PROGRAMMATIC BIOLOGICAL ASSESSMENT FOR THE 2013-2017 TEMPORARY BARRIERS PROJECT FOR NMFS-MANAGED SPECIES

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LIST OF ACRONYMS AND ABBREVIATIONS

2013–2017 TBP	2013–2017 Temporary Barriers Project
ag barriers	Agricultural Barriers
ASIP	Action-Specific Implementation Plan
BA	Biological Assessment
BMPs	best management practices
BIOP	Biological Opinion
CDEC	California Data Exchange Center
CESA	California Endangered Species Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHART	Critical Habitat Analytical Review Team
Corps	U.S. Army Corps of Engineers
CRR	Cohort Replacement Rates
CVP	Central Valley Project
CVTRT	Central Valley Technical Review Team
CWT	Coded Wire Tag
cy	cubic yards
DFG	California Department of Fish and Game
DIDSON	Dual-Frequency Identification Sonar
DO	dissolved oxygen
DPS	distinct population segment
DWR	California Department Water Resources
DWSC	Deep Water Shipping Channel
EFH	essential fish habitat
ESA	federal Endangered Species Act
Fish Facilities	Harvey O Banks Pumping Plant and John E. Skinner Fish Collection Facility
FMP	Fishery Management Plans
FRH	Feather River Hatchery
GCID	Glenn Colusa Irrigation District
GLC	Grant Line Canal near Tracy Boulevard Bridge
HOR	head of Old River at the divergence from the San Joaquin River
HU	Hydrologic Unit
Hz	hertz

IEP	Interagency Ecological Program
JPE	Juvenile Production Estimate
JPI	Juvenile Production Index
LED	light-emitting diode
LSNFH	Livingston Stone National Fish Hatchery
LWD	Large Woody Debris
MILs	Modulated Intense Lights
mm	millimeters
MR	Middle River near Victoria Canal
MRB	MR barrier
NAVD88	North American Vertical Datum of 1988
NMFS	National Marine Fisheries Service
NPB	non-physical barrier
NPS	non-point source
OCAP	Operations Criteria and Plan
ORT	Old River near Tracy
PAHs	poly aromatic hydrocarbons
PCEs	primary constituent elements
PFMC	Pacific Fishery Management Council
PS	Point Source
PVA	Population Viability Analysis
RBDD	Red Bluff Diversion Dam
RST	Rotary Screw Trap
RWQCB	Regional Water Quality Control Board
SDWA	South Delta Water Agency
SRA	Shaded Riverine Aquatic
SWP	State Water Project
TBP	South Delta Temporary Barriers Project
TL	Total Length
Trib	Tributary
UC	University of California
USFWS	U.S. Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Plan
yd^3	cubic yards

INTRODUCTION

The California Department Water Resources (DWR) initiated the South Delta Temporary Barriers Project (TBP) in 1991. The TBP involves the seasonal installation of three rock barriers in Middle River near Victoria Canal (MR), Old River near Tracy (ORT), and Grant Line Canal near Tracy Boulevard Bridge (GLC). These rock barriers are designed to act as flow control structures, “trapping” tidal waters behind them following a high tide. These barriers improve water levels and circulation for local south Delta farmers and are collectively referred to as Agricultural Barriers (ag barriers). A fourth barrier, installed at the head of Old River (HOR) at the divergence from the San Joaquin River, is designed to improve migration conditions for Central Valley fall-run Chinook salmon originating in the San Joaquin River watershed during adult and juvenile migrations, which occur annually in the fall and spring respectively. The fall HOR barrier also serves as a flow-control structure by keeping water in the San Joaquin River which improves downstream dissolved oxygen (DO) conditions. The spring barrier is intended to prevent downstream migrating salmon smolts (smolt) in the San Joaquin River from entering Old River. The HOR barrier is often referred to as a Fish Barrier. In 2009 and 2010, DWR installed and operated a non-physical barrier (NPB) at the HOR as an alternative to the spring HOR rock barrier. The NPB employs the use of underwater bubbles, light, and sound to act as a fish behavioral deterrent which is intended to exclude outmigrating smolts from entering the south Delta via Old River without having to physically block the flow of water into the channel with a rock structure. DWR retains the flexibility to install and operate the NPB at the HOR as an alternative to the spring HOR rock barrier.

The TBP was initiated with the intention that it would be a temporary program implemented only until permanent operable gates could be installed. However, the timing of implementation of permanent operable gates is uncertain and the TBP is proposed to continue until the permanent operable gates are implemented. Figures 1 and 2 are project vicinity and location maps.

This document is a Programmatic Biological Assessment (BA) and is intended to satisfy the Section 7 consultation requirements of the federal Endangered Species Act (ESA) of species managed by the National Marine Fisheries Service (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 fish species, their critical habitat, and EFH that may result from the construction of the TBP. All operations and hydrologic impacts have been taken into account under the Central Valley Project (CVP) and State Water Project (SWP) Operations Criteria and Plan (OCAP) Biological Opinion (BIOP) which addressed the effects of operations of the TBP.

THREATENED AND ENDANGERED SPECIES, CRITICAL HABITAT AND ESSENTIAL FISH HABITAT

The following species are addressed in this BA .

- Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*).
- Central Valley fall-/late fall–run Chinook salmon (*Oncorhynchus tshawytscha*).
- Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*).
- California Central Valley steelhead (*Oncorhynchus mykiss*).
- North American green sturgeon (*Acipenser medirostris*), southern distinct population segment (DPS).
- California Central Valley steelhead designated critical habitat.
- Southern DPS of North American green sturgeon designated critical habitat.
- Starry flounder *(Platichthys stellatus)* EFH.
- Northern anchovy *(Engraulis mordax)* EFH.
- Pacific salmon EFH.

