelhead designated critical habitat.
- Sacramento River winter-run Chinook salmon designated critical habitat.
- North American green sturgeon designated critical habitat.
- Delta smelt designated critical habitat.
- Starry flounder (*Platichthys stellatus*) EFH.

- Northern anchovy (*Engraulis mordax*) EFH.
- Chinook salmon EFH.

The species analyzed in this BA are protected under the ESA and/or CESA, and their listing status is presented in Table 1.

Table 1. Listed Fish Species Addressed in this Biological Assessment

Species	Status*
Central Valley spring-run Chinook salmon	FT, ST
Sacramento River winter-run Chinook salmon	FE, SE
Central Valley steelhead	FT
North American green sturgeon (southern DPS)	FT
Delta smelt	FT, SE

DPS = distinct population segment.
* Status definitions:
FE = listed as endangered under the federal Endangered Species Act.
FT = listed as threatened under the federal Endangered Species Act.
SE = listed as endangered under the California Endangered Species Act.
ST = listed as threatened under the California Endangered Species Act.

Emergency Drought Barriers Project Description

Purpose of and Need for the Emergency Drought Barriers Project

The purpose of the EDB is to prevent the intrusion of saltwater into the Delta, which would render the water undrinkable by 25 million Californians and unusable by the farms that are reliant upon this source, as well as to protect habitat for sensitive aquatic species in the Delta.

The EDB is needed because the water supply for all those dependent on the water in the Delta is at risk as water quality conditions in the Delta decline due to the severe drought conditions[1]. In January of this year, unusual amounts of saltwater began intruding into the Delta. The resulting water quality approached human health criteria at many locations in the south Delta and spread as far south as the SWP and CVP intakes near Tracy, putting several communities and local water purveyors dependent on that water supply at risk. The bromide levels also are increasing along with salinity (bromide concentrations are typically low in freshwater and higher in seawater). This is important because bromide plays a role in the formation of disinfection by-products (trihalomethanes and bromate), which are carcinogens and difficult to treat with existing drinking water purification processes.

The Delta is a complex system of interconnecting channels that provide numerous pathways for the tides to push saltwater inland. Normally, outflow is sufficient to prevent San Francisco Bay's saline water from migrating eastward into the Delta with each tidal pulse, but the record dry January experienced dramatically lower outflow levels. Subsequent storms in February temporarily increased freshwater flow into the Delta, stabilizing salinity levels in the Delta during late February through

[1] Calendar year 2013 was the driest year in recorded history for many areas of California, and current conditions suggest no change in sight for 2014 (DWR 2014a).

March. However, precipitation has been low in March, and the National Oceanic and Atmospheric Administration's seasonal drought outlook predicts drought conditions will persist or intensify through May 31. Sierra snowpack and most reservoirs are below or about at normal levels for this time of year. Currently, Lakes Shasta and Oroville are at 45 percent capacity, and Folsom Lake is at 41 percent capacity (Special Committee on Bay Delta 2014). More significantly, the snowpack that would typically refill them is about 24 percent of average (DWR 2014a), reducing the amount of runoff that will occur later this spring. Thus, there will be insufficient water in the natural runoff or stored in reservoirs that can be released to keep salinity out of the Delta without exhausting stored water before the end of the year. Given current reservoir storage and expected runoff, projections indicate that low river inflows will allow salinity intrusion to the extent that interior portions of the Delta will exceed water quality objectives by May (Resource Management Associates 2014).

The maximum mean daily salinity objective for municipal and industrial use in all water year types established by State Water Resources Control Board in D-1641 is approximately 415 milligrams per liter (mg/L) (Table 1, Water Quality Objectives for Municipal and Industrial Beneficial Uses). However, in August 2014, salinity is projected to peak and exceed 3,100 mg/L at the SWP intake (Resource Management Associates 2014). Such high salinity levels (with associated bromide levels) could preclude pumping and/or compromise municipal water supplies. This would be particularly devastating for communities without alternative water supplies, including the Contra Costa Water District, which serves approximately 500,000 people and is almost entirely dependent on the Delta for its water supply (Contra Costa Water District 2011).

Once salinity intrudes into the Delta, moving it back toward San Francisco Bay is difficult; thus, high salinity could persist for an extended period if high winter and spring freshwater flows are not available to dislodge it. This would effectively eliminate the Delta as a water supply for the Californians who depend on it, as well as for 3 million acres of farmland. This condition would exist, perhaps for many months, until sizeable storms could provide the necessary outflow to flush out the saline waters. In addition to being critical for the health and safety of those who depend on it, water flowing through the Delta is essential to the agricultural industry and businesses that drive the state's economy; it sustains $400 billion of California's statewide economy (DWR 2014b). Consequently, increased salinity levels would have a profound detrimental effect throughout the state.

Increased salinity levels also have an adverse effect on the sensitive aquatic resources that live in and pass through the Delta. This is both due to exceedances of water quality objectives and because the already limited water supplies stored in the upstream reservoirs would need to be released in order to meet objectives. As a result, cool water resources would be insufficient in late spring and summer to protect salmon eggs incubating in the gravels, and rearing habitat for juvenile salmon below Keswick, Oroville, and other dams would be depleted. Construction of the barriers would allow the conservation of additional amounts of cool water to protect natural resource values later in the year because less water would need to be released from the reservoirs for water quality earlier in the year. Additionally, more water also would be available for community needs in upstream areas.

If implemented quickly, the EDB could impede the intrusion of saltwater into the central and south Delta and optimize the use of fresh water flows to maintain water quality that meets human health criteria through the spring and summer. Modeling of salinity intrusion with variable installation dates demonstrated the greatest benefits are gained if the barriers are installed as soon as possible. For example, installation of the barriers in combination with modest changes to operation of the DCC by May 1 provides a substantial benefit compared to a later installation in June or July. Modeling data show that by June, electrical conductivity (EC) levels are already exceeding 1,500 Siemens per centimeter (µS/cm) at the Old River at Holland Tract site (approximately 960 mg/L), whereas a May 1 effective date for operation of the barriers and DCC would keep the EC levels near or below 1,000 µS/cm (approximately 640 mg/L) (Resource Management Associates 2014).

Project Location

The barriers would be located at three locations in the north and central Delta:

- Sutter Slough;
- Steamboat Slough;
- West False River.

The general locations of these sites are shown in Figures 1 and 2.

The Sutter Slough site is located in the north Delta about 0.6 miles directly west of the Sacramento River at the northwest end of Sutter Island. This site is approximately 1 mile southwest of the community of Courtland and 7 miles northwest of Walnut Grove and is on the border between Yolo and Sacramento counties. The barrier site is located about 1.25 miles downstream from the confluence of Sutter Slough and the Sacramento River.

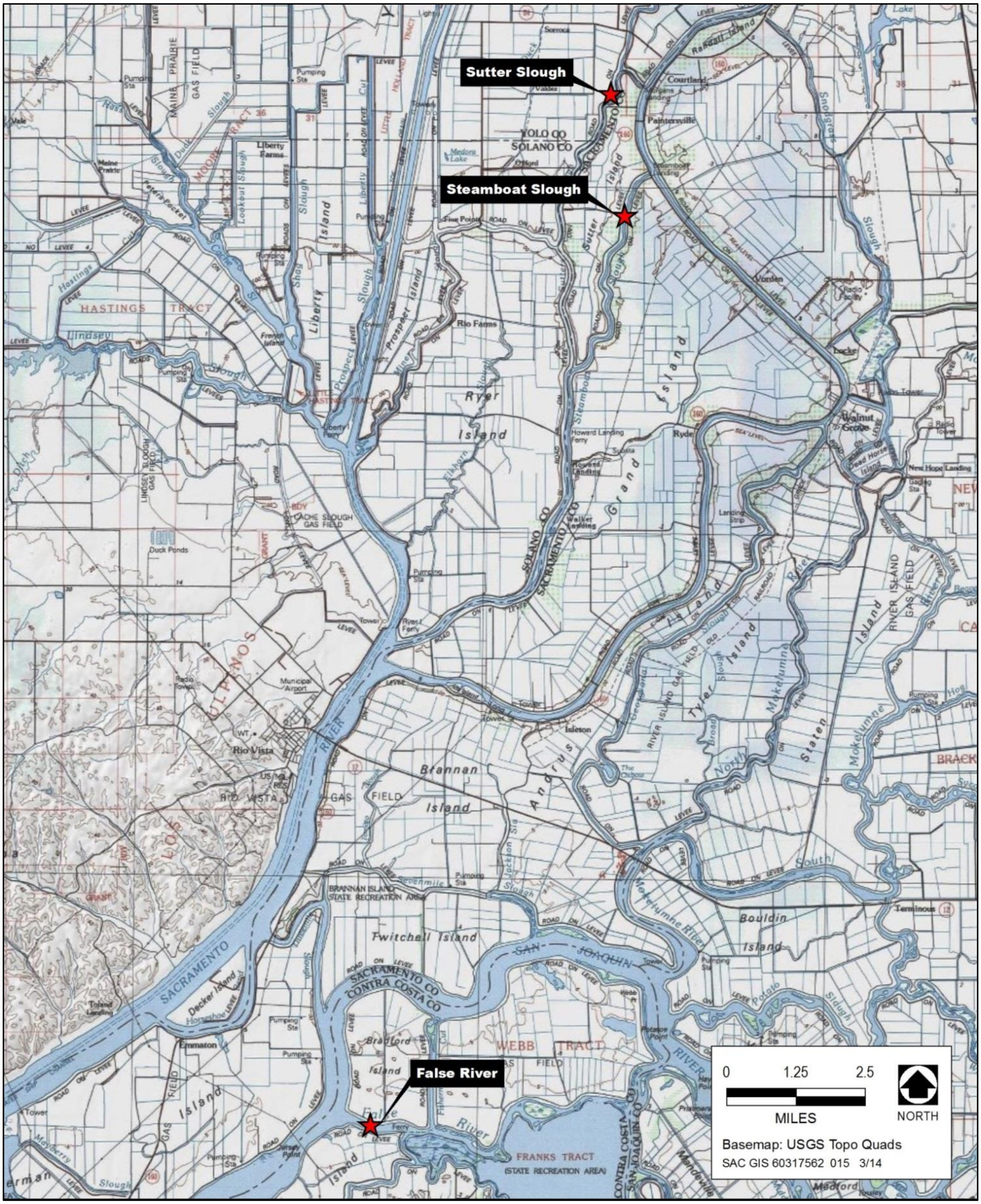
The Steamboat Slough site is approximately 2.1 miles south-southeast of the Sutter Slough site, on the east side of Sutter Island, and approximately 1.0 mile southwest of the Sacramento River in Sacramento County. The Steamboat Slough barrier site is located about 0.95 mile downstream from the confluence of Steamboat Slough and the Sacramento River and is between Sutter and Grand Islands.

The West False River site is located approximately 0.4 mile east of the confluence with the San Joaquin River, between Jersey and Bradford Islands in Contra Costa County, and is about 4.75 miles northeast of Oakley.

General Design and Installation Concepts

Rock (rip-rap) barrier weir structures would be installed at all three sites. All structures would be trapezoid-shaped rock barriers with a wide base tapering up to a 12-foot-wide top width set perpendicular to the channel alignment. Rock fill would be placed along the base of the levees for support at the Sutter Slough and Steamboat Slough sites. The West False River site would have transitions to the levees with 75-foot-long sheet pile walls supported by king piles and buttressed with rock because the levees are weaker in this area than at the northerly sites due to peat soil foundations. Design drawings for each location are included in Appendix A.

The rock barriers would be installed at each of the sites in spring 2014 (beginning around May 1st) and removed in November 2014, prior to the rainy season when freshwater runoff would occur and during the period that fall-run Chinook salmon would pass through the Delta. If drought conditions persist, the barriers could be reinstalled and removed in subsequent years during the same timeframes. Depending on location, the barriers would serve two important drought management purposes: the Sutter and Steamboat Slough barriers would redirect freshwater flows into the central Delta, and create a hydrologic barrier to repel higher saline water; and the West False River barrier would be a physical barrier at a key location that would reduce the intrusion of high-salinity water from Suisun Bay into the central and south Delta.



Source: Moffatt & Nichol 2014, AECOM 2014

Figure 1. Emergency Drought Barriers – Regional Location

Source: Moffatt & Nichol 2014, AECOM 2014

Figure 2. Project Site - Overview

The Sutter Slough and Steamboat Slough sites would be designed to allow fish passage and manage water quality on the downstream side of the barriers using a combination of a an overflow weir designed to be inundated in the event of a very high tide or high river discharge and the installation of four 48-inch culverts with slide gates. The West False River barrier does not include these features.

Tidal flows would be the main factor influencing water quality conditions at this barrier. Fish movement can occur through the adjacent San Joaquin River and through other channels, including Fisherman's Cut, East False River, and Dutch Slough during the West False River closure.

Vessel traffic would be blocked at each barrier site. Boat ramps would be provided on either side of the Steamboat Slough barrier. Vessels up to 24 feet and 10,000 pounds would be moved around the barrier by equipment and an operator provided by the State. Boats heading into Sutter Slough would be directed by signage to Steamboat Slough for passage. Larger vessels would have to transit the Sacramento River channel instead of passing through Sutter or Steamboat sloughs between Courtland and Rio Vista. Boat access would not be provided at the West False River site since alternative routes are available via the Stockton Deep Water Ship Channel in the San Joaquin River between Antioch and eastern Delta locations, or via Fisherman's Cut or East False River to south Delta destinations.

Solar-powered monitoring instruments would be placed at appropriate locations upstream and downstream at each site and would monitor parameters like dissolved oxygen, turbidity, salinity (EC), river stage, and flow velocity (see EDB Water Quality/Flow Monitoring Plan). Additional monitoring, including using DIDSON cameras, would be used to assess the Sutter Slough and Steamboat Slough sites for interaction with and passage of migratory fish through the culverts. One 48-inch culvert would remain fully open at all times at the Sutter Slough and Steamboat Slough barriers primarily for fish passage.

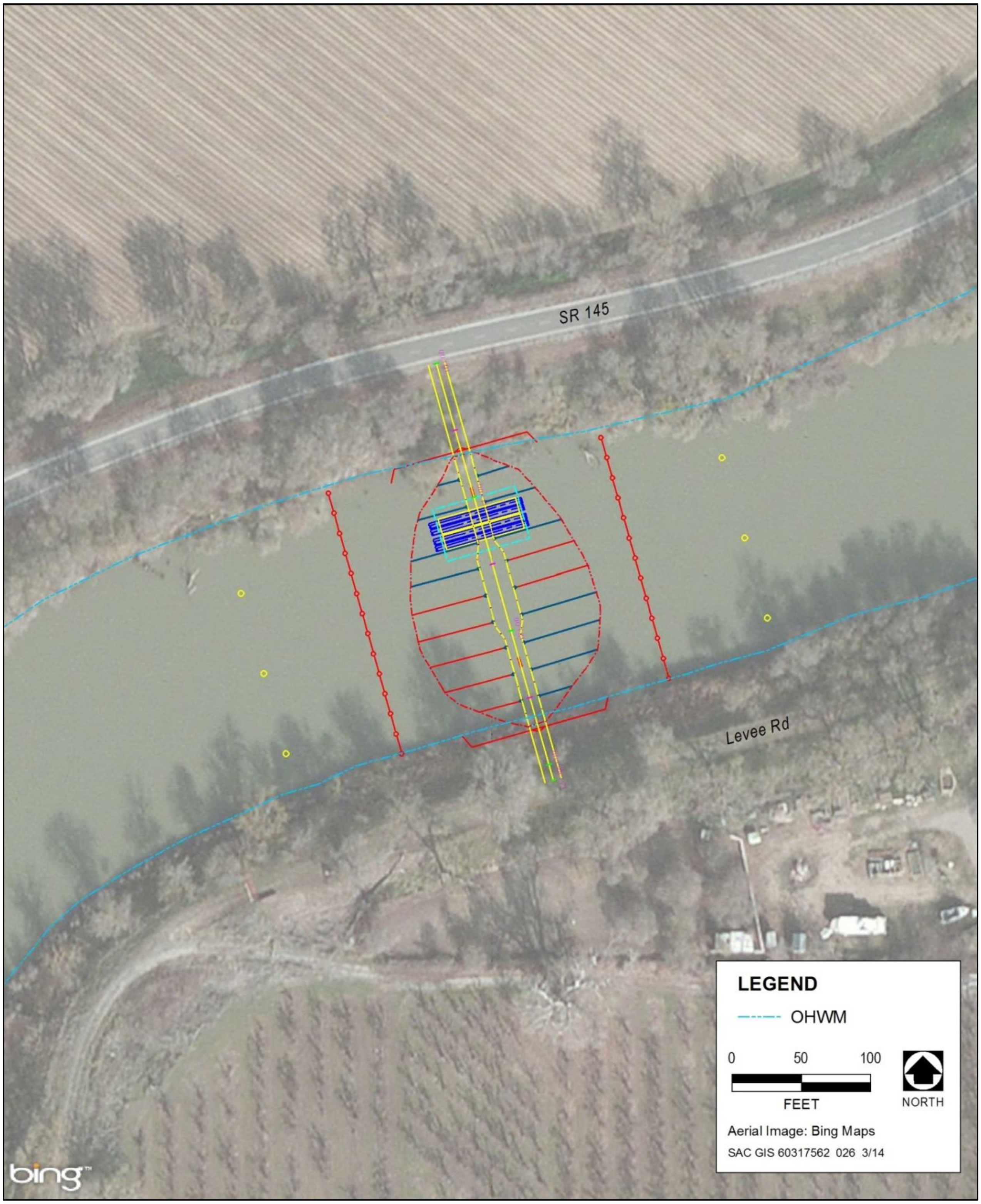
Appropriate navigation signage would be installed at each of the sites and would comply with navigation requirements established by the U.S. Aids to Navigation System and the California Waterway Marker system, as appropriate. Signs would be posted at upstream and downstream entrances to each waterway or other key locations, informing boaters of the restricted access. A Notice to Mariners would include information on the location, date, and duration of channel closures. Signs would be posted on each side of each barrier, float lines with orange ball floats would be located across the width of the channels to deter boaters from approaching the barriers, and solar-powered warning buoys with flashing lights would be present on the barrier crest, as well, in order to prevent accidents during nighttime hours. Additional information regarding navigational issues at each of the sites is provided below.

Structural Components

Sutter Slough Site

The Sutter Slough rock barrier (Figure 3) would be 200 feet long and up to143 feet wide at the base and 12 feet wide at the top. The top of the barrier would be set at an elevation of 9.50 feet across the crest and would include about a 50-foot overflow weir 20 feet wide at the top, set at 7.50 feet elevation[2]. The weir would allow overflows at high stage, and keep flow in the middle of the channel, minimizing the potential for erosion of the river banks. The barrier would include a submerged structure placed on a bed of crushed rock consisting of two steel frames with four 48-inch corrugated

[2] Vertical elevations are based on the North American Vertical Datum of 1988 (NAVD 88).



Source: Moffatt & Nichol 2014, AECOM 2014

Figure 3. Project Site – Sutter Slough

metal culverts set at an invert elevation of -2.0 feet. The culverts would be operated to allow fish passage and to regulate water levels and water quality on the downstream side of the barrier. One culvert would remain open at all times for fish passage, and the other culvert slide gates would be operated such that the culverts are fully open, fully closed, or at least 50% open as needed to improve water quality and/or stage downstream of the barriers.

The monitoring equipment and operable culverts would be accessed by the levee road on the north or via State Route 145. The site is navigable and is used primarily by recreational traffic, but signs would be posted at both entrances to the slough, informing boaters that Steamboat Slough provides boat passage for vessels up to 24 feet long and up to 10,000 pounds.

Steamboat Slough Site

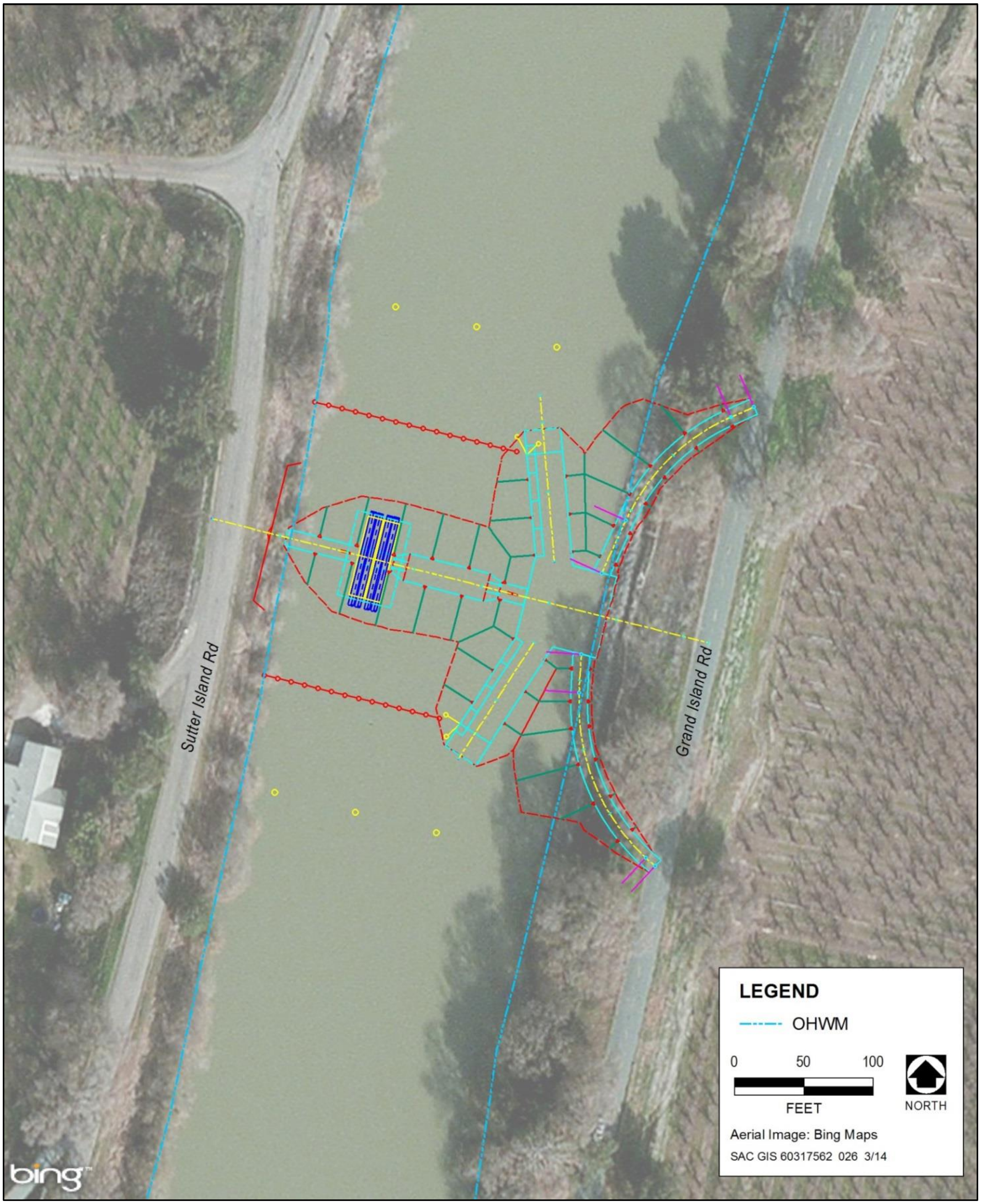
The Steamboat Slough rock barrier (Figure 4)would be 220 feet long, up to 110 wide at the base, and 12 feet wide at the top. The top of the structure would be at elevation 9.50 feet and would include about a 50-foot overflow weir 20 feet wide at the top, set at 7.50 feet and is designed to operate similar to the weir in Sutter Slough. Like the Sutter Slough site, it would include a submerged steel frame set at an invert elevation of -2.0 feet with four 48-inch corrugated metal culverts to allow fish passage and management of downstream water surface elevation and quality. One culvert would remain open at all times for fish passage, and the other culvert slide gates would be operated such that the culverts are fully open, fully closed, or at least 50% open as needed to improve water quality and/or stage downstream of the barriers.

This site is navigable by commercial and recreational traffic, and boat ramps on each side of the barrier would be provided on the east side of the channel. Two 12-foot-wide gravel roads would connect to Grand Island Road. The west access road would be about 150 feet long, and the east access road would be about 250 feet long. A State-provided boat tender would be present on the apron during daytime hours with a pickup truck and trailer. When a boat approaches, the trailer would be backed into the water, the boat would be placed on the trailer, and it would be driven to the boat ramp on the other side, where it would be placed back in the river. Boats up to 24 feet and 10,000 pounds could be accommodated. The site would not be available for launching boats from the land. The ramps would be approximately 6 feet by 20 feet and would be placed on rock fill with a 15 percent slope. Dock anchors (comparable to mooring lines) would be used to stabilize the boat ramps.

Workers would access the boat ramps via Grand Island Road, and the monitoring equipment and operable slide gates would be accessed via Sutter Island Road, both of which are public roads, or by boat.

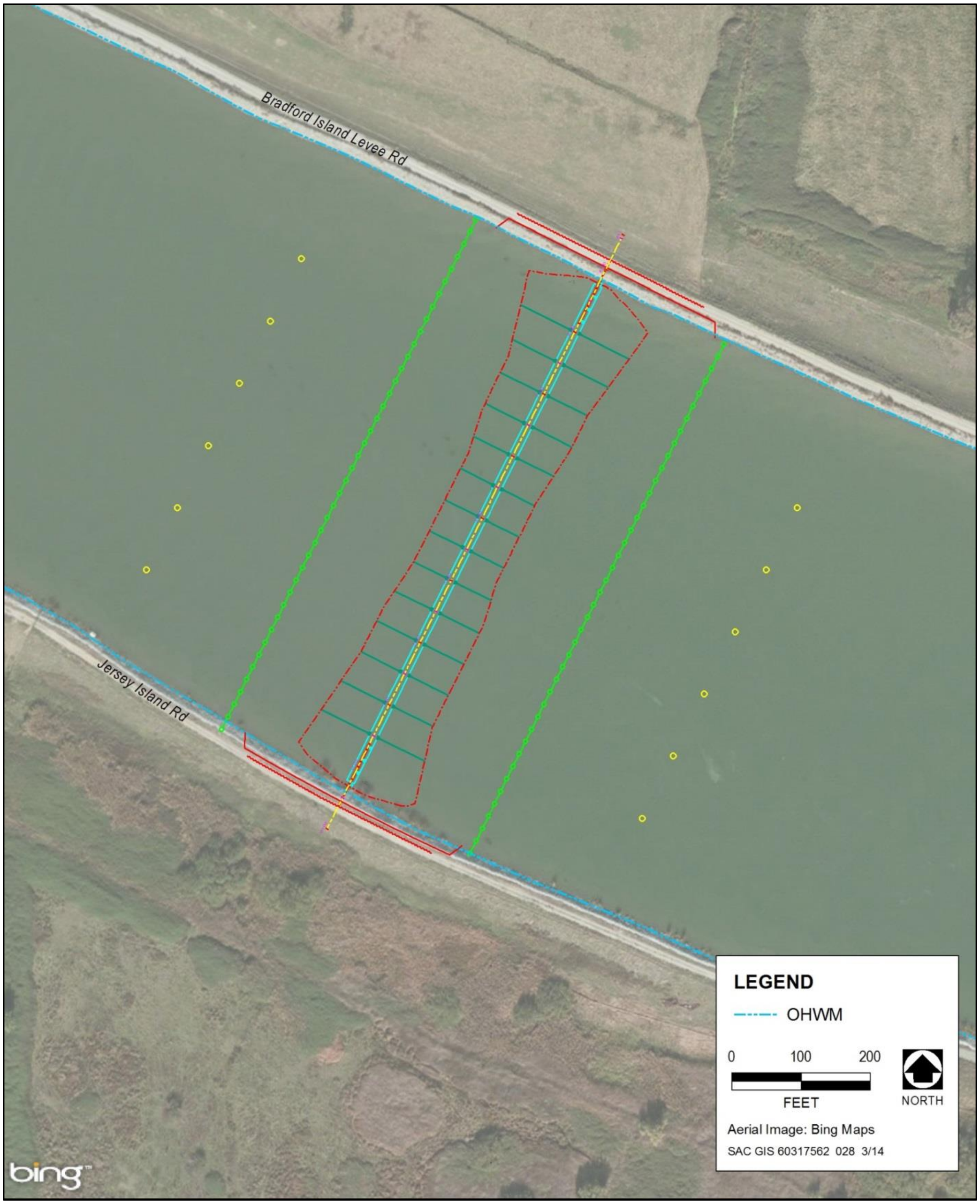
West False River Site

The West False River barrier (Figure 5) would be approximately 800 feet long and up to 150 feet wide at the base and 12 feet wide at the top. The top of the structure would be at an elevation of 7.00 feet across the entire crest. The barrier would include two king pile-supported sheet pile walls extending out from each levee into the channel for a distance of 75 feet. The sheet piles/king piles would be required because the levees are weaker at this location since they sit on peat, and placing a large volume of rock directly on the levees would cause too much stress. The walls would be buttressed with some rock on both sides, however. After barrier removal, rock would be used to make smooth transitions around the sheet pile abutments, which would remain in place for possible future use.



Source: Moffatt & Nichol 2014, AECOM 2014

Figure 4. Project Site – Steamboat Slough



Source: Moffatt & Nichol 2014, AECOM 2014

Figure 5. Project Site – West False River

No boat passage is provided around this barrier because alternative routes (Fisherman's Cut or False River east for vessel traffic between the south Delta to the San Joaquin River; and the Main San Joaquin River for vessel traffic between the Antioch and the eastern Delta) are available. No fish passage has been provided because migrating fish would use the adjacent San Joaquin River, Fisherman's Cut or Dutch Slough and their access would not be restricted.

To monitor water quality in the central Delta and the associated changes in water quality and flow resulting from the West False River barrier, DWR proposes to install up to four permanent water quality monitoring and or flow monitoring stations at Fisherman's Cut (approximately 1.5 miles east of the barrier), Frank's Tract, Sherman Lake, and potentially one additional site. The stations, which will be able to monitor several constituents including EC, would be installed on a 12-inch-diameter steel pipe piles. DWR would place navigational aids as needed at the stations.

Project Construction

Construction Practices

Notices of construction would be posted at local marinas and in the Local Notice to Mariners. Navigational markers would be used to prevent boaters from entering the immediate construction area, and speed limits would be posted. Safe vessel passage procedures would be coordinated with the Sector Waterways Management Division (U.S. Coast Guard Station Yerba Buena Island) and California Department of Parks and Recreation Division of Boating and Waterways (Cal Boating). An educational program would be implemented to inform boaters of the purpose of the EDB and the expected duration of installation activities. The program would include notices in local newspapers and boater publications as appropriate; notices also would be posted at local marinas and boat launches and on the EDB website.

The rock would come from one or more quarries, and structures such as the steel frames used to support culverts that allow fish passage and articulated concrete mats for boat ramps would be prefabricated. Most materials and construction equipment (e.g., cranes and clamshells and the vibratory pile driver used at the West False River site) would be brought to the site by barges, and most construction would take place from the water. The exceptions would be construction of the gravel roads used to access the boat ramps at the Steamboat Slough, the transport of road materials and boat ramps to this site, and perhaps the installation of portions of the king piles and sheet piles at the West False River site. Additionally, minimal vegetation and clearing would be required on the levees prior to placement of rock or the installation of sheet piles. This would be accomplished by a dozer or backhoe and hand clearing. The gravel access roads at the Steamboat Slough site also would be cleared and grubbed of trees and other vegetation and would be hauled off site and disposed of in an appropriate location. Any levee access roads that are damaged as a result of construction equipment or truck use would be restored to pre-construction conditions or better once construction is completed.

The rock barriers would be constructed by using a barge-mounted crane and clamshell to place the rock in the channel at the Sutter Slough and Steamboat Slough sites. Because of the greater width of the channel at the West False River site, a dump scow may be used to transport the rock and place it in the channel. Some rock placement at this site would require the use of a barge-mounted crane and bucket. Although some rock slope protection may need to be temporarily moved out of the sheet pile abutments alignments at False River, no channel dredging or excavation in the levee profiles would be required.

The sheet and king piles are anticipated to be installed by an appropriately-sized vibratory hammer, which appears to be feasible given the anticipated ground conditions and modest pile penetration of 20 feet to 50 feet in the ground. Vibratory penetration rates are normally limited to 20 inches per minute (per North American Sheet Piling Associations – Best Practices, www.nasspa.com), which would result in the following vibration times per pile assuming normal driving conditions:

- 20-ft ground penetration: 12 minutes
- 50-ft ground penetration: 30 minutes

Due to uncertainties of the ground conditions and the possibility of encountering dense soil layers and/or obstructions such as left-in-place rip-rap on the existing levee side slopes, a larger impact hammer will be available as a contingency measure, in the event unexpected difficult driving is encountered. The impact hammer will only be used if the vibratory hammer cannot reach design tip elevation of the pilings. If piles are driven by impact hammers in water deeper than one meter, a bubble curtain would be employed if underwater noise exceeds pre-established levels (peak pressure levels or cumulative sound exposure level) that would indicate potential injury to fish.

Construction Schedule

Construction would occur during regular daytime hours. Construction may occur concurrently at more than one EDB site, if adequate equipment is available[3]. The overall construction schedule is estimated to be 30 to 45 days. The barriers would be installed in the spring and removed in the fall. Removal would take approximately 30 to 45 days.

Facilities Removal

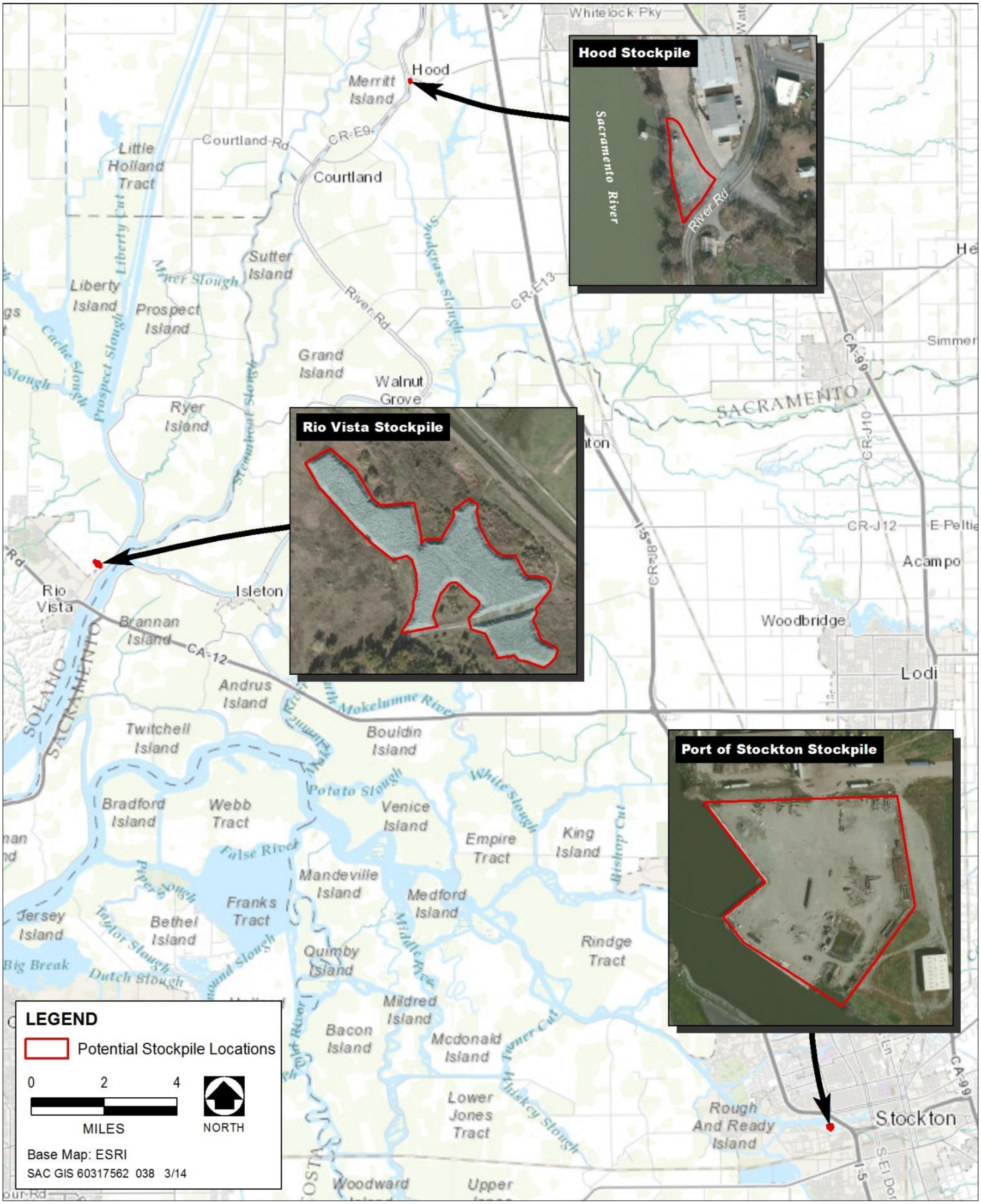
All rock, gravel, and structures would be removed from the EDB sites in the fall, with the exception of the sheet pile abutments at the West False River site. Bathymetric surveys would be completed after rock fill removal to confirm that the rock is removed. The materials would be transported from the area, primarily on barges. Materials would be stored at a nearby DWR storage facility, likely located in Hood, Rio Vista, or the Port of Stockton. These potential material storage locations are depicted in Figure 6. If lease arrangements can later be made with local landowners near the barrier sites, rock may be stored close to the barrier sites for use in future drought conditions if needed.

Site Restoration

Disturbed areas would be restored after initial construction and after Project structures are removed. The affected areas would be restored to meet local land use and resource agency requirements as soon as the barriers are no longer needed.

A restoration plan would be developed, as required by applicable regulatory agencies, and would be completed prior to the onset of construction. The restoration plan would identify areas that would be restored and restoration methods. Seed mixes, schedules, success criteria, and success monitoring for restoration of wetlands, streams, and drainages would be identified. The restoration plan would be

[3] As described in the Conservation Measures section, potential phasing of construction/operations would be coordinated with the permitting fish agencies in order to meet the purpose of the EDB while minimizing effects to listed fishes.



Source: DWR adapted by AECOM 2014

Figure 6. Potential Stockpile Locations

included in the contract specifications. The restoration plan would also consider the need for reinstallation of the barriers the following year if drought conditions continue.

Project Operations

EDB operations essentially would be limited to opening or closing the culvert slide gates at the Sutter and Steamboat slough sites as necessary for water quality or maintenance purposes. As described in the Conservation Measures section, monitoring data from nearby data stations will be used to inform the need to open or close the culverts. DWR would inform the permitting fish agencies should any major maintenance activities be required during the period of operation (May-November). A log of project operations and summary report of monitoring activities would be provided to the permitting agencies following completion of operations.

Action Area

The Action Area is defined as all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR § 402.02). The Action Area, for the purposes of this BA covering listed fish species, includes the waters of the legal Delta and the lands associated with the barrier footprints. Whereas the near-field effects of the EDB are very limited in extent (i.e., the footprints of the barriers and their environs), the far-field effects of the barriers are broad because of their influence on water quality and hydrodynamics; hence, the Action Area is large in extent.

Life Histories

Chinook Salmon

The following account is adapted from the NMFS (2014) BO on the Georgiana Slough Floating Fish Guidance Structure Study.

General Life History

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream- type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon can exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in the fall, and some of the juveniles may spend a year or more in freshwater before emigrating. The remaining fraction of the juvenile spring-run population may also emigrate to the ocean as young-of-the-year in spring. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers et al. 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes.

Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers et al. 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as fish with sexually immature gonads, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of sexual maturity with ripe gonads, move rapidly to their spawning areas on the main stem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

During their upstream migration, adult Chinook salmon require stream flows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate stream flows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38°F to 56°F (Bell 1991, CDFG 1998). Boles (1988) recommends water temperatures below 65°F for adult Chinook salmon migration, and Lindley et al. (2004) report that adult migration is blocked when temperatures reach 70°F, and that fish can become stressed as temperatures approach 70°F. Reclamation reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60°F; although salmon can tolerate temperatures up to 65°F before they experience an increased susceptibility to disease (Williams 2006).

Information on the migration rates of Chinook salmon in freshwater is scant and primarily comes from the Columbia River basin where information regarding migration behavior is needed to assess the effects of dams on travel times and passage (Matter et al. 2003). Keefer et al. (2004) found migration rates of Chinook salmon ranging from approximately 10 kilometers (km) per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter et al. (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River. Adult Chinook salmon inserted with sonic tags and tracked throughout the Delta and lower Sacramento and San Joaquin rivers were observed exhibiting substantial upstream and downstream movement in a random fashion while migrating upstream over the course of several days (CALFED Science Program 2001). Adult salmonids migrating upstream are assumed to make greater use of pool and mid-channel habitat than channel margins (Stillwater Sciences 2004), particularly larger salmon such as Chinook salmon, as described by Hughes (2004). Adults are thought to exhibit crepuscular behavior during their upstream migrations; meaning that they primarily are active during twilight hours. Recent hydroacoustic monitoring showed peak upstream movement of adult Central Valley spring-run Chinook salmon in lower Mill Creek, a tributary to the Sacramento River, occurring in the 4-hour period before sunrise and again after sunset.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. The upper preferred water temperature for spawning Chinook salmon is 55°F to 57°F (Chambers 1956, Smith 1973, Bjornn and Reiser 1991, Snider 2001).

Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel percolation, and poor water quality. Studies of Chinook salmon egg survival to hatching conducted by Shelton (1995) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel water circulation. The optimal water temperature for egg incubation ranges from 41°F to 56°F (44°F to 54°F [Rich 1997], 46°F to 56°F [NMFS 1997 Winter-run Chinook salmon Recovery Plan], and 41°F to 55.4°F [Moyle 2002]). A significant reduction in egg viability occurs at water temperatures above 57.5°F and total embryo mortality can occur at temperatures above 62°F (NMFS 1997). Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 61°F and 37°F, respectively, when the incubation temperature was held constant. As water temperatures increase, the rate of embryo malformations also increases, as well as the susceptibility to fungus and bacterial infestations. The length of development for Chinook salmon embryos is dependent on the ambient water temperature surrounding the egg pocket in the redd. Colder water necessitates longer development times as metabolic processes are slowed. Within the appropriate water temperature range for embryo incubation, embryos hatch in 40 to 60 days, and the alevins (yolk-sac fry) remain in the gravel for an additional 4 to 6 weeks before emerging from the gravel.

During the 4- to 6-week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. The post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and small aquatic invertebrates. As they switch from endogenous nourishment to exogenous feeding, the fry's yolk-sac is reabsorbed, and the belly suture closes over the former location of the yolk-sac (button-up fry). Fry typically range from 25 millimeters (mm) to 40 mm during this stage. Some fry may take up residence in their natal stream for several weeks to a year or more, while others are displaced downstream by the stream's current. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991). Fry then seek nearshore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer et al. 2001).

When juvenile Chinook salmon reach a length of 50 mm to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the channel margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 feet to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams may spur outmigration of juveniles when they have reached the appropriate stage of maturation (Kjelson et al. 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is crepuscular. Documents and data provided to NMFS in support of ESA section 10 research permit applications depicts that the daily migration of juveniles passing Red Bluff Diversion Dam (RBDD) is highest in the four-hour period prior to sunrise (Martin et al. 2001). Juvenile Chinook salmon migration rates vary considerably, presumably dependent on the physiological stage of the juvenile and ambient hydrologic conditions. Kjelson et al. (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River and Sommer et al. (2001) found rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1982).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, Central Valley spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin et al. 1997, Snider 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson et al. 1982, Sommer et al. 2001, MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer et al. 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54°F to 57°F (Brett 1952). In Suisun and San Pablo Bays water temperatures can reach 54°F by February in a typical year. Other portions of the Delta (i.e., south Delta and central Delta) can reach 70°F by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Levings et al. 1986, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle et al. (1989) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson et al. (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicates that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallones (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (i.e., fall-run Chinook salmon) MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

Sacramento River Winter-run Chinook Salmon

The distribution of winter-run Chinook salmon spawning and rearing historically was limited to the upper Sacramento River and its tributaries, where spring-fed streams provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid- summer period (Slater 1963, Yoshiyama et al. 1998). The headwaters of the McCloud, Pit, and Little Sacramento rivers, and Hat and Battle creeks, historically provided clean, loose gravel; cold, well-oxygenated water; and optimal stream flow in riffle habitats for spawning and incubation. These areas also provided the cold, productive waters necessary for egg and fry development and survival, and juvenile rearing over the summer. The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which has its own impediments to upstream migration (i.e., the fish weir at the Coleman National Fish Hatchery and other small hydroelectric facilities situated upstream of the weir) (Moyle et al. 1989, NMFS 1997, 1998a,b). Approximately 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run Chinook salmon. Yoshiyama et al. (2001) estimated that in 1938, the Upper Sacramento had a “potential spawning capacity” of 14,303 redds. Most components of the winter-run Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River.

Adult winter-run Chinook salmon enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate past the RBDD from mid-December through early August (NMFS 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type (see Table 2; Yoshiyama et al. 1998, Moyle 2002). Spawning occurs primarily from mid-April to mid-August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick Dam and RBDD (Vogel and Marine 1991). The majority of Sacramento River winter-run Chinook salmon spawners are 3 years old.

Table 2. The temporal occurrence of adult (a) and juvenile (b) Sacramento River winter-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

a) Adult migration

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[a]	M M	M M	H H	M M	M M	M M	M M					M M
Sac. River[b]	M M	M M	M M	M M	M M	M M					M M	M M

b) Juvenile migration

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River @ Red Bluff[c]	L L	L L	L L				L M	M M	M M	M M	M M	M M
Sac. River @ Red Bluff[b]	L L	L L	L L				L L	M M	M M	M M	M M	M M
Sac. River @ KL[d]	M M	M M	M M	L L	L L			L L	L L	L L	H H	H H
Lower Sac. River (seine)[e]	H H	H H	M M	L L	L L					L L	M M	H H
West Sac. River (trawl)[e]	M M	M M	H H	M M	L L						L L	M M

KL = Knights Landing

Relative Abundance: H = High; M = Medium; L = Low

Sources : [a]Yoshiyama et al. (1998); Moyle (2002); [b]Myers et al. (1998) ; Vogel and Marine(1991); [c]Martin et al. (2001); [d]Snider and Titus (2000); [e]USFWS (2001a, 2001b)

Sacramento River winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994). Emigration of juvenile Sacramento River winter-run Chinook salmon past RBDD may begin as early as mid-July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). Juvenile Sacramento River winter-run Chinook salmon occur in the Delta primarily from November through early May based on data collected from trawls in the Sacramento River at West Sacramento (River Mile 57; USFWS 2001a,b). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Winter-run Chinook salmon juveniles remain in the Delta until they reach a fork length of approximately 118 mm and are from 5 to 10 months of age, and then begin emigrating to the ocean as early as November and continue through May (Fisher 1994, Myers et al. 1998).

Historical Sacramento River winter-run Chinook salmon population estimates, which included males and females, were as high as approximately 100,000 fish in the 1960s, but declined to under 200 fish in the 1990s (Good et al. 2005). Population estimates in 2003 (8,218), 2004 (7,869), 2005 (15,839) and 2006 (17,296) show a recent increase in the population size (CDFG GrandTab, April 2013) and a 4-year average of 12,306 (Table 3). The 2006 run was the highest since the 1994 listing. Abundance measures over the last decade suggest that the abundance was initially increasing (Good et al. 2005). However, escapement estimates for 2007-2011, show a precipitous decline in escapement numbers based on red counts and carcass counts. Estimates place the adult escapement numbers for 2007 at 2,541 fish, 2,830 fish for 2008, and 4,537 fish for 2009, 1,596 fish for 2010, 827 fish for 2011, 2,767 for 2012 (CDFG GrandTab 2013), and 6,075 for 2013 (CDFW unpublished data).

Two current methods are utilized to estimate the juvenile production of Sacramento River winter-run Chinook salmon: the Juvenile Production Estimate (JPE) method, and the Juvenile Production Index (JPI) method (Gaines and Poytress 2004). Gaines and Poytress (2004) estimated the average juvenile population of Sacramento River winter-run Chinook salmon exiting the upper Sacramento River at RBDD to be 3,707,916 juveniles per year using the JPI method between the years 1995 and 2003 (excluding 2000 and 2001). Using the JPE method, they estimated an average of 3,857,036 juveniles exiting the upper Sacramento River at RBDD between the years of 1996 and 2003. Averaging these two estimates yields an estimated overall average population size of 3,782,476.

Based on the RBDD counts, the population has been growing rapidly since the 1990s with positive short-term trends (excluding the 2007-2011 escapement numbers). An age-structured density-independent model of spawning escapement by Botsford and Brittnacker (1998 as referenced in Good et al. 2005) assessing the viability of Sacramento River winter-run Chinook salmon found the species was certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with fewer than 50 females (Good et al. 2005). Lindley and Mohr (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the status of the Sacramento River winter-run Chinook salmon population had been improving until as recently as 2006, there is only one population, and it depends on cold-water releases from Shasta Dam, which could be vulnerable to a prolonged drought (Good et al. 2005). Recent population trends in the previous 5 years (2008 – 2012) have indicated that the status of the winter-run Chinook salmon population may be changing as reflected in the diminished abundance during this period. The most recent winter-run Chinook salmon JPE is for 2013 (2012 brood year) and estimates that only 532,809 fish entered the Delta, a substantial decline from the previous JPE values seen in the last decade. However, the two most recent years of adult escapement estimates (2012 and 2013) have shown a modest increase in the number of returning adults, compared to the recent low in 2011 (827 winter-run Chinook salmon).

In 2007, Lindley et al. (2007) determined that the Sacramento River winter-run Chinook salmon population that spawns below Keswick Dam is at a moderate extinction risk according to population

Table 3. Winter-run Chinook salmon population estimates from RBDD counts (1986 to 2001) and carcass counts (2001 to 2012), and corresponding cohort replacement rates for the years since 1986 (CDFW GrandTab April 2013 winter-run adult escapement estimate)

Year	Population Estimate[a]	5-Year Moving Average of Population Estimate	Cohort Replacement Rate[b]	5-Year Moving Average of Cohort Replacement Rate	NMFS -Calculated Juvenile Production Estimate (JPE)[c]
1986	2,596				
1987	2,185				
1988	2,878				
1989	696		0.27		
1990	430	1,757	0.20		
1991	211	1,280	0.07		40,100
1992	1,240	1,091	1.78		273,100
1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1,297	664	1.05	0.94	338,107
1996	1,337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	2,992	1,338	2.31	2.48	454,792
1999	3,288	1,959	2.46	2.80	289,724
2000	1,352	1,970	1.54	2.90	370,221
2001	8,224	3,347	2.75	2.76	1,864,802
2002	7,441	4,659	2.26	2.26	2,136,747
2003	8,218	5,705	6.08	3.02	1,896,649
2004	7,869	6,621	0.96	2.72	881,719
2005	15,839	9,518	2.13	2.84	3,831,286
2006	17,296	11,333	2.10	2.71	3,739,050
2007	2,541	10,353	0.32	2.32	589,900
2008	2,830	9,275	0.18	1.14	617,783
2009	4,537	8,609	0.26	1.00	1,179,650
2010	1,596	5,760	0.63	0.70	332,012
2011	827	2,466	0.29	0.34	162,051
2012d	2,767	2,511	0.61	0.39	532,809e
median	2,541	2466	1.00	2.23	412506.5
mean[f]	3,776	4,044	1.59	1.83	909,040
Last 10[g]	6,432	7,215	1.36	1.72	1,376,291
Last 6[h]	2,516	6,496	0.38	0.98	569,034
Last 3[i]	1,730	3,579i	0.51	0.48i	342,291

Year	Population Estimate[a]	5-Year Moving Average of Population Estimate	Cohort Replacement Rate[b]	5-Year Moving Average of Cohort Replacement Rate	NMFS -Calculated Juvenile Production Estimate (JPE)[c]

a Population estimates were based on RBDD counts until 2001. Starting in 2001, population estimates were based on carcass surveys.

b The majority of winter-run spawners are 3 years old. Therefore, NMFS calculated the Cohort Replacement Rate (CRR) using spawning population of a given year, divided by the spawning population 3 years prior.

c JPEs were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers.

d CDFW 2013 estimate to NMFS of adult winter-run escapement is 6,075 fish (CDFW 2014). Data for 2013 are not included in calculations.

e JPE value has not been calculated for 2013 at the time of this opinion's writing.

f Average of 1986 through 2012

g Average of last 10 years of data and derived calculations (2003 to 2012)

h Average of last 6 years of data and derived calculations (2007 to 2012)

I Average of last 3 years of data and derived calculations (2010 to 2012)

viability analysis (PVA), and at a low risk according to other criteria (i.e., population size, population decline, and the risk of wide ranging catastrophe). However, concerns of genetic introgression with hatchery populations are increasing. Hatchery-origin winter-run Chinook salmon from Livingston Stone National Fish Hatchery (LSNFH) have made up more than 5 percent of the natural spawning run in recent years and in 2005, it exceeded 18 percent of the natural run. If the proportion of hatchery origin fish from the LSNFH exceeded 15 percent in 2006-2007, Lindley et al. (2007) recommended reclassifying the winter-run Chinook population extinction risk as moderate, rather than low, based on the impacts of the hatchery fish over multiple generations of spawners. However, since 2005, the percentage of hatchery fish recovered at the LSNFH has been consistently below 15 percent.

Furthermore, Lindley et al. (2007) did not include the recent declines in adult escapement abundance which may modify the conclusion reached in 2007. The recent status review of the Sacramento River winter-run Chinook salmon evolutionary significant unit (ESU) in August 2011 (NMFS 2011a) did assess this recent decline and found that the winter-run Chinook salmon population was still at an elevated risk of extinction. Its current status did not warrant a change from its listing as endangered.

Lindley et al. (2007) also states that the winter-run Chinook salmon population fails the "representation and redundancy rule" because it has only one population, and that population spawns outside of the ecoregion in which it evolved. In order to satisfy the "representation and redundancy rule," at least two populations of winter-run Chinook salmon would have to be re-established in the basalt- and porous-lava region of its origin. An ESU represented by only one spawning population at moderate risk of extinction is at a high risk of extinction over an extended period of time (Lindley et al. 2007).

Viable Salmonid Population Summary for Sacramento River Winter-run Chinook Salmon

Abundance: During the first part of this decade, redd and carcass surveys as well as fish counts, suggested that the abundance of winter-run Chinook salmon was increasing since its listing. However, the depressed abundance estimates from 2007-2011 are contrary to this earlier trend and may represent a combination of a new cycle of poor ocean productivity (Lindley et al. 2009) and recent drought conditions in the Central Valley. The most recent two years have indicated a slight upwards trend in the population abundance for winter-run, when ocean conditions have been more positive for salmonid populations. Population growth is estimated to be positive in the short-term trend at 0.26; however, the long-term trend is negative, averaging -0.14. Recent winter-run Chinook salmon abundance represents only 3 percent of the maximum post-1967, five-year geometric mean, and is not yet well established (Good et al. 2005). The current annual and five-year averaged cohort replacement rates (CRR) are both below 1.0. The annual CRR has been below 1.0 for the past five years and indicates that the winter-run population is not replacing itself.

Productivity: ESU productivity has been positive over the short term, and adult escapement and juvenile production had been increasing annually (Good et al. 2005) until recently (2006). However, since 2006, there has been declining escapement estimates for the years 2007 through 2011, with only a moderate positive increase in adult escapement for 2012, over the low seen in 2011 (827 fish). The long-term trend for the ESU remains negative, as it consists of only one population that is subject to possible impacts from environmental and artificial conditions. The most recent CRR estimates suggest a reduction in productivity for the three separate cohorts, starting in 2007.

Spatial Structure: The greatest risk factor for winter-run Chinook salmon lies with their spatial structure (Good et al. 2005). The remnant population cannot access historical winter-run Chinook salmon habitat and must be artificially maintained in the Sacramento River by a regulated, finite cold-water pool behind Shasta Dam. Winter-run Chinook salmon require cold water temperatures in summer that simulate their upper Sacramento River basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek remains the most feasible opportunity for the ESU to expand its spatial structure, which currently is limited to the upper 25-mile reach of the main stem Sacramento River below Keswick Dam. Based on Reasonable and Prudent Alternative actions described in the CVP/SWP BO, passage of winter-run Chinook salmon above Keswick and Shasta Dams is being considered as one of the actions. This would reintroduce winter-run Chinook salmon into regions they had historically occupied and significantly benefit the spatial structure of the ESU.

Diversity: The second highest risk factor for the Sacramento River winter-run Chinook salmon ESU has been the detrimental effects on its diversity. The present winter-run Chinook salmon population has resulted from the introgression of several stocks that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam; and there may have been several others within the recent past (Good et al. 2005). Concerns of genetic introgression with hatchery populations are also increasing. Hatchery-origin winter-run Chinook salmon from LSNFH have made up more than 5 percent of the natural spawning run in recent years and in 2005, it exceeded 18 percent of the natural run. The average over the last 10 years (approximately 3 generations) has been 8 percent, still below the low-risk threshold for hatchery influence. Since 2005, the percentage of hatchery fish in the river has been consistently below 15 percent.

Central Valley Spring-Run Chinook Salmon

Historically the spring-run Chinook salmon were the second most abundant salmon run in the Central Valley (CDFG 1998). These fish occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The Central Valley Technical Review Team (CVTRT) estimated that historically there were 18 or 19 independent populations of Central Valley spring-run Chinook salmon, along with a number of dependent populations and four diversity groups (Lindley et al. 2004). Of these 18 populations , only three extant populations currently exist (Mill, Deer, and Butte creeks on the upper Sacramento River) and they represent only the northern Sierra Diversity group. All populations in the Basalt and Porous Lava Group and the Southern Sierra Nevada Group have been extirpated.

The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998, Fisher 1994). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (Skinner 1958, Fry 1961). Construction of other low elevation dams in the foothills of the Sierras on the American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers extirpated Central Valley spring-run Chinook salmon from these watersheds. Naturally-spawning populations of Central Valley spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998).

Adult Central Valley spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (Table 4 in text; Yoshiyama et al. 1998, Moyle 2002). Lindley et al. (2004) indicates adult Central Valley spring-run Chinook salmon enter native tributaries from the Sacramento River primarily between mid-April and mid-June. Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama et al. 1998).

Spring-run Chinook salmon spawning occurs between September and October depending on water temperatures. Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins et al. 1940, Fisher 1994).

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the- year or as juveniles or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley et al. 2004). Studies in Butte Creek (Ward et al. 2002, 2003, McReynolds et al. 2005) found the majority of Central Valley spring-run Chinook salmon migrants to be fry occurring primarily during December, January, and February; and that these movements appeared to be influenced by flow. Small numbers of Central Valley spring-run Chinook salmon remained in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley et al. 2004).

Once juveniles emerge from the gravel they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac and transition to exogenous feeding (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow larger. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002). The emigration period for spring-run Chinook salmon extends from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period (CDFG 1998). Peak movement of juvenile Central Valley spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000). Based on the available information, the emigration timing of Central Valley spring-run Chinook salmon appears highly variable (CDFG

Table 4. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance

(a) Adult migration																								
Location	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Sac.River basin[a,b]					M	M	M	M	H	H	H	H	M	M	M	M	M	M	L	L				
Sac. River mainstem[c]		L	L	L	M	M	M	M	M	M	M	M	M	M	L	L								
Mill Creek[d]					L	L	M	H	H	H	H	M	M	L	L									
Deer Creek[d]					L	L	M	H	H	H	H	M	M											
Butte Creek[d]			M	M	M	M	M	H	H	H	H	M	L											
(b) Adult Holding			M	M	M	M	M	H	H	H	H	H	H	H	H	H	H	M	M	L				
(c) Adult Spawning															L	M	H	H	M	L				
(d) Juvenile migration																								
Location	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Sac. River Tribs[e]	M	M	M	M	M	M													M	M	H	H	H	H
Upper Butte Creek[f]	H	H	H	H	M	M	M	M	M	M	L	L							L	L	L	L	H	H
Mill, Deer, Butte Creeks[d]	H	H	H	H	M	M	M	M	M	M	L	L							L	L	L	L	L	L
Sac. River at RBDD[c]	H	H	L	L	L	L	L	L	L												H	H	H	H
Sac. River at KL[g]	M	M	M	M	H	H	H	H	M	M											M	M	H	H

Relative Abundance: H = High M = Medium L = Low

Sources: [a]Yoshiyama et al. (1998); [b]Moyle (2002); [c]Myers et al. (1998); [d]Lindley et al. (2004); [e]CDFG (1998); [f]McReynolds et al. (2005); Ward et al. (2002, 2003); [g]Snider and Titus (2000)

1998). Some fish may begin emigrating soon after emergence from the gravel, whereas others over-summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998).

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the Feather River Fish Hatchery (FRFH). In 2002, the FRFH reported 4,189 returning spring-run Chinook salmon, which is 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag (CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to previous hatchery practices. Because Chinook salmon have not always been temporally separated in the hatchery, spring-run and fall-run Chinook salmon have been spawned together in the past, thus compromising the genetic integrity of the spring-run Chinook salmon stock in the Feather River. The most recent status review for Central Valley spring-run Chinook salmon (NMFS 2011b) reported that there were subtle differences between the FRFH spring-run Chinook salmon and the fall-run Chinook salmon stocks spawning in that river system (Garza and Pearse 2008) but that there was also a high level of similarity between the two runs, reflecting historic gene flow between them. Currently, the FRFH allows early returning fish that exhibit spring-run run timing behavior to enter the hatchery in spring, where they are tagged and then released back into the river below the hatchery to over-summer. When spawning the spring-run stock, the hatchery only spawns early returning fish with other early returning fish, as indicated by the tags. However, only a limited number of fish can be spawned for hatchery production, the remaining tagged fish remain in the river to spawn naturally. These fish may spawn with either other spring-run Chinook salmon or with fall-run Chinook salmon that have now entered the river system. It also is noted in the review that not all early returning fish exhibiting the spring-run timing characteristics enter the hatchery in spring, and thus a fraction of the run remains "unidentified" in the river and are not enumerated as spring-run in any census of the river. The number of naturally spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (Good et al. 2005). For the reasons discussed previously, the Feather River spring- run Chinook population numbers are not included in the following discussion of ESU abundance.

In addition, monitoring of the Sacramento River main stem during spring-run Chinook salmon spawning timing indicates some spawning occurs in the river. Here, the potential to physically separate spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon has made identification of a spring-run Chinook salmon in the main stem very difficult to determine, and there is speculation as to whether a true spring-run Chinook salmon population still exists below Keswick Dam. Although the conditions of the physical habitats in the Sacramento River below Keswick Dam are capable of supporting spring-run Chinook salmon, some years have had high water temperatures resulting in substantial levels of egg mortality. Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 salmon redds from Keswick Dam downstream to the RBDD. This is typically when spring-run spawn, however, these redds also could be early spawning fall-run. Therefore, even though physical habitat conditions may be suitable, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely to have caused extensive introgression between the populations (CDFG 1998). For these reasons, Sacramento River main stem spring-run Chinook salmon are not included in the following discussion of ESU abundance.

The Central Valley spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 24,903 in 1998 (Table 5). Sacramento River tributary populations in Mill, Deer, and Butte creeks are probably the best trend indicators for the Central Valley spring-run Chinook salmon ESU as a whole because these streams contain the primary independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991 up through 2005. Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish during the 10 year period between 1995 and 2005. During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although trends through the first half of the past decade were generally positive, annual abundance estimates display a high level of fluctuation, and the overall number of Central Valley spring-run Chinook salmon remains well below estimates of historic abundance. The past several years (since 2005) have shown declining abundance numbers in most of the tributaries. Exceptions to this negative population trend are increases in the number of spring-run Chinook entering Clear Creek and Battle Creek. Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21°C for 10 or more days in July (reviewed by Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of columnaris disease (*Flexibacter columnaris*) and ichthyophthiriasis (*Ichthyophthirius multifiis*) in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to the pre-spawning mortality of approximately

Table 5. Central Valley Spring-run Chinook salmon population estimates from CDFW GrandTab (April 2013) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average of Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	25,696	1,433	24,263						
1987	13,888	1,213	12,675						
1988	18,933	6,833	12,100						
1989	12,163	5,078	7,085		0.29			0.47	
1990	7,683	1,893	5,790	12,383	0.46		15,673	0.55	
1991	5,926	4,303	1,623	7,855	0.13		11,719	0.31	
1992	3,044	1,497	1,547	5,629	0.22		9,550	0.25	
1993	6,076	4,672	1,404	3,490	0.24	0.27	6,978	0.79	0.48
1994	6,187	3,641	2,546	2,582	1.57	0.52	5,783	1.04	0.59
1995	15,238	5,414	9,824	3,389	6.35	1.70	7,294	5.01	1.48
1996	9,083	6,381	2,702	3,605	1.92	2.06	7,926	1.49	1.72
1997	5,193	3,653	1,540	3,603	0.60	2.14	8,355	0.84	1.84
1998	31,649	6,746	24,903	8,303	2.53	2.60	13,470	2.08	2.09
1999	10,100	3,731	6,369	9,068	2.36	2.75	14,253	1.11	2.11
2000	9,244	3,657	5,587	8,220	3.63	2.21	13,054	1.78	1.46
2001	26,663	4,135	22,528	12,185	0.90	2.01	16,570	0.84	1.33
2002	25,043	4,189	20,854	16,048	3.27	2.54	20,540	2.48	1.66
2003	30,697	8,662	22,035	15,475	3.94	2.82	20,349	3.32	1.91
2004	17,150	4,212	12,938	16,788	0.57	2.47	21,759	0.64	1.81
2005	23,093	1,774	21,319	19,935	1.02	1.94	24,529	0.92	1.64
2006	12,906	2,181	10,725	17,574	0.49	1.86	21,778	0.42	1.56
2007	11,144	1,916	9,228	15,249	0.71	1.35	18,998	0.65	1.19
2008	13,387	1,460	11,927	13,227	0.56	0.67	15,536	0.58	0.64
2009	4,505	989	3,516	11,343	0.33	0.62	13,007	0.35	0.58
2010	4,623	1,661	2,962	7,672	0.32	0.48	9,313	0.41	0.48
2011	7,408	1,969	5,439	6,614	0.46	0.48	8,213	0.55	0.51
2012	22,249	3,738	18,511	8,471	5.26	1.39	10,434	4.94	1.37
Median	12,163	3,657	9,228	8,471	0.66	1.90	13,054	0.82	1.47
Average[c]	14,036	3,594	10,442	9,944	1.59	1.64	13,699	1.33	1.32
Last 10[d]	14,716	2,856	11,860	13,235	1.37	1.41	16,392	1.28	1.17
Last 6[e]	10,553	1,956	8,597	10,429	1.27	0.83	12,584	1.25	0.80
Last 3[f]	11,427	2,456	8,971	7,586 f	2.01	0.78 f	9,320 f	1.97	0.79 f

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average of Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR

a NMFS included both the escapement numbers from the FRFH and the Sacramento River and its tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from the FRFH and the tributaries.
b Abbreviations: CRR = Cohort Replacement Rate, Trib = tributary
c Grand average for years 1986 to 2012
d Average over last 10 years of data and derived calculations (2003 to 2012)
e Average over last 6 years of data and derived calculations (2007 to 2012)
f Average over last 3 years of data and derived calculations (2010 to 2012)

20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek.

Lindley et al. (2007) indicated that the spring-run population of Chinook salmon in the Central Valley had a low risk of extinction in Butte and Deer creeks, according to their PVA model and the other population viability criteria (i.e., population size, population decline, catastrophic events, and hatchery influence). The Mill Creek population of spring-run Chinook salmon is at moderate extinction risk according to the PVA model, but appears to satisfy the other viability criteria for low-risk status. However, like the winter-run Chinook salmon population, the Central Valley spring-run Chinook salmon population fails to meet the "representation and redundancy rule" (Lindley et al. 2007) since there is only one demonstrably viable population out of the three diversity groups that historically contained them. The spring-run population is only represented by the group that currently occurs in the northern Sierra Nevada. The spring-run Chinook salmon populations that formerly occurred in the basalt and porous-lava region and southern Sierra Nevada region have been extirpated. The northwestern California region contains a few ephemeral populations (e.g., Clear, Cottonwood, and Thomes creeks) of spring-run Chinook salmon that are likely dependent on the northern Sierra populations for their continued existence. Over the long term, these remaining independent populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run Chinook salmon populations in these three watersheds due to their close proximity to each other. One large event could eliminate all three populations.

Viable Salmonid Population Summary for Central Valley Spring-run Chinook Salmon

Abundance: Over the first half of the past decade, the Central Valley spring-run Chinook salmon ESU has experienced a trend of increasing abundance in some natural populations , most dramatically in the Butte Creek population (Good et al. 2005). There has been more opportunistic utilization of migration-dependent streams overall. The FRFH spring-run Chinook salmon stock has been included in the ESU based on its genetic linkage to the natural population and the potential development of a conservation strategy for the hatchery program at this facility. In contrast to the first half of the decade, the adult returns through 2010, indicate that population abundance declined sharply from the peaks seen in the 5 years prior (2001 to 2005) for the entire Sacramento River basin. According to the latest species status review (NMFS 2011b), the recent declines in abundance through 2010, place the Mill and Deer creek populations in the high extinction risk category due to the rate of decline, and in the case of Deer Creek, also the level of escapement. However, the estimates of adult escapement increased sharply in 2012 for both Deer and Mill creeks (734 and 768 fish, respectively), moving these populations back to a moderate risk category. Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in the past several years (2005 to 2011) is adequate to classify it as a moderate extinction risk based on this criterion. In 2012, the Butte Creek estimate of adult escapement increased from 4,505 fish to 16,140 fish moving the population's risk assessment back towards a low risk category. During the same period, some tributaries, such as Clear Creek and Battle Creek have shown indications of population gains, but the overall abundance numbers are still low compared to Butte Creek. Battle Creek has increased from approximately 200 adults per year (2006 to 2011) to nearly 800 fish in 2012. The recent increases in Battle Creek would qualify this population as being at a moderate risk of extinction based on the escapement estimates for the river. Spring-run Chinook salmon also occur on the Yuba River, with the annual run size generally ranging from a few hundred fish to several thousand fish, and the annual trends closely following the annual abundance trend of the FRFH spring-run Chinook salmon population. There appears to be considerable hatchery influence, as preliminary data from Barnett-Johnson et al. (2011) suggested that in 2009 only 9% of spawners were of Yuba River origin. This is not surprising as the Yuba River is a tributary to the Feather River. The Yuba River spring-run Chinook salmon population satisfies the moderate extinction risk criteria for abundance, but likely falls into the high risk category for hatchery influence. Spring-run Chinook salmon population trends in the Central Valley through 2010 are given in the NMFS 5-year review (NMFS 2011b).

Productivity: The 5-year geometric mean for the extant Butte, Deer, and Mill Creek spring-run Chinook salmon populations from 1986 to 2012 ranges from 235 to 1,236 (Mill Creek), 255 to 1,926 (Deer Creek) and 277 to 15,818 fish (Butte Creek) (Good et al. 2005, GrandTab 2013), with the highest 5-year geometric means occurring in 2006. The 5-year geometric mean increased fairly consistently from 1986 to 2006, indicating increasing productivity over the short-term and was projected to likely continue into the future (Good et al. 2005). However, a recent decline in the adult escapement in these tributaries has seen declining 5-year geometric mean values since 2006. As mentioned in the previous paragraph, the adult escapement to these tributaries from 2006 through 2010 has seen a cumulative decline in fish numbers and the CRR has declined in concert with the population declines. In the past decade (2002 to 2012), the 10-year average annual spring-run escapement for Mill, Deer, and Butte creeks has been 771, 1,050, and 9,541 fish, respectively. The average for the last 6 years for Mill, Deer, and Butte creeks has decreased to 523, 337, and 7,219 fish, respectively. Over the past 3 years the average escapement has been fairly steady compared to the previous 6 years; 539, 422, and 7,545 fish for Mill, Deer, and Butte creeks, respectively (GrandTab 2013) primarily due to good returns in 2012 that offset declining returns in 2010 and 2011. The productivity of the "wild" Feather River and Yuba River spring-run populations and contribution to the Central Valley spring-run ESU currently is unknown.

Spatial Structure: Spring-run Chinook salmon presence has been reported more frequently in several upper Central Valley creeks, but the sustainability of these runs is unknown. Butte Creek spring-run Chinook salmon cohorts have recently utilized all currently available habitat in the creek; and it is unknown if individuals have opportunistically migrated to other systems. The spatial structure of the spring-run Chinook salmon ESU has been reduced with the extirpation of all San Joaquin River basin spring-run Chinook salmon populations. In the near future, an experimental population of Central Valley spring-run Chinook salmon will be reintroduced into the San Joaquin River below Friant Dam as part of the San Joaquin River Settlement Agreement. Its long term contribution to the Central Valley spring-run Chinook salmon ESU is uncertain. The populations in Clear Creek and Battle Creek may add to the spatial structure of the Central Valley spring-run population if they can persist by colonizing waterways in the Basalt and Porous Lava and Northwestern California Coastal Range diversity group areas. The most recent returns for Battle Creek indicate that there is reason to believe that this tributary may sustain another population of spring-run and therefore re-colonize the Basalt and Porous Lava eco-region of the Central Valley.

Diversity: The Central Valley spring-run Chinook salmon ESU comprises two genetic complexes. Analysis of natural and hatchery spring-run Chinook salmon stocks in the Central Valley indicates that the Northern Sierra Nevada spring-run Chinook salmon population complex (Mill, Deer, and Butte creeks) retains genetic integrity. The genetic integrity of the Northern Sierra Nevada spring-run Chinook salmon population complex in the Feather River has been somewhat compromised. The Feather River spring-run Chinook salmon have introgressed with the fall-run Chinook salmon, and it appears that the Yuba River population may have been impacted by FRFH fish straying into the Yuba River. The diversity of the spring-run Chinook salmon ESU has been further reduced with the extirpation of the San Joaquin River basin spring-run Chinook salmon populations (Southern Sierra Diversity Group) and the Basalt and Porous Lava Diversity Group independent populations. A few dependent populations persist in the Northwestern California Diversity Group, and their genetic lineage appears to be closely aligned with strays from the Northern Sierra Diversity group.

Central Valley Steelhead

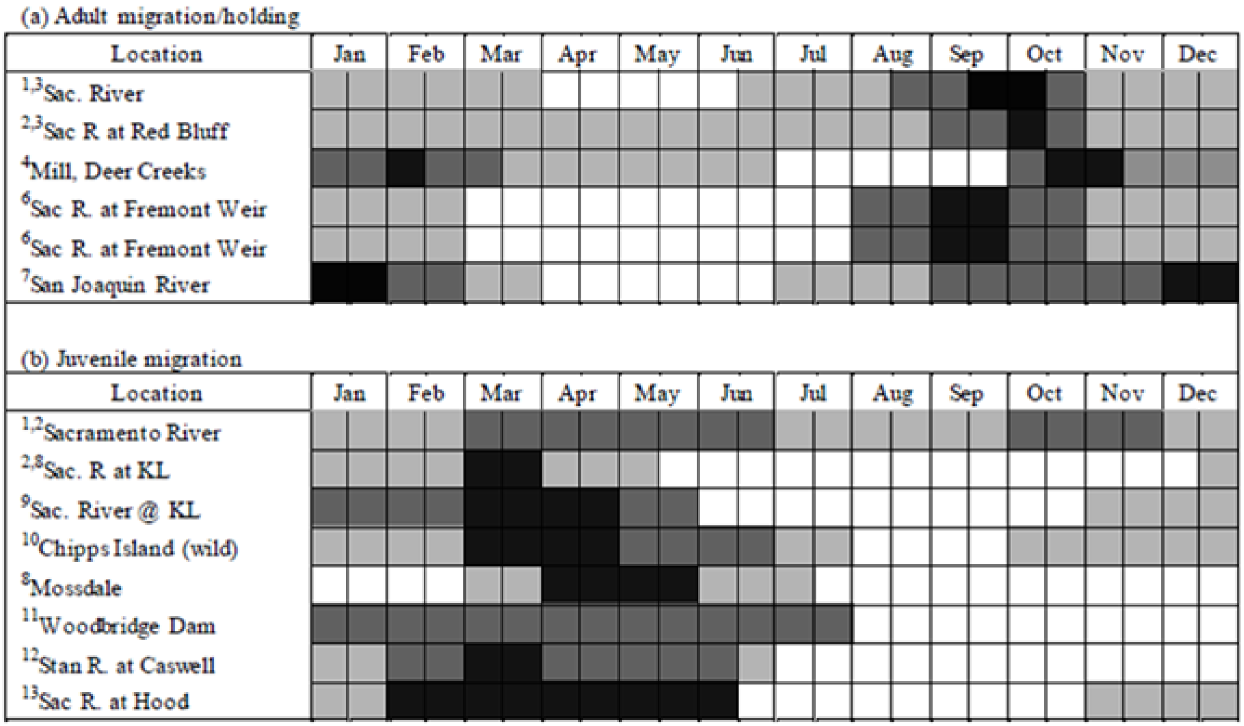
The following account is adapted from the NMFS (2014) BO on the Georgiana Slough Floating Fish Guidance Structure Study.

Steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Only winter-run steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer-run steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program [IEP] Steelhead Project Work Team 1999). At present, summer-run steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity river systems (McEwan and Jackson 1996).

California Central Valley steelhead generally leave the ocean from August through April (Busby et al. 1996), and spawn from December through April with peaks from January through March in small streams and tributaries where cool, well oxygenated water is available year-round (Hallock et al. 1961, McEwan and Jackson 1996; Table 6 in text). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches at river mouths, and associated lower water temperatures. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Barnhart et al. 1986, Busby et al. 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Busby et al. 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby et al. 1996). Although one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams.

Spawning occurs during winter and spring months. The length of time it takes for eggs to hatch depends mostly on water temperature. Hatching of steelhead eggs in hatcheries takes about 30 days at 51°F. Fry emerge from the gravel usually about 4 to 6 weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Newly emerged fry move to the shallow, protected areas associated with the stream margin (McEwan and Jackson 1996) and they soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft 1954).

Table 6. The Temporal Occurrence of Adult (A) and Juvenile (B) California Central Valley Steelhead In the Central Valley



Sources : [1]Hallock 1961; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFG1995; [5]Hallock et al. 1957; [6]Bailey 1954; [7]CDFG Steelhead Report Card Data; [8]CDFG unpublished data; [9]Snider and Titus 2000; [10]Nobriga and Cadrett 2001; [11]Jones & Stokes Associates, Inc., 2002; [12]S.P. Cramer and Associates, Inc. 2000 and 2001; [13]Schaffter 1980, 1997.

Note: Darker shades indicate months of greatest relative abundance.

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating California Central Valley steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Juvenile California Central Valley steelhead feed mostly on drifting aquatic organisms and terrestrial insects and will also take active bottom invertebrates (Moyle 2002).

Some steelhead may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Hallock et al. (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall. Nobriga and Cadrett (2001) also have verified these temporal findings based on analysis of captures at Chipps Island.

Historic California Central Valley steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially. Hallock et al. (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Nobriga and Cadrett (2001) compared CWT and untagged (wild) steelhead smolt catch ratios at Chipps Island trawl from 1998 through 2001 to estimate that about 100,000 to 300,000 steelhead juveniles are produced naturally each year in the Central Valley. In the Updated Status Review of West Coast Salmon and Steelhead (Good et al. 2005), the Biological Review Team (BRT) made the following conclusion based on the Chipps Island data:

> "If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1 percent of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s".

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in Big Chico and Butte creeks and a few wild steelhead are produced in the American and Feather rivers (McEwan and Jackson 1996). Snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (J. Newton, USFWS, pers. comm. 2002, as reported in Good et al. 2005). Because of the large resident O. mykiss population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, California Central Valley steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001). Zimmerman et al. (2008) has documented California Central Valley steelhead in the Stanislaus, Tuolumne and Merced rivers based on otolith microchemistry.

It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, throughout accessible streams and rivers in the Central Valley (Good et al. 2005). CDFG staff have prepared catch summaries for juvenile migrant California Central Valley steelhead on the San Joaquin River near Mossdale which represents migrants from the Stanislaus, Tuolumne, and Merced rivers. Based on trawl recoveries at Mossdale between 1988 and 2002, as well as rotary screw trap efforts in all three tributaries, CDFG staff stated that it is "clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River" (Marston 2004). The documented returns on the order of single fish in these tributaries suggest that existing populations of California Central Valley steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed.

Recent assessments of the status of California Central Valley steelhead have indicated that the population was in danger of extinction. Lindley et al. (2006) indicated that prior population census estimates completed in the 1990s found the California Central Valley steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good et al. (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). California Central Valley steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates. The future of California Central Valley steelhead is uncertain due to limited data concerning their status. However, Lindley et al. (2007), citing evidence presented by Yoshiyama et al. (1996); McEwan (2001); and Lindley et al. (2006), concluded that there is sufficient evidence to suggest that the DPS is at moderate to high risk of extinction.

The most recent status review of the California Central Valley steelhead DPS (NMFS 2011c) found that the status of the population appears to have worsened since the 2005 status review (Good et al. 2005), when it was considered to be in danger of extinction. Analysis of data from the Chipps Island monitoring program indicates that natural steelhead production has continued to decline and that hatchery origin fish represent an increasing fraction of the juvenile production in the Central Valley. Since 1998, all hatchery produced steelhead in the Central Valley have been adipose fin clipped (ad-clipped). Since that time, the trawl data indicates that the proportion of ad-clip steelhead juveniles captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. In recent years, the proportion of hatchery produced juvenile steelhead in the catch has exceeded 90 percent and in 2010 was 95 percent of the catch. Because hatchery releases have been fairly consistent through the years, this data suggests that the natural production of steelhead has been declining in the Central Valley.

Salvage of juvenile steelhead at the CVP and SWP fish collection facilities have also shown a shift towards reduced natural production. The annual salvage of juvenile steelhead at the two facilities in the south Delta has fluctuated since 1993. In the past decade, there has been a marked decline in the total number of salvaged juvenile steelhead, with the salvage of hatchery produced steelhead showing the larger decline at the facilities in absolute numbers of fish salvaged. However, the percentage of wild fish to hatchery produced fish has also declined during the past decade. Thus, while the total number of salvaged hatchery produced fish has declined, naturally produced steelhead have also declined at a consistently higher rate than hatchery produced fish, thereby consistently reducing the ratio of wild to hatchery produced steelhead in the salvage data.

In contrast to the data from Chipps Island and the CVP and SWP fish collection facilities, some populations of wild California Central Valley steelhead appear to be improving (Clear Creek) while others (Battle Creek) appear to be better able to tolerate the recent poor ocean conditions and dry hydrology in the Central Valley compared to hatchery produced fish (NMFS 2011c). Since 2003, fish returning to the Coleman National Fish Hatchery have been identified as wild (adipose fin intact) or hatchery produced (ad-clipped). Returns of wild fish to the hatchery have remained fairly steady at 200-300 fish per year, but represent a small fraction of the overall hatchery returns. Numbers of hatchery origin fish returning to the hatchery have fluctuated much more widely; ranging from 624 to 2,968 fish per year. The returns of wild fish remained steady, even during the recent poor ocean conditions and the 3-year drought in the Central Valley, while hatchery produced fish showed a decline in the numbers returning to the hatchery (NMFS 2011c). Furthermore, the continuing widespread distribution of wild steelhead throughout most of the watersheds in the Central Valley provides the spatial distribution necessary for the DPS to survive and avoid localized catastrophes. However, these populations are frequently very small, and lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change.

Viable Salmonid Population Summary for California Central Valley Steelhead

Abundance: All indications are that the naturally produced California Central Valley steelhead population has continued to decrease in abundance and in the proportion of naturally spawned fish to hatchery produced fish over the past 25 years (Good et al. 2005, NMFS 2011c); the long-term abundance trend remains negative. There has been little comprehensive steelhead population monitoring, despite 100 percent marking of hatchery steelhead since 1998. Efforts are underway to improve this deficiency, and a long-term adult escapement monitoring plan is being considered (NMFS 2011c). Hatchery production and returns are dominant over natural fish and include significant numbers of non-DPS-origin Eel River steelhead stock. Continued decline in the ratio between wild juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of ad-clipped fish to wild adipose fin bearing fish has steadily increased over the past several years.

Productivity: An estimated 100,000 to 300,000 natural juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005). Concurrently, 1,000,000 in-DPS hatchery steelhead smolts and another 500,000 out-of-DPS hatchery steelhead smolts are released annually in the Central Valley. The estimated ratio of non-clipped to clipped steelhead has decreased from 0.3 to less than 0.1, with a net decrease to one-third of wild female spawners from 1998 to 2000 (Good et al. 2005). Recent data from the Chipps Island fish monitoring trawls indicates that in recent years over 90 percent of captured steelhead smolts have been of hatchery origin. In 2010, the data indicated hatchery fish made up 95 percent of the catch (NMFS 2011c).

Spatial Structure: Steelhead appear to be well-distributed where found throughout the Central Valley (Good et al. 2005, NMFS 2011c). Until recently, there was very little documented evidence of steelhead due to the lack of monitoring efforts. Since 2000, steelhead have been confirmed in the Stanislaus, Tuolumne, Merced, and Calaveras rivers (Zimmerman et al. 2009, NMFS 2011c). The efforts to provide passage of salmonids over impassable dams may increase the spatial diversity of California Central Valley steelhead populations if the passage programs are implemented for steelhead.

Diversity: Analysis of natural and hatchery steelhead stocks in the Central Valley reveal genetic structure remaining in the DPS (Nielsen et al. 2003). There appears to be a great amount of gene flow among upper Sacramento River basin stocks, due to the post-dam, lower basin distribution of steelhead and management of stocks. Recent reductions in natural population sizes have created genetic bottlenecks in several California Central Valley steelhead stocks (Good et al. 2005; Nielsen et al. 2003). The out-of-basin steelhead stocks of the Nimbus and Mokelumne River hatcheries are currently not included in the California Central Valley steelhead DPS. However, recent work (Garza and Pearse 2008) has identified introgression of stray domestic rainbow trout genes with steelhead, which may be occurring either during egg taking practices in hatcheries or in-river spawning between domesticated strains of rainbow trout and steelhead. Garza and Pearse (2008) also found that all below dam steelhead populations in the Central Valley were genetically closely related and that these populations had a high level of genetic similarity to populations of steelhead in the Klamath and Eel river basins. This genetic data suggests that the progeny of out-of-basin steelhead reared in the

Nimbus and Mokelumne river hatcheries have become widely introgressed with natural steelhead populations throughout the anadromous sections of rivers and streams in the Central Valley, including the tail-water sections below impassable dams. This suggests the potential for the loss of local genetic diversity and population structure over time in these waters. Their work also indicates that in contrast to the similarity of the steelhead genetics below dams in the Central Valley, the ancestral genetic structure is still relatively intact above the impassable barriers. This would indicate that extra precautions should be included in restoration plans before above dam access is provided to the steelhead from the below dam populations in order to maintain genetic heritage and structure in the above dam steelhead populations.

Southern Distinct Population Segment of Green Sturgeon

The following account is adapted from the NMFS (2014) BO on the Georgiana Slough Floating Fish Guidance Structure Study.

In North America, spawning populations of green sturgeon are currently found in only three river systems: the Sacramento and Klamath rivers in California and the Rogue River in southern Oregon. Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (Erickson and Hightower 2007, Huff et al. 2011, Lindley et al., 2008, 2011). During the late summer and early fall, sub-adults and non-spawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific Coast (Emmett et al. 1991, Moser and Lindley 2007, Huff et al. 2011).

Particularly large concentrations of green sturgeon from both the northern and southern populations occur in the Columbia River estuary, Willapa Bay, Grays Harbor, and Winchester Bay, with smaller aggregations in Humboldt Bay, Tillamook Bay, Nehalem Bay, and San Francisco and San Pablo bays (Emmett et al 1991, Moyle et al. 1992, Beamesderfer et al. 2007, Lindley et al. 2008, 2011). Lindley et al. (2008, 2011) reported that green sturgeon make seasonal migratory movements along the west coast of North America, overwintering north of Vancouver Island, British Columbia, and south of Cape Spencer, Alaska. Individual fish from the Southern DPS of North American green sturgeon have been detected in these seasonal aggregations. Lindley (2006) presented preliminary results of large-scale green sturgeon migration studies, and verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. This work was further expanded by recent tagging studies of green sturgeon conducted by Erickson and Hightower (2007) and Lindley et al. (2008, 2011). To date, the data indicate that North American green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia River estuary. This information also agrees with the results of previous green sturgeon tagging studies (CDFG 2002), where CDFG tagged a total of 233 green sturgeon in the San Pablo Bay estuary between 1954 and 2001. A total of 17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of the Oregon and Washington coasts. Eight of the 12 recoveries were in the Columbia River estuary (CDFG 2002).

The Southern DPS of North American green sturgeon includes all green sturgeon populations south of the Eel River, with the only known spawning population being in the Sacramento River basin (fertilized green sturgeon eggs were recovered in the Feather River in 2011). Green sturgeon life history can be broken down into four main stages: eggs and larvae, juveniles, sub-adults, and sexually mature adults. Sexually mature adults are those fish that have fully developed gonads and are capable of spawning. Female green sturgeon are typically 13 to 27 years old when sexually mature and have a total body length (TL) ranging between 145 and 205 centimeters (cm) at sexual maturity (Nakamoto et al. 1995, Van Eenennaam et al. 2006). Male green sturgeon become sexually mature at a younger age and smaller size than females. Typically, male green sturgeon reach sexual maturity between 8 and 18 years of age and have a TL ranging between 120 cm to 185 cm (Nakamoto et al. 1995, Van Eenennaam et al. 2006). The variation in the size and age of fish upon reaching sexual maturity is a reflection of their growth and nutritional history, genetics, and the environmental conditions they were exposed to during their early growth years. Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid shrimp, grass shrimp, and amphipods (Radtke 1966). Adult sturgeon caught in Washington State waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle et al. 1992). It is unknown what forage species are consumed by adults in the Sacramento River upstream of the Delta.