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

TABLE 1: SPECIAL-STATUS FISH SPECIES ADDRESSED IN THIS BIOLOGICAL ASSESSMENT

Species	Status*
Central Valley spring-run Chinook salmon	FT, ST
Central Valley fall-/late fall–run Chinook salmon	FSC
Sacramento River winter-run Chinook salmon	FE, SE
California Central Valley steelhead	FT
North American green sturgeon (southern DPS)	FT

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.
FSC = federal species of concern; species for which existing information indicates it may warrant listing but for which substantial biological information to support a proposed rule is lacking.
SE = listed as endangered under the California Endangered Species Act.
ST = listed as threatened under the California Endangered Species Act.

CONSULTATION TO DATE

The regulatory permit history of the TBP begins in 1991 and includes many separate consultations, take authorizations, and permits from the U.S. Army Corps of Engineers (Corps), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Fish and Game (DFG), and the Regional Water Quality Control Board (RWQCB). DWR is pursuing two multi-year Section 404 U.S. Clean Water Act / Section 10 Rivers and Harbors Act permits from the Corps to cover the construction of the TBP through the end of 2017. The two projects of the TBP that will be subject to separate permit applications to the Corps are:

- TBP-Ag Barriers
- TBP-HOR Barrier

Below is the recent consultation history and environmental permits applicable to the TBP:

- In 2004, the USFWS issued a Programmatic Biological Opinion (BIOP) on the Issuance of Section 10 and 404 Permits for Projects with Relatively Small Effects on the Delta Smelt and its Critical Habitat within the Jurisdiction of the Sacramento Fish and Wildlife Office of the USFWS, CA (USFWS File# 1-1-04-F-0345). This non-expiring Programmatic BIOP is still valid and was used in 2009 and 2010 to cover the HOR NPB, which was authorized under the Corps' Nationwide Permit 4.
- In 2008, the USFWS issued the Central Valley Project (CVP) and State Water Project (SWP) Operations Criteria and Plan (OCAP) Biological Opinion (BIOP) which addressed the effects of operations (i.e., hydrodynamic effects) of the MR, ORT, GLC and HOR rock barriers on delta smelt *(Hypomesus transpacificus)* (USFWS File# 81420-2008-F-1481-5). This non-expiring BIOP is still valid and covers the TBP-Ag Barriers and HOR Rock Barriers.
- **In 2008, the NMFS issued a biological opinion for the construction of the TBP (NMFS # 2007/07586).**
- In 2009, the USFWS issued a biological opinion which addressed the effects of construction of the MR, ORT, GLC and HOR rock barriers on delta smelt and its designated critical habitat (USFWS File# 81420-2008-F-0522) (U.S. Fish and Wildlife Service 2008). This non-expiring BIOP is still valid and covers the TBP-Ag Barriers and HOR Rock Barriers.
- In 2009, the USFWS issued a biological opinion which addressed the effects of construction and operation of the 2009 HOR NPB on delta smelt that appended the project covered under the Corps Nationwide Permit 4 to the 2004 Programmatic BIOP for delta smelt (USFWS File# 1-1-04-F-0345).
- **In 2009, the NMFS issued a biological opinion for the construction of the non-physical barrier at the HOR (NMFS # 2009/01239).**
- In 2010, the USFWS provided concurrence to the Corps that the 2010 HOR NPB would not likely adversely affect delta smelt and amended the 2009 HOR NPB BIOP with the 2010 HOR NPB project description (USFWS File# 81410-2010-F-0004).
- In 2011, the Central Valley Regional Water Quality Control Board (RWQCB) issued Clean Water Act Section 401 Water Quality Certification for the construction and removal of the four rock

barriers and construction and removal of the HOR NPB (WDID# 5B39CR00191). This permit covers all three TBP projects listed above through 2016.

- In 2011, the California Department of Fish and Game (DFG) issued a Final Lake or Streambed Alteration Agreement for the construction and removal of the four rock barriers and construction and removal of the HOR NPB (DFG tracking # 1600-2010-0375-R3). This permit covers all three TBP projects listed above through 2016.
- In 2011, DFG issued an incidental take permit for the construction and removal of the four rock barriers, construction and removal of the HOR NPB, implementation of the predator study, and implementation of the Fish Monitoring Project. (DFG tracking # 2081-2011-019-03). This permit covers all three TBP projects listed above through 2016.
- **In 2011, the NMFS issued a biological opinion which addressed the effects of construction of the four rock barriers and the HOR NPB (NMFS # 2010/06485). This BIOP expired on December 31, 2011.**
- In 2012, the USFWS amended the 2009 HOR BiOp with the updated 2012 project description and schedule and amended the Effects Analysis (USFWS File # 08FBDT00-2012-F-0010).
- **In 2012, the NMFS issued a biological opinion for the 2012 Temporary Barriers Project (NMFS File # 2012/00152), which included the construction and removal of the four rock barriers.**
- In 2012, DFG amended the 2011 Lake and Streambed Alteration Agreement with the updated 2012 project description and schedule (DFG tracking # 1600-2010-0375-R3).
- In 2012, DFG amended the 2011 Incidental Take Permit with the updated 2012 project description and schedule (DFG tracking # 2081-2011-019-03).
- In 2012, the USACE modified the 2001 Temporary Barriers Project- Agricultural Barriers, Clean Water Act Section 404 permit (SPK # 200100121) with the updated 2012 schedule for the construction of the three agricultural barriers.
- In 2012, the USACE modified the 2000 Temporary Barriers Project- HOR Rock Barriers, Clean Water Act Section 404 permit (SPK # 200000696) with the updated 2012 project description and schedule for the construction of the spring and fall HOR rock barriers.
- In 2012, the Central Valley Regional Water Quality Control Board (RWQCB) amended the Clean Water Act Section 401 Water Quality Certification for the construction and removal of the four rock barriers and construction and removal of the HOR NPB (WDID# 5B39CR00191).

DESCRIPTION OF THE PROPOSED ACTION

The proposed 2013-2017 TBP would consist of annual construction, maintenance and removal of the MR, ORT, GLC, HOR fall rock barrier, and either the spring HOR rock barrier or the spring HOR NPB. Additionally, a fish study may be conducted to gain an understanding of the HOR barrier effectiveness, to better understand the movement and behavior of salmonids and predatory fish and/or to understand how those movements and behaviors change as a result of the installation and operation of the barrier. Barriers cannot be constructed when ambient flows in the San Joaquin River are above 5000 cfs, as measured at the Vernalis monitoring station, as high flows create extremely hazardous and unsafe working conditions and cause rocks to move as they are placed.

AGRICULTURAL BARRIERS

The TBP-Agricultural Barriers (Ag Barriers) includes the annual construction, maintenance and removal of the MR, ORT, and GLC rock barriers. The design of the 2013–2017 Ag Barriers would be essentially the same as in years past. However, DWR may require modification of the weir height of the MR barrier (MRB) during some years of the permit, as was done in summer 2010 and 2012. If implemented, and after concerns for impacts to delta smelt in the south Delta have passed, the height of the MRB weir would be increased by 1 foot from the current design elevation of 3.3 feet to an elevation of 4.3 feet based on the North American Vertical Datum of 1988 (NAVD88).

MIDDLE RIVER

The MRB is located about a half mile south of the confluence of Middle River, Trapper Slough, and North Canal. The MRB is a rock barrier constructed with a center weir section that allows tidal flows to enter the Middle River upstream of the barrier by overtopping the weir crest and flowing through submerged culverts (Figure 3). The tidal flow is retained behind the barrier in part during the ebb tide by the barrier elevation and the closure of the flap-gates. This allows agricultural pumps to operate throughout each tidal cycle by maintaining a minimum water elevation of 2.6 feet (NAVD88) measured at the Howard Road Bridge station.

Each year the MRB weir section is reconstructed by placing approximately 2,300 cubic yards (cy) of rock between the two previously constructed abutments that are left in place year-round. Each abutment has three, 48-inch diameter culverts with tidally-operated flap-gates that are also left in place. Placement of rock completes the barrier that is 270-feet long and 50 feet-wide (0.31 acre). The rock weir section is 140-feet long and 18-feet wide at its crest. By September 15th, a 10 foot-wide notch (fall notch) is constructed in the weir for salmon passage. The notch allows a minimum depth of 6 inches of water to pass over the barrier during low-high tide events and shall remain in place until the barrier is removed.

Decision 1641 (D-1641), which was issued from the SWRCB, set defined salinity standards in the Delta. Raising the MRB would allow the barrier to trap more of the fresh water found below the barrier, thereby raising water quality levels above the barrier. The CVRWQCB issued a *Water Quality Control Plan for the Sacramento and San Joaquin River* (Basin Plan; revised in 2011) which set defined DO standards for the Delta. Raising the MRB in conjunction with tying open the ORT barrier culvert flapgates is intended to create net circular flow up MR and down OR which would decrease zones of stagnant water. In an effort to maintain these water quality standards DWR retains the option to raise the height of the MRB during peak irrigation months, the height of the weir may be increased from 3.3 (typical) to 4.3 feet (NAVD88). Raising the barrier height one foot will require an additional 100 cy of rock and will reduce the width of the crest to 15 feet. However, it is expected that this will result in little, if any, disturbance to the riverbed or channel and there will be no change in the footprint of the MRB. The MRB will only be raised when risks to delta smelt have passed and full barrier operations are allowed by the USFWS and DFG. DWR proposes to continue optionally raising the MRB weir because it will:

- Decrease salinity levels in the south Delta by using the tidal cycles to add additional fresh Sacramento River water into south Delta channels system via Middle River;
- Increase the circulation upstream of the barriers thereby improving water quality and agricultural diversions for crops; and
- Reduce null zones where stagnant water creates low DO levels and algae blooms.

The center weir section of the MRB is removed during the non-irrigation season (December through March). The flap-gates are tied open when the center weir section is removed. The fall notch in the MRB will remain the same elevation regardless of the 1 foot increase in weir height. The notch will be 10 feet wide and at an elevation of 2.6 feet (NAVD88).

While the culverts are left in place for most years, periodic culvert replacement (every 10-15 years) may occur in order to ensure their functionality.

OLD RIVER TRACY

The ORT barrier is located near the CVP's Tracy fish screen facility on Old River, approximately 0.5 miles east of the CVP's inlet. The structure allows tidal flows to enter the channel upstream of the barrier by overtopping the weir crest and flowing through the submerged culverts. The tidal flow is then partially retained during the ebb tide by the barrier elevation and the closure of tidal flap-gates on the upstream side of each culvert.