Adult green sturgeon are gonochoristic (sex genetically fixed), oviparous, and iteroparous. They are believed to spawn every 2 to 5 years, with most spawning occurring at 3- to 4-year intervals (Beamesderfer et al. 2007, Brown 2007, Poytress et al., 2012). Upon maturation of their gonadal tissue, but prior to ovulation or spermiation, the sexually mature fish enter freshwater and migrate upriver to their spawning grounds. The remainder of the adult's life is generally spent in the ocean or near-shore environment (bays and estuaries) without venturing upriver into freshwater. Younger females may not spawn the first time they undergo oogenesis and subsequently they reabsorb their gametes without spawning. Adult female green sturgeon produce between 60,000 and 140,000 eggs, depending on body size, with a mean egg diameter of 4.3 mm (Moyle et al. 1992, Van Eenennaam et al. 2001). They have the largest egg size of any sturgeon, and the volume of yolk ensures an ample supply of energy for the developing embryo. The outside of the eggs are adhesive, and are more dense than those of white sturgeon (*Acipenser transmontanus*) (Kynard et al. 2005, Van Eenennaam et al. 2009).

Kelly et al. (2007) indicated that green sturgeon enter the San Francisco estuary during the spring and remain until autumn (Table 7). The authors studied the movement of adults in the San Francisco estuary and found them to make significant long-distance movements with distinct directionality. The movements were not found to be related to salinity, current, or temperature, and Kelly et al. (2007) surmised that they are related to resource availability and foraging behavior. Adults begin their upstream spawning migrations into freshwater in late February with spawning occurring between March and July (CDFG 2002, Heublein 2006, Heublein et al. 2009, Vogel 2008) with peaks in spawning activity influenced by factors including water flow and temperature (Heublein et al. 2009, Poytress et al. 2011). Peak spawning is believed to occur between April and June. Spawning primarily occurs in cool sections of the upper mainstem Sacramento River in deep pools containing clean gravel or cobble substrate (Poytress et al. 2011). Females broadcast spawn their eggs over this substrate, while the male releases its milt (sperm) into the water column. Fertilization occurs externally in the water column and the fertilized eggs sink into the interstices of the substrate where they develop further (Kynard et al. 2005, Heublein et al. 2009). Known historic and current spawning occurs in the Sacramento River (Adams et al. 2002, Beamesderfer et al. 2004, Adams et al. 2007). Currently, Keswick and Shasta dams on the mainstem of the Sacramento River block passage to the upper river. Based on egg surveys (Poytress et al. 2009; Poytress et al. 2010-2012) and telemetry studies (Heublein et al. 2009, Thomas et al. 2013), Southern DPS of North American green sturgeon are known to spawn in several locations in the mainstem Sacramento River below Keswick Dam, both upstream and downstream of the RBDD as was noted in Brown (2007). Behavioral observations in Thomas et al. (2013) suggest that males may fertilize the eggs of multiple females.

Table 7. The temporal occurrence of (a) adult, (b) larval (c) juvenile and (d) sub-adult coastal migrant Southern DPS of North American green sturgeon. Locations emphasize the Central Valley of California

(a) Adult-sexually mature (≥145 – 205 cm TL for females and ≥ 120 – 185 cm TL old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Sac. River[a,b,c,i]	Low	Low	Medium	Medium / High	High	High / Medium	Medium	Medium	Medium	Low	Low	Low
SF Bay Estuary[d,h,i]	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Low

(b) Larval and juvenile (≤10 months old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RBDD, Sac River[e]					Medium	High	High	Medium				
GCID, Sac River[e]					Medium	High	High	Medium	Low	Low		

(c) Older Juvenile (> 10 months old and ≤3 years old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
South Delta*[f]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Sac-SJ Delta[f]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Sac-SJ Delta[e]				Medium	Medium	Medium	Medium	Medium	Medium	Medium		
Suisun Bay[e]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

(d) Sub-Adult/non-sexually mature (approx. 75 cm to 145 cm for females and 75 to 120 cm for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pacific Coast[c,g]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

Relative Abundance: ■ = High ■ = Medium ■ = Low

Sources : [a]USFWS (2002); [b]Moyle et al. (1992); [c]Adams et al. (2002) and NMFS (2005); [d]Kelly et al. (2007); [e]CDFG (2002); [f]IEP Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [g]Nakamoto et al. (1995); [h]Heublein (2006); [i]CDFG Draft Sturgeon Report Card (2007)

Note:Darker shades indicate months of greatest relative abundance.

* Fish Facility salvage operations

Although no historical accounts exist for identified green sturgeon spawning occurring above the current dam sites, suitable spawning habitat existed and the geographic extent of spawning has been reduced due to the impassable barriers constructed on the river.

Spawning on the Feather River is suspected to have occurred in the past due to the continued presence of adult green sturgeon in the river below Oroville Dam. This continued presence of adults below the dam suggests that fish are trying to migrate to upstream spawning areas now blocked by the dam, which was constructed in 1968. In 2011, fertilized green sturgeon eggs were recovered during monitoring activities by DWR on the Feather River and several adult green sturgeon were recorded on video congregating below Daguerre Point Dam on the Yuba River. In January 2012, a natural barrier to upstream migration at Shanghai Bend was breached by river flows, thus allowing access to sections of the Feather River above Shanghai Bend over a wider range of flows.

Spawning in the San Joaquin River system has not been recorded historically or observed recently, but alterations of the San Joaquin River and its tributaries (Stanislaus, Tuolumne, and Merced rivers) occurred early in the European settlement of the region. During the latter half of the 1800s, impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for approximately a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. Additional impacts to the watershed include the increased loads of selenium entering the system through agricultural practices on the western side of the San Joaquin Valley. Green sturgeon have recently been identified by University of California, Davis researchers as being highly sensitive to selenium levels. Currently, only white sturgeon have been encountered in the San Joaquin River system upstream of the Delta, and adults have been captured by sport anglers as far upstream on the San Joaquin River as Hills Ferry and Mud Slough which are near the confluence of the Merced River with the main stem San Joaquin River (2007 sturgeon report card - CDFG 2008).

Post-spawn fish may hold for several months in the Sacramento River and out-migrate in the fall, or move into and out of the river quickly during the summer months, although the holding behavior is the behavior that is most commonly observed (Heublein et al. 2009). Acoustic tagging studies on the Rogue River (Erickson et al. 2002) have shown that adult green sturgeon will hold for as much as 6 months in deep (> 5 m), low gradient reaches or off channel sloughs or coves of the river during summer months when water temperatures were between 15°C and 23°C. When ambient temperatures in the river dropped in autumn and early winter (<10°C) and flows increased, fish moved downstream and into the ocean. Erickson et al. (2002) surmised that this holding in deep pools was to conserve energy and utilize abundant food resources. Benson et al. (2007) found similar behavior on the Klamath and Trinity river systems with adult sturgeon acoustically tagged during their spawning migrations. Most fish held over the summer in discrete locations characterized by deep, low velocity pools until late fall or early winter when river flows increased with the first storms of the rainy season. Fish then moved rapidly downstream and out of the system. Recent data gathered from acoustically tagged adult green sturgeon revealed comparable behavior by adult fish on the Sacramento River based on the positioning of adult green sturgeon in holding pools on the Sacramento River above the Glenn Colusa Irrigation District (GCID) diversion (RM 205). Studies by Heublein (2006, 2009) and Vogel (2008) have documented the presence of adults in the Sacramento River during the spring and through the fall into the early winter months. These fish hold in upstream locations prior to their emigration from the system later in the year. Like the Rogue and Klamath river systems, downstream migration appears to be triggered by increased flows, decreasing water temperatures, and occurs rapidly once initiated. It should also be noted that some adults rapidly leave the system following their suspected spawning activity and enter the ocean only in early summer (Heublein 2006). This behavior has also been observed on the other spawning rivers (Benson et al. 2007) but may have been an artifact of the stress of the tagging procedure in that study.

Previously, spawning appeared to occur primarily above RBDD, based on the recovery of eggs and larvae at the dam in monitoring studies (Gaines and Martin 2002, Brown 2007) but more recent data indicates that several areas downstream of the site of the RBDD may be used as spawning areas for green sturgeon based on the recovery of eggs below deep holes in the Sacramento River (Poytress et al. 2011 – 2013). Green sturgeon larvae hatch from fertilized eggs after approximately 169 hours at a water temperature of 59°F (Van Eenennaam et al. 2001, Deng et al. 2002), which is similar to the sympatric white sturgeon development rate (176 hours). Studies conducted at the University of California, Davis by Van Eenennaam et al. (2005) indicated that an optimum range of water temperature for egg development ranged between 57.2°F and 62.6°F. Temperatures over 23°C (73.4°F) resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 63.5°F and 71.6°F resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 57.2°F, hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so.

Newly hatched green sturgeon are approximately 12.5 mm to 14.5 mm in length and have a large ovoid yolk sac that supplies nutritional energy until exogenous feeding occurs. These yolk sac larvae are less developed in their morphology than older juveniles and external morphology resembles a "tadpole" with a continuous fin fold on both the dorsal and ventral sides of the caudal trunk. The eyes are well developed with differentiated lenses and pigmentation.

Olfactory and auditory vesicles are present while the mouth and respiratory structures are only shallow clefts on the head. At 10 days of age, the yolk sac has become greatly reduced in size and the larvae initiates exogenous feeding through a functional mouth. The fin folds have become more developed and formation of fin rays begins to occur in all fin tissues. By 45 days of age, the green sturgeon larvae have completed their metamorphosis, which is characterized by the development of dorsal, lateral, and ventral scutes, elongation of the barbels, rostrum, and caudal peduncle, reabsorption of the caudal and ventral fin folds, and the development of fin rays. The juvenile fish resembles the adult form, including the dark olive coloring, with a dark mid-ventral stripe (Deng et al. 2002) and are approximately 75 mm TL. At this stage of development, the fish are considered juveniles and are no longer larvae.

Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other Acipenseridae. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. After 6 days, the larvae exhibit nocturnal swim-up activity (Deng et al. 2002) and nocturnal downstream migrational movements (Kynard et al. 2005). Juvenile fish continue to exhibit nocturnal behavior beyond the metamorphosis from larvae to juvenile stages. Kynard et al.'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 46.4°F, downstream migrational behavior diminished and holding behavior increased. These data suggest that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds.

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetics performance i.e. growth, food conversion, swimming ability) between 59°F and 66.2°F under either full or reduced rations (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed. Ambient water temperature conditions in the Rogue and Klamath river systems range from 39°F to approximately 75.2°F. The Sacramento River has similar temperature profiles, and, like the previous two rivers, is a regulated system with several dams controlling flows on its main stem (Shasta and Keswick dams), and its tributaries (Whiskeytown, Oroville, Folsom, and Nimbus dams).

Larval and juvenile green sturgeon are subject to predation by both native and introduced fish species. Prickly sculpin (*Cottus asper*) have been shown to be an effective predator on the larvae of sympatric white sturgeon (Gadomski and Parsley 2005). This study also indicated that the lowered turbidity found in tailwater streams and rivers due to dams increased the effectiveness of sculpin predation on sturgeon larvae under laboratory conditions.

Larval and juvenile sturgeons have been caught in traps at two sites in the upper Sacramento River: below the RBDD (RM 243) and from the GCID pumping plant (RM 205) (CDFG 2002). Larvae captured at the RBDD site are typically only a few days to a few weeks old, with lengths ranging from 24 mm to 31 mm. This body length is equivalent to 15 to 28 days post hatch as determined by Deng et al. (2002). Recoveries of larvae at the RBDD rotary screw traps (RSTs) occur between late April/early May and late August with the peak of recoveries occurring in June (1995-1999 and 2003-2008 data). The mean yearly total length of post-larval green sturgeon captured in the GCID RSTs, approximately 30 miles downstream of RBDD, ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG 2002) indicating they are approximately 3 to 4 weeks old (Van Eenennaam et al. 2001, Deng et al. 2002). Taken together, the average length of larvae captured at the two monitoring sites indicate that fish were hatched upriver of the monitoring site and drifted downstream over the course of 2 to 4 weeks of growth. According to the CDFG document commenting on the NMFS proposal to list the Southern DPS (CDFG 2002), some green sturgeon rear to larger sizes above RBDD, or move back to this location after spending time downstream. Two sturgeon between 180 mm and 400 mm TL were captured in the RST during 1999 and green sturgeon within this size range have been impinged on diffuser screens associated with a fish ladder at RBDD (K. Brown, USFWS, pers. comm., as cited in CDFG 2002).

Juvenile green sturgeon have been salvaged at the Skinner Fish Facility (FCF) and Tracy FCF (together, the Fish Facilities) in the south Delta, and captured in trawling studies by CDFG during all months of the year (CDFG 2002). The majority of these fish were between 200 mm and 500 mm, indicating they were from 2 to 3 years of age based on Klamath River age distribution work by Nakamoto et al. (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicates that juveniles of the Southern DPS of North American green sturgeon likely hold in the main stem Sacramento River, as suggested by Kynard et al. (2005).

Population abundance information concerning the Southern DPS of North American green sturgeon is described in the NMFS status reviews (Adams et al. 2002, NMFS 2005). The California Department of Fish and Wildlife (CDFW) [formerly California Department of Fish and Game (CDFG)] conducts annual field sampling for sturgeon in San Pablo and Suisun bays in the months of August through September. Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFW sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures, CDFW provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Reports from 2005-2012 describe encounters with relatively small numbers of sub-adult and (to a lesser extent) adult fish (2005: 14; 2006: 28; 2007: 17; 2008: 14; 2009: 103; 2010: 37; 2011: 16; 2012: 17; annual reports are available at http://www.dfg.ca.gov/delta/data/sturgeon/bibliography.asp). The high capture rate in 2009 occurred because of an encounter with a large aggregation of green sturgeon, particularly in San Pablo Bay, during the CDFW white sturgeon surveys (pers. comm. with Marty Gingras [CDFW] and Phaedra Doukakis [NMFS], May 10, 2013). Since the study is primarily designed to study white sturgeon, the results cannot be interpreted for estimates of or trends in Southern DPS abundance.

The only existing information regarding long-term changes in the abundance of the Southern DPS of North American green sturgeon includes changes in abundance at the at the SWP and CVP fish collection facilities between 1968 and 2012. The average number of North American green sturgeon taken per year at the Skinner FCF prior to 1986 was 732; from 1986 on, the average per year was 47 (70 Federal Register [FR] 17386, April 6, 2005). For the Tracy FCF, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386, April 6, 2005). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of North American green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386, April 6, 2005). No green sturgeon were recovered at either the CVP or SWP in 2010. In 2011, a total of 14 green sturgeon were salvaged, 12 at the CVP and 2 at the SWP facilities. In 2012 and 2013, no green sturgeon were salvaged at the Fish Facilities. Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the percentage of the catch belonging to the Southern DPS of North American green sturgeon is unknown as these captures were primarily located in San Pablo Bay which is known to consist of a mixture of Northern and Southern DPS of North American green sturgeon.

Since 2006, modeling, genetic, and field-based studies have been conducted to describe the population characteristics of the Southern DPS of North American green sturgeon. Young-of-year abundance data have been collected incidentally during juvenile salmonid monitoring efforts at the RBDD and near the GCID pumping facility, both located on the upper Sacramento River. Using RSTs set downstream of RBDD, USFWS captured approximately 7,500 larval green sturgeon from 1994 to 2011. In 2011, a wet year, approximately 3,700 larvae were collected in in the monitoring efforts (Poytress et al. 2012). Over 2,000 larvae were also collected in fyke nets and RSTs at GCID between 1986 and 2003. No apparent trend in larval abundance at either site have emerged across years, though annual distributions have been found to peak during June at RBDD and July at GCID (Adams et al. 2002).

Recent spawning population estimates using sibling based genetics by Israel (2006b) indicates spawning populations of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71). More recently, Israel and May (2010) used genetic analyses to estimate the number of spawning individuals in the upper Sacramento River (above RBDD). Their kinship analysis of larvae collected at RBDD suggests an estimated 10-28 individual Southern DPS of North American green sturgeon effectively reproduce above RBDD in the upper Sacramento River annually (Israel and May 2010). This effective spawning population estimate was stable over the five year sampling period (2002-2006). It is important to note that this does not include animals spawning downstream of RBDD, and thus does not represent a complete estimate of the effective adult spawning population. The study was also conducted during the time when the gates at RBDD would be lowered for several months of the year from late spring through summer, thus prohibiting green sturgeon from ascending upstream to spawn above the location of the RBDD. Since 2012, the gates at RBDD have been in the up position year round.

DIDSON surveys of aggregating sites in the upper Sacramento River are providing the first data for abundance estimation of the adult portion of the Southern DPS population based on actual observations of fish in the river. Preliminary results from 2010 and 2011 surveys indicate abundance of (presumably) adult Southern DPS of North American green sturgeon in the Sacramento River as follows: 06/07/2010: 164 ± 47; 07/06/2010: 245 ± 64; 06/16/2011 220 ± 42 (Ethan Mora, University of California, Davis, unpublished data). These abundance estimates are smaller than observed numbers in rivers where Northern DPS green sturgeon occur (Klamath 2010: 349 ± 52; 2011: 471 ± 42; Rogue 2010: 327 ± 50; 2011: 454 ± 46 (Ethan Mora, University of California, Davis, unpublished data). Furthermore, estimates for the Klamath and Rogue rivers are about twice those in the Sacramento River.

The number of holes occupied in the Sacramento River for the two summer 2010 dates plus the one summer 2011 date was small (13) when compared to the number of total holes surveyed (125). Holes with sturgeon were, however, distributed across most of the study area, with green sturgeon found in holes spanning 75 miles of the river. There was also a difference in the holes occupied by sturgeon during any given sampling time: some holes were occupied on all three sampling dates, some on only two sampling dates, and some on just one date. Thus, there is temporal and spatial variation in the holes occupied by Southern DPS of North American green sturgeon within the Sacramento River.

Caution is needed in interpreting these survey data as representative of the total spawning population size of Southern DPS of North American green sturgeon. First, this estimate does not include green sturgeon spawning in the Feather River. Also, although most sturgeon encountered are likely green sturgeon, this must be verified by video surveys, which is in progress. Movement in and out of the study area could also confound the results. Still, the estimates provide a working number for modeling total population size as detailed below.

To generate a rough population estimate, the assumption can be made that the observations of 164 to 245 sturgeon in the main stem Sacramento River during the spawning seasons of 2010 and 2011 were observations of Southern DPS of North American green sturgeon adults and are representative of the total spawning run size for those survey years. The uncertainty associated with using these estimates, particularly given the caveats stated above, should be noted. Further assumptions include a spawning periodicity of 2 to 4 years and the age distribution expected at equilibrium generated by Beamesderfer et al. (2007) (25 percent juveniles, 63 percent sub-adults, 12 percent adults). This would amount to an estimate of a total of 328 to 980 adults and 1,722 to 5,145 sub-adults in the population. The estimated total population of juveniles, sub-adults, and adults combined ranges from 2,733 to 8,166 individuals.

In summary, recent information regarding the spawning population of adult green sturgeon in the Sacramento River suggests that they are spatially constrained during spawning and the post-spawning holding period in the summer months. This is concerning, given that a catastrophic event impacting just a few holes could affect a significant portion of the adult population. The information does not, however, indicate that the population status of Southern DPS of North American green sturgeon has changed since the last review, since no comparable data on spatial occupancy were available in 2006. Continued monitoring of the adult population in the Sacramento River will provide valuable trend data and information to enhance spatial protection. Of note is the fact that all of the holes where green sturgeon were found in the DIDSON survey area (Highway 32 overcrossing to the City of Redding) are currently included in the range where new CDFW restrictions prohibit fishing for sturgeon. Enforcement of these regulations is thus of great importance.

Available information on green sturgeon indicates that, as with winter-run Chinook salmon, the main stem Sacramento River may be the last viable spawning habitat (Good et al. 2005) for the Southern DPS of North American green sturgeon. The observation of fertilized green sturgeon eggs in the Feather River in 2011 is a significant event, as it indicates that at least in high flow years, the Feather River may support an additional spawning region for green sturgeon. Additional observations of spawning activity or evidence of fertilized eggs in the Feather River in subsequent years are needed to confirm this river as an additional spawning area for the Southern DPS of North American green sturgeon. Lindley et al. (2007) pointed out that an ESU represented by a single population at moderate risk is at a high risk of extinction over the long-term. Although the extinction risk of the Southern DPS of North American green sturgeon has not been assessed, NMFS believes that the extinction risk has increased because there is only one known population, and that population consistently spawns within the main stem Sacramento River.

Population Viability Summary for the Southern DPS of North American Green Sturgeon

The Southern DPS of North American green sturgeon has not been analyzed to characterize their status and viability as has been done in recent efforts for Central Valley salmonid populations (Good et al. 2005; Lindley et al. 2006; Lindley et al. 2007; NMFS 2011a, b, c) however, this review is in preparation. NMFS assumes that the general categories for assessing salmonid population viability will also be useful in assessing the viability of the Southern DPS of North American green sturgeon. The following summary has been compiled from the best available data and information on North American green sturgeon to provide a general synopsis of the viability parameters for this DPS.

Abundance: Currently, there are no reliable data on population sizes, and data on population trends are also lacking. Fishery data collected at the Skinner FCF and Tracy FCF in the south Delta indicate a decreasing trend in abundance between 1968 and 2006 (70 FR 17386). Captures of larval green sturgeon in the RBDD RSTs have shown variable trends in spawning success in the upper river over the past several years and have been complicated by the operations of the RBDD gates during the green sturgeon spawning season in previous years. In 2011, a wet year in the Sacramento River, captures in the RST have been substantially higher than in previous years (3,701 fish). The last strong year-class, based on captures of larval sturgeon was in 1995. This would suggest that the 2011 year-class for green sturgeon would be a strong year-class. However, only 14 green sturgeon juveniles were salvaged in 2011, and none in 2012 and 2013, which suggests that this large population may not have successfully emigrated downstream to the Delta to rear. Recent captures of juvenile green sturgeon in the RBDD RST were 289 fish in 2012 and 443 fish in 2013. Estimates of spawning adult population size range from 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71) (Israel 2006b). More recently, Israel and May, (2010) estimated that 10-28 individual Southern DPS of North American green sturgeon effectively reproduce above RBDD in the upper Sacramento River annually. DIDSON camera observations in 2010 and 2011 identified aggregations of (presumably) green sturgeon adults in the Sacramento River ranging between 164 and 245 individuals per observation cycle (Ethan Mora, University of California, Davis, unpublished data). Assuming that all of these observed sturgeons are truly green sturgeon adults, and adults spawn every 2 to 4 years, and using the population structure from Beamesderfer et al. (2007), the calculated estimate would be 328 to 980 adults and 1,722 to 5,145 sub-adults in the population. The estimated total population of juveniles, sub-adults, and adults combined ranges from 2,733 to 8,166 individuals.

Productivity: There is insufficient information to evaluate the productivity of green sturgeon. However, as indicated above, there appears to be a declining trend in abundance, which indicates low to negative productivity.

Spatial Structure: Current data indicate that the Southern DPS of North American green sturgeon is comprised of a single spawning population in the Sacramento River. Although some individuals have been observed in the Feather and Yuba rivers, it is not yet known if these fish represent separate spawning populations or are strays from the main stem Sacramento River. Therefore, the apparent presence of a single reproducing population puts the DPS at risk, due to the limited spatial structure. As mentioned previously, the confirmed presence of fertilized green sturgeon eggs in the Feather River suggests that spawning can occur in the river, at least during wet years with sustained high flows. Likewise, observations of several adult green sturgeon congregating below Daguerre Point Dam on the Yuba River suggest another potential spawning area. Consistent use of these two different river areas by green sturgeon exhibiting spawning behavior or by the collection of fertilized eggs and/or larval green sturgeon would indicate that a second spawning population of green sturgeon may exist in the Sacramento River basin besides that which has been identified in the upper reaches of the Sacramento River below Keswick Dam.

In general, sub-adult (from the age of ocean entry to age of first spawning) and adult North American green sturgeon spend most of their lives in oceanic environments where they occupy nearshore coastal waters from the Bering Sea, Alaska (Colway and Stevenson 2007) to Baja California, Mexico (Rosales-Casian and Almeda-Juaregui 2009). Telemetry data and genetic analyses suggests that Southern DPS of North American green sturgeon generally occur from Graves Harbor, Alaska to Monterey Bay, California (Moser and Lindley 2007; Lindley et al. 2008, 2011) and within this range, most frequently occur in coastal waters of Washington, Oregon, and Vancouver Island and near San Francisco and Monterey bays (Huff et al. 2011). Within the nearshore marine environment, tagging data indicate that northern and southern DPSs of North American green sturgeon prefer marine waters of less than a depth of 110 m (Erickson and Hightower 2007). Modeling based on acoustic and satellite tag data indicate that Northern and Southern DPS of North American green sturgeon spend more time in areas with high seafloor complexity, including areas with boulders, and depths between 20 and 60 m and water temperatures from 9.5-16.0 °C (Huff et al. 2011). This habitat-use pattern may correspond with prey availability or refuge from predators.

Adult and sub-adult Southern DPS of North American green sturgeon are observed in large concentrations in the summer and autumn within coastal bays and estuaries along the west coast of the United States, including the Columbia River estuary, Willapa Bay, and Grays Harbor (Moser and Lindley 2007; Lindley et al. 2008, 2011). The Umpqua River estuary seems to be a preferred habitat for the Northern DPS (Lindley et al. 2011). These areas, particularly Willapa Bay, are likely used for foraging and possibly as thermal refugia (Moser and Lindley 2007). Both the northern and southern DPSs of North American green sturgeon co-occur on the continental shelf of western North America, and mixtures of these population also co-occur in the estuaries and bays along the West Coast of the United States. However, the two DPSs do not appear to comingle in their respective natal watersheds above tidal influence. Lindley et al. (2011) further confirms this green sturgeon DPS structure given that green sturgeon tagged in the Klamath or Rogue rivers were not detected at the Golden Gate Bridge area and green sturgeon tagged in San Pablo Bay/Sacramento River area were not detected in the Rogue or Klamath rivers. Green sturgeon tagged in the Klamath River were detected in the Rogue River, consistent with the idea that green sturgeon originating from these two rivers belong to one DPS (Northern). Movement between the two rivers was infrequent, however, suggesting that the Klamath and Rogue rivers should be managed separately. Northern DPS green sturgeon showed a high affinity for the Umpqua River estuary, which was used for summer and autumn holding. New acoustic tagging studies in the Umpqua River estuary found that only a small number of tagged fish (3 of 20) were subsequently detected in the Sacramento River. The patterns of detection in San Francisco Bay were consistent with this habitat being used by Southern DPS sub-adults and adults as a migration corridor. Other telemetry data suggests that sub-adults and non-spawning adults utilize the San Francisco Bay area in the summer for other reasons, possibly to feed, because residency periods are fairly long, averaging 49 days.

To date there have been no detections of acoustically-tagged Southern DPS of North American green sturgeon upstream of tidal influence in rivers north of, and including, the Eel River in northern California. All green sturgeon observed upstream of the head of the tide in freshwater rivers south of the Eel River are assumed to be Southern DPS fish. All green sturgeon observed upstream of the head of the tide in freshwater rivers north of and including the Eel River are assumed to be northern DPS fish, and those areas are not considered critical habitat for Southern DPS of North American green sturgeon. This is consistent with the original DPS structure for green sturgeon described in Adams et al. (2002).

In summary, the Southern DPS of North American green sturgeon is represented by one spawning population utilizing the Sacramento River main stem, and perhaps opportunistic use of some of the major tributaries to the Sacramento River (Feather River and Yuba River). The adults and sub-adults of the Southern DPS utilize the continental shelf along the Pacific Coast out to a depth of approximately 110 m from Alaska to northern Baja California, as well as numerous bays and estuaries along the coastline for migration, holding, and rearing. In these waters the Southern DPS co-occurs with the northern DPS of North American green sturgeon. There does not appear to be any straying between the two populations based on genetics and tagged fish movements.

Diversity: Green sturgeon genetic analyses shows strong differentiation between northern and southern populations, and therefore, the species was divided into northern and southern DPSs. However, the genetic diversity of the Southern DPS is not well understood.

Delta Smelt

A summary of the frequency of occurrence of delta smelt life stages from available survey data was provided by Merz et al. (2011; Table 8). The following account of the basic species life history is adapted from the USFWS (2014b) BO on the 2014 Georgiana Slough Floating Fish Guidance Structure Study.

Adult delta smelt spawn during the late winter and spring months, with most spawning occurring during April through mid-May (Moyle 2002). Spawning occurs primarily in sloughs and shallow edge areas in the Delta. Delta smelt spawning has also been recorded in Suisun Marsh and the Napa River (Moyle 2002). Most spawning occurs at temperatures between 12-18°C. Although spawning may occur at temperatures up to 22°C, hatching success of the larvae is very low (Bennett 2005).

Fecundity of females ranges from about 1,200 to 2,600 eggs, and is correlated with female size (Moyle 2002). Moyle et al. (1992) considered delta smelt fecundity to be "relatively low." However, based on Winemiller and Rose (1992), delta smelt fecundity is fairly high for a fish its size. In captivity, females survive after spawning and develop a second clutch of eggs (Mager et al. 2004); field collections of ovaries containing eggs of different size and stage indicate that this also occurs in the wild (Adib-Samii, pers comm. 2008). Captive delta smelt can spawn up to 4-5 times. While most adults do not survive to spawn a second season, a few (<5 percent) do (Moyle 2002; Bennett 2005). Those that do survive are typically larger (90-110 mm Standard Length [SL]) females that may contribute disproportionately to the population's egg supply (Moyle 2002 and references therein). Two-year-old females may have 3-6 times as many ova as first year spawners.

Most of what is known about delta smelt spawning habitat in the wild is inferred from the location of spent females and young larvae captured in the California Department of Fish and Wildlife Spring Kodiak Trawl (SKT) and 20-mm Survey, respectively. In the laboratory, delta smelt spawned at night (Baskerville-Bridges et al. 2000; Mager et al. 2004). Other smelts, including marine beach spawning species and estuarine populations and the landlocked Lake Washington longfin smelt, are secretive spawners, entering spawning areas during the night and leaving before dawn. If this behavior is exhibited by delta smelt, then delta smelt distribution based on the SKT, which is conducted during daylight hours in offshore habitats, may reflect general regions of spawning activity, but not actual spawning sites.

Table 8. Average Annual Frequency (Percent) of Delta Smelt Occurrence by Life Stage, Interagency Ecological Program Monitoring Program, and Region

	Average Annual Frequency (%)										
Region Life Stage:	Larvae (<15 mm)	Sub-Juvenile (≥15, <30 mm)		Juvenile (30–55 mm)			Sub-Adult (>55 mm)	Mature Adults (>55 mm)		Pre-Spawning[a]	Spawning[a]
Monitoring Program:	20-mm	20-mm	STN	20-mm	STN	FMWT	FMWT	BS	BMWT	KT	KT
Years of Data Used:	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2006	2002–2009	2002–2009
Time Period:	Apr–Jun	Apr–Jul	Jun–Aug	May–Jul	Jun–Aug	Sep–Dec	Sep–Dec	Dec–May	Jan–May	Jan–Apr	Jan–May
San Francisco Bay	NS	NS	NS	NS	NS	NS	NS	0.0	0.0	NS	NS
West San Pablo Bay	NS	NS	NS	NS	NS	0.2	0.0	0.0	1.2	NS	NS
East San Pablo Bay	0.0	1.0	0.0	2.8	3.6	0.7	0.6	NS	2.7	NS	NS
Lower Napa River	7.3	7.7	3.3	13.3	14.0	1.7	0.8	NS	NS	14.3	11.8
Upper Napa River	11.6	21.2	NS	12.0	NS	NS	NS	NS	NS	NS	NS
Carquinez Strait	5.7	9.3	1.1	24.4	33.7	1.9	3.3	NS	5.4	16.7	0.0
Suisun Bay (SW)	17.8	18.3	1.3	17.5	26.9	4.3	4.3	NS	4.3	23.3	5.6
Suisun Bay (NW)	2.2	8.9	1.1	21.7	34.8	7.3	10.0	NS	8.7	23.3	5.6
Suisun Bay (SE)	19.5	24.9	11.0	20.9	45.7	11.0	12.1	NS	6.5	28.3	6.9
Suisun Bay (NE)	17.8	19.2	33.6	29.7	66.7	20.3	29.3	NS	28.3	48.3	13.9
Grizzly Bay	16.3	27.6	17.9	42.9	72.8	15.0	19.6	NS	30.4	30.0	5.6
Suisun Marsh	21.4	33.6	14.2	18.5	19.2	22.8	27.2	NS	NS	62.0	23.1
Confluence	35.7	41.6	25.7	29.2	36.1	20.2	24.5	1.8	17.4	30.0	10.4
Lower Sacramento River	16.5	37.0	43.3	26.2	55.5	22.9	37.1	NS	18.8	54.4	17.8
Upper Sacramento River	10.8	8.2	1.3	0.0	0.0	2.7	8.0	5.8	16.7	21.7	15.3
Cache Slough and Ship Channel	17.2	47.3	NS	54.3	NS	9.8	26.7	NS	NS	33.9	21.1
Lower San Joaquin River	28.0	24.5	4.1	5.1	5.6	2.6	3.5	0.9	12.6	30.6	9.7

Region Life Stage:	Larvae (<15 mm)	Sub-Juvenile (≥15, <30 mm)		Juvenile (30–55 mm)			Sub-Adult (>55 mm)	Mature Adults (>55 mm)		Pre-Spawning[a]	Spawning[a]
	Average Annual Frequency (%)										
Monitoring Program:	20-mm	20-mm	STN	20-mm	STN	FMWT	FMWT	BS	BMWT	KT	KT
Years of Data Used:	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2006	2002–2009	2002–2009
Time Period:	Apr–Jun	Apr–Jul	Jun–Aug	May–Jul	Jun–Aug	Sep–Dec	Sep–Dec	Dec–May	Jan–May	Jan–Apr	Jan–May
East Delta	14.6	8.8	0.0	1.2	0.0	0.0	0.0	1.6	NS	5.7	2.3
South Delta	18.4	10.8	0.0	1.4	0.3	0.0	0.0	0.3	NS	7.1	1.1
Upper San Joaquin River	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS
Sacramento Valley	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS

Source: Merz et al. 2011

a Gonadal stages of male and female delta smelt found in Spring Kodiak Trawl database were classified by California Department of Fish and Wildlife following Mager (1996). Descriptions of these reproduction stages are available at: <http://www.dfg.ca.gov/delta/data/skt/eggstages.asp>.

Mature adults, pre-spawning: Reproductive stages[a]: females 1–3; males 1–4.

Mature adults: spawning: Reproductive stages[a]: females 4; males 5.

20-mm = 20-millimeter Townet
BMWT = Bay Midwater Trawl.
BS = Beach Seine.
FMWT = Fall Midwater Trawl.
KT = Kodiak Trawl.
NS = indicates no survey conducted in the given life stage and region.
SKT = Spring Kodiak Trawl.
STM = Summer Tow-Net.

Delta smelt spawning has only been directly observed in the laboratory and eggs have not been found in the wild. Consequently, what is known about the mechanics of delta smelt spawning is derived from laboratory observations and observations of related smelt species. Delta smelt eggs are I mm diameter and are adhesive and negatively buoyant (Moyle 1976, 2002; Mager et al. 2004; Wang 1986, 2007). Laboratory observations indicate that delta smelt are broadcast spawners, discharging eggs and milt close to the bottom over substrates of sand and/or pebble in current (DWR and Reclamation 1994; Brown and Kimmerer 2002; Lindberg et al. 2003; Wang 2007). Spawning over gravel or sand can also aid in the oxygenation of delta smelt eggs. Eggs that may have been laid in silt or muddy substrates might get buried or smothered, preventing their oxygenation from water flow (Lindberg pers. comm. 2011). The eggs of surf smelts and other beach spawning smelts adhere to sand particles, which keeps them negatively buoyant but not immobile, as the sand may move ("tumble") with water currents and turbulence (Hay 2007). It is not known whether delta smelt eggs "tumble incubate" in the wild, but tumbling of eggs may moderately disperse them, which might reduce predation risk within a localized area.

The locations in the Delta where newly hatched larvae are present, most likely indicates spawning occurrence. The 20-mm trawl has captured small (5 mm SL) larvae in Cache Slough, the lower Sacramento River, San Joaquin River, and at the confluence of these two rivers (e.g., 20-mm trawl Survey 1 in 2005). Larger larvae and juveniles (size> 23 mm SL), which are more efficiently sampled by the 20-mm trawl gear, have been captured in Cache Slough and the Sacramento Deep Water Channel in July (e.g., 20-mm trawl Survey 9 in 2008). Because they are small fish inhabiting pelagic habitats with strong tidal and river currents, delta smelt larval distribution depends on both the spawning area from which they originate and the effect of transport processes caused by flows. Larval distribution is further affected by water salinity and temperature. Hydrodynamic simulations reveal that tidal action and other factors may cause substantial mixing of water with variable salinity and temperature among regions of the Delta (Monson et al. 2007). This could result in rapid dispersion of larvae away from spawning sites.

The timing of spawning may affect delta smelt population dynamics. Lindberg (2011) has suggested that smelt larvae that hatch early, around late February, have an advantage over larvae hatched during late spawning in May. Early season larvae have a longer growing season and may be able to grow larger faster during more favorable habitat conditions in the late winter and early spring. An early growing season may result in higher survivorship and a stronger spawning capability for that generation. Larvae hatched later in the season have a shorter growing season which effectively reduces survivorship and spawning success for the following spawning season.

Sampling of larval delta smelt in the Bay-Delta in 1989 and 1990 suggested that spawning occurred in the Sacramento River; in Georgiana, Prospect, Beaver, Hog, and Sycamore sloughs; in the San Joaquin River adjacent to Bradford Island and Fisherman's Cut; and possibly other areas (Wang 1991). However, in recent years, the densest concentrations of both spawners and larvae have been recorded in the Cache Slough/Sacramento Deepwater Ship Channel complex in the north Delta. Some delta smelt spawning occurs in Napa River, Suisun Bay and Suisun Marsh during wetter years (Sweetnam 1999; Wang 1991; Hobbs et al. 2007). Early stage larval delta smelt have also been recorded in Montezuma Slough near Suisun Bay (Wang 1986).

Mager et al. (2004) reported that embryonic development to hatching takes 11-13 days at 14-16°C for delta smelt, and Baskerville-Bridges et al. (2000) reported hatching of delta smelt eggs after 8-10 days at temperatures between 15-l7°C. Lindberg et al. (2003) reported high hatching rates of delta smelt eggs in the laboratory at 15°C, and Wang (2007) reported high hatching rates at temperatures between 14-17°C. Hatching success peaks near 15°C (Bennett 2005) and swim bladder inflation occurring at 60-70 days post-hatch at 16-17°C (Mager et al. 2004). At hatching and during the succeeding three days, larvae are buoyant, swim actively near the water surface, and do not react to bright direct light (Mager et al. 2004). As development continues, newly hatched delta smelt become semi-buoyant and sink in stagnant water. However, larvae are unlikely to encounter stagnant water in the wild.

Growth rates of wild-caught delta smelt larvae are faster than laboratory-cultured individuals. Mager et al. (2004) reported growth rates of captive-raised delta smelt reared at near-optimum temperatures (16°C-17°C). Their fish were about 12 mm long after 40 days and about 20 mm long after 70 days. In contrast, analyses of otoliths indicated that wild delta smelt larvae were 15-25 mm, or nearly twice as long at 40 days of age (Bennett 200S). By 70 days, most wild fish were 30-40 mm long and beyond the larval stage. This suggests there is strong selective pressure for rapid larval growth in nature, a situation that is typical for fish in general (Houde 1987). The food available to larval fishes is constrained by mouth gape and status of fin development. Larval delta smelt cannot capture as many kinds of prey as larger individuals, but all life stages have small gapes that limit their range of potential prey. Prey availability is also constrained by habitat use, which affects what types of prey are encountered. Larval delta smelt are visual feeders. They find and select individual prey organisms and their ability to see prey in the water is enhanced by turbidity (Baskerville-Bridges et al. 2004). Thus, delta smelt diets are largely comprised of small crustacean that inhabit the estuary's turbid, low-salinity, open-water habitats (i.e., zooplankton). Larval delta smelt have particularly restricted diets (Nobriga 2002). They do not feed on the full array of zooplankton with which they co-occur; they mainly consume three copepods: *Eurytemora affinis*, *Pseudodiaptomus forbesi*, and freshwater species of the family Cyclopidae. Further, the diets of first-feeding delta smelt larvae are largely restricted to the larval stages of these copepods; older, larger life stages of the copepods are increasingly targeted as the delta smelt larvae grow, their gape increases, and they become stronger swimmers.

In the laboratory, a turbid environment (>25 Nephelometric Turbidity Units [NTU]) was necessary to elicit a first feeding response (Baskerville-Bridges et al. 2000; Baskerville-Bridges 2004). Successful feeding seems to depend on a high density of food organisms and turbidity, and increases with stronger light conditions (Baskerville-Bridges et al. 2000; Mager et al. 2004; Baskerville-Bridges et al. 2004). Laboratory-cultured delta smelt larvae have generally been fed rotifers at first-feeding (Baskerville-Bridges et al. 2004; Mager et al. 2004). However, rotifers rarely occur in the guts of wild delta smelt larvae (Nobriga 2002). The most common first prey of wild delta smelt larvae is the larval stages of several copepod species. These copepod 'nauplii' are larger and have more calories than rotifers. This difference in diet may enable the faster growth rates observed in wild-caught larvae.

The triggers for and duration of delta smelt larval movement from spawning areas to rearing areas is not known. Hay (2007) noted that eulachon (*Thaleichthys pacificus*) larvae are probably flushed into estuaries from upstream spawning areas within the first day after hatching, but downstream movement of delta smelt larvae occurs much later. Most larvae gradually move downstream toward the two parts per thousand (ppt) isohaline (X2). X2 is scaled as the distance in kilometers from the Golden Gate Bridge (Jassby et al. 1995).

At all life stages, delta smelt are found in greatest abundance in the water column and usually not in close association with the shoreline. They inhabit open, surface waters of the Delta and Suisun Bay, where they presumably aggregate in loose schools where conditions are favorable (Moyle 2002). In years of moderate to high Delta outflow (above normal to wet water years), delta smelt larvae are abundant in the Napa River, Suisun Bay, and Montezuma Slough, but the degree to which these larvae are produced by locally spawning fish versus the degree to which they originate upstream and are transported by tidal currents to the bay and marsh is uncertain.

Most young-of-the-year delta smelt rear in the low salinity zone (LSZ) from late spring through fall and early winter. Once in the rearing area growth is rapid, and juvenile fish are 40-50-mm standard length by early August (Erkkila et al. 1950; Ganssle 1966; Radtke 1966). They reach adult size (55-70-mm standard length) by early fall (Moyle 2002). Delta smelt growth during the fall months slows considerably (only 3-9 mm total), presumably because most of the energy ingested is being directed towards gonadal development (Erkkila et al. 1950; Radtke 1966). Some delta smelt remain in areas upstream of the LSZ, in particular the Cache Slough complex including Liberty Island the Sacramento Deepwater Ship Channel (Sommer et al. 2011, Sommer and Mejia 2013).

Trends in Abundance and Population Viability

Delta smelt abundance, as indexed by relative abundance in fall midwater trawling conducted since 1967, underwent downward step changes in the early 1980s and again in the early 2000s (Thomson et al. 2010); the annual fall midwater trawl index generally has remained low and in 2013 was the second lowest of all time (see http://www.dfg.ca.gov/delta/data/fmwt/Indices/sld002.asp). Bennett (2005) conducted a population viability analysis as the probability of extinction based on fall midwater trawl data up to 2003. He specified three extinction levels of 800; 8,000; and 80,000 fish, with the value of 80,000 roughly corresponding to the then-lowest fall midwater trawl index of relative abundance from 1994. The fall midwater trawl index in 1994 was 102; the lowest value was 17 in 2009, which would be closer to the estimate of 8,000 fish used by Bennett (2005). The analysis by Bennett suggested that the median time to 50% of extinction probabilities would be 20 years for 8,000 fish and 42-55 years for 800 fish; there was an estimated 50-55% probability of abundance reaching 8,000 fish in 20 years, compared to an estimated 26-30% probability of reaching in 800 fish in 20 years.

Critical Habitat

Central Valley Spring-Run Chinook Salmon and Central Valley Steelhead

Critical habitat was designated for Central Valley spring-run Chinook salmon and California Central Valley steelhead on September 2, 2005, (70 FR 52488). Critical habitat for Central Valley spring-run Chinook salmon includes stream reaches such as those of the Feather and Yuba rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, as well as portions of the northern Delta. Critical habitat for California Central Valley steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries, and the waterways of the Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (Bain and Stevenson 1999; 70 FR 52488). Critical habitat for Central Valley spring-run Chinook salmon and steelhead is defined as specific areas that contain the primary constituent elements (PCE) and physical habitat elements essential to the conservation of the species. Inland PCEs for Central Valley spring-run Chinook salmon and California Central Valley steelhead include spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine areas.

- Freshwater spawning habitat includes water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most spawning habitat in the Central Valley for Chinook salmon and steelhead is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for Sacramento River winter-run Chinook salmon is restricted to the Sacramento River primarily between RBDD and Keswick Dam. Central Valley spring-run Chinook salmon also spawn on the main stem Sacramento River between RBDD and Keswick Dam and in tributaries such as Mill, Deer, and Butte creeks (however, little spawning activity has been recorded in recent years on the Sacramento River main stem for spring-run Chinook salmon). Spawning habitat for California Central Valley steelhead is similar in nature to the requirements of Chinook salmon, primarily occurring in reaches directly below dams (i.e., above RBDD on the Sacramento River) on perennial watersheds throughout the Central Valley. These reaches can be subjected to variations in flows and temperatures, particularly over the summer months, which can have adverse effects upon salmonids spawning below them. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.
- Freshwater rearing habitat includes water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large woody material, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their out-migration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (e.g., the lower Cosumnes River, Sacramento River reaches with setback levees [i.e., primarily located upstream of the City of Colusa]) and flood bypasses (i.e., Yolo and Sutter bypasses). However, the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Freshwater rearing habitat also has a high conservation value even if the current conditions are significantly degraded from their natural state. Juvenile life stages of salmonids are dependent on the function of this habitat for successful survival and recruitment.
- Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the lower main stems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of out-migrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (i.e., hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For

successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For this reason, freshwater migration corridors are considered to have a high conservation value even if the migration corridors are significantly degraded compared to their natural state.

- Estuarine areas free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging large woody material, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Estuarine areas are considered to have a high conservation value as they provide factors which function to provide predator avoidance and as a transitional zone to the ocean environment.

Sacramento River Winter-Run Chinook Salmon

The designated critical habitat for Sacramento River winter-run Chinook salmon includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Estuary to the Golden Gate Bridge north of the San Francisco/Oakland Bay Bridge. In the Sacramento River, critical habitat includes the river water column, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. In the areas westward of Chipps Island, critical habitat includes the estuarine water column and essential foraging habitat and food resources used by Sacramento River winter-run Chinook salmon as part of their juvenile emigration or adult spawning migration.

Critical habitat for Sacramento River winter-run Chinook salmon in the Delta is limited to the Sacramento River and therefore does not include the EDB site footprints; however, the EDB do have the potential to affect the Sacramento River during their operation, through effects on water quality and hydrodynamics.

Southern DPS of North American Green Sturgeon

Critical habitat was designated for the Southern DPS of North American green sturgeon on October 9, 2009 (74 FR 52300). Critical habitat for Southern DPS green sturgeon includes the stream channels and waterways in the Delta to the ordinary high water line except for certain excluded areas. Critical habitat also includes the main stem Sacramento River upstream from the I Street Bridge to Keswick Dam, and the Feather River upstream to the fish barrier dam adjacent to the FRFH. Coastal marine areas include waters out to a depth of 60 m from Monterey Bay, California, to the Juan De Fuca Straits, Washington. Coastal estuaries designated as critical habitat include San Francisco Bay, Suisun Bay, San Pablo Bay, and the lower Columbia River estuary. Certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) are also included as critical habitat for Southern DPS green sturgeon.

Critical habitat for the Southern DPS of North American green sturgeon includes the estuarine waters of the Delta, which contain the following PCEs: food resources, water flow, water quality, migratory corridors, water depth, and sediment quality.

- Abundant food resources within estuarine habitats and substrates for juvenile, sub-adult, and adult life stages are required for the proper functioning of this PCE for green sturgeon. Prey species for juvenile, sub-adult, and adult green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, callianassid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, sub-adult, and adult green sturgeon within the bays and estuaries.

- Within bays and estuaries adjacent to the Sacramento River (i.e., the Delta and the Suisun, San Pablo, and San Francisco bays), sufficient water flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds is required. Sufficient flows are needed to attract adult green sturgeon to the Sacramento River from the bay and to initiate the upstream spawning migration into the upper river.
- Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures for juvenile green sturgeon should be below 24°C (75°F). At temperatures above 24°C, juvenile green sturgeon exhibit decreased swimming performance (Mayfield and Cech 2004) and increased cellular stress (Allen et al. 2006). Suitable salinities in the estuary range from brackish water (10 ppt) to salt water (33 ppt). Juveniles transitioning from brackish to salt water can tolerate prolonged exposure to salt water salinities, but may exhibit decreased growth and activity levels (Allen and Cech 2007), whereas sub-adults and adults tolerate a wide range of salinities (Kelly et al. 2007). Sub-adult and adult green sturgeon occupy a wide range of dissolved oxygen (DO) levels (Kelly et al. 2007, Moser and Lindley 2007). Adequate levels of DO are also required to support oxygen consumption by juveniles ranging from 61.78 to 76.06 milligrams (mg) oxygen (O_2) per hour per kilogram (kg) of weight (Allen and Cech 2007). Suitable water quality also includes water free of contaminants (e.g., organochlorine pesticides, poly aromatic hydrocarbons (PAHs), or elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of sub-adult or adult stages.
- Safe and unobstructed migratory corridors are necessary for the safe and timely passage of adult, sub-adult, and juvenile fish within the region's different estuarine habitats and between the upstream riverine habitat and the marine habitats. Within the waterways comprising the Delta, and bays downstream of the Sacramento River, safe and unobstructed passage is needed for juvenile green sturgeon during the rearing phase of their life cycle. Rearing fish need the ability to freely migrate from the river through the estuarine waterways of the delta and bays and eventually out into the ocean. Passage within the bays and the Delta is also critical for adults and sub-adults for feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean. Within bays and estuaries outside of the Delta and the areas comprised by Suisun, San Pablo, and San Francisco bays, safe and unobstructed passage is necessary for adult and sub-adult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage to the ocean.
- A diversity of water depths is necessary for shelter, foraging, and migration of juvenile, sub-adult, and adult life stages. Tagged adults and sub-adults within the San Francisco Bay estuary primarily occupied waters over shallow depths of less than 10 m, either swimming near the surface or foraging along the bottom (Kelly et al. 2007). In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 3–8 feet deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke 1966). Thus, a diversity of depths is important to support different life stages and habitat uses for green sturgeon within estuarine areas.

- Sediment quality (i.e., chemical characteristics) is necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants (e.g., elevated levels of selenium, PAHs, and organochlorine pesticides) that can cause negative effects on all life stages of green sturgeon.

Delta Smelt

USFWS designated critical habitat for the delta smelt on December 19, 1994 (59 FR 65256). The geographic area encompassed by the designation includes all water and all submerged lands below the ordinary high water line and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the legal Delta (as defined in section 12220 of the California Water Code) (USFWS 1994).

PCEs for delta smelt include physical habitat, water, river flow, and salinity.

- Physical habitat is defined as the structural components of habitat. Because delta smelt is a pelagic fish, spawning substrate is the only known important structural component of habitat. It is possible that depth variation is an important structural characteristic of pelagic habitat that helps fish maintain position within the estuary's LSZ (Bennett et al. 2002).
- Water is defined as water of suitable quality to support various delta smelt life stages with the abiotic elements that allow for survival and reproduction. Delta smelt inhabit open waters of the Delta and Suisun Bay. Certain conditions of water temperature, turbidity, and food availability characterize suitable pelagic habitat for delta smelt. Factors such as high entrainment risk and contaminant exposure can degrade this PCE even when the basic water quality is consistent with suitable habitat.
- River flow is defined as transport flow to facilitate spawning migrations and transport of offspring to LSZ rearing habitats. River flow includes both inflow to and outflow from the Delta, both of which influence the movement of migrating adult, larval, and juvenile delta smelt. Inflow, outflow, and Old and Middle River flows (OMR) influence the vulnerability of delta smelt larvae, juveniles, and adults to entrainment at the Banks and Jones pumping facilities. River flow interacts with the fourth primary constituent element, salinity, by influencing the extent and location of the highly productive LSZ where delta smelt rear.
- Salinity is defined as the LSZ nursery habitat. The LSZ is where freshwater transitions into brackish water; the LSZ is defined as 0.5-6.0 practical salinity units (psu) (Kimmerer 2004). The 2 psu isohaline is a specific point within the LSZ where the average daily salinity at the bottom of the water is 2 psu (Jassby et al. 1995). By local convention the location of the LSZ is described in terms of the distance from the 2 psu isohaline to the Golden Gate Bridge (X2); X2 is an indicator of habitat suitability for many San Francisco Estuary organisms and is associated with variance in abundance of diverse components of the ecosystem (Jassby et al. 1995; Kimmerer 2002a). The LSZ expands and moves downstream when river flows into the estuary are high. Similarly, it contracts and moves upstream when river flows are low. During the past 40 years, monthly average X2 has varied from as far downstream as San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km). At all times of year, the location of X2 influences both the area and quality of habitat available for delta smelt to successfully complete their life cycle. In general, delta smelt habitat quality and surface area are greater when X2 is located in Suisun Bay. Both habitat quality and quantity diminish the more frequently and further the LSZ moves upstream, toward the confluence of the Sacramento and San Joaquin rivers.

Environmental Baseline

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).

Status of the Species and Critical Habitat in the Action Area

Status of the Species Within the Action Area

NMFS-Managed Species

The description of environmental baseline conditions in the Action Area for NMFS-managed species is largely derived from the NMFS (2014) BO on the Georgiana Slough Floating Fish Guidance Structure Study. The Action Area for the construction and operation of the EDB functions primarily as a migratory corridor for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the Southern DPS of North American green sturgeon, but it also provides some use as holding and rearing habitat for each of these species as well.

Central Valley Spring-Run Chinook Salmon

CVP and SWP salvage records and northern and central Delta fish monitoring data indicate that juvenile spring-run Chinook salmon first begin to appear in the Action Area in December and January, but that a significant presence does not occur until March and peaks in April (17.2 and 65.9 percent of average annual salvage, respectively; see Table 10 of NMFS 2014). By May, the salvage of juvenile Central Valley spring-run Chinook salmon declines sharply and essentially ends by the end of June (15.5 and 1.2 percent of average annual salvage, respectively). The data from the northern and central Delta fish monitoring programs indicate that a small proportion of the annual juvenile spring-run emigration occurs in January (3 percent) and is considered to be mainly composed of older yearling spring-run juveniles based on their size at date (Table 9). Based on the Delta size criteria by date, the majority of spring-run Chinook salmon juveniles (young-of-the- year size) emigrate in March (53 percent) and April (43 percent) and tails off sharply by May (1 percent) and thus will be present in the Action Area during these periods. This pattern is further supported and consistent with salmonid passage estimates derived from RST data collected by USFWS dating back to 2003, which indicate two significant peaks in the annual passage of juvenile spring-run Chinook salmon at RBDD occurring in the months of December and April. During the proposed EDB construction period (April-May 2014), historical monitoring data suggest that approximately 44 percent of the annual spring-run juvenile population may move into the Delta waterways within the Action Area. During the proposed EDB implementation period (occurring between May and November 2014), nearly all of the annual juvenile spring-run Chinook salmon population will have moved into and through the Action Area.

Adult spring-run Chinook salmon would be expected to start entering the Action Area in approximately January. Low levels of adult migration are expected through early March. The peak of adult spring-run Chinook salmon movement through the Action Area in the Delta is expected to occur between April and June with adults continuing to enter the system through the summer. During the proposed EDB construction window of April to May 2014, approximately 5-6 percent of the estimated annual adult escapement population will have moved upriver through the Action Area (Table 10).

Table 9. Percentage of Juvenile Sacramento River-watershed Salmonids Entering the Delta by Month

Month	Fall-Run	Spring-Run	Winter-Run	Sacramento Steelhead
January	14	3	17	5
February	13	0	19	32
March	23	53	37	60
April	6	43	1	0
May	26	1	0	0
June	0	0	0	0
July	0	0	0	0
August	1	0	0	0
September	0	0	0	1
October	9	0	0	0
November	8	0	3	1
December	0	0	24	1

Source: National Marine Fisheries Service 2009: 633.

Table 10. Percentage of Adult Chinook Salmon Passing Above Red Bluff Diversion Dam By Month

Month	Fall-Run	Late Fall–Run	Spring-Run	Winter-Run
January	0	17.5	0	3.75
February	0	17.5	0	13.75
March	0	6.25	1.25	37.5
April	0	1.25	1.25	25
May	0	0	4.5	10
June	0	0	10.5	7
July	2.5	0	15	1.5
August	10	0	25	1.5
September	32.5	0	27.5	0
October	40	20	15	0
November	12.5	17.5	0	0
December	2.5	20	0	0

Source: Adapted from Vogel and Marine (1991), averaging wet and dry years and assuming midpoints for values denoted as 'greater than' or 'less than' by Vogel and Marine (1991).

During the proposed EDB operation period between May and November, 2014, it is estimated that much of the remainder of the adult escapement will move upriver through the Delta waterways associated with the Action Area. The removal of the barrier (November) is expected to occur outside of the adult spring-run Chinook salmon. Currently, all known populations of Central Valley spring-run Chinook salmon inhabit the Sacramento River watershed.

Sacramento River Winter-Run Chinook Salmon

The temporal occurrence of Sacramento River winter-run Chinook salmon smolts and juveniles within the Action Area (northern Delta and central Delta) are best described by a combination of the salvage records of the CVP and SWP fish collection facilities (see Table 10 of NMFS 2014) and the fish monitoring programs conducted in the northern and central Delta (Table 9). Based on salvage records covering the period between 1999 and 2009 at the south Delta fish salvage facilities, juvenile Sacramento River winter-run Chinook salmon are typically present in the Action Area starting in December. Their presence peaks in March and then rapidly declines from April through June. Nearly 50 percent of the average annual salvage of Sacramento River winter-run Chinook salmon juveniles occurs in March. Salvage in April accounts for only 2.8 percent of the average annual salvage and falls to less than 1 percent for May and June combined. Using the fish monitoring data from the northern and central Delta, 24 percent of the annual winter run juvenile population emigrates into the Delta in December, 17 percent in January, 19 percent in February, 37 percent in March, 1 percent in April, and very low numbers from May onwards. Therefore it would be expected that only a small percentage of winter-run juveniles would be enter the Action Area during the proposed EDB construction window (April-May 2014). The proposed EDB implementation period occurring sometime between May through November 2014, would mostly be outside the juvenile winter-run population migration period.

Presence of adult winter-run Chinook salmon in the Delta is inferred from historical data derived from the passage of adults fish past RBDD (Table 10). It is assumed that based on a migratory movement rate of 25 km per day, fish would be in the Delta approximately 2 weeks earlier than the dates at RBDD. Adult winter-run Chinook salmon are expected to enter the Action Area starting in January (approximately 3 percent), with the majority of adults passing through the action area between February 1 and the end of April (approximately 66 percent). During the proposed 30-60-day construction period occurring in April-May 2014, approximately 35 percent of the adult winter-run spawning population may pass through the Action Area. During the proposed EDBoperation period between May and November, 2014, a relatively low (<10%) proportion of the adult spawning population would move through the Action Area based on the RBDD data. The removal phase of the project (November 2014) would be outside the migration period of winter-run Chinook salmon adults (Table 10).

Central Valley Steelhead

California Central Valley steelhead occur in both the Sacramento River and the San Joaquin River watersheds. However the spawning population of fish is much greater in the Sacramento River watershed and accounts for nearly all of the DPS' population. Small, remnant populations of California Central Valley steelhead are known to occur on the Stanislaus River and the Tuolumne River and their presence is assumed on the Merced River due to regional proximity, similar aquatic habitats, otilith microchemistry indicating maternal anadromy in some specimens collected within the tributary (Zimmerman 2008, 2009), and historical presence prior to dam construction. California Central Valley steelhead smolts first start to appear in the Action Area in November based on the records from the CVP and SWP fish salvage facilities (Table 10 of NMFS 2014), as well as the fish monitoring program in the northern and central Delta (Table 9). Their presence increases through December and January (21.6 percent of average annual salvage) and peaks in February (37.0 percent) and March (31.1 percent) before rapidly declining in April (7.7 percent). By June, the emigration has essentially ended, with only a small number of fish being salvaged through the summer at the CVP and SWP. Kodiak trawls conducted by the USFWS and CDFW on the mainstem of the San Joaquin River upstream from the City of Stockton routinely catch low numbers of out-migrating steelhead smolts from the San Joaquin River Basin during the months of April and May. Data from the northern and central Delta fish monitoring programs indicate that steelhead smolts begin to enter the northern Delta as early as November and December, but do not substantially increase in numbers until February and March.

Based on these data, very few juvenile steelhead emigrants would be expected to move into and through the Action Area during the EDB construction window (April to May 2014). The proposed EDB operation period would be between May and November 2014, during which time only a very low proportion of the juvenile steelhead population would be expected to enter the Action Area (Table 9).

Some adult steelhead are expected to move through the Action Area during EDB construction, but the peak of upriver immigration is likely to have occurred earlier (August through November on the Sacramento River) and therefore may coincide more with operation and removal of the EDB. There is potential for exposure of adult steelhead moving back downstream through the Action Area in a post-spawn condition (kelts) during the EDB construction period. It is expected that more kelts will be observed earlier in the construction period because the timing of spawning in the Sacramento River basin generally would precede the construction period (Figure 28 in NMFS 2014). There is also potential for adult steelhead to be present in the Action Area during EDB removal during November 2014.

Southern DPS of North American Green Sturgeon

Juvenile green sturgeon from the Southern DPS are routinely collected at the Fish Facilities throughout the year. However, numbers are considerably lower than for other species of fish monitored at the Fish Facilities. Based on the salvage records from 1981 through 2013, green sturgeon may be present during any month of the year, and have been particularly prevalent during July and August. The sizes of these fish are less than 1 m and average 330 mm with a range of 136 mm to 774 mm. The size range indicates that these are sub-adult fish rather than adult or larval/juvenile fish. It is believed that these sub-adult fish utilize the Delta for rearing for up to a period of approximately 3 years. The Action Area is located on the main migratory route that juvenile green sturgeon would utilize to enter the Delta from their natal areas upstream on the upper Sacramento River. The fact that juvenile green sturgeon are captured at the Fish Facilities, which are in the southwest portion of the Delta, suggests that green sturgeon are more likely to be present in the Action Area during the EDB, and in higher densities, than are observed at the Fish Facilities.

Because the Action Area is on the main adult green sturgeon migratory route for access to the spawning grounds in the upper Sacramento River, it is likely that adult green sturgeon will be present in the Action Area. Adult green sturgeon begin to enter the Delta in late February and early March during the initiation of their upstream spawning run. The peak of adult entrance into the Delta appears to occur in late February through early April with fish arriving upstream in April and May. Adults continue to enter the Delta until early summer (June-July) as they move upriver to spawn. It is also possible that some adult green sturgeon will be moving back downstream in April and May through the Action Area, either as early post spawners or as unsuccessful spawners. Some adult green sturgeon have been observed to rapidly move back downstream following spawning, while others linger in the upper river until the following fall.

Delta Smelt

The Action Area functions as a migratory corridor and as spawning habitat for delta smelt. Given the long list of stressors discussed in the USFWS (2008) Operations Criteria and Plan (OCAP) BO, the range-wide status of the delta smelt is currently declining and abundance levels were the lowest ever recorded in 2009. Although there was a spike in the population in 2011, the declining abundance of delta smelt is clear. The 2013 fall midwater trawl index was the second lowest ever. This abundance trend has been influenced by multiple factors, some of which are affected or controlled by CVP and SWP operations and others that are not. Although it is becoming increasingly clear that the long-term decline of the delta smelt was very strongly affected by ecosystem changes caused by non-indigenous species invasions and other factors influenced, but not controlled by CVP and SWP operations, the CVP and SWP have played an important direct role in that decline, especially in terms of entrainment and habitat-related impacts that add increments of additional mortality to the stressed delta smelt population. Further, past CVP and SWP operations have played an indirect role in the decline of the delta smelt by creating an altered environment in the Delta that has fostered both the establishment of non-indigenous species and habitat conditions that exacerbate their adverse influence on delta smelt population dynamics. Past CVP and SWP operations have been a primary factor influencing delta smelt abiotic and biotic habitat suitability, health, and mortality.

Within the Action Area, delta smelt probably are more likely to occur near the West False River barrier than the Sutter and Steamboat Slough barriers. Merz et al. (2011) examined survey data for occurrence of different delta smelt life stages in a number of regions within the Delta (Table 8). They found that the Lower San Joaquin River region (including the West False River area) had the second highest occurrence of delta smelt larvae of all sampled regions (found in 28% of 20-mm survey samples from April to June of 1995 to 2009); only the confluence of the Sacramento and San Joaquin rivers had a higher frequency of occurrence of delta smelt larvae (36%). The frequency of occurrence of sub-juveniles (15-30 mm) from the same survey was slightly greater than the all-zone average. The frequency of occurrence of juvenile and sub-adult delta smelt during summer and fall in the Lower San Joaquin River zone was well below the all-zone average, which is in keeping with the generally poorer rearing habitat in relation to other zones such as the confluence and Suisun Bay. Mature, pre-spawning, and spawning adult delta smelt frequency of occurrence from various surveys was in the Lower San Joaquin River zone to the all-zone average (Merz et al. 2011; Table 8).

The Sutter and Steamboat slough barrier locations are in the zone classified as the Upper Sacramento River by Merz et al. (2011; Table 8). Sampling in the vicinity of the barrier locations is less common than sampling near the West False River barrier location. The Upper Sacramento River zone covers an area below Rio Vista on the main stem Sacramento River to the City of Sacramento in the north. The frequency of occurrence of immature delta smelt life stages in the Upper Sacramento River zone (larvae, sub-juveniles, juveniles, and sub-adults) was well below the all-zone averages. In contrast, the frequency of occurrence of mature adults and spawning adults was greater than the all-zone averages for these life stages, reflecting upstream movement of the species to spawn. The frequency of occurrence of mature adult delta smelt in beach seines in the Upper Sacramento River zone from December to May was actually the highest of all the zones, although it was still a relatively low percentage (6%; Table 8).

Status of Critical Habitat Within the Action Area

NMFS-Managed Species

The Action Area occurs within the CALWATER Hydrologic Unit (HU) for the Sacramento Delta (HU 5510) and San Joaquin Delta Subbasin (HU 5544). Designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the Southern DPS of North American green sturgeon occur in these HUs. The PCEs for steelhead and spring-run Chinook salmon habitat within the action area include freshwater rearing habitat, freshwater migration corridors, and estuarine areas. The features of the PCEs included in these different sites essential to the conservation of California Central Valley steelhead and Central Valley spring-run Chinook salmon include the following: sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions necessary for salmonid development and mobility, sufficient water quality, food and nutrient sources, natural cover and shelter, migration routes free from obstructions, no excessive predation, holding areas for juveniles and adults, and shallow water areas and wetlands. Habitat within the action area is primarily utilized for freshwater rearing and migration by California Central Valley steelhead and Central Valley spring-run Chinook salmon juveniles and smolts and for adult freshwater migration. No spawning of California Central Valley steelhead or Central Valley spring-run Chinook salmon occurs within the Action Area.

Critical habitat for winter-run Chinook salmon includes the Sacramento River reach within the Action Area. Critical habitat elements include the river water, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. Downstream migration of juveniles and upstream migration of adults should not be impeded or blocked. Adequate forage base is required to provide food for emigrating juvenile winter-run.

With respect to the designated critical habitat for the Southern DPS of North American green sturgeon, the Action Area includes PCEs concerned with adequate food resources for all life stages utilizing the Delta; water flows sufficient to allow adults, sub-adults, and juveniles to orient to flows for migration and normal behavioral responses; water quality sufficient to allow normal physiological and behavioral responses; unobstructed migratory corridors for all life stages utilizing the Delta; a broad spectrum of water depths to satisfy the needs of the different life stages present in the estuary; and sediment with sufficiently low contaminant burdens to allow for normal physiological and behavioral responses to the environment.

The general condition and function of the aquatic habitat in the Delta was described by NMFS in recent biological opinions such as that for the 2014 Georgiana Slough Floating Fish Guidance Structure (NMFS 2014). In brief, the substantial degradation over time of several of the essential critical elements has diminished the function and condition of freshwater rearing and migration habitat in the Action Area; the habitat has only rudimentary function compared to its historical status. The channels of the Delta have been heavily riprapped with coarse stone slope protection on artificial levee banks and these channels have been straightened to enhance water conveyance through the system. The extensive riprapping and levee construction has precluded natural river channel migrations and the formation of riffle pool configurations in the Delta's channels. The natural floodplains have essentially been eliminated, and the once extensive wetlands and riparian zones have been drained and cleared for farming. Little natural old growth riparian vegetation remains in the Delta, having been substantially replaced by non-native species. Remaining native vegetation is primarily limited to tules or cattails growing along the foot of artificial levee banks. Shallow water habitat along the toe of the levees is limited to a narrow bench that extends out towards mid-channel from the levee, and is frequently infested with non-native plant species such as the Brazilian waterweed (*Egeria densa*).

Although the habitat within the Delta, and in particular along the main stem Sacramento and San Joaquin Rivers, has been substantially altered and its quality diminished through years of human actions, its conservation value remains high for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and Southern DPS of North American green sturgeon. All juvenile winter-run and spring-run Chinook salmon, Southern DPS of North American green sturgeon, as well as those California Central Valley steelhead smolts originating in the Sacramento River basin must pass into and through the Sacramento Delta Subbasin HU to reach the lower Delta and the ocean. A portion of these Sacramento-origin fish, together with all of the Central Valley steelhead originating in the San Joaquin River basin, also pass through the San Joaquin Delta Subbasin HU. Likewise, adults originally born in the Sacramento basin that are migrating upstream to spawn must pass through Sacramento Delta HU to reach their upstream spawning areas on the tributary watersheds or main stem Sacramento River, and may pass through the San Joaquin Delta HU. Central Valley steelhead from the San Joaquin Basin will pass back through the San Joaquin Delta HU on their way to upstream spawning habitat. Therefore, it is of critical importance to the long-term viability of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon, the Southern DPS of North American green sturgeon, and California Central Valley steelhead to maintain a functional migratory corridor and freshwater rearing habitat through the Action Area and the Sacramento and San Joaquin Delta Subbasin HUs.

Delta Smelt

The existing physical appearance and hydrodynamics of the Action Area have changed substantially from the environment in which native fish species like delta smelt evolved. The Action Area once consisted of tidal marshes with networks of diffuse dendritic channels connected to floodplains of wetlands and upland areas (Moyle 2002). The in-Delta channels were further connected to drainages of larger and smaller rivers and creeks entering the Action Area from the upland areas. In the absence of upstream reservoirs, freshwater inflow from smaller rivers and creeks and the Sacramento and San Joaquin Rivers were highly seasonal and more strongly and reliably affected by precipitation patterns than they are today. Consequently, variation in hydrology, salinity, turbidity, and other characteristics of the Delta aquatic ecosystem was greater in the past than it is today (Kimmerer 2002b). For instance, in the early 1900s, the location of maximum salinity intrusion into the Delta during dry periods varied from Chipps Island in the lower Delta to Stockton along the San Joaquin River and Merritt Island in the Sacramento River (DWR Delta Overview[4]). Operations of upstream reservoirs have reduced spring flows while releases of water for Delta water export and increased flood control storage have increased late summer and fall inflows (Knowles 2002), though Delta outflows have been tightly constrained during late summer-fall for several decades.

Channelization, conversion of Delta islands to agriculture, and water operations have substantially changed the physical appearance, water salinity, water clarity, and hydrology of the Action Area. As a consequence of these changes, most life stages of the delta smelt are now distributed across a smaller area than historically (Arthur et al. 1996, Feyrer et al. 2007). Wang (1991) noted in a 1989 and 1990 study of delta smelt larval distribution that, in general, the San Joaquin River was used more intensively for spawning than the Sacramento River. Though not restricting spawning per se, based on particle tracking modeling, export of water by the CVP and SWP would usually restrict reproductive success of spawners in the San Joaquin River by entraining most larvae during downstream movement from spawning sites to rearing areas (Kimmerer and Nobriga 2008). There is one, non-wet year exception to this generalization: in 2008, delta smelt entrainment was managed under a unique system of restrictions imposed by the Court in NRDC v Kempthorne. The USFWS (2008) OCAP BO subsequently limited CVP/SWP operations to reduce entrainment of adult, larval, and early juvenile delta smelt.

As described in recent BOs such as the USFWS (2014b) BO on the Georgiana Slough Floating Fish Guidance Structure, a number of factors in addition to SWP/CVP have affected delta smelt critical habitat in the Action Area, e.g., contaminants and *Microcystis*, both of which may affect delta smelt prey. Introduced species have also impacted the Action Area in several ways including added predation to adult and juvenile delta smelt from introduced piscivorous fishes, changes in prey

[4] http://baydeltaoffice.water.ca.gov/sdb/tbp/deltaoverview/delta_overview.pdf

composition due to the introduction of several copepod species, added competition for food resources from introduced filter feeders, and submerged aquatic vegetation (particularly *Egeria densa*) that traps sediment and provides habitat for introduced piscivorous fishes.

Factors Affecting the Species and Habitat in the Action Area

NMFS-Managed Species

The Action Area encompasses a small portion of the area utilized by Sacramento River winter-run and Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the Southern DPS of North American green sturgeon. Many of the factors affecting these species throughout their range are discussed in recent BOs such as that for the 2014 Georgiana Slough Floating Fish Guidance Structure (NMFS 2014), and are considered the same in the Action Area.

The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs affecting listed salmonids in the Action Area. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices require peak flood discharges to be held back and released over a period of weeks to avoid overwhelming the flood control structures downstream of the reservoirs (i.e., levees and bypasses). Consequently, managed flows in the main stem of the river often truncate the peak of the flood hydrograph and extend reservoir releases over a protracted period. These actions reduce necessary cues for upstream spawning migrations and downstream emigration to the ocean created by variability in the hydrograph.

Levee construction and bank protection have affected salmonid 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 (SRA) cover. Individual bank protection sites typically range from a few hundred to a few thousand linear feet in length. Such bank protection generally results 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 accumulative impacts to ecosystem functions and processes that accrue from multiple bank protection sites within a given river reach (USFWS 2000). 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 large woody debris (LWD). Levee construction substantially reduces and typically eliminates any overbank flooding typical of natural river courses. Any overbank flows typically occur on small terraces adjacent to the riverside of the levee crown, providing minimal floodplain habitat for salmonids.

The use of rock armoring limits recruitment of LWD (i.e., from non-riprapped areas), and greatly reduces, if not eliminates, the retention of LWD once it enters the river channel. Riprapping creates a relatively clean, smooth surface which diminishes the ability of LWD to become securely snagged and anchored by sediment. LWD tends to become only temporarily snagged along riprap, and generally moves downstream with subsequent high flows. Habitat value and ecological functioning aspects are thus greatly reduced, because wood needs to remain in place to generate maximum values to fish and wildlife (USFWS 2000). Recruitment of LWD is limited to any eventual, long-term tree mortality and whatever abrasion and breakage may occur during high flows (USFWS 2000). Juvenile salmonids are likely being impacted by reductions, fragmentation, and general lack of connectedness of remaining nearshore refuge areas.

Point and non-point sources of pollution resulting from agricultural discharge and urban and industrial development occur upstream of, and within the Action Area. Environmental stressors as a result of low water quality can lower reproductive success and may account for low productivity rates in fish (e.g. green sturgeon; Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element (i.e. heavy metals) concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995b). The high numbers of diversions in the Action Area on the Sacramento River and in the north Delta are also potential threats to listed fish within the Action Area. Other impacts to adult migration present in the Action Area include migration barriers, water conveyance factors, water quality, and are discussed further by NMFS (2014).

Delta Smelt

Factors affecting delta smelt and its critical habitat were previously discussed in the sections discussing Status of the Species Within the Action Area and Status of Critical Habitat Within the Action Area.

Environmental Baseline Conditions Specific to 2014

The environmental baseline in the Action Area was described previously in general terms. There are several important factors specific to 2014 that require special consideration.

Temporary Urgency Change Petition and Drought Emergency Contingency Planning

Temporary Urgency Change Petition

On January 29, 2014, drought-related conditions prompted DWR and Reclamation to jointly file a Temporary Urgency Change Petition (TUCP) that requested the SWRCB to temporarily modify water right permit and license terms for the CVP and SWP. Specifically, the TUCP requested temporary modification of Delta outflow and DCC gate requirements imposed pursuant to State Water Board Decision 1641 (D-1641). On January 31, 2014, the SWRCB Executive Director, acting under delegated authority, issued an Order approving the temporary change that does the following:

- Allows a reduced level of Delta outflow so that DWR and Reclamation can conserve water in upstream reservoirs;
- Requires that water saved as a result of this action remain in storage to release later in the season for health and safety and ecosystem protection;
- Requires DWR and Reclamation to report flows, storage, and water deliveries;
- Provides flexibility to DWR and Reclamation to operate the DCC gates to conserve water and to minimize salinity intrusion from San Francisco Bay; and
- Allows limited water exports from the Delta for public health and safety needs.

DCC gates operations have particular significance to ESA-listed fishes, in particular Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. Juvenile salmonids entering the interior Delta through the DCC and Georgiana Slough typically have an appreciably lower probability of surviving to Chipps Island than those remaining in the main stem Sacramento River (e.g., Perry et al. 2010; Perry et al. 2012). Whereas the DCC gates typically are closed to protect downstream-migrating juvenile salmonids from December to June, drought conditions in 2014 have necessitated opening of the gates at times under the provisions of the TUCP. There is concern that opening of the DCC would result in greater entrainment into the interior Delta of juvenile salmonid out-migrants.

Several modifications to subsequent to the January 31 order have been petitioned and ordered. These, and the main features of the original January 31 order, are summarized below.

January 31 Order

The January 31, 2014 TUCP Order allowed DWR and the Bureau to meet a lower Delta Outflow level of 3,000 cubic feet per-second (cfs) in February (compared to required Delta outflow without the TUCP of 7,100 cfs) and allowed the DCC Gates to be operated flexibly from February 1 through May 20 (compared to required closure from February through May 20 per D-1641 and the NMFS OCAP BO). The Order restricted exports in the Delta at the SWP and CVP pumping facilities to health and safety needs of no more than 1,500 cfs, with the exception of water transfers. The Order also required that DWR and Reclamation consult with the SWRCB, DFW, NMFS, and USFWS through a Real-Time Drought Operations Management Team (RTDOMT) to discuss real time operational issues. The Order further required DWR and Reclamation to calculate and maintain a record of the amount of water conserved by the changes and keep that water in storage for use later in the year for purposes of maintaining water supplies, improving water quality, or protecting flows for fisheries. The Order required DWR and Reclamation to develop a monthly water balance and to conduct necessary modeling and monitoring to inform real time operational decisions. The Order stated that it may be modified based on additional public input or changed circumstances.

February 7 Modification

The February 7, 2014 modification to the TUCP Order clarified requirements that would apply when the requirements of D-1641 are met. The February 7 Revised Order adjusted the temporary export limitations when precipitation events occur that enable DWR and Reclamation to comply with the Delta Outflow and DCC Gate Closure requirements contained in Table 3 of D-1641. In these circumstances, exports greater than 1,500 cfs would be allowed up to the export limits contained in D-1641, except that any SWP and CVP exports greater than 1,500 cfs shall be limited to natural or abandoned flows, or transfers (not additional reservoir releases). The Order did not require DWR and Reclamation to meet the D-1641 Delta Outflow requirements unless exports were greater than 1,500 cfs. All other provisions of the January 31, 2014 Order were continued.

February 28 Modification

The February 28, 2014 modification to the TUCP Order continued for the month of March the modified Delta Outflow levels of 3,000 cfs originally approved on January 31, 2014. This modification to the Order continued to allow DWR and Reclamation to conserve stored water needed to maintain water supplies, improve water quality, and protect fishery resources later in the year. All other provisions of the February 7, 2014 Order continued to be in effect.

March 18 Modification

The March 18, 2014 modification to the TUCP Order provides alternate (reduced) outflow requirements, based on footnote 10 of Table 3 of D-1641, of 7,100 cfs (X2 of 81 km at Collinsville) during periods of increased inflow from the March runoff events. Exports can be greater than 1,500 cfs only if the provisions of footnote 10 or Table 3 are satisfied. Exports must return to a maximum of 1,500 cfs when the daily average EC at Collinsville increases to greater than 2,640 uS/cm.

Drought Emergency Contingency Planning

Contingency planning by DWR, Reclamation, and NMFS pursuant to Reasonable and Prudent Alternative (RPA) Action I.2.3.C of the NMFS BO on the OCAP for the CVP and SWP has included consideration of a matrix of potential gate operations that would aim to limit the potential for entrainment through the DCC, e.g., by restricting gate operations to periods when listed juvenile salmonids are not abundant in the Sacramento River near the DCC, and by focusing DCC opening to diurnal periods when movement of juvenile salmonids is less likely (Stelle 2014). Also of relevance to the potential for entrainment into the DCC is the possibility of installation of a floating fish guidance structure to lessen the probability of juvenile salmonid movement into the DCC. This is discussed further herein.

2014 Georgiana Slough Floating Fish Guidance Structure Study

As described in the NMFS (2014) BO, DWR is conducting the 2014 Georgiana Slough Floating Fish Guidance Structure (FFGS) Study from March-May/June 2014. The FFGS essentially is a floating fish screen that encompasses the top 5 feet of the water column with the intent of reducing the probability of downstream migrating juvenile salmonids from entering Georgiana Slough from the main stem Sacramento River. DWR is testing the effectiveness of the FFGS by placing it in the 'on' position for approximately a full tidal cycle (25 hours), then retracting it to the 'off' position flush with the river bank for the next tidal cycle, and so on. Diel operations of the FFGS began around March 7. Acoustically tagged juvenile Chinook salmon are being used to test the effectiveness of the FFGS in the 'on' position relative to the 'off' position. These fish are released from the City of Sacramento. DCC operations approved as part of the TUCP could result in some of the FFGS study fish being lost into DCC and never experiencing the FFGS. DWR may install a second FFGS just upstream of the DCC to reduce the probability of entry into the DCC should it be opened during the Georgiana Slough FFGS study period. These factors may affect juvenile salmonid survival in the Action Area during the EDB construction and early operation period and are discussed further in the effects analysis that follows.

Old and Middle River Index Demonstration Project

Beginning in 2014, Reclamation proposes to implement the OMR Index Demonstration Project, which would use an OMR index (instead of tidally filtered daily OMR flow reported by the U.S. Geological Survey) to operate to the required 14-day running average OMR flow from the NMFS (2009) OCAP BO's RPA Action IV.2.3. In addition, as part of this project, Reclamation proposes to eliminate the 5-day running average requirement. NMFS determined that this project would have no additional adverse effects to listed anadromous fishes and authorized the OMR Index Demonstration Project for one year, under the condition that operations revert to the RPA, as written, should any unanticipated adverse effects occur (Rea 2014).

Delta Levee Special Flood Control Projects Program

There is a current proposal to construct a seepage berm on the landside of levees at the West False River EDB site as part of the Delta Levee Special Flood Control Projects Program. This program was established in 1988 by Senate Bill 34 and continues to operate under subsequent legislation that extended and provided funding for the program. Any Local Agency with a Project or Non-Project levee in the Primary Zone of the Delta or a Non-Project levee in the Secondary Zone of the Delta is eligible to apply for the program, which provides financial assistance to local levee maintaining agencies for flood control projects and related habitat projects in the Delta. It is not known whether the seepage berms will be constructed before or after the EDB is installed.

Effects Assessment

This section describes the potential effects of implementing the EDB on the species and habitats listed in Table 1. The assessment is divided into construction effects and operations effects.

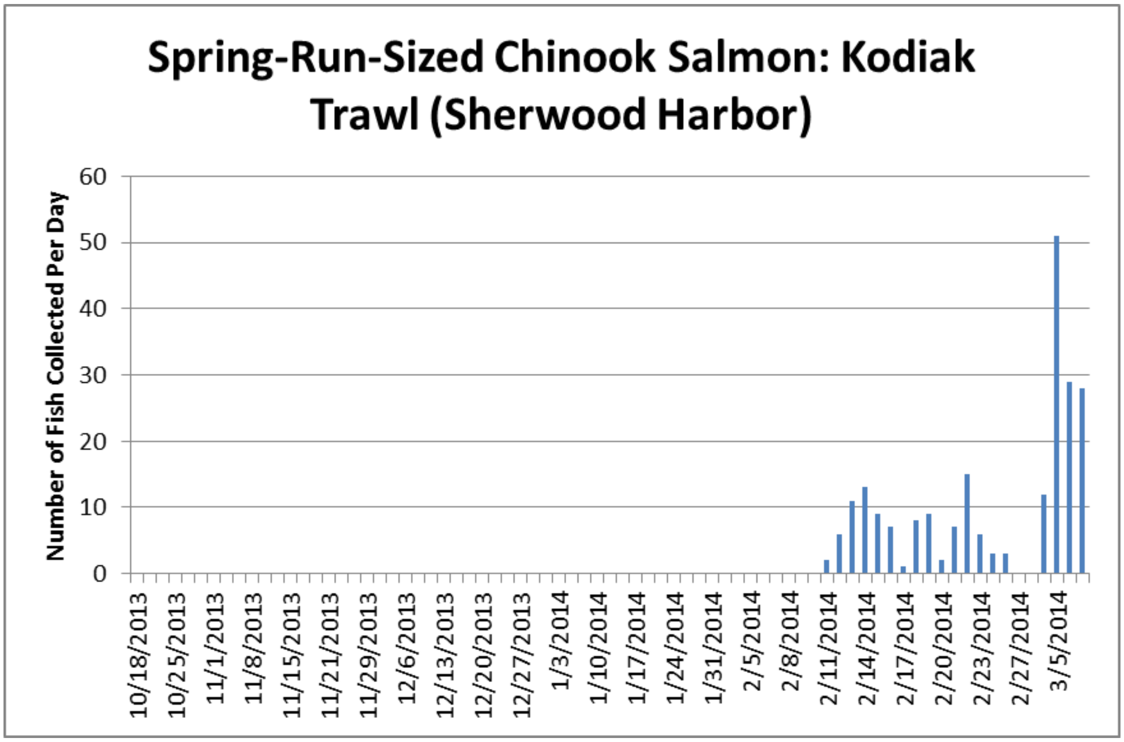
Construction Effects on Fish

Chinook Salmon and Central Valley Steelhead

As noted in the environmental baseline description, juveniles of both listed races of Chinook salmon and Central Valley steelhead may be found in the vicinity of the EDB during construction and the early period of operation (Table 9). Construction, operation, and removal of the EDB encompasses the period from April until November. Historic data suggest that the percentage of juvenile Sacramento River-watershed salmonids entering the Delta at this time would be greater for spring-run Chinook salmon than for winter-run Chinook salmon or steelhead (Table 9).

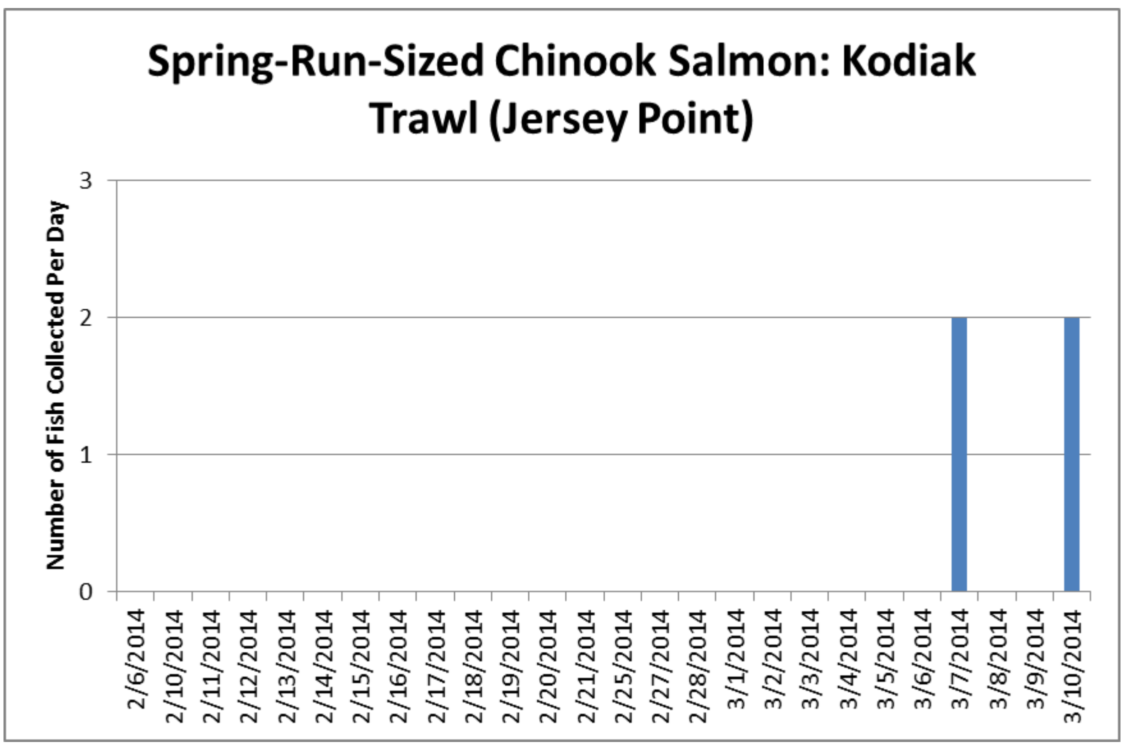
Monitoring data are available from several different locations in order to assess the relative abundance and distribution of juvenile Chinook salmon and steelhead in the Action Area in water year 2014. The following summary uses length at date criteria for Chinook salmon race classification, which has some uncertainty (see Harvey 2011) but has been used for various studies (del Rosario et al. 2013; Roberts et al. 2013). Kodiak trawling at Sherwood Harbor on the Sacramento River first yielded spring-run-sized Chinook salmon in early/mid-February, in response to the first winter storm that resulted in greater Sacramento River flow; a second, larger pulse of fish was detected following a somewhat greater storm in late February/early March (Figure 6). Only four spring-run-sized Chinook juveniles were collected in the drought-related Kodiak trawling at Jersey Point that commenced in early February (Figure 7). The first catches of spring-run-sized Chinook juveniles from midwater trawling at Chipps Island occurred on March 7 and 10 (Figure 8), suggesting that most of the February/March pulse of fish remains in the Action Area.

Winter-run-sized Chinook salmon juveniles also first were collected in appreciable numbers at Sherwood Harbor in early/mid-February, but in contrast to spring-run-sized fish, the first pulse of fish was greater than the second pulse of fish from late February/mid-March (Figure 9). Only one winter-run-sized Chinook juvenile was collected during the Jersey Point Kodiak trawling (Figure 10). In early March, a relatively large pulse of winter-run-sized Chinook juveniles was collected in the midwater trawling at Chipps Island, with the highest catches occurring on March 7 and 10 (Figure 11), just under one month since the main pulse of winter-run-sized fish was collected at Sherwood Harbor. This suggests that as of early March, winter-run-size juvenile Chinook salmon had begun to the leave



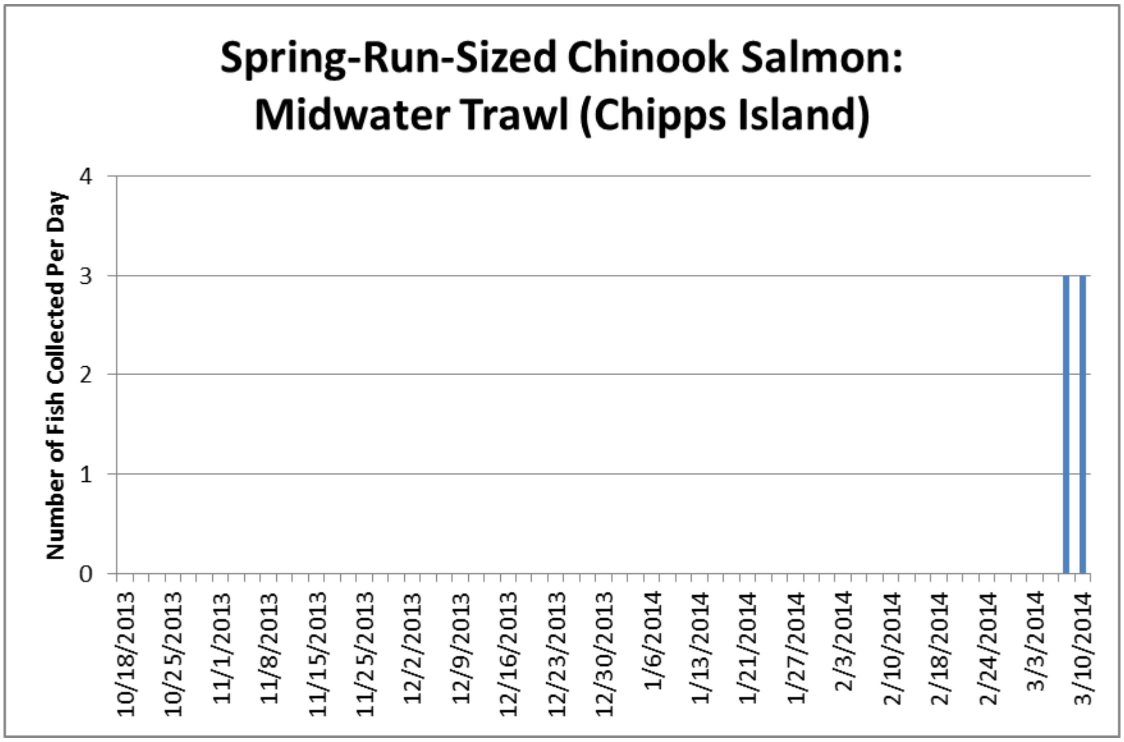
Source: Speegle (pers. comm.). Note that typical daily sampling frequency is ten 20-minute trawls.

Figure 6. Daily Number of Spring-Run-Sized Chinook Salmon Collected During Kodiak Trawling at Sherwood Harbor on the Sacramento River, October 2013-March 2014.



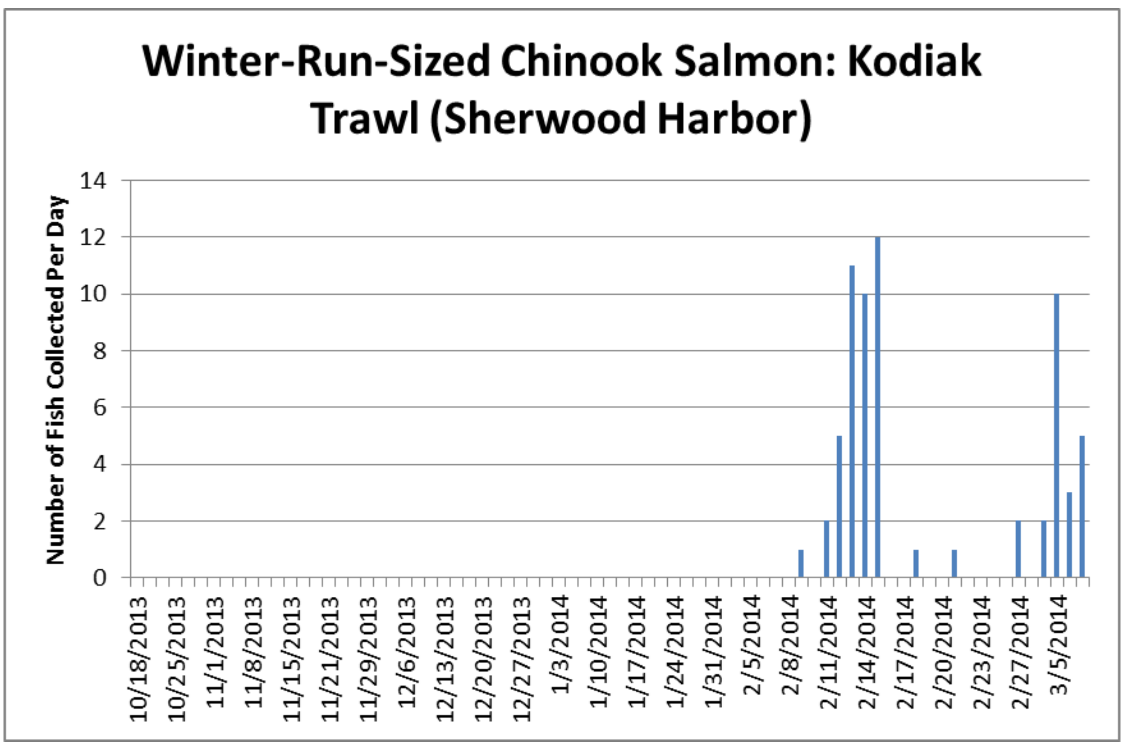
Source: Speegle (pers. comm.). Note that typical daily sampling frequency is fifteen 10-minute trawls.

Figure 7. Daily Number of Spring-Run-Sized Chinook Salmon Collected During Kodiak Trawling at Jersey Point on the San Joaquin River, February-March 2014.



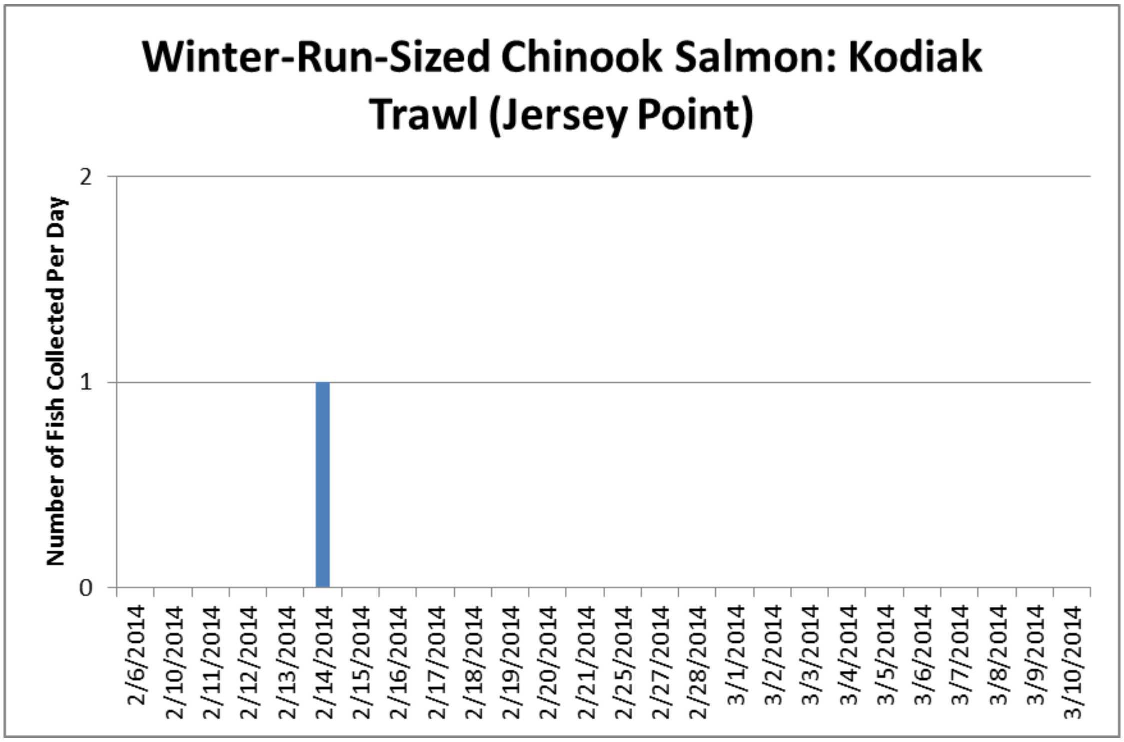
Source: Speegle (pers. comm.). Note that typical daily sampling frequency is ten 20-minute trawls.

Figure 8. Daily Number of Spring-Run-Sized Chinook Salmon Collected During Midwater Trawling at Chipps Island, October-March 2014.



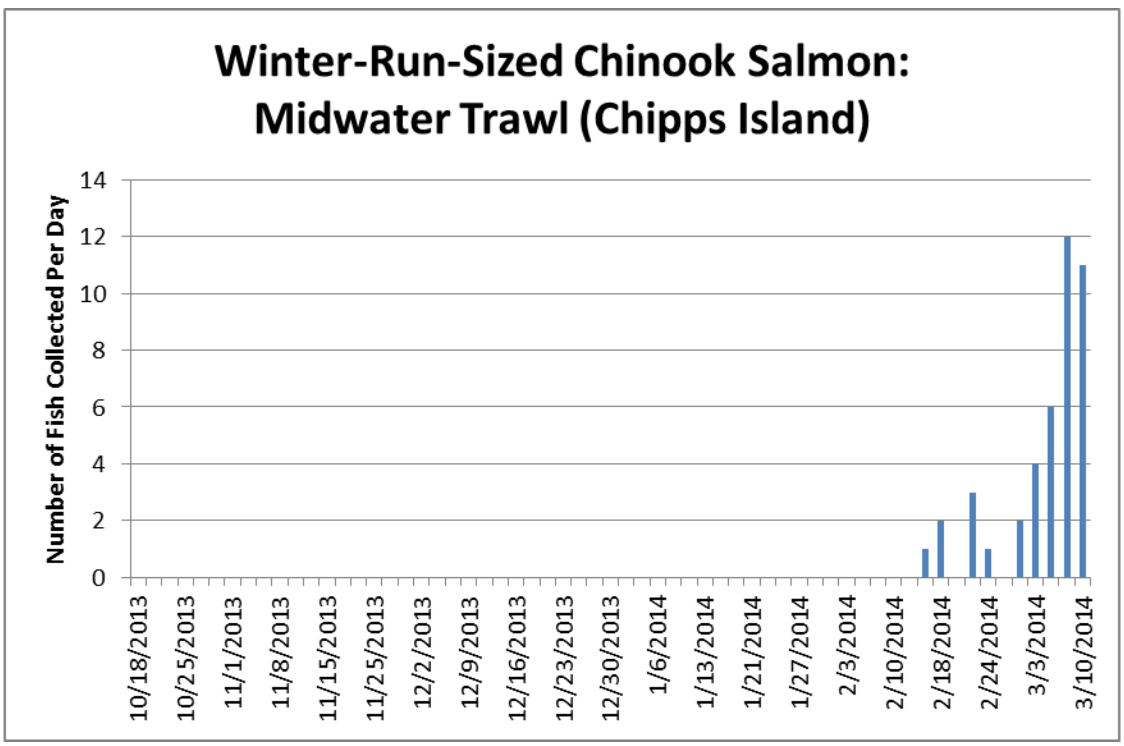
Source: Speegle (pers. comm.). Note that typical daily sampling frequency is ten 20-minute trawls.

Figure 9. Daily Number of Winter-Run-Sized Chinook Salmon Collected During Kodiak Trawling at Sherwood Harbor on the Sacramento River, October 2013-March 2014.



Source: Speegle (pers. comm.). Note that typical daily sampling frequency is fifteen 10-minute trawls.

Figure 10. Daily Number of Winter-Run-Sized Chinook Salmon Collected During Kodiak Trawling at Jersey Point on the San Joaquin River, February-March 2014.



Source: Speegle (pers. comm.). Note that typical daily sampling frequency is ten 20-minute trawls.

Figure 11. Daily Number of Winter-Run-Sized Chinook Salmon Collected During Midwater Trawling at Chipps Island, October-March 2014.

the Action Area; del Rosario et al. (2013) found that there was relatively little variation in time of Delta exit at Chipps Island (March being the typical month for the 50th percentile of the population), whereas Delta entry timing was considerably more variable and related to upstream Sacramento River flow.

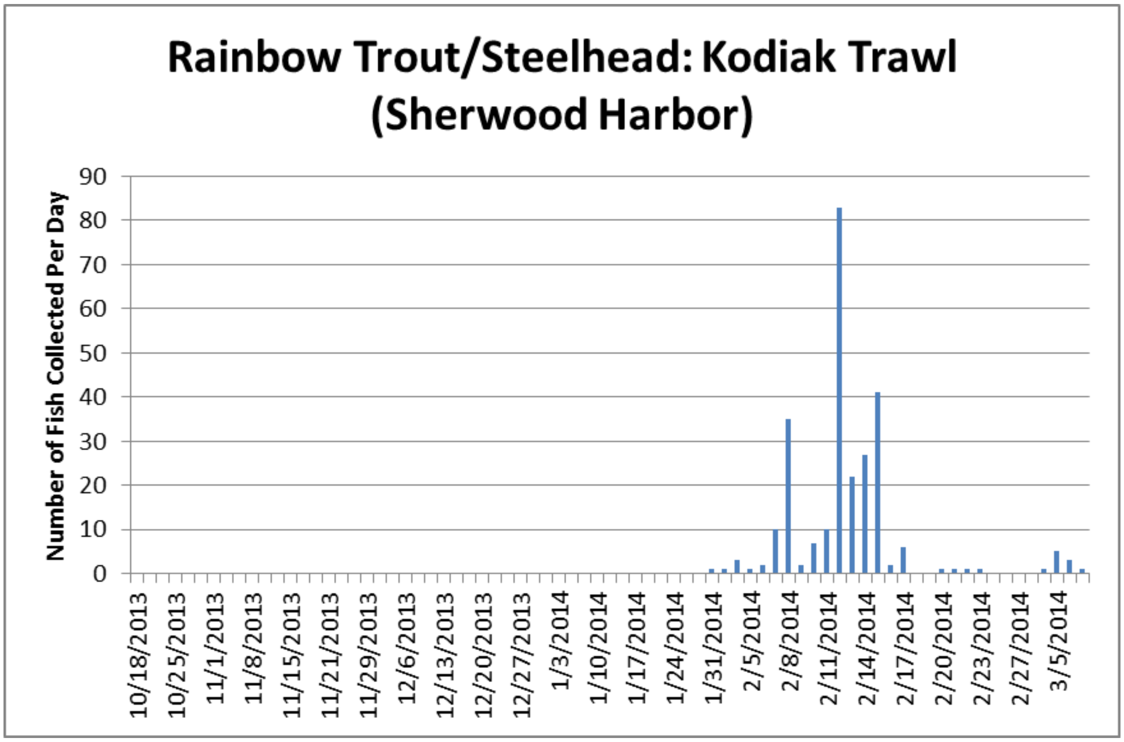
In common with spring-run-sized and winter-run-sized Chinook salmon, juvenile rainbow trout/steelhead first were collected at Sherwood Harbor in early/mid-February (Figure 12). However, these fish were nearly all from hatchery releases and, based on subsequent catches at Chipps Island, resided in the Action Area for a short time (Figure 13): the peak catch at Sherwood Harbor occurred on February 12, whereas the peak catch at Chipps Island occurred on February 18. Peaks in wild steelhead catch generally occur in the spring (Nobriga and Cadrett 2001), i.e., noticeably later than the hatchery releases. Therefore the main movement of juvenile steelhead through the Action Area may not yet have occurred. No juvenile rainbow trout/steelhead were collected from the Jersey Point trawling, suggesting relatively low abundance in that part of the Action Area. However, the pattern of capture at Sherwood Harbor and Chipps Island generally was also reflected in salvage monitoring at the south Delta facilities (Figure 14).

As described in the environmental baseline section, adult Chinook salmon of all races, including listed Central Valley spring-run and Sacramento River winter-run, may migrate upstream through the Action Area towards spawning areas during the construction and operation of the EDB (Table 10). The data in Table 10 refer to passage above RBDD because detailed data do not exist for passage through the Delta; assuming an upstream migration rate of 25 km per day (see Williams [2006] for a range of migration rates), the adult salmonids would have passed through the Delta approximately two weeks before reaching Red Bluff. McEwan (2001) describes peak steelhead migration as occurring from September to March, although the species has a protracted migration and holding period that encompasses much of the year (NMFS 2009: Table 4-6 of OCAP BO).

As noted in the Project Description, most materials needed for the construction of the barriers would be brought to the sites by barge; the exceptions include construction of the gravel roads used to access the boat ramps at the Steamboat Slough barrier and the transport of road materials and boat ramps to this site, and the installation of portions of the king piles and sheet piles at the West False River site. Additionally, minimal vegetation and clearing would be required on the levees prior to placement of rock or the installation of sheet piles. The more substantial of these land-based activities generates noise that could potentially disturb fish in the immediate area. The placement of rock below the waterline also generates noise as well as creates a physical disturbance that may harass, injure, kill or displace juvenile and adult salmonids. Rock placement in the river channels causes increased turbulence and turbidity in the water column. The increased turbidity levels associated with construction may negatively impact juvenile fishes temporarily through reduced availability of food, reduced feeding efficiency, and exposure to potentially toxic sediment released into the water column. These potential effects would be limited because they are temporary, only small areas of the three subject channels are disturbed or affected by construction, most fish are expected to move away from the area of disturbance, and DWR will employ a number of conservation measures intended to minimize the extent of take (see Conservation Measures section).

Pile driving will be used in the construction of the West False River barrier, as noted in the Project Description. High levels of underwater noise from pile driving can adversely affect some fish species[5],

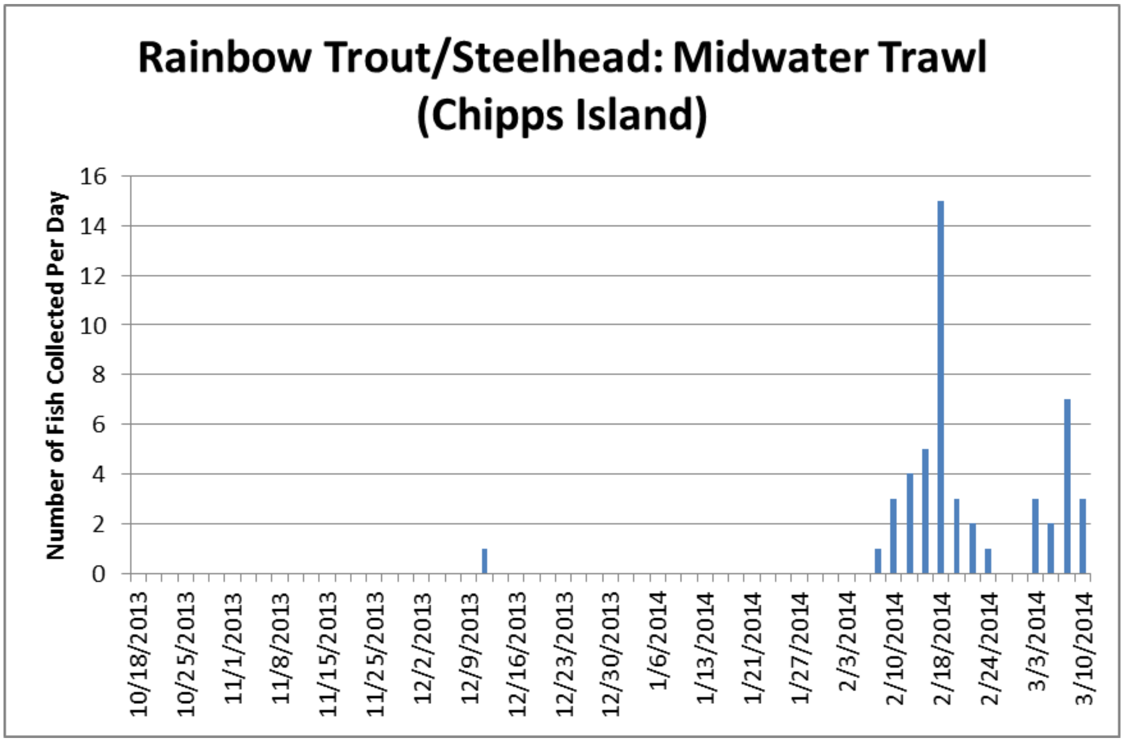
[5] Three metrics are commonly used in evaluating hydroacoustic impacts on fish: peak sound pressure level (LPEAK), root mean square (RMS) sound pressure, and sound exposure level (SEL) (ICF Jones & Stokes and Illingworth &



Source: Speegle (pers. comm.). Note that typical daily sampling frequency is ten 20-minute trawls.

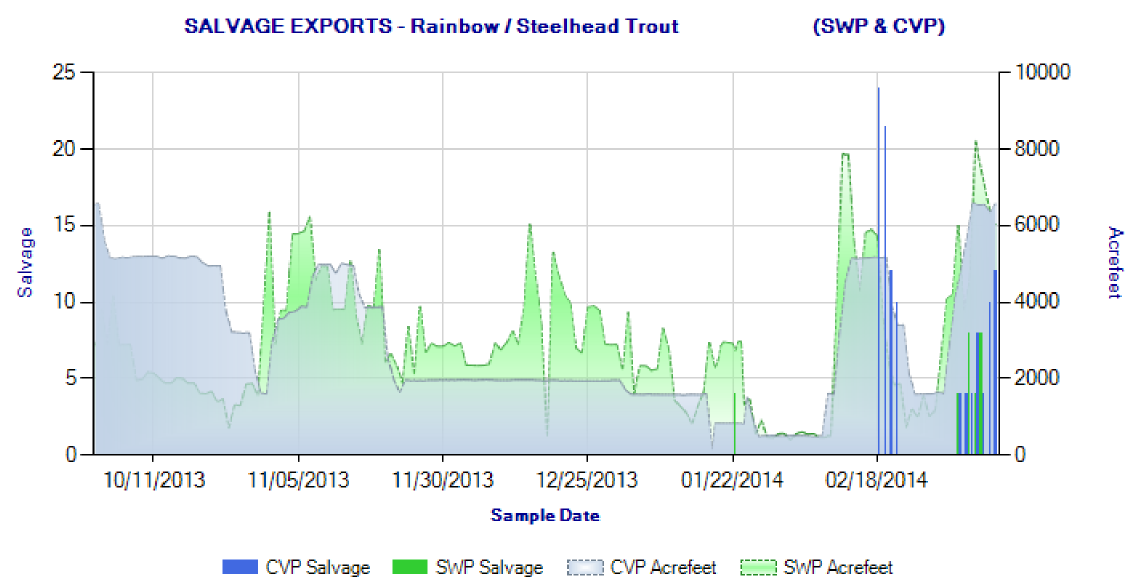
Figure 12. Daily Number of Rainbow Trout/Steelhead Collected During Kodiak Trawling at Sherwood Harbor on the Sacramento River, October 2013-March 2014.

Rodkin 2009). SEL is defined as the constant sound level acting for one second, which has the same amount of acoustic energy as the original sound (Hastings and Popper 2005). Reference sound levels from pile driving normally are reported at a fixed distance of 10 meters. Underwater peak and RMS decibel levels are usually referenced to 1 micropascal (µPa), and the SEL is referenced to 1 micropascal squared per second (dB re: $1\mu Pa^2$-s). (Hastings and Popper 2005).



Source: Speegle (pers. comm.). Note that typical daily sampling frequency is ten 20-minute trawls.

Figure 13. Daily Number of Rainbow Trout/Steelhead Collected During Midwater Trawling at Chipps Island, October-March 2014.



Source:
http://www.dfg.ca.gov/delta/apps/salvage/SalvageExportChart.aspx?Species=22&SampleDate=2%2f26%2f2014&Facility=1

Figure 14. Daily Rainbow Trout/Steelhead Salvage and South Delta Exports from October 1 to March 11, 2014.

as discussed by NMFS and others (Hastings and Popper 2005; Popper et al. 2006; Carlson et al. 2007; NMFS 2008a). To the extent possible, the EDB will use a vibratory hammer to install the sheet pile dikes and king piles (wall) at the West False River barrier; however, impact driving may be necessary for some pile driving. Vibratory hammers are generally much quieter than impact hammers and are routinely used on smaller piles (ICF Jones & Stokes and Illingworth & Rodkin 2009). Fish impacts from exposure to pile driving activities were reviewed by Hastings and Popper (2005), and they provided recommendations to protect fish from physical injury (see also Popper et al. 2006; Carlson et al. 2007). In 2008 NMFS, USFWS and DFG adopted interim criteria of a peak sound pressure level of 208 decibels (dB) referenced to 1 µPascal per second and a cumulative sound exposure level (SEL) of 187 dB referenced to 1µPascal per second (Fisheries Hydroacoustic Working Group 2008, ICF Jones & Stokes and Illingworth & Rodkin 2009). Although these criteria were specific to impact or percussive pile driving, they have served as a general guideline for noise thresholds for the onset of physical injury in fish exposed to the impact sound associated with pile driving (NMFS 2008a).

Pile driving at the West False River barrier site would occur over a several-day period in order to install the two sheet pile walls and associated eight king piles. It is anticipated that a vibratory hammer will be used for the sheet and king pile driving, which is quieter than impact driving (ICF Jones & Stokes and Illingworth & Rodkin 2009). Vibratory driving appears to be feasible given the anticipated ground conditions and modest pile penetration of 20-50 feet into the ground (Broadbaek, pers. comm.). Vibratory penetration rates are normally limited to 20 inches per minute (per North American Sheet Piling Associations – Best Practices, www.nasspa.com), which would result in the following maximum vibration times per pile assuming normal driving conditions:

- 20-ft ground penetration: 12 minutes
- 50-ft ground penetration: 30 minutes

Because of uncertainties in ground conditions and the possibility of encountering dense soil layers or obstructions such as left-in-place rip-rap on the existing levee side slopes, a larger impact hammer would be used as a contingency measure, in the event that unexpected harder driving is encountered. The impact hammer would only be used if the vibratory hammer cannot reach the design tip elevation of the pilings.

Although peak sound levels of vibratory hammers can be substantially less than those produced by impact hammers, the total energy imparted can be comparable to impact driving because the vibratory hammer operates continuously and requires more time to install the pile (ICF Jones & Stokes and Illingworth & Rodkin 2009). Sound levels during vibratory pile driving were measured at the City of Stockton Downtown Marina (ENTRIX 2008). Peak sound pressure levels ranged from 184 to 202 dB, while accumulated SELs ranged from 181 to 195 dB, as measured at 10 m from the pile and mid-water depth (approximately 2 to 3 m below the water surface). The duration of pile driving ranged approximately 6 to 12 minutes, with periods of 11 to 71 minutes between pile driving (Power Engineering and City of Stockton 2008). The peak sound pressure levels were below recommended levels, while the accumulated SELs slightly exceeded the recommended criteria by 8 dB. During the 5-week period of observing each pile installation at the City of Stockton Downtown Marina, technicians did not observe effects on salmonids or other species related to the pile installations.

It is anticipated that pile driving associated with the EDB Project would have similar results in terms of SEL and peak sound pressure levels. This, combined with the relatively short duration expected to drive each king pile and sheet pile and the adoption of attenuation measures (i.e., bubble curtains; see

Conservation Measures) suggest that physical injury to fish is unlikely. In general, bubble curtains provide between 0 and 20 dB of attenuation (ICF Jones & Stokes and Illingworth & Rodkin 2009).

Anticipated responses of any fish within the work area would more likely be behavioral in nature (e.g., startle response and avoidance), although these would diminish with distance from the construction sites. Hastings and Popper (2005) concluded that data are lacking on behavioral responses to pile driving, such as a startle response to noise or movement away from highly utilized habitats impacted by sound. Carlson et al. (2001) reported migrating juvenile salmon reacting with startle behavior in response to routine channel maintenance activities in the Columbia River. Some of the fish that did not immediately recover from the disorientation of turbidity and noise from channel dredges and pile driving swam directly into the point of contact with predators.

Overall, it is anticipated that the potential adverse effects of EDB construction on Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Central Valley steelhead would be limited for the following reasons:

- the effects would be temporary (total construction period of 30-60 days, with each individual site requiring considerably less than this total);
- pile driving on each day would be limited not to exceed NMFS-established thresholds for injury to fishes, and would be undertaken with a vibratory pile driver to the extent possible, with any necessary impact driving incorporating bubble curtains and other conservation measures to attenuate noise effects (see Conservation Measures section);
- sound data taken during the 2012 installation of rock barriers as part of the TBP showed that noise levels at 100 m from construction were below the NMFS criteria for adverse behavioral effects (Shields 2012), suggesting that the area of construction effects would be relatively small;
- the effects of noise on fish would likely be limited to avoidance behavior in response to movements, noises, and shadows caused by construction personnel and equipment operation in or adjacent to the river;
- most fish are expected to move away from the area of disturbance;
- DWR would employ a number of conservation measures to limit the potential for take (see Conservation Measures section).

Southern DPS of North American Green Sturgeon

There are insufficient quantitative data from which to assess the percentage of green sturgeon within the Action Area during construction and operation of the EDB. Adult green sturgeon may be present in the San Francisco Bay-Delta from March to September, with the principal occurrence in upstream spawning areas in the Sacramento River occurring from mid-April to mid-June (NMFS 2009: Table 4-7 of OCAP BO). Older juveniles (between 10 months and 3 years old) may be present in the Delta year-round (NMFS 2009: Table 4-7 of OCAP BO). Juvenile green sturgeon are routinely collected at the SWP and CVP salvage facilities throughout the year (NMFS 2009). Salvage records indicate that sub-adult green sturgeon may be present in the Delta during any month of the year in low numbers, but are most commonly salvaged in July and August; these fish range in size from 136 to 744 mm (NMFS 2009).

The effects on green sturgeon of construction-related activities associated with the installation of the EDB would be similar to those described previously for Chinook salmon and steelhead. In summary, those green sturgeon juveniles and sub-adults that do enter the project area during the specified construction periods are likely to experience increased turbidity and sediment-associated toxicant levels, noise, and potential harassment by construction activities. However, adverse effects are expected to have a limited negative impact on green sturgeon for the reasons previously described for salmonid species.

Delta Smelt

Adult migrating and spawning delta smelt have the potential to be adversely affected by construction activities associated with implementing the EDB. Migrating and spawning adult delta smelt may be present in the Action Area during the construction of the rock barriers because construction activities in April would coincide with the main period of delta smelt spawning.

Available survey data from 2014 suggest that adult delta smelt were in the general vicinity of the West False River barrier location during the Spring Kodiak Trawl Survey 2 (February 10-13; Figures 15 and 16); male and female delta smelt were collected in the lower San Joaquin River and the lower Mokelumne River (i.e., upstream and downstream of the West False River location). This is corroborated by the frequent collection of delta smelt in the drought-related Kodiak trawling at Jersey Point (Figure 17).

Construction also would overlap with the early life stages of the subsequent generation (larvae and early juveniles). As of Smelt Larva Survey 5 (March 3-5), no larval delta smelt had been collected in the vicinity of the West False River barrier location, and this was the first survey in which delta smelt larvae had been collected (mostly in the Cache Slough area; see Figures 18, 19, 20, 21, and 22), suggesting spawning commenced in February. Given the distribution of adult delta smelt (see above), it is likely that larval and juvenile delta smelt could be found in the vicinity of the West False River barrier during construction.

The main smelt-focused surveys do not sample close to the Sutter Slough and Steamboat Slough barrier locations. However, as noted in the Environmental Baseline section, delta smelt adults and early life stages have been collected in the Sacramento River upstream of Georgiana Slough historically and therefore could be present at the Sutter Slough and Steamboat Slough sites. Indeed, delta smelt were collected by trawling at Sherwood Harbor during early March (Figure 23).

The installation of the EDB has the potential to harass and displace delta smelt present in the general area of the construction activity, primarily because of in-water rock placement and any associated pile driving that would occur. Additionally, the increased turbidity levels associated with construction may negatively impact delta smelt temporarily through reduced availability of food, reduced feeding efficiency, and exposure to toxic sediments released into the water column. Removal of the EDB in November may be less likely to affect delta smelt because the timing of that action would not overlap with the general occurrence of the species in the locations of the barriers, although this is dependent on environmental conditions (e.g., water temperature, salinity, and turbidity).

The construction of the EDB may take delta smelt, however, take is anticipated to be limited because:

- the effects would be temporary (total construction period of 30-60 days, with each individual site requiring considerably less than this total);
- pile driving on each day would be limited not to exceed NMFS-established thresholds for injury to fishes, and would be undertaken with a vibratory pile driver to the extent possible, with any necessary impact driving incorporating bubble curtains and other conservation measures to attenuate noise effects (see Conservation Measures section);

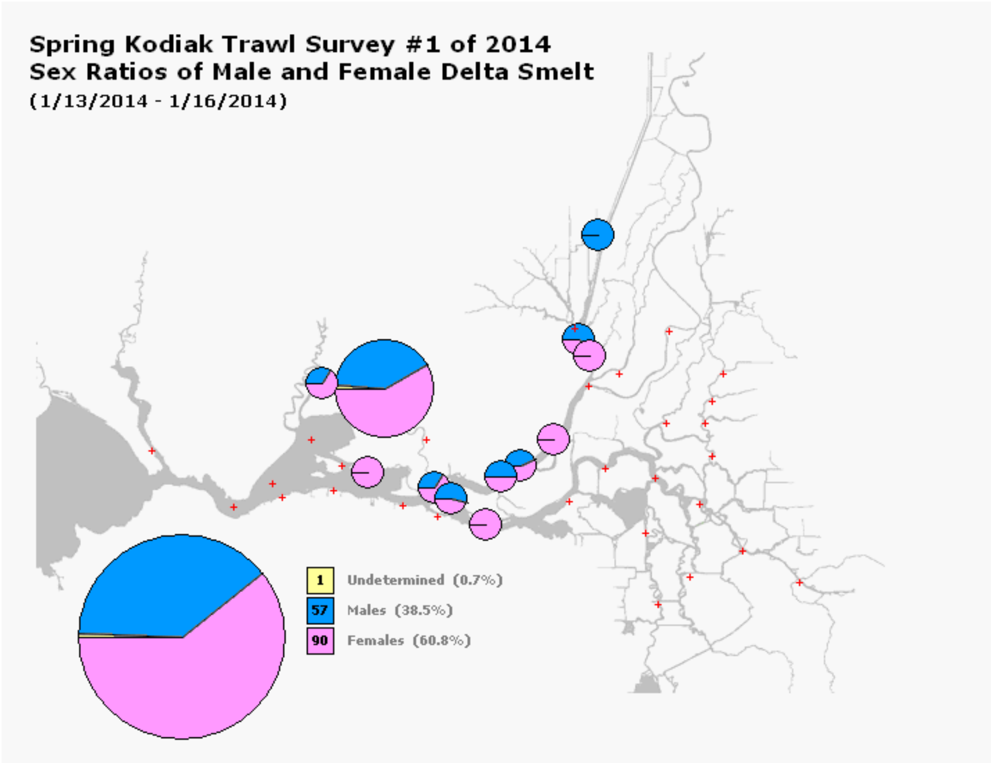


Figure 15. Delta Smelt Density from Spring Kodiak Trawl Survey 1 of 2014. Source: http://www.dfg.ca.gov/delta/data/skt/DisplayMaps.asp

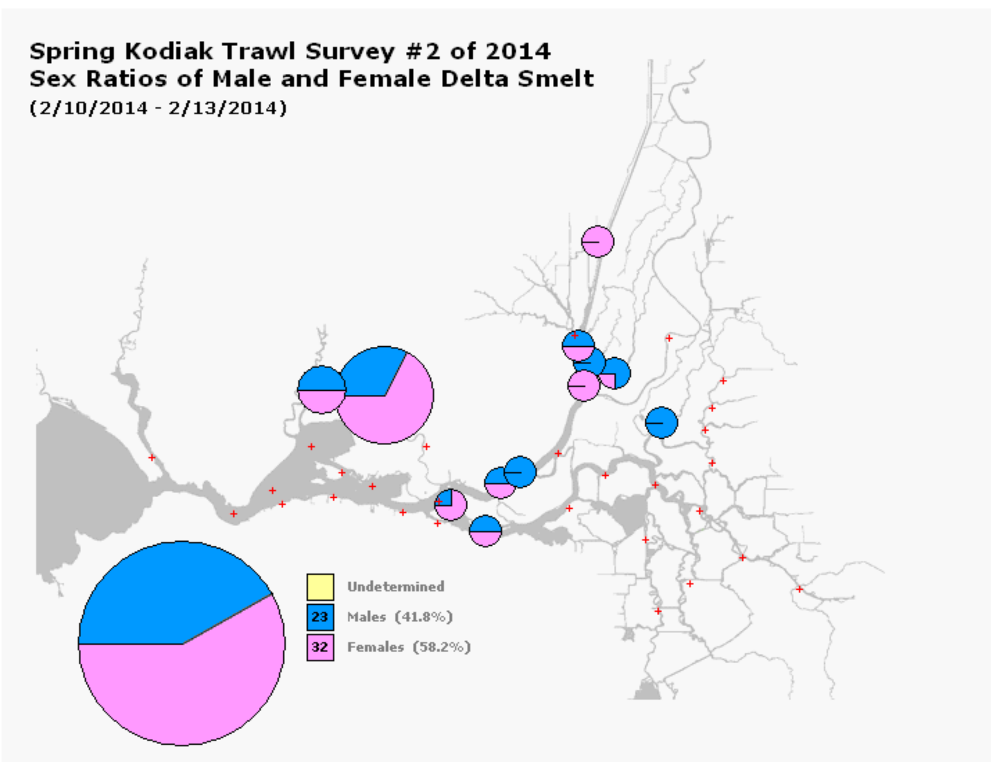
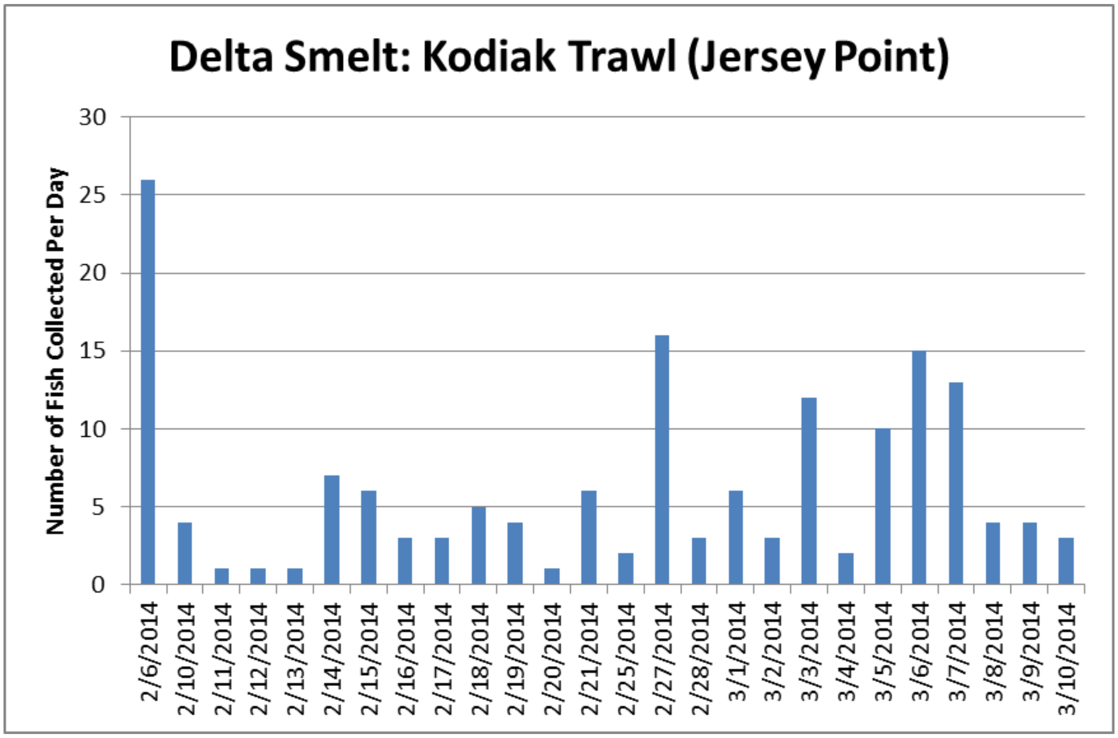


Figure 16. Delta Smelt Density from Spring Kodiak Trawl Survey 2 of 2014. Source: http://www.dfg.ca.gov/delta/data/skt/DisplayMaps.asp



Source: Speegle (pers. comm.). Note that typical daily sampling frequency is fifteen 10-minute trawls.

Figure 17. Daily Number of Delta Smelt Collected During Kodiak Trawling at Jersey Point on the San Joaquin River, February-March 2014.

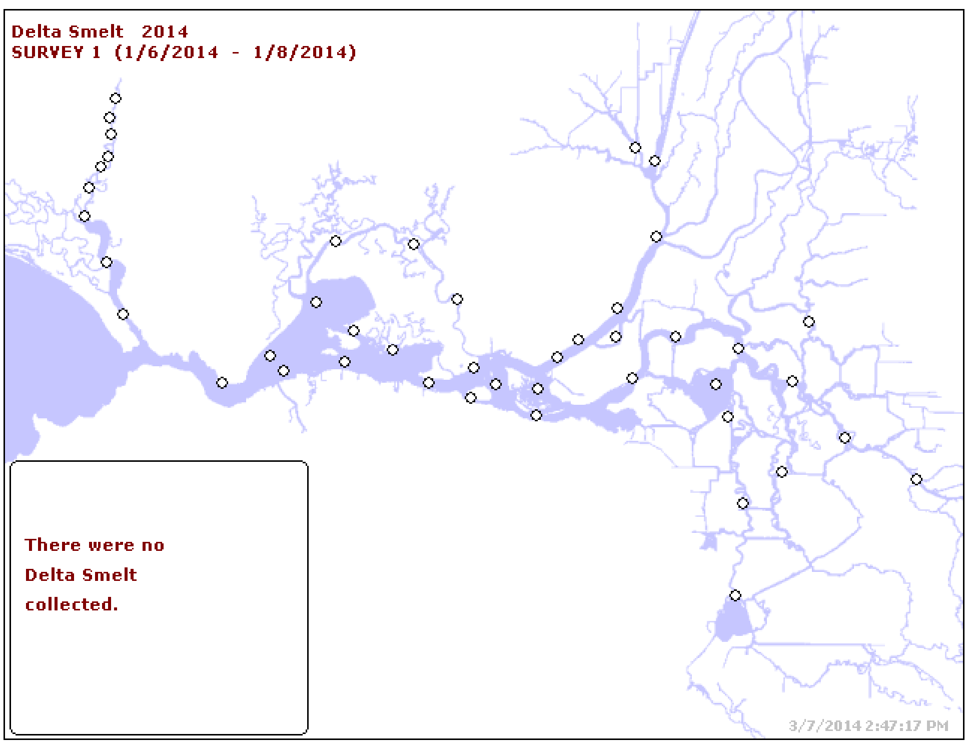


Figure 18. Larval Delta Smelt Density from Smelt Larva Survey 1 of 2014. Source: http://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

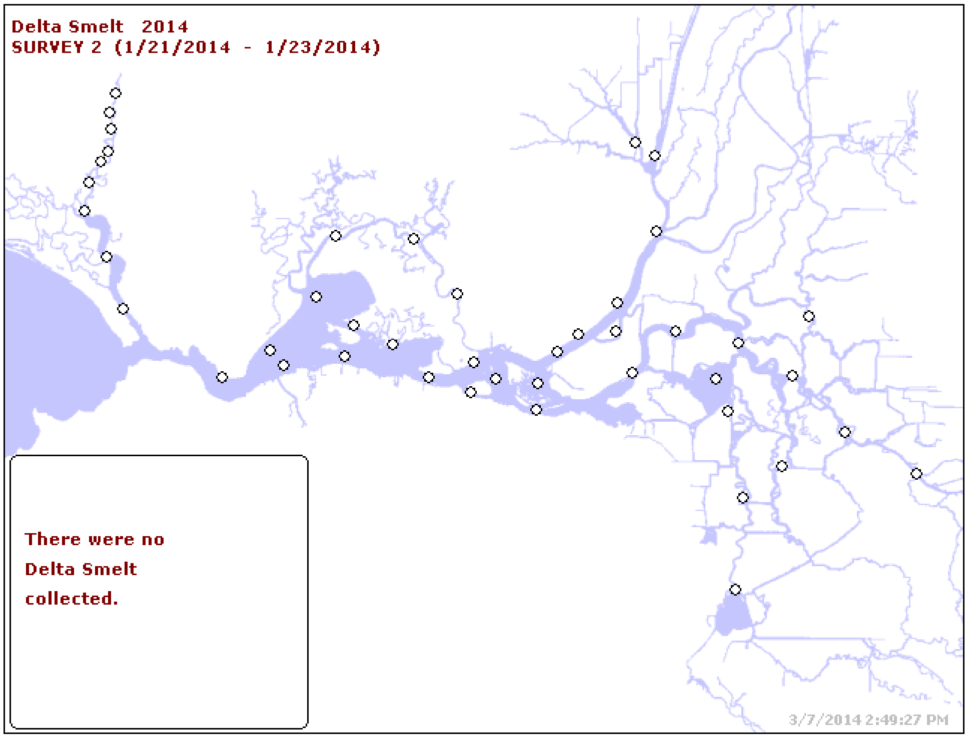


Figure 19. Larval Delta Smelt Density from Smelt Larva Survey 2 of 2014. Source: http://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

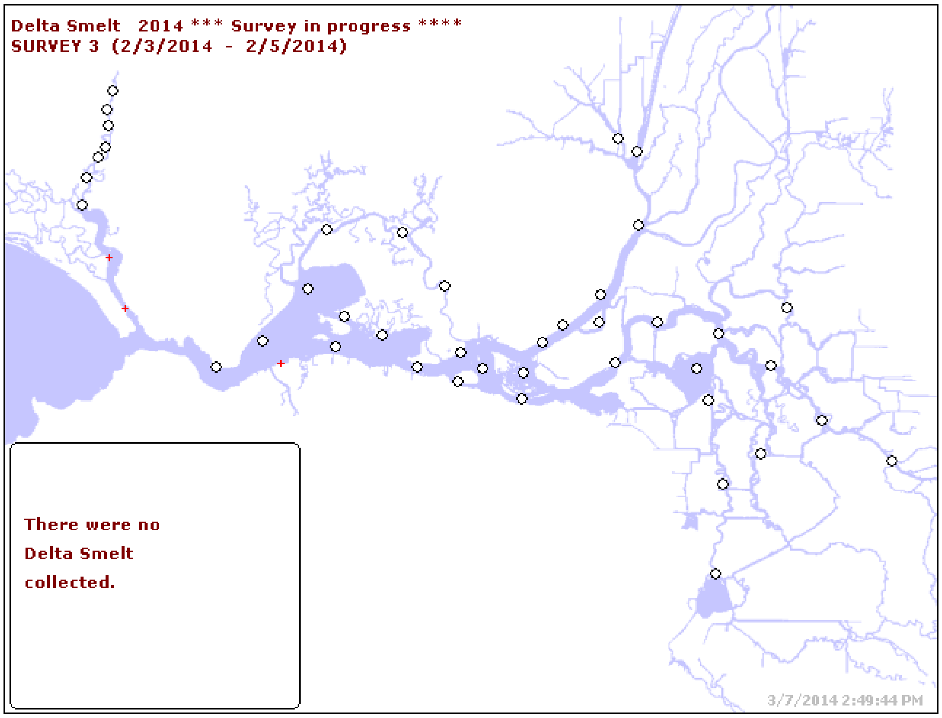


Figure 20. Larval Delta Smelt Density from Smelt Larva Survey 3 of 2014. Source: http://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

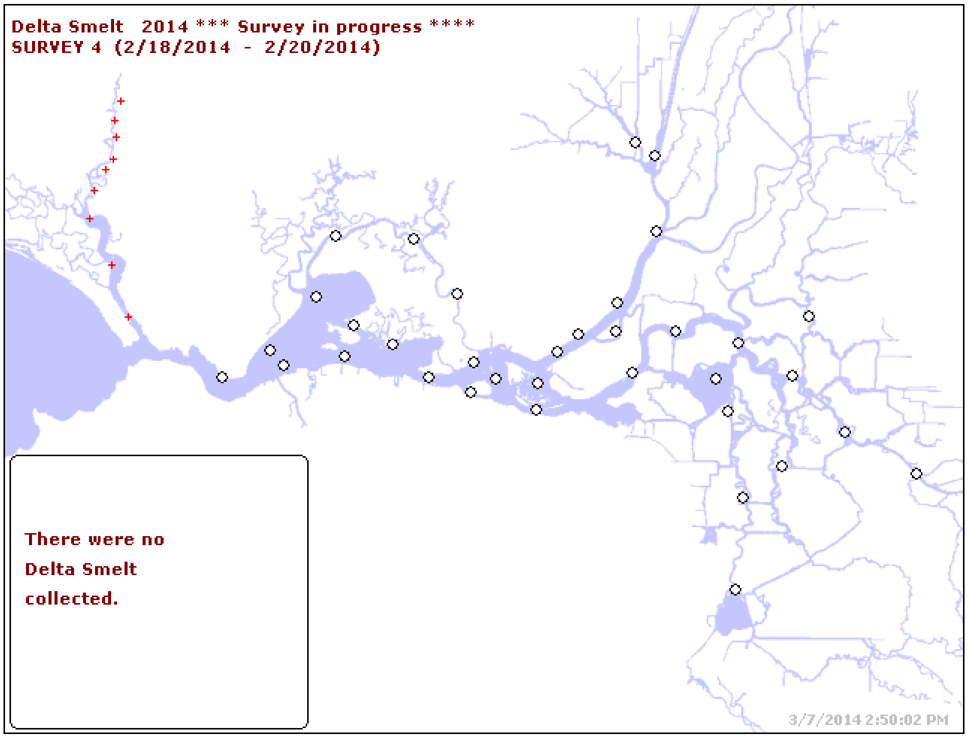


Figure 21. Larval Delta Smelt Density from Smelt Larva Survey 4 of 2014. Source: http://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp

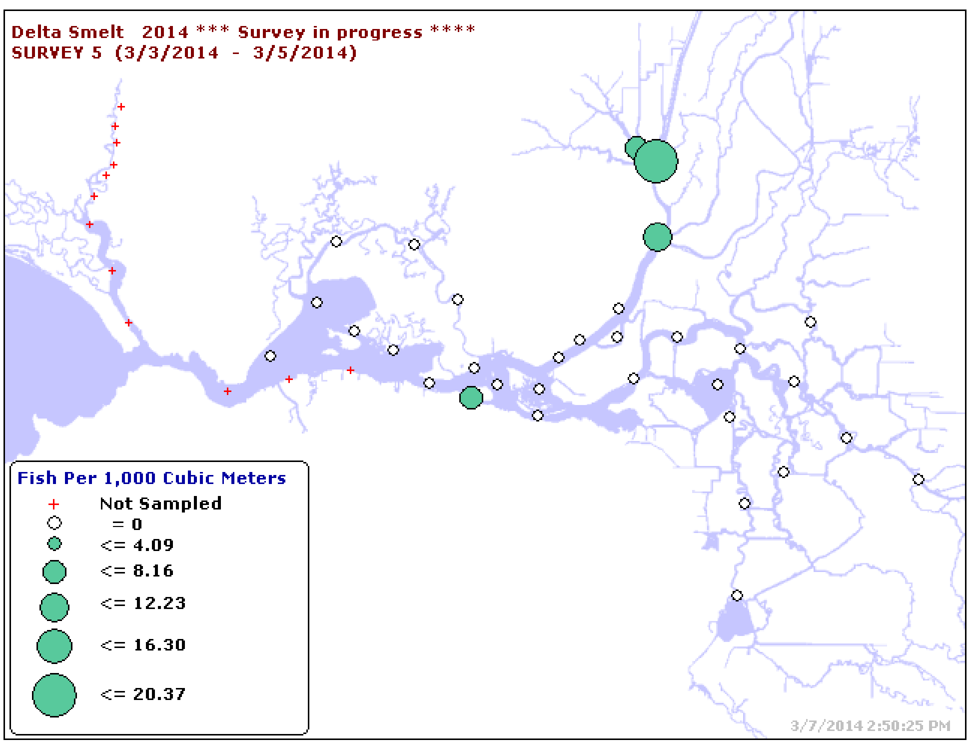
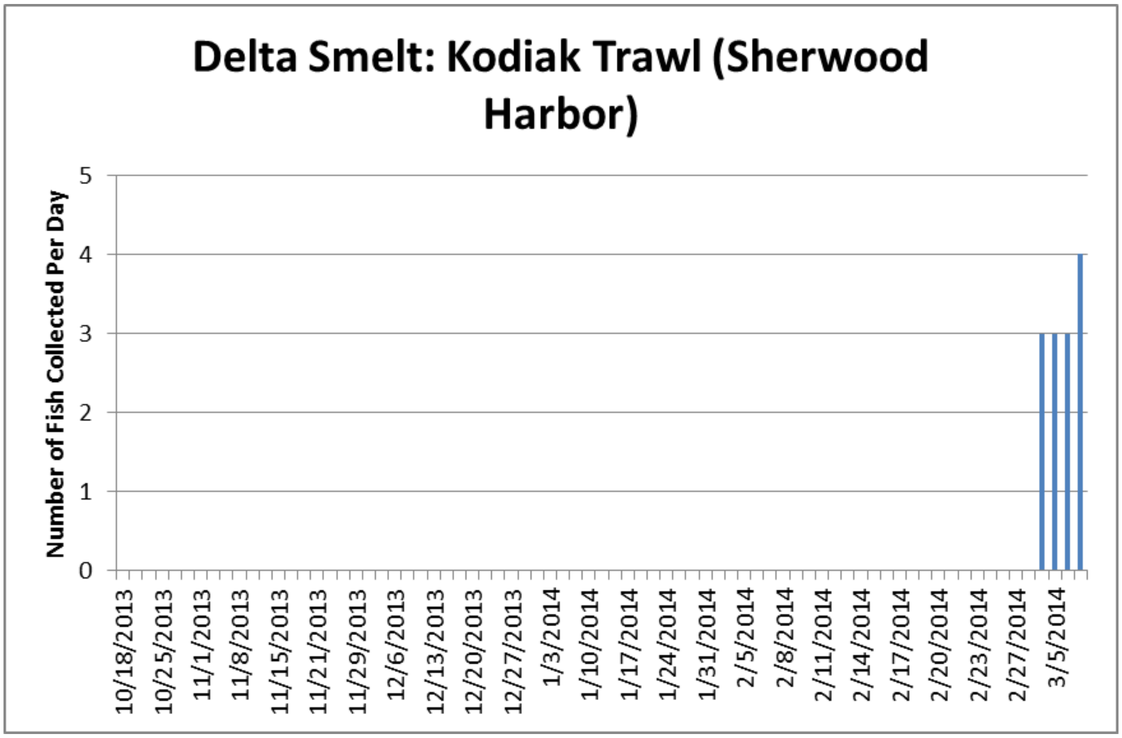


Figure 22. Larval Delta Smelt Density from Smelt Larva Survey 5 of 2014. Source: http://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp



Source: Speegle (pers. comm.). Note that typical daily sampling frequency is ten 20-minute trawls.

Figure 23. Daily Number of Delta Smelt Collected During Kodiak Trawling at Sherwood Harbor on the Sacramento River, October-March 2014.

- sound data taken during the 2012 installation of rock barriers as part of the TBP showed that noise levels at 100m from construction were below the NMFS criteria for adverse behavioral effects (Shields 2012), suggesting that the area of construction effects would be relatively small;
- the effects of noise on fish would likely be limited to avoidance behavior in response to movements, noises, and shadows caused by construction personnel and equipment operation in or adjacent to the river;
- most fish are expected to move away from the area of disturbance;

  DWR would employ a number of conservation measures to limit the potential for take (see Conservation Measures section).

Operations Effects on Fish

Chinook Salmon and Central Valley Steelhead

As outlined in the Project Description, operation of the EDB would commence following construction, i.e., approximately May 1, 2014. As described in the Environmental Baseline section, historic data suggest that this timeframe has relatively little overlap with the occurrence of juvenile listed salmonids from the Sacramento River basin (Table 9), but there may be some individuals occurring at this time. In addition, listed adult Chinook salmon may occur during the early operations and adult steelhead may occur in greatest numbers during the latter part of the operational period (see Environmental Baseline section).

Operational effects of the EDB are discussed in relation to hydrodynamic effects, water quality effects, and near-field predation effects.

Hydrodynamic Effects

The main hydrodynamic effects of the EDB on Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Central Valley steelhead would be altered flow routing in the lower Sacramento River leading to changes in seaward migration pathways for juveniles. There may be changes to juvenile salmonid entrainment susceptibility at the South Delta export facilities because of changes in tidal hydraulics in the lower San Joaquin River caused by the West False River barrier acting in concert with more flow entering the interior Delta through Georgiana Slough and the DCC. In addition, the EDB may result in delays for upstream migrating adult Chinook salmon. Each of these mechanisms is discussed separately.

Juvenile Migration Pathways

Operation of the Sutter and Steamboat slough barriers would block most flow entering these divergences from the Sacramento River. Studies of acoustically tagged late fall-run Chinook salmon smolts have shown that these fish generally enter divergences at approximately the same proportion as the proportion of flow entering the divergences (Perry et al. 2010). These studies have shown that there is a lower probability of survival for fish taking the Georgiana Slough or DCC pathways to Chipps Island than for fish taking the Sacramento River or Steamboat Slough pathways; Sutter Slough survival generally is intermediate (Table 11). Rescaling survival for each release event to the maximum observed in each event (last column of Table 11) for the events in which Sutter and Steamboat slough survival pathways were separately estimated shows that with the DCC open, the mean survival in the Steamboat Slough and Sacramento Rivers was greatest, and on average was nearly double that of the Sutter Slough pathway; survival down the Georgiana Slough pathway was slightly less than that of the Sutter Slough pathway, and the DCC pathway had by far the lowest survival (Table 12). With the DCC closed, there was much less difference between the Sutter Slough and Sacramento River/Steamboat Slough pathways, while survival down the Georgiana Slough pathway was considerably lower than all of the other pathways. These results generally were consistent with the results for late-fall run Chinook salmon and steelhead observed by Singer et al. (2013), although these authors did not separate survival in the Sutter/Steamboat or Georgiana Slough/DCC pathways (Table 13).

Two related actions that are not part of the EDB would influence potential outcomes of EDB operations, as noted in the section on Environmental Baseline Conditions Specific to 2014. First, contingency planning by NMFS for drought conditions has included a proposal for potential diurnal operation of the DCC (i.e., closure of the DCC gates at night). The foundation for this potential action lies in the work of Plumb et al. (2014), who found that the large majority (83%) of acoustically tagged late fall-run Chinook salmon released at Sacramento over the 24-hour cycle in 10 events between November 11, 2008, and January 19, 2009, arrived at the DCC at night. The probability of nighttime arrival was negatively related to both the proportion of diel Sacramento River flow above DCC that was reversed (moving upstream) and to Sacramento River flow below Georgiana Slough, and was positively related to water temperature. For fish arriving at the DCC, the probability of entrainment into the DCC was negatively related to Sacramento River flow below Georgiana Slough (with very high probability of entrainment during reversing flows) and positively related to change in river flow; there was no effect of the diel period on probability of entering the DCC. Plumb et al. (2014) combined the two elements of their investigation in order to estimate the joint probability of arriving by day or

Table 11. Survival to Chipps Island and Migration Pathway Use By Acoustically Tagged Late Fall-Run Chinook Salmon Juveniles

Source	Migration pathway, release date	Survival	SE	Pathway use	SE	Proportion of max. survival by release
Perry et al. (2010)	Sac. R., 12/5/06	0.443	0.146	0.352	0.066	1.000
Perry et al. (2010)	Sutter/Steamboat Sl., 12/5/06	0.263	0.112	0.296	0.062	0.594
Perry et al. (2010)	DCC, 12/5/06	0.332	0.152	0.235	0.059	0.749
Perry et al. (2010)	Geo. Sl., 12/5/06	0.332	0.179	0.117	0.045	0.749
Perry et al. (2010)	Sac. R., 1/17/07	0.564	0.086	0.498	0.060	1.000
Perry et al. (2010)	Sutter/Steamboat Sl., 1/17/07	0.561	0.092	0.414	0.059	0.995
Perry et al. (2010)	DCC, 1/17/07	NA	NA	0.000	0.000	NA
Perry et al. (2010)	Geo. Sl., 1/17/07	0.543	0.200	0.088	0.034	0.963
Perry(2010)	Sac. R., 12/07	0.283	0.054	0.387	0.044	1.000
Perry(2010)	Sutter/Steamboat Sl., 12/07	0.136	0.039	0.345	0.042	
Perry(2010)	Sutter Sl., 12/07	0.107	0.037	0.230	0.037	0.378
Perry(2010)	Steamboat Sl., 12/07	0.193	0.060	0.115	0.028	0.682
Perry(2010)	DCC, 12/07	0.041	0.021	0.117	0.029	0.145
Perry(2010)	Geo. Sl., 12/07	0.087	0.028	0.150	0.033	0.307
Perry(2010)	Sac. R., 1/08	0.244	0.048	0.490	0.048	0.853
Perry(2010)	Sutter/Steamboat Sl., 1/08	0.245	0.059	0.198	0.037	
Perry(2010)	Sutter Sl., 1/08	0.192	0.070	0.086	0.026	0.671
Perry(2010)	Steamboat Sl., 1/08	0.286	0.070	0.112	0.029	1.000
Perry(2010)	DCC, 1/08	NA	NA	0.000	0.000	NA
Perry(2010)	Geo. Sl., 1/08	0.086	0.023	0.311	0.045	0.301
Perry(2010)	Sac. R., 12/08	0.448	0.053	0.392	0.040	0.709
Perry(2010)	Sutter/Steamboat Sl., 12/08	0.394	0.056	0.321	0.037	
Perry(2010)	Sutter Sl., 12/08	0.281	0.061	0.217	0.033	0.445

Source	Migration pathway, release date	Survival	SE	Pathway use	SE	Proportion of max. survival by release
Perry(2010)	Steamboat Sl., 12/08	0.632	0.059	0.104	0.025	1.000
Perry(2010)	DCC, 12/08	0.117	0.048	0.224	0.045	0.185
Perry(2010)	Geo. Sl., 12/08	0.315	0.054	0.164	0.164	0.498
Perry(2010)	Sac. R., 1/09	0.398	0.051	0.459	0.043	0.913
Perry(2010)	Sutter/Steamboat Sl., 1/09	0.432	0.067	0.253	0.036	
Perry(2010)	Sutter Sl., 1/09	0.426	0.086	0.096	0.024	0.977
Perry(2010)	Steamboat Sl., 1/09	0.436	0.075	0.158	0.030	1.000
Perry(2010)	DCC, 1/09	NA	NA	0.000	0.000	NA
Perry(2010)	Geo. Sl., 1/09	0.163	0.033	0.288	0.040	0.374
Perry et al. (2012)	Sac. R., 12/2-5/09	0.584	0.057	0.512	0.048	0.954
Perry et al. (2012)	Sutter/Steamboat Sl., 12/2-5/09	0.446	0.076	0.223	0.039	
Perry et al. (2012)	Sutter Sl., 12/2-5/09	0.336	0.090	0.134	0.032	0.549
Perry et al. (2012)	Steamboat Sl., 12/2-5/09	0.612	0.077	0.089	0.027	1.000
Perry et al. (2012)	DCC, 12/2-5/09	0.236	0.080	0.038	0.019	0.386
Perry et al. (2012)	Geo. Sl., 12/2-5/09	0.248	0.047	0.227	0.041	0.405
Perry et al. (2012)	Sac. R., 12/16-19/09	0.510	0.059	0.392	0.045	1.000
Perry et al. (2012)	Sutter/Steamboat Sl., 12/16-19/09	0.345	0.061	0.319	0.043	
Perry et al. (2012)	Sutter Sl., 12/16-19/09	0.302	0.065	0.243	0.044	0.592
Perry et al. (2012)	Steamboat Sl., 12/16-19/09	0.483	0.087	0.076	0.028	0.947
Perry et al. (2012)	DCC, 12/16-19/09	NA	NA	0.000	0.000	NA
Perry et al. (2012)	Geo. Sl., 12/16-19/09	0.223	0.040	0.289	0.042	0.437
Perry et al. (2012)	Sac. R., 1/31/10	0.485	0.059	0.449	0.045	0.951
Perry et al. (2012)	Sutter/Steamboat Sl., 1/31/10	0.468	0.062	0.447	0.049	
Perry et al. (2012)	Sutter Sl., 1/31/10	0.432	0.079	0.242	0.091	0.847

Source	Migration pathway, release date	Survival	SE	Pathway use	SE	Proportion of max. survival by release
Perry et al. (2012)	Steamboat Sl., 1/31/10	0.510	0.084	0.205	0.085	1.000
Perry et al. (2012)	DCC, 1/31/10	NA	NA	0.000	0.000	NA
Perry et al. (2012)	Geo. Sl., 1/31/10	0.179	0.074	0.104	0.022	0.351
Perry et al. (2012)	Sac. R., 2/5/10	0.577	0.043	0.600	0.038	0.937
Perry et al. (2012)	Sutter/Steamboat Sl., 2/5/10	0.550	0.061	0.221	0.030	
Perry et al. (2012)	Sutter Sl., 2/5/10	0.508	0.076	0.135	0.027	0.825
Perry et al. (2012)	Steamboat Sl., 2/5/10	0.616	0.071	0.086	0.022	1.000
Perry et al. (2012)	DCC, 2/5/10	NA	NA	0.000	0.000	NA
Perry et al. (2012)	Geo. Sl., 2/5/10	0.314	0.075	0.179	0.030	0.510

Table 12. Mean Proportion of Maximum Pathway Survival By Acoustically Tagged Late Fall-Run Chinook Salmon Juveniles, Based on Release Events For Which Sutter and Steamboat Slough Survival Were Calculated Separately

Pathway	DCC Open (N = 3)	DCC Closed (N = 5)
Sac R.	0.888	0.931
Sutter Sl.	0.457	0.782
Steamboat Sl.	0.894	0.989
DCC	0.239	NA
Geo Sl.	0.404	0.395

Source: Data in Table 11

Table 13. Proportional Survival and Pathway Use of Acoustically Tagged Steelhead and Late Fall-Run Chinook Salmon[a]

		Steelhead		Chinook Salmon	
Pathway		2009	2010	2009	2010
Sutter/Steamboat b	Proportion using pathway	0.23	0.29	0.21	0.32
	Survival to ocean	0.10	0.30	0.30	0.31
Interior Delta[c]	Proportion using pathway	0.17	0.19	0.15	0.14
	Survival to ocean	0.19	0.10	0.09	0.16
Mainstem Sacramento River[d]	Proportion using pathway	0.60	0.52	0.64	0.54
	Survival to ocean	0.25	0.33	0.20	0.26

a Reported by Singer et al. (2013).
b Originally called West Delta by Singer et al. (2013).
c Originally called East Delta (i.e., Georgiana Slough and DCC).
d Originally called Mainstem.

night and being entrained into the DCC, based on the environmental conditions that occurred from November 2008 to March 2009. They found that the joint probability of arriving by day and being entrained into the DCC averaged about 0.06 (6%), whereas the joint probability of arriving by night and being entrained into the DCC averaged about 0.19 (19%). These results reflected both the greater probability of arriving at night and also the fact that tidal/diel asymmetry results in more flow entering the DCC during the day. The results of the study implied that closure of the DCC by night therefore would lessen the 19% entrainment risk into DCC to around 6%. However, as Plumb et al. (2014) noted, caution is warranted when applying these specific findings because of juvenile Chinook salmon plasticity in diel activity patterns (i.e., the patterns observed in the study may not be fixed), specific environmental conditions that may differ depending on the time of year (e.g., water temperature, turbidity, and predation risk), life stage (fry, parr, or smolt), and salmonid characteristics (species, origin [hatchery or wild], and run type). Thus, although a separate study by Chapman et al. (2013) found that late-fall run Chinook salmon in the Delta undertook ~70% of their migration at night (corroborating the results of Plumb et al. 2014), the same study indicated that steelhead in the Delta were only slightly more nocturnal (53%) than diurnal in their migration (albeit a statistically significant difference).

Also relevant to consideration of EDB operations effects on juvenile salmonid migration pathways is the operation of the 2014 Georgiana Slough Floating Fish Guidance Structure (FFGS). Should preliminary results from this study suggest that the FFGS holds promise for deterring fish from entering Georgiana Slough, DWR will leave the FFGS installed until the main juvenile salmonid migration period ends in June. During the FFGS test period (March-May), the FFGS will be operated on an approximately 25-hour cycle, then withdrawn to the side of the channel, in order to assess differences in entrainment into Georgiana Slough between the operating and non-operating positions. Concerns over the loss of study fish into the DCC should it be opened during the Georgiana Slough FFGS test period have prompted DWR to request agency permission to install a second FFGS at the mouth of the DCC; this may reduce entrainment into the DCC.

To illustrate the potential operational effect of Sutter and Steamboat slough barriers increasing the proportion of downstream migrating juvenile Chinook salmon remaining in the main stem Sacramento River (and therefore being susceptible to entrainment into the DCC and Georgiana Slough), relative survival values presented in Table 12 were related to the proportion of flow that would pass through each migration pathway (Sutter Slough, Steamboat Slough, Sacramento River main stem, DCC, and Georgiana Slough), making the simplifying assumption of fish moving proportionally with flow splits. Overall survival was calculated from the mean survival down all pathways weighted by the proportion of flow moving through each pathway. A range of potential Sacramento River flows at Freeport was examined (5,000-15,000 cubic feet per second [cfs]). Effects of the DCC being open or closed also were assessed. The effects of installing the Sutter and Steamboat slough barriers together as well as the Sutter Slough barrier alone; this was done to explore the potential benefits of phasing installation, e.g., blocking off the pathway with lower survival (Sutter Slough; see Table 12) prior to installing the Steamboat Slough barrier. Potential effectiveness of Georgiana Slough and DCC FFGS were examined with sensitivity analyses, assuming low (10%) or high (50%) effectiveness for deterring fish from these divergences when the DCC was open. Finally, Development of the flow-split equations used in the analysis is discussed in Appendix B. It is important to note that the analysis is intended to be illustrative of potential differences between scenarios and not predictive. There are a number of uncertainties because the survival data used to develop the survival estimates differ in a number of respects from the situation to which they are being applied, e.g., season (winter vs. spring), race of salmon (late fall-run vs. winter-run and spring-run), origin of salmon (hatchery vs. wild). These caveats aside, it is assumed that the available provide at least a relative sense of potential differences between scenarios.

The analysis illustrated that the calculated relative survival with no EDB and DCC open ranged from 0.44 at 5,000 cfs to 0.56 at 15,000 cfs, which was appreciably less than relative survival with no EDB and DCC closed (range from 0.71 to 0.79) (Figure 24). With the DCC open, there was comparatively little difference in relative survival between no EDB (range 0.44-0.56) and both Sutter and Steamboat slough barriers operating (range 0.44-0.53); operation of only the Sutter Slough barrier gave slightly greater relative survival (0.48-0.61) than no EDB. This reflects the exclusion of fish from the poor-survival Sutter Slough pathway, as well as Sacramento River flow not being lost to Sutter Slough, which would give a greater proportion of flow (and fish) entering the high-survival Steamboat Slough route. Relatively more Sacramento River approaching DCC and Georgiana Slough results in a relatively lower proportion of flow entering these divergences (see Appendix B). With the DCC closed, there was less relative difference between the three scenarios (no EDB, Sutter Slough barrier only, and Sutter and Steamboat slough barriers combined) (Figure 24). Overall, these

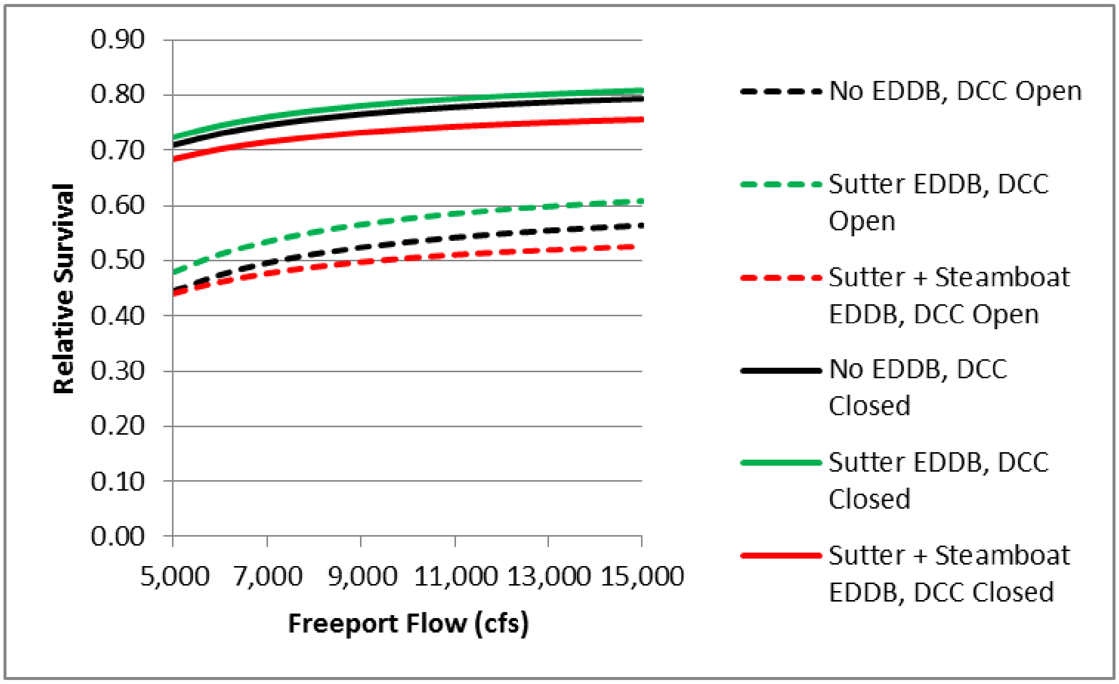


Figure 24. **Relative Survival of Chinook Salmon Juveniles For Different Combinations of Emergency Drought Barriers (EDB) and Delta Cross Channel Gates (DCC), Based on Application of Calculated Flow Splits to Survival Results from Perry (2010), Perry et al. (2010), and Perry et al. (2012).**

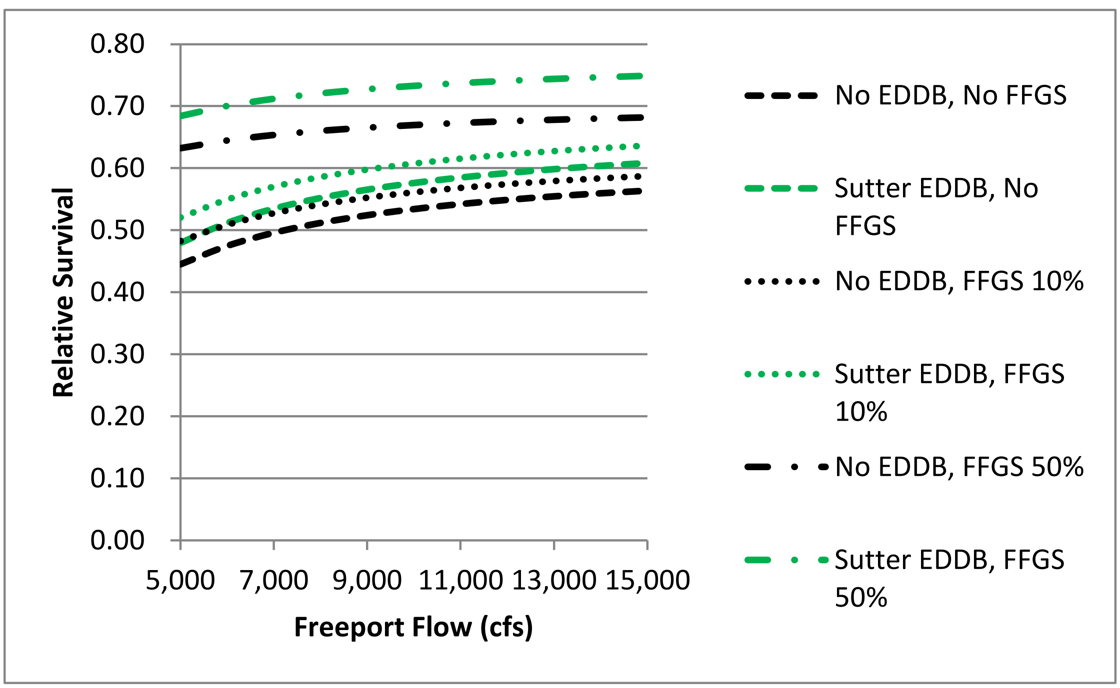


Figure 25. **Relative Survival of Chinook Salmon Juveniles In Relation to Floating Fish Guidance Structures at Delta Cross Channel and Georgiana Slough (10% or 50% Exclusion of Fish) For No Emergency Drought Barriers (No EDB) and the Sutter Slough Barrier (Delta Cross Channel Gates Open in All Cases), Based on Application of Calculated Flow Splits to Survival Results from Perry (2010), Perry et al. (2010), and Perry et al. (2012).**

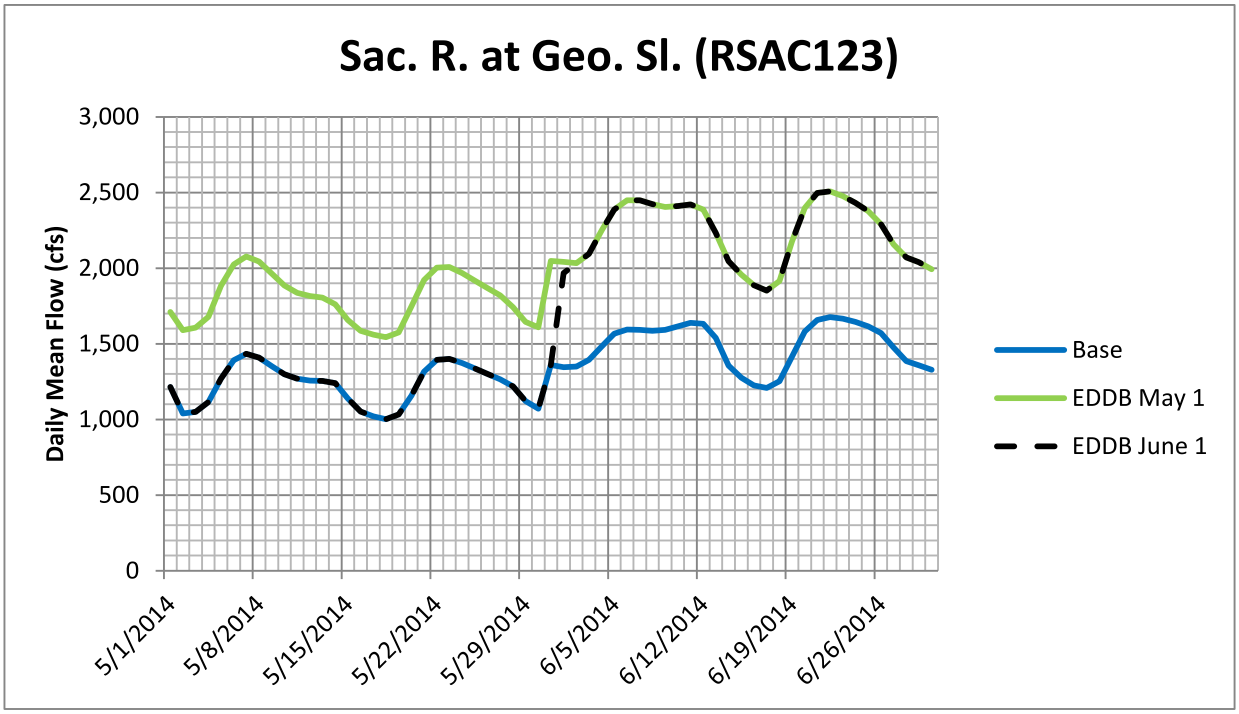
results suggested that operation of both Sutter and Steamboat slough barriers at the same time could give somewhat lower relative survival of Chinook salmon juveniles than with no EDB, whereas operating the Sutter Slough barrier alone could result in slightly higher relative survival compared to no EDB. Further discussion of potential phasing of barrier installation is provided in the Conservation Measures section. Should drought contingency operations include diurnal operation of the DCC, the results from the analyses of DCC closed should receive more weight, given the greater proportion of migrating juveniles that could pass through the action area by night (Chapman et al. 2013; Plumb et al. 2014).

The sensitivity analysis of the potential exclusion of fish from Georgiana Slough and DCC by FFGS illustrated the change in relative survival from 10% and 50% exclusion (Figure 25). With no EDB, relative survival was 0.44-0.56 with no FFGS, 0.48-0.59 with an FFGS excluding 10% of fish from entering Georgiana Slough and DCC, and 0.63-0.68 with 50% exclusion from Georgiana Slough and DCC. Similarly, relative survival with the Sutter Slough barrier only and no FFGS was 0.48-0.61, which compared to 0.52-0.64 with 10% FFGS exclusion and 0.68-0.75 with 50% FFGS exclusion (Figure 25).

The foregoing analysis only includes the effects of the barriers at Sutter and Steamboat sloughs on flow in terms of changing the probability that a migrating salmonid juvenile would take a particular pathway, i.e., because of changing flow splits. Changes in flow could also affect survival probability within individual reaches, e.g., by changing residence time and velocity, which could affect probability of predation. For example, Perry (2010; see his Figures 5.7 and 5.8) found evidence of the probability of survival along the main stem Sacramento River from Georgiana Slough/DCC to Chipps Island increasing with increasing flow. DSM2-HYDRO modeling based on the February forecast for operations and 90% exceedance hydrology[6], with DCC open in May and June, suggested that flow in the Sacramento River at Georgiana Slough would be greater under EDB than a base case without EDB; this reflects the presence of the Sutter and Steamboat slough barriers (Figure 26). As described in the Hydrodynamic Effects on delta smelt presented later herein, the EDB may provide a slight benefit to fish in the lower San Joaquin River near False River and Old River, by increasing net flow towards Antioch; this would reduce the risk of entrainment into the south Delta.

Conceptually, the analysis of flow splits and differential survival based on migration pathways described above is a simpler version of the more formal statistical treatment by Perry et al. (2013), who conducted sensitivity analysis of the effects on through-Delta survival of changing the proportion of fish entering Sutter/Steamboat sloughs (combined) and Georgiana Slough/DCC (combined), based on the data from 2006-2007, 2007-2008, and 2008-2009 shown in Table 11. They found varying effects of changing the proportion of fish entering Sutter/Steamboat sloughs: for two releases (December 2006 and December 2007), eliminating fish entry into Sutter and Steamboat sloughs resulted in higher through-Delta survival (10-11% in relative terms); for another two releases (January 2008 and January 2009), eliminating fish entry into Sutter and Steamboat sloughs resulted in lower through-Delta survival (6-9% in relative terms); for the remaining two releases (January 2007 and December 2008), there was only a small positive change (2-3% in relative terms) in through-Delta survival with elimination of entry into Sutter/Steamboat sloughs. Note, however, that the analysis by Perry et al. (2013) did not attempt to change survival down each pathway in response to potential changes in environmental conditions (e.g., there was no assumption about flow being kept in the main stem Sacramento River, as would be the case with

[6] Discussion of this scenario is provided in Appendix C.



Source: Smith, pers. comm. Note: EDB May 1 and EDB June 1 assume EDB operations commence May 1 and June 1, respectively.

Figure 26. Forecasted Mean Daily Flow at Jersey Point in May and June 2014, from DSM2-HYDRO Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.

physical barrier such as those proposed under the EDB; as described above, positive flow-survival relationships have been found for some reaches in the action area [Perry 2010]). Nor did Perry et al. (2013) change the flow proportion at the Georgiana Slough/DCC junction with the Sacramento River in response to changing flow in the Sacramento River that could be caused by physical barriers. The analysis by Perry et al. (2013) thus perhaps best illustrated the effects on total survival from changes in fish pathways that might occur with non-physical barriers that do not alter flow routing through the Action Area. The analysis nonetheless provides a detailed and important illustration of the importance of both a) survival differences between different reaches of the Action Area, and b) the proportion of fish approaching divergences that lead to pathways with greatly different survival (e.g., Georgiana Slough/DCC).

Adult Migration Pathways

Adult Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Central Valley steelhead may experience migratory delays because of the operation of the EDB, in particular because of the Sutter and Steamboat slough barriers. In contrast to juvenile salmonids, there are few data assessing migratory pathways taken by adult salmonids through the Action Area. Stein and Cuetara (2004) discussed the results of a preliminary study in which adult Chinook salmon were tagged during October-November 2003 to assess the effects of the Suisun Marsh Salinity Control gates (see Vincik 2013 for more details) and examine passage through different pathways within the Delta. Of 66 adult Chinook salmon entering the Delta, a large proportion entered the Cache Slough complex, possibly because of the greater channel cross-section and tidal flows entering that location, relative to the main stem Sacramento River (Figure 27). Stein and

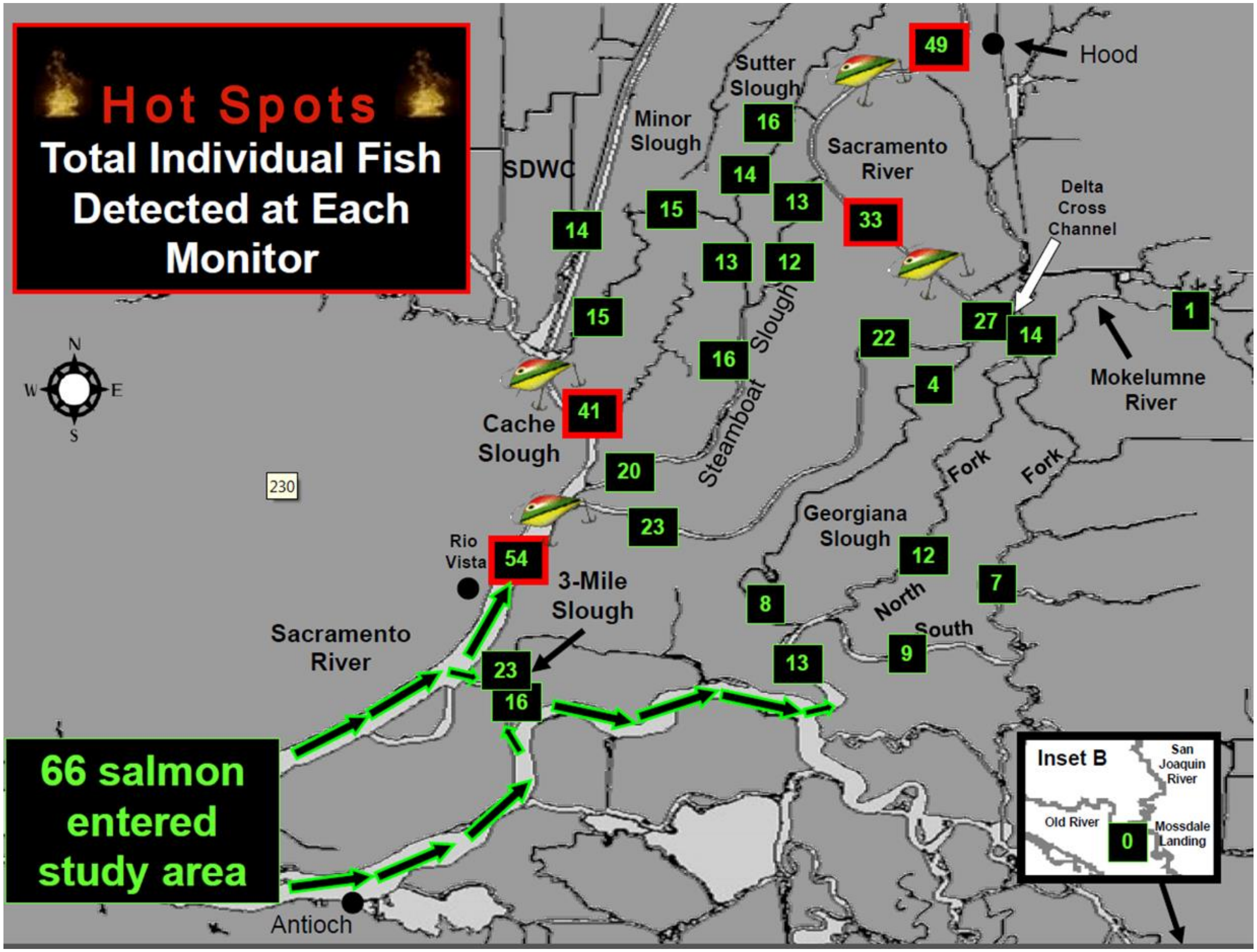
Cuetara (2004) noted that many fish entering the Cache Slough complex subsequently returned to Rio Vista. Sixteen of the original 66 tagged adults were detected near the proposed Sutter Slough barrier location and 13 of the fish were detected near the proposed Steamboat Slough barrier location (Figure 27). Although it is unclear to what extent migratory movements in these waterways could be influenced by changes in river flow moving downstream (e.g., less movement into the sloughs when the barriers are operating, perhaps because of less of an olfactory stimulus from upstream), there is the potential for migratory delay based on the available information for adult Chinook salmon movement through the Action Area. Presumably similar migratory behavior may occur in Central Valley steelhead, with a similar potential for adverse effects from migratory delay.