Each year construction of the ORT barrier begins with placement of a rock and gravel pad followed by the placement of three metal culvert frames each containing three 48-inch diameter culverts (nine culverts total) with flap-gates on the prepared pad. The culverts are then covered with approximately 5,000 cy of rock to form a 250-foot long berm that is 60 feet wide at its base (0.34 acre) (Figures 4a and 4b). The center of the barrier has a 75-foot wide weir with a crest elevation of 4.4 feet based on the NAVD88. Beneath the weir, are the nine culverts, each 60 feet long and 1 foot apart, with tidally activated flap-gates on the upstream ends. During summer months, some of the flap-gates may be tied to the open position to improve circulation in this area. Tying the flap gates open in conjunction with the Middle River raise is intended to increase net downstream flow and reduces stagnant zones in Old River. A temporary boat ramp will be constructed with riprap at the base, followed by crushed rock, and topped with articulated concrete mats. Because much of the boat ramp structure will be underwater, divers will aid in the positioning of the concrete mats. Similarly to the MRB, a 10 foot-wide notch is constructed by September 15 each fall to allow adult salmon passage.

GRANT LINE CANAL

Each year the GLC barrier is constructed with approximately 12,600 cy of rock that is placed between the existing south abutment and the north canal bank to create a 300-foot long barrier that is up to 100 feet wide at its base (0.34 acre) (Figures 5a and 5b). The center of the barrier has a weir section with a crest at 3.3 feet elevation (NAVD88) that is 125 feet long and 24 feet wide. The existing south abutment contains six 48-inch diameter, 60-foot long culverts with flap-gates on the upstream end. A catwalk structure is affixed to the top of each culvert with a winch and hand crank allowing access to and operation of the flap-gates attached to the upstream end of each culvert. A 10 foot wide flashboard structure is also built at the south abutment, which can be adjusted to allow delta smelt passage in spring and salmon passage in the fall. Similarly to the ORT barrier, a ramped boat portage facility is also provided at the north levee. The boat ramp is constructed with riprap at the base, followed by crushed rock, and topped with articulated concrete mats. Because much of the boat ramp structure will be underwater, divers will aid in the positioning of the concrete mats.

While the culverts are left in place for most years, periodic culvert replacement (every 10-15 years) may occur in order to ensure their functionality.

HEAD OF OLD RIVER BARRIER

The HOR barrier is located at the divergence of Old River from the San Joaquin River near the City of Lathrop. The HOR barrier serves a dual purpose and may be installed in the spring and in the fall. In the spring, the barrier acts as a fish barrier to decrease the number of salmonid smolts entering Old River. This can be accomplished by installing a rock barrier or a Non Physical Barrier (NPB). In the fall, the barrier may be needed to increase flows and dissolved oxygen levels downstream in the San Joaquin River including the Stockton deepwater shipping channel; therefore, a rock barrier must be used.

SPRING ROCK BARRIER

The spring HOR rock barrier is intended to prevent downstream-migrating salmon smolts in the San Joaquin River from entering Old River, which would expose them to State Water Project (SWP) and Central Valley Project (CVP) diversion operations and unscreened agricultural diversions. The spring HOR rock barrier is constructed with approximately 12,500 cy of rock to form a 225-foot long and 85-foot wide (at the base) berm (0.44 acre) (Figures 6a and 6b) and it has a crest elevation of 12.3 feet (NAVD88). Construction at the south end of the barrier includes the placement of six to eight, 48-inch diameter culverts with slide-gates into the barrier abutment. The middle section includes a 75-foot weir at an elevation of 8.3 feet that is capped with clay up to the barrier crest elevation (12.3 feet, NAVD88). Unlike the ORT and GLC barriers, there is no boat portage facility at this barrier. A ramp and dock may be secured to the shore in order to allow storage and safe access to small boats that may be used for construction, maintenance and research purposes.

FALL ROCK BARRIER

Installation of the fall HOR rock barrier may be needed to increase flows and dissolved oxygen levels downstream in the San Joaquin River. The fall HOR rock barrier is constructed similarly to the spring barrier, but using approximately 7,500 cy of rock to form a smaller 225-foot long and 65-foot wide (at the base) berm (0.34 acre) that is constructed to a crest elevation of 8.3 feet and includes a 30-foot wide notch at elevation 2.3 feet (NAVD88; Figures 7a and 7b) to allow the passage of adult salmonids.

SPRING NON-PHYSICAL BARRIER

The HOR NPB is a multi-stimulus fish barrier that combines high-intensity light-emitting diode (LED) Modulated Intense Lights (MILs), an air bubble "curtain," and sound at frequencies and levels that are repellent to Chinook salmon (Bowen et al. 2009; Bowen and Bark 2010). The sound system and MIL flash rate can be tuned to known sensitivities of various fish species. Investigations have indicated that the most effective acoustic deterrents for multiple fish species fall within the sound frequency range of 5 to 600 hertz (Hz) (Bowen and Bark 2010). Studies with Chinook salmon and delta smelt have shown that when the sound and strobe light flash rate were tuned according to these species' sensitivities, the barrier was particularly effective as a deterrent for Chinook salmon smolts (Bowen et al. 2008). Based on these studies, it has been hypothesized that the sound is the deterrent. The sound is trapped by refraction within the bubble curtain, producing a sharply defined sound field that fish do not detect until within a few meters of the barrier. The flashing MILs are aligned such that the light beam projects onto the bubble curtain. This helps identify the bubbles so that the source of the sound can be determined by the fish. A narrow, vertical MIL beam minimizes light saturation within the experimental area.

Modifications to the length and orientation of the HOR NPB may be made each year based on acoustic telemetry data obtained during operation. The 2009 HOR NPB was approximately 367 linear feet and spanned across the mouth of the Old River. The 2010 HOR NPB was 450 linear feet and was oriented further out in San Joaquin River than the 2009 NPB. Future HOR NPB's, if constructed, may have varying orientations in order to improve the barriers effectiveness on deterring and protecting smolts.