Forty-eight-inch-diameter culverts would be included in the Sutter and Steamboat slough barriers. For each barrier, one culvert would be left open at all times to facilitate upstream adult fish passage, as described in the Conservation Measures section. Monitoring of the culverts would occur to assess migratory delay and successful passage, e.g., using Dual-Frequency Identification Sonar (DIDSON). Unanticipated maintenance needs, including debris removal, may require slide gate closures of the culverts when they otherwise would be open. Water velocity through the culverts would vary based on river flow and tidal flow, with higher velocities at low tides and lower velocities at high tides. In 2007, water velocity through the barrier culverts at the head of Old River was monitored with readings every 15 minutes (DWR 2012a). Measured water velocities ranged from around 3 feet per second (ft/s) up to 8 ft/s and daily fluctuations were as high as 3 ft/s.

DSM2-HYDRO modeling based on the February forecast (see further discussion below), and assuming Sutter and Steamboat Slough barriers installed on May 1 (with flow through all culverts), gave estimates of mean daily stage differences upstream and downstream of the barriers in Sutter and Steamboat Sloughs. Based on data for May 1-June 30, 2014 (Liu, pers. comm.), the median of the difference in daily mean stage upstream and downstream of the barriers was 0.53 feet (range 0.44-0.67 feet) for Steamboat Slough and 0.52 feet (range 0.45-0.64 feet) for Sutter Slough. Assuming that these stage differences are a reasonable representation of head differences upstream and downstream of the barrier, and estimating flow for each 80-foot-long, 4-foot-diameter culvert using the equation of flow in culverts from Brater and King (1976: 4-23)[7], gives estimates of median culvert velocity (flow/area of culvert) of 3.4 ft/s (range 3.1-3.8 ft/s) for the Steamboat Slough barrier and 3.4 ft/s (range 3.1-3.7 ft/s) for the Sutter Slough barrier. As noted above, these estimates are for all four culverts being open. Estimates of stage differences are not available for the opening of a single culvert, but are available for no culverts being open; applying these stage differences to the equation estimating flow through the culverts gives median velocity estimates of 3.9 ft/s (range 3.5-4.4 ft/s) for the Steamboat Slough barrier and 4.0 ft/s (range 3.6-4.5 ft/s) for the Sutter Slough barrier.

Bell (1973) reported sustained swimming speeds for Chinook salmon to be up to 3.4 ft/s, prolonged swimming speeds (fatigue after 15 seconds to 200 minutes) to be from 3.4-10.8 ft/s and burst speeds (fatigue in less than 15 seconds) of up to 22.4 ft/s. Based on this information adult Chinook salmon and steelhead could swim through the open culverts at the range of velocities observed at the head of Old River and estimated from DSM2-HYDRO modeling for the Sutter and Steamboat

[7] The equation is $Q = Ca(2gh)^{0.5}$, where C = coefficient of discharge, a = area of culvert (12.566 ft^2 for EDB), h = head difference across the barrier, L = length of culvert pipe (80 feet for the EDB), and d = diameter of pipe (4 feet for the EDB). The coefficient of discharge for corrugated metal pipes is $C = (1+0.16d^{0.6} + (0.106L/d^{1.2})^{-0.5}$.



Source: Stein and Cuetara (2004).

Figure 27. Number of Individual Acoustically Adult Chinook Salmon Detected at Hydrophones Deployed During October-November 2003

Slough barriers. As noted in the Conservation Measures section, monitoring (e.g., with DIDSON) would be used to assess anadromous adult fish upstream passage at the barriers.

Water Quality Effects

A reduction in the proportion of Sacramento River flow entering Sutter and Steamboat sloughs, coupled with reduced tidal action upstream of the barriers in these sloughs, may give poorer water quality in portions of these sloughs that are upstream of the barriers; monitoring of water quality (e.g., dissolved oxygen) would occur and culverts would be opened as necessary in order to improve water quality as necessary (see Conservation Measures section). More lentic conditions may increase the potential for predation by predatory fishes for any juvenile salmonids entering the upper portions of Sutter and Steamboat sloughs; however, fewer fish may enter the sloughs because most of the flow would be remaining in the Sacramento River.

Near-Field Predation Effects

Predatory fish may congregate below manmade barriers in rivers to feed on prey passing through the barriers. For example, Tucker et al. (1998) described the problem of relatively high predation of juvenile Chinook salmon below RBDD on the Sacramento River. Predatory fish (e.g., largemouth bass [*Micropterus salmoides*]) fitted with acoustic tags have been shown to associate with the head of Old River barrier that was installed in 2012 (DWR unpublished data), and predation rates of acoustically tagged Chinook salmon juveniles at or near the barrier were high. Because there is evidence that rock barriers attract predatory fish and may result in elevated rates of predation, juvenile Chinook salmon or steelhead present in the project area during the period when the barriers are operating may be more vulnerable to predation. This concern would be greatest for Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Central Valley steelhead emigrating down the Sacramento River that may enter Sutter and Steamboat sloughs and encounter the barriers in those locations; the West False River barrier location is less likely to be encountered by these species and may instead result in predation effects for some Central Valley steelhead emigrating from the San Joaquin River watershed.

The barriers in Steamboat and Sutter Sloughs would be removed entirely in November 2014, whereas the abutments (sheet piles and king piles) at the West False River barrier would be left in place. As noted in the Project Description, the sheet piles would extend approximately 75 feet from the levee into the river channel. These sheet piles would create hydrodynamic eddies and may create ambush habitat for predatory fishes, which could result in predation of listed salmonids that pass close to the barriers. Over time, presence of these sheet piles may cause accumulation of sediment and formation of shallow water areas near the sheet piles; depending on ambient velocity, such areas may be susceptible to colonization by submerged aquatic vegetation (particularly *Egeria densa*) and therefore could increase predation risk for juvenile salmonids passing close to these areas because of the association of predatory fishes such as largemouth bass with submerged aquatic vegetation.

Southern DPS of North American Green Sturgeon

The Southern DPS of North American green sturgeon could be affected by similar operational effects of the EDB as noted for listed salmonids, i.e., hydrodynamic effects (including blockage of migratory pathways), water quality effects, and near-field predation effects. Of the potential effects noted for salmonids, blockage of migratory pathways may be the most likely to give adverse effects because juvenile and sub-adult green sturgeon are relatively large and presumably are less susceptible to predation than juvenile salmonids.

Data for pre-spawning adult sturgeon (primarily white sturgeon) in the Sacramento River suggest that upstream migration ceases or fish move back downstream at flows below approximately 5,300 cfs (Schaffter 1997, as cited by Webber et al. 2007). Therefore, reductions in river flow down Sutter and Steamboat sloughs could affect stimuli for upstream migrating green sturgeon. The mostly demersal swimming behavior of green sturgeon is accounted for by the proposed inclusion of graded 2:1 rock slopes leading to the barrier culverts, which would be approximately 10-15 feet above the substrate. As described in the Conservation Measures section, these slopes are intended to facilitate passage for green sturgeon by increasing the probability of them finding the culvert openings. As described in the Conservation Measures section, monitoring of the culverts would occur to assess migratory delay and successful passage. Successful passage through the culverts would be a function of swimming ability. Investigations of adult white sturgeon swimming performance in a laboratory flume fitted with simulated fish-ladder-type partial baffles found that faster velocities (>1.5 ft/s) stimulated the fish to swim upstream, and that they could reach a swimming velocity greater than 8.3 ft/s. Such swimming velocity would be sufficient to pass through the culverts of the rock barriers if velocity was within the range observed at the head of Old River (3-8 ft/s; DWR 2012a) and estimated for the Sutter and Steamboat Slough barriers based on stage differences from DSM2-HYDRO modeling (see also previous discussion of Adult Migration Pathways for Chinook salmon and steelhead). The culverts at the barriers would be 80 feet long, which is somewhat longer than the distance that white sturgeon adults swam in short bursts during the flume trials of Webber et al. (2007). However, velocity in the flume trials varied along the length of the flume: Webber et al. (2007) concluded that successful white sturgeon passage would be facilitated by providing rapid-velocity sections (e.g., 2.75-8.2 ft/s) coupled with low-velocity sections (e.g., 1.67-2.2 ft/s). These data, if applicable to the southern DPS green sturgeon, confirm that migratory delay is a potential adverse effect of the EDB, even for fish attempting to pass through the culverts having located them in the barrier cross-section. This may be particularly true for juvenile and sub-adult green sturgeon, which would be smaller than the adult white sturgeon (135-198 cm TL) tested by Webber et al. (2007). As noted in the Conservation Measures section, monitoring (e.g., with DIDSON) would be used to assess anadromous adult fish upstream passage at the barriers.

Juvenile green sturgeon may reside in the Delta for extended periods and so could be affected by reduced water quality caused by restricted circulation because of the Sutter and Steamboat slough barriers. As described for salmonids, monitoring of water quality upstream and downstream of these barriers would be done in order to inform the need for opening culverts to improve circulation (see Conservation Measures section).

Delta Smelt

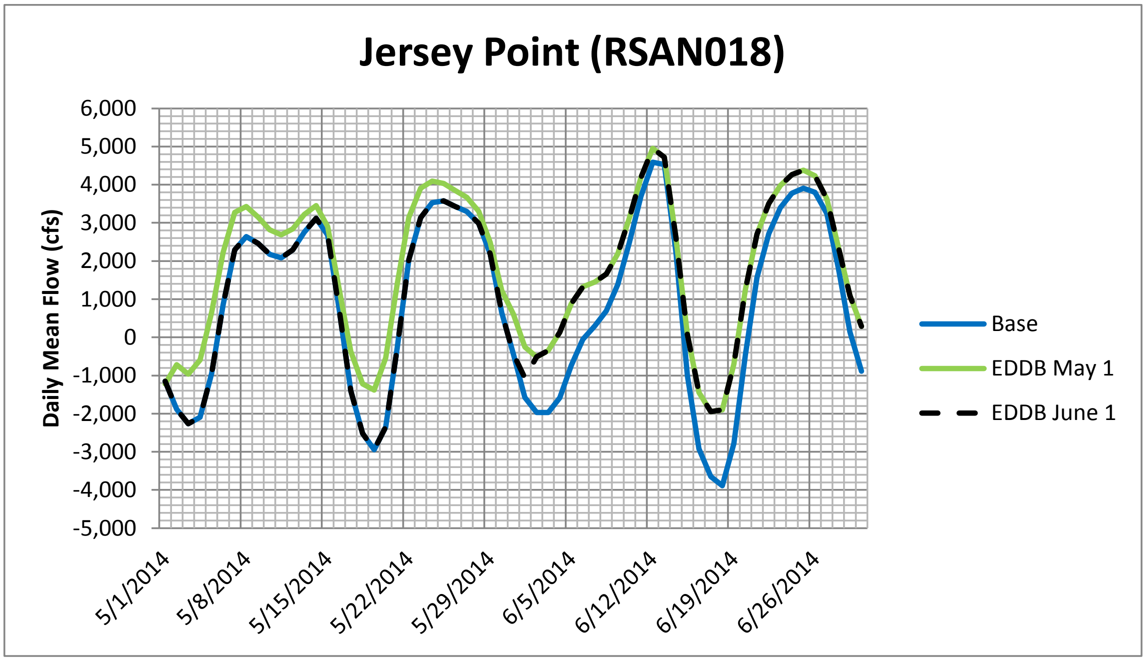
As described for Construction Effects, delta smelt may be more likely to occur in the vicinity of the West False River barrier than near the Sutter and Steamboat slough barriers. The Environmental Baseline section described that occurrence of delta smelt in the lower San Joaquin River was more frequent during the mature adult and earliest life stages, with relatively low occurrence during the juvenile and sub-adult life stages in summer/fall (Merz et al. 2011). Collection of delta smelt in the general vicinity of Steamboat and Sutter sloughs indicates that some individuals may be found near the Sutter and Steamboat slough barriers as well. In general, delta smelt would be expected to occur near to the barriers in spring and gradually move further downstream as they grow older (e.g., Dege and Brown 2004); however the species is distributed according to habitat features such as salinity, water temperature, and water clarity (e.g., Nobriga et al. 2008; Sommer and Mejia 2013). The low-salinity zone that is occupied by delta smelt is likely to be further upstream in summer/fall 2014 than in recent years because of low flow conditions.

Hydrodynamic Effects

Early operations of the EDB in May and June 2014 have the potential to reduce slightly the likelihood of entrainment of delta smelt larvae and juveniles occurring in the lower San Joaquin River toward the south Delta export facilities. The West False River barrier would reduce the potential for delta smelt to move through Franks Tract and into Old River. As described further in the subsequent Water Quality Effects section, recent modeling suggests that the potential for greater tidal flow up the lower San Joaquin River (between West False River and the mouth of Old River) is counteracted by more flow coming down the Mokelumne River because of the Sutter and Steamboat slough barriers. This is reflected in net flows at Jersey Point being higher with the EDB than a base case without the EDB, assuming DCC gates open in May and June together with 90% exceedance historical hydrology and forecasted operations[8]: with EDB operations commencing May 1, Jersey Point flow under EDB averages over 1,800 cfs in May, compared to around 990 cfs under the base case; in June, mean flow is just over 1,700 cfs for EDB and slightly below 700 cfs for the base case (Figure 28). Commencing EDB operations on June 1 simply keeps flows under EDB the same as the base case in May. Should the DCC gates be open in May and June, this also may result in a lower risk of entrainment for delta smelt in the lower San Joaquin River, based on results of particle tracking modeling for particles released in Georgiana Slough (see Figure 13C of Kimmerer and Nobriga 2008). Results of particle tracking modeling specific to the proposed configuration of the Delta under the EDB were not available at the time of preparation of this BA, but would elucidate more of the hydrodynamic effects of the EDB. The additional DCC and Georgiana Slough flow, with DCC gates open and with the Sutter and Steamboat slough barriers, would provide an increase in the net positive flow from the Mokelumne River mouth past Antioch (Figure 29).

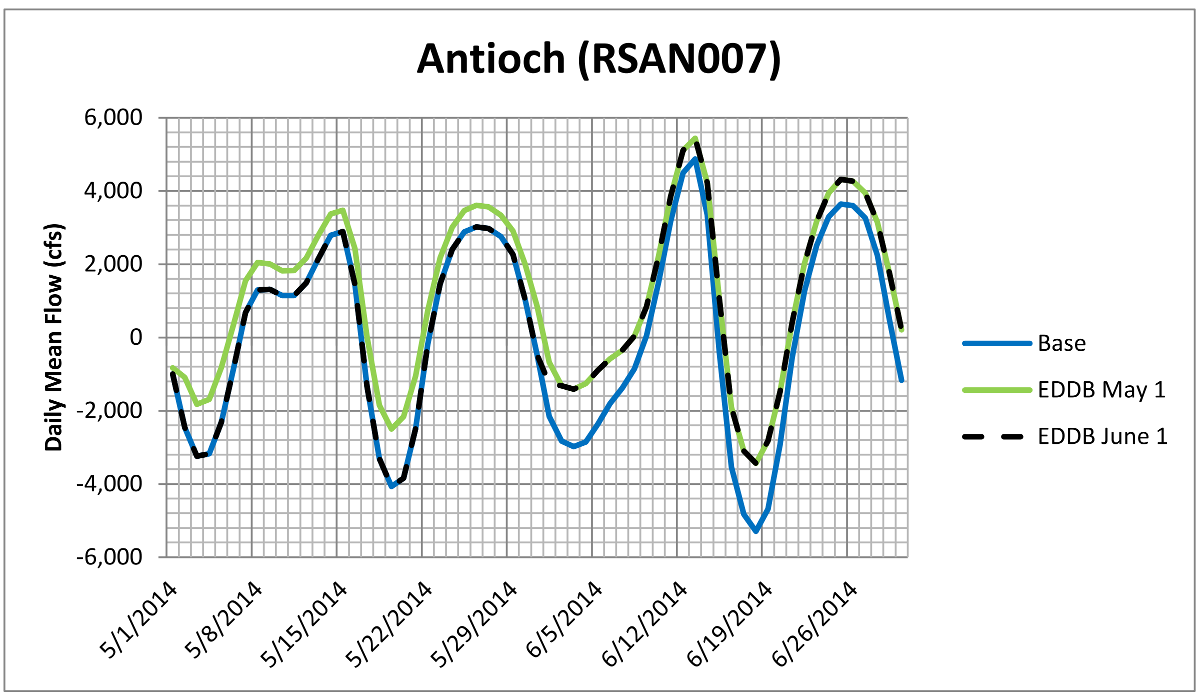
As described in the Conservation Measures section, DWR would develop a plan for phasing of barrier installation, e.g., installation of the West False River barrier first, followed by the Sutter and Steamboat Slough barriers. Regardless of the status of the Sutter and Steamboat Slough barriers or DCC gate status, installation of the West False River barrier would have the potential to reduce entrainment of delta smelt in the lower San Joaquin River into the south Delta (and ultimately the SWP/CVP south Delta export facilities) by blocking off one of the main points of entry into the south Delta.

[8] Note that these runs were based on forecasted hydrology prior to the precipitation events in late February/early March 2014. Appendix C summarizes the forecast used for this modeling, as well as additional relevant considerations. As described in the section discussing Environmental Baseline Conditions Specific to 2014, the January 31 TUCP Order and its modifications influence potential Delta outflow and therefore salinity conditions. It is anticipated that similar outflow and export conditions to March will be required in April, and perhaps for the remainder of the year; these are the assumed baseline conditions evaluated for the EDB.



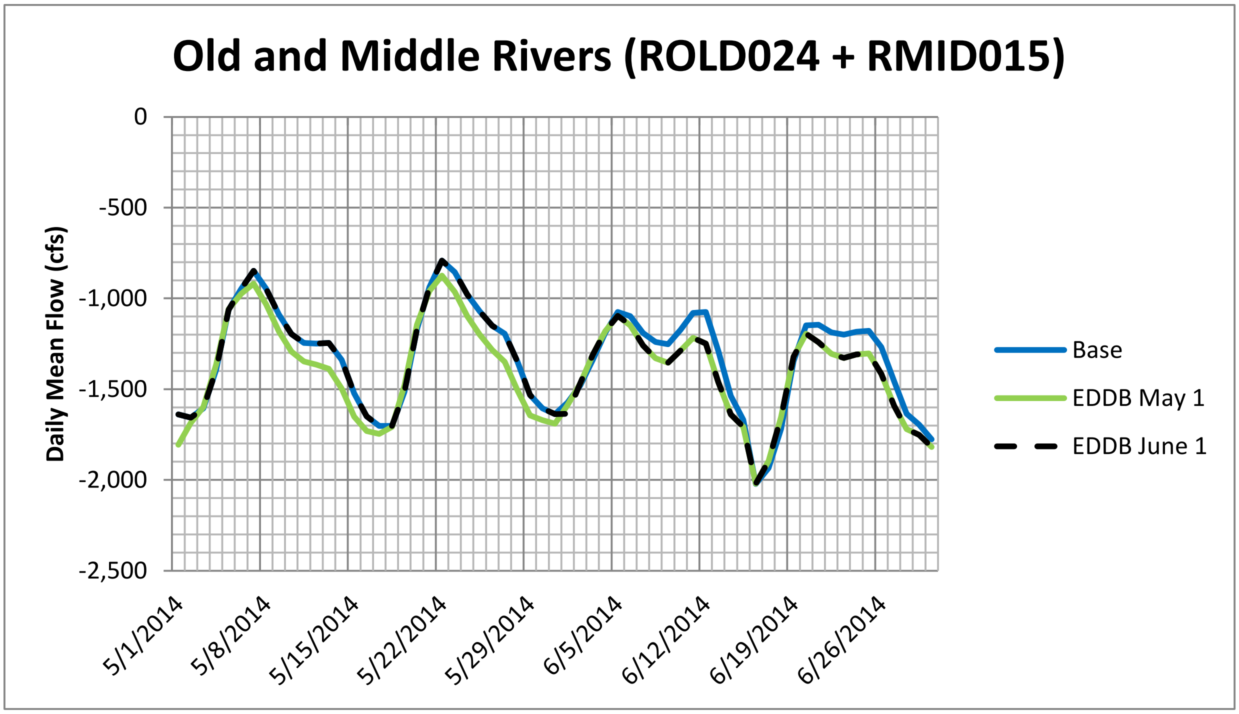
Source: Smith, pers. comm. Note: EDB May 1 and EDB June 1 assume EDB operations commence May 1 and June 1, respectively.

Figure 28. Forecasted Mean Daily Flow at Jersey Point in May and June 2014, from DSM2-HYDRO Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.



Source: Smith, pers. comm. Note: EDB May 1 and EDB June 1 assume EDB operations commence May 1 and June 1, respectively.

Figure 29. Forecasted Mean Daily Flow at Antioch in May and June 2014, from DSM2-HYDRO Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.



Source: Smith, pers. comm. Note: EDB May 1 and EDB June 1 assume EDB operations commence May 1 and June 1, respectively.

Figure 30. Forecasted Mean Daily Flow at Old and Middle Rivers in May and June 2014, from DSM2-HYDRO Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.

Operation of the West False River barrier could trap delta smelt that are present upstream of the barrier (e.g., in the Franks Tract area). With the EDB changing hydrodynamics in the central and south Delta, OMR flows become slightly more negative in the modeling based on the February forecast (Figure 30). Assuming EDB installation on May 1, the mean OMR flow under EDB is -1,360 cfs in May and -1,440 cfs in June, which compares with -1,290 cfs in May and -1,370 cfs in June for the base case. The fate of delta smelt found southeast of the West False River barrier may well be entrainment at the south Delta export facilities regardless of the presence of the barrier, based on simulated fates of neutrally buoyant particles (Kimmerer and Nobriga 2008). Very few delta smelt appear to be upstream of the West False River barrier, based on the most recent survey data from February/March 2014 (Figures 15, 16, 22).

Water Quality Effects

DSM2-QUAL modeling conducted primarily to assess the potential effects of the EDB on water quality for export and in-Delta use also provides some perspective on potential effects in relation to changes in salinity (electrical conductivity, EC) that could affect delta smelt[9]. Note that this modeling was based on the February forecast for subsequent hydrology and did not account for precipitation

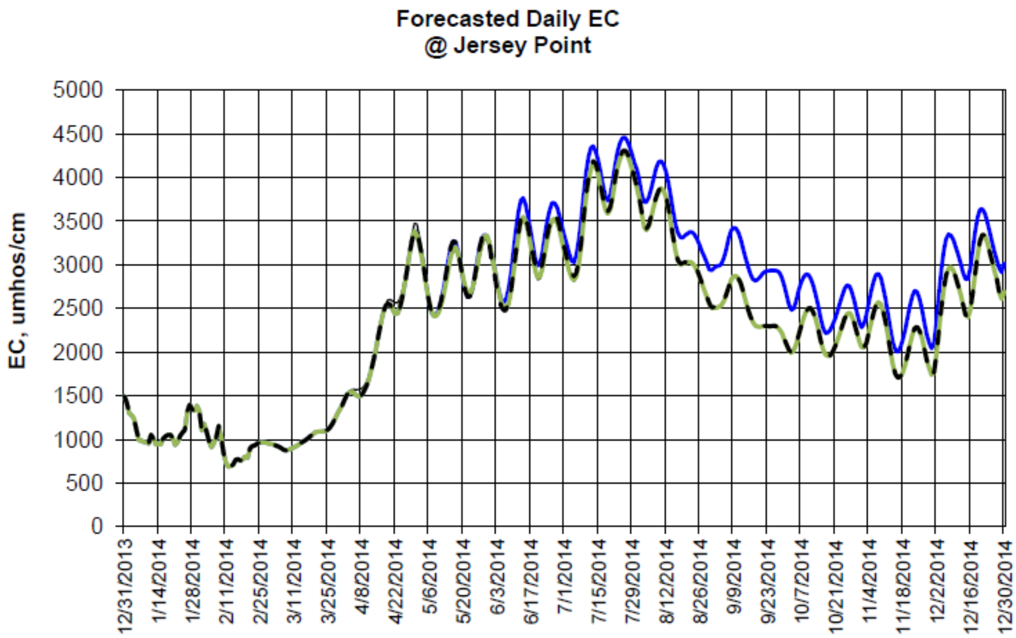
[9] Note that DSM2-QUAL modeling may give estimates of EC that are biased slightly low (McQuirk pers. comm.), so that relative comparisons between scenarios may be more appropriate for consideration as opposed to absolute values.

in late February/early March; although the maximum salinity patterns are uncertain (dependent on actual outflow), the seasonal increases at the various locations and the changes caused by the EDB are more reliable and indicative of the likely habitat conditions. This is discussed further in Appendix C.

In general, the modeling suggests that there would be little difference in conductivity during the operational period of the barriers on the lower San Joaquin River seaward of False River (e.g., at Jersey Point; Figure 31), whereas conductivity would be lower with the barriers in place along the water supply channels (e.g., Old River, Middle River and Rock Slough [Figure 32]) that are important for some water users, including in-Delta diversions, south Delta exports, and diversions by Contra Costa Water District. Although the barrier at West False River would prevent most tidal flow from entering False River and therefore tidal flow would tend to move further upstream on the lower San Joaquin River, the modeling suggests that the greater flow coming down the Mokelumne River (via Georgiana Slough and DCC) caused by the Sutter and Steamboat slough barriers would counteract this effect. From this information it is inferred that there would little effect on delta smelt from changes in conductivity in the lower San Joaquin River, particularly in light of the relatively low occurrence of delta smelt in this area during the summer (Merz et al. 2011; see discussion above).

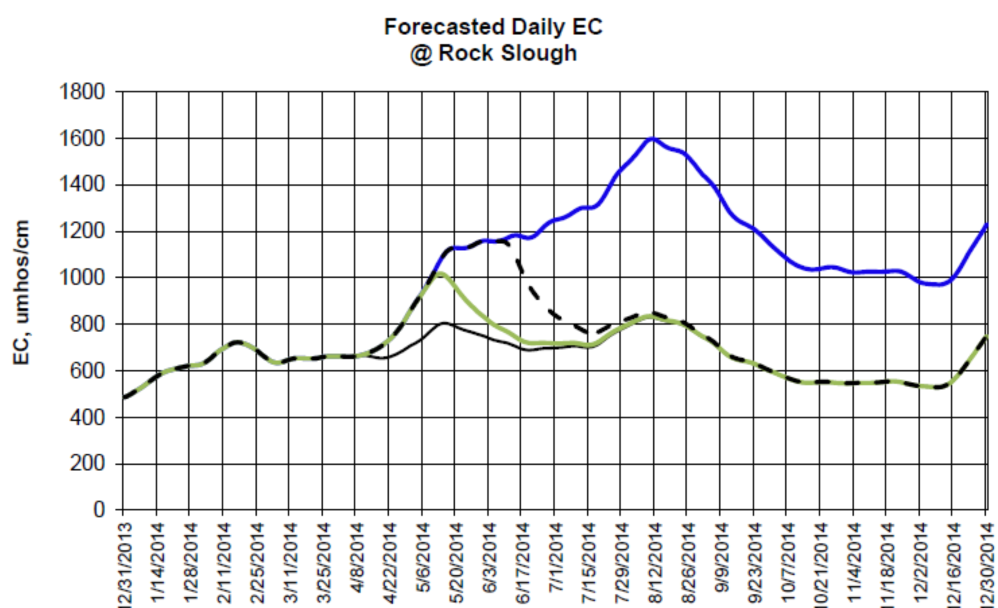
In contrast to the situation on the lower San Joaquin River, slightly higher conductivity would occur further upstream on the lower Sacramento River because of less freshwater moving down Sutter and Steamboat sloughs and in the Sacramento River at Rio Vista. For example, preliminary DSM2-QUAL modeling based on 90% exceedance historical hydrology and forecasted operations through the remainder of 2014 estimated that conductivity at Rio Vista would be between 1,200 and 1,800 micromhos per centimeter (µmhos/cm) during June-August with the EDB operating, whereas without the EDB conductivity would be 700 to 1,400 µmhos/cm (Figure 33). At Emmaton, conductivity also would be slightly higher (Figure 34). Greater conductivity further upstream on the lower Sacramento River could result in the delta smelt population that reside in the low salinity zone moving further upstream on the lower Sacramento River than would be the case without the EDB operating. This could result in a slightly smaller area of abiotic habitat, given the general decrease in habitat with movement upstream of the low-salinity zone (Feyrer et al. 2007). As Sommer and Mejia (2013: 8) noted, however, delta smelt are not confined to a narrow salinity range and occur from fresh water to relatively high salinity, even though the center of distribution is consistently associated with X2 (Sommer et al. 2011). Nobriga et al. (2008) found that the probability of occurrence of delta smelt was highest at low conductivity (1,000-5,000 µmhos/cm), and declines at higher conductivity (Figure 35); conductivity forecasts at Rio Vista with the EDB operating and not operating are within this range during much of the summer (and more so with the EDB operating), whereas at Emmaton conductivity with the EDB operating is greater than 5,000 µmhos/cm during much of the summer/fall and more frequently within the 1,000-5,000 µmhos/cm range with the EDB not operating. These Sacramento River conductivity values are relatively high compared to historical conditions; updated forecast modeling may indicate that the Delta outflow can be maintained at 3,000 cfs or higher, reducing these relatively high conductivity estimates at Emmaton and Rio Vista.

Because the EDB would not affect Delta outflow, conductivity at locations further downstream (e.g., Collinsville, Mallard Island, and Port Chicago) would not be affected by the EDB (Figures 36, 37, 38).



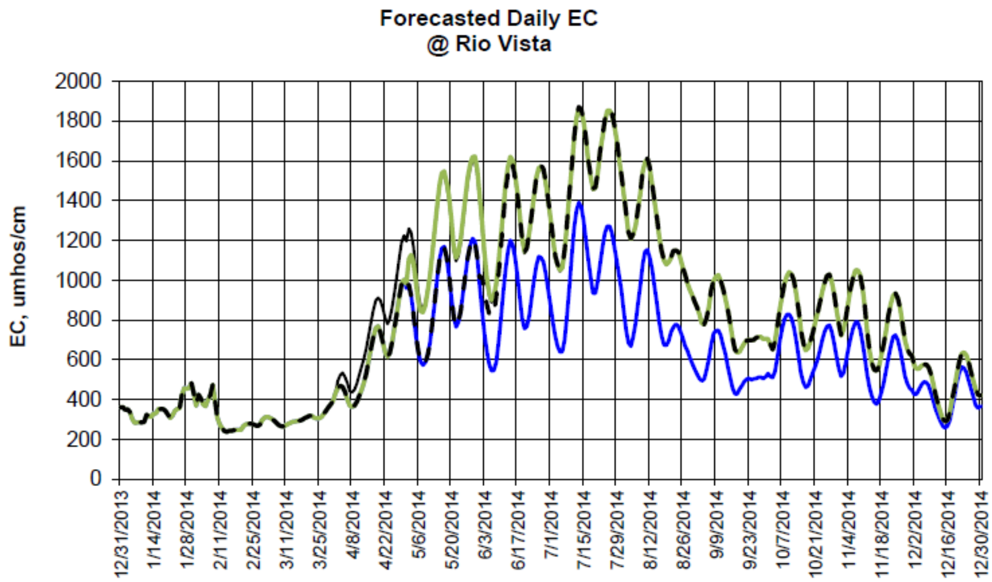
Source: Smith, pers. comm. Legend: Blue line = base case (no barriers); green line = EDB operations commencing May 1; broken black line = EDB operations commencing June 1. (The thin black line represents EDB operations commencing April 1, and should be ignored).

Figure 31. Forecasted Daily Electrical Conductivity at Jersey Point, from DSM2-QUAL Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.



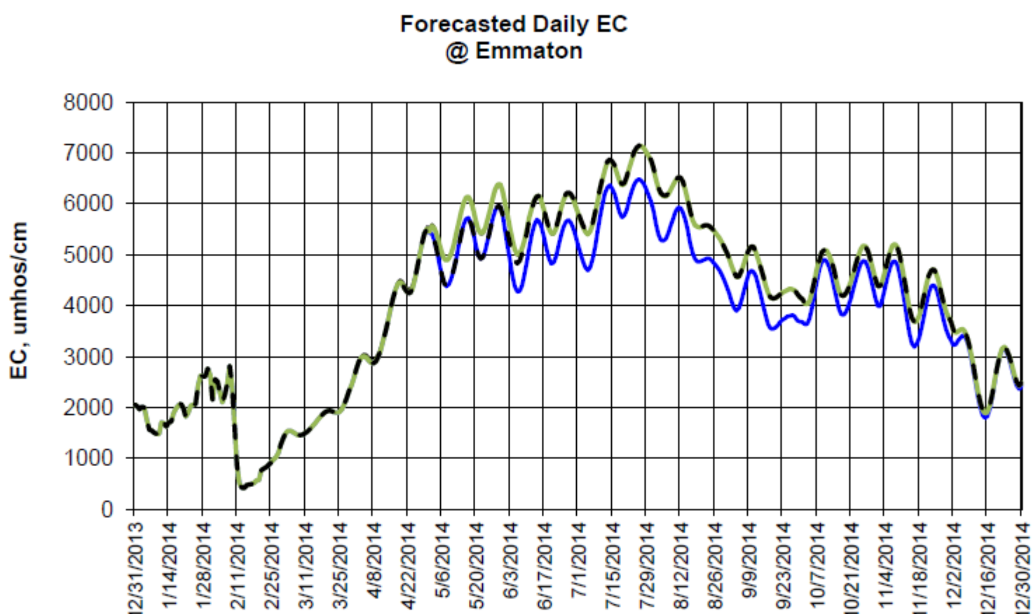
Source: Smith, pers. comm. Legend: Blue line = base case (no barriers); green line = EDB operations commencing May 1; broken black line = EDB operations commencing June 1. (The thin black line represents EDB operations commencing April 1, and should be ignored).

Figure 32. Forecasted Daily Electrical Conductivity at Rock Slough, from DSM2-QUAL Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.



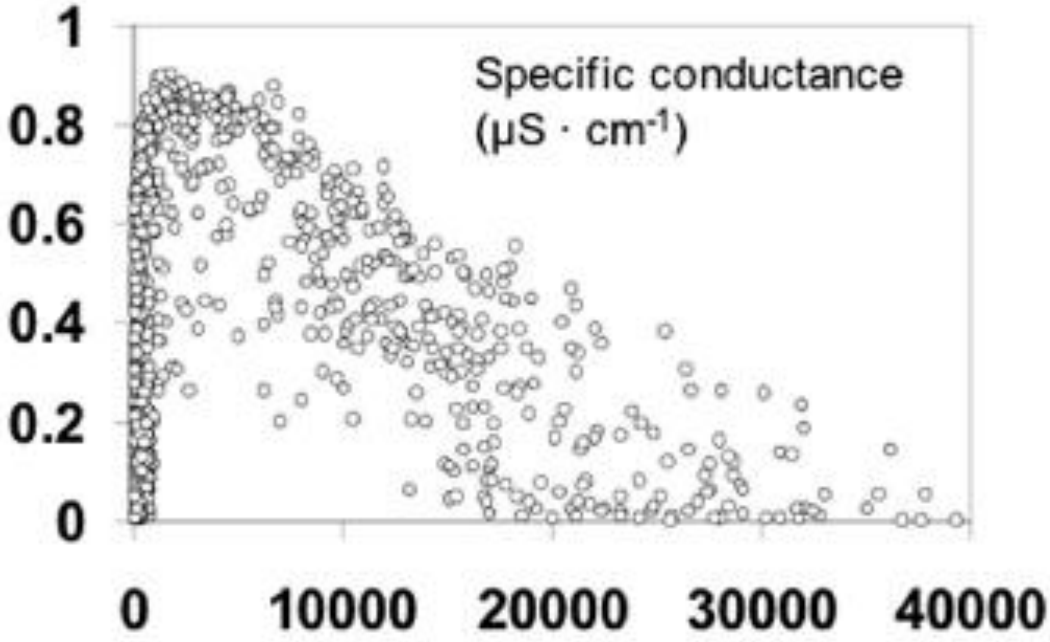
Source: Smith, pers. comm. Legend: Blue line = base case (no barriers); green line = EDB operations commencing May 1; broken black line = EDB operations commencing June 1. (The thin black line represents EDB operations commencing April 1, and should be ignored).

Figure 33. Forecasted Daily Electrical Conductivity at Rio Vista, from DSM2-QUAL Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.



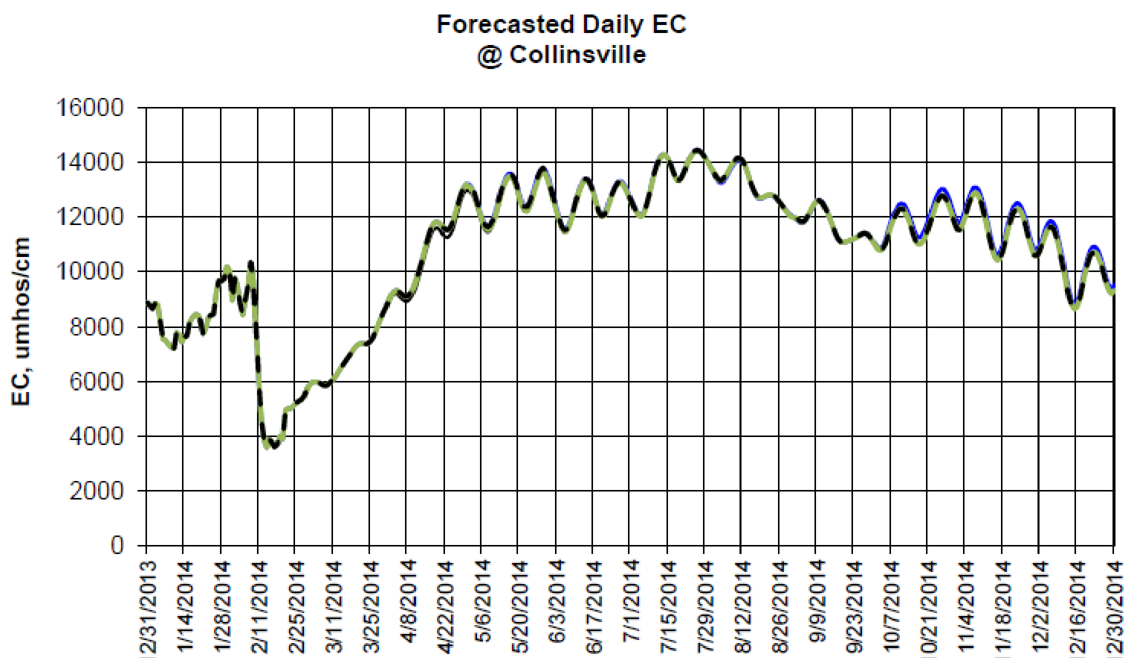
Source: Smith, pers. comm. Legend: Blue line = base case (no barriers); green line = EDB operations commencing May 1; broken black line = EDB operations commencing June 1. (The thin black line represents EDB operations commencing April 1, and should be ignored).

Figure 34. Forecasted Daily Electrical Conductivity at Emmaton, from DSM2-QUAL Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.



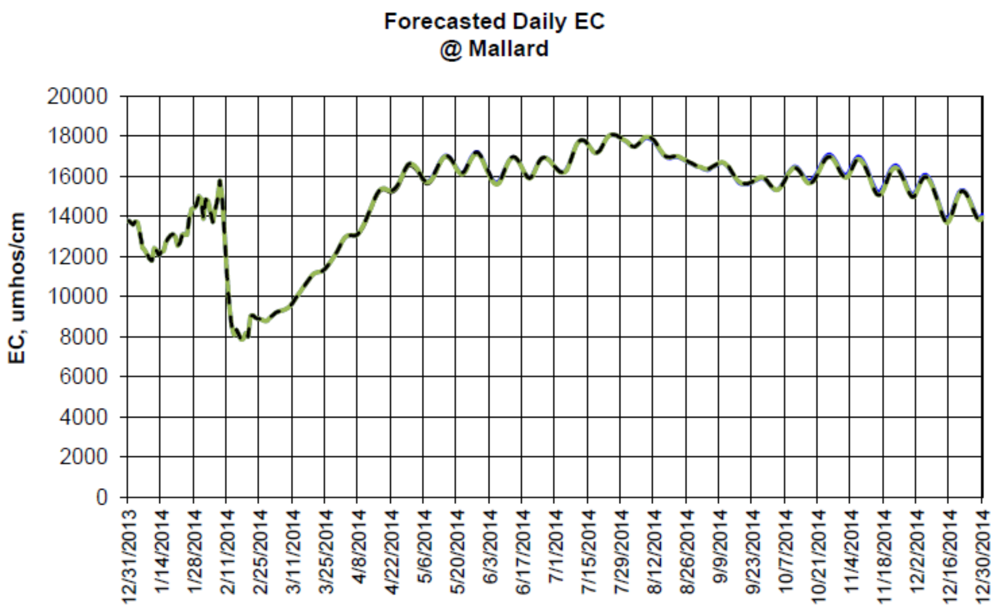
Source: Nobriga et al. (2008).

Figure 35. Predicted Capture Probability of Delta Smelt Juveniles in 1974-2004 July Summer Townet Surveys From Generalized Additive Modeling In Relation to Specific Conductance, With Scatter Depicting Variation Caused by Secchi Depth and Water Temperature.



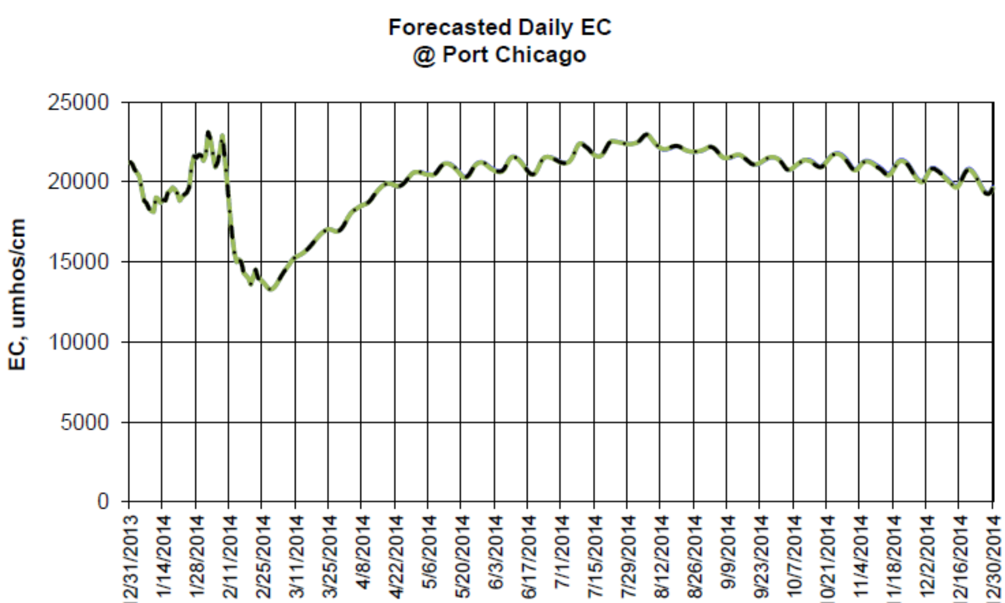
Source: Smith, pers. comm. Legend: Blue line = base case (no barriers); green line = EDB operations commencing May 1; broken black line = EDB operations commencing June 1. (The thin black line represents EDB operations commencing April 1, and should be ignored).

Figure 36. Forecasted Daily Electrical Conductivity at Collinsville, from DSM2-QUAL Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.



Source: Smith, pers. comm. Legend: Blue line = base case (no barriers); green line = EDB operations commencing May 1; broken black line = EDB operations commencing June 1. (The thin black line represents EDB operations commencing April 1, and should be ignored).

Figure 37. Forecasted Daily Electrical Conductivity at Mallard Island, from DSM2-QUAL Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.



Source: Smith, pers. comm. Legend: Blue line = base case (no barriers); green line = EDB operations commencing May 1; broken black line = EDB operations commencing June 1. (The thin black line represents EDB operations commencing April 1, and should be ignored).

Figure 38. Forecasted Daily Electrical Conductivity at Port Chicago, from DSM2-QUAL Modeling, Based on 90% Exceedance Historical Hydrology and Delta Cross Channel Open in May and June.

Near-Field Predation Effects

Whereas enhanced predation of juvenile salmonids in relation to artificial structures has been observed in the Central Valley (e.g., juvenile salmonids downstream of RBDD; Tucker et al. 1998), there have not been observations of such predation on delta smelt. Nevertheless, predation at greater rates than normal may result should delta smelt occur in close proximity to any of the barriers.

As described previously for juvenile salmonids, the abutments (sheet piles and king piles) at the West False River barrier would be left in place following removal of the rest of the barrier and would extend approximately 75 feet from the levee into the river channel, creating hydrodynamic eddies and possibly ambush habitat for predatory fishes; this could result in an enhanced predation risk for delta smelt that pass close to the abutments, e.g., adults moving into nearshore areas to spawn. Over time, presence of these sheet piles may cause accumulation of sediment and increase the potential for colonization by submerged aquatic vegetation (particularly *Egeria densa*), which could enhance predation risk for delta smelt because of the creation of habitat more suitable for predatory largemouth bass and other species that associate with submerged aquatic vegetation.

Effects on Critical Habitat

Central Valley Spring-Run Chinook Salmon, Sacramento River Winter-Run Chinook Salmon, and Central Valley Steelhead

The effects of EDB installation and removal on physical habitat would be limited to the footprint area of each of the rock barriers as shown in Table 14.

Table 14. Barrier Footprint Acreages

Barrier	Aquatic Footprint (acres)[1]	Terrestrial Footprint	Total Footprint
Sutter Slough Barrier	0.450	0.003	0.453
Steamboat Slough Barrier	0.768	0.212	0.980
West False River Barrier	2.620	0.000	2.62
Total	3.838	0.215	4.053

1 Based on area below OHWM of +6.5 feet at Steamboat and Sutter Sloughs and below +5.5 feet at West False River and as shown in Appendix A.

The duration of the physical "smothering" of the channel bottom by the rocks of the three EDB would be approximately six months. Disturbance of the channel substrate due to the installation and removal of the EDB, and, to a lesser extent, due to any incidental sediment removal activities, would affect the benthic community within the barriers' footprints, and non-native species, capable of rapidly colonizing the disturbed substrate, may be favored following removal of the EDB.

The installation of the EDB would affect salmonids migrating through the Action Area. As previously described, blockage of Sutter and Steamboat sloughs would affect the migration success of juvenile Chinook salmon and steelhead out-migrants from the Sacramento River watershed by increasing the likelihood of entering the interior Delta through Georgiana Slough and the DCC. As described previously, the EDB also would create impediments to free movement of fish within the Delta channels (e.g., for adult salmonids), as well as attract predatory fish and create areas that enhance their foraging success on juvenile salmonids passing through the reaches affected by the placement of the barriers. These effects, although periodic, reduce the functionality of the PCEs of Central Valley spring-run Chinook salmon and Central Valley steelhead critical habitat in the Delta.

The use of construction equipment near the river has the potential to impair water quality if hazardous chemicals (e.g., fuels and petroleum-based lubricants) were spilled or entered the river. These potential effects would be minimal because they would be temporary. DWR will implement a spill prevention and control plan to ensure avoidance of any accidental spills or releases (see Conservation Measures below). Additionally, DWR will adhere to the standard construction best management practices (BMPs) described in the current California Department of Transportation Construction Site Best Management Practices Manual (California Department of Transportation 2003).

Southern DPS of North American Green Sturgeon

As previously described, water quality, hydrodynamics, and passage could potentially be affected by EDB project implementation. However, these effects are expected to have minimal effect on green sturgeon critical habitat because they would be temporary and localized. Additionally, green sturgeon food resources have the potential to be affected in the project area as a result of sediment disturbance and sediment removal. Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (NMFS 2008b) and the aforementioned activities would disturb and reduce benthic habitat in the areas occupied by the barriers. However, because these areas are only a small portion of the total critical habitat for green sturgeon, and because the effects would be temporary, the overall impact to critical habitat would be low.

Delta Smelt

Physical habitat, and potentially water quality, would be affected by construction of the EDB. River flow and salinity would not be affected by the construction of the EDB, however these PCEs would be affected by the hydrologic changes caused by the operation of the barriers. The effect of construction activities on physical habitat in areas where the rock barriers are installed would be limited to the footprint area of each of the three rock barriers as shown in Table 14. As shown in Table 14, approximately 3.838 acres of delta smelt critical habitat, in the form of physical habitat, would be adversely affected by the EDB. Additionally, construction activities could potentially impair water quality if hazardous chemicals (e.g., fuels and petroleum-based lubricants) or other construction materials are spilled or enter the waterways near the EDB. This risk is limited to the construction period and is not likely to occur because of the proposed conservation measures. Regardless, DWR will implement a spill prevention and control plan to ensure avoidance of any accidental spills or releases. As such, there would be no effects on the water PCE.

As described in the Operations Effects on Fish section, barrier operation would result in salinity moving further upstream on the lower Sacramento River, whereas salinity on the lower San Joaquin River near or upstream of the West False River barrier would be similar or lower than without the barriers. These changes could slightly alter the quantity of abiotic habitat available for delta smelt in the lower Sacramento River and Sacramento-San Joaquin Rivers confluence area, although as noted previously, the changes in conductivity generally are within the range of salinity occupied most by juvenile delta smelt in summer/fall.

Effects on Essential Fish Habitat

The Magnuson-Stevens Act defines EFH as "those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity." The 1996 amendments to the Magnuson-Stevens Act require federal agencies to consult with NMFS regarding effects on EFH for those species managed under federal Fishery Management Plans (FMP). The northern anchovy and starry flounder are managed by the Coastal Pelagic Species FMP and the Pacific Coast Groundfish FMP of the Pacific Fishery Management Council (PFMC), respectively. The PFMC manages Chinook salmon under the Pacific Coast Salmon FMP.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The following EFH components must be adequate for spawning, rearing, and migration: substrate composition; water quality; water quantity, depth, and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and habitat connectivity. EFH is designated for starry flounder, northern anchovy, and Chinook salmon in the Bay-Delta and includes areas where the EDB would be implemented.

The effects of the proposed action on salmonid habitat have been described above, and generally are expected to apply to Chinook salmon EFH. Installation and operation of the EDB may degrade certain functional habitat characteristics of northern anchovy and starry flounder EFH (i.e., free movement of fish, passage obstructions, alterations of water quality parameters, and creation of lentic conditions) during the period of operation.

Starry flounder would be most likely to occur in the vicinity of the EDB during low outflows as young-of-the-year fish, with abundance tending to be very low prior to June, when recruitment begins in earnest (Baxter et al. 1999). As the species grows, it tends to move into higher salinity waters and so would be unlikely to be present in the Action Area as yearling or older fish. A total of 45 northern anchovy were collected from 2002 to 2010 during the annual Spring Kodiak Trawl sampling program that is undertaken at 40 stations in the Bay-Delta from January to May (CDFG 2010). The species was collected in January-May, with collections in May being most common and accounting for 50% of samples containing northern anchovy. The furthest upstream that the species has been collected from this sampling program is from station 508 in the vicinity of Chipps Island. Northern anchovy abundance is generally low in winter, increasing in spring, and high in summer, before declining again in the fall (Baxter et al. 1999). It is likely that northern anchovy abundance would be low in the vicinity of the EDB.

Northern anchovy and starry flounder are primarily marine and estuarine species that are more abundant seaward of the EDB. EFH for these species is expected to be only minimally affected by the alteration of habitat under the EDB.

Cumulative Effects

Under the ESA, cumulative effects are "those effects of future state, tribal, local, or private actions that are reasonably certain to occur within the action area of the federal action subject to consultation" (50 Code of Federal Regulations [CFR] 402.2). Future federal actions that are unrelated to the proposed action are not considered in this assessment because they require separate consultation pursuant to Section 7 of the ESA.

The following discussion is adapted from the NMFS (2014) and USFWS (2014b) BOs on the Georgiana Slough Floating Fish Guidance Structure Study. Of the factors discussed, several (urbanization, bank protection, and climate change) may be more applicable to longer-term effects on the species than the relatively limited duration of the EDB.

Entrainment

Within the Action Area, non-federal diversions of water (e.g., municipal and industrial uses, as well as diversions through intakes serving numerous small, private agricultural lands) are on-going and likely to continue into the foreseeable future. These non-federal diversions are not likely to entrain many delta smelt based on the results of a study by Nobriga et al. (2004). Nobriga et al. (2004) reasoned that the littoral location and low-flow operational characteristics of these diversions reduced their risk of entraining delta smelt. Although these non-federal diversions do not appear to entrain large numbers of delta smelt, they are a source of entrainment for delta smelt. These diversions also entrain juvenile salmonids and, based on laboratory studies, may pose a risk to juvenile green sturgeon approaching close to them during operating periods (Mussen et al. 2014).

Contaminants

Adverse effects to ESA-listed fishes and their critical habitat may result from point and non-point source chemical contaminant discharges within the Action Area. These contaminants include, but are not limited to ammonia/ammonium, numerous pesticides and herbicides, and oil and gasoline product discharges. Oil and gasoline product discharges may be introduced into Delta waterways from shipping and boating activities and from urban activities and runoff. Implicated as potential stressors of delta smelt, these contaminants may adversely affect fish reproductive success and survival rates.

Ammonia loading in the Bay-Delta has increased significantly in the last 25 years (Jassby 2008). Effects of elevated ammonia levels on fish range from irritation of skin, gills, and eyes to reduced swimming ability, and mortality (Wicks et al. 2002). Delta smelt have shown direct sensitivity to ammonia at the larval and juvenile stages (Werner et al. 2008). Connon et al. (2011) investigated the sublethal effects of ammonia exposure on the genes of juvenile delta smelt and found that ammonia altered gene transcription including specific genes related to cell membrane integrity, energy metabolism, and cellular responses to environmental stimuli. The study supports the possibility of ammonia exposure-induced cell membrane destabilization that would affect membrane permeability and thus enhance the uptake of other contaminants. Ammonia also can be toxic to several species of copepods important to larval and juvenile fishes (Werner et al. 2010; Teh et al. 2011). There is increasing evidence that ammonium loading has affected the lower food web by changing nutrient balance (e.g., Parker et al. 2012).

Urbanization

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. A number of cities in the Delta watershed anticipate in their respective general plans rapid growth in the future. The anticipated growth will occur along both the I-5 and US-99 transit corridors in the east and Highway 205/120 in the south and west. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those that are situated away from waterbodies, will not require federal permits, and thus will not undergo review through the ESA Section 7 consultation processes with the USFWS or NMFS; they therefore may contribute to cumulative effects.

Increased urbanization also is expected to result in increased recreational activities in the region. Among the activities expected to increase in volume and frequency is recreational boating. Boating activities typically result in increased wave action and propeller wash in waterways. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation and other littoral habitats. This in turn would reduce habitat quality for the invertebrate forage base that is consumed by juvenile salmonids and green sturgeon moving through the system, and may affect delta smelt occurring in littoral areas (e.g., during spawning). Increased recreational boat operation in the Delta is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the water bodies of the Delta. Furthermore, increased recreational boating greatly increases the risk of spreading non-native invasive species into the Delta, particularly if boats are trailered between different water bodies.

Bank Protection

Bank protection actions may cumulatively affect listed fishes by altering riparian and littoral habitat through installation of large rock. Such actions may be undertaken by state and local agencies, but are likely to require USFWS and NMFS consultations because of the need to acquire USACE permits for in-water work.

Climate Change

Effects of climate change could be particularly profound for aquatic ecosystems and include increased water temperatures and altered hydrology, along with changes in the extent, frequency, and magnitude of extreme events such as droughts, floods, and wildfires (Reiman and Isaak 2010). Numerous climate models predict changes in precipitation frequency and pattern in the western United States (Intergovernmental Panel on Climate Change [IPCC] 2007). Projections indicate that temperature and precipitation changes will diminish snowpack, changing the availability of natural water supplies (U.S. Bureau of Reclamation 2011). Warming may result in more precipitation falling as rain and less storage as snow. This would result in increased rain on snow events and increase winter runoff as spring runoff decreases (U.S. Bureau of Reclamation 2011). Earlier seasonal warming increases the likelihood of rain-on-snow events, which are associated with mid-winter floods. Smaller snowpacks that melt earlier in the year result in increased drought frequency and severity (Rieman and Isaak 2010). These changes may lead to increased flood and drought risk during the 21st century (U.S. Bureau of Reclamation 2011). The National Academy of Sciences (NAS) projected that sea levels along the California coast south of Cape Mendocino will rise 4-30 cm (2-12 inches) by 2030, 12-61 cm (5-24 inches) by 2050, and 42-167 cm (16-66 inches) by 2100 (NAS 2012) compared to 2000 sea levels.

Increased summer temperatures and less flow in upstream tributaries would make habitat less suitable for listed salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff is expected to be replaced by warmer precipitation runoff. This should shorten the duration of suitable cold-water conditions below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool developed from melting snowpack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (i.e., Sacramento River winter-run Chinook salmon and California Central Valley steelhead) that must hold below dams over the summer and fall periods. Climate change effects also are predicted to be adverse to spring-run Chinook salmon that inhabit tributaries throughout the summer, e.g., in Butte Creek (Thompson et al. 2012).

It is uncertain how a change in the timing and duration of freshwater flows will affect delta smelt. The melting of the snowpack earlier in the year could result in higher flows in January and February, ahead of peak spawning and hatching months for delta smelt. This could alter the timing or magnitude of migration and spawning cues, and potentially result in decreased spawning success. Sea level rise is likely to increase the frequency and range of saltwater intrusion. Salinity within the northern San Francisco Bay is projected to rise by 4.5 psu by the end of the century (Cloern et al. 2011). Elevated salinity levels could push the LSZ farther up the estuary and could result in increased distances that delta smelt must migrate to reach spawning habitats. The upstream movement of the LSZ would result in a decrease in suitable abiotic habitat (Brown et al. 2013). As the freshwater boundary moves farther inland into the Delta with increasing sea level and reduced flows, adult delta smelt would need to migrate farther into the Delta to spawn, increasing the risk of predation and the potential for entrainment into water export facilities and diversions for both themselves and their progeny. Warmer water temperatures could increase delta smelt mortality and constrict suitable habitat throughout the Delta during the summer months. Due to warming temperatures, delta smelt are projected to spawn between 10-25 days earlier in the season depending on the location (Brown et al. 2013). Also due to expected temperature increases, total number of high mortality days is expected to increase for all IPCC climate change scenarios (Brown et al. 2013). The number of stress days is expected to be stable or decrease partly because many stress days will become high mortality days. This could lead to delta smelt being forced to grow under highly stressful conditions during summer and fall with less time to mature because of advanced spawning (Brown et al. 2013).

Conservation Measures

Prepare and Implement an Erosion Control Plan

An Erosion Control Plan will be prepared prior to construction activities that will cause ground disturbance. Site-specific erosion-control, spill-prevention, and control of sedimentation and runoff measures will be developed and implemented as part of the plan.

Prepare and Implement a Spill Prevention and Control Program

DWR will prepare a spill prevention and control program prior to the start of construction to minimize the potential for hazardous, toxic, or petroleum substances release into the project area during construction and project operation. In addition, DWR will place sand bags, biologs, or other containment features around the areas used for fueling or other uses of hazardous materials to ensure that these materials do not accidentally leak into the river. DWR will adhere to the standard construction BMPs described in the current California Department of Transportation Construction Site Best Management Practices Manual (California Department of Transportation 2003).

Prepare and Implement a Hazardous Materials Management Program

DWR will prepare a Hazardous Materials Management Program (HMMP) that identifies the hazardous materials to be used during construction; describes measures to prevent, control, and minimize the spillage of hazardous substances; describes transport, storage, and disposal procedures for these substances; and outlines procedures to be followed in case of a spill of a hazardous material. The HMMP will require that hazardous and potentially hazardous substances stored onsite be kept in securely closed containers located away from drainage courses, storm drains, and areas where stormwater is allowed to infiltrate. It will also stipulate procedures to minimize hazard during onsite fueling and servicing of construction equipment. Finally, the HMMP will require that adjacent land uses be notified immediately of any substantial spill or release.

Implement Sacramento Metropolitan Air Quality Management District Basic and Enhanced Construction Emission Control Practices to Reduce Fugitive Dust

The construction contractor will implement the following applicable basic and enhanced control measures to reduce construction-related fugitive dust during site grading.

- Water all exposed surfaces two times daily as needed. Exposed surfaces include, but are not limited to soil piles, graded areas, unpaved parking areas, staging areas, and unpaved access roads.
- Use wet power vacuum street sweepers as needed to remove any visible trackout mud or dirt onto adjacent public roads at least once a day. Use of dry power sweeping is prohibited.
- Limit vehicle speeds on unpaved roads to 15 miles per hour (mph).
- Minimize idling time either by shutting equipment off when not in use or reducing the time of idling to 5 minutes (required by California Code of Regulations, Title 13, sections 2449[d][3] and 2485). Provide clear signage that posts this requirement for workers at the entrances to the site.
- Maintain all construction equipment in proper working condition according to manufacturer's specifications. The equipment must be checked by a mechanic and determined to be running in proper condition before it is operated.

Additionally, the contractor will implement the following applicable enhanced measures to reduce operation-related diesel particulate matter.

- Acceptable options for reducing emissions may include use of late model engines, low-emission diesel products, alternative fuels, engine retrofit technology, after-treatment products, and other options as they become available.

Conduct a Worker Environmental Awareness Program

Construction personnel will participate in a permitting-fish-agency-approved worker environmental awareness program. Under this program, workers will be informed about the presence of listed fish and habitat associated with the species and that unlawful take of the animals or destruction of their habitat is a violation of the ESA/CESA. Prior to construction activities, a qualified biologist(s) approved by the USFWS/NMFS/DFW will instruct all construction personnel about the life history of the listed fishes and the terms and conditions of the EDB BOs and CESA ITP. Proof of this instruction will be submitted to the permitting fish agencies.

Conduct Biological Monitoring

A permitting-agency-approved biologist will be onsite daily to conduct compliance inspections and monitor all construction activities that may result in the take of listed species covered in permitting documents (BOs and ITP). The qualifications of the biologist(s) will be presented to the permitting agencies for review and written approval at least ten working days prior to project activities in the action area. Prior to approval, the biologist(s) will submit a letter to the permitting agencies that states that they understand the terms and conditions of the permitting documents (Biological Opinions, CESA ITP). The biologist(s) will keep a copy of the permitting documents in their possession when onsite. The biologist(s) shall be given the authority to stop work that may result in, or in the event that there is, take of listed species in excess of limits provided by the permitting agencies in permitting documents (BOs, ITP). If the biologist(s) exercise(s) this authority, the permitting agencies shall be notified by telephone and electronic mail within one working day.

A report of daily records from monitoring activities and observations will be prepared and provided to the permitting agencies.

Conduct Real-Time Monitoring and Adjust Construction Activities Accordingly

DWR will monitor weather patterns and river forecasts for the period preceding the start of construction. If precipitation events or increases in river levels and flows are predicted to occur immediately prior to the start of construction, DWR shall notify the fishery agencies (DFW, NMFS, and USFWS) prior to initiating construction and informally confer with them to determine if construction actions are still feasible as previously considered. Sudden increases in river flows, imminent precipitation events that create changes in river stage in the Sacramento and San Joaquin valleys, or observed sudden increases in turbidity in the Sacramento or San Joaquin rivers upstream of the Delta may initiate pulses of fish migration into the Action Area (e.g., juvenile salmonids moving downstream, pre-spawning delta smelt moving upstream).

DWR also will monitor the capture of listed fishes in the fish monitoring programs currently being employed in and close to the Action Area, i.e., Sacramento area beach seines and trawling (Sherwood Harbor and Jersey Point) by USFWS; Knights Landing and Tisdale Weir RSTs, 20-mm survey, Spring Kodiak Trawl, and salvage monitoring by DFW. If increasing presence of listed fishes (principally juvenile salmonids and smelts) is detected in these monitoring efforts, DWR shall immediately contact the fishery agencies (DFW, NMFS, and USFWS) to allow informal conference to determine if construction actions will place fish at substantial additional risk within the Action Area.

Phase Barrier Construction and Operation In Collaboration With Permitting Fish Agencies and In Consideration of Real-Time Monitoring Data

DWR will collaborate with the permitting fish agencies to develop a phased construction and operation plan intended to fulfill the main purpose of the EDB (i.e., to prevent excessive salinity intrusion into the Delta and conserve water in reservoirs) while minimizing adverse effects on ESA-listed fishes. The plan would be developed in consideration of the latest real-time monitoring data to assess the temporal and spatial distribution of listed fishes that could be affected by operations.

A preliminary concept for potential phasing includes the following operation start dates for each barrier location:

- West False River barrier: as soon as possible but not earlier than May 1
- Sutter Slough barrier: second but not sooner than May 20
- Steamboat Slough barrier: June 1

As illustrated in the effects analysis for juvenile Chinook salmon, the Sutter Slough migration pathway has relatively low survival compared to the main stem Sacramento River and Steamboat Slough, so operation of the Sutter Slough barrier before Steamboat Slough is considered a potential means of limiting EDB effects.

Facilitate Upstream Barrier Passage for Adult Anadromous Fishes (Culvert Opening and Slopes Leading to Culverts) and Monitor Effectiveness

DWR will facilitate upstream passage of adult anadromous fishes (Chinook salmon, steelhead, and sturgeon) at the Sutter and Steamboat slough barriers by keeping a single culvert at each barrier open at all times. To increase the probability of sturgeon locating the culvert openings, DWR will provide a 4-foot pad in front of the downstream culvert mouths and a gravel slope from the culvert mouths to the channel bed. These slopes would be provided on the downstream sides of both barriers, in order to facilitate passage.

Passage success of adult anadromous fishes approaching the barrier will be assessed with appropriate monitoring, e.g., DIDSON. A monitoring plan would be developed in collaboration with the fish agencies.

Conduct Pile Driving With a Vibratory Driver To The Extent Possible; Minimize Effects of Impact Driving

DWR is committed to conducting pile driving using a vibratory hammer to minimize to the extent possible the noise generated from pile-driving activities. Compared to the standard impact driving method, vibratory driving substantially reduces the distance that noise exceeds NMFS thresholds, thereby substantially reducing or avoiding the potential to cause take of listed species. However, in certain circumstances (e.g., vibratory driving is not capable of reaching required embedment), impact pile driving may be necessary. If impact driving is necessary, the following provisions would be made to minimize adverse effects on listed fishes:

- For pilings in less than 1 m water depth, piles may be driven without the use of a confined bubble curtain, and no underwater sound level monitoring is required.
- For pilings in greater than 1 m water depth, one piling will be driven without the use of a confined bubble curtain in order to establish the maximum noise level. A bubble curtain will be used for all other pilings in greater than 1 m water depth. Three additional pilings will be driven, and underwater sound levels will be monitored at a depth of approximately 3 m and a distance of 10 m from the pile being driven. If sound levels do not exceed 187 dB RMS or 207 dB LPeak at these locations, pile driving may proceed. If sound levels exceed 187 dB RMS or 207 dB LPeak at these locations, pile driving will be restricted to the period between 1 hour prior to slack water and 1 hour following slack water.

Install ln-Water Navigational Buoys, Lights, and Signage

Navigational buoys, lights, and signage would be installed in Sutter and Steamboat sloughs and West False River upstream and downstream from the EDB, to advise boaters about the presence of the EDB and maintain navigation along both waterways. DWR would coordinate with the U.S. Coast Guard on signage and buoys.

Implement Turbidity Monitoring During Construction

DWR will monitor turbidity levels in Sutter and Steamboat sloughs and West False River during ground-disturbing activities, including placement of rock fill material. Monitoring will be conducted by measuring upstream and downstream of the disturbance area to determine if the change exceeds 20%, a threshold derived from the Sacramento and San Joaquin Rivers Basins Plan (Central Valley Regional Water Quality Control Board 1998). If so, DWR contractors will slow or adjust work to ensure that turbidity levels do not exceed the 20% threshold. If slowing or adjusting work to lower turbidity levels is not practical or if thresholds cannot be met, DWR will work with the SWRCB and fish agencies to determine the most appropriate method to move construction forward while minimizing turbidity impacts to the maximum extent feasible.

Develop a Water Quality Plan to Monitor Water Quality and Operate Barrier Culverts to Improve Water Quality

DWR will develop a water quality plan to assess the effects of the EDB on flow and water quality in the Central and North Delta. DWR will monitor water quality with solar-powered monitoring instruments upstream and downstream of the Sutter and Steamboat slough barriers, in addition to assessing monitoring data from existing stations in the Delta. DWR will open the slide gates of additional culverts to allow greater water flow into Sutter and Steamboat Sloughs, should water quality issues arise.

The water quality plan will document the procedures for producing the following elements:

- Water quality data from new monitoring sites and augmentation of existing sites;
- Monthly water quality summaries;
- Monthly water quality maps for Franks Tract (discrete data);
- Final report on the effects of the EDB on water quality.

Return Disturbed Areas to Pre-Project Conditions And Conserve Habitat

DWR and its contractors will strive to limit riparian impacts from EDB construction. If riparian impacts are unavoidable, such as pruning of vegetation to facilitate equipment setup in staging areas, DWR would aim to return disturbed riparian habitat pre-project conditions. Restoration of disturbed area would be done with native plants.

Return of disturbed habitat to pre-project conditions will not be possible in all cases. To mitigate for affected habitat, DWR will purchase 4 acres of shallow water habitat credits covering the EDB.

Conclusion

It is concluded that the Emergency Drought Barriers Project will have adverse effects on all of the ESA-listed fish species occurring in the Action Area, and will adversely modify their critical habitat (Table 15).

Table 15. Effects Determinations on ESA-Listed Fishes and Critical Habitat From the Emergency Drought Barriers Project

Species	Status*	Effect Determination
Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*)	FT, ST	May Affect, Likely to Adversely Affect
Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*)	FE, SE	May Affect, Likely to Adversely Affect
Central Valley steelhead (*Oncorhynchus mykiss*)	FT	May Affect, Likely to Adversely Affect
North American green sturgeon (*Acipenser medirostris*), southern distinct population segment (DPS)	FT	May Affect, Likely to Adversely Affect
Delta smelt (*Hypomesus transpacificus*)	FT, SE	May Affect, Likely to Adversely Affect
Central Valley steelhead designated critical habitat	X	May Affect, Likely to Adversely Modify
North American green sturgeon designated critical habitat	X	May Affect, Likely to Adversely Modify
Delta smelt designated critical habitat	X	May Affect, Likely to Adversely Modify

DPS = distinct population segment.

* Status definitions:

FE = listed as endangered under the federal Endangered Species Act.
FT = listed as threatened under the federal Endangered Species Act.
X = designated Critical Habitat under the Federal Endangered Species Act.
SE = listed as endangered under the California Endangered Species Act.
ST = listed as Threatened under the California Endangered Species Act.

Implementation of the above conservation measures will avoid or minimize adverse effects to the maximum extent practicable. The Emergency Drought Barriers Project would not jeopardize the continued existence of the ESA-listed species occurring in the Action Area.

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Appendix A
Additional Design Details for the Emergency Drought Barriers Project

LOCATION MAP

STATE OF CALIFORNIA

CALIFORNIA NATURAL RESOURCES AGENCY

DEPARTMENT OF WATER RESOURCES

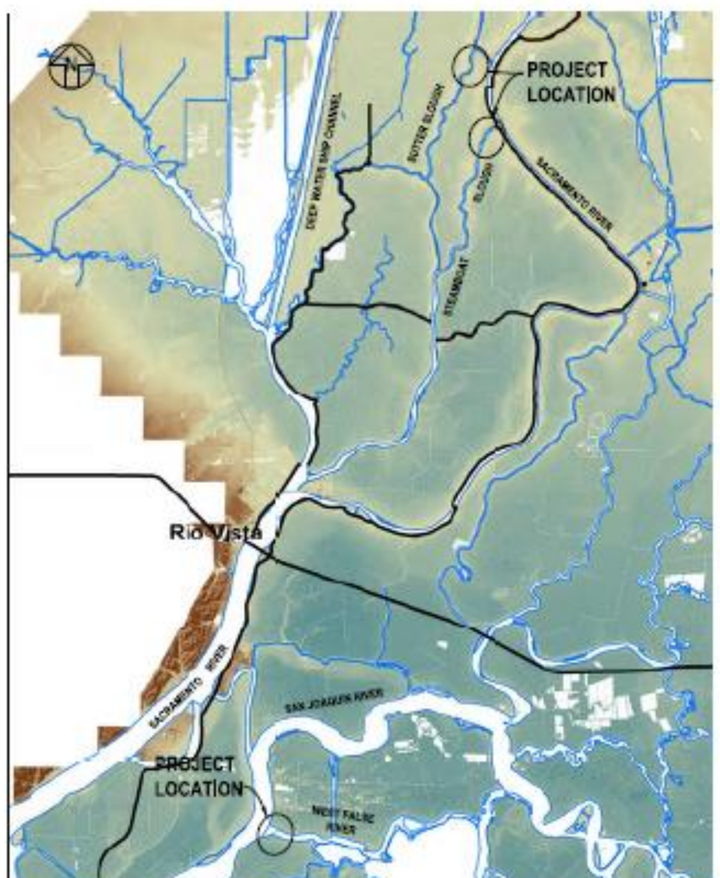
DIVISION OF ENGINEERING

STATE WATER FACILITIES

DROUGHT EMERGENCY - TEMPORARY ROCK BARRIERS

SUTTER SLOUGH, STEAMBOAT SLOUGH AND WEST FALSE RIVER - SACRAMENTO RIVER DELTA

SPECIFICATION NO. 14-11



LOCATION MAP

LIST OF DRAWINGS

SHEET NO.	DRAWING NO.	DRAWING TITLE
001	G-101	COVER SHEET, LOCATION MAP AND LIST OF DRAWINGS
002	C-201	GENERAL PLAN
003	C-202	SUTTER SLOUGH - GENERAL PLAN
004	C-203	SUTTER SLOUGH - SITE PLAN
005	C-204	SUTTER SLOUGH - PROFILE AND SECTIONS
006	C-205	STEAMBOAT SLOUGH - GENERAL PLAN
007	C-206	STEAMBOAT SLOUGH - SITE PLAN
008	C-207	STEAMBOAT SLOUGH - PROFILES
009	C-208	STEAMBOAT SLOUGH - SECTIONS
010	C-209	WEST FALSE RIVER - GENERAL PLAN
011	C-210	WEST FALSE RIVER - SITE PLAN AND PROFILE
012	C-211	WEST FALSE RIVER - DETAILS AND SECTION
013	C-212	WEST FALSE RIVER - DETAILS 2
014	C-213	TYPICAL CULVERT PLAN AND SECTIONS
015	C-214	TYPICAL 8' BARBED WIRE FENCING

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

DEPARTMENT OF WATER RESOURCES • STATE OF CALIFORNIA •

REV.	DESCRIPTION	SUB.	APP.

THINK SAFETY - ACT SAFELY

APPROVED: DATE:

CHIEF, DIVISION OF ENGINEERING, REG. C.E. No. 52071

SPEC. NO.	SHEET NO.	REVISION	DRAWING NO.
	001		G-101

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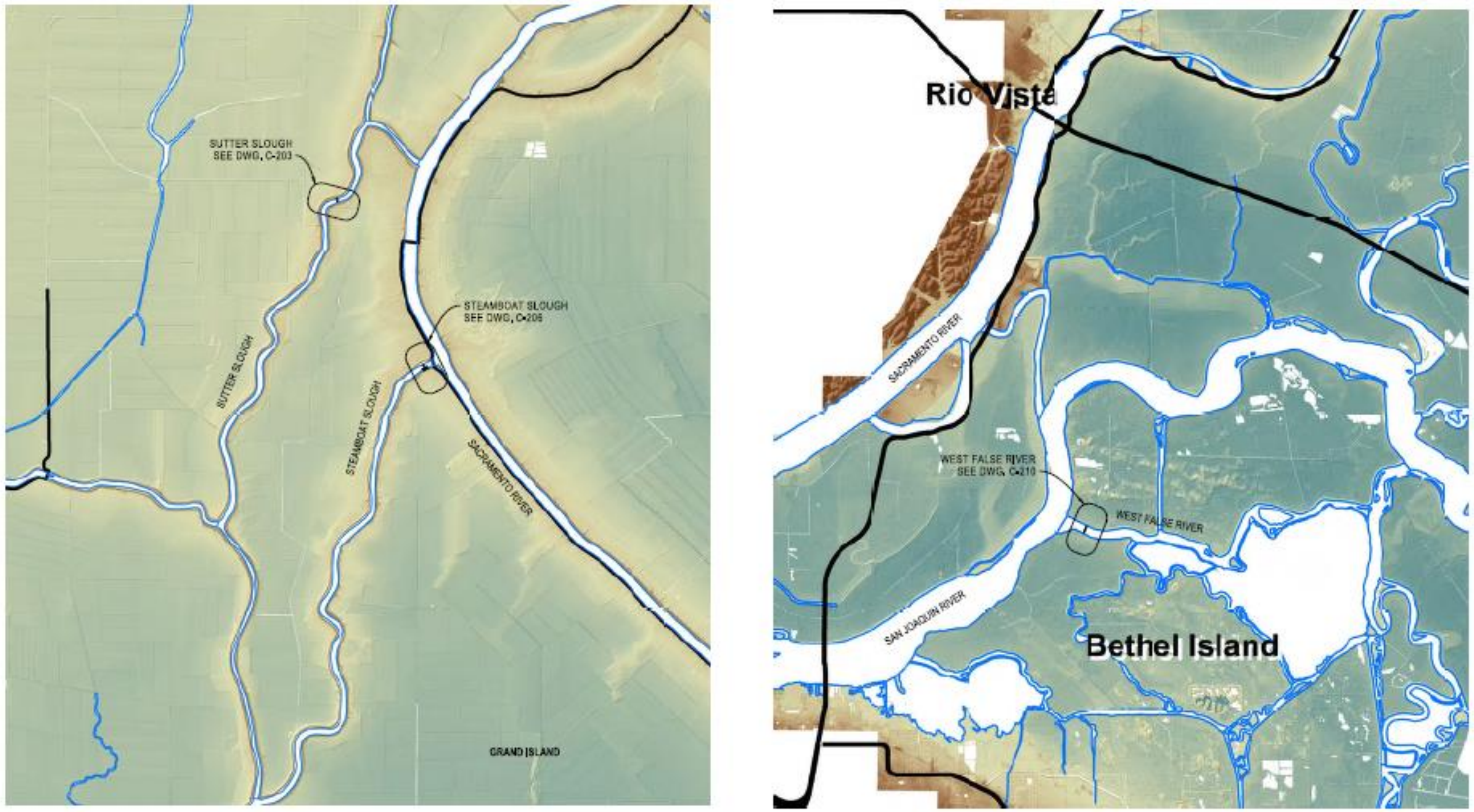

GENERAL PLAN

NOT TO SCALE

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

REV. | DESCRIPTION | SUB. | APP.

DESIGNED: [illegible] REG. C.E. No. [illegible]
CHECKED:
DRAWN: [illegible] REG. C.E. No. [illegible]
REVIEWED: James M. Lopez REG. C.E. No. [illegible]
SUBMITTED: James M. Lopez REG. C.E. No. [illegible]
APPROVAL RECOMMENDED: DATE:
CHIEF, GENERAL ENGINEERING SECTION, REG. C.E. No. [illegible]
APPROVED: DATE:
CHIEF, DELTA ENGINEERING BRANCH, REG. C.E. No. [illegible]

THINK SAFETY - ACT SAFELY

STATE WATER FACILITIES

DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS

SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER

GENERAL PLAN

SPEC. NO.	SHEET NO.	REVISION	DRAWING NO.
	002		C-201


STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA
(E) LEVEE ROAD
ROCK BARRIER
SUTTER SLOUGH
2- 48" DIA. CMP
DUAL PIPE FRAMES
(E) LEVEE ROAD
SUTTER SLOUGH - GENERAL PLAN
REV.
DESCRIPTION
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THINK SAFETY -
ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT
SLOUGH, AND WEST FALSE RIVER
SUTTER SLOUGH
GENERAL PLAN
SPEC. NO.
SHEET NO.
003
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DRAWING NO.
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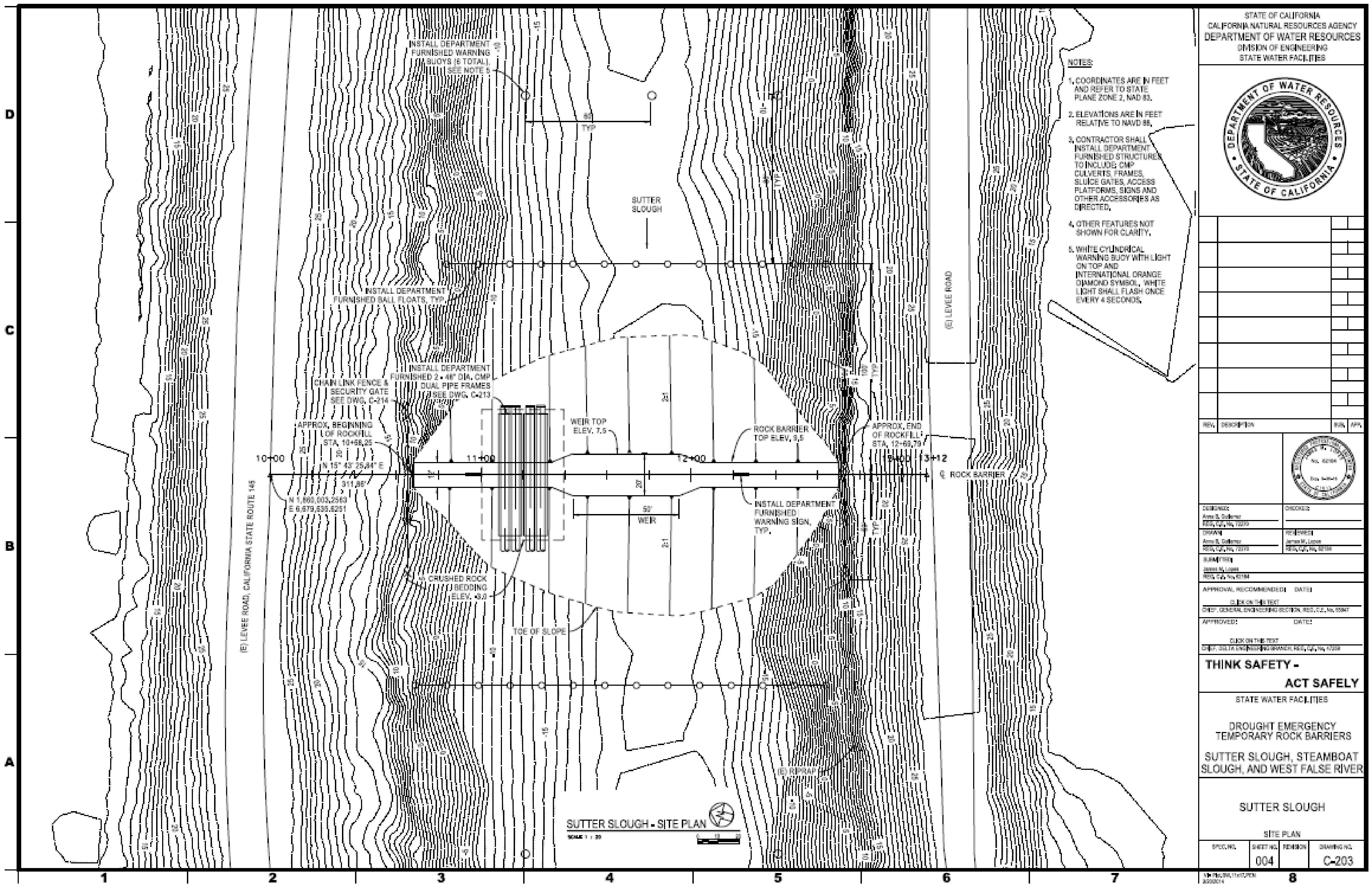
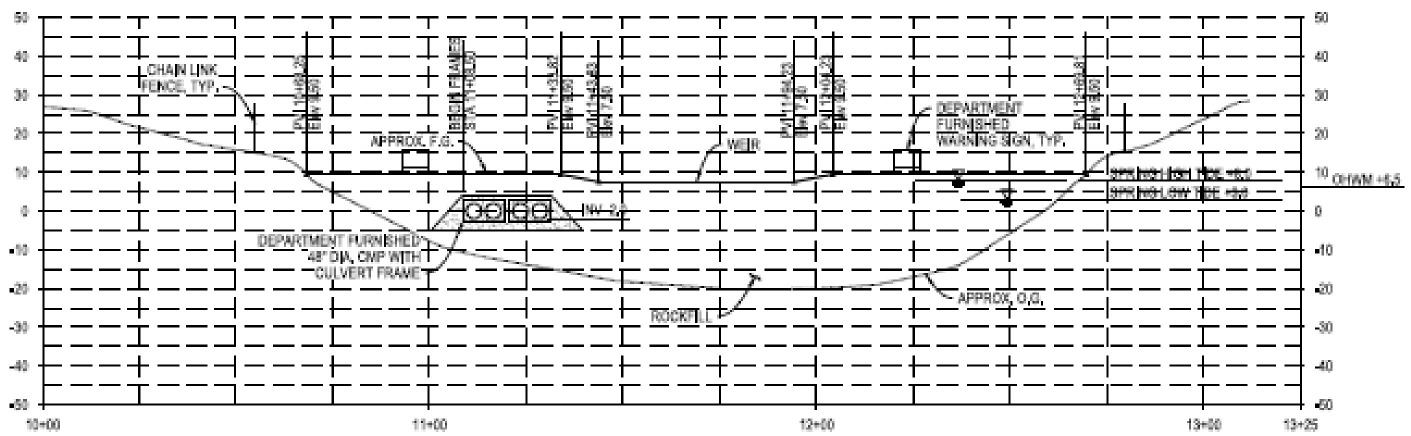
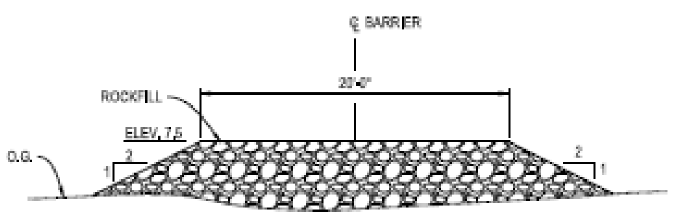


STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
NOTES:
1. COORDINATES ARE IN FEET AND REFER TO STATE PLANE ZONE 2, NAD 83.
2. ELEVATIONS ARE IN FEET RELATIVE TO NAVD 88.
3. CONTRACTOR SHALL INSTALL DEPARTMENT FURNISHED STRUCTURES TO INCLUDE: CMP CULVERTS, FRAMES, SLUICE GATES, ACCESS PLATFORMS, SIGNS AND OTHER ACCESSORIES AS DIRECTED.
4. OTHER FEATURES NOT SHOWN FOR CLARITY.
5. WHITE CYLINDRICAL WARNING BUOY WITH LIGHT ON TOP AND INTERNATIONAL ORANGE DIAMOND SYMBOL. WHITE LIGHT SHALL FLASH ONCE EVERY 4 SECONDS.
INSTALL DEPARTMENT FURNISHED WARNING BUOYS (6 TOTAL). SEE NOTE 5
SUTTER SLOUGH
INSTALL DEPARTMENT FURNISHED BALL FLOATS, TYP.
(E) LEVEE ROAD
CHAIN LINK FENCE & SECURITY GATE SEE DWG. C-214
INSTALL DEPARTMENT FURNISHED 2 - 48" DIA. CMP DUAL PIPE FRAMES SEE DWG. C-213
APPROX. BEGINNING OF ROCKFILL STA. 10+68.25
WEIR TOP ELEV. 7.5
ROCK BARRIER TOP ELEV. 9.5
APPROX. END OF ROCKFILL STA. 12+69.79
10+00
11+00
12+00
13+12
℄ ROCK BARRIER
N 15° 43' 25.84" E
311.86'
N 1,860,003.2563
E 6,679,635.8251
50' WEIR
INSTALL DEPARTMENT FURNISHED WARNING SIGN, TYP.
(E) LEVEE ROAD, CALIFORNIA STATE ROUTE 145
CRUSHED ROCK BEDDING ELEV. -3.0
TOE OF SLOPE
(E) RIPRAP
SUTTER SLOUGH - SITE PLAN
REV. DESCRIPTION
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:
THINK SAFETY - ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER
SUTTER SLOUGH
SITE PLAN
SHEET NO. 004
DRAWING NO. C-203



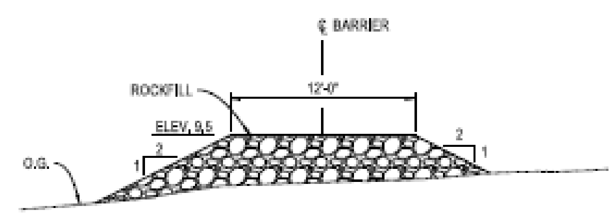
PROFILE

SCALE 1 : 20



TYPICAL WEIR SECTION

SCALE 1 : 5



TYPICAL BARRIER SECTION

SCALE 1 : 5

NOTES:

1. ELEVATIONS ARE IN FEET RELATIVE TO NAVD 88.
2. OTHER FEATURES NOT SHOWN FOR CLARITY.

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

REV.	DESCRIPTION	SUB.	APP.

DESIGNED: CHECKED:

DRAWN: REVIEWED:

SUBMITTED:

APPROVAL RECOMMENDED: DATE:

APPROVED: DATE:

THINK SAFETY - ACT SAFELY

STATE WATER FACILITIES

DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER

SUTTER SLOUGH

PROFILE AND SECTIONS

SPEC. NO.	SHEET NO.	REVISION	DRAWING NO.
	005		C-204

Steamboat Slough
Sutter Island Rd.
Boat Ramp, Typ
N 1869186.80
E 6681231.30
Access Road, Typ
N 1869097.63
E 6681588.65
Rock Barrier
Grand Island Rd.
STEAMBOAT SLOUGH SITE PLAN
Horizontal Datum: California State Plane Zone 3, NAD 83, Feet
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA
REV. DESCRIPTION SUB. APP.
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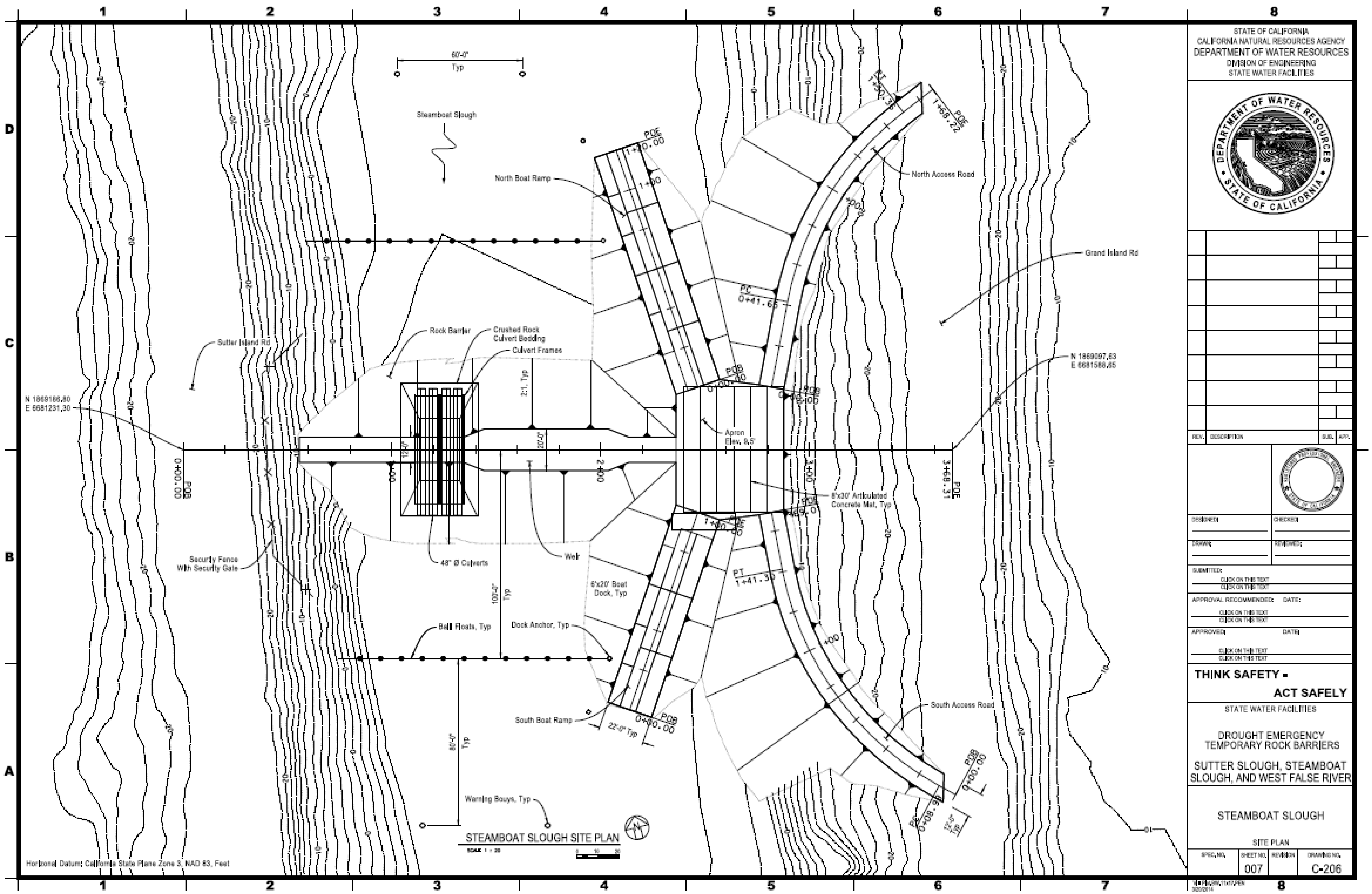
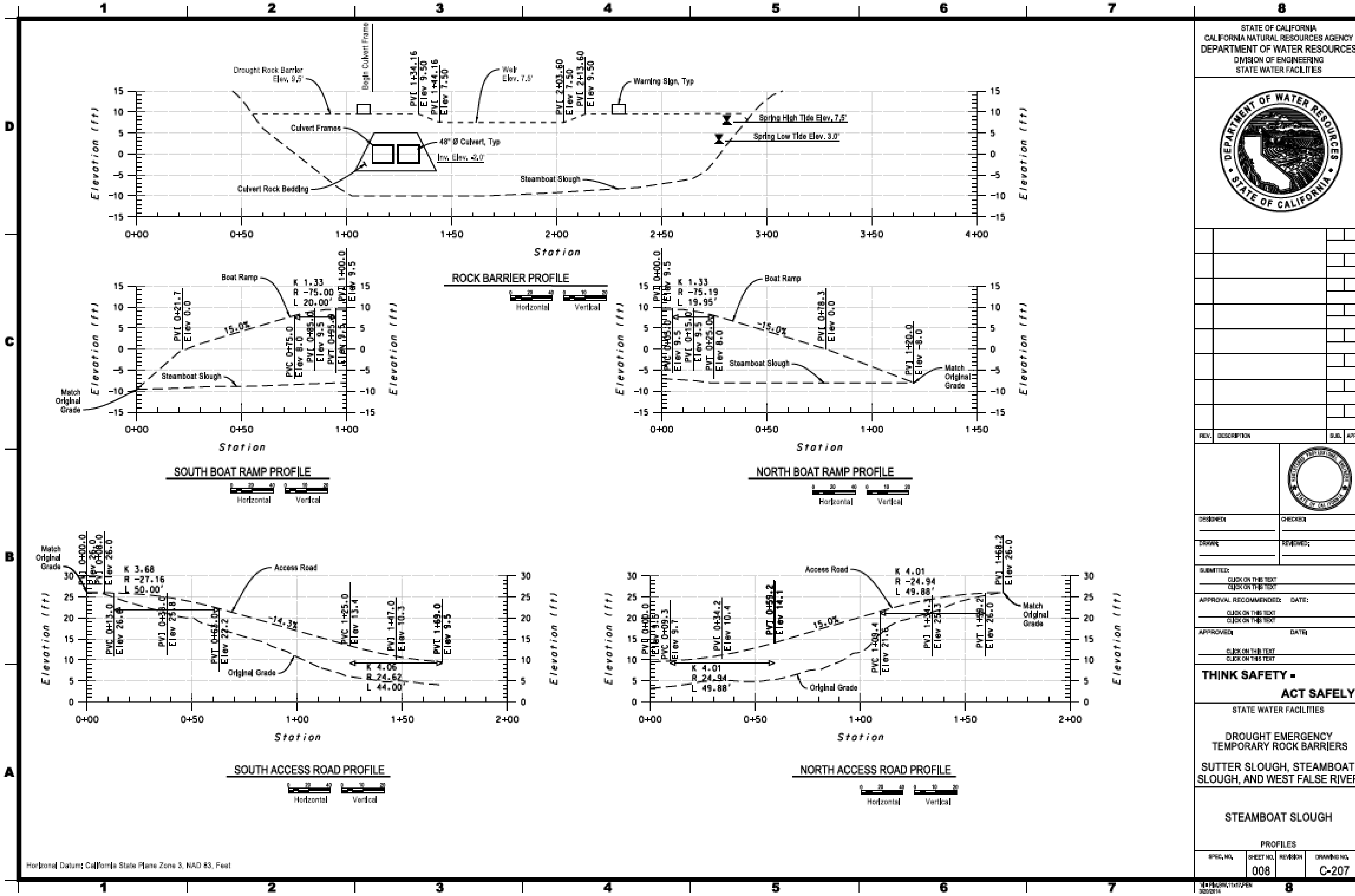
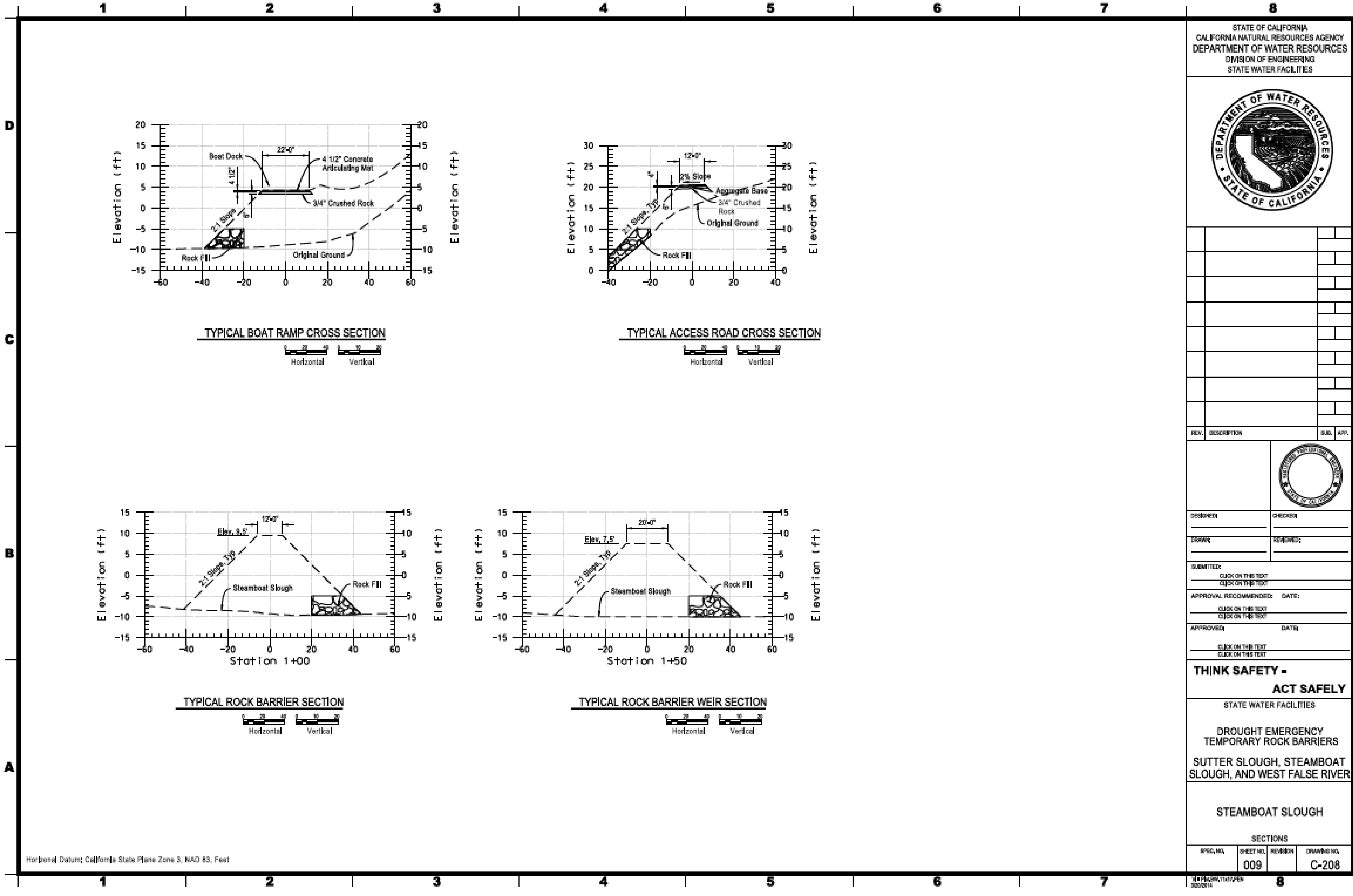
THINK SAFETY -
ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER
STEAMBOAT SLOUGH
GENERAL PLAN
SPEC. NO. SHEET NO. REVISION DRAWING NO.
006
C-205


STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
Steamboat Slough
North Boat Ramp
North Access Road
Grand Island Rd
Rock Barrier
Crushed Rock Culvert Bedding
Culvert Frames
Sutter Island Rd
N 1869186.80
E 6681231.30
N 1869097.63
E 6681588.65
Apron Elev. 8.5'
8'x30' Articulated Concrete Mat, Typ
48" Ø Culverts
Weir
Security Fence With Security Gate
6'x20' Boat Dock, Typ
Ball Floats, Typ
Dock Anchor, Typ
South Boat Ramp
South Access Road
Warning Bouys, Typ
STEAMBOAT SLOUGH SITE PLAN
Horizontal Datum: California State Plane Zone 3, NAD 83, Feet
THINK SAFETY - ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER
STEAMBOAT SLOUGH
SITE PLAN
007
C-206


ROCK BARRIER PROFILE
SOUTH BOAT RAMP PROFILE
NORTH BOAT RAMP PROFILE
SOUTH ACCESS ROAD PROFILE
NORTH ACCESS ROAD PROFILE
Drought Rock Barrier Elev. 9.5'
Culvert Frames
48" Ø Culvert, Typ
Inv. Elev. -2.0'
Culvert Rock Bedding
Steamboat Slough
Warning Sign, Typ
Spring High Tide Elev. 7.5'
Spring Low Tide Elev. 3.0'
Boat Ramp
Access Road
Original Grade
Match Original Grade
Elevation (ft)
Station
Horizontal
Vertical
Horizontal Datum: California State Plane Zone 3, NAD 83, Feet
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
THINK SAFETY - ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER
STEAMBOAT SLOUGH
PROFILES
008
C-207


STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA
TYPICAL BOAT RAMP CROSS SECTION
Boat Dock
22'-0"
4 1/2" Concrete Articulating Mat
3/4" Crushed Rock
2:1 Slope
Rock Fill
Original Ground
Elevation (ft)
Horizontal
Vertical
TYPICAL ACCESS ROAD CROSS SECTION
12'-0"
2% Slope
Aggregate Base
3/4" Crushed Rock
Original Ground
2:1 Slope, Typ
Rock Fill
TYPICAL ROCK BARRIER SECTION
Elev. 9.5'
12'-0"
2:1 Slope, Typ
Steamboat Slough
Rock Fill
Station 1+00
TYPICAL ROCK BARRIER WEIR SECTION
Elev. 7.5'
20'-0"
2:1 Slope, Typ
Steamboat Slough
Rock Fill
Station 1+50
Horizontal Datum: California State Plane Zone 3, NAD 83, Feet
REV. DESCRIPTION SUB. APP.
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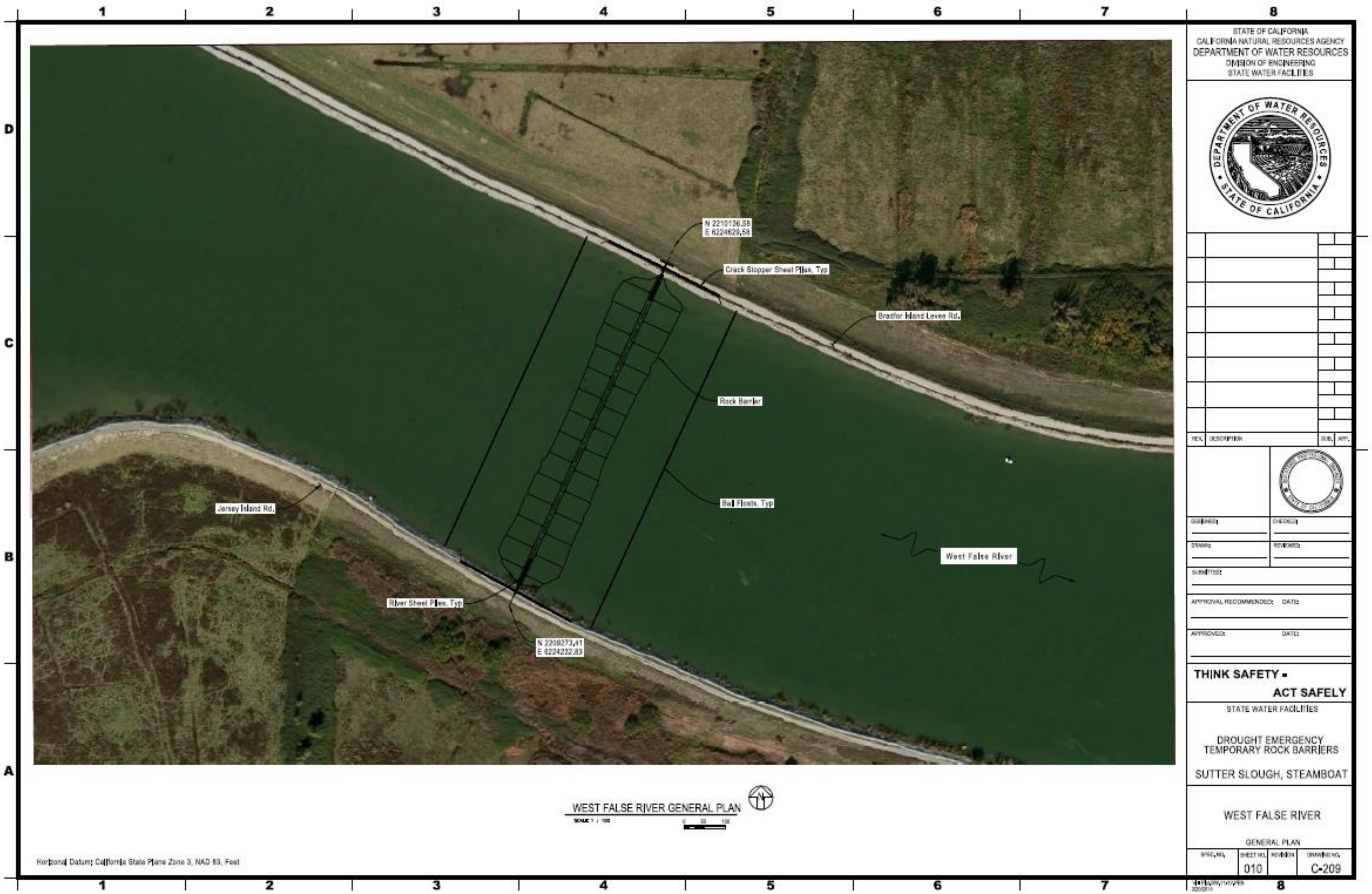
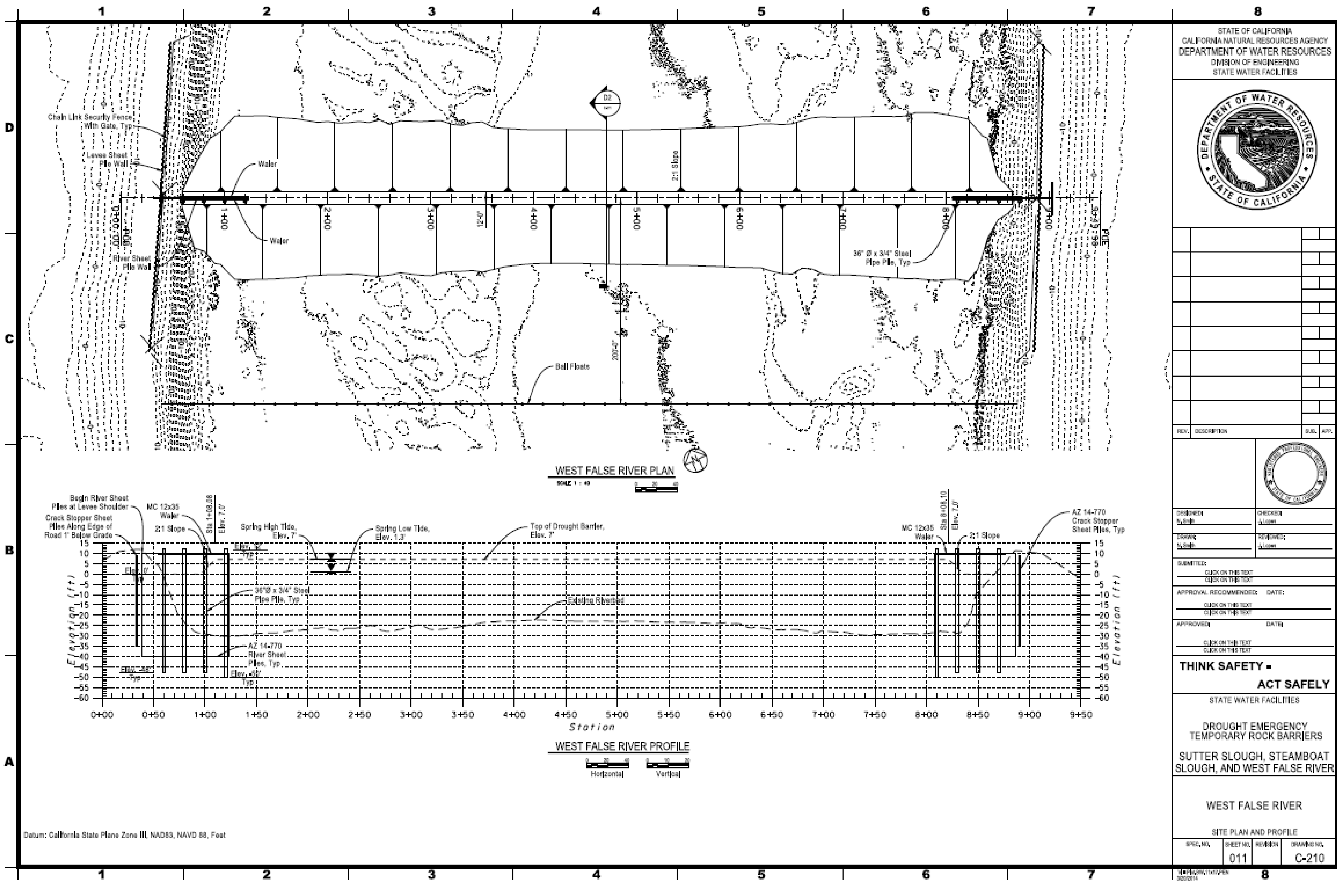
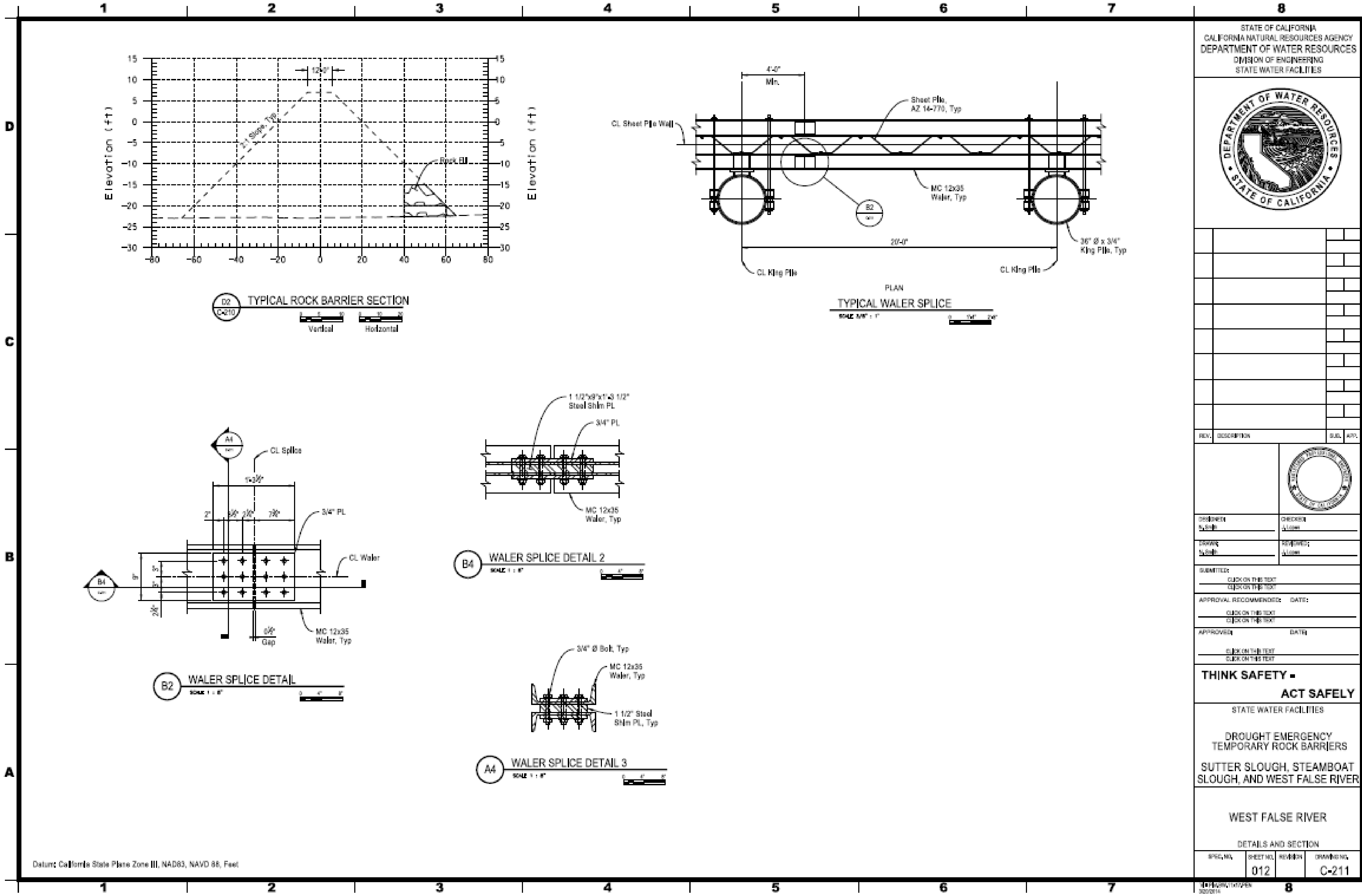
THINK SAFETY - ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER
STEAMBOAT SLOUGH
SECTIONS
SPEC. NO. SHEET NO. REVISION DRAWING NO.
009
C-208


STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
N 2210136.58
E 6224629.58
Crack Stopper Sheet Piles, Typ
Bradfor Island Levee Rd.
Rock Barrier
Jersey Island Rd.
Ball Floats, Typ
West False River
River Sheet Piles, Typ
N 2209273.41
E 6224232.83
WEST FALSE RIVER GENERAL PLAN
Horizontal Datum: California State Plane Zone 3, NAD 83, Feet
APPROVAL RECOMMENDED: DATE:
APPROVED: DATE:
THINK SAFETY -
ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT
WEST FALSE RIVER
GENERAL PLAN
SHEET NO. 010
DRAWING NO. C-209


STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
Chain Link Security Fence, With Gate, Typ
Levee Sheet Pile Wall
River Sheet Pile Wall
Waler
36" Ø x 3/4" Steel Pipe Pile, Typ
2:1 Slope
Ball Floats
WEST FALSE RIVER PLAN
Begin River Sheet Piles at Levee Shoulder
Crack Stopper Sheet Piles Along Edge of Road 1' Below Grade
MC 12x35 Waler
2:1 Slope
Spring High Tide, Elev. 7'
Spring Low Tide, Elev. 1.3'
Top of Drought Barrier, Elev. 7'
Existing Riverbed
36"Ø x 3/4" Steel Pipe Pile, Typ
AZ 14-770 River Sheet Piles, Typ
AZ 14-770 Crack Stopper Sheet Piles, Typ
Elevation (ft)
Station
WEST FALSE RIVER PROFILE
Horizontal
Vertical
Datum: California State Plane Zone III, NAD83, NAVD 88, Feet
THINK SAFETY - ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER
WEST FALSE RIVER
SITE PLAN AND PROFILE
011
C-210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CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA
Elevation (ft)
2:1 Slope, Typ
12'-0"
Rock Fill
TYPICAL ROCK BARRIER SECTION
D2
C-210
Vertical
Horizontal
4'-0"
Min.
CL Sheet Pile Wall
Sheet Pile, AZ 14-770, Typ
MC 12x35 Waler, Typ
B2
20'-0"
36" Ø x 3/4" King Pile, Typ
CL King Pile
CL King Pile
PLAN
TYPICAL WALER SPLICE
A4
CL Splice
3/4" PL
CL Waler
MC 12x35 Waler, Typ
Gap
B4
WALER SPLICE DETAIL
1 1/2"x9"x1'-3 1/2" Steel Shim PL
3/4" PL
MC 12x35 Waler, Typ
WALER SPLICE DETAIL 2
3/4" Ø Bolt, Typ
MC 12x35 Waler, Typ
1 1/2" Steel Shim PL, Typ
WALER SPLICE DETAIL 3
Datum: California State Plane Zone III, NAD83, NAVD 88, Feet
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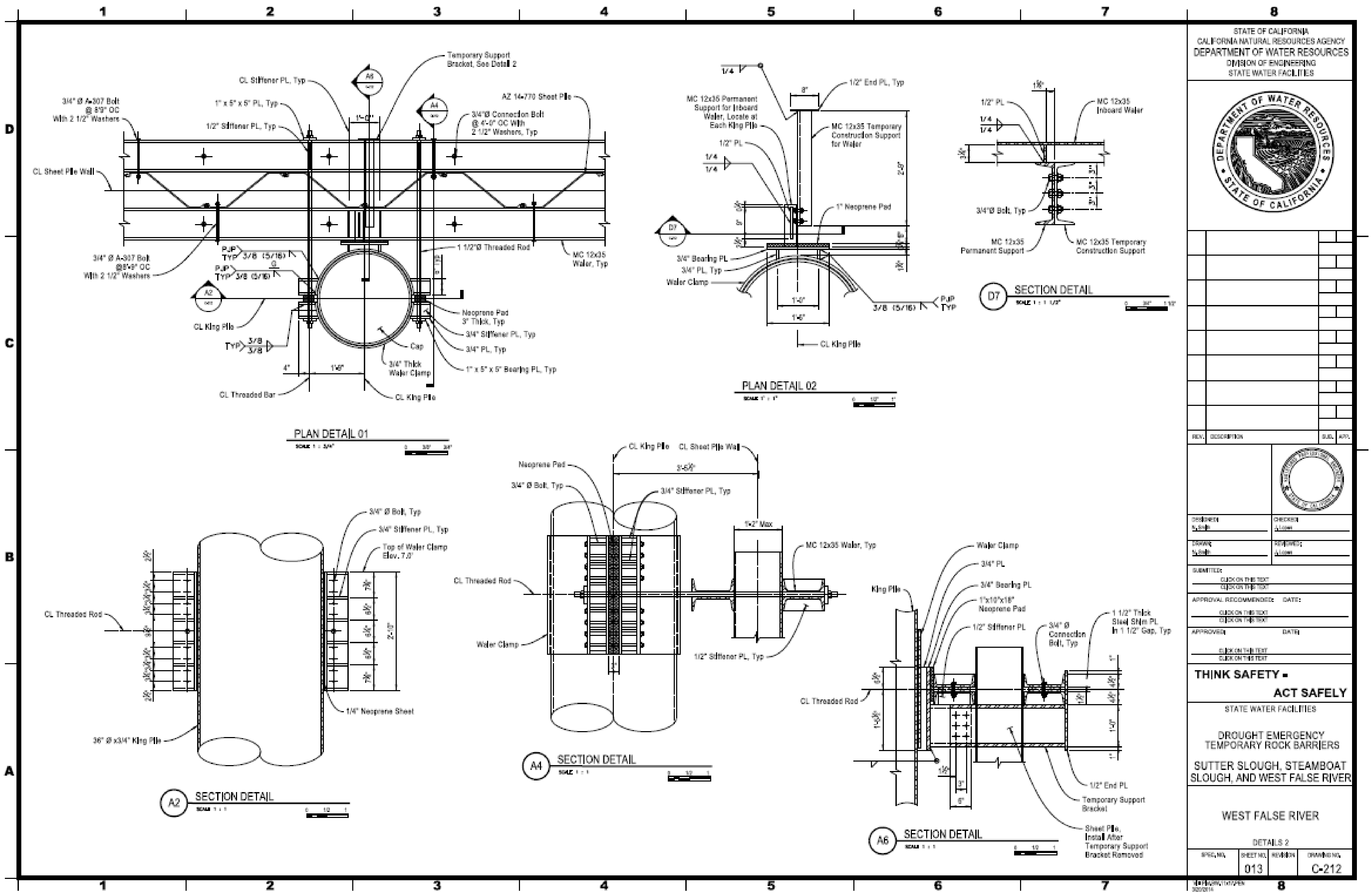
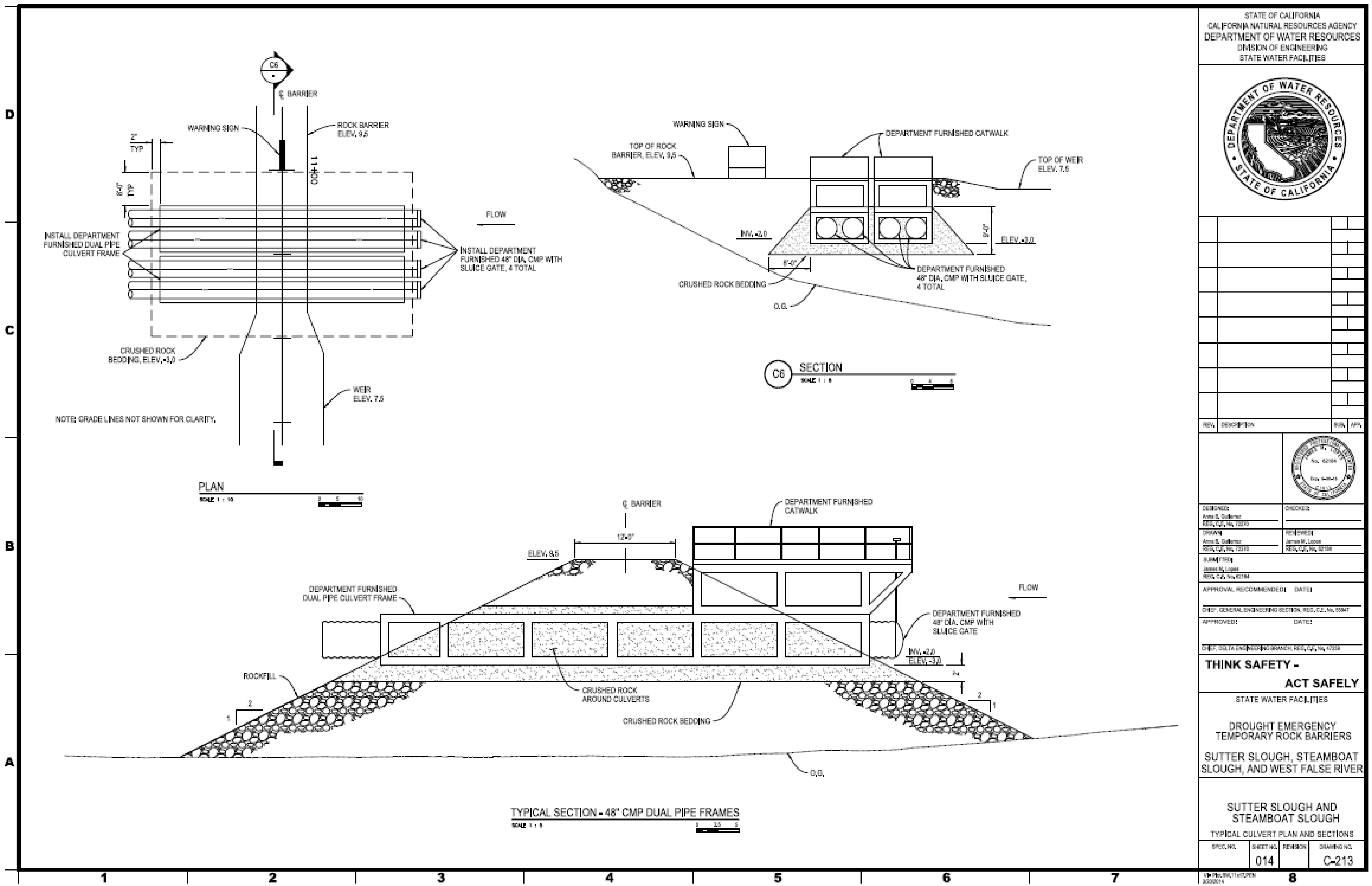
THINK SAFETY -
ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT
SLOUGH, AND WEST FALSE RIVER
WEST FALSE RIVER
DETAILS AND SECTION
SPEC. NO.
SHEET NO.
REVISION
DRAWING NO.
012
C-211


STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
PLAN DETAIL 01
PLAN DETAIL 02
D7 SECTION DETAIL
A2 SECTION DETAIL
A4 SECTION DETAIL
A6 SECTION DETAIL
Temporary Support Bracket, See Detail 2
CL Stiffener PL, Typ
AZ 14-770 Sheet Pile
3/4" Ø A-307 Bolt @ 8'9" OC With 2 1/2" Washers
1" x 5" x 5" PL, Typ
1/2" Stiffener PL, Typ
3/4"Ø Connection Bolt @ 4'-0" OC With 2 1/2" Washers, Typ
CL Sheet Pile Wall
1 1/2"Ø Threaded Rod
MC 12x35 Waler, Typ
CL King Pile
Neoprene Pad 3" Thick, Typ
3/4" Stiffener PL, Typ
3/4" PL, Typ
Cap
3/4" Thick Waler Clamp
1" x 5" x 5" Bearing PL, Typ
CL Threaded Bar
1/2" End PL, Typ
MC 12x35 Permanent Support for Inboard Waler, Locate at Each King Pile
MC 12x35 Temporary Construction Support for Waler
1/2" PL
1" Neoprene Pad
3/4" Bearing PL
3/4" PL, Typ
Waler Clamp
MC 12x35 Inboard Waler
3/4"Ø Bolt, Typ
MC 12x35 Permanent Support
MC 12x35 Temporary Construction Support
3/4" Ø Bolt, Typ
Top of Waler Clamp Elev. 7.0'
CL Threaded Rod
1/4" Neoprene Sheet
36" Ø x3/4" King Pile
Neoprene Pad
CL Sheet Pile Wall
1'-2" Max
MC 12x35 Waler, Typ
1/2" Stiffener PL, Typ
King Pile
3/4" PL
1"x10"x18" Neoprene Pad
1/2" Stiffener PL
3/4" Ø Connection Bolt, Typ
1 1/2" Thick Steel Shim PL In 1 1/2" Gap, Typ
1/2" End PL
Temporary Support Bracket
Sheet Pile, Install After Temporary Support Bracket Removed
THINK SAFETY - ACT SAFELY
STATE WATER FACILITIES
DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER
WEST FALSE RIVER
DETAILS 2
013
C-212


C6
℄ BARRIER
WARNING SIGN
ROCK BARRIER ELEV. 9.5
11+00
2" TYP
8'-0" TYP
FLOW
INSTALL DEPARTMENT FURNISHED DUAL PIPE CULVERT FRAME
INSTALL DEPARTMENT FURNISHED 48" DIA. CMP WITH SLUICE GATE, 4 TOTAL
CRUSHED ROCK BEDDING, ELEV. -3.0
WEIR ELEV. 7.5
NOTE: GRADE LINES NOT SHOWN FOR CLARITY.
PLAN
SCALE 1 : 10
WARNING SIGN
TOP OF ROCK BARRIER, ELEV. 9.5
DEPARTMENT FURNISHED CATWALK
TOP OF WEIR ELEV. 7.5
INV. -2.0
ELEV. -3.0
6'-0"
CRUSHED ROCK BEDDING
DEPARTMENT FURNISHED 48" DIA. CMP WITH SLUICE GATE, 4 TOTAL
O.G.
C6 SECTION
℄ BARRIER
12'-0"
ELEV. 9.5
DEPARTMENT FURNISHED CATWALK
FLOW
DEPARTMENT FURNISHED DUAL PIPE CULVERT FRAME
DEPARTMENT FURNISHED 48" DIA. CMP WITH SLUICE GATE
INV. -2.0
ELEV. -3.0
ROCKFILL
CRUSHED ROCK AROUND CULVERTS
CRUSHED ROCK BEDDING
O.G.
TYPICAL SECTION - 48" CMP DUAL PIPE FRAMES
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES
DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA
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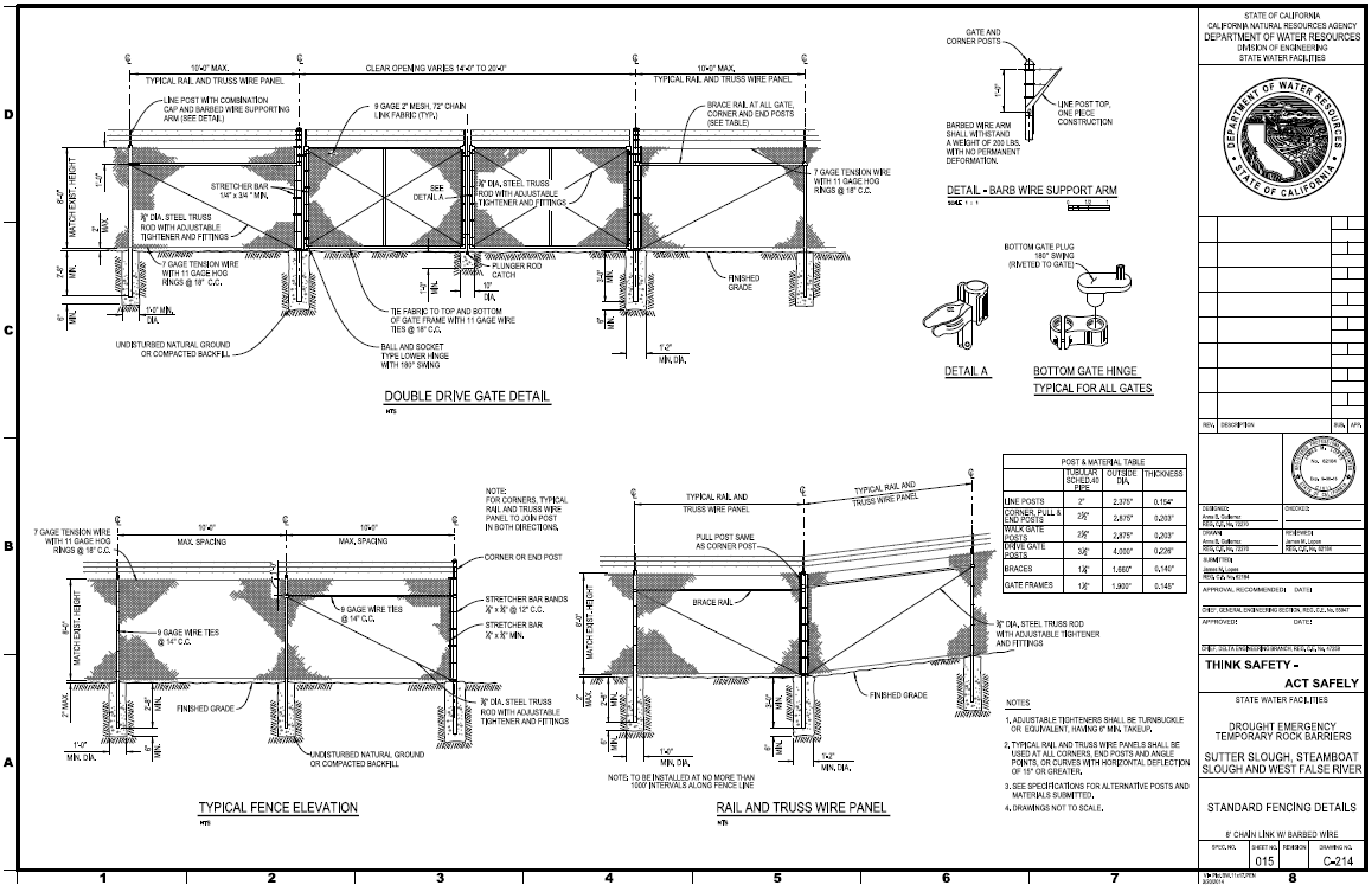
STATE WATER FACILITIES
DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS
SUTTER SLOUGH, STEAMBOAT SLOUGH, AND WEST FALSE RIVER
SUTTER SLOUGH AND STEAMBOAT SLOUGH
TYPICAL CULVERT PLAN AND SECTIONS
014
C-213
1
2
3
4
5
6
7
8
A
B
C
D



POST & MATERIAL TABLE

	TUBULAR SCHED.40 PIPE	OUTSIDE DIA.	THICKNESS
LINE POSTS	2"	2.375"	0.154"
CORNER, PULL & END POSTS	2½"	2.875"	0.203"
WALK GATE POSTS	2½"	2.875"	0.203"
DRIVE GATE POSTS	3½"	4.000"	0.226"
BRACES	1¼"	1.660"	0.140"
GATE FRAMES	1½"	1.900"	0.145"

Appendix B
Development of Flow Split Equations for Sutter/Steamboat Sloughs and Georgiana Slough/Delta Cross Channel

The effects analysis in this Biological Assessment includes consideration of potential changes in juvenile Chinook salmon migration pathways because of the operation of the EDB. This analysis was facilitated by the development of flow split equations for Sutter and Steamboat Sloughs. In addition, consideration was given to opening of the Delta Cross Channel (DCC), related to emergency contingency planning for drought conditions. This appendix summarizes the development of flow split equations.

Effects of Delta Cross Channel Gates

The analysis of opening the DCC gates starts with the evaluation of the tidal hydraulics of the Sacramento River portion of the Delta. The DCC effects on water flows are summarized with the DAYFLOW equations[10] for combined DCC and Georgiana Slough flow. The equations estimate the combined flow with the DCC closed or open as a function of the Sacramento River flow at Freeport. The DAYFLOW equations are:

DCC and Georgiana Slough Flow (DCC open) = 2,090 + 0.293 x Freeport Flow

Georgiana Slough Flow (DCC closed) = 829 + 0.133 x Freeport Flow

The difference between DCC closed and DCC open is the operational effect being evaluated:

Effect of Opening DCC = 1,261 + 0.16 x Freeport Flow

The diversion flows increase linearly with Freeport flow. For analysis at the low flows prompting the EDB, the Georgiana Slough and DCC diversions at relatively low flows are of greatest interest. Table B1 gives the calculated DCC and Georgiana Slough combined flows for a range of Sacramento River at Freeport flows from 5,000 cfs to 15,000 cfs with the DCC open and closed. A larger fraction of the Sacramento River flow is diverted into the DCC and Georgiana Slough at relatively low flows (<10,000 cfs).

Because there are four channels downstream of Freeport that divert water from the Sacramento River, a more detailed description of the diversion flows at each channel is needed for accurately evaluating the effects of opening the DCC gates on these Sacramento River diversions. At low flows, the tidal elevations and corresponding tidal flows have a stronger influence on the diversion flows into Sutter Slough, Steamboat Slough, Delta Cross Channel, and Georgiana Slough. Opening the DCC gates has an upstream effect on the tidal elevations and diversions at Sutter and Steamboat Sloughs.

The channel geometry of the Sacramento River and each diversion (i.e., width, depth, cross-sectional area) also influence the diversion flows. The DSM2-HYDRO (or RMA Delta) model can be used to simulate the tidal flows in each diversion channel for a range of Sacramento River flows, with the DCC gates opened or closed. The diversions at other channels will be slightly higher if any of the channels are closed (e.g., DCC, Sutter, or Steamboat). Tidal elevations and tidal flows (from downstream) will be reduced in any channel that is closed (blocked).

---

10 Discussion of the equations is provided at http://www.water.ca.gov/dayflow/documentation/dayflowDoc.cfm#QXGEO2

Table B1. Calculated DCC and Georgiana Slough Combined Flows for a Range of Sacramento River at Freeport Flows with DCC Closed and Open

Freeport Flow (cfs)	DCC Closed (cfs)	DCC Open (cfs)	Change for DCC Open (cfs)	DCC Closed Freeport Diverted %	DCC Open Freeport Diverted %	Change for DCC Open %
5,000	1,494	3,555	2,061	30%	71%	41%
6,000	1,627	3,848	2,221	27%	64%	37%
7,000	1,760	4,141	2,381	25%	59%	34%
8,000	1,893	4,434	2,541	24%	55%	32%
9,000	2,026	4,727	2,701	23%	53%	30%
10,000	2,159	5,020	2,861	22%	50%	29%
11,000	2,292	5,313	3,021	21%	48%	27%
12,000	2,425	5,606	3,181	20%	47%	27%
13,000	2,558	5,899	3,341	20%	45%	26%
14,000	2,691	6,192	3,501	19%	44%	25%
15,000	2,824	6,485	3,661	19%	43%	24%

Diversions to Sutter and Steamboat Sloughs, DCC, and Georgiana Slough

Sutter and Steamboat Sloughs are "tidal flow diversions" because the Sacramento River flow and elevations at the channel junctions vary with the tide and with the upstream net flow.

Results from DSM2 (monthly average flows for WY 1976-1991) were used to approximate the daily diversion flows at the four channels with simple algebraic functions of the upstream flow. Because opening the DCC will slightly reduce the Sacramento River elevations upstream, the Sutter and Steamboat diversions will be reduced when the DCC is opened. These hydraulic "flow-split" equations can then be linked to allow the daily diversion flows in each channel to be calculated for any Sacramento River flow with any combination of barriers and DCC gates (open or closed). Figure B1 shows the DSM2 results for the Sutter Slough diversions as a function of the upstream Sacramento River flow (at Freeport). For higher Freeport flows (>25,000 cfs) the DCC gates are closed and the Sutter Slough diversions are about 25% of the Sacramento River flow (purple lines). For lower flows, when the DCC is closed, the Sutter Slough diversion is a slightly smaller fraction of the Sacramento River flow (22% at 10,000 cfs and 18% at 5,000 cfs). When the DCC gates are open, the Sutter Slough diversions are reduced by about 5% (green lines). The diversion is about 20% at a Sacramento River flow of 20,000 cfs, about 15% at a Sacramento River flow of 10,000 cfs and about 10% at a Sacramento River flow of 5,000 cfs. The DSM2 results include several months when the DCC was closed for a portion of the month, giving a monthly average diversion that was intermediate between the two cases (DCC closed and DCC open).

Figure B2 shows the DSM2 results for the Steamboat Slough diversions as a function of the upstream Sacramento River flow (below Sutter Slough). When the DCC gates are closed, the Steamboat Slough diversions at higher flows are about 25% of the Sacramento River flow above Steamboat Slough

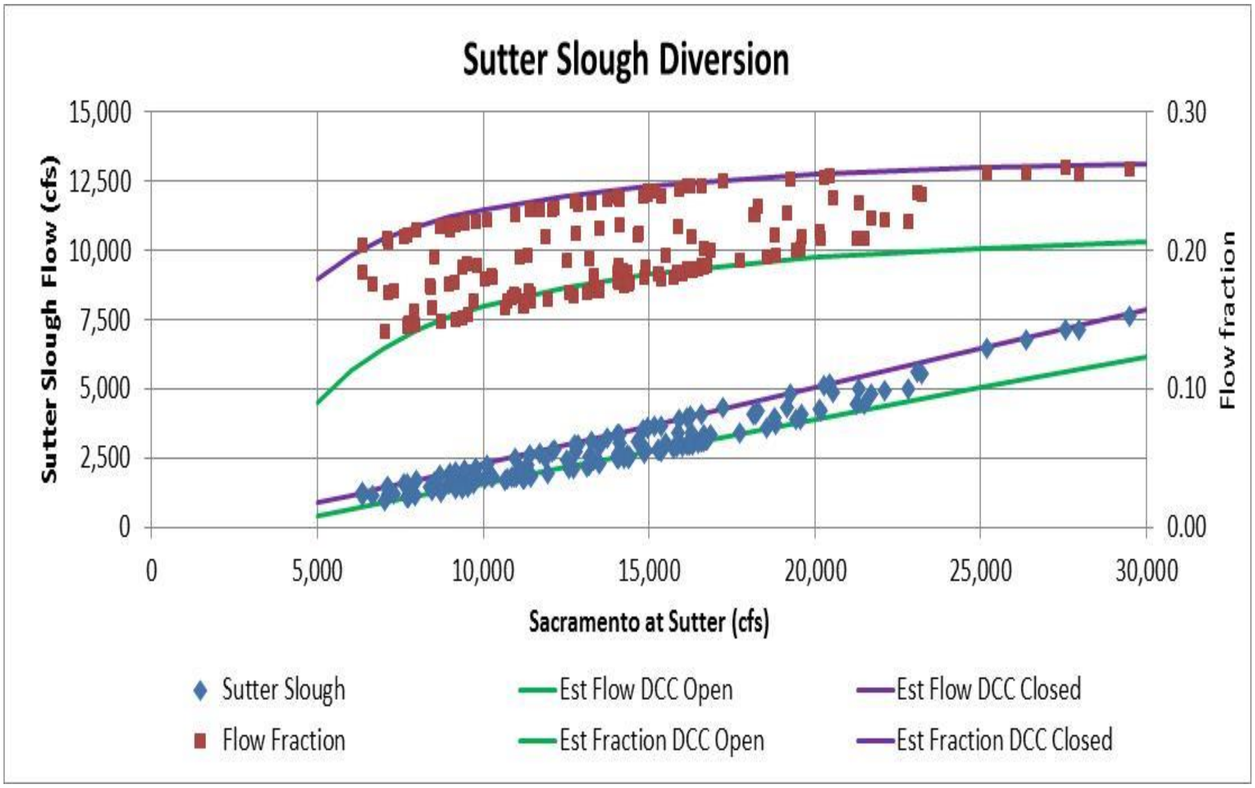


Figure B1. DSM2 Simulated Average Daily Diversions into Sutter Slough

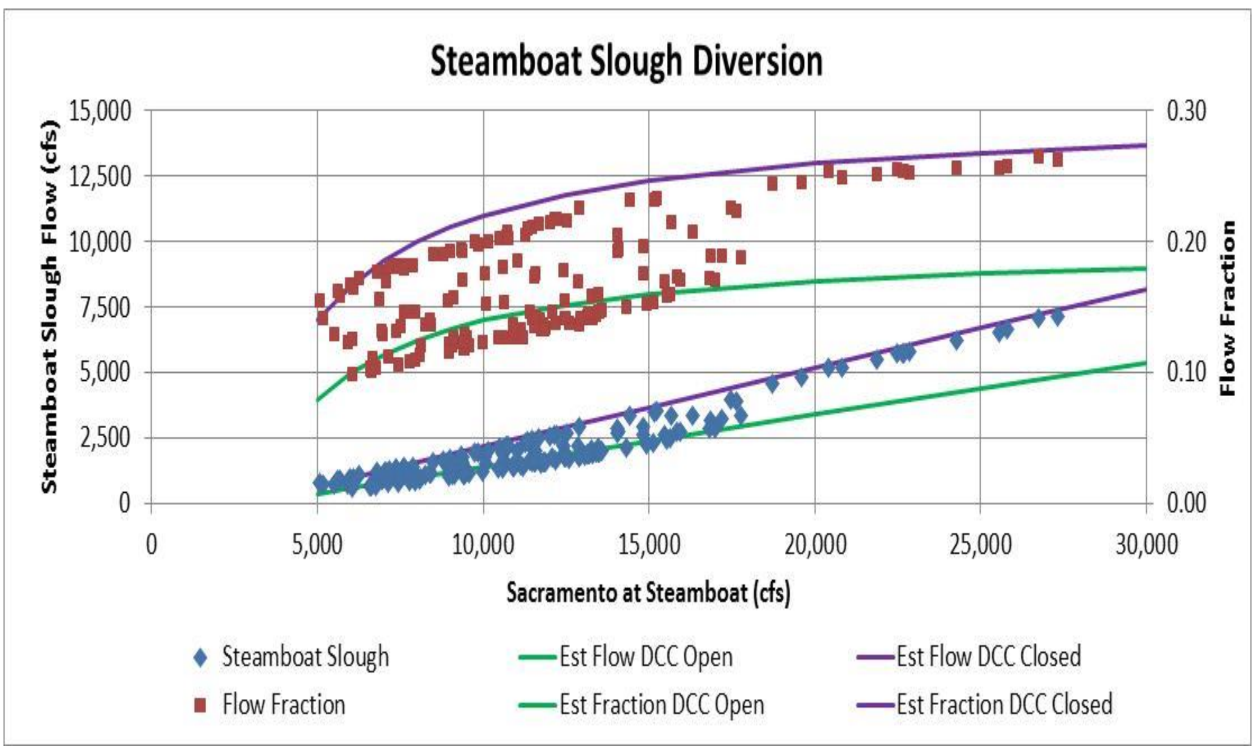


Figure B2. DSM2-Simulated Daily Average Diversions into Steamboat Slough

(purple lines). For lower flows, when the DCC is closed, the Steamboat Slough diversion is a slightly smaller fraction of the Sacramento River flow (20% at 10,000 cfs and 15% at 5,000 cfs). When the DCC gates are open, the Steamboat Slough diversions are reduced by about 7% (green lines). The diversion is about 15% at a Sacramento River flow of 15,000 cfs, about 12.5% at a Sacramento River flow of 10,000 cfs and about 10% at a Sacramento River flow of 5,000 cfs. The DSM2 results include several months when the DCC was closed for a portion of the month, giving a monthly average diversion that was intermediate between the two cases (DCC closed and DCC open).

Figure B3 shows the DSM2 results for the Delta Cross Channel diversion as a function of the upstream Sacramento River flow (below Steamboat Slough). The diversion fraction is about 40% of the Sacramento River flow at the DCC. This is the diversion flow through DCC, which the DAYFLOW equation does not estimate (DAYFLOW equation gives the combined DCC and Georgiana Slough flow).

Figure B4 shows the DSM2 results for the Georgiana Slough diversion as a function of the upstream Sacramento River flow (below DCC). The diversion fraction is about 30% of the Sacramento River flow below the DCC for relatively high flows (20,000 cfs) and the diversion fraction increases at lower flows; the diversion fraction is about 35% at a flow of 10,000 cfs, is about 45% at a flow of 5,000 cfs, and is about 55% at a flow of 2,500 cfs. These hydraulic flow-split equations can be applied sequentially to estimate the four individual diversion flows.

The sequential flow-split equations from the DSM2 results are:

Sutter (DCC closed) = -500 + 0.28 x Sacramento Flow at Sutter

Sutter (DCC open) = -700 + 0.23 x Sacramento River at Sutter

Steamboat (DCC closed) = -800 + 0.30 x Sacramento Flow at Steamboat

Steamboat (DCC open) = -600 + 0.20 x Sacramento Flow at Steamboat

DCC = 250 + 0.39 x Sacramento Flow at DCC

Georgiana Slough = 750 + 0.27 x Sacramento Flow at Georgiana

The Georgiana Slough flow with the DCC closed, and the combined DCC and Georgiana Slough flow for the DCC open can be compared to the DAYFLOW equations. The DAYFLOW estimates of Georgiana Slough flow range from 1,500 cfs for a Freeport flow of 5,000 cfs to about 2,825 cfs at a Freeport flow of 15,000 cfs, while the sequential flow-split equations for Georgiana Slough flow would give 1,750 cfs at a Freeport flow of 5,000 cfs and 3,100 cfs at a Freeport flow of 15,000 cfs. The DAYFLOW estimates of Georgiana Slough flow are about 250 cfs less than the flow-split estimates. The combined DCC and Georgiana Slough flow calculated with the DAYFLOW equation is 3,555 at a Freeport flow of 5,000 cfs and is 6,485 at a Freeport flow of 15,000 cfs, while the sequential flow-split equations would give 3,285 cfs at a Freeport flow of 5,000 cfs and 6,700 cfs at a Freeport flow of 15,000 cfs. The DCC and Georgiana Slough flow estimates with the DAYFLOW and the sequential flow-split equations are very similar.

The following section describes the development of flow equations from WY 2014 data, which were used in the effects analysis.

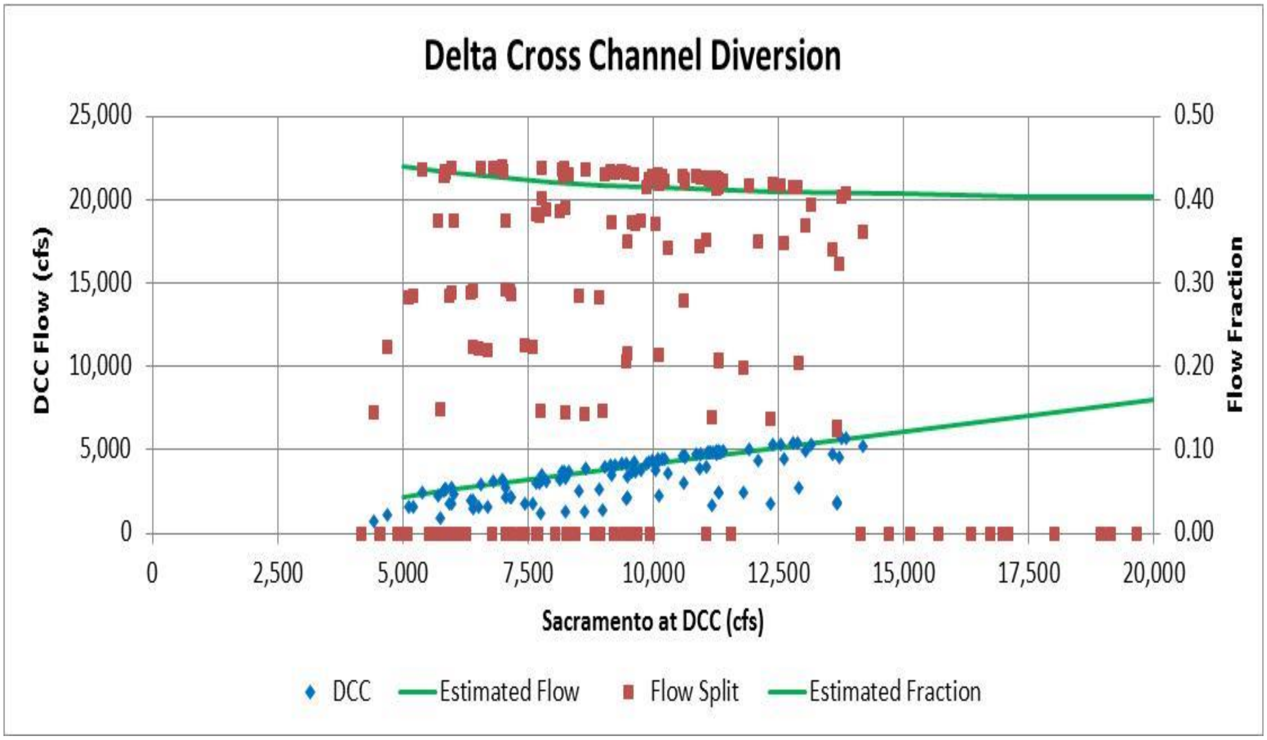


Figure B3. DSM2-Simulated Daily Average Diversions into Delta Cross Channel

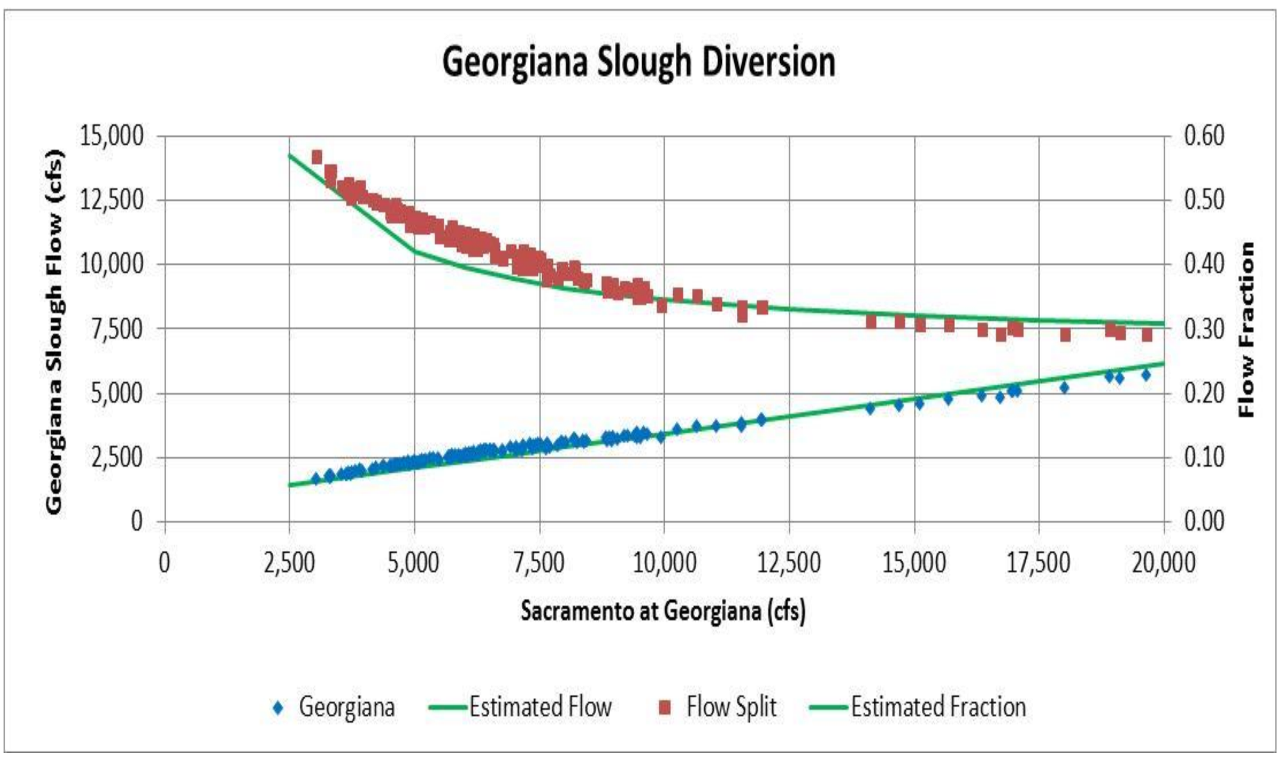


Figure B4. DSM2-Simulated Daily Average Diversions into Georgiana Slough

Measured Tidal Flows in the Sacramento River and in the Diversion Channels

In recent years the Sacramento River tidal flows and velocities at Freeport, above the DCC and below the Georgiana Slough have been measured by USGS. These data for WY 2014 (October 2013 through February 2014) have been used to confirm the DSM2 flow split equations.

Figure B5 shows the 15-minute Sacramento River flow at Freeport; there is a substantial tidal flow variation of about 15,000 cfs at Freeport (i.e., average ± 7,500 cfs) , even though Freeport is 75 km upstream of Collinsville (155 km from Golden Gate). The tidal flow variation was greatly reduced during the two storm events in February flows, when the average tidal elevation was higher than the normal high tide elevation. Figure B6 illustrates flow at Steamboat Slough for the same time period, and Figure B7 illustrates Sacramento River daily mean flows at Freeport, above DCC, and below Georgiana Slough, and shows the relative decrease in net flow with movement downstream, reflecting loss of flow at the different channel divergences.

Figure B8 shows the daily average Sutter Slough flow as a function of the upstream flow at Freeport. The fraction of the Freeport flow entering Sutter Slough is also shown. The Sacramento River flow ranged from about 5,000 cfs to about 25,000 cfs, and the Sutter Slough flow was about 20% to 25% of the Freeport flow, slightly less than the DSM2 results. The Sutter Slough tidal flow station did not operate until mid-December and the DCC was only open for a few of the days with measured flow.

Figure B9 shows the daily average Steamboat Slough flow as a function of the upstream flow at Freeport. The fraction of the Freeport flow entering Steamboat Slough is also shown. As described above, the flow-split equation uses the flow above Steamboat (after the Sutter Slough diversion), but the Steamboat flow is shown as a function of the upstream Freeport flow, so that the fraction of the Sacramento flow diverted into Steamboat Slough can be estimated. The Steamboat Slough flow was about 20% of the Freeport flow at 25,000 cfs, and was about 15% of the Freeport flow at 5,000 cfs when the DCC was closed (highest diversions). This was about 5% less than the DSM2 results. The Steamboat Slough diversion was reduced when the DCC was opened (red diamonds); the fraction of the Freeport flow was reduced by about 5% at low flows , similar to the DSM2 results. When the DCC is closed, Sutter and Steamboat Sloughs together divert about 35% of the Freeport flow at 5,000 cfs and divert about 45% of the Freeport flow at 15,000 cfs. When the DCC is open, the Sutter and Steamboat diversions are about 25% of the Freeport flow at 5,000 cfs and about 35% of the Freeport flow at 15,000 cfs.

Figure B10 shows the daily average DCC flow as a function of the upstream flow at Freeport. The fraction of the Freeport flow entering DCC is also shown. As described above, the flow-split equation uses the flow above the DCC (after the Sutter and Steamboat diversions), but the DCC flow is shown as a function of the upstream Freeport flow, so that the fraction of the Sacramento flow diverted into DCC can be estimated. The DCC flow was about 25% to 30% of the Freeport flow at 10,000 cfs (when it was open), and was about 15% of the Freeport flow at 5,000 cfs when the DCC was closed (highest diversions). This was similar to the DSM2 results.

Figure B11 shows the daily average Georgiana Slough flow as a function of the upstream flow (below DCC). The fraction of the Freeport flow entering Georgiana Slough is also shown. The Georgiana Slough flow was about 20% of the Freeport flow at 25,000 cfs, and was about 35% of the Freeport flow at 5,000 cfs when the DCC was closed (highest diversions). This was similar to the DSM2

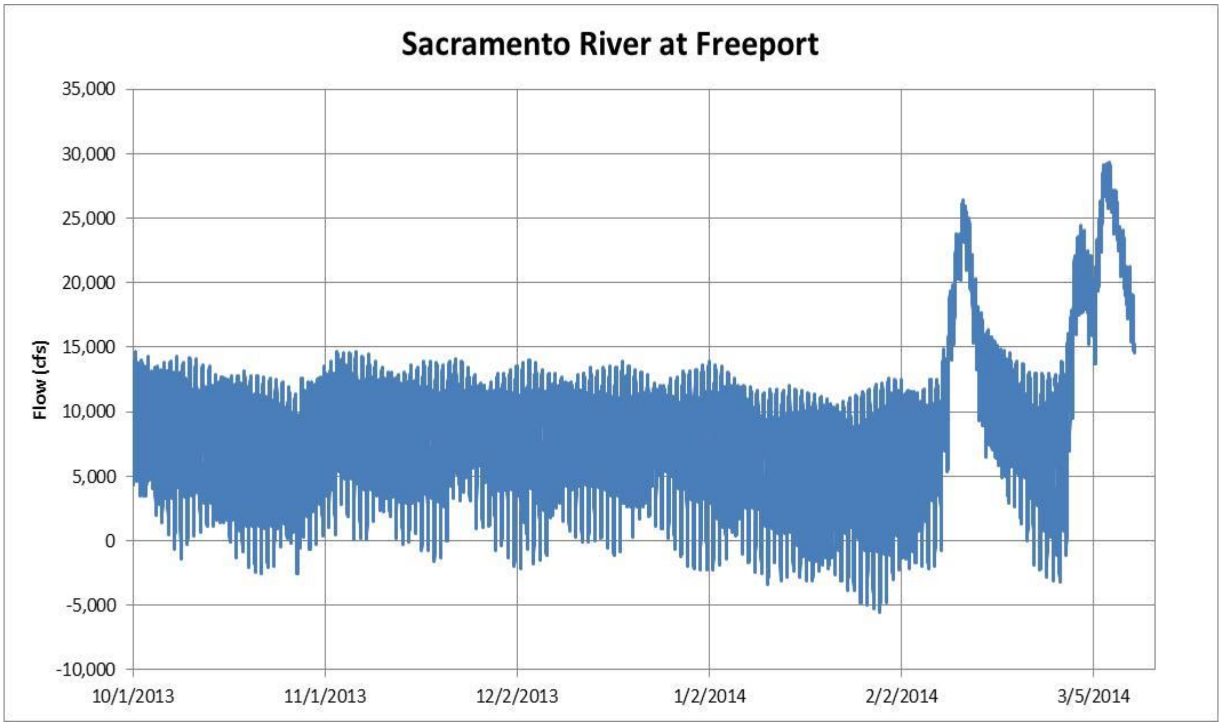


Figure B5. Measured Sacramento River Tidal Flow at Freeport for WY 2014.

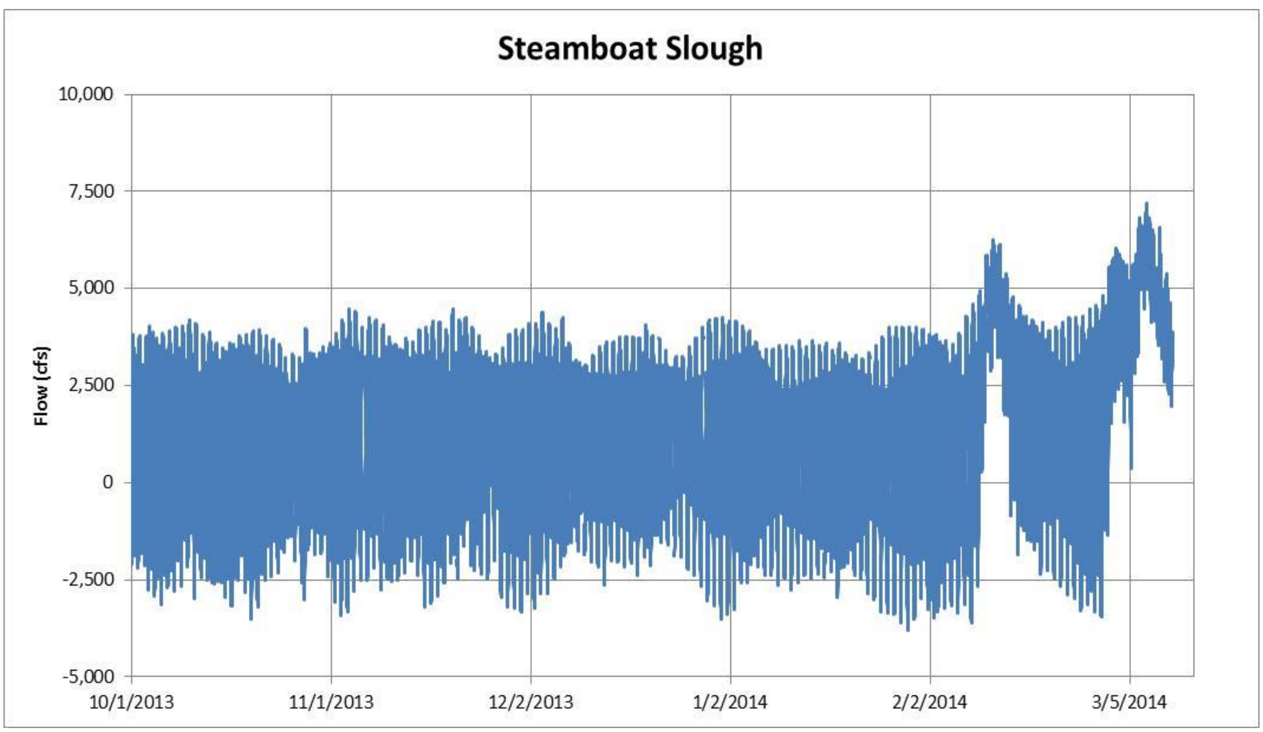


Figure B6. Measured Steamboat Slough Tidal Flow at Upstream End (Head) for WY 2014.

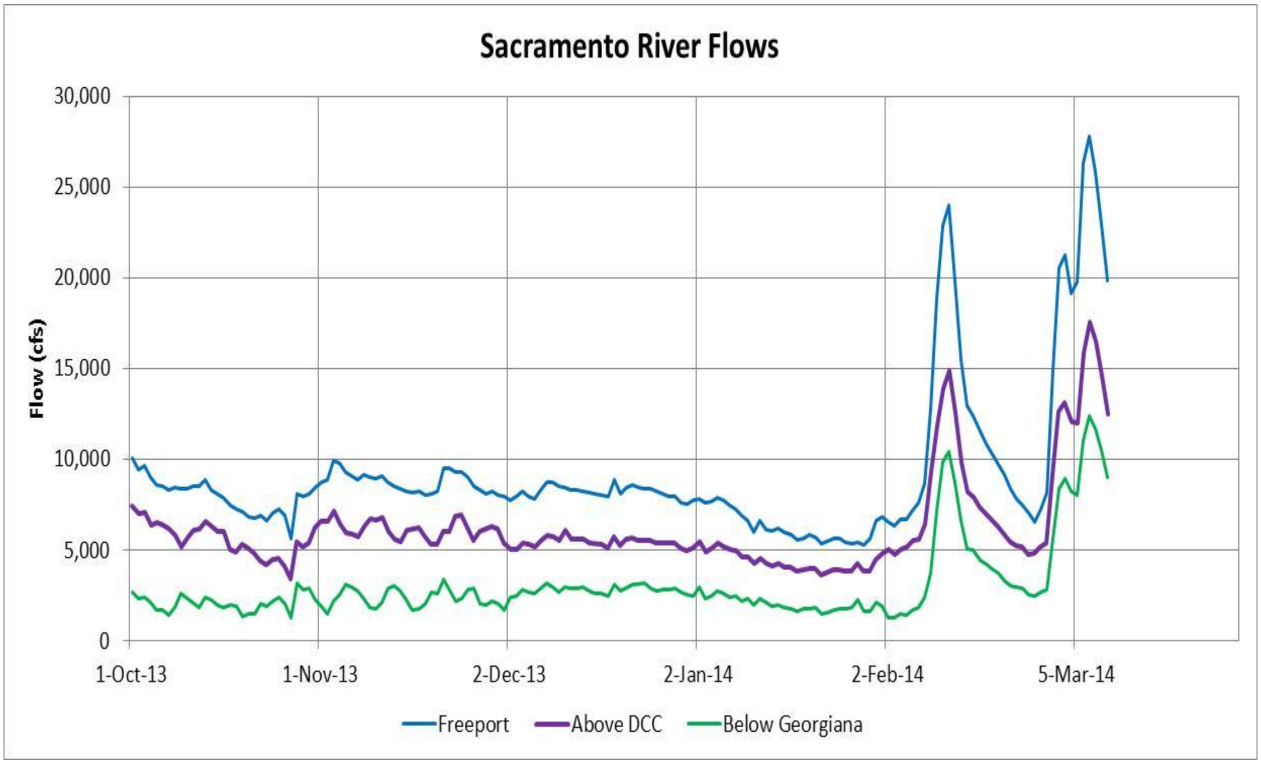


Figure B7. Daily Mean Sacramento River Flow at Freeport, above the DCC, and below Georgiana Slough for WY 2014.

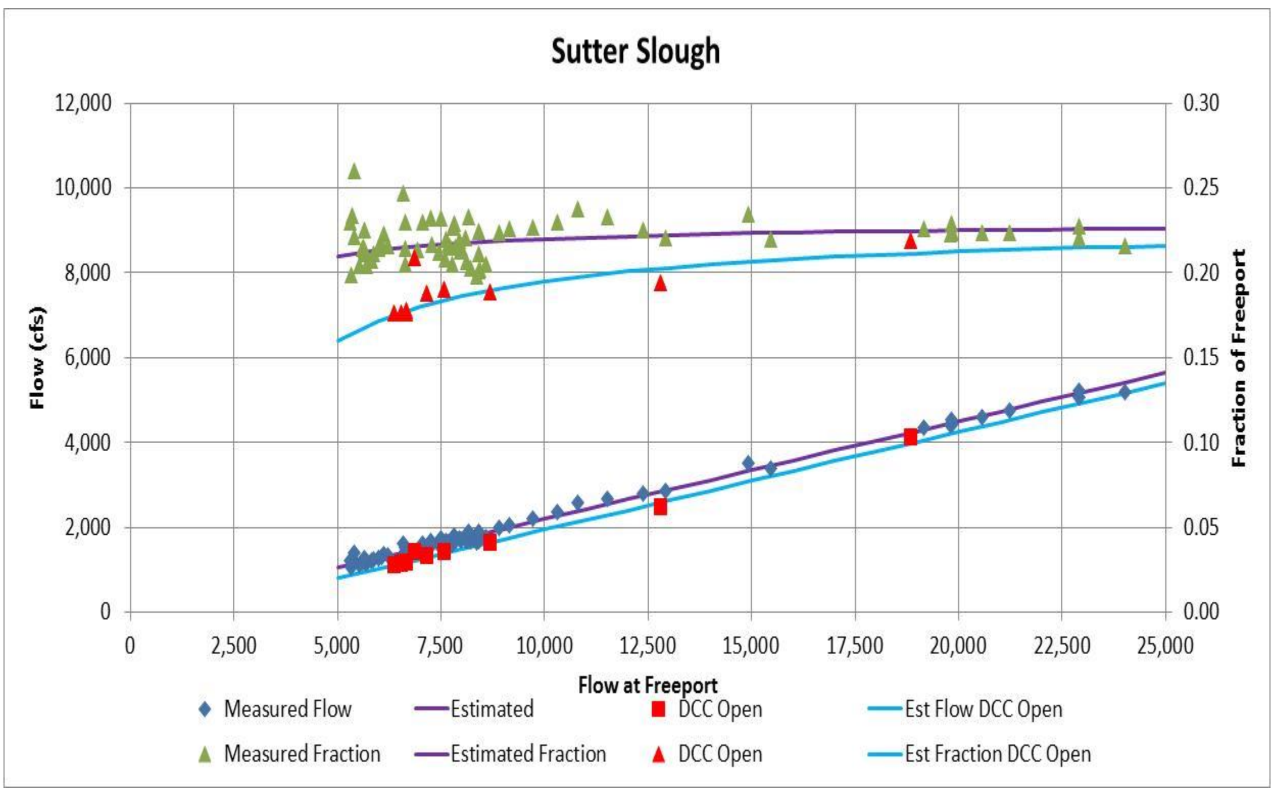


Figure B8. Measured Daily Sutter Slough Flow as a Fraction of Sacramento River Flow at Freeport.

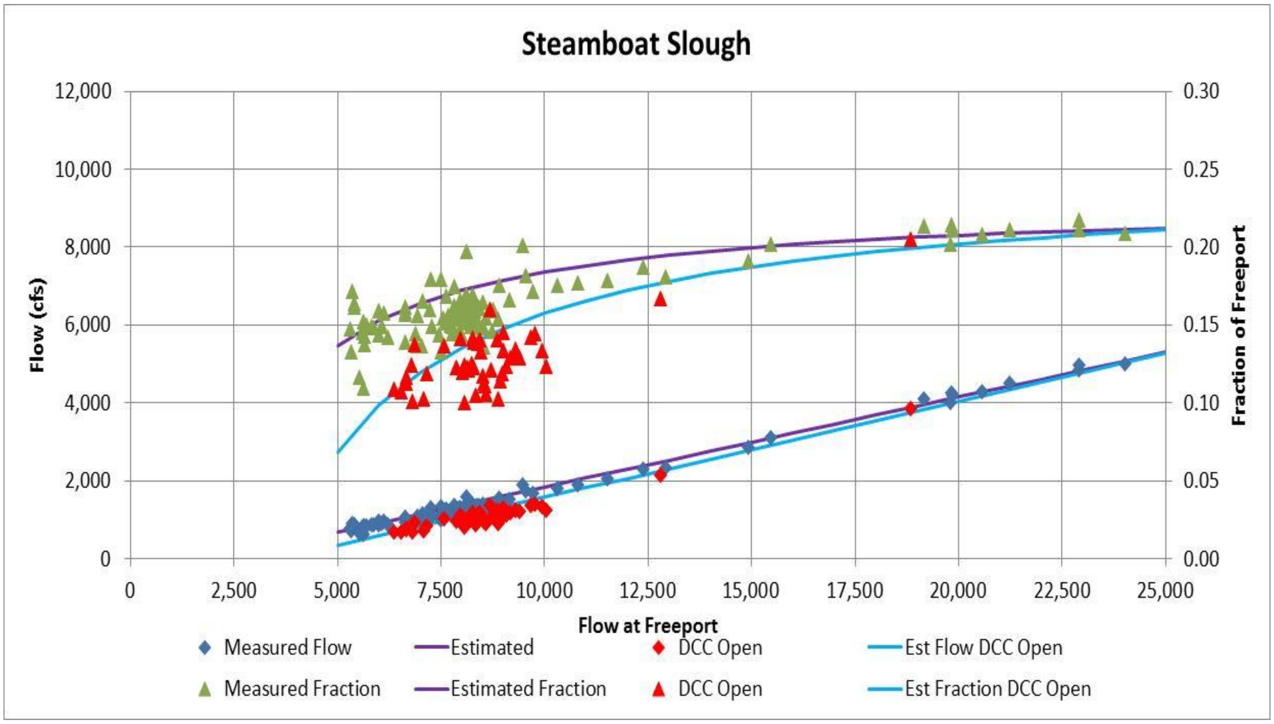


Figure B9. Measured Daily Steamboat Slough Flow as a Fraction of Sacramento River Flow at Freeport.

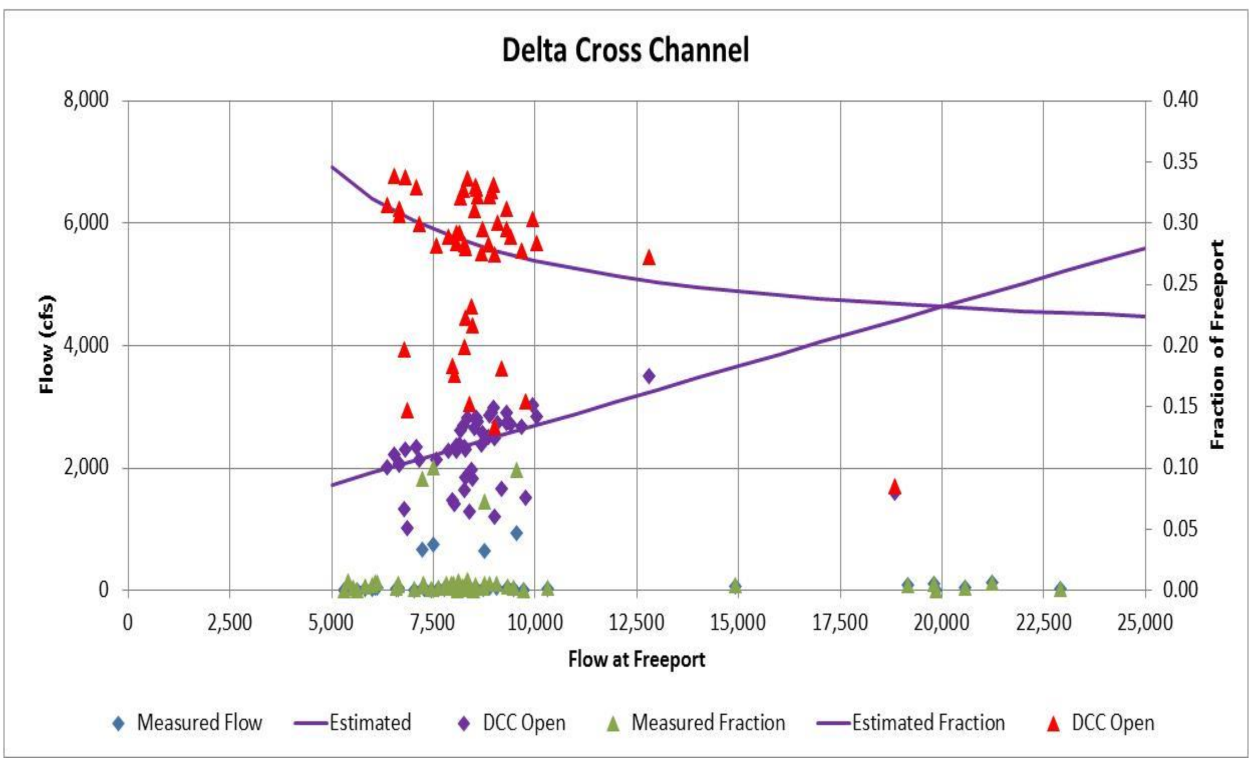


Figure B10. Measured Daily Delta Cross Channel Flow as a Fraction of Sacramento River Flow at Freeport

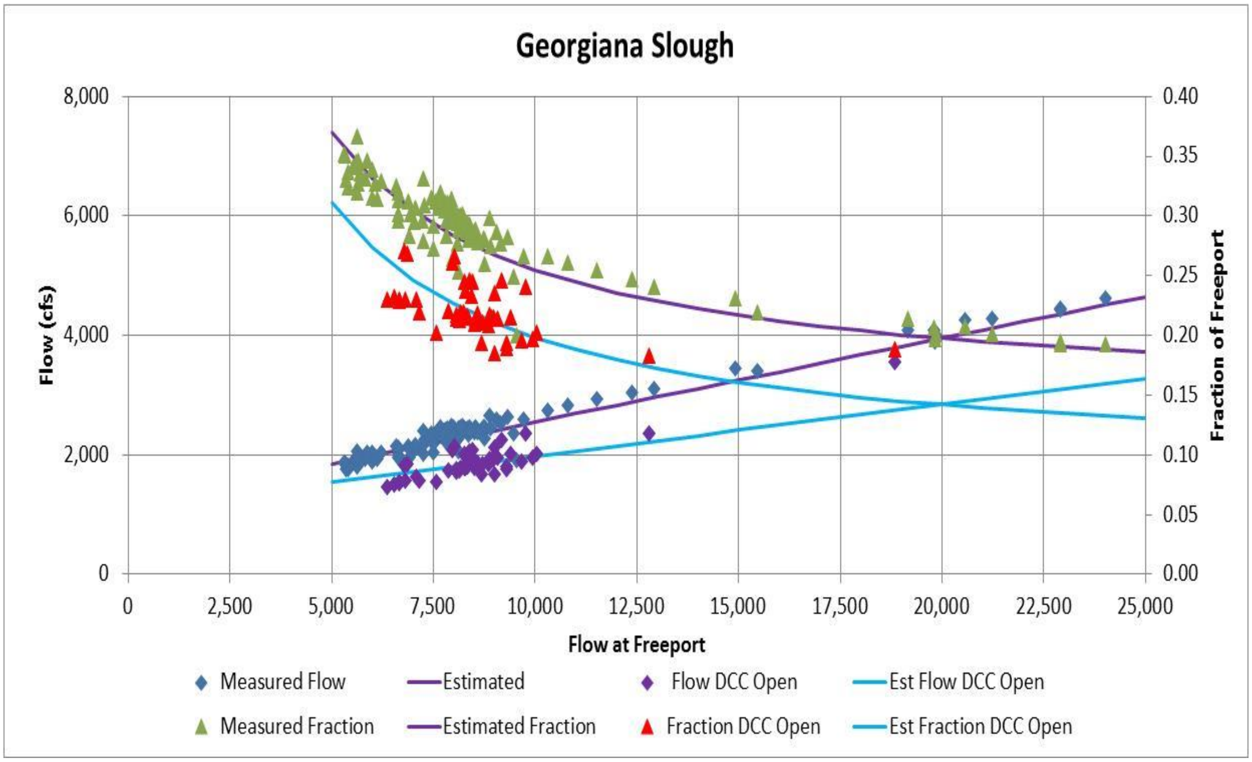


Figure B11. Measured Daily Georgiana Slough Flow as a Fraction of Sacramento River Flow at Freeport

results. The Georgiana Slough diversion was reduced considerably when the DCC was opened, because the flow above Georgiana Slough was less; the flow-split relationship was the same for DCC open and DCC closed.

The sequential flow-split equations based on the daily flows measured in WY 2014 are:

Sutter (DCC closed) = -100 + 0.23 x Sacramento Flow at Sutter

Sutter (DCC open) = -350 + 0.23 x Sacramento Flow at Sutter

Steamboat (DCC closed) = -500 + 0.30 x Sacramento Flow at Steamboat

Steamboat (DCC closed) = -1000 + 0.32 x Sacramento Flow at Steamboat

DCC = 300 + 0.37 x Sacramento Flow at DCC

Georgiana Slough = 1000 + 0.26 x Sacramento Flow at Georgiana

The sequential flow-split equations estimated from the daily flows measured in WY 2014 are similar to the flow equations estimated with the DSM2 results, confirming this approach to approximate the flow-split relationships. The flow-split equations shown above were used in the effects analysis illustrate the effects of different barrier operations on flow splits across a range of Sacramento River inflows.