Current ideas on barrier design have been refined based on information collected in 2009 and 2010. The barrier may be up to 700 feet long and may be comprised of as many as 30 metal framed sections. The sections will be positioned along the barrier line such that, during average annual flow conditions, as much of the barrier as possible is at a depth where the height of the bubble curtain is less than 12 feet. The frames will be placed approximately 18 inches from the channel bottom. The top of the frame sections will be at 5–10 feet below the water surface elevation at low tide during average annual flow conditions. The barrier frames will be supported and secured with steel piles and concrete pier blocks. The NPB will require as many as 8 piles (including one scientific pile) and 30 pier blocks. Figures 9 a-d show plan and profile views of one option for a HOR NPB.

Each barrier frame section will have approximately four sound projectors spaced 6.5 feet apart, eight strobe lights, and a perforated "bubble" pipe. The bubble pipe will be positioned along each frame below and upstream of the sound projectors. A bubble curtain will be created by passing compressed air into the perforated pipe. The air flow rate will typically be 1.38 cubic feet per minute (cfm) per linear foot for the length of the barrier. The MILs will be powered from an "accumulator" positioned on each frame section. A mounting plate will be attached to the support tray to house the accumulators. The junction of each frame section can pivot with the adjacent section, and where needed, each frame section will be supported at either end with a piling or pier block.

Light cables, sound cables, and air lines will run from generators and air compressors located on the water side berm along the south bank of the San Joaquin River adjacent to the NPB, where a portion of the stockpile for the HOR rock barrier is stored. Approximately 120 amps (115 volts) of an inductively –rated power supply will be required to run the complete electrical system. A small trailer will house the control units, signal generators and amplifiers. A temporary floating dock will be installed near the trailer to tether a small boat used for operation, maintenance, and monitoring. See Figure 9e, for an example of placement locations of air lines, cables, and onshore equipment. All generators, air compressors, trailers and fuel storage containers will be placed such that it can be removed quickly and most equipment will be readily towable while staged.

In addition to the NPB structure, warning signs, lighted warning buoys, high visibility float rope, and ball buoys will be deployed around the barrier to alert boaters of its location. Up to 40 concrete anchors would be placed on the river bottom or on river banks to anchor the warning buoys and signs in place. Figure 9d show an example of the buoy layout and Figure 9f shows details of the example buoys, signs, and concrete anchors and pier blocks.

TEMPORARY BARRIERS PROJECT FISH STUDY

In general, the program includes tagging and releasing salmon and steelhead in the south Delta, installing an acoustic receiver network including a two-dimensional (2-D) biotelemetry system, implementing a mobile monitoring effort to find acoustic tags on the river bottom using global positioning system (GPS), monitoring fish using Dual-Frequency Identification Sonar (DIDSON) cameras, placement of hydroacoustic and other scientific instrumentation and sampling, tagging and releasing predatory fish. Scientific equipment will be affixed to several types of mounting brackets depending on equipment type, barrier type and location. Up to 50 anchors made from sections of railroad track will be used to anchor floating scientific equipment, such as hydrophones (Figure 10 and Figure 11) in the water column using tensioned lines. Additionally, up to 10 weighted stands and one scientific pile will be used for placing stationary equipment such as ADCP's and DIDSON cameras. A scientific pile will only be placed if the NPB is used at the HOR. The minimum required number of railroad track anchors and weighted stands will be placed each year and scientific equipment will be placed using barrier related structure, as much as possible. All scientific equipment will be affixed to anchors and stands similar in nature and impacts to those used for ADCP's, DIDSON cameras and hydrophones. Additional studies of salmonid smolts and predatory fish may occur, however, techniques used to capture predatory fish will be limited to electrofishing, hook and line sampling and fyke trapping.

Study techniques used in the past and likely to be used for future studies include 2-D tracking of acoustically tagged Chinook salmon and steelhead smolts, 2-D tracking of acoustically tagged predatory fish, acoustic tagging of salmonid smolts and predatory fish, capture of predatory fish using multiple techniques, placement of a 2-D hydrophone array within ½ mile of barrier locations, placement of hydrophone nodes at strategic locations within the south Delta (e.g. peripheral nodes to determine migration paths; See Figure 13), placement of ADCP's within ½ mile of barrier locations, placement of DIDSON cameras within ½ mile of barrier locations, and mobile hydroacoustic monitoring within the south Delta. Advanced technologies and monitoring techniques may be used in the future, as they are developed. A study plan will be prepared and submitted to the NMFS for comment and approval for each year a study is planned.

CONSTRUCTION AND REMOVAL

Construction activities for all of the barriers would begin as early as March 1 and removal would be completed no later than November 30 of each year. Any rock barrier operating on or after September 15 will be notched beginning September 15 to allow for passage of adult salmon. At GLC, flashboards will be removed to create the notch in the barrier. Historic information on the actual construction schedules of the barriers since 1968 are included in Appendix B and approximate construction durations are included in Table 2.

TABLE 2: CONSTRUCTION AND REMOVAL REQUIREMENTS FOR EACH OF THE TEMPORARY BARRIERS.