Appendix C
Summary of CVP/SWP Operational Forecasts used for the DSM2 Tidal Flows and Salinity Modeling

The Emergency Drought Barriers project (EDB) has the basic purposes of improving salinity conditions in the southern Delta during periods of relatively low Delta outflow so that more water can remain in upstream reservoirs to provide acceptable carryover storage conditions (end of September 2014). A minimum required Delta outflow and a minimum level of exports for urban water supplies (called "health and safety" exports in TUCP) are assumed in the forecasted Delta operations; the upstream storage and reservoir releases are controlled by the forecasted runoff, the required deliveries to exchange contractors and high priority water right holders, and minimum reservoir releases for fish habitat and water temperature conditions.

The water quality benefits of the EDB in the south Delta (Old and Middle River diversions and CVP and SWP exports) will be greater as the Delta outflow is reduced; the minimum Delta outflow allowed by D-1641 objectives in some months (August-October) of critical years is 3,000 cfs. Installation of barriers under the EDB would occur in May-June 2014, and so the Delta channel flows and salinity conditions from May 2014 through December 2014 are of particular interest. The assumed minimum outflow of 3,000 cfs was used for March-December in the DSM2 modeling of the EDB, using the February 9, 2014 forecast of runoff and reservoir operations. This forecast of Delta conditions was called FOR1 in the DSM2 modeling. The FOR1 conditions also included an average of 1,500 cfs CVP/SWP exports for the March-December 2014 period.

Because the upstream reservoir operations are of general interest to the permitting fish agencies during drought conditions, the full set of forecasted reservoir and Delta operations are summarized here for context. Upon release of an updated March forecast by DWR, the updated forecast (including mid-February and early March storms) can be compared to the FOR1 Delta conditions. However, because reservoir storages remain very low, any updated forecasts of Delta conditions (inflows, exports, and outflows) for May-December of 2014 are expected to be similar to the FOR1 Delta conditions. Perhaps the greatest uncertainty in the forecasts will be the minimum required Delta outflows that will be allowed in 2014.

Forecasting Procedures

This appendix summarizes the results from a series of interrelated tasks and procedures used by CVP and SWP to plan (forecast) water operations in the Central Valley and in the Delta. Reservoir forecasting is done with a monthly timestep for the next year. In a simplified format, there are seven necessary inputs or assumptions needed for a forecast of CVP/SWP operations. These are described as steps below:

- Step 1. Monthly runoff projections are determined from snowpack and historical runoff distributions; for example, the existing snowpack can be combined with the 90% exceedence (higher in 9/10 years) of future month precipitation (rainfall and snowpack accumulation) to give monthly forecast runoff to the reservoirs.
- Step 2. The minimum required monthly reservoir releases are determined; these are specified in the reservoir operations manuals or operational objectives (for critical years). For example, the minimum Sacramento River releases at Keswick Dam are 3,250 in many months, and the minimum American River releases at Nimbus Dam are 500 cfs. In most years, the maximum storage for flood control is specified to determine when flood control spills might be required (this is not necessary for 2014).

- Step 3. The deliveries downstream of the reservoirs for settlement contractors and other water districts with senior water rights are specified; also specified are the accretions and inflows from tributaries along the Sacramento, and from the Mokelumne and Cosumnes, and San Joaquin Rivers. Together, these diversions and accretions allow the Delta inflows to be calculated from the forecasted reservoir releases at CVP and SWP reservoirs.
- Step 4. The minimum required Delta outflow is specified. This is relatively simple in most years, when the D-1641 objectives for Delta outflow (dependent on water year type) and the X2 objectives for February-June (dependent on previous month's forecasted runoff) can be identified. For a critical year, the January required outflow is 4,500 cfs, the February-April X2 would require an outflow of 7,100 cfs, and the May and June required outflow would be relaxed to 4,000 cfs (if the SRI is less than 8.1 MAF). The July required outflow is 4,000 cfs, the August-October required outflow is 3,000 cfs, and the November-December required outflow is 3,500 cfs. But during 2014, Reclamation and DWR (as operators of the CVP and SWP) have already requested several adjustments in the required minimum outflows and may request additional adjustments in the required Delta outflow.
- Step 5. The assumed Delta channel depletion (consumptive use) that reflects the irrigation diversions in the Delta us specified. There is a typical seasonal pattern used in the forecast model, with a maximum of about 4,500 cfs in July. Adjustments to the Delta CU values may be necessary in a drought year.
- Step 6. The water allocations for CVP and SWP contractors are specified. Generally this is done iteratively using the forecast model, beginning with the requested water (demands). Because the CVP and SWP allocations in 2014 are extremely low, minimum exports have been specified: about 1,500-2,000 cfs in March-August, 4,350 cfs in September, 2,000 cfs in October, 2,650 cfs in November and 4,250 cfs in December.
- Step 7. Export pumping limits are specified. In most years, the export limits must be specified for OMR in December-June, for SJR/E in April-May, and for E/I in all months. However for 2014, it is unlikely that the OMR restrictions will limit exports; the SJR/E will limit exports to 1,500 cfs in April and May, and the E/I limits of 0.35 will not likely limit exports in February-June.

With these seven specified inputs for each reservoir or for the Delta, the forecast model will calculate a feasible monthly operations plan that will meet the required releases and Delta outflow, and meet the specified water demands within the allowable export limits. However, the reservoir storage will be calculated from the forecasted runoff and the calculated releases; the reservoir storage may be reduced to low volumes. In most years, the water demands are reduced and the forecast model is re-run to determine if the reservoir storage will be at acceptable levels at the end of September. The difficulty in 2014 is that very little water can be delivered to south of Delta CVP/SWP contractors. The drought barriers will be an effective measure to reduce the salinity in south Delta locations during this year of very low Delta outflow. If minimum required outflow is reduced to less than the critical year D-1641 objectives, the western Delta salinity will increase (Emmaton and Jersey Point) but the drought barriers will remain effective in reducing the salinity in the south Delta, to allow irrigation diversions, CCWD diversions and CVP/SWP exports, generally within the critical year EC and chloride objectives.

Summary of February Forecast Delta Conditions

Forecasted Delta conditions can be summarized with just a few monthly flows. Table C1 gives the monthly flows used in the DSM2 modeling for the EDB (FOR1). There are three inflows; Sacramento River, San Joaquin River and the Cosumnes-Mokelumne River inflow (eastside). The Delta consumptive use and the CVP/SWP exports are the only two Delta diversions, and the remaining water flows into the estuary as Delta outflow.

Table C1. Forecasted Delta Flows Based on DWR Reservoir Operations Forecast for February 9, 2014

Month	Sacramento River	San Joaquin River	Cosumnes-Mokelumne Rivers	Delta CU	CVP Exports	SWP Exports	CCWD Diversions	Delta Outflow
January	6,652	862	244	1,008	439	1,123	81	5,399
February	10,678	828	504	1,998	1,296	1,314	54	7,621
March	6,351	1,668	244	2,833	733	733	114	4,141
April	4,470	1,721	252	3,059	756	756	108	2,066
May	6,115	1,713	244	3,691	748	829	104	3,025
June	7,663	1,082	252	4,740	807	773	108	2,890
July	7,563	933	244	5,106	797	781	210	2,165
August	7,920	807	244	3,577	1,203	781	221	3,516
September	8,924	811	252	2,353	3,361	756	242	3,571
October	6,294	638	50	1,967	1,073	749	244	3,207
November	7,320	694	60	1,729	755	1,628	275	3,890
December	9,458	623	40	1,707	1,545	2,423	280	4,378
Total (taf)	5,380	748	157	2,042	812	762	124	2,752

As described in the section discussing Environmental Baseline Conditions Specific to 2014 (main body of this BA), the January 31 TUCP Order and its modifications influence potential Delta outflow and therefore salinity conditions. The DSM2 modeling of the EDB shown in the Operations Effects section provides a reliable comparison of Delta flows and Delta salinity within delta smelt critical habitat. Although forecasted Delta conditions may change slightly, low Delta outflow and low Delta exports are likely; the minimum Delta outflows are likely to be about 3,000 cfs and the maximum Delta exports are likely to be less than 2,500 cfs for most of 2014.

Biological Assessment for
Terrestrial Species Managed by the U.S. Fish and Wildlife Service

Emergency Drought Barriers Project

Prepared for:

California Department of Water Resources

Prepared by:

AECOM

March 2014

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ACRONYMS AND ABBREVIATIONS

BA	Biological Assessment
CNDDB	California Natural Diversity Database
CVP	Central Valley Project
Delta	Sacramento–San Joaquin River Delta
DFW	California Department of Fish and Wildlife
DWR	California Department of Water Resources
EC	electrical conductivity
EDB	Emergency Drought Barriers
ESA	federal Endangered Species Act
HMMP	Hazardous Materials Management Program
NMFS	National Marine Fisheries Service
Project	2014 Emergency Drought Barriers Project
Reclamation	Bureau of Reclamation
SWP	State Water Project
SWRCB	State Water Resources Control Board
USFWS	U.S Fish and Wildlife Service

1 INTRODUCTION

Water quality conditions in the Sacramento-San Joaquin River Delta (Delta) are declining as a result of persistent drought conditions, putting municipal and agricultural water supplies at risk. The declining water quality conditions also are degrading habitat for threatened and endangered fish dependent on the Delta. In response to these conditions, the U.S. Department of Agriculture identified 54 counties in California as eligible for natural disaster assistance, including funding for emergency watershed protection and water assistance for rural communities following President Obama's announcement of an administration-wide drought response in February 2014.

Additionally, on January 17, 2014, California's Governor Edmund G. Brown Jr. signed a proclamation declaring a State of Emergency, prompted by record dry conditions and projections that 2014 will be the driest year on record (see http://gov.ca.gov/news.php?id=18368). In his proclamation, he found that the lack of precipitation is beyond the ability of local authorities to address and has placed the safety of people and property existing within California in peril due to water shortage from persistent drought conditions. Governor Brown issued a number of directives calling for immediate action to implement conservation programs, to secure water supplies for at risk communities, and to protect critical environmental resources.

Many of these actions would be undertaken by the California Department of Water Resources (DWR) and its various federal, state, and local partners. These actions include temporary modifications of requirements included in the State Water Resources Control Board's Revised Decision 1641 (D-1641) to meet water quality objectives in the Water Quality Control Plan for the Bay-Delta, including increased flexibility for water transfers, regulating diversions, and Delta Cross Channel (DCC) gate operations. The drought proclamation also directed DWR to take other necessary actions to protect water quality and water supply in the Delta, including installation of temporary barriers or temporary water supply connections as needed, and coordination with the California Department of Fish and Wildlife (DFW) to minimize impacts on affected aquatic species.

DWR's proposed 2014 Emergency Drought Barriers (EDB) Project seeks to protect the quality of water for users that rely on Delta water. The EDB would include installation of temporary rock barriers near the heads of Sutter and Steamboat sloughs in order to keep more flow in the Sacramento River, thereby facilitating a greater flow of freshwater through Georgiana Slough and the DCC in order to repel salinity from the central/south Delta and maintain water quality. An additional barrier in West False River near its confluence with the San Joaquin River would be installed to limit salinity intrusion along the lower San Joaquin River and the channels leading from it. The barriers are intended to specifically benefit:

- Communities and farmers in and adjacent to the Delta that rely exclusively on this source for drinkable water and irrigation.
- Upstream resources and communities, because once installed, the barriers would reduce demand on reservoir releases to maintain salinity levels in the Delta, leaving more water upstream for both fishery and community needs.
- The State Water Project (SWP) and Central Valley Project (CVP), as they attempt to maintain access to water supplies for human health and safety.

There is precedent for the EDB. Several rock barriers were installed at Delta locations during 1976 and 1977 to help mitigate for drought conditions. In 1976, one barrier was installed at Sutter Slough to help meet water quality criteria, to conserve water during the drought, and to enable increased SWP and CVP pumping, and the second barrier was installed at Old River at its divergence from the San Joaquin River (often referred to as head of Old River) to protect fishery resources in the Delta. In 1977, as drought conditions continued, barriers were installed at six different locations in the Delta. In addition, control facilities were built at two additional locations. The six barrier locations constructed in 1977 included Old River east of Clifton Court, San Joaquin River near Mossdale, Rock Slough, Indian Slough, Dutch Slough, and the head of Old River.

2 CONSULTATION HISTORY

The consultation history for the EDB includes the following:

- March 5, 2014: Representatives from the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) attended an EDB coordination meeting hosted by DWR, which also included representatives from the Bureau of Reclamation (Reclamation), USACE, SWRCB, and the AECOM-led consulting team.

- March 12, 2014: Representatives from NMFS and USFWS attended an EDB coordination meeting hosted by DWR, which also included representatives from Reclamation, USACE, SWRCB, DFW, and the AECOM-led consulting team.

3 PURPOSE AND SCOPE OF THIS BIOLOGICAL ASSESSMENT

This Biological Assessment (BA) is intended to satisfy the Section 7 consultation requirements of the Endangered Species Act (ESA) for terrestrial species managed by the USFWS. Delta smelt (*Hypomesus transpacificus*) is separately addressed in a BA prepared for aquatic species managed by the National Marine Fisheries Service and USFWS. A USFWS species list was generated for the U.S. Geologic Survey quadrangle in which each if the three proposed temporary barriers is located, as well as the surrounding eight quadrangles. The Sutter Slough and Steamboat Slough barrier locations are in the Courtland quadrangle, and the West False River barrier location is in the Jersey Island quadrangle. Additional quadrangles covered by the species lists include: Antioch North, Antioch South, Birds landing, Bouldin Island, Brentwood, Bruceville, Clarksburg, Florin, Isleton, Liberty Island, Rio Vista, Thornton, Saxon, and Woodward Island. This BA describes effects potentially resulting from implementation of the Project on the following two species listed as threatened under the ESA:

- Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)
- Giant garter snake (*Thamnophis gigas*)

Many additional species included on the USFWS lists generated for the 16 quadrangles were evaluated for their potential to occur in the vicinity of at least one of the EDB sites and potentially be affected by the proposed action. The following terrestrial species were eliminated from consideration in this BA because the EDB sites are outside of the current range of the species or field observations and review of aerial photography concluded there is no suitable habitat for the species on, or adjacent to, any of the EDB sites:

- Lange's metalmark butterfly (*Apodemia mormo langei*)
- Conservancy fairy shrimp (*Branchinecta conservatio*)
- Longhorn fairy shrimp (Branchinecta longiantenna)
- Vernal pool fairy shrimp (*Branchinecta lynchi*)
- Delta green ground beetle (*Elaphrus viridis*)
- Vernal pool tadpole shrimp (*Lepidurus packardi*)
- California tiger salamander, central population (*Ambystoma californiense*)
- California red-legged frog (*Rana draytonii*)
- Alameda whipsnake (Masticophis lateralis euryxanthus)
- California clapper rail (Rallus longirostris obsoletus)
- California least tern (*Sterna antillarum browni*)
- Salt marsh harvest mouse (*Reithrodontomys raviventris*)
- San Joaquin kit fox (*Vulpes macrotis mutica*)
- Large-flowered fiddleneck (*Amsinckia grandiflora*)
- Soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*)
- Contra Costa wallflower (*Erysimum capitatum* ssp. *angustatum*)
- Contra Costa goldfields (*Lasthenia conjugens*)
- Colusa grass (Neostapfia colusana)
- Solano grass (Tuctoria mucronata)
- Antioch Dunes evening-primrose (*Oenothera deltoides* ssp. *howellii*)
- Keck's checker-mallow (*Sidalcea keckii*)

4 PROJECT DESCRIPTION

4.1 PURPOSE AND NEED

The purpose of the EDB is to prevent the intrusion of saltwater into the Delta, which would render the water undrinkable by 25 million Californians and unusable by the farms that are reliant upon this source, as well as to protect habitat for sensitive aquatic species in the Delta.

The EDB is needed because the water supply for all those dependent on the water in the Delta is at risk as water quality conditions in the Delta decline due to the severe drought conditions[1]. In January of this year, unusual amounts of saltwater began intruding into the Delta. The resulting water quality approached human health criteria at many locations in the south Delta and spread as far south as the SWP and CVP intakes near Tracy, putting several communities and local water purveyors dependent on that water supply at risk. The bromide levels also are increasing along with salinity (bromide concentrations are typically low in freshwater and higher in seawater). This is important because bromide plays a role in the formation of disinfection by-products (trihalomethanes and bromate), which are carcinogens and difficult to treat with existing drinking water purification processes.

The Delta is a complex system of interconnecting channels that provide numerous pathways for the tides to push saltwater inland. Normally, outflow is sufficient to prevent San Francisco Bay’s saline water from migrating

[1] Calendar year 2013 was the driest year in recorded history for many areas of California, and current conditions suggest no change in sight for 2014 (DWR 2014a).

eastward into the Delta with each tidal pulse, but the record dry January experienced dramatically lower outflow levels. Subsequent storms in February temporarily increased freshwater flow into the Delta, stabilizing salinity levels in the Delta during late February through March. However, precipitation has been low in March, and the National Oceanic and Atmospheric Administration's seasonal drought outlook predicts drought conditions will persist or intensify through May 31. Sierra snowpack and most reservoirs are below or about at normal levels for this time of year. Currently, Lakes Shasta and Oroville are at 45 percent capacity, and Folsom Lake is at 41 percent capacity (Special Committee on Bay Delta 2014). More significantly, the snowpack that would typically refill them is about 24 percent of average (DWR 2014a), reducing the amount of runoff that will occur later this spring. Thus, there will be insufficient water in the natural runoff or stored in reservoirs that can be released to keep salinity out of the Delta without exhausting stored water before the end of the year. Given current reservoir storage and expected runoff, projections indicate that low river inflows will allow salinity intrusion to the extent that interior portions of the Delta will exceed water quality objectives by May (Resource Management Associates 2014).

The maximum mean daily salinity objective for municipal and industrial use in all water year types established by State Water Resources Control Board in D-1641 is approximately 415 milligrams per liter (mg/L) (Table 1, Water Quality Objectives for Municipal and Industrial Beneficial Uses). However, in August 2014, salinity is projected to peak and exceed 3,100 mg/L at the SWP intake (Resource Management Associates 2014). Such high salinity levels (with associated bromide levels) could preclude pumping and/or compromise municipal water supplies. This would be particularly devastating for communities without alternative water supplies, including the Contra Costa Water District, which serves approximately 500,000 people and is almost entirely dependent on the Delta for its water supply (Contra Costa Water District 2011).

Once salinity intrudes into the Delta, moving it back toward San Francisco Bay is difficult; thus, high salinity could persist for an extended period if high winter and spring freshwater flows are not available to dislodge it. This would effectively eliminate the Delta as a water supply for the Californians who depend on it, as well as for 3 million acres of farmland. This condition would exist, perhaps for many months, until sizeable storms could provide the necessary outflow to flush out the saline waters. In addition to being critical for the health and safety of those who depend on it, water flowing through the Delta is essential to the agricultural industry and businesses that drive the state's economy; it sustains $400 billion of California's statewide economy (DWR 2014b). Consequently, increased salinity levels would have a profound detrimental effect throughout the state.

Increased salinity levels also have an adverse effect on the sensitive aquatic resources that live in and pass through the Delta. This is both due to exceedances of water quality objectives and because the already limited water supplies stored in the upstream reservoirs would need to be released in order to meet objectives. As a result, cool water resources would be insufficient in late spring and summer to protect salmon eggs incubating in the gravels, and rearing habitat for juvenile salmon below Keswick, Oroville, and other dams would be depleted. Construction of the barriers would allow the conservation of additional amounts of cool water to protect natural resource values later in the year because less water would need to be released from the reservoirs for water quality earlier in the year. Additionally, more water also would be available for community needs in upstream areas.

If implemented quickly, the EDB could impede the intrusion of saltwater into the central and south Delta and optimize the use of fresh water flows to maintain water quality that meets human health criteria through the spring and summer. Modeling of salinity intrusion with variable installation dates demonstrated the greatest benefits are gained if the barriers are installed as soon as possible. For example, installation of the barriers in combination with modest changes to operation of the DCC by May 1 provides a substantial benefit compared to a later installation in June or July. Modeling data show that by June, electrical conductivity (EC) levels are already exceeding 1,500 Siemens per centimeter (µS/cm) at the Old River at Holland Tract site (approximately 960 mg/L), whereas a May 1 effective date for operation of the barriers and DCC would keep the EC levels near or below 1,000 µS/cm (approximately 640 mg/L) (Resource Management Associates 2014).

4.1.1 PROJECT LOCATION

The barriers would be located at three locations in the north and central Delta:

- Sutter Slough;
- Steamboat Slough;
- West False River.

The general locations of these sites are shown in Figures 1 and 2.

The Sutter Slough site is located in the north Delta about 0.6 miles directly west of the Sacramento River at the northwest end of Sutter Island. This site is approximately 1 mile southwest of the community of Courtland and 7 miles northwest of Walnut Grove and is on the border between Yolo and Sacramento counties. The barrier site is located about 1.25 miles downstream from the confluence of Sutter Slough and the Sacramento River.

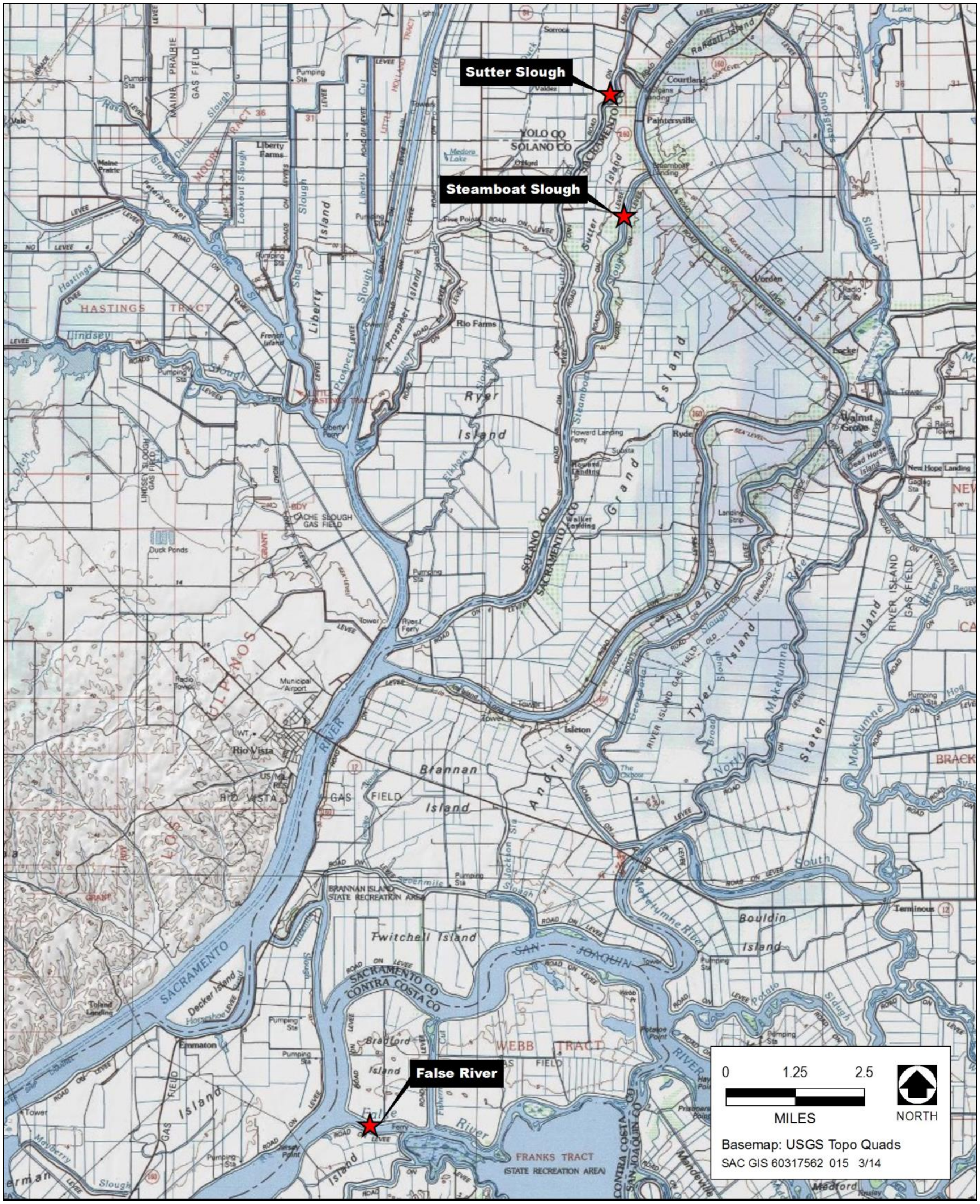
The Steamboat Slough site is approximately 2.1 miles south-southeast of the Sutter Slough site, on the east side of Sutter Island, and approximately 1.0 mile southwest of the Sacramento River in Sacramento County. The Steamboat Slough barrier site is located about 0.95 mile downstream from the confluence of Steamboat Slough and the Sacramento River and is between Sutter and Grand Islands.

The West False River site is located approximately 0.4 mile east of the confluence with the San Joaquin River, between Jersey and Bradford Islands in Contra Costa County, and is about 4.75 miles northeast of Oakley.

4.1.2 GENERAL DESIGN AND INSTALLATION CONCEPTS

Rock (rip-rap) barrier weir structures would be installed at all three sites. All structures would be trapezoid-shaped rock barriers with a wide base tapering up to a 12-foot-wide top width set perpendicular to the channel alignment. Rock fill would be placed along the base of the levees for support at the Sutter Slough and Steamboat Slough sites. The West False River site would have transitions to the levees with 75-foot-long sheet pile walls supported by king piles and buttressed with rock because the levees are weaker in this area than at the northerly sites due to peat soil foundations. Design drawings for each location are included in Appendix A.

The rock barriers would be installed at each of the sites in spring 2014 (beginning around May 1st) and removed in November 2014, prior to the rainy season when freshwater runoff would occur and during the period that fall-run Chinook salmon would pass through the Delta. If drought conditions persist, the barriers could be reinstalled and removed in subsequent years during the same timeframes. Depending on location, the barriers would serve two important drought management purposes: the Sutter and Steamboat Slough barriers would redirect freshwater flows into the central Delta, and create a hydrologic barrier to repel higher saline water; and the West False River barrier would be a physical barrier at a key location that would reduce the intrusion of high-salinity water from Suisun Bay into the central and south Delta.



Source: DWR

Figure 1 **Emergency Drought Barriers Project – Regional Location**

Source: Moffatt & Nichol 2014, AECOM 2014

Figure 2 **Project Sites – Overview**

The Sutter Slough and Steamboat Slough sites would be designed to allow fish passage and manage water quality on the downstream side of the barriers using a combination of a an overflow weir designed to be inundated in the event of a very high tide or high river discharge and the installation of four 48-inch culverts with slide gates. The West False River barrier does not include these features. Tidal flows would be the main factor influencing water quality conditions at this barrier. Fish movement can occur through the adjacent San Joaquin River and through other channels, including Fisherman's Cut, East False River, and Dutch Slough during the West False River closure.

Vessel traffic would be blocked at each barrier site. Boat ramps would be provided on either side of the Steamboat Slough barrier. Vessels up to 24 feet and 10,000 pounds would be moved around the barrier by equipment and an operator provided by the State. Boats heading into Sutter Slough would be directed by signage to Steamboat Slough for passage. Larger vessels would have to transit the Sacramento River channel instead of passing through Sutter or Steamboat sloughs between Courtland and Rio Vista. Boat access would not be provided at the West False River site since alternative routes are available via the Stockton Deep Water Ship Channel in the San Joaquin River between Antioch and eastern Delta locations, or via Fisherman's Cut or East West False River to south Delta destinations.

Solar-powered monitoring instruments would be placed at appropriate locations upstream and downstream at each site and would monitor parameters like dissolved oxygen, turbidity, salinity (EC), river stage, and flow velocity (see Conservation Measures section). Additional monitoring, including using DIDSON cameras, would be used to assess the Sutter Slough and Steamboat Slough sites for interaction with and passage of migratory fish through the culverts. One 48-inch culvert would remain fully open at all times at the Sutter Slough and Steamboat Slough barriers primarily for fish passage.

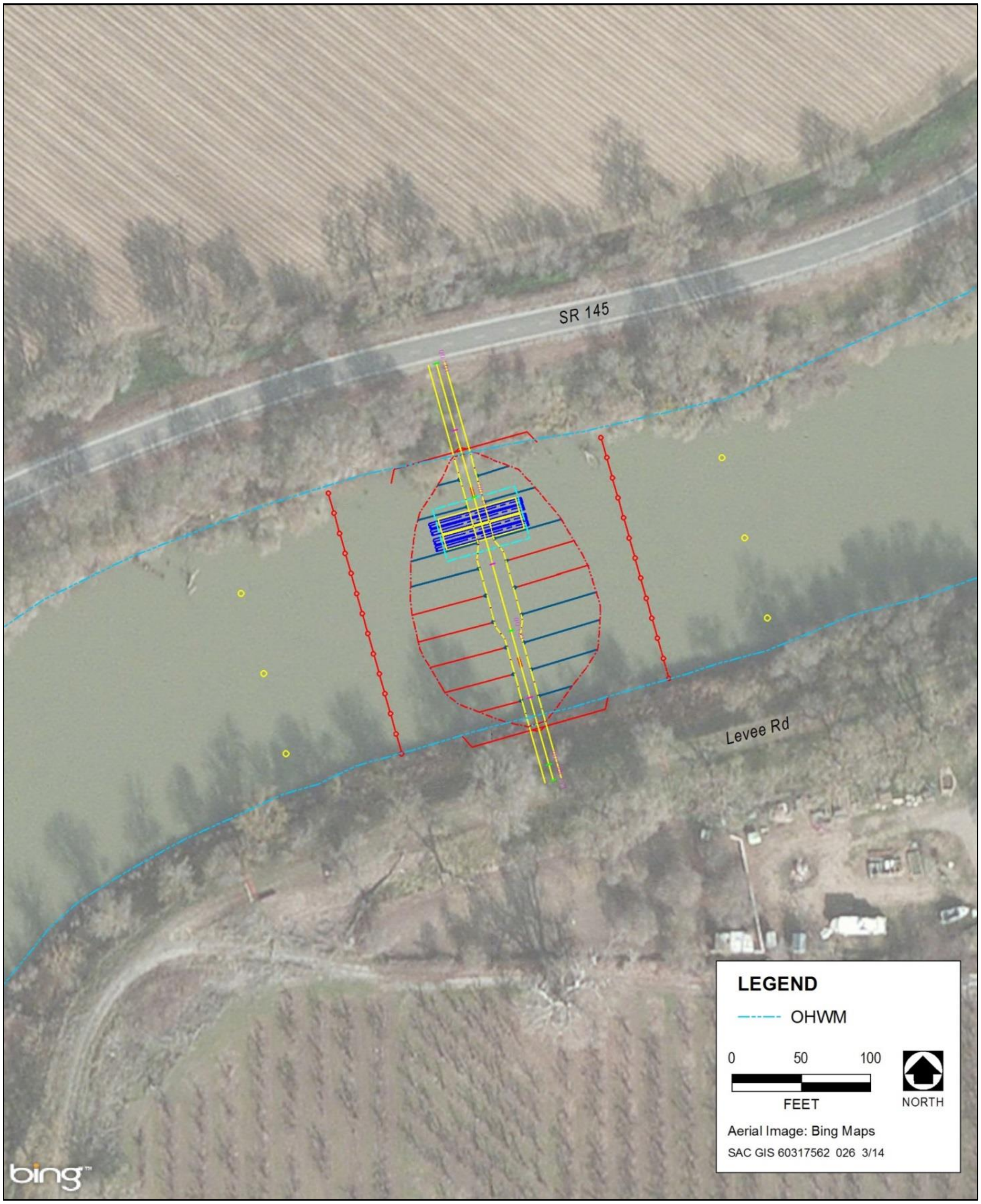
Appropriate navigation signage would be installed at each of the sites and would comply with navigation requirements established by the U.S. Aids to Navigation System and the California Waterway Marker system, as appropriate. Signs would be posted at upstream and downstream entrances to each waterway or other key locations, informing boaters of the restricted access. A Notice to Mariners would include information on the location, date, and duration of channel closures. Signs would be posted on each side of each barrier, float lines with orange ball floats would be located across the width of the channels to deter boaters from approaching the barriers, and solar-powered warning buoys with flashing lights would be present on the barrier crest, as well, in order to prevent accidents during nighttime hours. Additional information regarding navigational issues at each of the sites is provided below.

4.2 STRUCTURAL COMPONENTS

4.2.1 SUTTER SLOUGH

The Sutter Slough rock barrier (Figure 3) would be 200 feet long and up to143 feet wide at the base and 12 feet wide at the top. The top of the barrier would be set at an elevation of 9.50 feet across the crest and would include about a 50-foot overflow weir 20 feet wide at the top, set at 7.50 feet elevation[2]. The weir would allow overflows at high stage and keep flow in the middle of the channel, minimizing the potential for erosion of the river banks.

[2] Vertical elevations are based on the North American Vertical Datum of 1988 (NAVD 88).



Source: Moffatt & Nichol 2014

Figure 3 **Project Site – Sutter Slough**

The barrier would include a submerged structure placed on a bed of crushed rock consisting of two steel frames with four 48-inch corrugated metal culverts set at an invert elevation of -2.0 feet. The culverts would be operated to allow fish passage and to regulate water levels and water quality on the downstream side of the barrier. One culvert would remain open at all times for fish passage, and the other culvert slide gates would be operated such that the culverts are fully open, fully closed, or at least 50% open as needed to improve water quality and/or stage downstream of the barriers.

The monitoring equipment and operable culverts would be accessed by the levee road on the north or via State Route 145. The site is navigable and is used primarily by recreational traffic, but signs would be posted at both entrances to the slough, informing boaters that Steamboat Slough provides boat passage for vessels up to 24 feet long and up to 10,000 pounds.

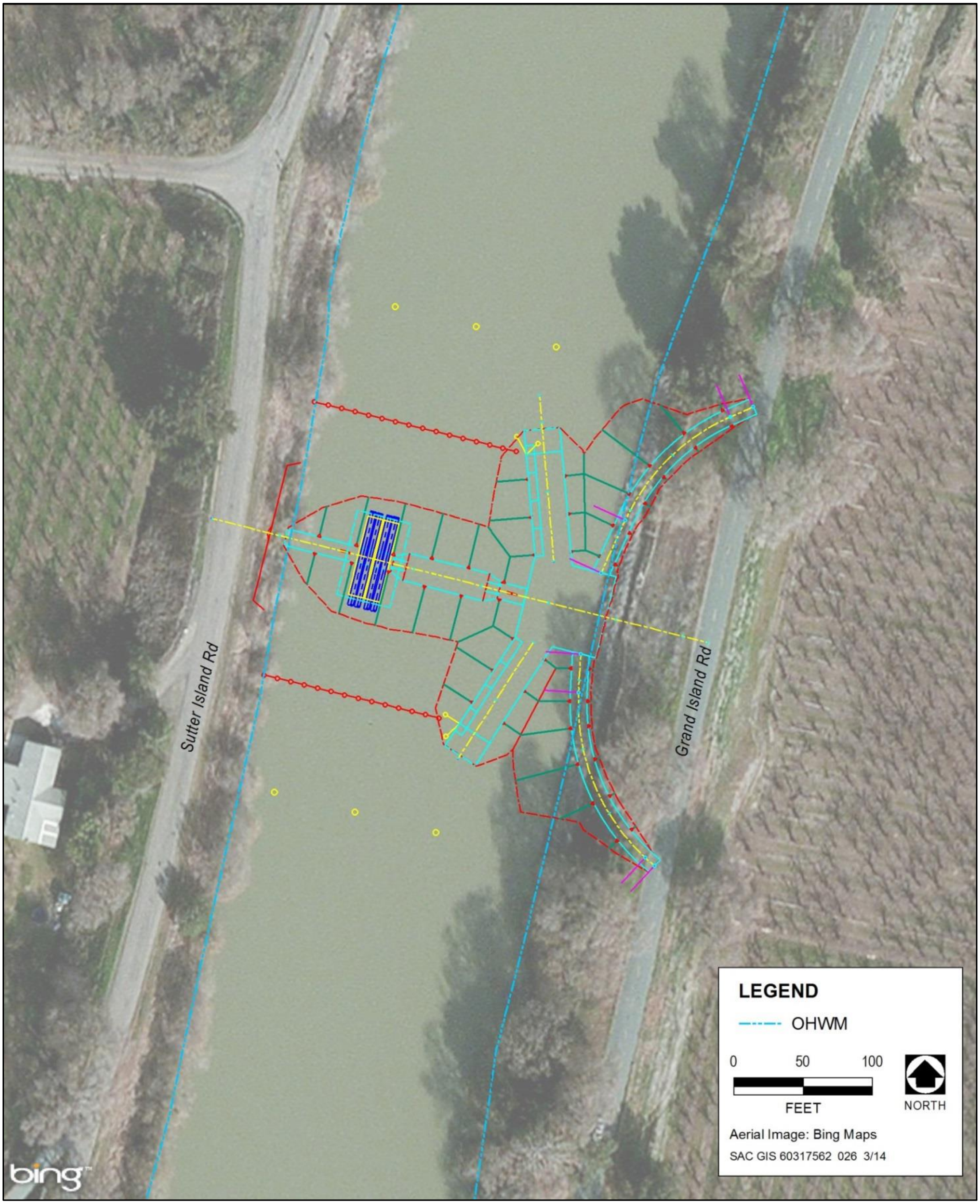
4.2.2 STEAMBOAT SLOUGH

The Steamboat Slough rock barrier (Figure 4) would be 220 feet long, up to 110 wide at the base, and 12 feet wide at the top. The top of the structure would be at elevation 9.50 feet and would include about a 50-foot overflow weir 20 feet wide at the top, set at 7.50 feet and is designed to operate similar to the weir in Sutter Slough. Like the Sutter Slough site, it would include a submerged steel frame set at an invert elevation of -2.0 feet with four 48-inch corrugated metal culverts to allow fish passage and management of downstream water surface elevation and quality. One culvert would remain open at all times for fish passage, and the other culvert slide gates would be operated such that the culverts are fully open, fully closed, or at least 50% open as needed to improve water quality and/or stage downstream of the barriers.

This site is navigable by commercial and recreational traffic, and boat ramps on each side of the barrier would be provided on the east side of the channel. Two 12-foot-wide gravel roads would connect to Grand Island Road. The west access road would be about 150 feet long, and the east access road would be about 250 feet long. A State-provided boat tender would be present on the apron during daytime hours with a pickup truck and trailer. When a boat approaches, the trailer would be backed into the water, the boat would be placed on the trailer, and it would be driven to the boat ramp on the other side, where it would be placed back in the river. Boats up to 24 feet and 10,000 pounds could be accommodated. The site would not be available for launching boats from the land. The ramps would be approximately 6 feet by 20 feet and would be placed on rock fill with a 15 percent slope. Dock anchors (comparable to mooring lines) would be used to stabilize the boat ramps. Workers would access the boat ramps via Grand Island Road, and the monitoring equipment and operable slide gates would be accessed via Sutter Island Road, both of which are public roads, or by boat.

4.2.3 WEST FALSE RIVER

The West False River barrier (Figure 5) would be approximately 800 feet long and up to 150 feet wide at the base and 12 feet wide at the top. The top of the structure would be at an elevation of 7.00 feet across the entire crest. The barrier would include two king pile-supported sheet pile walls extending out from each levee into the channel for a distance of 75 feet. The sheet piles/king piles would be required because the levees are weaker at this location since they sit on peat, and placing a large volume of rock directly on the levees would cause too much stress. The walls would be buttressed with some rock on both sides, however. After barrier removal, rock would



Source: Moffatt & Nichol 2014

Figure 4 **Project Site – Steamboat Slough**

Source: Moffatt & Nichol 2014

Figure 5 **Project Site – West False River**

be used to make smooth transitions around the sheet pile abutments, which would remain in place for possible future use.

No boat passage is provided around this barrier because alternative routes (Fisherman's Cut or False River east for vessel traffic between the south Delta to the San Joaquin River; and the Main San Joaquin River for vessel traffic between the Antioch and the eastern Delta) are available. No fish passage has been provided because migrating fish would use the adjacent San Joaquin River, Fisherman's Cut or Dutch Slough and their access would not be restricted.

To monitor water quality in the central Delta and the associated changes in water quality and flow resulting from the West False River barrier, DWR proposes to install up to four permanent water quality monitoring and or flow monitoring stations at Fisherman's Cut (approximately 1.5 miles east of the barrier), Frank's Tract, Sherman Lake, and potentially one additional site. The stations, which will be able to monitor several constituents including EC, would be installed on a 12-inch-diameter steel pipe piles. DWR would place navigational aids as needed at the stations.

4.3 PROJECT CONSTRUCTION

4.3.1 CONSTRUCTION PRACTICES

Notices of construction would be posted at local marinas and in the Local Notice to Mariners. Navigational markers would be used to prevent boaters from entering the immediate construction area, and speed limits would be posted. Safe vessel passage procedures would be coordinated with the Sector Waterways Management Division (U.S. Coast Guard Station Yerba Buena Island) and California Department of Parks and Recreation Division of Boating and Waterways (Cal Boating). An educational program would be implemented to inform boaters of the purpose of the EDB and the expected duration of installation activities. The program would include notices in local newspapers and boater publications as appropriate; notices also would be posted at local marinas and boat launches and on the EDB website.

The rock would come from one or more quarries, and structures such as the steel frames used to support culverts that allow fish passage and articulated concrete mats for boat ramps would be prefabricated. Most materials and construction equipment (e.g., cranes and clamshells and the vibratory pile driver used at the West False River site) would be brought to the site by barges, and most construction would take place from the water. The exceptions would be construction of the gravel roads used to access the boat ramps at the Steamboat Slough, the transport of road materials and boat ramps to this site, and perhaps the installation of portions of the king piles and sheet piles at the West False River site. Additionally, minimal vegetation and clearing would be required on the levees prior to placement of rock or the installation of sheet piles. This would be accomplished by a dozer or backhoe and hand clearing. The gravel access roads at the Steamboat Slough site also would be cleared and grubbed of trees and other vegetation and would be hauled off site and disposed of in an appropriate location. Any levee access roads that are damaged as a result of construction equipment or truck use would be restored to pre-construction conditions or better once construction is completed.

The rock barriers would be constructed by using a barge-mounted crane and clamshell to place the rock in the channel at the Sutter Slough and Steamboat Slough sites. Because of the greater width of the channel at the West False River site, a dump scow may be used to transport the rock and place it in the channel. Some rock placement at this site would require the use of a barge-mounted crane and bucket. Although some rock slope protection may need to be temporarily moved out of the sheet pile abutments alignments at False River, no channel dredging or excavation in the levee profiles would be required.

The sheet and king piles are anticipated to be installed by an appropriately-sized vibratory hammer, which appears to be feasible given the anticipated ground conditions and modest pile penetration of 20 feet to 50 feet in the ground. Vibratory penetration rates are normally limited to 20 inches per minute (per North American Sheet Piling Associations – Best Practices, www.nasspa.com), which would result in the following vibration times per pile assuming normal driving conditions:

- 20-ft ground penetration: 12 minutes
- 50-ft ground penetration: 30 minutes

Due to uncertainties of the ground conditions and the possibility of encountering dense soil layers and/or obstructions such as left-in-place rip-rap on the existing levee side slopes, a larger impact hammer will be available as a contingency measure, in the event unexpected difficult driving is encountered. The impact hammer will only be used if the vibratory hammer cannot reach design tip elevation of the pilings. If piles are driven by impact hammers in water deeper than one meter, a bubble curtain would be employed if underwater noise exceeds pre-established levels (peak pressure levels or cumulative sound exposure level) that would indicate potential injury to fish.

4.3.2 CONSTRUCTION SCHEDULE

Construction would occur during regular daytime hours. Construction may occur concurrently at more than one EDB site, if adequate equipment is available[3]. The overall construction schedule is estimated to be 30 to 45 days. The barriers would be installed in the spring and removed in the fall. Removal would take approximately 30 to 45 days.

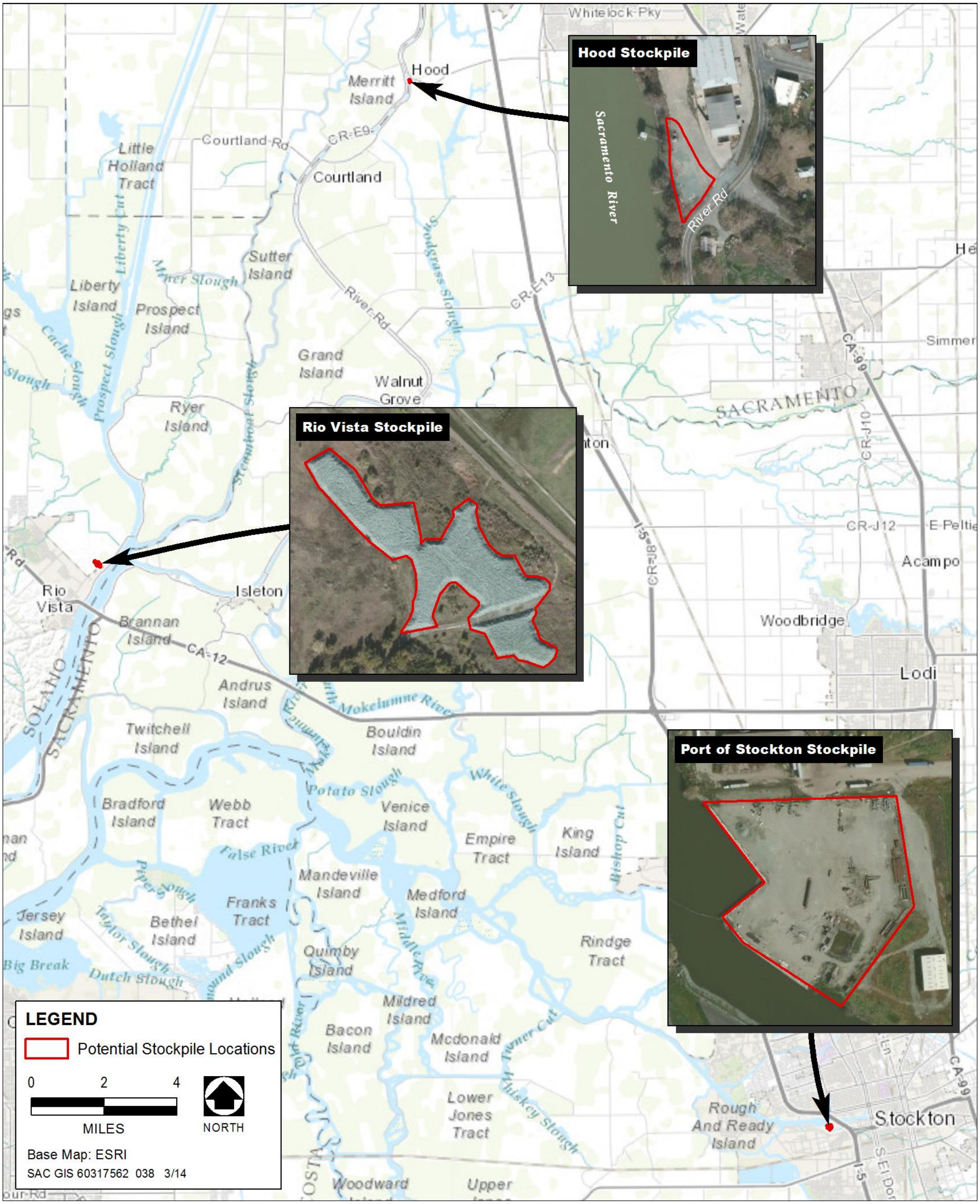
4.3.3 FACILITIES REMOVAL

All rock, gravel, and structures would be removed from the EDB sites in the fall, with the exception of the sheet pile abutments at the West False River site. Bathymetric surveys would be completed after rock fill removal to confirm that the rock is removed. The materials would be transported from the area, primarily on barges. Materials would be stored at a nearby DWR storage facility, likely located in Hood, Rio Vista, or the Port of Stockton. These potential material storage locations are depicted in Figure 6. If lease arrangements can later be made with local landowners near the barrier sites, rock may be stored close to the barrier sites for use in future drought conditions if needed.

4.3.4 SITE RESTORATION

Disturbed areas would be restored after initial construction and after EDB structures are removed (see Conservation Measures section). The affected areas would be restored to meet local land use and resource agency requirements as soon as the barriers are no longer needed.

[3] As described in the Conservation Measures section, potential phasing of construction/operations would be coordinated with the permitting fish agencies in order to meet the purpose of the EDB while minimizing effects to listed fishes.



Source: DWR adapted by AECOM 2014

Figure 6 **Potential Stockpile Locations**

A restoration plan would be developed, as required by applicable regulatory agencies, and would be completed prior to the onset of construction. The restoration plan would identify areas that would be restored and restoration methods. Seed mixes, schedules, success criteria, and success monitoring for restoration of wetlands, streams, and drainages would be identified. The restoration plan would be included in the contract specifications. The restoration plan would also consider the need for reinstallation of the barriers the following year if drought conditions continue.

4.4 PROJECT OPERATIONS

EDB operations essentially would be limited to opening or closing the culvert slide gates at the Sutter and Steamboat slough sites as necessary for water quality or maintenance purposes. As described in the Conservation Measures section, monitoring data from nearby data stations will be used to inform the need to open or close the culverts. DWR would inform the permitting fish agencies should any major maintenance activities be required during the period of operation (May-November). A log of project operations and summary report of monitoring activities would be provided to the permitting agencies following completion of operations.

5 ACTION AREA

The Action Area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). For the purposes of this BA, the Action Area includes the footprint of each temporary barrier and associated monitoring instruments and navigational aids, as well as a surrounding area adequate to incorporate any suitable habitat for valley elderberry longhorn beetle or giant garter snake that could be adversely affected. Based on conditions observed during the field surveys, it was determined a 500-foot buffer surrounding the anticipated area of disturbance associated with each barrier would be appropriate for evaluating potential effects of EDB installation, operation, and removal. The action area also includes the location where the West False River water quality monitoring station would be installed at Fisherman’s Cut and the three potential material storage locations. Figures 3 – 5 depict the EDB sites and adjacent habitats, and representative photographs of each site are provided in Appendix B.

6 LIFE HISTORIES

6.1 VALLEY ELDERBERRY LONGHORN BEETLE

The valley elderberry longhorn beetle has four life stages: egg, larva, pupa, and adult. The species is nearly always found on or close to its host plant, elderberry (*Sambucus* species). Females lay their eggs on the bark, and larvae hatch and burrow into the stems. The larval stage can last 2 years, after which the larvae enter the pupal stage and transform into adults. Adults are active (feeding and mating) from March to June (USFWS 2006).
It appears that to function as habitat for the valley elderberry longhorn beetle, host elderberry shrubs must have stems that are 1.0 inch or greater in diameter at ground level. Use of the plants by the beetle is rarely apparent. Frequently, the only exterior evidence of the shrub’s use by the beetle is an oval exit hole created by the larva just before the pupal stage. Field studies conducted along the Cosumnes River and in the Folsom Lake area suggest that larval galleries can be found in elderberry stems with no evidence of exit holes, because the larvae either succumb before constructing an exit hole or are not far enough along in the developmental process to construct an exit hole (USFWS 1996).

6.2 GIANT GARTER SNAKE

Giant garter snakes inhabit marshes, sloughs, ponds, small lakes, low gradient streams and other waterways and agricultural wetlands. They are inactive or greatly reduce their activities during the late fall and winter months, typically emerging from winter retreats in late March to early April and often remaining active through October. The timing of their annual activities is subject to varying seasonal weather conditions. Giant garter snakes feed on small fishes, tadpoles, and frogs (Hansen 1988). They breed in March and April, with females giving birth to live young from late July though early September (Hansen and Hansen 1990).

Suitable giant garter snake habitat is characterized by all of the features necessary to support permanent populations of the species, including: (1) adequate water during the snake's active season, (2) emergent herbaceous wetland vegetation for escape and foraging habitat, (3) grassy banks and openings in waterside vegetation for basking, and (4) higher elevation upland habitat for cover and refuge from flooding (USFWS 2012). Occupied aquatic habitats typically contain permanent or seasonal water, mud bottoms, and vegetated dirt banks (Hansen and Brode 1980).

The width of uplands used by giant garter snake varies considerably. Many summer basking and refuge areas used by this snake are immediately adjacent to canals and other aquatic habitats, and may even be located in the upper canal banks. While this species is strongly associated with aquatic habitats, individuals have been noted using burrows as far as 165 feet from marsh edges during the active season and retreats more than 820 feet from the edge of wetland habitats while overwintering (Wylie et al. 1997, USFWS 1999). Therefore, land within this further distance may be important for snake survival in some cases (Hansen 1988).

7 ENVIRONMENTAL BASELINE

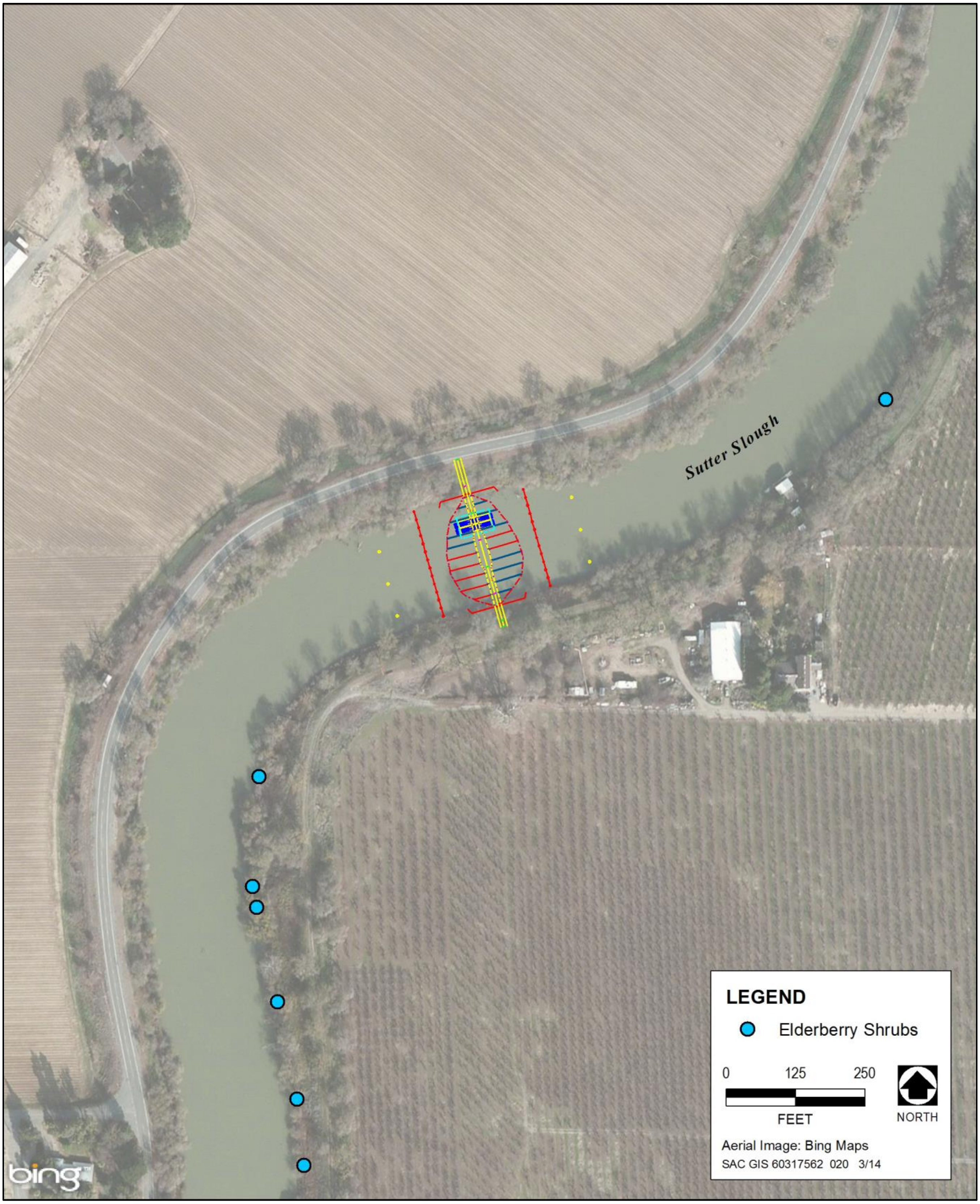
The environmental baseline "includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR §402.02).

7.1 STATUS OF THE SPECIES IN THE ACTION AREA

The description of environmental baseline conditions for valley elderberry longhorn beetle and giant garter snake is based on observations made during a reconnaissance-level field survey of each proposed barrier location and information presented in the *Bay Delta Conservation Plan* (DWR 2013). The field survey of the Sutter Slough and Steamboat Slough sites was made on March 13, 2014 and the survey of the West False River site was made on March 14, 2014.

7.1.1 VALLEY ELDERBERRY LONGHORN BEETLE

Elderberry shrubs, the host plant of valley elderberry longhorn beetle, were observed at only one of the proposed barrier locations: Sutter Slough. Figure 7 depicts the location of individual elderberry shrubs and shrub clusters observed in the vicinity of the Sutter Slough EDB site. The nearest of these shrubs/clusters is approximately



Sources: AECOM 2014, Moffatt & Nichol 2014

Figure 7 **Elderberry Shrub Locations Adjacent to the Sutter Slough Project Site**

500 feet from the barrier footprint. It is not known whether valley elderberry longhorn beetles occur in the shrubs observed near the site because it was not feasible at the time to examine stems for beetle exit holes.

The EDB sites were surveyed as comprehensively as possible based on access available at the time, and visibility of areas adjacent to the sites was generally good. There is, however, potential for additional elderberry shrubs to be present in areas that may have been partially obscured adjacent to the sites.

No elderberry shrubs are present at any of the potential material storage areas because all of the areas are currently disturbed and do not support natural vegetation. It is possible, however, that elderberry shrubs are present adjacent to the Hood and Rio Vista locations; no elderberry shrubs are anticipated to occur adjacent to the Stockton location.

7.1.2 Giant Garter Snake

A large portion of the Delta has not been comprehensively surveyed for giant garter snake, primarily because the majority of land is privately owned. Historical and recent surveys have failed to identify any extant population clusters in the region (Hansen 1986; Patterson 2003, 2005; Patterson and Hansen 2004), including during DWR surveys of various Delta sites in 2009. However, several individuals were trapped at White Slough Wildlife Area and several photographed near Little Connection Slough (USFWS 2012). These sites are considered the furthest west into the Delta where giant garter snakes are known to currently exist; they are over 9 miles east of the West False River EDB site.

The California Natural Diversity Database (CNDDB) includes two relatively recent observations of giant garter snakes closer to the West False River project site, a 2002 observation approximately 1.5 miles east of the site and a 2010 observation approximately 5 miles southwest of the site. Two older occurrences are also documented in the CNDDB, a 1998 observation approximately 3.5 miles northwest of the site and a pre-1986 specimen collected in the vicinity of the 2002 observation. There is speculation that recent observations in the central Delta were of snakes that occasionally move into the region by ‘washing-down’ from known populations and that these occurrences do not represent local breeding populations (Hansen pers. comm. in DWR 2013). Therefore, occurrences near the West False River project site likely represent single displaced snakes, not viable populations like those in the eastern Delta. CNBBD occurrences nearest to the Sutter Slough and Steamboat Slough project sites are from approximately 4 miles east and include an unknown number of snakes observed in 1992 and pre-1986 at and near Snodgrass Slough.

The potential for giant garter snakes to occur in the vicinity of the EDB sites is low. All three of the sites are many miles from any known populations of the species and none of the sites provide high-quality habitat for the species. Although the sloughs provide marginally suitable aquatic habitat, suitability of bankside habitat at all sites is limited. The Sutter Slough and Steamboat Slough project sites have a nearly continuous canopy of riparian shrubs and trees along the banks, and land uses adjacent to these sites are dominated by orchards and other unsuitable agricultural crops (as seen in the aerial photographs of Figures 3 and 4). Uplands adjacent to the West False River EDB site are more suitable for giant garter snake, but, as described above, occurrence of giant garter snake in this part of the Delta is likely accidental and uncommon.

None of the potential material storage areas support suitable aquatic habitat for giant garter snake, nor is suitable aquatic habitat present within 200 feet of the sites. The area immediately north of the RioVista location could support aquatic habitat beyond 200 feet, but the storage site does not provide suitable upland habitat for the species. In addition, this region is not thought to support any giant garter snake populations.

7.2 FACTORS AFFECTING THE SPECIES AND HABITAT IN THE ACTION AREA

A number of factors have and continue to affect valley elderberry longhorn beetle and giant garter snakes throughout their ranges. Ongoing activities and past and potential future actions that could affect these species include agricultural activities, roadside vegetation maintenance, levee maintenance, and flood control improvements. The only known project within the EDB action area for terrestrial species is a current proposal to construct a seepage berm on the landside of the levees at the West False River EDB site as part of the Delta Levee Special Flood Control Projects Program. This program was established in 1988 by Senate Bill 34 and continues to operate under subsequent legislation that extended and provided funding for the program. Any Local Agency with a Project or Non-Project levee in the Primary Zone of the Delta or a Non-Project levee in the Secondary Zone of the Delta is eligible to apply for the program, which provides financial assistance to local levee maintaining agencies for flood control projects and related habitat projects in the Delta. It is not known whether the seepage berms will be constructed before or after the EDB is installed.

7.2.1 VALLEY ELDERBERRY LONGHORN BEETLE

The valley elderberry longhorn beetle is thought to have suffered a long-term decline because of human activities that have resulted in widespread alteration and fragmentation of riparian habitats and, to a lesser extent, upland habitats that support the beetle (USFWS 2006). These factors are very applicable to the EDB sites. The Sutter Slough and Steamboat Slough sites support a very narrow riparian corridor, and both are immediately bordered by at least one paved roadway and intensive agricultural production. The West False River site does not support any riparian corridor, and only small patches of scattered trees and shrubs are present in this portion of the action area. The adjacent lands support a mix of agricultural crop production and cattle grazing. No elderberry shrubs occur at or adjacent to the West False River site, but shrubs could be present elsewhere within the area that would be affected by the proposed Delta Levee Special Flood Control Projects Program seepage berms.

The elderberry shrubs adjacent to the Sutter Slough EDB site occur within the narrow (150-200 feet wide) riparian corridor, which is bordered by an unpaved agricultural road and orchards. Insecticide and herbicide use in agricultural areas have been identified as potential factors limiting the beetle's distribution (USFWS 2006). This is likely a factor affecting elderberry shrubs in the action area. In addition, dust from movement of farm vehicles and equipment on the unpaved roadway and in the orchards could also have adverse effects.

7.2.2 GIANT GARTER SNAKE

The primary cause of giant garter snake decline throughout its current and former ranges has been attributed to aquatic habitat loss. The most serious current threats to the species are loss and fragmentation of habitat from both urban and agricultural development and potential loss of habitat associated with changes in rice production (USFWS 2012). Activities such as water management and water transfers that result in habitat loss are also of particular concern. Secondary threats include introduced predators, road construction, and erosion control.

As discussed above, giant garter snake is unlikely to occur in the actions area, based on the combination of habitat conditions and the current distribution of the species. Based on review of historic aerial photography, habitat at the EDB sites has changed little in the past 20 years, and areas adjacent to Sutter Slough and Steamboat Slough already supported agricultural crops unsuitable for the snake in the early 1990s.

8 EFFECTS ASSESSMENT

This section describes the potential effects of implementing the EDB Project on valley elderberry longhorn beetle and giant garter snake. The assessment is divided into construction effects and operations effects.

8.1 VALLEY ELDERBERRY LONGHORN BEETLE

8.1.1 Construction Effects

There is minimal potential for valley elderberry longhorn beetle to be affected by installation or removal of barriers at the Steamboat Slough and West False River EDB sites, because no elderberry shrubs are present on or adjacent to these sites. Several elderberry shrubs are present in the vicinity of the Sutter Slough EDB site, but no removal of elderberry shrubs would be required. In addition, no indirect effects are anticipated to occur during barrier installation or removal, because the nearest known shrubs are located approximately 500 feet from the project footprint, beyond the likely influence of such effects. If land-based access is required at this site, the likely route would be at least 250 feet from the nearest of these shrubs at its closest point. Potential adverse impacts from dust or other effects associated with potential use of this access route are anticipated to be minor, if any.

As mentioned above, there is a small possibility additional elderberry shrubs are present adjacent to the EDB sites and the potential material storage sites near Hood and Rio Vista. Such shrubs could be adversely affected by installation and removal of the EDB, including material storage. However, it is anticipated potential adverse effects to these shrubs, if present, could be adequately minimized by implementation of conservation measures described below.

8.1.2 Operations Effects

No effects to valley elderberry beetle would result from EDB operations.

8.2 GIANT GARTER SNAKE

8.2.1 Construction Effects

Giant garter snake is unlikely to be adversely affected by installation or removal of the proposed barriers, because the EDB sites provide only marginally suitable habitat and the potential material storage sites do not provide any suitable habitat. In addition, the species is not known to occur in the vicinity and is unlikely to occur at any of these sites.

8.2.2 Operations Effects

Giant garter snake is not anticipated to be adversely affected by operation of the proposed barriers, because the EDB sites provide only marginally suitable habitat and the species is unlikely to occur at any of the sites.

9 CUMULATIVE EFFECTS

Under the ESA, cumulative effects are those effects of future state, tribal, local, or private actions that are reasonably certain to occur within the action area of the federal action subject to consultation (50 Code of Federal Regulations 402.2). Future federal actions that are unrelated to the proposed action are not considered in this assessment because they require separate consultation under Section 7 of the ESA.

Although present and future projects not subject to federal authorization or funding could alter the habitat for and/or result in direct take of valley elderberry longhorn beetle and giant garter snake, the proposed project would not make a considerable contribution to any adverse cumulative effects because it is unlikely to adversely affect either species.

10 CONSERVATION MEASURES

The following conservation measures will be implemented to avoid and minimize potential adverse effects of the EDB. Where applicable, measures are the same as those proposed in the BA prepared for aquatic species.

10.1 LIMIT LAND-BASED ACCESS ROUTES AND CONSTRUCTION AREA

The number of land-based access routes and construction area will be limited to the minimum necessary. Access routes will be restricted to established roadways. During construction and operations, land-based stockpiling of materials, portable equipment, vehicles, and supplies will be restricted to the construction area and no land-based staging areas will be used. Construction area boundaries will be clearly demarcated.

10.2 MINIMIZE WILDLIFE ATTRACTION

To eliminate attraction of wildlife to the EDB sites, all food-related trash items, such as wrappers, cans, bottles, and food scraps, will be disposed of in closed containers and removed from the sites on a daily basis.

10.3 CONDUCT A WORKER ENVIRONMENTAL AWARENESS PROGRAM

Construction personnel will participate in a USFWS-approved worker environmental awareness program. Under this program, workers will be informed about the presence of elderberry shrubs and that unlawful destruction of the shrubs or take of any listed species is a violation of the ESA. Prior to construction activities, a qualified biologist(s) approved by USFWS will instruct all construction personnel about the life history of valley elderberry longhorn beetle and giant garter snake, the importance of limiting disturbance to the demarcated construction and staging areas, and the terms and conditions of all regulatory permits. Proof of this instruction will be submitted to USFWS.

10.4 CONDUCT BIOLOGICAL MONITORING

A USFWS-approved biologist will be onsite daily to conduct compliance inspections and monitor all construction activities that may adversely affect federally-listed terrestrial species. The qualifications of the biologist(s) will be presented to the permitting agencies for review and written approval at least ten working days prior to project activities in the action area. Prior to approval, the biologist(s) will submit a letter to the permitting agencies that states that they understand the terms and conditions of the Biological Opinions. The biologist(s) will keep a copy of the Biological Opinion in their possession when onsite. The biologist(s) shall be given the authority to stop work that may result in, or in the event that there is, take of listed species in excess of limits provided by the permitting agencies in the Biological Opinion. If the biologist(s) exercise(s) this authority, the permitting agencies will be notified by telephone and electronic mail within one working day. A report of daily records from monitoring activities and observations will be prepared and provided to the permitting agencies.

10.5 PREPARE AND IMPLEMENT AN EROSION CONTROL PLAN

An Erosion Control Plan will be prepared prior to construction activities that will cause ground disturbance. Site-specific erosion-control, spill-prevention, and control of sedimentation and runoff measures will be developed and implemented as part of the plan.

If applicable, tightly woven fiber netting (mesh size less than 0.25 inch) or similar material will be used for erosion control and other purposes at the EDB site to ensure wildlife does not become trapped or entangled in the erosion control material. Coconut coir matting is an acceptable erosion control material, but no plastic mono-filament matting will be used for erosion control. If feasible, the edge of the material will be buried in the ground to prevent wildlife from crawling underneath the material.

10.6 PREPARE AND IMPLEMENT A SPILL PREVENTION AND CONTROL PROGRAM

DWR will prepare a spill prevention and control program prior to the start of construction to minimize the potential for hazardous, toxic, or petroleum substances release into the project area during construction and project operation. In addition, DWR will place sand bags, biologs, or other containment features around the areas used for fueling or other uses of hazardous materials to ensure that these materials do not accidentally leak into the river. DWR will adhere to the standard construction best management practices described in the current California Department of Transportation *Construction Site Best Management Practices (BMP)s Manual* (California Department of Transportation 2003).

10.7 PREPARE AND IMPLEMENT A HAZARDOUS MATERIALS MANAGEMENT PROGRAM

DWR will prepare a Hazardous Materials Management Program (HMMP) that identifies the hazardous materials to be used during construction; describes measures to prevent, control, and minimize the spillage of hazardous substances; describes transport, storage, and disposal procedures for these substances; and outlines procedures to be followed in case of a spill of a hazardous material. The HMMP will require that hazardous and potentially hazardous substances stored onsite be kept in securely closed containers located away from drainage courses, storm drains, and areas where stormwater is allowed to infiltrate. It will also stipulate procedures to minimize hazard during onsite fueling and servicing of construction equipment. Finally, the HMMP will require that adjacent land uses be notified immediately of any substantial spill or release.

10.8 IMPLEMENT SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT BASIC AND ENHANCED CONSTRUCTION EMISSION CONTROL PRACTICES TO REDUCE FUGITIVE DUST

The construction contractor will implement the following applicable basic and enhanced control measures to reduce construction-related fugitive dust during site grading.

- Water all exposed surfaces two times daily as needed. Exposed surfaces include, but are not limited to soil piles, graded areas, unpaved parking areas, staging areas, and unpaved access roads.

- Use wet power vacuum street sweepers as needed to remove any visible trackout mud or dirt onto adjacent public roads at least once a day. Use of dry power sweeping is prohibited.

- Limit vehicle speeds on unpaved roads to 15 miles per hour.

- Minimize idling time either by shutting equipment off when not in use or reducing the time of idling to 5 minutes (required by California Code of Regulations, Title 13, sections 2449[d][3] and 2485). Provide clear signage that posts this requirement for workers at the entrances to the site.

- Maintain all construction equipment in proper working condition according to manufacturer's specifications. The equipment must be checked by a mechanic and determined to be running in proper condition before it is operated.

Additionally, the contractor will implement the following applicable enhanced measures to reduce operation-related diesel particulate matter.

- Acceptable options for reducing emissions may include use of late model engines, low-emission diesel products, alternative fuels, engine retrofit technology, after-treatment products, and other options as they become available.

10.9 IMPLEMENT TURBIDITY MONITORING DURING CONSTRUCTION

DWR will monitor turbidity levels in Sutter and Steamboat sloughs and West False River during ground-disturbing activities, including placement of rock fill material. Monitoring will be conducted by measuring upstream and downstream of the disturbance area to determine if the change exceeds 20%, a threshold derived from the Sacramento and San Joaquin Rivers Basins Plan (Central Valley Regional Water Quality Control Board 1998). If so, DWR contractors will slow or adjust work to ensure that turbidity levels do not exceed the 20% threshold. If slowing or adjusting work to lower turbidity levels is not practical or if thresholds cannot be met, DWR will work with the SWRCB and fish agencies to determine the most appropriate method to move construction forward while minimizing turbidity impacts to the maximum extent feasible.

10.10 DEVELOP A WATER QUALITY PLAN TO MONITOR WATER QUALITY AND OPERATE BARRIER CULVERTS TO IMPROVE WATER QUALITY

DWR will develop a water quality plan to assess the effects of the EDB on flow and water quality in the Central and North Delta. DWR will monitor water quality with solar-powered monitoring instruments upstream and downstream of the Sutter and Steamboat slough barriers, in addition to assessing monitoring data from existing stations in the Delta. DWR will open the slide gates of additional culverts to allow greater water flow into Sutter and Steamboat Sloughs, should water quality issues arise.

The water quality plan will document the procedures for producing the following elements:

- Water quality data from new monitoring sites and augmentation of existing sites;
- Monthly water quality summaries;
- Monthly water quality maps for Franks Tract (discrete data);
- Final report on the effects of the EDB on water quality.

10.11 IMPLEMENT PROTOCOLS FOR VALLEY ELDERBERRY LONGHORN BEETLE

DWR will implement protective buffers around known and previously unidentified elderberry shrubs adjacent to the EDB sites or potential material storage sites. A 100-foot (or wider) buffer will be established and maintained around elderberry plants containing stems measuring 1.0 inch or greater in diameter at ground level.

A fenced avoidance area will be established to protect all elderberry shrubs located adjacent to construction or storage areas. High-visibility fencing will be placed at least 100 feet from the dripline of the shrubs to prevent encroachment of construction personnel and vehicles.

If maintaining 100-foot protective buffers around all elderberry shrubs with a stem greater than 1 inch in diameter at ground level is not feasible, DWR will coordinate with USFWS to determine if the specific site conditions allow implementation of reduced buffers to adequately minimize adverse impacts on and avoid take of valley elderberry longhorn beetle.

10.12 RETURN DISTURBED AREAS TO PRE-PROJECT CONDITIONS AND CONSERVE HABITAT

DWR and its contractors will strive to limit riparian impacts from EDB construction. If riparian impacts are unavoidable, such as pruning of vegetation to facilitate equipment setup in staging areas, DWR would aim to return disturbed riparian habitat pre-project conditions. Restoration of disturbed area would be done with native plants.

Return of disturbed habitat to pre-project conditions will not be possible in all cases. To mitigate for affected habitat, DWR will purchase 4 acres of shallow water habitat credits covering the EDB.

11 CONCLUSION

It is concluded that the Emergency Drought Barriers project is not likely to adversely affect valley elderberry longhorn beetle or giant garter snake. Implementation of the above conservation measures will avoid or minimize the very limited potential for adverse effects to these species. The EDB Project would not jeopardize the continued existence of any federally-listed terrestrial species.

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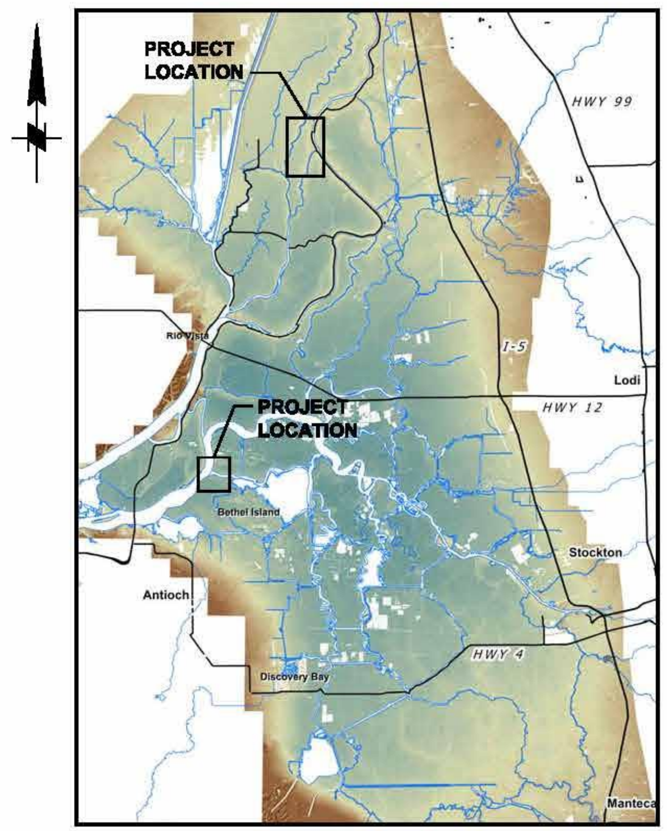
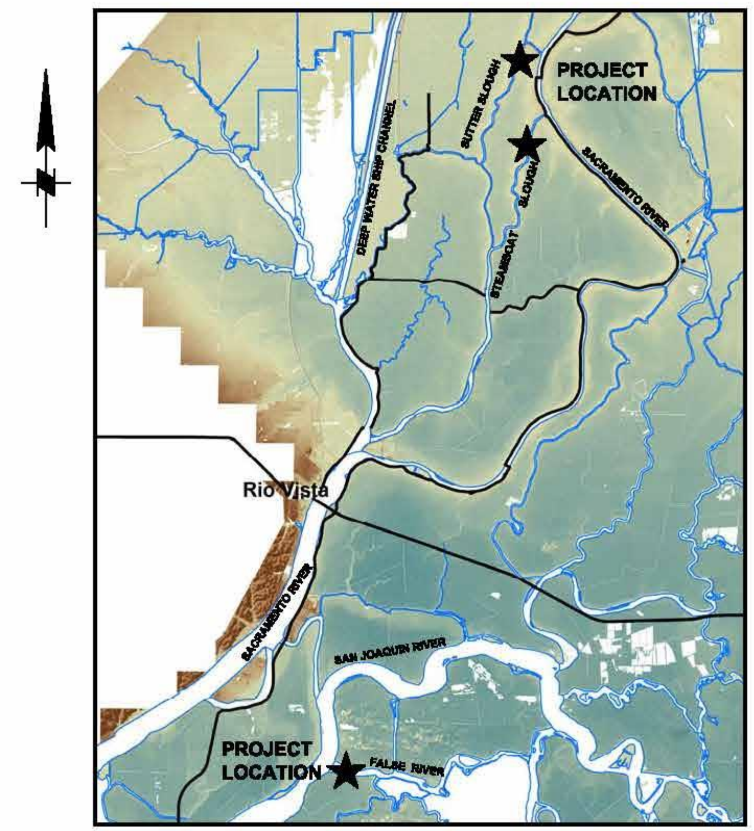
APPENDIX A

Additional Design Details for the Emergency Drought Barriers Project

2014 DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS
STEAMBOAT AND SUTTER SLOUGHS AND FALSE RIVER, CALIFORNIA



VICINITY MAP
NTS



LOCATION MAP
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2014 DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS

DATE 03/2014
SHEET 1 OF 15

TITLE SHEET

G1

INDEX OF DRAWINGS

SHEET NUMBER	DRAWING NUMBER	DESCRIPTION
		GENERAL
1	G1	TITLE SHEET
2	G2	INDEX OF DRAWINGS
3	G3	GENERAL NOTES, ABBREVIATIONS AND LEGEND
4	G4	PROJECT GENERAL PLAN
		STEAMBOAT SLOUGH
5	C1	STEAMBOAT SLOUGH, SITE PLAN
6	C2	STEAMBOAT SLOUGH, TEMPORARY ROCK BARRIER PROFILE AND SECTIONS
7	C3	STEAMBOAT SLOUGH, BOAT RAMP PLAN AND PROFILE
8	C4	STEAMBOAT SLOUGH ACCESS ROADS PLAN AND PROFILE
		SUTTER SLOUGH
9	C5	SUTTER SLOUGH, SITE PLAN
10	C6	SUTTER SLOUGH, TEMPORARY ROCK BARRIER PROFILE AND SECTIONS
		FALSE RIVER
11	C7	FALSE RIVER, SITE PLAN
12	C8	FALSE RIVER, TEMPORARY ROCK BARRIER PROFILE, SECTION AND DETAIL
13	C9	SHEET PILE WALL DETAILS, SHEET 1
14	C10	SHEET PILE WALL DETAILS, SHEET 2
		COMMON DETAILS
15	C11	CULVERT TYPICAL SECTION

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TEMPORARY ROCK BARRIERS

DATE 03/2014
SHEET 2 OF 15

INDEX OF DRAWINGS

G2

GENERAL NOTES

TOPOGRAPHIC AND BATHYMETRIC DATA IS BASED ON WANG, R. & ATELJEVICH, E. (2012). A CONTINUOUS SURFACE ELEVATION MAP FOR MODELING (CHAPTER 6). IN METHODOLOGY FOR FLOW AND SALINITY ESTIMATES IN THE SACRAMENTO-SAN JOAQUIN DELTA AND SUISUN MARS, 23RD ANNUAL PROGRESS REPORT TO THE STATE WATER RESOURCES CONTROL BOARD. CALIFORNIA DEPARTMENT OF WATER RESOURCES, BAY-DELTA OFFICE, DELTA MODELING SECTION.

VERTICAL DATUM

PROJECT ELEVATIONS ARE BASED ON NAVD88.

HORIZONTAL DATUM

STEAMBOAT & SUTTER SLOUGH:

PROJECT COORDINATES ARE BASED ON THE CALIFORNIA STATE PLANE COORDINATE SYSTEM NAD 1983, ZONE 2.

FALSE RIVER:

PROJECT COORDINATES ARE BASED ON THE CALIFORNIA STATE PLANE COORDINATE SYSTEM NAD 1983, ZONE 3.

ABBREVIATIONS

&	AND
Δ	DELTA
#	NUMBER
%	PERCENT
APPROX	APPROXIMATE
ASTM	ASTM INTERNATIONAL
BVC	BEGIN VERTICAL CURVE
C/C	CENTER TO CENTER
CJP	COMPLETE JOINT PENETRATION
℄	CENTER LINE
CIP	CAST-IN-PLACE
CLR	CLEAR
CMP	CORRUGATED METAL PIPE
CONC	CONCRETE
CONT	CONTINUOUS
DIA, ⌀	DIAMETER
DIMS	DIMENSIONS
DWG	DRAWING
DWT	DEAD WEIGHT
(E)	EXISTING
E	EASTING
ELEV	ELEVATION
EJ	EXPANSION JOINT
EVC	END VERTICAL CURVE
EW	EACH WAY
FG	FINISH GRADE
FT	FOOT OR FEET
GALV	GALVANIZED
H	HORIZONTAL
HD	HEAD
HDPE	HIGH DENSITY POLYETHYLENE
HW	HIGH WATER
IBC	INTERNATIONAL BUILDING CODE
ID	INSIDE DIAMETER
INFO	INFORMATION
INV	INVERT
L	LENGTH
LB	POUND
LVC	LENGTH VERTICAL CURVE
LW	LOW WATER
MAX	MAXIMUM
MFG	MANUFACTURING
MIN	MINIMUM
N	NORTHING
NAD	NORTH AMERICAN DATUM
NAVD	NORTH AMERICAN VERTICAL DATUM
NIC	NOT IN CONTRACT
NTS	NOT TO SCALE
OC	ON CENTER
OD	OUTSIDE DIAMETER
OG	ORIGINAL GROUND
OHWM	ORDINARY HIGH WATER MARK
OPP	OPPOSITE
PC/PS	PRECAST/PRESTRESSED
ℙ	PLATE
PJP	PARTIAL JOINT PENETRATION
PSF	POUNDS PER SQUARE FOOT
PVI	POINT VERTICAL INTERSECTION
R	RADIUS
REF	REFERENCE
REINF	REINFORCEMENT
SA	SEISMIC ACCELERATION
SCH	SCHEDULE
SIM	SIMILAR
SPA	SPACES
STA	STATION
STD	STANDARD
STIF	STIFFENER
SYMM	SYMMETRICAL
TEMP	TEMPORARY
THRU	THROUGH
TYP	TYPICAL
UHMW	ULTRA HIGH MOLECULAR WEIGHT
UON	UNLESS OTHERWISE NOTED
V	VERTICAL
VAR	VARIES
VC	VERTICAL CURVE
WP	WORK POINT
WT	WALL THICKNESS
W/	WITH

CROSS-REFERENCE LEGEND

A / CXX — SECTION OR DETAIL IDENTIFICATION, SEE NOTE; REFERENCE SHEET ON WHICH SECTION OR DETAIL IS SHOWN

NOTE: LETTER INDICATES SECTION; NUMBER INDICATES DETAIL. WHERE THERE IS NO REFERENCE SHEET INDICATED, IT MEANS THE DETAIL OR SECTION IS TAKEN AND SHOWN ON THE SAME SHEET.