		Construction (Days)	Removal (Days)
HORB	Spring Rock	24	24
	Spring NPB	20	15
	Fall Rock	18	18
Ag Barriers	MR	5 (+5 if culverts are replaced)	5 (+5 if culverts are replaced)
	ORT	20	20
	GLC	24 (+10 if culverts are replaced)	21 (+10 if culverts are replaced)

AGRICULTURAL BARRIERS

Construction of the ag barriers entails the placement of rock barriers in the spring within the channels of the Middle River, Old River, and Grant Line Canal. At the ORT barrier, quarry rock is stockpiled about ½ mile upstream of the barrier site on the inland side of the levee crown. The rock materials for MR are stockpiled adjacent to the barrier site on the water side of the levee crown and rock for the GLC barrier is stockpiled offsite at the Howard Road (2.0 miles) storage area. Each spring, heavy construction equipment is mobilized to move the stockpiled rock from its storage location into the channel to form the barriers. Large front loaders, dump trucks, off-road haulers, cranes, long reach excavators and drag lines are used to move and place the materials. Typically, machinery works from one or both banks of the channel to place the rock, as well as any additional materials such as culverts, articulating concrete mats, or other structures. Depending on the individual design of each barrier, the 48-inch diameter steel pipes used as culverts are placed by crane after the gravel pad of the barrier is constructed. At the MR and GLC barriers the abutments and the culverts remain in place over the winter. As the rock barrier is extended into the channel, machinery can utilize the crown of the barrier to move farther into the channel on top of the barrier to place additional materials. Each of the barriers is adequately marked with navigational aids and warning signs approved for placement by the U.S. Coast Guard (Private Aids Permit #s 2832-2839).

Barrier installation, including in-water work, and associated construction activities such as mobilization and site clean-up, typically takes approximately 5 working days for the MRB, 20 working days for the ORT barrier and 24 working days for the GLC barrier. However, extreme weather, tide and river flow conditions may impact the barriers construction schedules.

While the culverts are left in place for most years at MR and GLC, periodic culvert replacement may occur in order to ensure their functionality. Removal of the culverts would occur during the fall barrier removal. The removal of the culverts and the abutments at MR and GLC would add approximately 10 days for GLC and 5 days for MR to the removal schedule. The culverts and their associated structures would then be repaired or replaced and reset into the normal position using similar techniques to the culvert placement at ORT. The replacement would occur the following spring add approximately 10 days of work for GLC and 5 days for MR. The normally permanent rock abutments in each of these locations would be rebuilt as they have been previously constructed. The culverts at MR and GLC barriers have been replaced in recent years and are not likely to be replaced during the 2013-2017 period.

Removal of the barriers will occur in the fall and the installation procedure is reversed. Barrier removal, including in-water work, and associated construction activities such as mobilization and site clean-up, typically takes approximately 5 working days for the MRB, 20 working days for the ORT barrier and 21 working days for the GLC barrier. The rock barriers will be removed with an excavator and a dragline. An excavator will remove the majority of the rock down to the underwater pad of the culvert frames. Because the culvert pad is longer and wider than the "reach" of the excavator, a dragline with a bucket will be necessary to remove the remainder of the underwater rock associated with the barriers. The removed rock is stockpiled outside of the waterway until used again. At the barrier sites, the channel bottom is restored to pre-project conditions after the barriers are removed. Confirmation that the channel bottom has been restored to pre-project conditions is accomplished via bathymetric surveys which are conducted each year before construction (pre-project) and after removal. The barrier culverts and abutments at MR will remain in place throughout the year, as will the culverts and south barrier abutment at GLC.

HEAD OF OLD RIVER ROCK BARRIERS

Construction of the HOR rock barrier may entail the placement of a rock barrier in the spring and/or fall within the channel of Old River. Minor sediment removal may be required in order to prepare the area for barrier installation. The removal of sediment in the vicinity to the HOR barrier will be limited to the minimum amount necessary that will allow for the installation of the crushed rock bed for the culverts and will not extend beyond 200 feet in any direction from the barrier footprint. All removed sediment will be deposited and retained in an area that has no connection to waters of the United States. The culverts and articulated mats for the HOR rock barriers are stockpiled offsite at Howard Road storage area, while the rock is stockpiled adjacent to the HOR site. Heavy construction equipment will be mobilized to move the stockpiled culverts, articulated mats and rock from its storage location into the channel to form the barrier. Large front loaders, dump trucks, long reach excavators and barges with spuds and tug boat are used to move and place the materials. Typically, machinery works from both banks of the channel and from a barge within the channel to place the rock, as well as any additional materials such as culverts, concrete reinforcing mats, clay or other structures or materials. Depending on the design of the barrier, the 48-inch diameter steel pipes used as culverts are placed by crane from shore or from a barge after the gravel pad of the barrier is constructed. As the rock barrier is extended into the channel, machinery can utilize the crown of the barrier to move farther into the channel on top of the barrier to place additional materials. The barrier will be adequately marked with navigational aids and warning signs approved for placement by the U.S. Coast Guard (Private Aids Permit #s 2832-2839).

Barrier installation, including in-water work, and associated construction activities such as mobilization and site clean-up, typically takes approximately 24 working days for the spring HOR rock barrier and 18 working days for the fall HOR rock barrier. However, extreme weather, tide, and river flow conditions may impact the barriers construction schedule.

Removal of the barriers can occur in the spring and/or fall and the installation procedure is reversed. Removal of the spring HOR rock barrier can take up to 24 days and the removal of the fall HOR rock barrier can take up to 18 working days. The rock barriers will be removed with an excavator and a dragline or a crane with clamshells. Equipment will work both from shore and from a barge with spuds and a tug boat. The excavator and/or crane will remove the majority of the rock down to the underwater pad of the culvert frames. A dragline with a bucket may be necessary to remove the remainder of the underwater rock associated with the barriers. The removed rock is stockpiled outside of the waterway until used again. At the barrier site, the channel bottom is restored to pre-project conditions after the barrier is removed. Confirmation that the channel bottom has been restored to pre-project conditions is accomplished via bathymetric surveys which are conducted each year before construction (pre-construction) and after removal.

HEAD OF OLD RIVER NON-PHYSICAL BARRIER

In 2010 construction of the barrier took a total of 11 days including pile driving, assembly and installation. However, the nature of in-water work makes it highly dependent on weather and flow conditions. Wet weather, high river flows, and increased pile driving requirements have the potential to make in-water work conditions unsafe during the construction period, thus halting work and delaying the construction completion date. Installation will be completed in approximately 20 days including up to 10 days of in-water work. Removal of the NPB and piles will take approximately 15 days including up to 5 days of in water work. Construction and related site cleanup activities may occur during daylight hours, up to 12 hours per day, 7 days per week.

Construction vehicles will access the project site using existing roads, including those on the levee crown, that are typically used during installation and removal of the HOR rock barriers. It is anticipated that the following equipment will be used during construction and installation of the non-physical barrier: flatbed tractor/trailer; off-road forklift; barge with spuds and tug boat; barge-mounted crane; vibratory hammer pile driver; work boat; diesel or liquid petroleum gas generator; and air compressors.

The pile foundation and concrete pier blocks for the non-physical barrier frames will be installed first. Up to eight, 8- to 12-inch diameter steel piles will be driven with a vibratory driver in the wetted channel from a barge. It is anticipated it will take about 30 minutes to position each pile and the driving will occur in one to two days resulting in less than 80 minutes total driving time. Each pile will be driven approximately 15 to 30 feet into the river bed. It will require approximately one hour between pile driving to position the barge and load the next pile.

The NPB frame sections will be assembled on land, in sets of two, with pier blocks positioned between adjacent frame modules. The pier blocks and frame sets are then lowered into the water with the crane. Divers will attach the frame sets to the piles and pier blocks and then attach the air lines and power cords to the non-physical barrier.

TEMPORARY BARRIERS PROJECT FISH STUDY

Construction activities associated with the fish studies are minimal due to the nature of these studies designs, however, yearly placement of anchors, weighted stands, cabling and one temporary pile may occur. DWR may study the "no barrier", NPB, or the rock barrier condition at the HOR depending on the barrier used in any given year. Additionally DWR may conduct other studies using the aforementioned tools anywhere within the projects action area. Fish studies may not occur in all years.

ACOUSTIC TELEMETRY TRACKING SYSTEM

An acoustic telemetry tracking system consisting of hydrophone arrays will be used to monitor juvenile salmonids and predatory fish. Juvenile salmonids obtained from local hatcheries (e.g., Mokulumne River Fish Hatchery) will be surgically implanted with bio-acoustic tags and then released upstream from the HOR. Each acoustic tag transmits an underwater sound signal (i.e., acoustic "ping") that sends identification information about the tagged fish to strategically placed hydrophones, onshore receivers, data loggers, and data processing computers that listen for, and record the location of the tagged fish as they move through the study area. Up to 50 hydrophones will be deployed in the rivers to detect the tagged fish. Each hydrophone would be secured to an anchor made from a short section of railroad track with a section of rope and a floating buoy (See Figure 10 and 11). The data will be analyzed to determine the barrier's effectiveness and predatory fish behavior. The hydrophone placement will likely include an array to collect 2-D tracks around the HORB and several other hydrophone node placements further from the barriers to determine the fates of tagged fish (See Figure 12 and 13) .

VISUAL TRACKING SYSTEM

DIDSON cameras may be installed with weighted stands or attached to structures associated with the installed barrier. One temporary pile may be installed adjacent to the HORB on years that a NPB is constructed to support components of a visual tracking system consisting of a DIDSON camera and/or other scientific equipment. DIDSON cameras are intended to regularly monitor fish behavior around the barrier and will be operated to obtain data to achieve defined study objectives. The objectives may include gaining a better understanding of how predatory fish interact with the barrier, how other fish interact with the barriers, predation events near the barriers, and juvenile salmonid response to the barriers. DIDSON cameras are likely to be placed within ½ mile of the HORB, however, no more than 10 weighted stands will be placed during any study year.

SCHEDULE FOR INSTALLATION

Barrier installation, including in-water work, and associated construction activities such as mobilization and site clean-up, typically takes approximately 24 working days for the spring HOR rock barrier, 18 working days for the fall HOR rock barrier, 20 working days for the HOR NPB, 5 working days for the MRB, 20 working days for the ORT barrier and 24 working days for the GLC barrier. However, extreme weather, tide and river flow conditions may impact the barriers completion date. Construction activities for all of the barriers would begin as early as March 1 and removal would be completed no later than November 30 of each year. Any rock barrier operating on or after September 15 will be notched beginning September 15 to allow for passage of adult salmon. At GLC, flashboards will be removed to create the notch in the barrier. The HORB cannot be constructed when ambient flows in the San Joaquin River are above 5000 cfs, as measured at Vernalis monitoring station. Historic information on the actual construction schedules of the barriers since 1968 are included in Appendix B.

HEAD OF OLD RIVER BARRIER

The HORB serves a dual purpose. In the spring, the barrier acts as a fish barrier to decrease the number of salmonid smolts entering Old River. This can be accomplished by installing a rock barrier or a NPB. In the fall the barrier may be needed to increase flows and dissolved oxygen levels downstream in the San Joaquin River including the Stockton deepwater shipping channel, therefore, a rock barrier must be used.