LEGEND

EXISTING FEATURE

PROPOSED FEATURE

5 — EXISTING CONTOUR

TOP OF SLOPE / DOWN / TOE OF SLOPE — SLOPE

WORK POINT

DOWNSTREAM FLOW DIRECTION

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2014 DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

GENERAL NOTES, ABBREVIATIONS AND LEGEND

DATE 03/2014

SHEET 3 OF 15

G3

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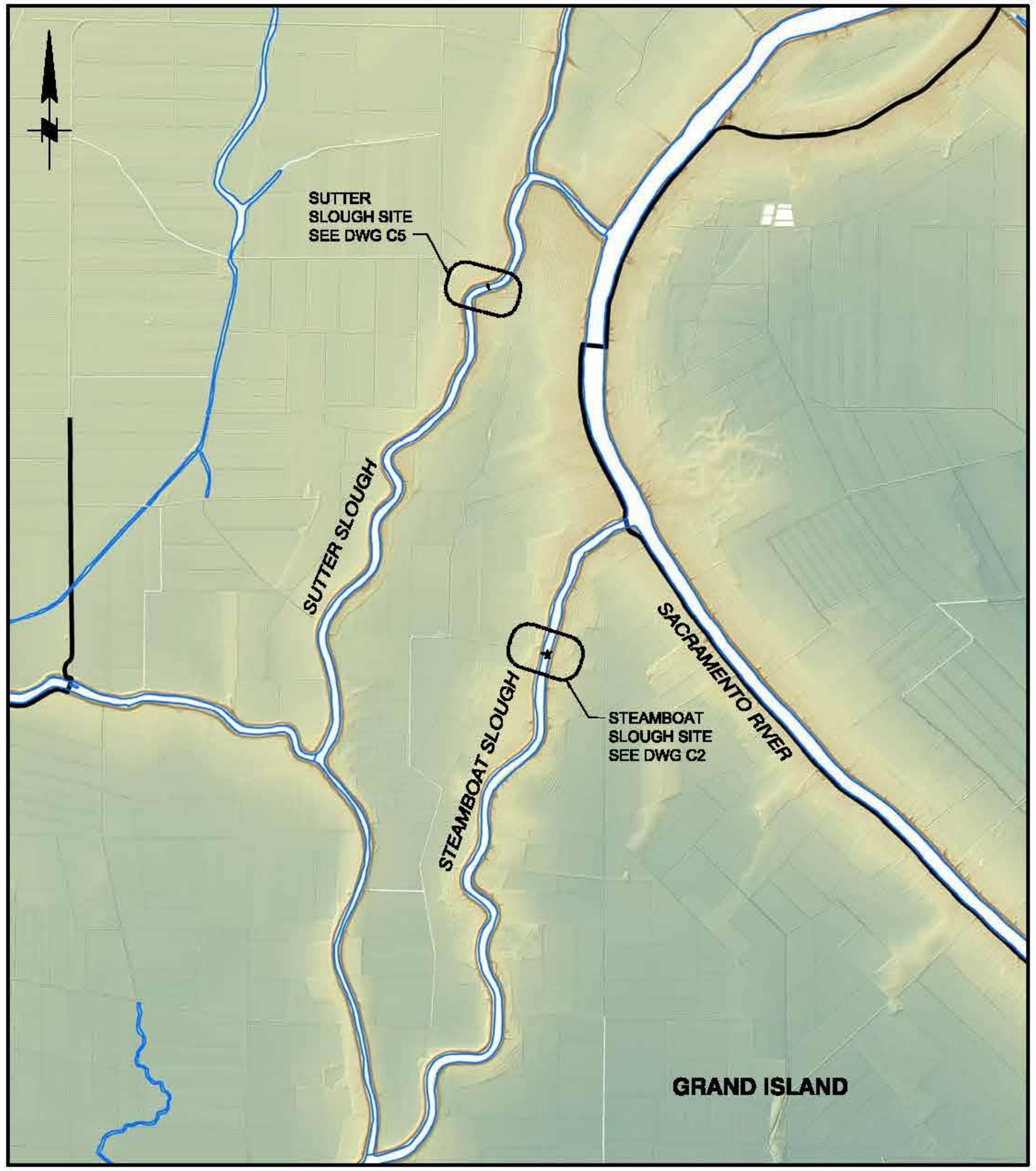

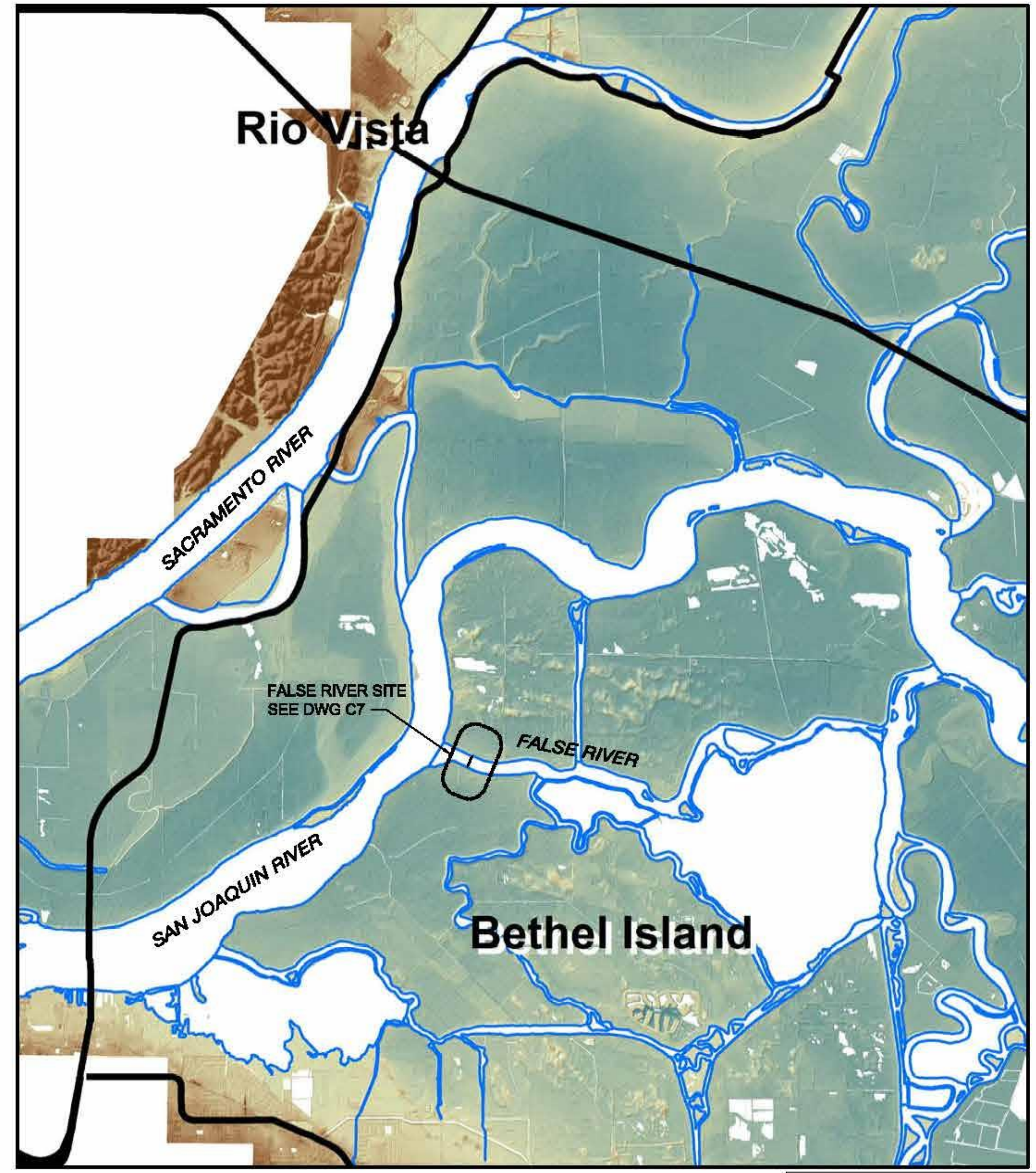

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PROJECT GENERAL PLAN
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TEMPORARY ROCK BARRIERS

DATE 03/2014
SHEET 4 OF 15

PROJECT GENERAL PLAN

G4

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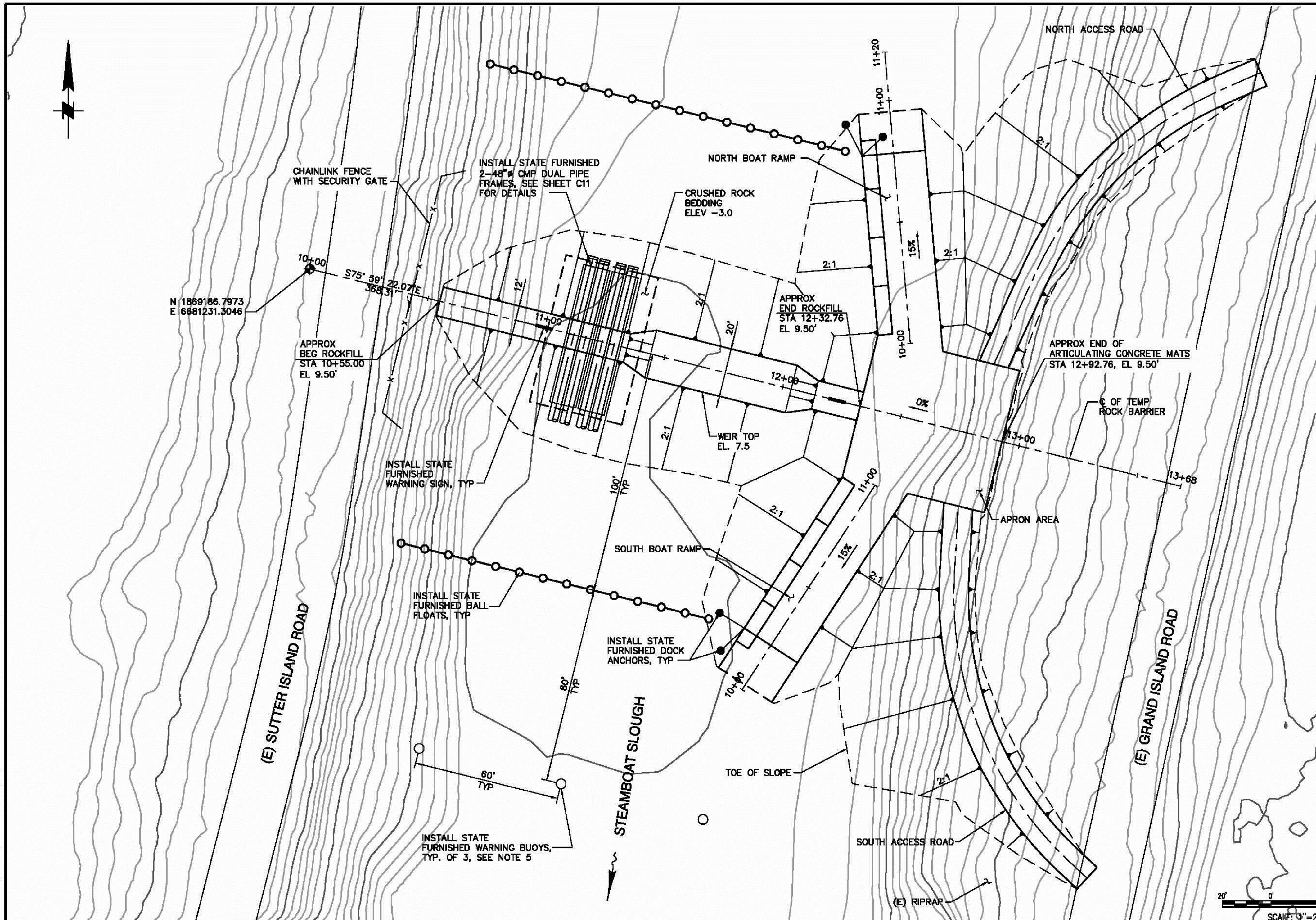

NOTES:

1. COORDINATES ARE IN FEET AND REFER TO STATE PLANE ZONE 2, NAD 83.
2. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
3. CONTRACTOR SHALL INSTALL DEPARTMENT FURNISHED STRUCTURES TO INCLUDE: CMP CULVERTS, FRAMES, SLUICE GATES, ACCESS PLATFORMS, CATWALKS, SIGNS, ARTICULATING CONCRETE MATS AND OTHER ACCESSORIES AS DIRECTED.
4. OTHER FEATURES NOT SHOWN FOR CLARITY.
5. WHITE CYLINDRICAL WARNING BUOY WITH LIGHT ON TOP AND INTERNATIONAL ORANGE DIAMOND SYMBOL. WHITE LIGHT SHALL FLASH ONCE EVERY 4 SECONDS.
6. SEE SHEET C2 FOR TYPICAL SECTIONS OF ROCK BARRIER AND WEIR SECTIONS.

NOTE:

ALL OTHER FEATURES NOT SHOWN FOR CLARITY.

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TEMPORARY ROCK BARRIERS

STEAMBOAT SLOUGH
SITE PLAN

DATE 03/2014
SHEET 5 OF 15
C1

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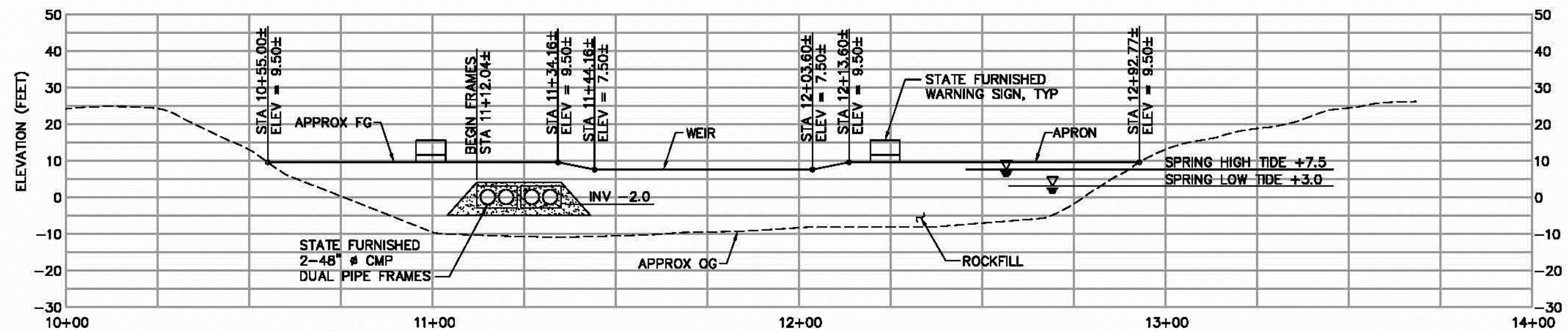
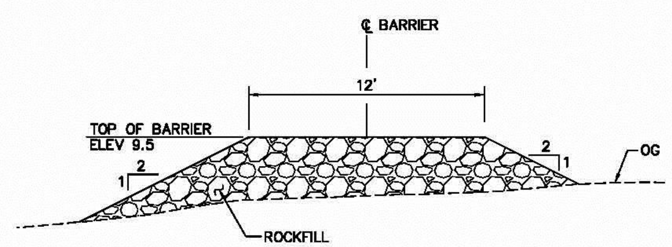
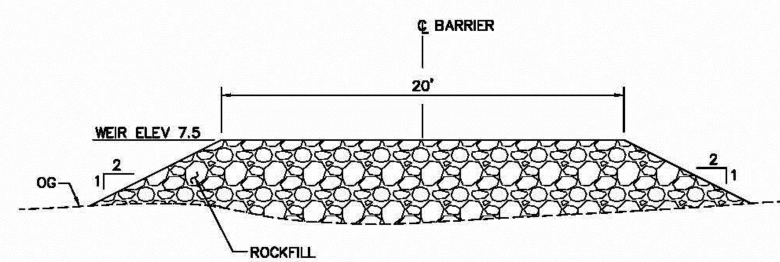


PROFILE
SCALE: 1"= 20'



TYPICAL SECTION-ROCK BARRIER
SCALE: 1"= 4'



TYPICAL SECTION-WEIR
SCALE: 1"= 4'

NOTE:

1. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
2. OTHER FEATURES NOT SHOWN FOR CLARITY.

PROGRESS DRAFT
3/14/2014

4' 0' 4' 8'
SCALE: 1"=4'

20' 0' 20' 40'
SCALE: 1"=20'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT - SCALE REDUCED ACCORDINGLY.

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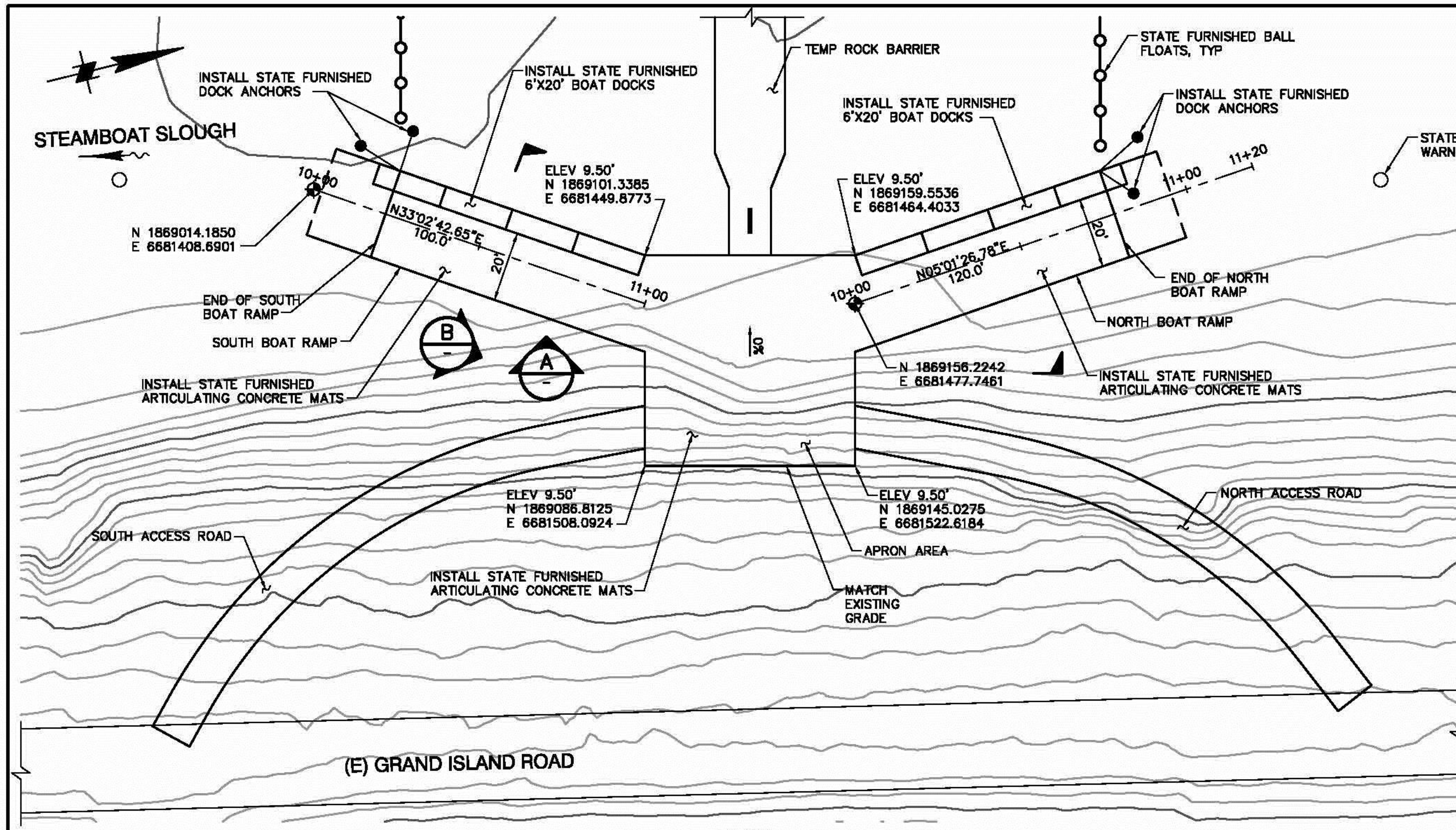
2014 DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS

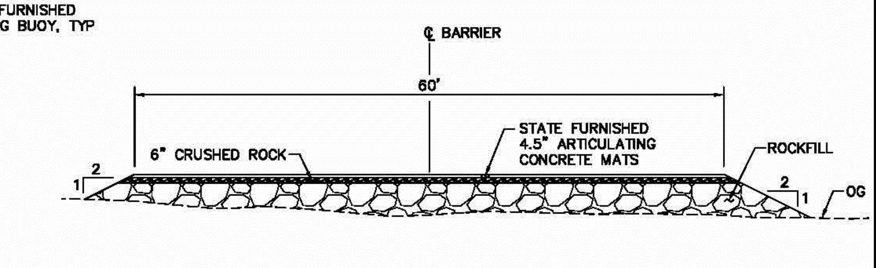
STEAMBOAT SLOUGH
TEMPORARY ROCK BARRIER
PROFILE AND SECTIONS

DATE 03/2014
SHEET 6 OF 15
C2

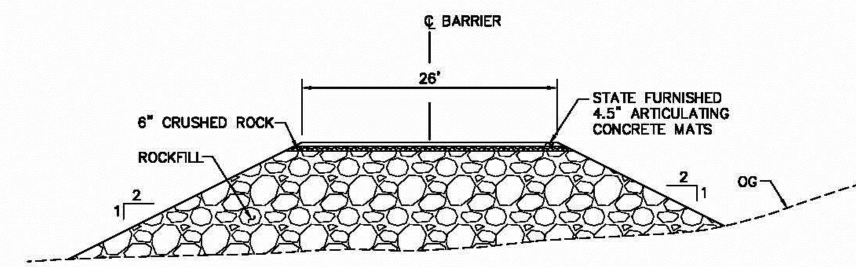
P:\8204 MWD-BAY DELTA SERVICES\6.CADD\8204-C2.DWG 3/14/2014 10:42 AM



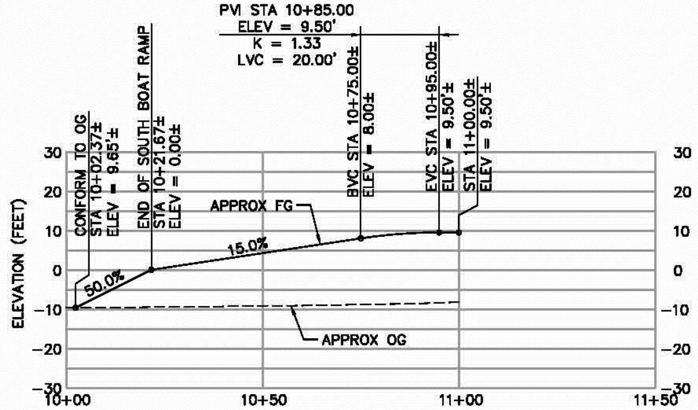
PLAN
SCALE: 1" = 20'



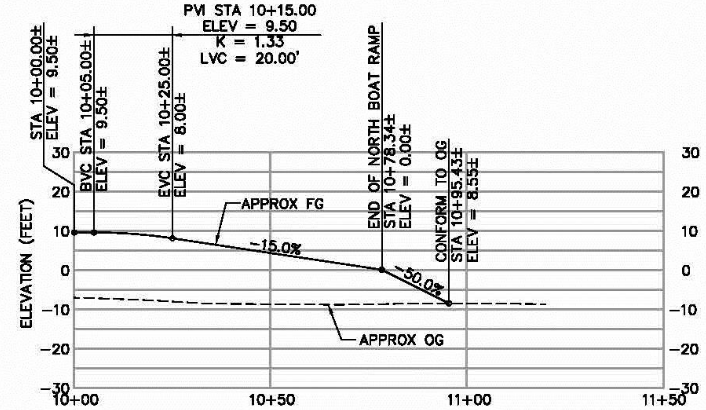
A SECTION
SCALE: 1"=8'



B SECTION
SCALE: 1"=8'



SOUTH BOAT RAMP PROFILE
SCALE: 1"= 20'H
1"= 20'V



NORTH BOAT RAMP PROFILE
SCALE: 1"= 20'H
1"= 20'V

NOTES:

1. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
2. OTHER FEATURES NOT SHOWN FOR CLARITY.

PROGRESS DRAFT
3/14/2014

SCALE: 1"=8' (8' 0' 8' 16')

SCALE: 1"=20' (20' 0' 20' 40')

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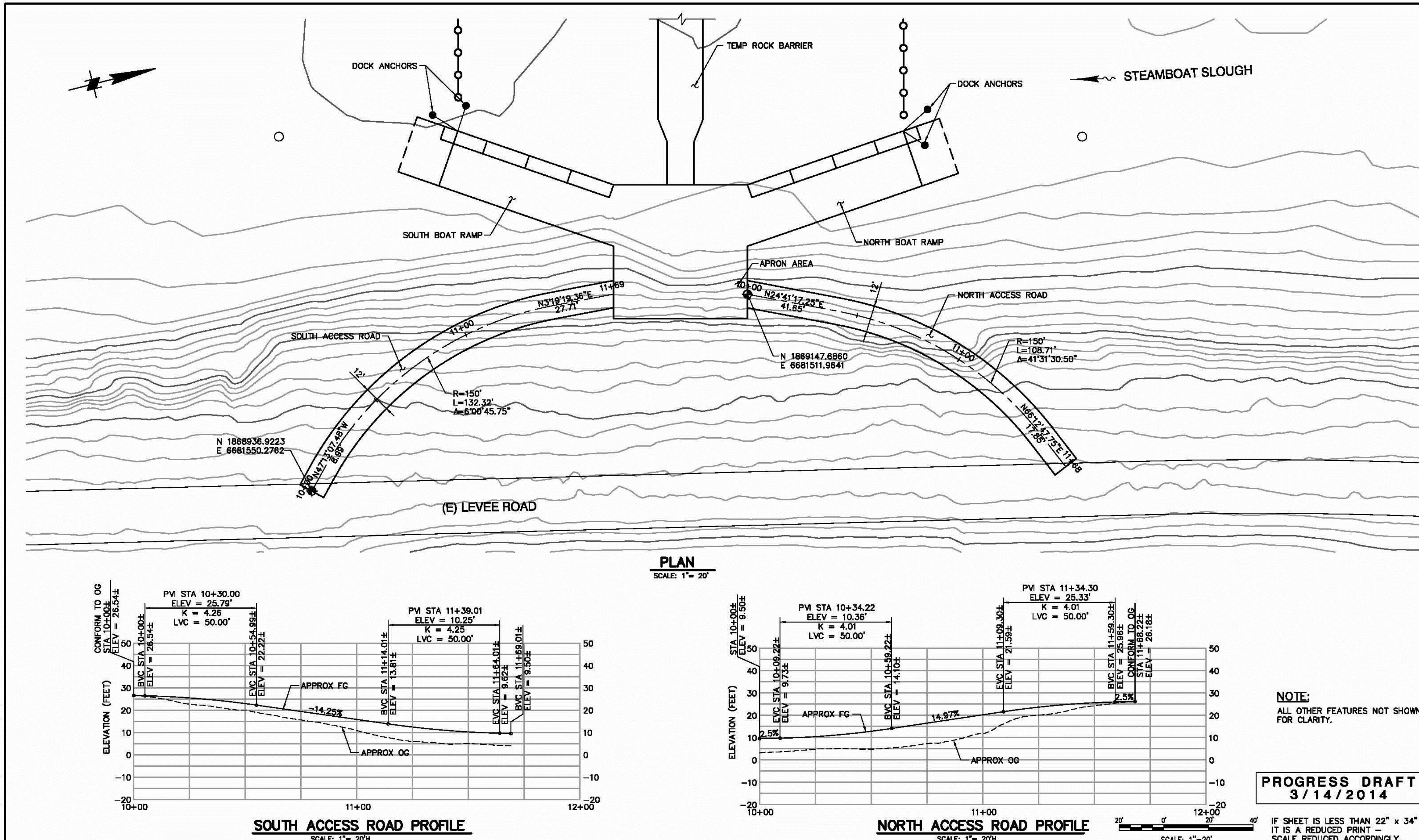
2014 DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS

STEAMBOAT SLOUGH
BOAT RAMP
PLAN AND PROFILE

DATE 03/2014
SHEET 7 OF 15
C3

P:\8204 MWD-BAY DELTA SERVICES\6.CADD\8204-C3.DWG 3/14/2014 2:29 PM



NOTE:
ALL OTHER FEATURES NOT SHOWN FOR CLARITY.

PROGRESS DRAFT
3/14/2014

SCALE: 1"=20'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

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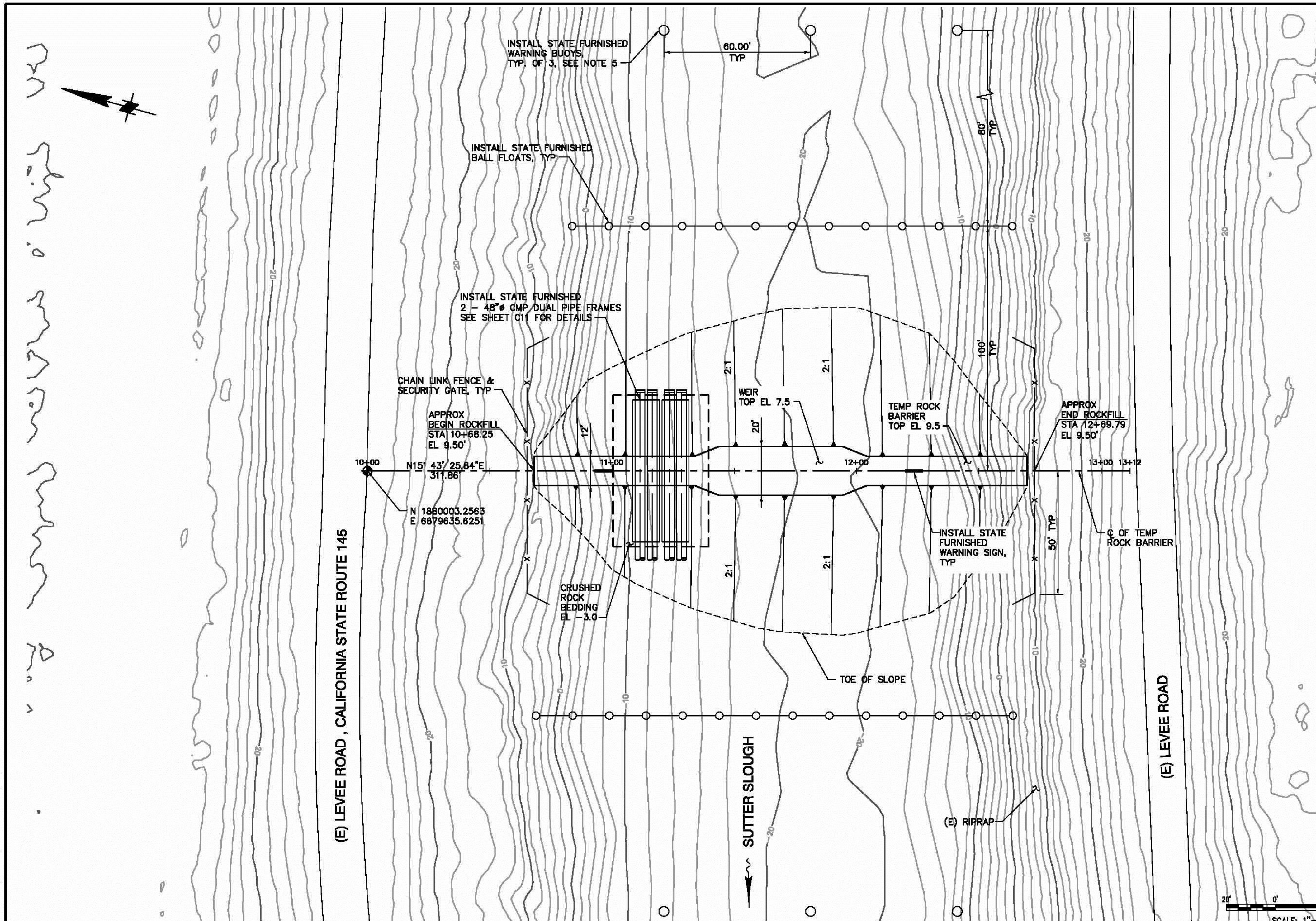
2014 DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

STEAMBOAT SLOUGH
ACCESS ROADS
PLAN AND PROFILE

DATE 03/2014
SHEET 8 OF 15
C4



NOTES:

1. COORDINATES ARE IN FEET AND REFER TO STATE PLANE ZONE 2, NAD 83.
2. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
3. CONTRACTOR SHALL INSTALL DEPARTMENT FURNISHED STRUCTURES TO INCLUDE: CMP CULVERTS, FRAMES, SLUICE GATES, ACCESS PLATFORMS, SIGNS AND OTHER ACCESSORIES AS DIRECTED.
4. OTHER FEATURES NOT SHOWN FOR CLARITY.
5. WHITE CYLINDRICAL WARNING BUOY WITH LIGHT ON TOP AND INTERNATIONAL ORANGE DIAMOND SYMBOL. WHITE LIGHT SHALL FLASH ONCE EVERY 4 SECONDS.
6. SEE SHEET C6 FOR TYPICAL SECTIONS OF ROCK BARRIER AND WEIR SECTIONS.

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

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2014 DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS

SUTTER SLOUGH
SITE PLAN

DATE 03/2014
SHEET 9 OF 15
C5

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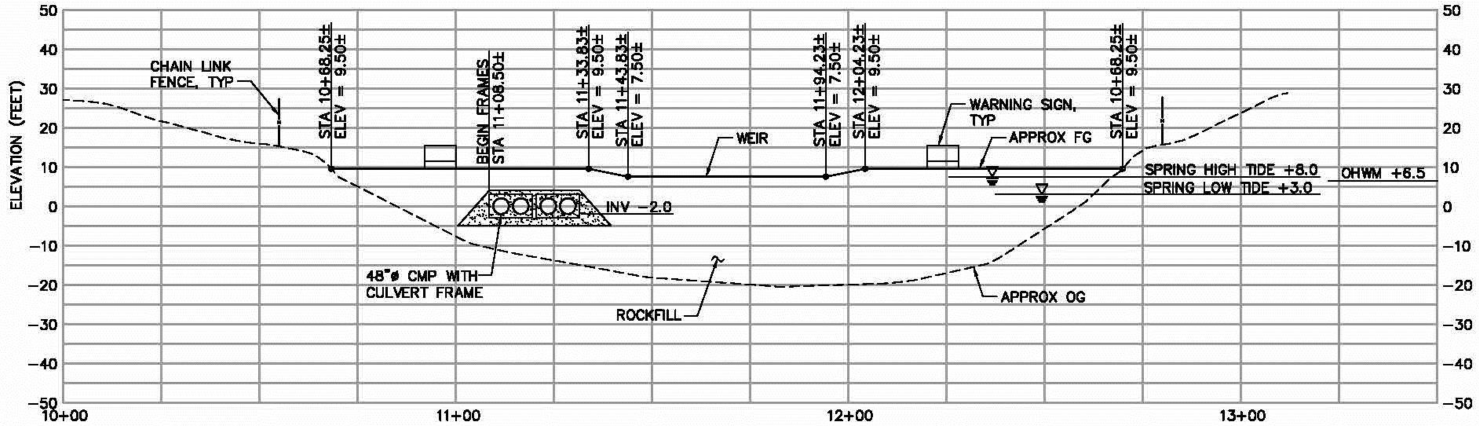
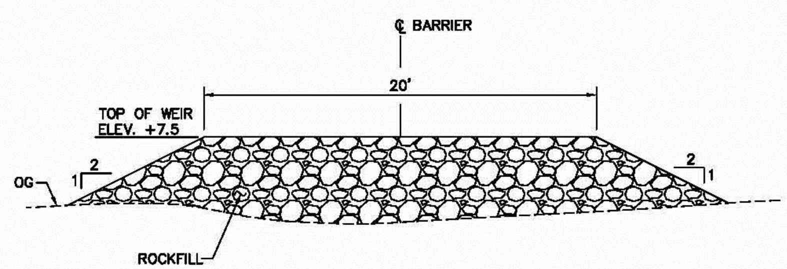


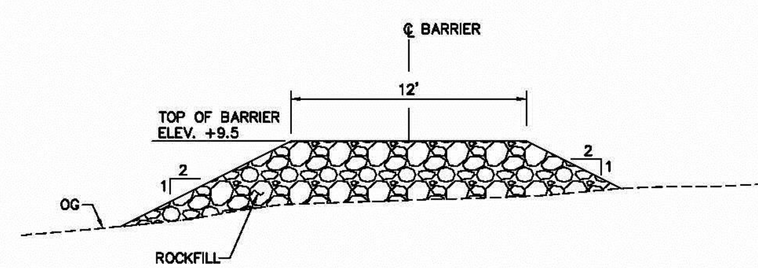
PROFILE

SCALE: 1"= 20'



TYPICAL SECTION–WEIR

SCALE: 1"= 4'



TYPICAL SECTION–ROCK BARRIER

SCALE: 1"= 4'

NOTES:

1. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
2. OTHER FEATURES NOT SHOWN FOR CLARITY.

PROGRESS DRAFT
3/14/2014

SCALE: 1"=4'

SCALE: 1"=20'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

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TEMPORARY ROCK BARRIERS

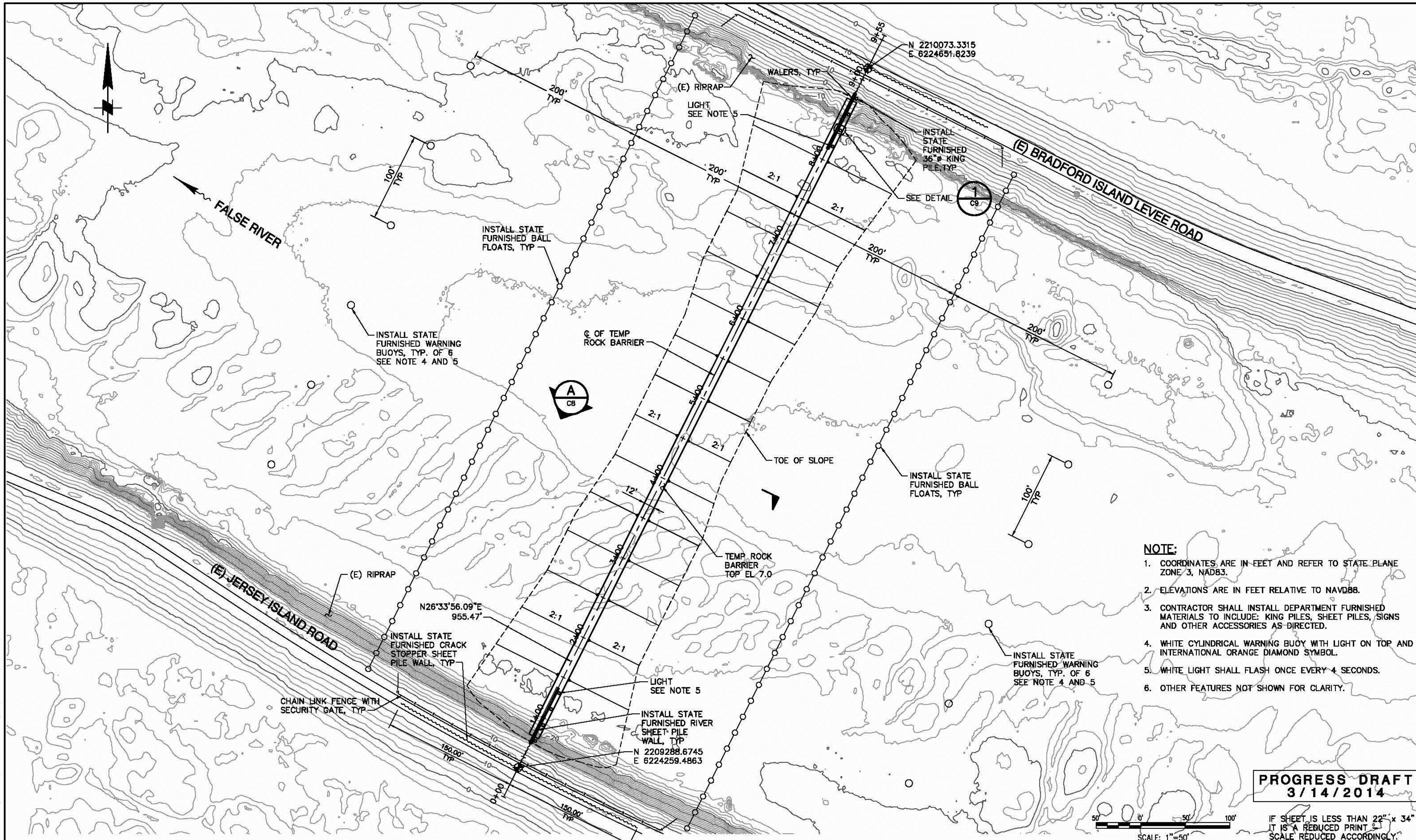
SUTTER SLOUGH
TEMPORARY ROCK BARRIER
PROFILE AND SECTIONS

DATE 03/2014

SHEET 10 OF 15

C6

P:\8204 MWD-BAY DELTA SERVICES\6.CADD\8204-C6.DWG 3/12/2014 7:42 PM



NOTE:

1. COORDINATES ARE IN FEET AND REFER TO STATE PLANE ZONE 3, NAD83.
2. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
3. CONTRACTOR SHALL INSTALL DEPARTMENT FURNISHED MATERIALS TO INCLUDE: KING PILES, SHEET PILES, SIGNS AND OTHER ACCESSORIES AS DIRECTED.
4. WHITE CYLINDRICAL WARNING BUOY WITH LIGHT ON TOP AND INTERNATIONAL ORANGE DIAMOND SYMBOL.
5. WHITE LIGHT SHALL FLASH ONCE EVERY 4 SECONDS.
6. OTHER FEATURES NOT SHOWN FOR CLARITY.

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2014 DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

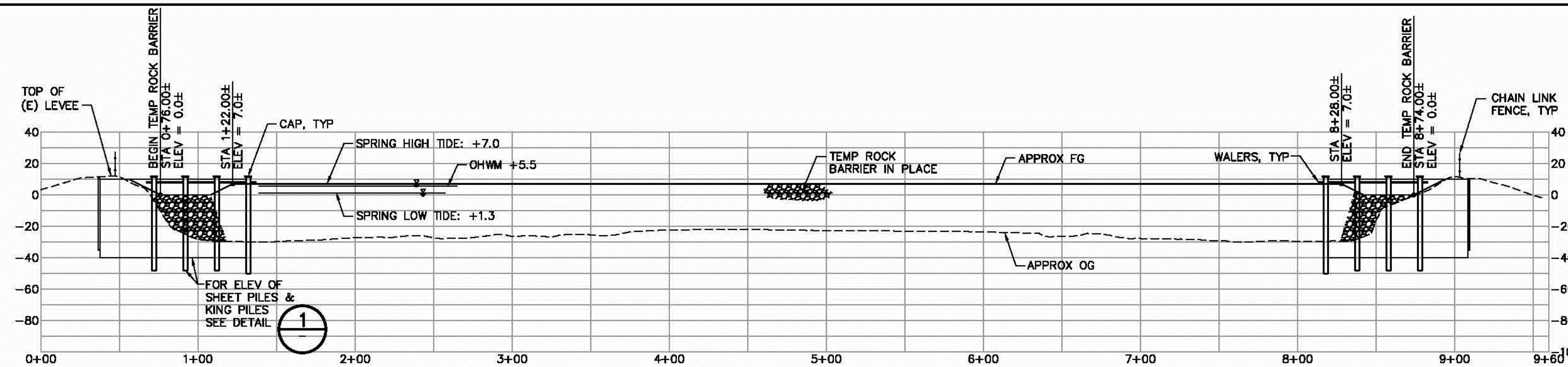
DATE 03/2014

SHEET 11 OF 15

FALSE RIVER SITE PLAN

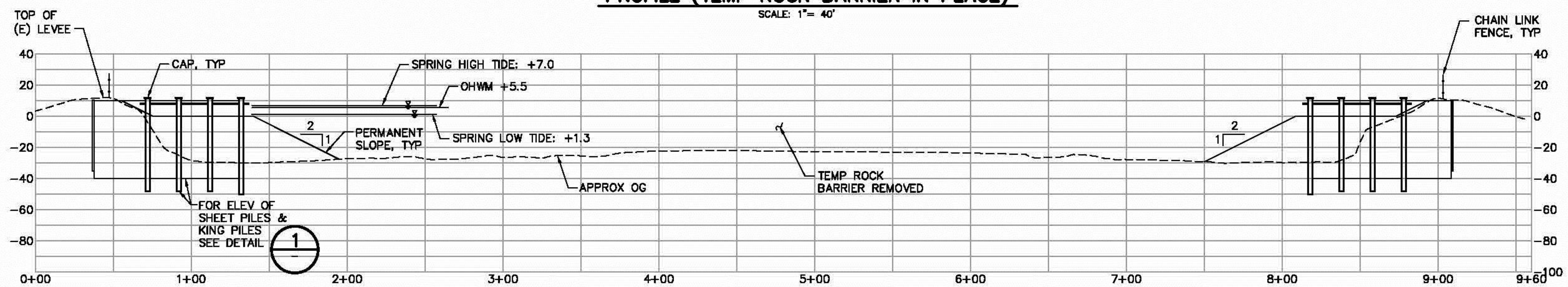
C7

P:\8204 MWD-BAY DELTA SERVICES\6.CADD\8204-C7.DWG 3/14/2014 1:39 PM



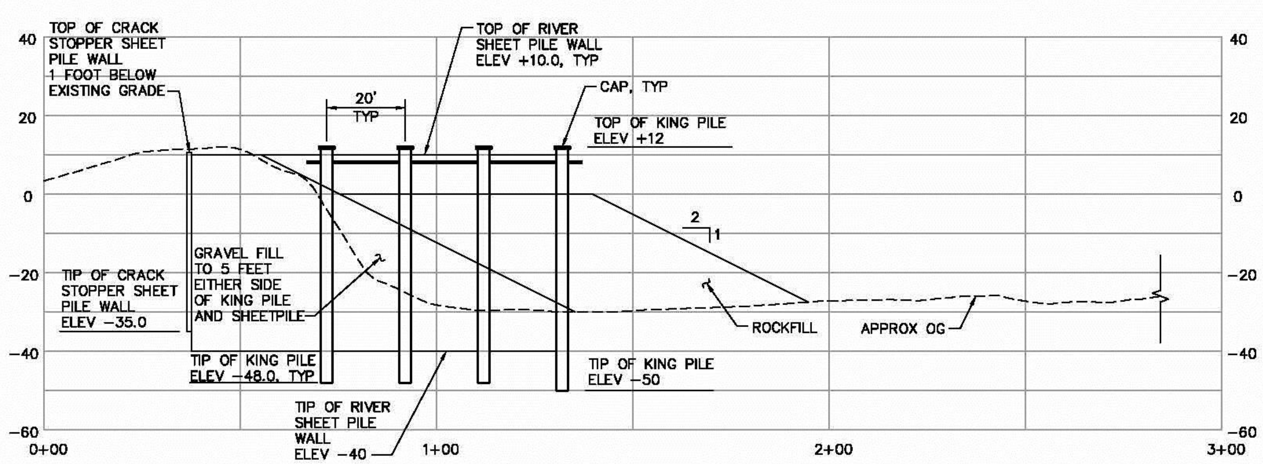
PROFILE (TEMP ROCK BARRIER IN PLACE)

SCALE: 1"= 40'



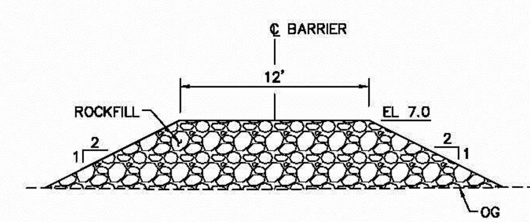
PROFILE (TEMP ROCK BARRIER REMOVAL)

SCALE: 1"= 40'



1 DETAIL

SCALE: 1"=20'



A SECTION

C7

SCALE: 1"=5'

NOTE:

OTHER FEATURES NOT SHOWN FOR CLARITY.

PROGRESS DRAFT 3/14/2014

SCALE: 1"=40'

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2014 DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

FALSE RIVER TEMPORARY ROCK BARRIER PROFILE, SECTION AND DETAIL

DATE 03/2014
SHEET 12 OF 15
C8

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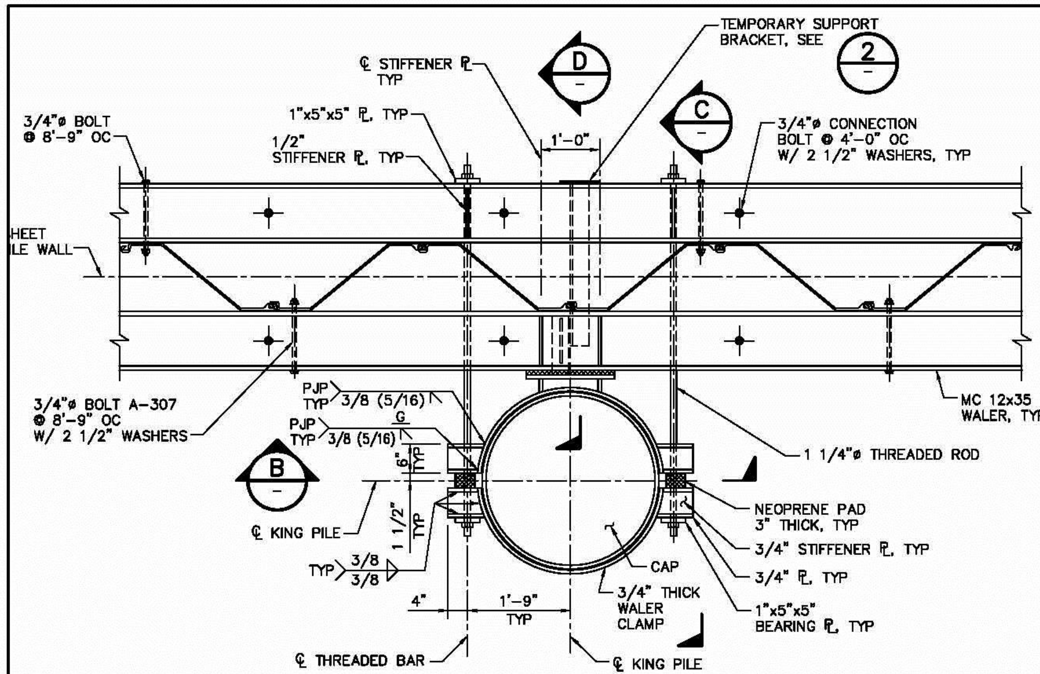
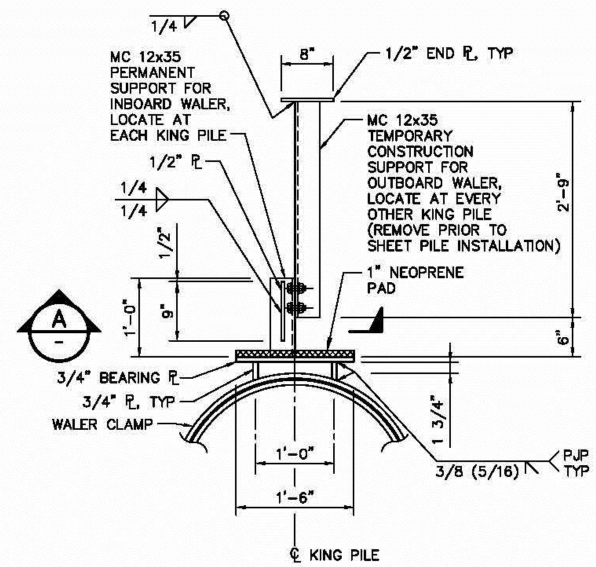
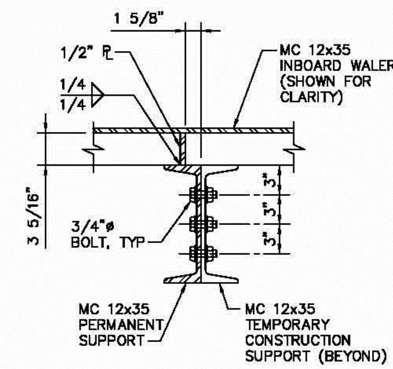


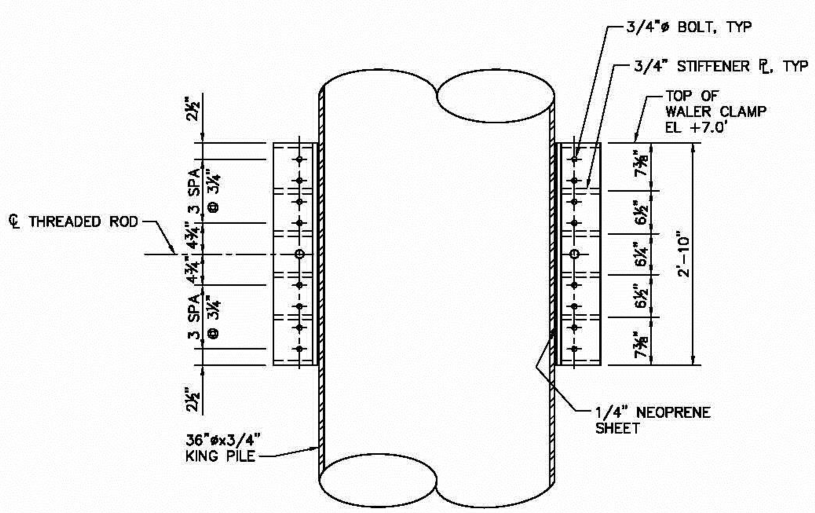
1 DETAIL C35
SCALE: 3/4" = 1'-0"
C5, C6



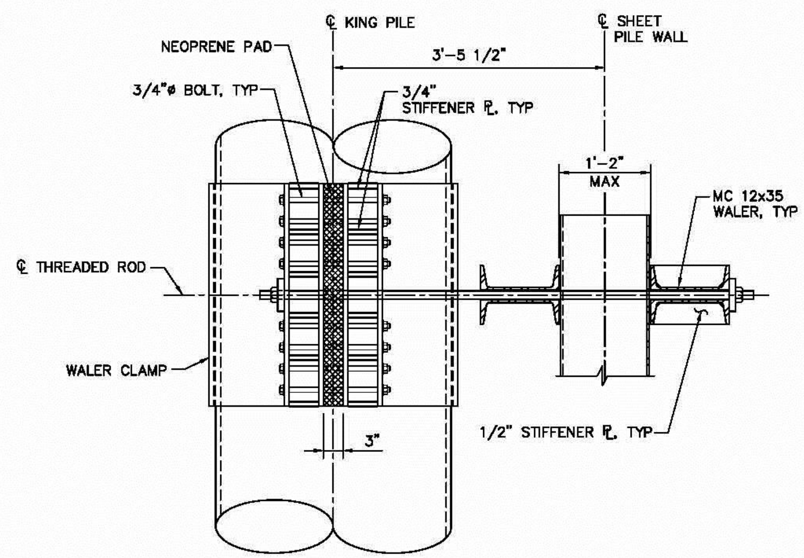
2 DETAIL
SCALE: 1" = 1'-0"



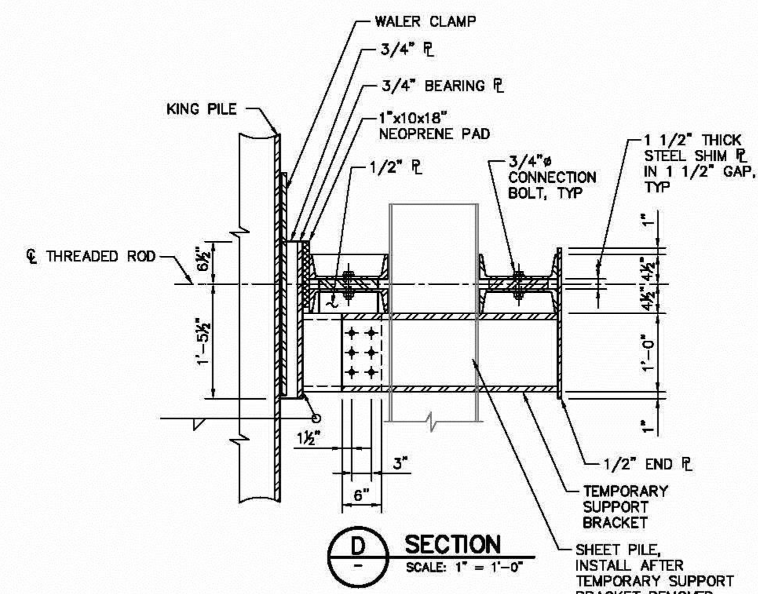
A SECTION
SCALE: 1 1/2" = 1'-0"



B SECTION
SCALE: 1" = 1'-0"



C SECTION
SCALE: 1" = 1'-0"



D SECTION
SCALE: 1" = 1'-0"

PROGRESS DRAFT
3/14/2014

SCALE: 1"=1'-0"   SCALE: 3/4"=1'-0"

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT - SCALE REDUCED ACCORDINGLY.

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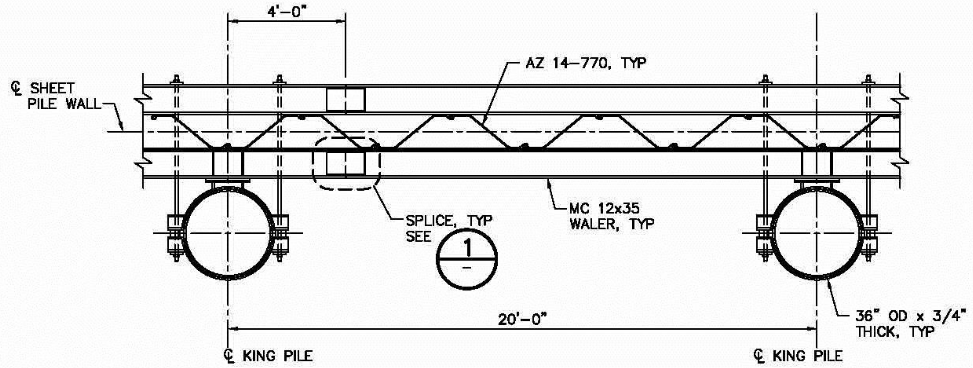
2014 DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS

DATE 03/2014
SHEET xx OF 15

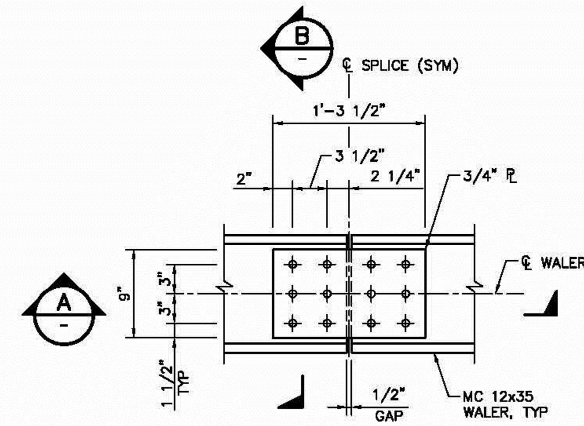
SHEET PILE WALL DETAILS
SHEET 1

C9



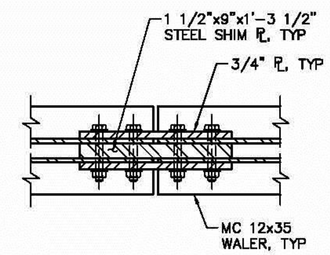
PLAN

TYPICAL WALER SPLICE DETAIL (SEE NOTE 1)
SCALE: 3/8"= 1'-0"

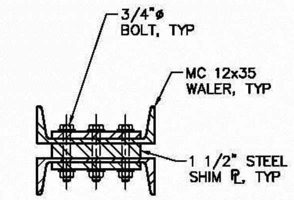


PLAN

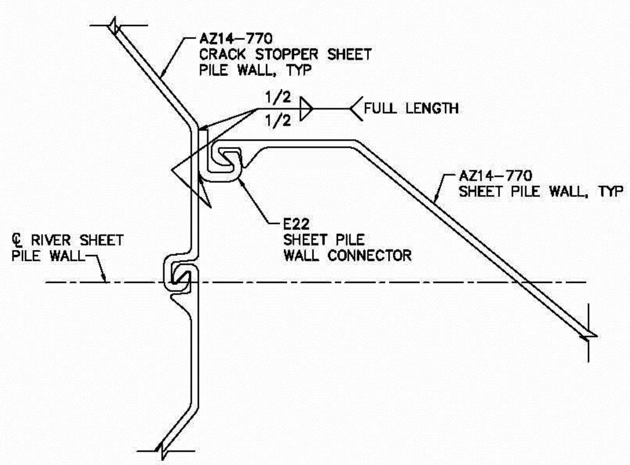
1 DETAIL
SCALE: 1 1/2" = 1'-0"



A SECTION
SCALE: 1 1/2" = 1'-0"



B SECTION
SCALE: 1 1/2" = 1'-0"



2 DETAIL
SCALE: 3" = 1'-0"

NOTES:

1. LOCATE WALER SPLICES AS REQUIRED.

PROGRESS DRAFT
3/14/2014

2'-0" 0'-0" 1'-0" 2'-0"
SCALE: 3/4"=1'-0"

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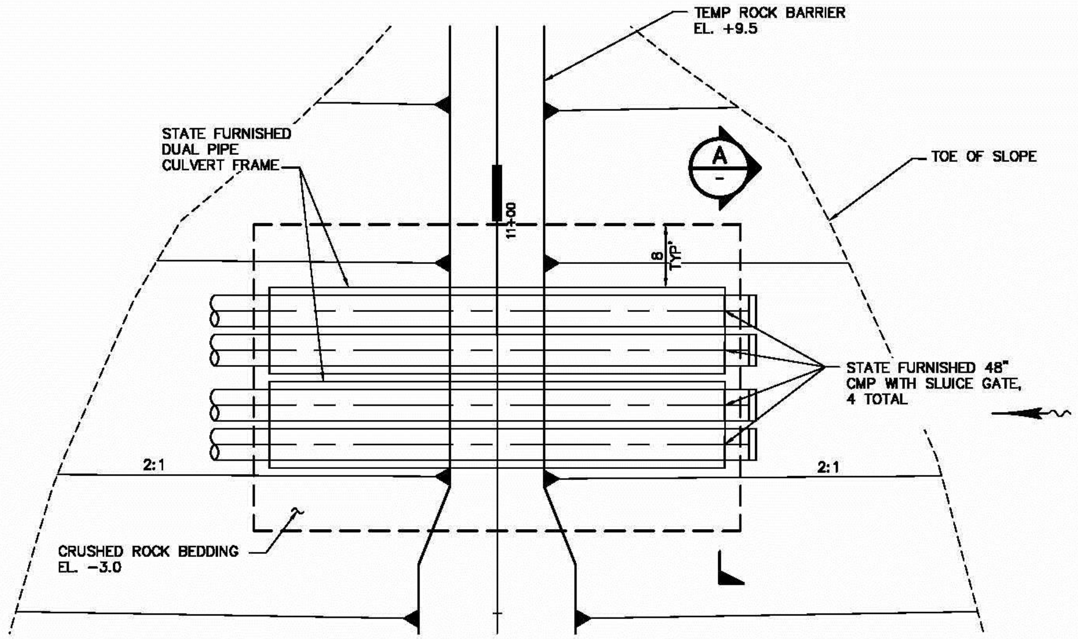
TEMPORARY ROCK BARRIERS

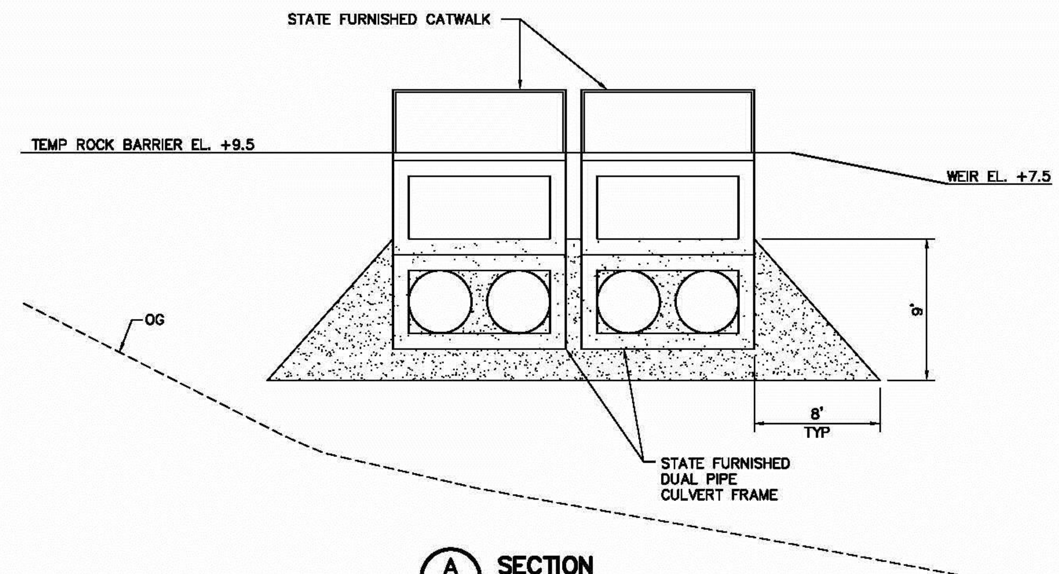
SHEET PILE WALL DETAILS
SHEET 2

DATE 03/2014
SHEET xx OF 15
C10

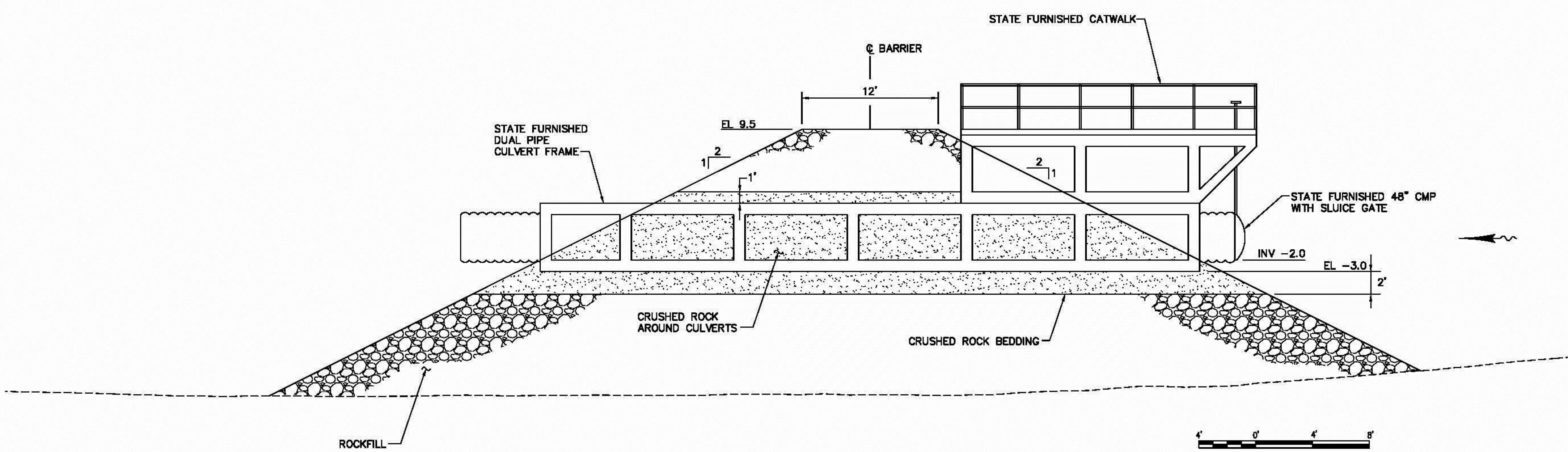
P:\8204 MWD-BAY DELTA SERVICES\6.CADD\8204-C10.DWG 3/14/2014 2:53 PM



PLAN
SCALE: 1"= 10'



A SECTION
SCALE: 1"=4'



TYPICAL SECTION – 48" CMP DUAL PIPE FRAMES
SCALE: 1"= 5'

NOTES:
OTHER FEATURES NOT SHOWN FOR CLARITY.

PROGRESS DRAFT 3/14/2014

4' 0' 4' 8' — SCALE: 1"=4'
5' 0' 5' 10' — SCALE: 1"=5'
10' 0' 10' 20' — SCALE: 1"=10'

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TEMPORARY ROCK BARRIERS

CULVERT TYPICAL SECTION

DATE 03/2014
SHEET 15 OF 15
C11

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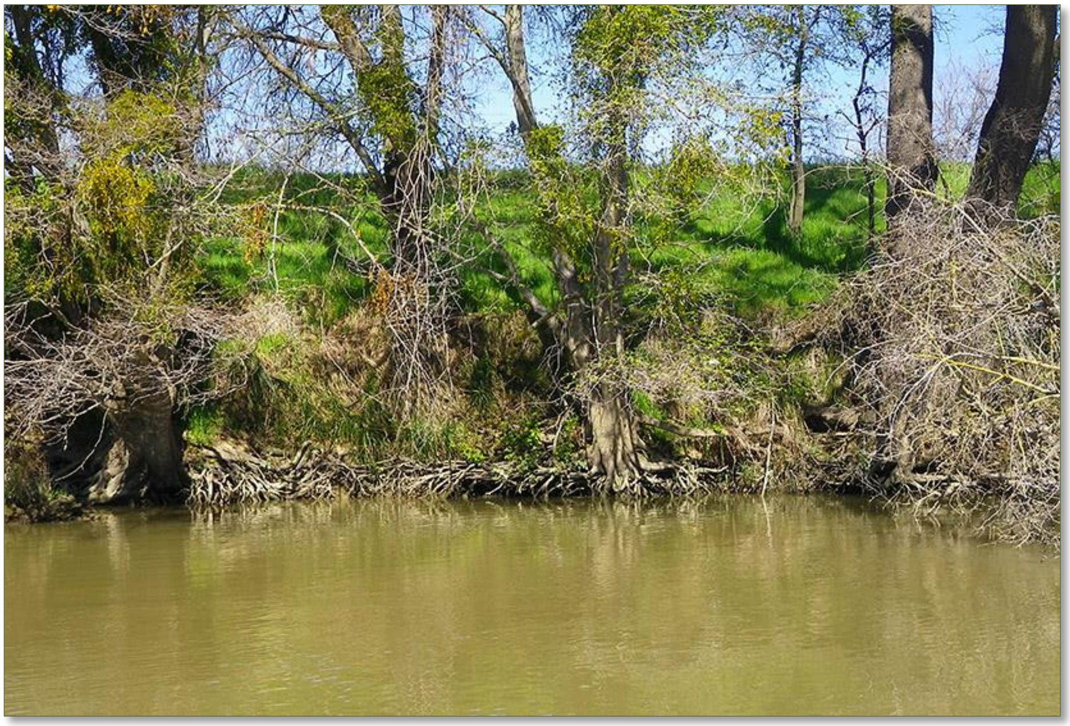
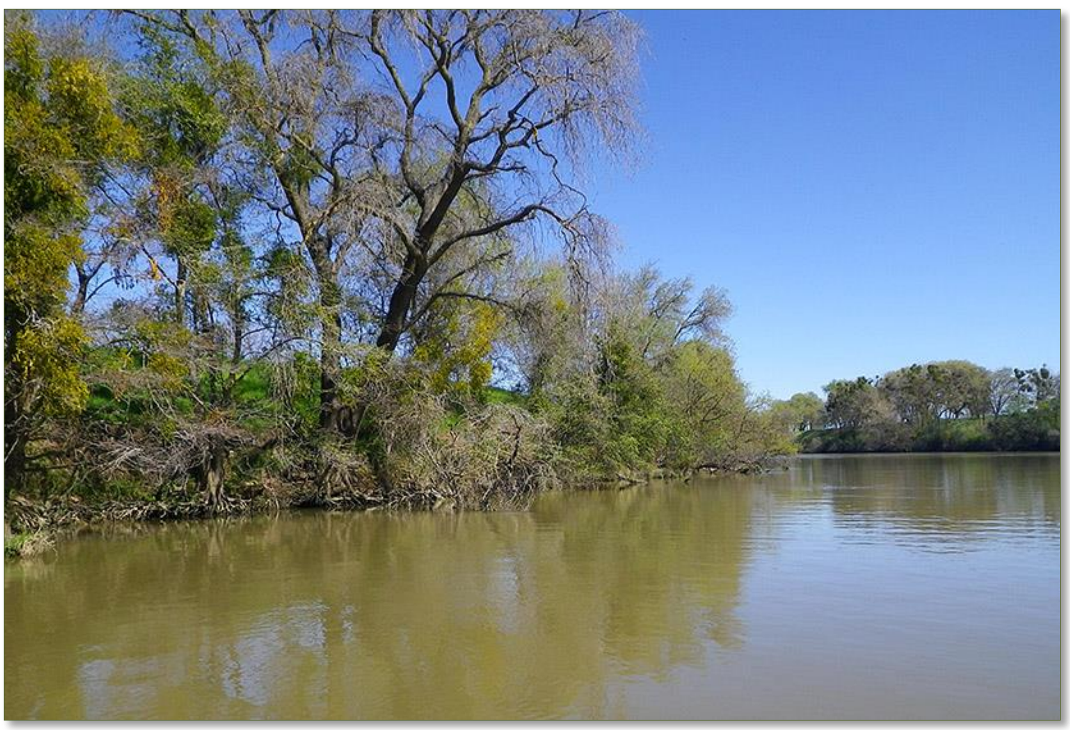
APPENDIX B

Representative Photographs of the Emergency Drought Barriers Sites



Representative habitat at the Sutter Slough barrier site, looking west at the west bank of the slough.



Representative habitat at the Sutter Slough barrier site, looking north at the west bank of the slough in the foreground and east bank in the background.

Representative habitat at the Steamboat Slough barrier site, looking northwest at the west bank of the slough.

Representative habitat at the Steamboat Slough barrier site, looking west at the west bank of the slough.

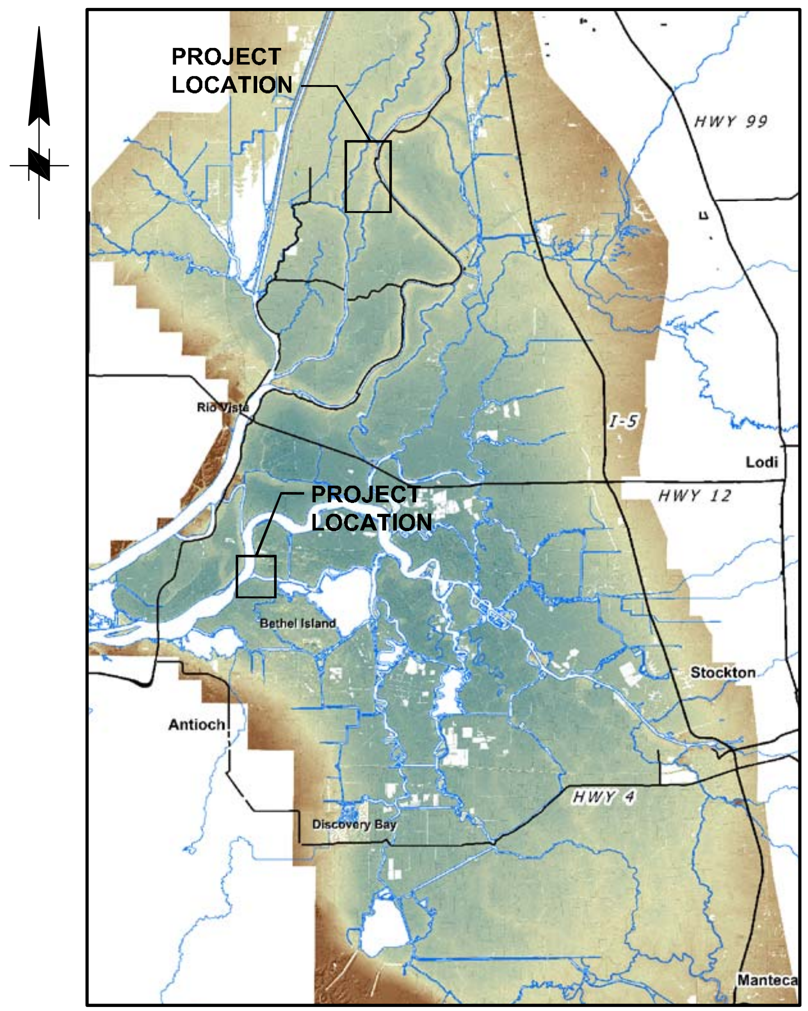
Representative habitat at the West False River barrier site, looking south at the south bank of the channel.

Representative habitat at the West False River barrier site, looking west at the south bank of the channel.

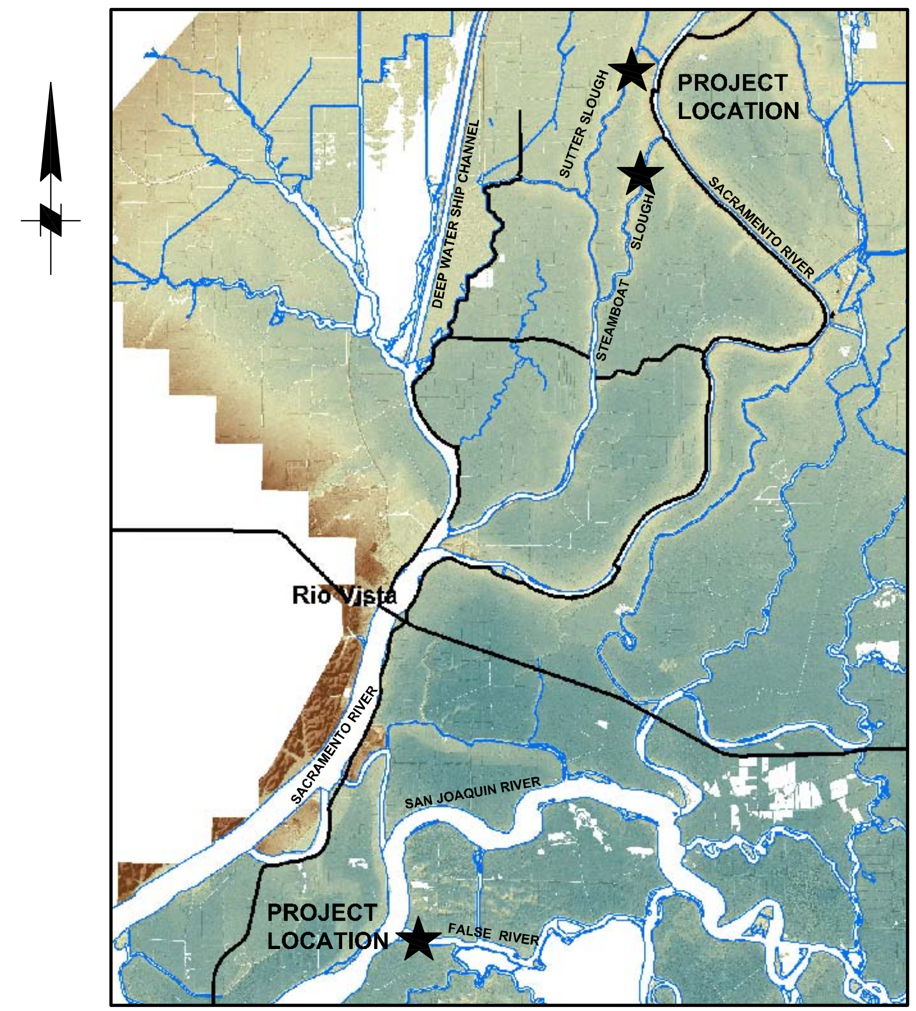
ATTACHMENT D

Design Drawings

2014 DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS
STEAMBOAT AND SUTTER SLOUGHS AND FALSE RIVER, CALIFORNIA



VICINITY MAP
NTS



LOCATION MAP
NTS

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TEMPORARY ROCK BARRIERS

TITLE SHEET

DATE 03/2014
SHEET 1 OF 15
G1

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INDEX OF DRAWINGS

SHEET NUMBER	DRAWING NUMBER	DESCRIPTION
		GENERAL
1	G1	TITLE SHEET
2	G2	INDEX OF DRAWINGS
3	G3	GENERAL NOTES, ABBREVIATIONS AND LEGEND
4	G4	PROJECT GENERAL PLAN
		STEAMBOAT SLOUGH
5	C1	STEAMBOAT SLOUGH, SITE PLAN
6	C2	STEAMBOAT SLOUGH, TEMPORARY ROCK BARRIER PROFILE AND SECTIONS
7	C3	STEAMBOAT SLOUGH, BOAT RAMP PLAN AND PROFILE
8	C4	STEAMBOAT SLOUGH ACCESS ROADS PLAN AND PROFILE
		SUTTER SLOUGH
9	C5	SUTTER SLOUGH, SITE PLAN
10	C6	SUTTER SLOUGH, TEMPORARY ROCK BARRIER PROFILE AND SECTIONS
		FALSE RIVER
11	C7	FALSE RIVER, SITE PLAN
12	C8	FALSE RIVER, TEMPORARY ROCK BARRIER PROFILE, SECTION AND DETAIL
13	C9	SHEET PILE WALL DETAILS, SHEET 1
14	C10	SHEET PILE WALL DETAILS, SHEET 2
		COMMON DETAILS
15	C11	CULVERT TYPICAL SECTION

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2014 DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

DATE 03/2014

SHEET 2 OF 15

INDEX OF DRAWINGS

G2

GENERAL NOTES

TOPOGRAPHIC AND BATHYMETRIC DATA IS BASED ON WANG, R. & ATELJEVICH, E. (2012). A CONTINUOUS SURFACE ELEVATION MAP FOR MODELING (CHAPTER 6). IN METHODOLOGY FOR FLOW AND SALINITY ESTIMATES IN THE SACRAMENTO–SAN JOAQUIN DELTA AND SUISUN MARS, 23RD ANNUAL PROGRESS REPORT TO THE STATE WATER RESOURCES CONTROL BOARD. CALIFORNIA DEPARTMENT OF WATER RESOURCES, BAY–DELTA OFFICE, DELTA MODELING SECTION.

VERTICAL DATUM

PROJECT ELEVATIONS ARE BASED ON NAVD88.

HORIZONTAL DATUM

STEAMBOAT & SUTTER SLOUGH:

PROJECT COORDINATES ARE BASED ON THE CALIFORNIA STATE PLANE COORDINATE SYSTEM NAD 1983, ZONE 2.

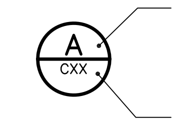
FALSE RIVER:

PROJECT COORDINATES ARE BASED ON THE CALIFORNIA STATE PLANE COORDINATE SYSTEM NAD 1983, ZONE 3.

ABBREVIATIONS

&	AND
Δ	DELTA
#	NUMBER
%	PERCENT
APPROX	APPROXIMATE
ASTM	ASTM INTERNATIONAL
BVC	BEGIN VERTICAL CURVE
C/C	CENTER TO CENTER
CJP	COMPLETE JOINT PENETRATION
℄	CENTER LINE
CIP	CAST–IN–PLACE
CLR	CLEAR
CMP	CORRUGATED METAL PIPE
CONC	CONCRETE
CONT	CONTINUOUS
DIA, ø	DIAMETER
DIMS	DIMENSIONS
DWG	DRAWING
DWT	DEAD WEIGHT
(E)	EXISTING
E	EASTING
ELEV	ELEVATION
EJ	EXPANSION JOINT
EVC	END VERTICAL CURVE
EW	EACH WAY
FG	FINISH GRADE
FT	FOOT OR FEET
GALV	GALVANIZED
H	HORIZONTAL
HD	HEAD
HDPE	HIGH DENSITY POLYETHYLENE
HW	HIGH WATER
IBC	INTERNATIONAL BUILDING CODE
ID	INSIDE DIAMETER
INFO	INFORMATION
INV	INVERT
L	LENGTH
LB	POUND
LVC	LENGTH VERTICAL CURVE
LW	LOW WATER
MAX	MAXIMUM
MFG	MANUFACTURING
MIN	MINIMUM
N	NORTHING
NAD	NORTH AMERICAN DATUM
NAVD	NORTH AMERICAN VERTICAL DATUM
NIC	NOT IN CONTRACT
NTS	NOT TO SCALE
OC	ON CENTER
OD	OUTSIDE DIAMETER
OG	ORIGINAL GROUND
OHWM	ORDINARY HIGH WATER MARK
OPP	OPPOSITE
PC/PS	PRECAST/PRESTRESSED
ℙ	PLATE
PJP	PARTIAL JOINT PENETRATION
PSF	POUNDS PER SQUARE FOOT
PVI	POINT VERTICAL INTERSECTION
R	RADIUS
REF	REFERENCE
REINF	REINFORCEMENT
SA	SEISMIC ACCELERATION
SCH	SCHEDULE
SIM	SIMILAR
SPA	SPACES
STA	STATION
STD	STANDARD
STIF	STIFFENER
SYMM	SYMMETRICAL
TEMP	TEMPORARY
THRU	THROUGH
TYP	TYPICAL
UHMW	ULTRA HIGH MOLECULAR WEIGHT
UON	UNLESS OTHERWISE NOTED
V	VERTICAL
VAR	VARIES
VC	VERTICAL CURVE
WP	WORK POINT
WT	WALL THICKNESS
W/	WITH

CROSS–REFERENCE LEGEND



SECTION OR DETAIL IDENTIFICATION, SEE NOTE

REFERENCE SHEET ON WHICH SECTION OR DETAIL IS SHOWN

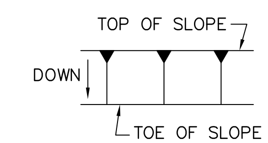
NOTE: LETTER INDICATES SECTION; NUMBER INDICATES DETAIL. WHERE THERE IS NO REFERENCE SHEET INDICATED, IT MEANS THE DETAIL OR SECTION IS TAKEN AND SHOWN ON THE SAME SHEET.

LEGEND

EXISTING FEATURE

PROPOSED FEATURE

5 — EXISTING CONTOUR



SLOPE

WORK POINT

DOWNSTREAM FLOW DIRECTION

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GENERAL NOTES, ABBREVIATIONS AND LEGEND

DATE 03/2014
SHEET 3 OF 15
G3

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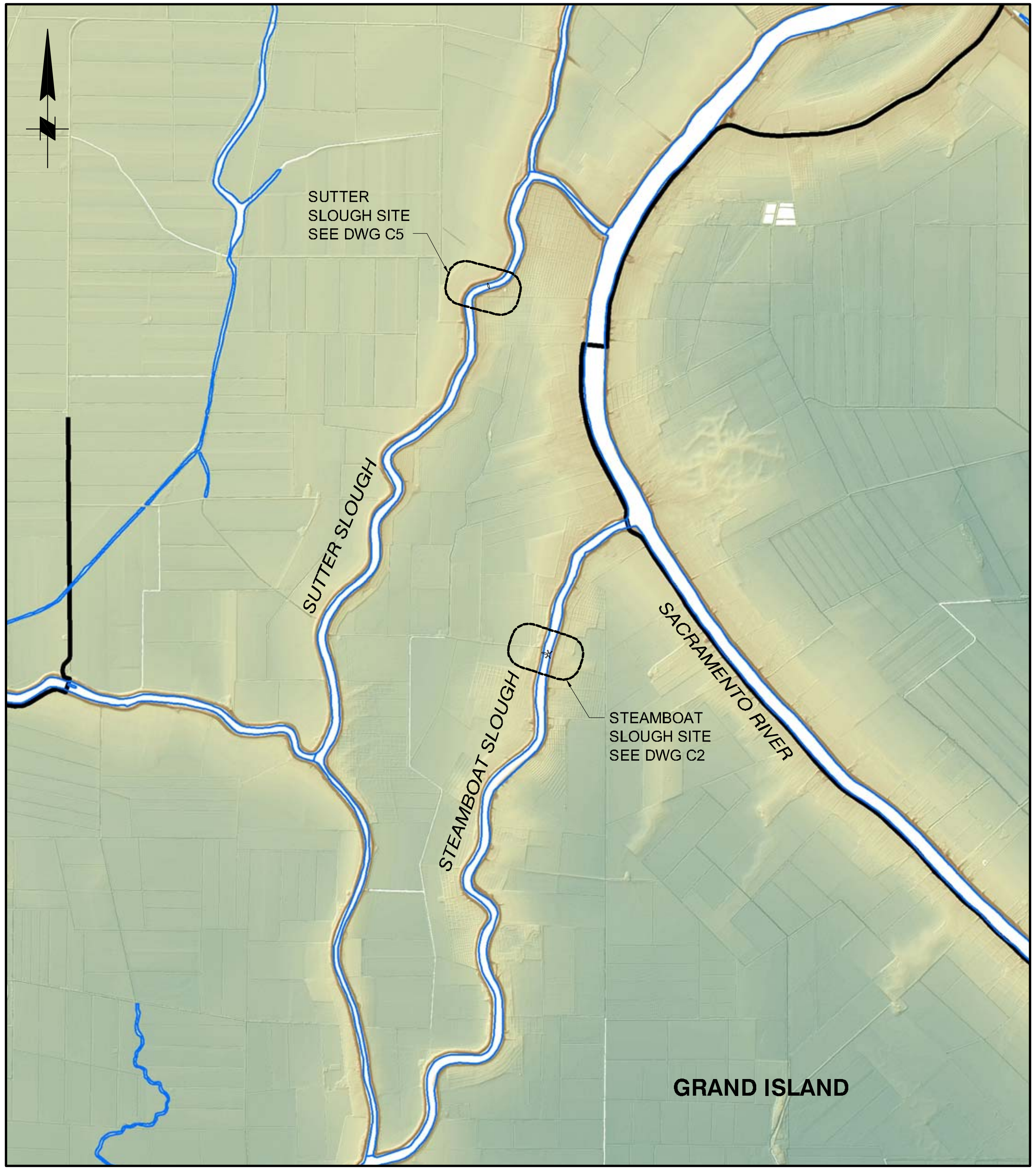

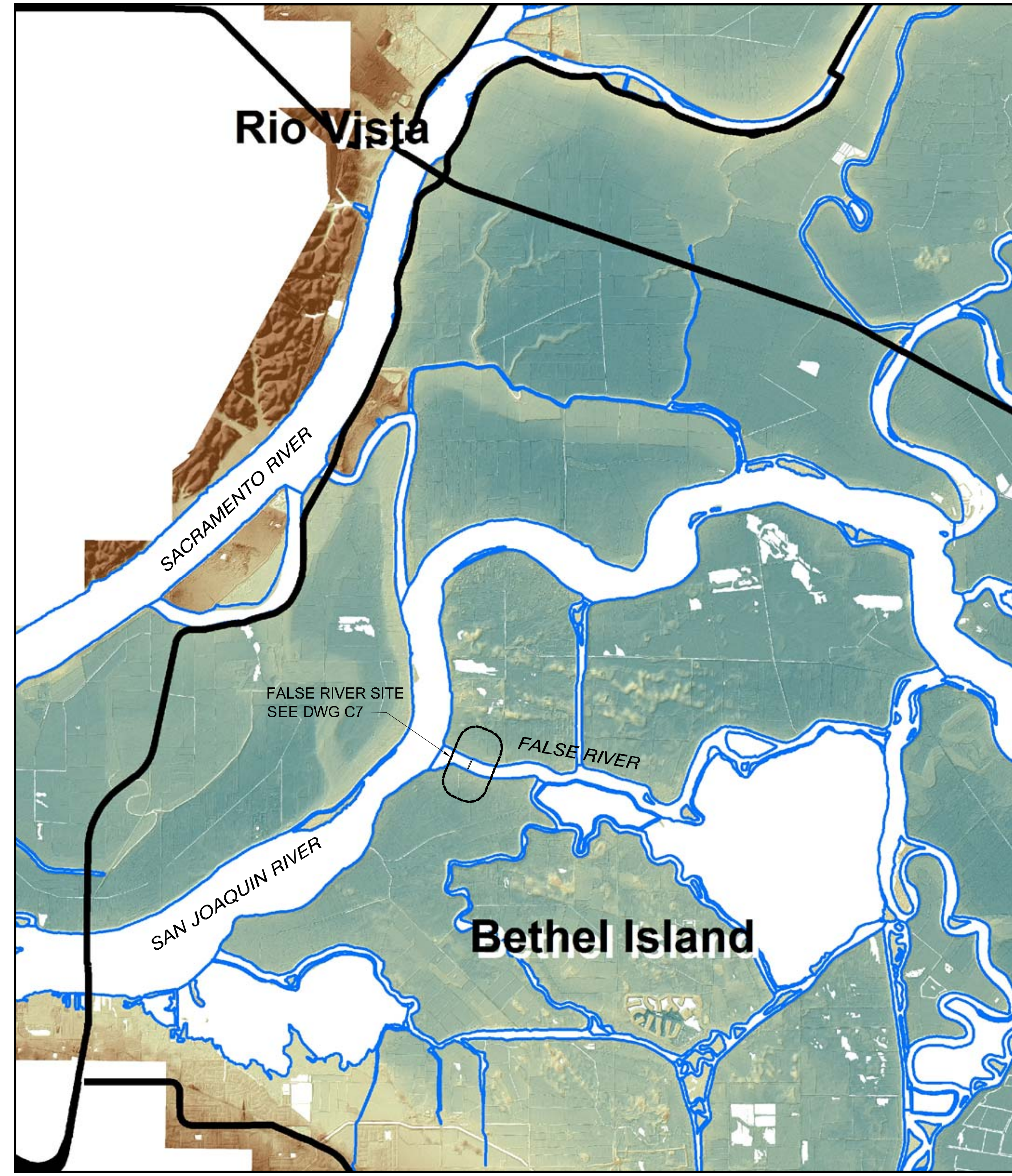

PROJECT GENERAL PLAN

NTS

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TEMPORARY ROCK BARRIERS

PROJECT GENERAL PLAN

DATE 03/2014

SHEET 4 OF 15

G4

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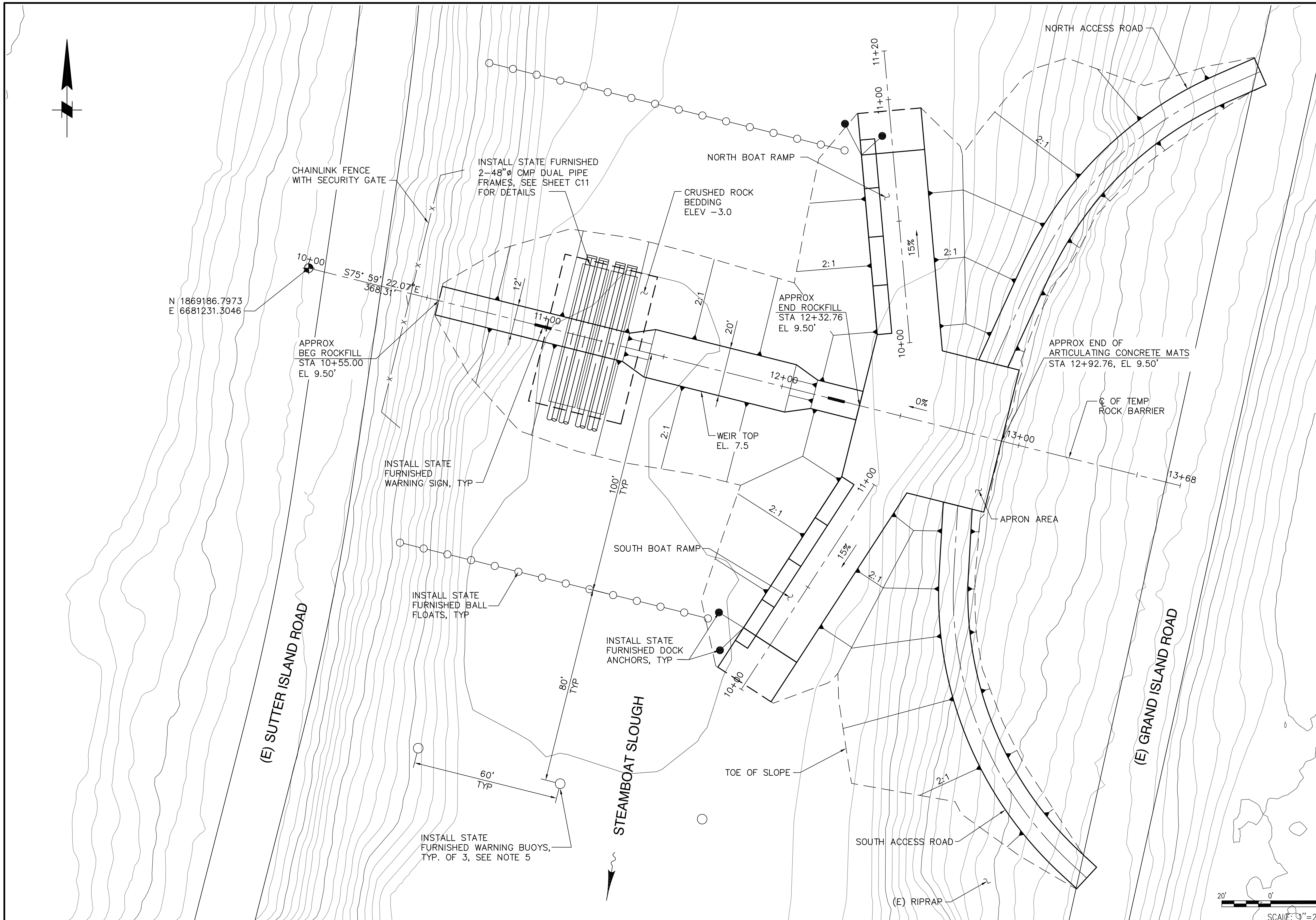

NOTES:

1. COORDINATES ARE IN FEET AND REFER TO STATE PLANE ZONE 2, NAD 83.
2. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
3. CONTRACTOR SHALL INSTALL DEPARTMENT FURNISHED STRUCTURES TO INCLUDE: CMP CULVERTS, FRAMES, SLUICE GATES, ACCESS PLATFORMS, CATWALKS, SIGNS, ARTICULATING CONCRETE MATS AND OTHER ACCESSORIES AS DIRECTED.
4. OTHER FEATURES NOT SHOWN FOR CLARITY.
5. WHITE CYLINDRICAL WARNING BUOY WITH LIGHT ON TOP AND INTERNATIONAL ORANGE DIAMOND SYMBOL. WHITE LIGHT SHALL FLASH ONCE EVERY 4 SECONDS.
6. SEE SHEET C2 FOR TYPICAL SECTIONS OF ROCK BARRIER AND WEIR SECTIONS.

NOTE:

ALL OTHER FEATURES NOT SHOWN FOR CLARITY.

20' 0' 20' 40'
SCALE: 1"=20'

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DATE 03/2014

SHEET 5 OF 15

STEAMBOAT SLOUGH SITE PLAN

C1

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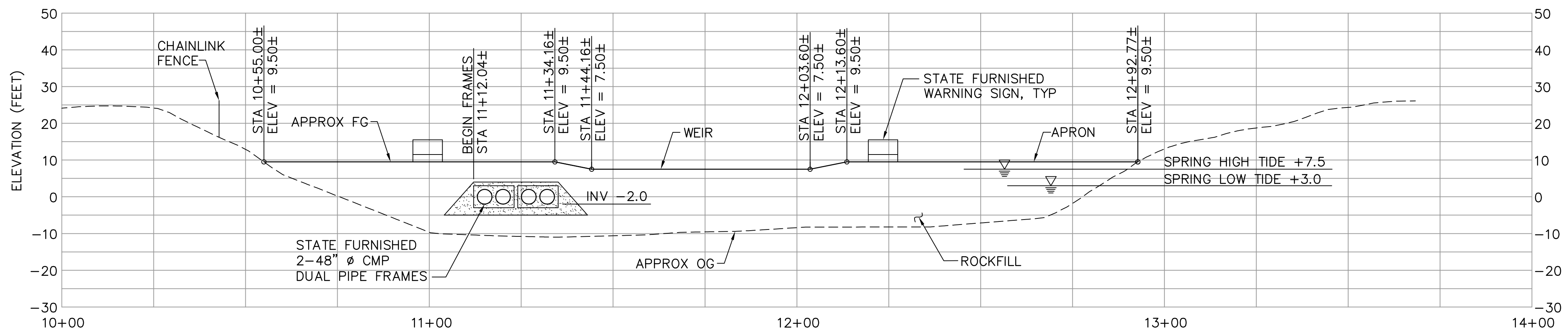
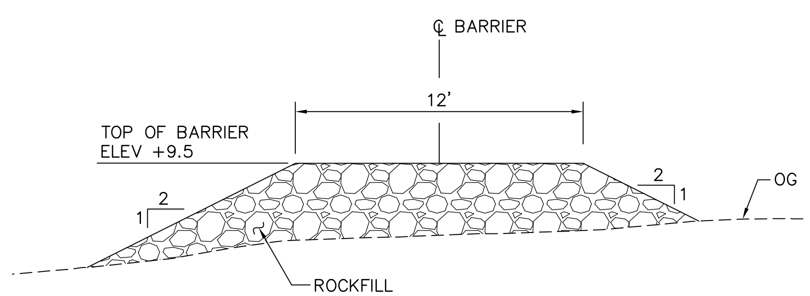


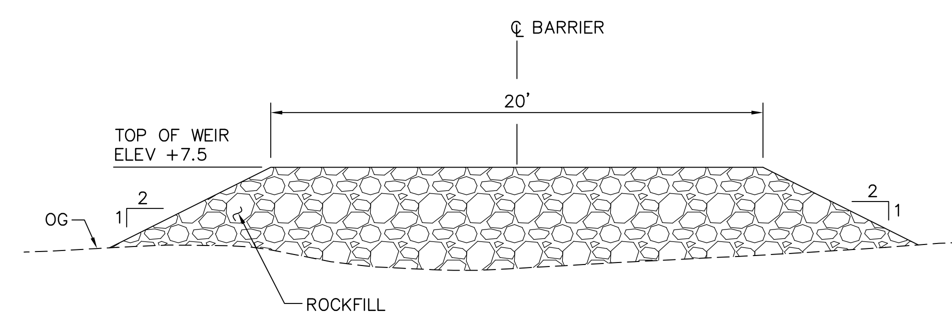
PROFILE

SCALE: 1"= 20'



TYPICAL SECTION–ROCK BARRIER

SCALE: 1"= 4'



TYPICAL SECTION–WEIR

SCALE: 1"= 4'

NOTE:

1. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
2. OTHER FEATURES NOT SHOWN FOR CLARITY.

4' 0' 4' 8'
SCALE: 1"=4'

20' 0' 20' 40'
SCALE: 1"=20'

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TEMPORARY ROCK BARRIERS

STEAMBOAT SLOUGH
TEMPORARY ROCK BARRIER
PROFILE AND SECTIONS

DATE 03/2014
SHEET 6 OF 15
C2

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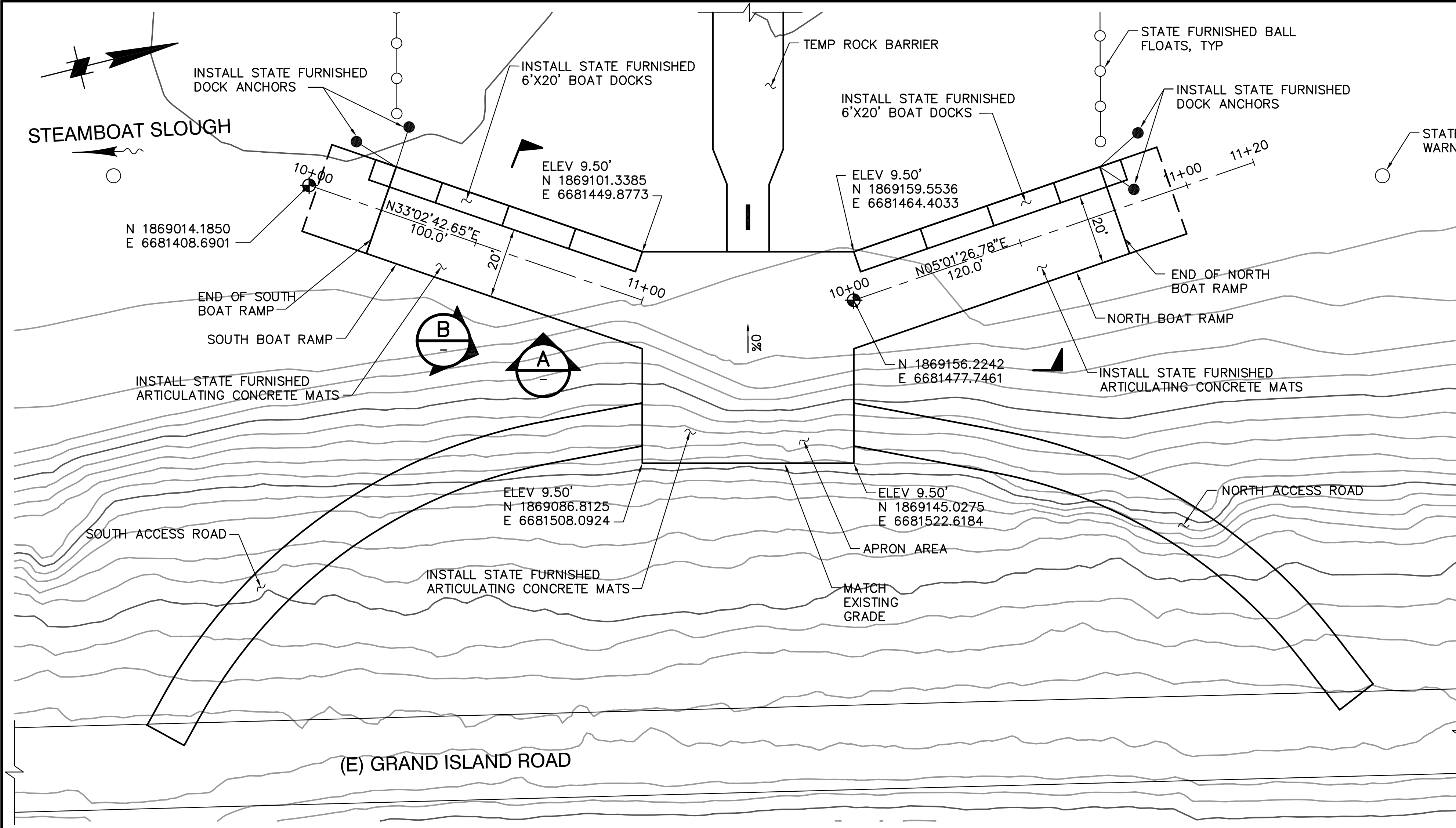
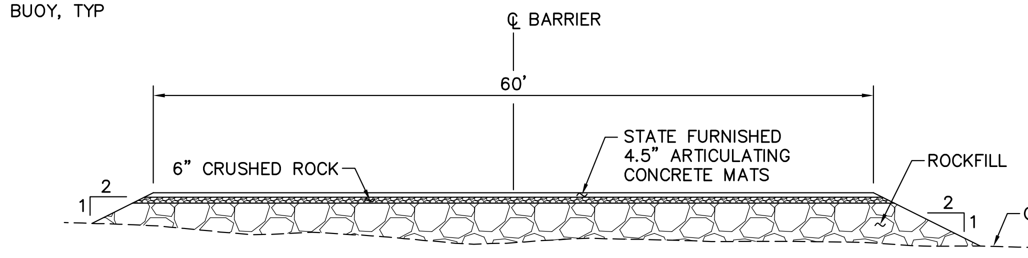
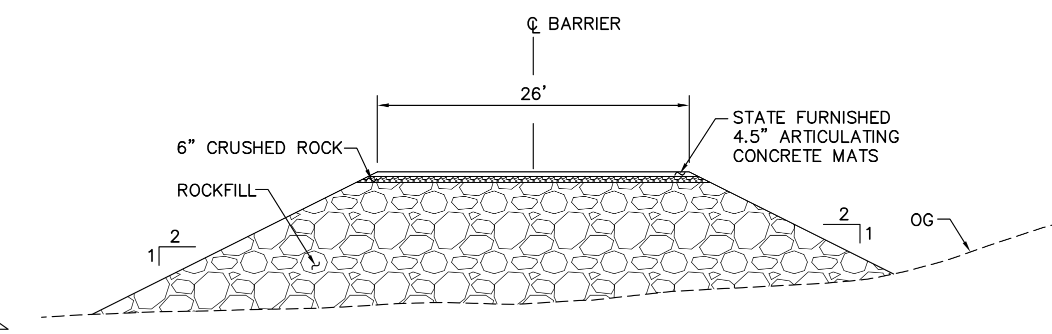


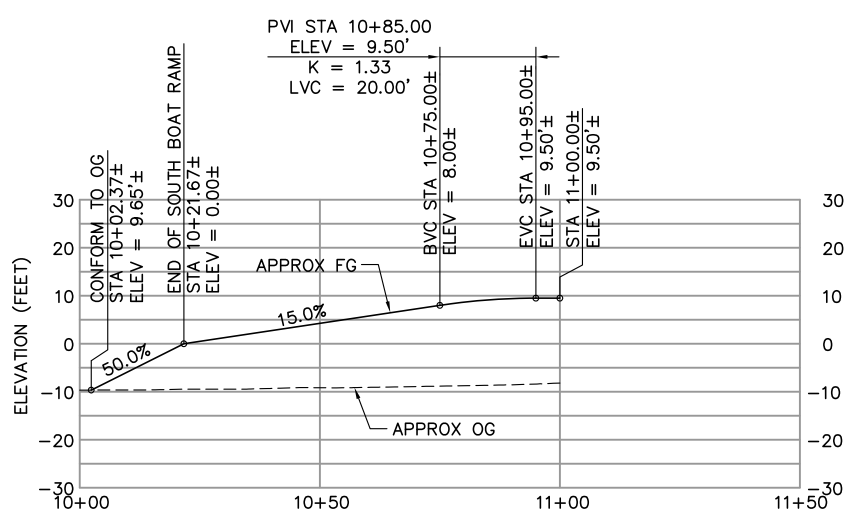
PLAN
SCALE: 1"= 20'



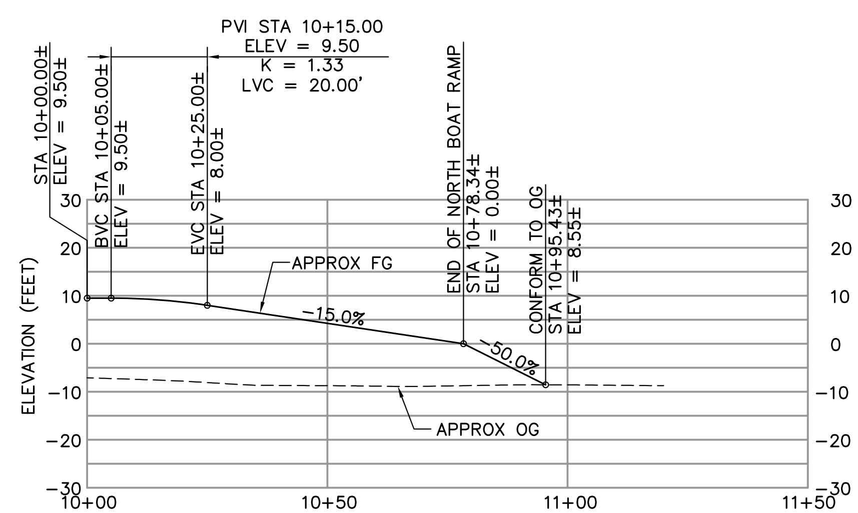
A SECTION
SCALE: 1"=8'



B SECTION
SCALE: 1"=8'



SOUTH BOAT RAMP PROFILE
SCALE: 1"= 20'H
1"= 20'V



NORTH BOAT RAMP PROFILE
SCALE: 1"= 20'H
1"= 20'V

NOTES:

1. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
2. OTHER FEATURES NOT SHOWN FOR CLARITY.

8' 0' 8' 16'
SCALE: 1"=8'

20' 0' 20' 40'
SCALE: 1"=20'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

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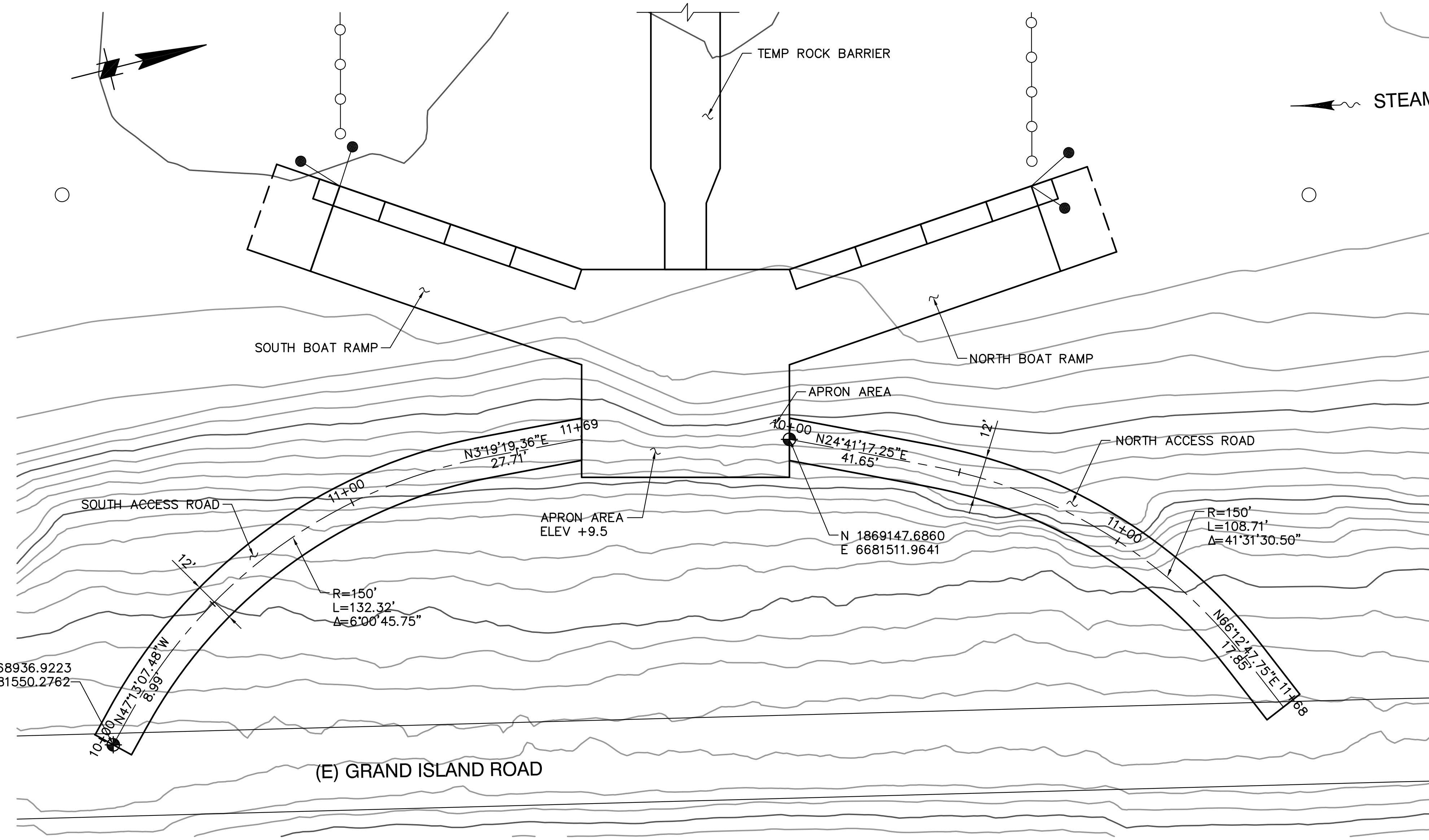
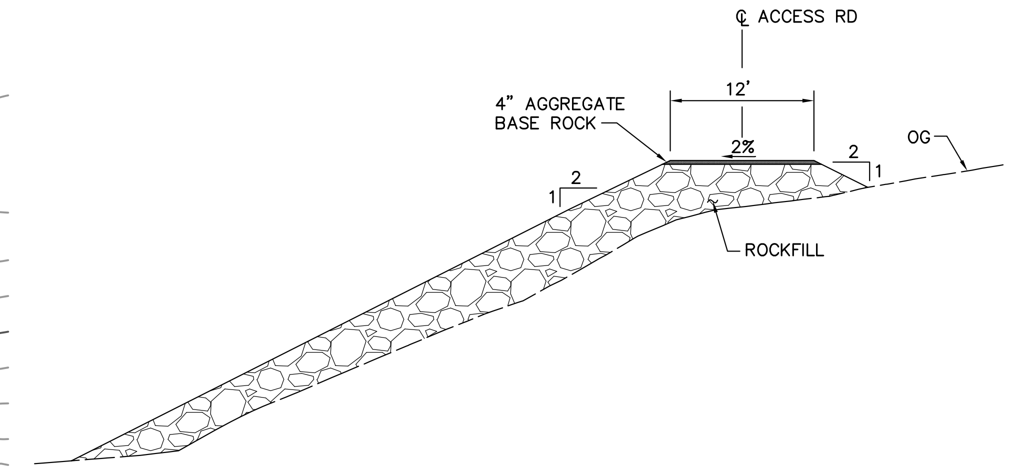
STEAMBOAT SLOUGH
BOAT RAMP
PLAN AND PROFILE

DATE 03/2014
SHEET 7 OF 15
C3



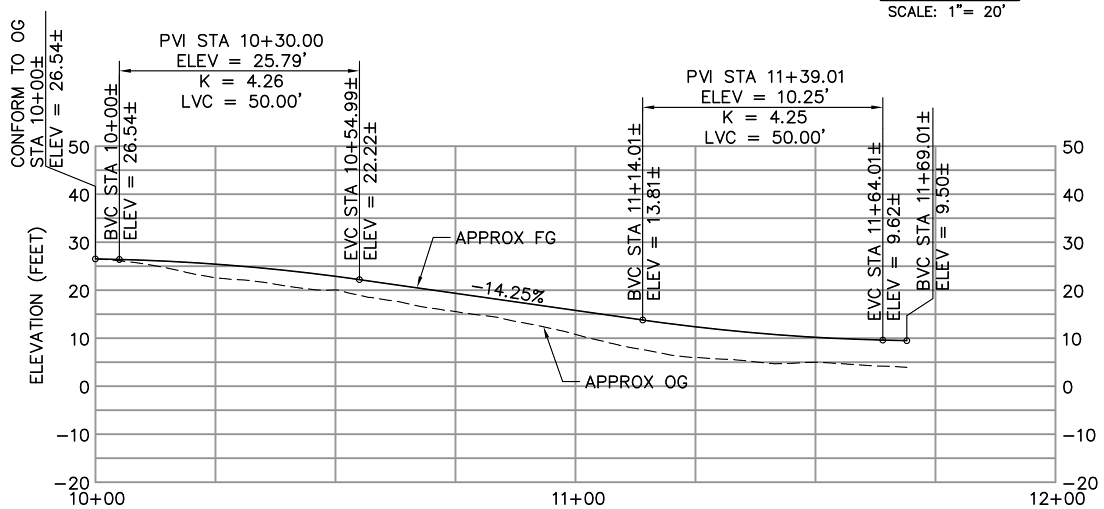
PLAN

SCALE: 1"= 20'



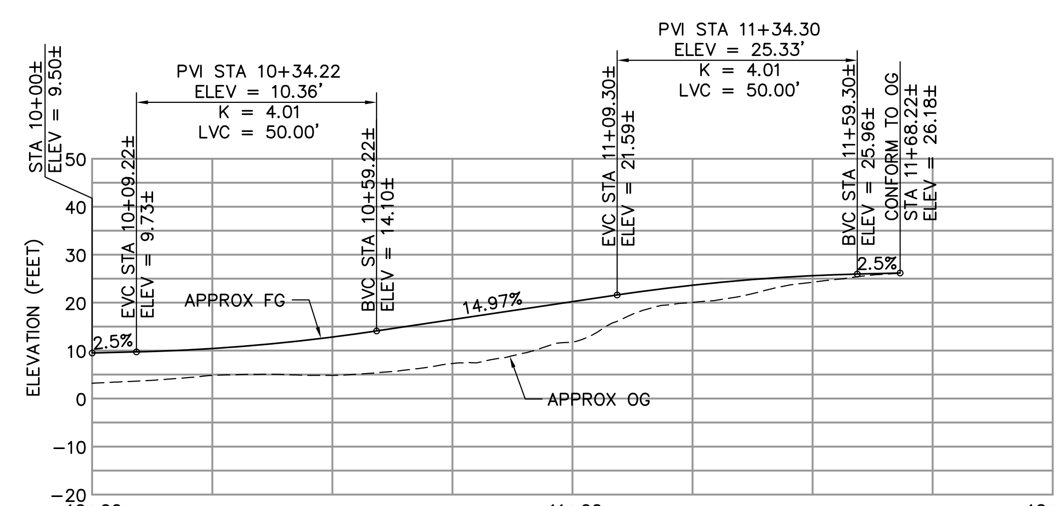
TYPICAL SECTION–ACCESS ROAD

SCALE: 1"= 8'



SOUTH ACCESS ROAD PROFILE

SCALE: 1"= 20'H
1"= 20'V



NORTH ACCESS ROAD PROFILE

SCALE: 1"= 20'H
1"= 20'V

NOTES:

OTHER FEATURES NOT SHOWN FOR CLARITY.

20' 0' 20' 40'

SCALE: 1"=20'

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TEMPORARY ROCK BARRIERS

STEAMBOAT SLOUGH
ACCESS ROADS
PLAN AND PROFILE

DATE 03/2014

SHEET 8 OF 15

C4

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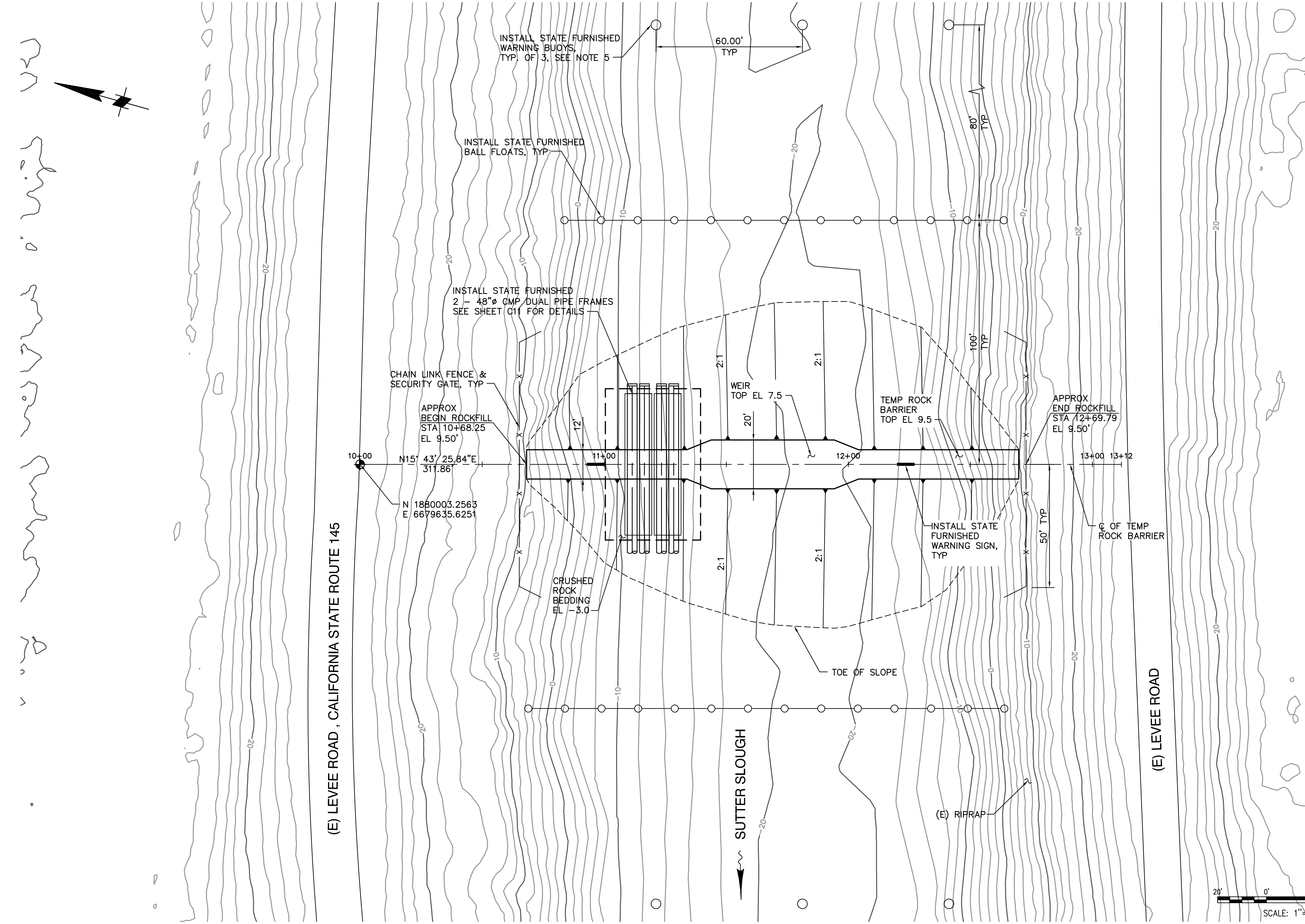

NOTES:

1. COORDINATES ARE IN FEET AND REFER TO STATE PLANE ZONE 2, NAD 83.
2. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
3. CONTRACTOR SHALL INSTALL DEPARTMENT FURNISHED STRUCTURES TO INCLUDE: CMP CULVERTS, FRAMES, SLUICE GATES, ACCESS PLATFORMS, SIGNS AND OTHER ACCESSORIES AS DIRECTED.
4. OTHER FEATURES NOT SHOWN FOR CLARITY.
5. WHITE CYLINDRICAL WARNING BUOY WITH LIGHT ON TOP AND INTERNATIONAL ORANGE DIAMOND SYMBOL. WHITE LIGHT SHALL FLASH ONCE EVERY 4 SECONDS.
6. SEE SHEET C6 FOR TYPICAL SECTIONS OF ROCK BARRIER AND WEIR SECTIONS.

20' 0' 20' 40'
SCALE: 1"=20'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

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SUTTER SLOUGH SITE PLAN

DATE 03/2014
SHEET 9 OF 15
C5

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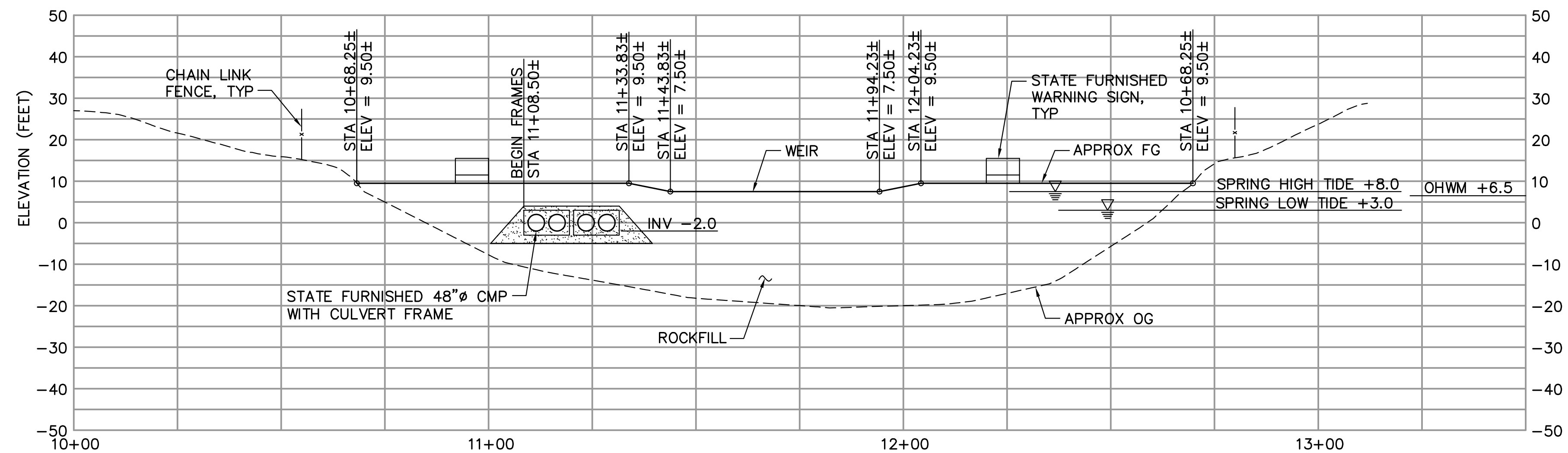
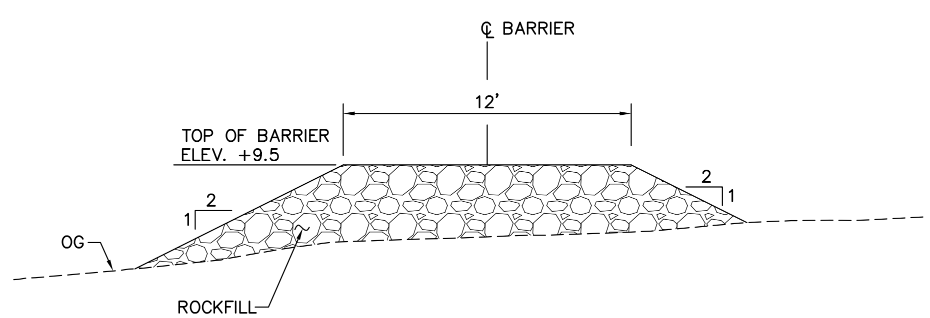


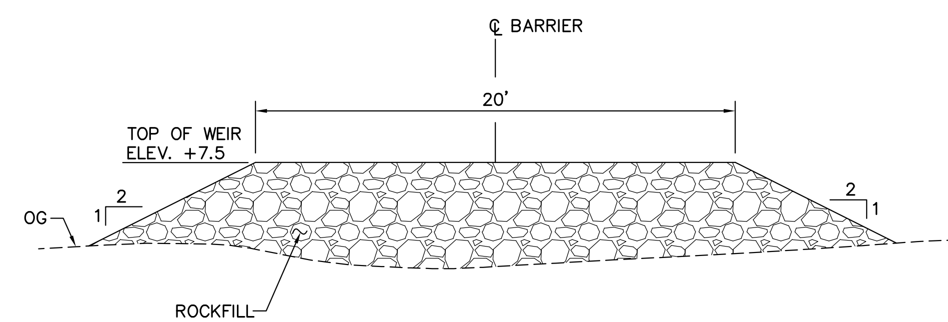
PROFILE

SCALE: 1"= 20'



TYPICAL SECTION–ROCK BARRIER

SCALE: 1"= 4'



TYPICAL SECTION–WEIR

SCALE: 1"= 4'

NOTES:

1. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
2. OTHER FEATURES NOT SHOWN FOR CLARITY.

4' 0' 4' 8'
SCALE: 1"=4'

20' 0' 20' 40'
SCALE: 1"=20'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

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2014 DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

SUTTER SLOUGH TEMPORARY ROCK BARRIER PROFILE AND SECTIONS

DATE 03/2014

SHEET 10 OF 15

C6

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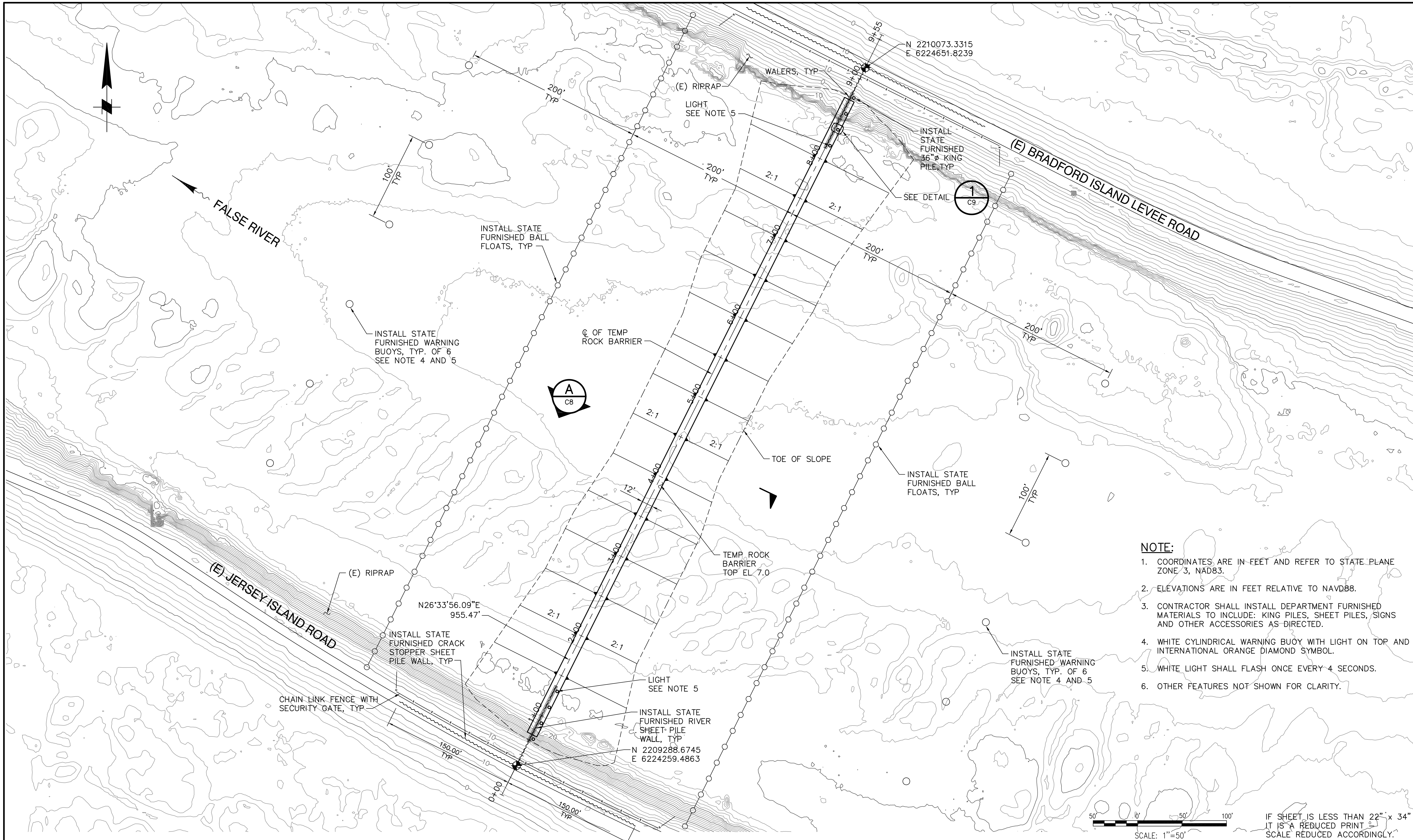

NOTE:

1. COORDINATES ARE IN FEET AND REFER TO STATE PLANE ZONE 3, NAD83.
2. ELEVATIONS ARE IN FEET RELATIVE TO NAVD88.
3. CONTRACTOR SHALL INSTALL DEPARTMENT FURNISHED MATERIALS TO INCLUDE: KING PILES, SHEET PILES, SIGNS AND OTHER ACCESSORIES AS DIRECTED.
4. WHITE CYLINDRICAL WARNING BUOY WITH LIGHT ON TOP AND INTERNATIONAL ORANGE DIAMOND SYMBOL.
5. WHITE LIGHT SHALL FLASH ONCE EVERY 4 SECONDS.
6. OTHER FEATURES NOT SHOWN FOR CLARITY.

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

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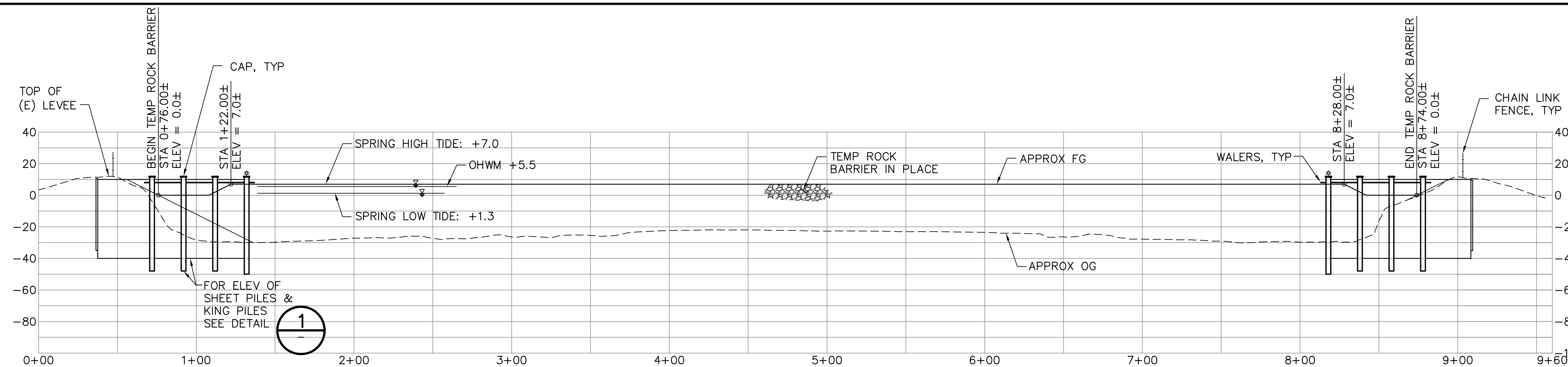
2014 DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS

FALSE RIVER
SITE PLAN

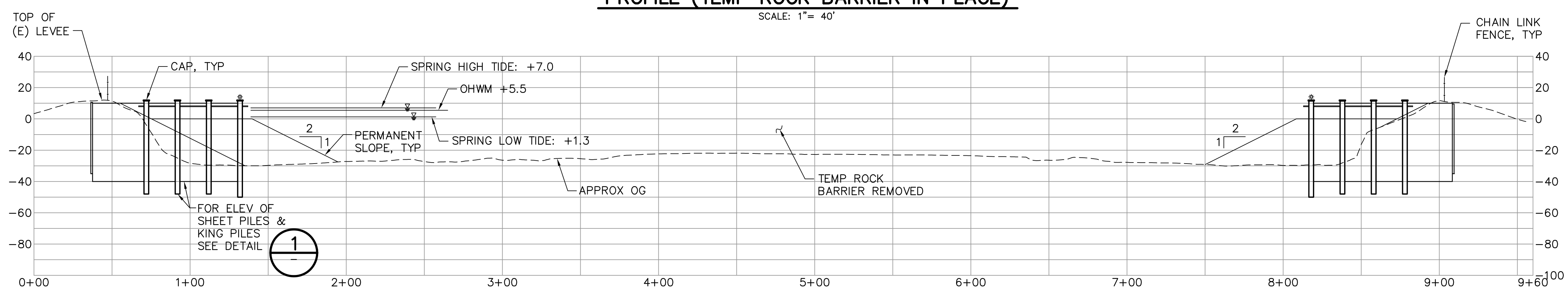
DATE 03/2014
SHEET 11 OF 15
C7

P:\8204 MWD-BAY DELTA SERVICES\6.CADD\8204-C7.DWG 3/14/2014 4:11 PM



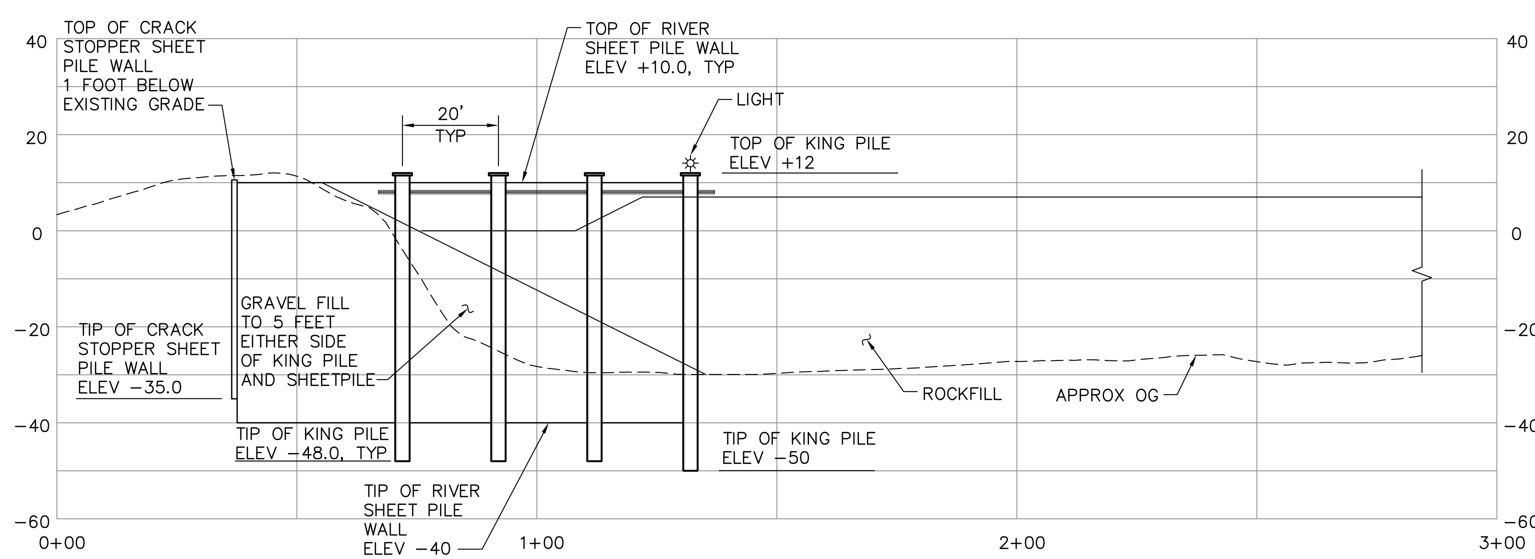
PROFILE (TEMP ROCK BARRIER IN PLACE)

SCALE: 1"= 40'



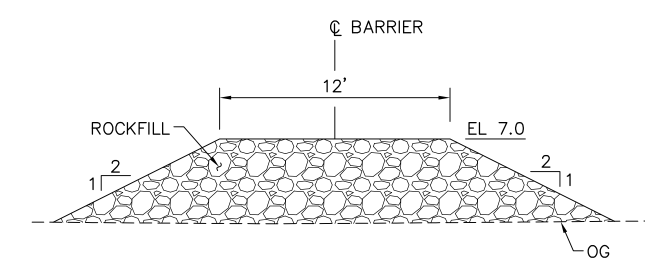
PROFILE (TEMP ROCK BARRIER REMOVAL)

SCALE: 1"= 40'



1 DETAIL

SCALE: 1"=20'



A SECTION

C7

SCALE: 1"=5'

NOTES:

1. ELEVATIONS ARE IN FEET RELATIVE TO NAVD 88.
2. OTHER FEATURES NOT SHOWN FOR CLARITY.

40' 0' 40' 80'

SCALE: 1"=40'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

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2014 DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

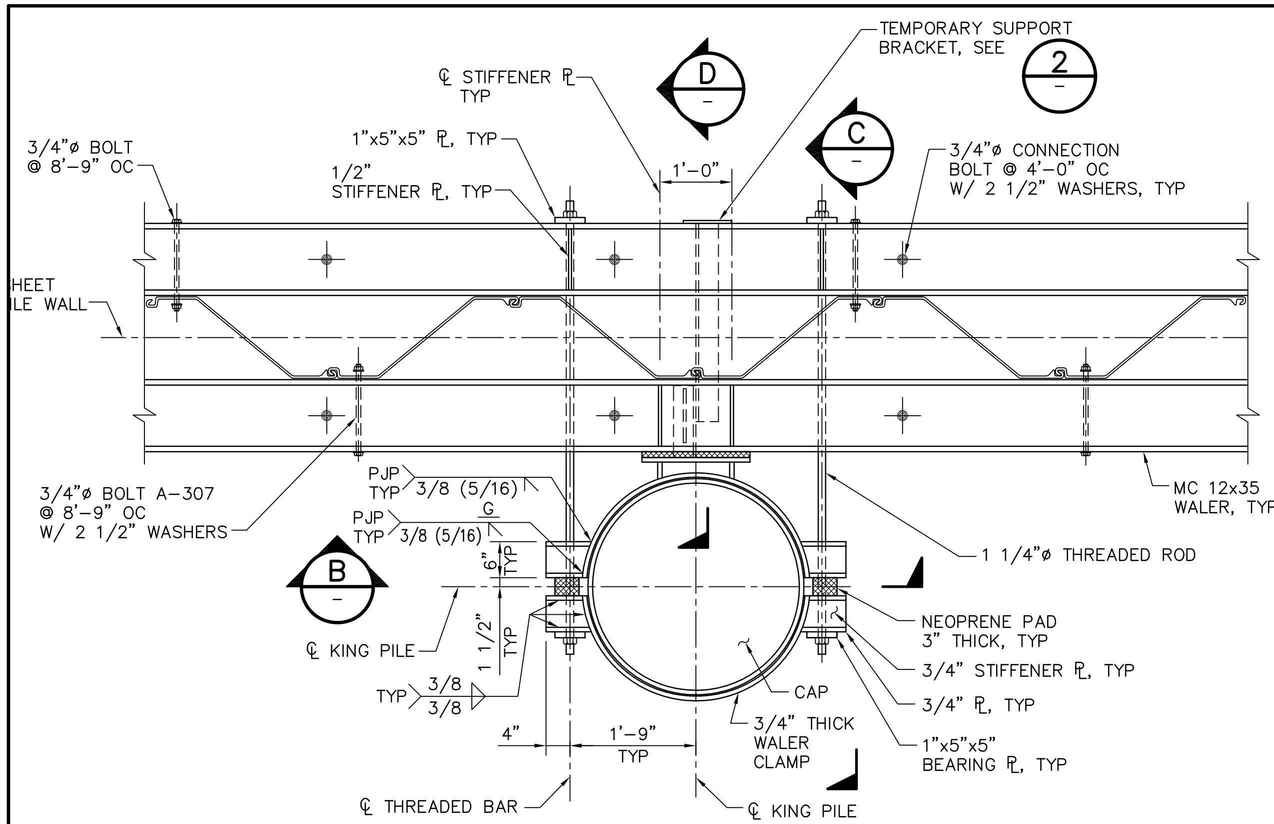
FALSE RIVER
TEMPORARY ROCK BARRIER
PROFILE, SECTION AND DETAIL

DATE 03/2014

SHEET 12 OF 15

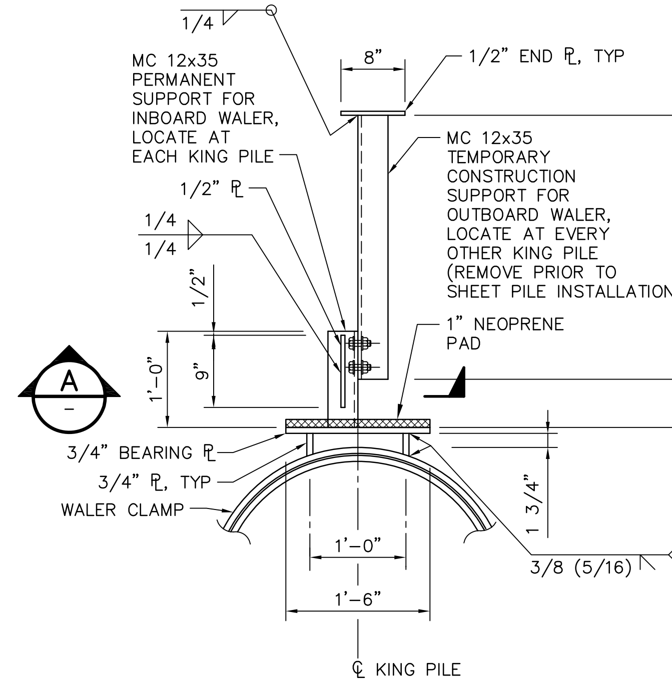
C8

P:\8204 MWD-BAY DELTA SERVICES\6.CADD\8204-C8.DWG 3/14/2014 4:09 PM



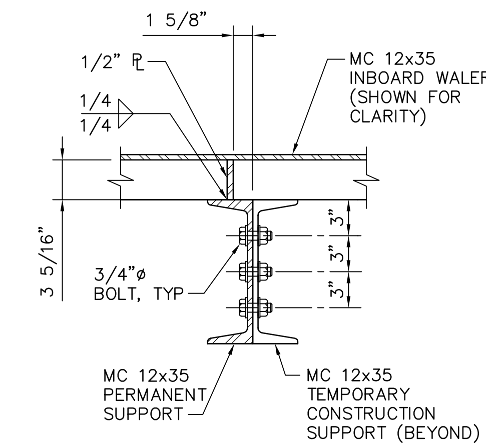
PLAN

1 DETAIL
C35
C5, C6
SCALE: 3/4" = 1'-0"

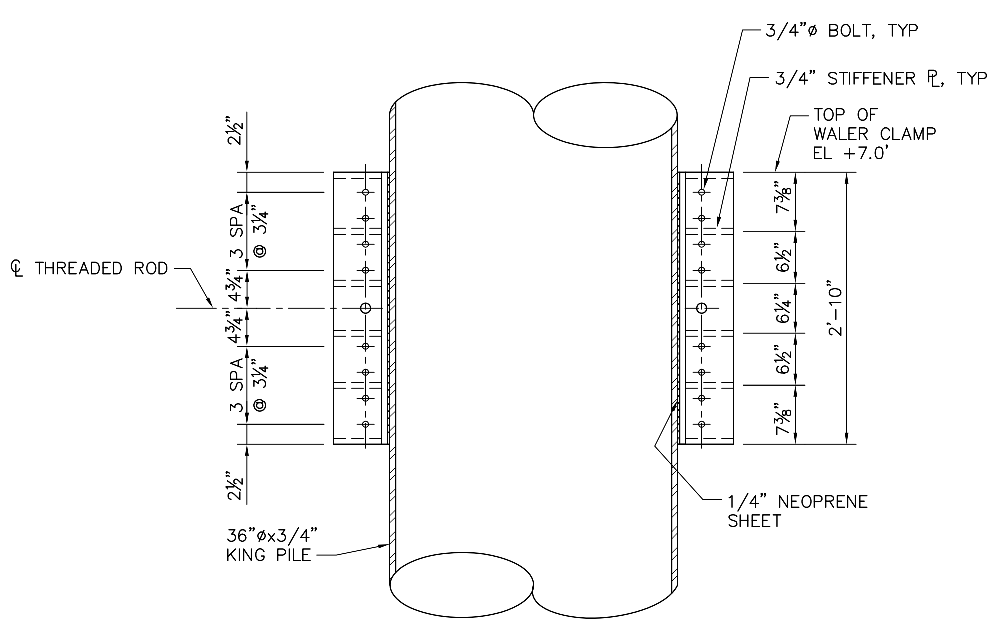


PLAN

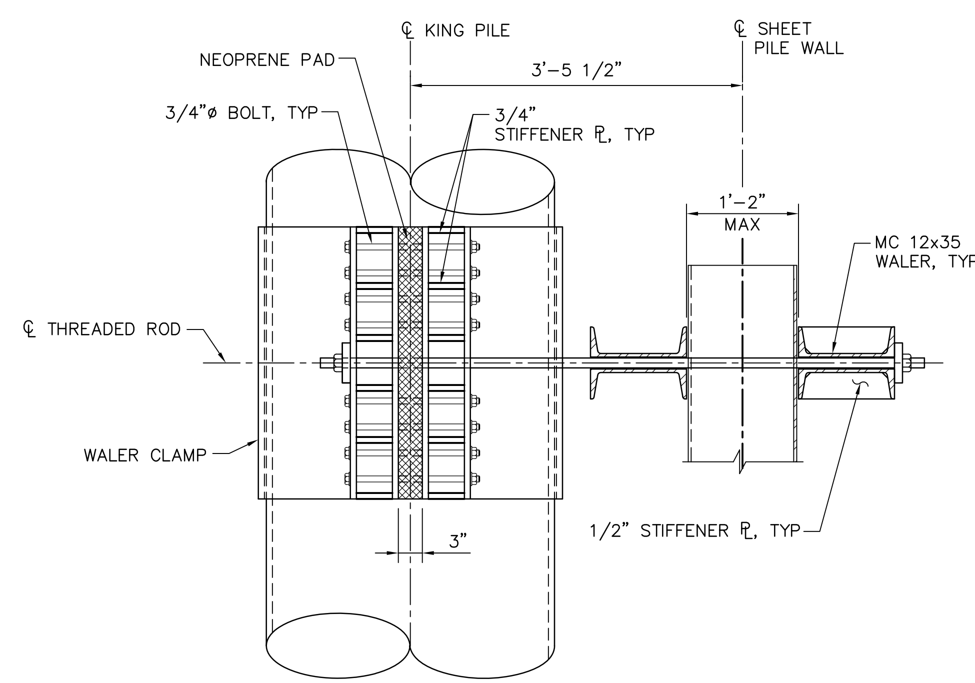
2 DETAIL
SCALE: 1" = 1'-0"



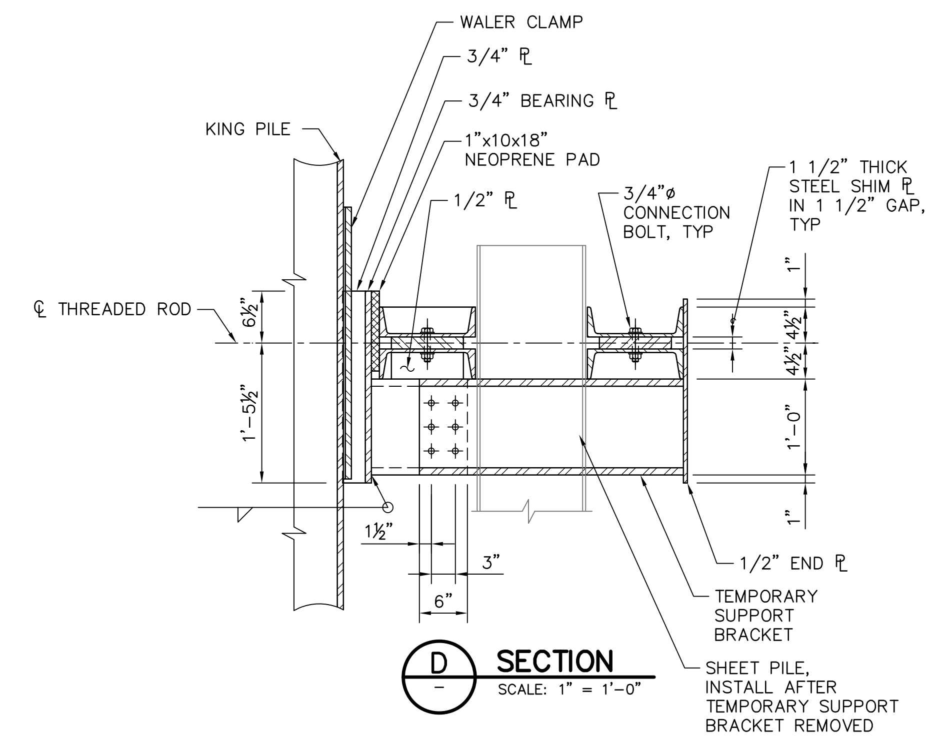
A SECTION
SCALE: 1 1/2" = 1'-0"



B SECTION
SCALE: 1" = 1'-0"



C SECTION
SCALE: 1" = 1'-0"



D SECTION
SCALE: 1" = 1'-0"

SCALE: 1"=1'-0"

SCALE: 3/4"=1'-0"

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

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REVISION	DESCRIPTION	BY	DATE

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

Moffatt & Nichol
2185 N. California Blvd., Suite 500
Walnut Creek, California 94596
(925) 944-5411

DSGN | DR | CHK
JOB NO. 8204 | SUBMITTED BY

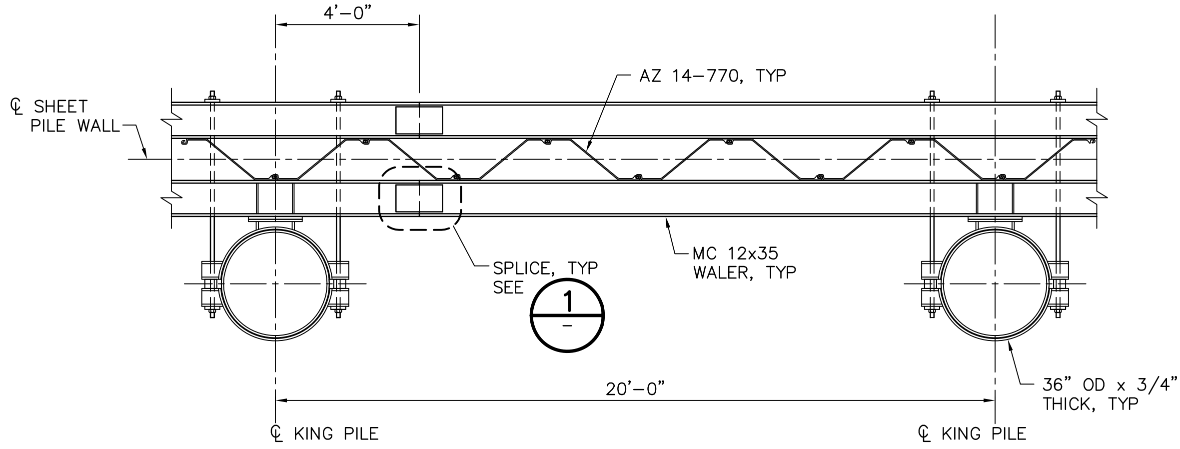
2014 DROUGHT EMERGENCY
TEMPORARY ROCK BARRIERS

SHEET PILE WALL DETAILS
SHEET 1

DATE 03/2014

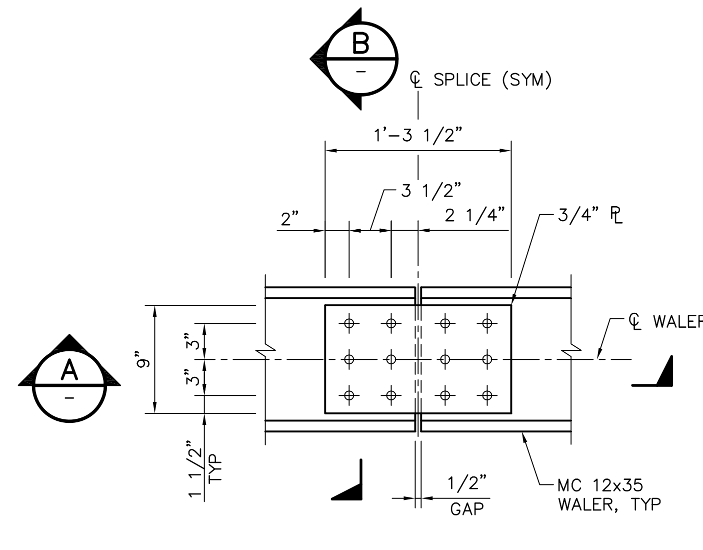
SHEET 13 OF 15

C9



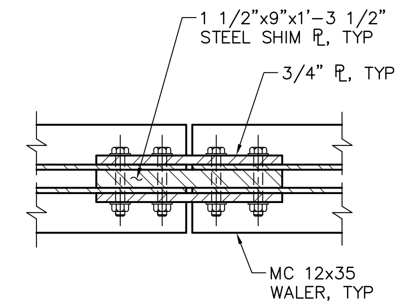
PLAN

TYPICAL WALER SPLICE DETAIL (SEE NOTE 1)
SCALE: 3/8"= 1'-0"

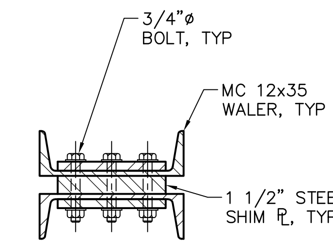


PLAN

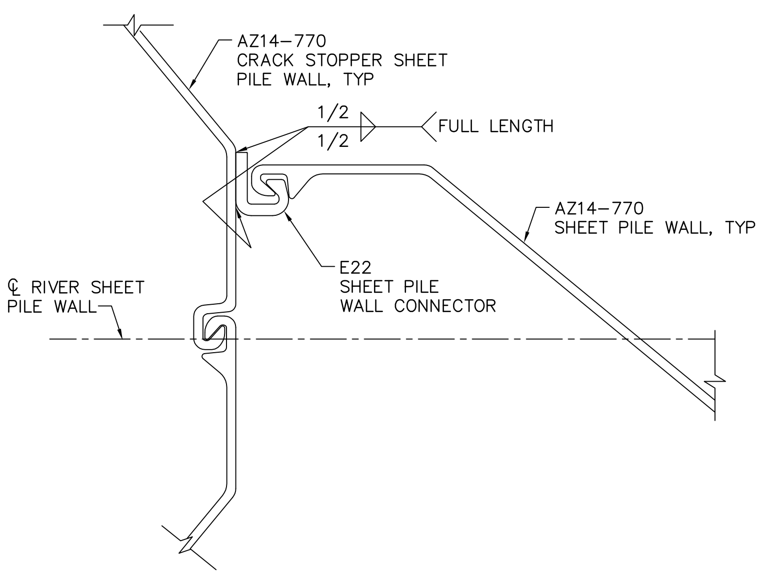
1 DETAIL
SCALE: 1 1/2" = 1'-0"



A SECTION
SCALE: 1 1/2" = 1'-0"



B SECTION
SCALE: 1 1/2" = 1'-0"



2 DETAIL (C7)
SCALE: 3" = 1'-0"

NOTES:

1. LOCATE WALER SPLICES AS REQUIRED.

2'-0" 0'-0" 1'-0" 2'-0"
SCALE: 3/4"=1'-0"

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

Moffatt & Nichol
2185 N. California Blvd., Suite 500
Walnut Creek, California 94596
(925) 944-5411

DSGN | DR | CHK
JOB NO. 8204 | SUBMITTED BY

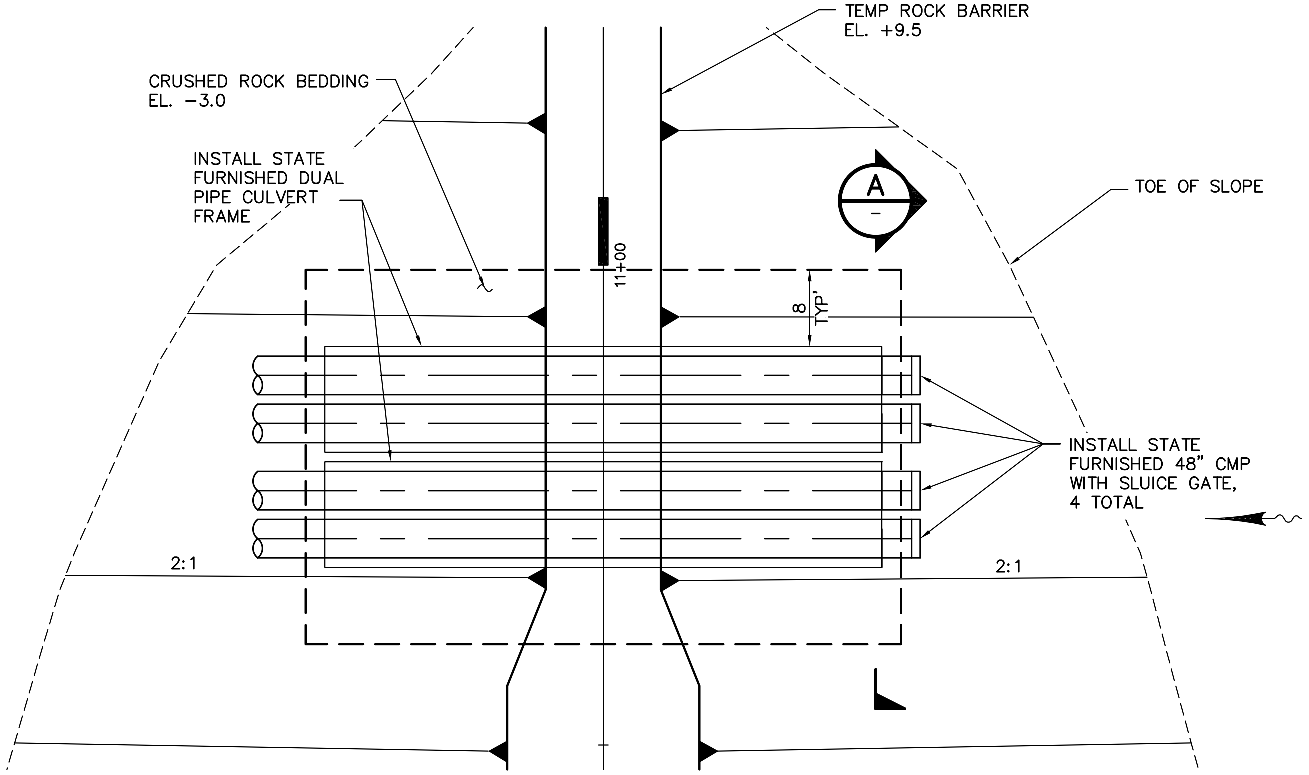
2014 DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

DATE 03/2014

SHEET 14 OF 15

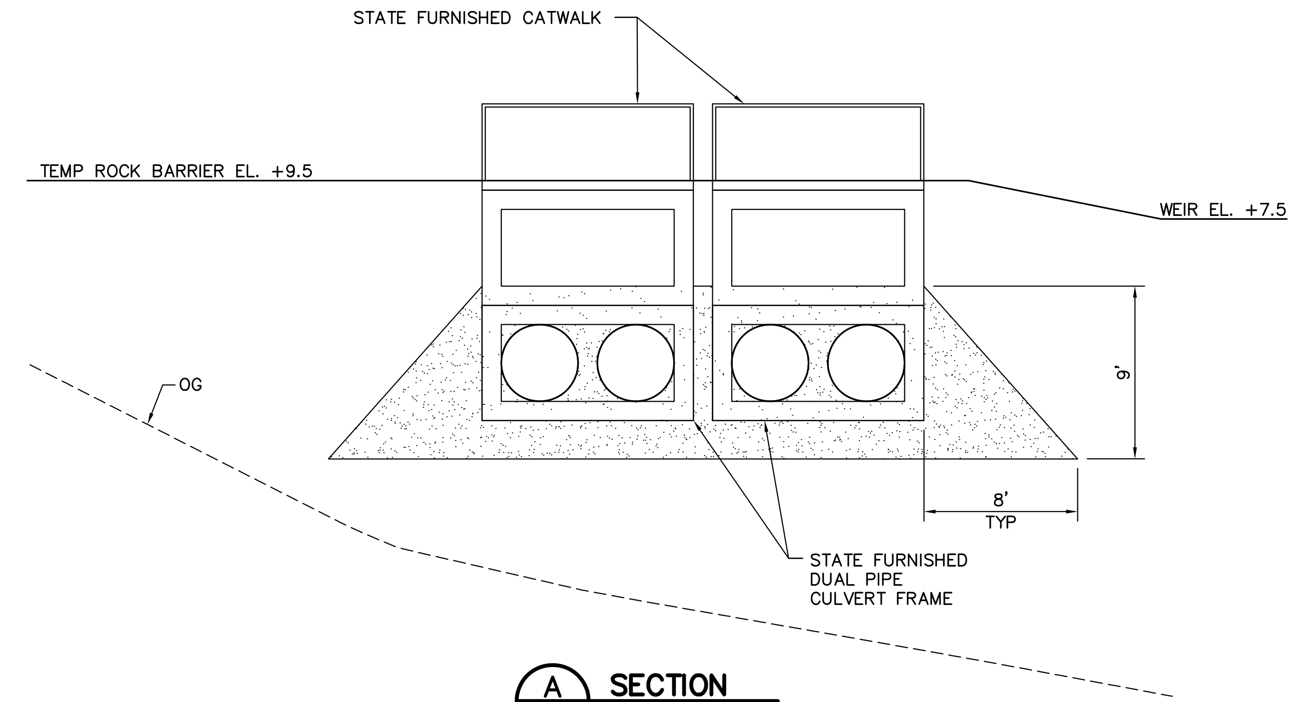
SHEET PILE WALL DETAILS SHEET 2

C10



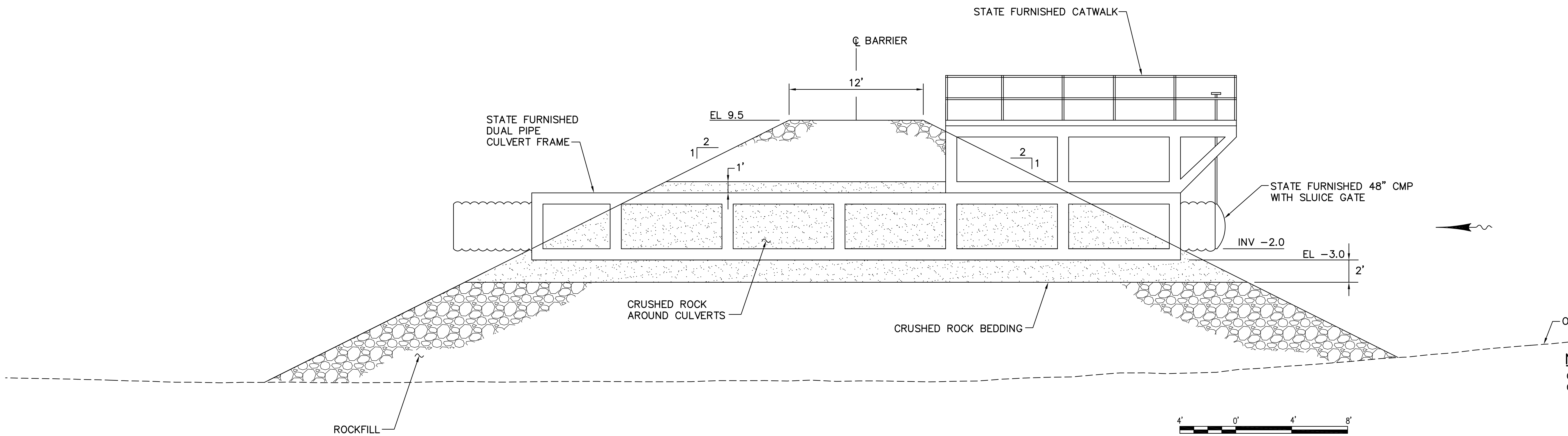
PLAN

SCALE: 1"= 10'



A SECTION

SCALE: 1"=4'



TYPICAL SECTION – 48" CMP DUAL PIPE FRAMES

SCALE: 1"= 5'

NOTES:

OTHER FEATURES NOT SHOWN FOR CLARITY.

SCALE: 1"=4'

SCALE: 1"=5'

SCALE: 1"=10'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENGINEERING
STATE WATER FACILITIES

Moffatt & Nichol
2185 N. California Blvd., Suite 500
Walnut Creek, California 94596
(925) 944-5411

DSGN | DR | CHK
JOB NO. 8204 | SUBMITTED BY

2014 DROUGHT EMERGENCY TEMPORARY ROCK BARRIERS

CULVERT TYPICAL SECTION

DATE 03/2014

SHEET 15 OF 15

C11

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ATTACHMENT E

Copy of Permit Applications

State Water Resources Control Board

CLEAN WATER ACT §401 WATER QUALITY CERTIFICATION APPLICATION FORM

(Use only for multi-regional projects, otherwise use the appropriate Regional Board application form)

1. APPLICANT/AGENT INFORMATION

a) Applicant: Paul A. Marshall	b) Agent[1]: Jacob McQuirk
Address: California Dept. of Water Resources	Address: California Dept. of Water Resources
1416 9th Street, Room 215-37	1416 9th Street, Room 215-23
Sacramento, CA 95814	Sacramento, CA 95814
Phone No. 916-653-1099	Phone No. 916-653-9883
Fax No. 916-653-6077	Fax No. 916-653-6077
E-mail Address: Paul.Marshall@water.ca.gov	E-mail Address: Jacob.McQuirk@water.ca.gov
Have you previously contacted the Regional Board staff regarding this project? If 'yes' provide information on date, person, and brief summary of subject matter. No, only the SWRCB has been contacted about this Project.	

STATEMENT OF AUTHORIZATION

I hereby authorize Jacob McQuirk to act in my behalf as my agent in the processing of this application, and to furnish upon request, supplemental information in support of this permit application.

____________________________ Applicant's Signature

________________________ Date

[1]Complete only if applicable

2. PROJECT DESCRIPTION

a) Project Title: Emergency Drought Barriers Project
b) Project Purpose: See Supplemental Information, Attachment A for the Project purpose.
c) Project Activities: See Supplemental Information, Attachment A for a complete description of Project activities.
d) Proposed Schedule (start-up, duration, and completion dates): See Supplemental Information, Attachment A, Project Description, for the proposed schedule.

3. FEDERAL LICENSES/PERMITS

a) Federal Agency(ies)/File Number(s):

U.S. Army Corps of Engineers X Other U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and U.S. Coast Guard

File No.(s) (if known) T.B.D.

b) Permit Type(s) (please provide permit number(s) if known):

Nationwide Permit No.(s)____________________ Regional General Permit No.(s) ___________

Individual Permit T.B.D.

c) Does the project require any Federal Application(s), Notification(s) or Correspondence?

Yes X (attach copy[ies]) No _____ (attach detailed explanation)

d) Provide copies of the license/permit/application. See Supplemental Information, Attachment E for copies of the permit applications.

4. OTHER LICENSES/PERMITS/AGREEMENTS

a) Please list all other required, including local regulatory approvals (submit final or draft copy if available). Include information on any Dewatering, NPDES, and Storm Water permits.

Agency	License/Permit/Agreement	Permit No.	Approval Date
USFWS	ESA BO	T.B.D.	T.B.D.
NMFS	ESA BO	T.B.D.	T.B.D.
SHPO	MOU	T.B.D.	T.B.D.
USACE	RHA Sections 10 and 408	T.B.D.	T.B.D.
USCG	RHA Section 9	T.B.D.	T.B.D.
CVFPB	Encroachment Permit	T.B.D.	T.B.D.
CDFW	CESA Section 2081 ITP and Section 1602 LSAA	T.B.D.	T.B.D.
RWQCB	Construction General Permit NPDES	T.B.D.	T.B.D.
SLC	MOU	T.B.D.	T.B.D.

b) Does the project require a Federal Energy Regulatory Commission (FERC) license or amendment to a FERC license? No

5. CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

Indicate CEQA Document (submit final or draft copy if available*):

Type of CEQA Document	Date of filing of Notice of Exemption/ Preparation and Name of Lead Agency
Statutory Exemption/Class Title	T.B.D. by DWR
Categorical Exemption/Class Title	T.B.D. by DWR
Negative Declaration	
Mitigated Negative Declaration	
Environmental Impact Report	

Note: Ample time must be provided to the certifying agency to properly review a final copy of valid CEQA documentation before certification can occur.

6. APPLICATION FEE

Provide an initial deposit of $1,097.00 for the application. Please write a check made out to the State Water Resources Control Board.
Is a check enclosed? Yes Check Number T.B.D. Amount $21,294.00

7. PROJECT SITE DESCRIPTION – GENERAL (Include areas outside of US waters)

a) Project Location (attach map of suitable quality and detail):

City or Area: Unincorporated Counties: Sutter Slough in Yolo County; Steamboat Slough in Sacramento County; and False River in Contra Costa County.

Longitude/Latitude: Sutter Slough at approximately 38.323069° and -121.588910°; Steamboat Slough at approximately 38.293707° and -121.582812°; and False River at approximately 38.057057° and -121.670432°

b) Total Project Size: The Project area, not including staging, is approximately 4.07 acres.

c) Site description of the entire project area (including areas outside of jurisdictional water of the US): See both the aquatic and terrestrial biological assessments (Supplemental Information, Attachment C) for an environmental setting.

8. WATER BODY IMPACT

a) **Water Body Name(s)[2]**:
Clearly indicate on a published map of suitable detail, quality, and scale (1:24K) to allow the certifying agency to easily identify the area(s) and water body(ies) receiving any discharge. See Supplemental Information, Attachment B for maps showing impacts to waters of the U.S. and state.

b) **Fill and Excavation:** Indicate in ACRES and/or LINEAR FEET the proposed waters to be impacted, and identify the impacts(s) as permanent and/or temporary for each water body type listed below:

Water Body Type	Permanent Impact		Temporary Impact	
	Acres	Linear Feet	Acres	Linear Feet
Wetland[3]				
Streambed	0.75	20	3.14	583
Lake/Reservoir				
Ocean/Estuary/Bay				
Riparian				
Non-Federal Waters				

Provide the name, title, and affiliation of person that carried out wetland delineation. AECOM biologists (Sarah Bennett and Tracy Walker) completed a wetland delineation and field assessment which included a field verification of the ordinary high-water mark at Steamboat Slough, Sutter Slough, and False River. A separate report was not prepared; however delineations are shown in the impact maps (Supplemental Information, Attachment B).

c) Dredging: Total volume (cubic yards) of dredged material proposed for project. DWR does not propose to dredge into waters of the U.S. and state.

d) Provide information on the Q_2, Q_{10}, Q_{100} for pre- and post-project implementation. For both pre- and post-project implementation, the approximate range of instantaneous flow ranges for each barrier location is provided below:
- Sutter Slough: 2,700 to 4,200 cfs;
- Steamboat Slough: 4,000 to 4,200 cfs; and
- False River: 55,000 cfs to 60,000 cfs.

e) Indicate type(s) of material proposed to be discharged in waters of the United States: DWR proposes to fill approximately 116,167 cubic yards of rock rip-rap into waters of the U.S. and state.

[2] Both US Army Corps of Engineer's jurisdictional- and non-jurisdictional water bodies.
[3] Per US Army Corps of Engineer's wetland delineation protocol.

9. COMPENSATORY MITIGATION (Please complete attached Mitigation Checklist)

a) Is compensatory mitigation proposed? DWR proposes to restore the affected areas to meet local land use and resource agency requirements as soon as they are no longer needed. DWR would restore the channel beds to grade with clean sand.

b) Indicate in ACRES and LINEAR FEET (where appropriate) the total quantity of **waters of the United States** proposed to be Created, Restored, Enhanced, or Preserved.

Water Body Type	Created	Restored	Enhanced	Preserved
Wetland				
Streambed		3.14 acres		
Lake/Reservoir				
Ocean/Estuary/Bay				
Riparian				
Non-Federal Waters				

c) If contributing to a Mitigation Bank provide the following: To Be Determined

Mitigation Bank Name:
Name of Mitigation Bank Operator:
Office Address of Operator/Phone Number:
Mitigation Bank Location (Latitude/Longitude, County, and City):
Mitigation Bank Water Body Type(s):
Mitigation Area (acres or linear feet) and cost (dollar):

d) Provide/attach a map with suitable detail, quality, and scale (1:24K) that will easily provide information as to the location(s) and water body(ies) of the mitigation area.

10. THREATENED/ENDANGERED SPECIES

a) Does the project require coordination with the US Fish and Wildlife Service or National Marine Fisheries Service under the Federal Endangered Species Act?

Yes X (provide copies of Biological Report) No ____ (provide basis of determination)

b) Does the project require coordination with the State of California Department of Fish and Wildlife under the California Endangered Species Act?

Yes X (provide copies of Biological Report) No ____ (provide basis of determination)

11. OTHER ACTIONS/BEST MANAGEMENT PRACTICES (BMPs)

Briefly describe other actions/BMPs to be implemented to Avoid and/or Minimize impacts to waters of the United States, including preservation of habitats, erosion control measures, project scheduling, flow diversions, etc. See both the aquatic and terrestrial biological assessments (Supplemental Information, Attachment C) for a complete list of other conservation measures/BMPs.

12. PAST/FUTURE PROPOSALS BY THE APPLICANT

Briefly list/describe any projects carried out in the last 5 years or planned for implementation in the next 5 years that are in any way related to the proposed activity or may impact the same receiving body of water. Include estimated adverse impacts. DWR has neither carried out projects in the last five years nor does DWR plan on implementing additional activities on Steamboat and Sutter sloughs and False River to mitigate the effects of drought as directed in the Governor's proclamation.

______________________________ _______________

Applicant's Signature (or Agent) Date

For further information please email:
http://www.swrcb.ca.gov/water_issues/programs/cwa401/docs/staffdirectory.pdf

U.S. ARMY CORPS OF ENGINEERS **APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT** 33 CFR 325. The proponent agency is CECW-CO-R.	OMB APPROVAL NO. 0710-0003 EXPIRES: 28 FEBRUARY 2013

Public reporting for this collection of information is estimated to average 11 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters, Executive Services and Communications Directorate, Information Management Division and to the Office of Management and Budget, Paperwork Reduction Project (0710-0003). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. Please DO NOT RETURN your form to either of those addresses. Completed applications must be submitted to the District Engineer having jurisdiction over the location of the proposed activity.

PRIVACY ACT STATEMENT

Authorities: Rivers and Harbors Act, Section 10, 33 USC 403; Clean Water Act, Section 404, 33 USC 1344; Marine Protection, Research, and Sanctuaries Act, Section 103, 33 USC 1413; Regulatory Programs of the Corps of Engineers; Final Rule 33 CFR 320-332. Principal Purpose: Information provided on this form will be used in evaluating the application for a permit. Routine Uses: This information may be shared with the Department of Justice and other federal, state, and local government agencies, and the public and may be made available as part of a public notice as required by Federal law. Submission of requested information is voluntary, however, if information is not provided the permit application cannot be evaluated nor can a permit be issued. One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application (see sample drawings and/or instructions) and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

(ITEMS 1 THRU 4 TO BE FILLED BY THE CORPS)

1. APPLICATION NO.	2. FIELD OFFICE CODE	3. DATE RECEIVED	4. DATE APPLICATION COMPLETE

(ITEMS BELOW TO BE FILLED BY APPLICANT)

5. APPLICANT'S NAME	8. AUTHORIZED AGENT'S NAME AND TITLE (agent is not required)
First - Paul Middle - A Last - Marshall	First - Jacob Middle - Last - McQuirk
Company - California Department of Water Resources	Company - California Department of Water Resources
E-mail Address - Paul.Marshall@water.ca.gov	E-mail Address - Jacob.McQuirk@water.ca.gov
6. APPLICANT'S ADDRESS:	9. AGENT'S ADDRESS:
Address- 1416 9th Street, Room 215-37	Address- 1416 9th Street, Room 215-23
City - Sacramento State - CA Zip - 95814 Country - USA	City - Sacramento State - CA Zip - 95814 Country - USA
7. APPLICANT'S PHONE NOs. w/AREA CODE	10. AGENTS PHONE NOs. w/AREA CODE
a. Residence N/A / b. Business 916-653-1099 / c. Fax 916-653-6077	a. Residence N/A / b. Business 916-653-9883 / c. Fax 916-653-6077

STATEMENT OF AUTHORIZATION

11. I hereby authorize, Jacob McQuirk to act in my behalf as my agent in the processing of this application and to furnish, upon request, supplemental information in support of this permit application.

SIGNATURE OF APPLICANT DATE

NAME, LOCATION, AND DESCRIPTION OF PROJECT OR ACTIVITY

12. PROJECT NAME OR TITLE (see instructions)

Emergency Drought Barriers Project

13. NAME OF WATERBODY, IF KNOWN (if applicable)	14. PROJECT STREET ADDRESS (if applicable)
Sutter Slough, Steamboat, and False River	Address Not Applicable
15. LOCATION OF PROJECT Latitude: °N See Attachment B Longitude: °W	City - State- Zip-

16. OTHER LOCATION DESCRIPTIONS, IF KNOWN (see instructions)

State Tax Parcel ID Not Applicable Municipality Unincorporated

Section - See Attachment B Township - See Attachment B Range - See Attachment B

17. DIRECTIONS TO THE SITE

To Sutter Slough from West Sacramento, take SR 84 south for approximately 17.2 miles. Turn left onto Courtland Road and head east for approximately 0.2 miles. Turn right onto Road 145 and head south for approximately 1.3 miles. To Steamboat Slough from Sutter Slough, take Road 145 north for approximately 1.3 miles. Turn right onto Courtland Road and head east for approximately 0.8 miles. Turn right onto South River Road and head south for approximately 2.2 miles. Turn right onto Sutter Island Road and head southwest for approximately 1 mile. To False River from Oakley, take Main Street southeast for approximately 1 mile. Turn left onto East Cypress Road and head east for approximately 2.1 miles. Turn left onto Jersey Island Road and head north for approximately 1.2 miles. Take a slight left to stay on Jersey Island Road and head northwest for approximately 1.7 miles. Turn right to stay on the road for approximately 4.4 miles.

18. Nature of Activity (Description of project, include all features)

See Supplemental Information, Attachment A for a complete description of Project activities.

19. Project Purpose (Describe the reason or purpose of the project, see instructions)

See Supplemental Information, Attachment A for the Project purpose.

USE BLOCKS 20-23 IF DREDGED AND/OR FILL MATERIAL IS TO BE DISCHARGED

20. Reason(s) for Discharge

See Supplemental Information, Attachment B for the reasons for discharge.

21. Type(s) of Material Being Discharged and the Amount of Each Type in Cubic Yards:

Type Amount in Cubic Yards	Type Amount in Cubic Yards	Type Amount in Cubic Yards
116,167 cy. of rock rip-rap		

22. Surface Area in Acres of Wetlands or Other Waters Filled (see instructions)

Acres 3.89 acres

or

Linear Feet 603 feet

23. Description of Avoidance, Minimization, and Compensation (see instructions)

See both the aquatic and terrestrial biological assessments (Supplemental Information, Attachment C) for avoidance and minimization measures. DWR proposes to restore the affected areas to meet local land use and resource agency requirements after barrier removal.

24. Is Any Portion of the Work Already Complete? ☐ Yes ☒ No IF YES, DESCRIBE THE COMPLETED WORK

25. Addresses of Adjoining Property Owners, Lessees, Etc., Whose Property Adjoins the Waterbody (if more than can be entered here, please attach a supplemental list).

a. Address- See Supplemental Information, Attachment B for addresses of adjoining property owners whose property adjoins the water.

City - State - Zip -

b. Address-

City - State - Zip -

c. Address-

City - State - Zip -

d. Address-

City - State - Zip -

e. Address-

City - State - Zip -

26. List of Other Certificates or Approvals/Denials received from other Federal, State, or Local Agencies for Work Described in This Application.

AGENCY	TYPE APPROVAL*	IDENTIFICATION NUMBER	DATE APPLIED	DATE APPROVED	DATE DENIED
See Supplemental					
Information, Attach-					
ment B for a list of					
approvals.					

* Would include but is not restricted to zoning, building, and flood plain permits

27. Application is hereby made for permit or permits to authorize the work described in this application. I certify that this information in this application is complete and accurate. I further certify that I possess the authority to undertake the work described herein or am acting as the duly authorized agent of the applicant.

SIGNATURE OF APPLICANT DATE SIGNATURE OF AGENT DATE

The Application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in block 11 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up any trick, scheme, or disguises a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statements or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.