The spring HORB can be operated from April 1 through May 31 and installation of the fall HORB will be at the timing and discretion of the DFG, NMFS and FWS based on DO levels in the San Joaquin River. The Spring and Fall HORB will be installed and operated following the criteria listed in Table 3.

TABLE 3: INSTALLATION AND OPERATION OF THE HORB

	HORB
October 1 of preceding year	Spring barrier type (rock barrier or NPB) to be used must be determined in coordination with DFG, NMFS and USFWS. Default barrier type is the rock barrier if no determination is made by this date.
March 1	Spring installation of rock barrier or NPB may begin.
April 1-May 31	Full closure and/or operation of the spring barrier may occur.
	If a physical HORB is used and 1) the GLC is breached due to Delta Smelt concerns **OR:** 2) the GLC cannot be closed when the need is clearly demonstrated by DWR, the HORB must be breached and removed as soon as possible, unless otherwise instructed by the DFG, NMFS and USFWS.
May 15-May 31	Full closure and/or operation may continue, at the discretion of the DFG, NMFS and USFWS.
On or after September 1	Fall barrier installation may begin at the discretion of DFG, NMFS and USFWS.
November 30	Barrier must be completely removed.

The ag barriers are installed and operated based on the spring HOR barrier installation. If the spring HOR barrier is not installed the ag barriers will be installed and operated following **Table 4**. If the spring HOR barrier is installed the ag barriers will be installed and operated following **Table 5**.

TABLE 4: AGRICULTURAL BARRIER INSTALLATION AND OPERATION SCHEDULE, FOR YEARS WHEN THE SPRING HORB IS NOT INSTALLED

	MR	**ORT**	**GLC**
May 1	Installation may begin.	Installation may begin.	Installation may begin.
May 15 to May 31	Full operation and closure may occur if: • the need for MR full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: • the need for ORT full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation of flapgates and/or closure of the center rock section may occur if: 1) the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS two weeks in advance of closing the flapgates and center sections of the barrier). **AND:** 1) the incidental take concern level for delta smelt at the SWP/CVP facilities has not been reached. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
June 1 to November 30	Full operation and closure may occur. Barrier elevation can be raised from 3.3 feet NAVD to 4.3 feet NAVD with DFG and USFWS approval.	Full operation and closure may occur.	Full operation of flapgates and/or closure of the center rock section may occur if: If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
September 15	Barrier must be notched to allow passage of adult salmon.	Barrier must be notched to allow passage of adult salmon.	Barrier must have enough flashboards removed to allow passage of adult salmon.
November 30	Barrier must be completely removed.	Barrier must be completely removed.	Barrier must be completely removed.

Table 5: Agricultural Barrier installation and operation schedule, for years when the Spring HORB is installed

	MR	**ORT**	**GLC**
March 1	Installation may begin.	Installation may begin.	Installation may begin.
April 1 to May 31, after HORB is fully operational	Full operation and closure may occur. If HORB is breached, flap gates must be tied in open position.	Full operation and closure may occur. If HORB is breached, flap gates must be tied in open position.	Full operation of flapgates and/or closure of the center rock section may occur if: 1) the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS two weeks in advance of closing the flap gates and center sections of the barrier). **AND:** 2) the DFG, NMFS and USFWS, in coordination with DWR, approves closure. If HORB is breached, flap gates must be tied in open position. If HORB is breached due to Delta Smelt concerns, flap gates must be tied in the open position and the center section shall be removed until concerns have passed.
June 1 to November 30	Full operation and closure may occur . Barrier elevation can be raised from 3.3 feet NAVD to 4.3 feet NAVD with DFG and USFWS approval.	Full operation and closure may occur .	Full operation of flapgates and/or closure of the center rock section may occur if: 2) the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG and USFWS two weeks in advance of closing the flap gates and center sections of the barrier). **AND:** 3) the incidental take concern level for delta smelt at the SWP/CVP facilities has not been reached. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
September 15	Barrier must be notched to allow passage of adult salmon.	Barrier must be notched to allow passage of adult salmon.	Barrier must have enough flashboards removed to allow passage of adult salmon.
November 30	Barrier must be completely removed.	Barrier must be completely removed.	Barrier must be completely removed.

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 biological assessment includes the southern Sacramento-San Joaquin Delta and generally comprises the lands and waterways of the Delta southwest of the City of Stockton. Major waterways within the south Delta include the San Joaquin River, Old River, Middle River, Woodward and North Victoria canals, Grant Line and Fabian canals, Italian Slough, Tom Paine Slough and the adjoining canals of the CVP and SWP. However, due to the anticipated effects of the TBP, the action area for this consultation not only encompasses the lands and waterways described above but includes lands and waterways of the central Delta including the lower San Joaquin downstream of Old River, Columbia Cut and Turner Cut, and all reaches of Middle River and Old River and adjoining sloughs and canals (Figure 1).

SPECIES ACCOUNTS

SPECIES LIFE HISTORY AND POPULATION DYNAMICS

CHINOOK SALMON

GENERAL LIFE HISTORY

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Streamtype" 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 immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, 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 at a time (CALFED 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 red 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 1995a). 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, and 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 flow. 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 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 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 1996a). 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 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 depending on the physiological stage of the juvenile and 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 1981). 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 oceantype 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 midsummer 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 6; 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.

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 (RM 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 near 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 (15,875) and 2006 (17,304) show a recent increase in the population size (DFG GrandTab, April 2012) and a 4-year average of 12,316 (see Table 7). 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, 2008, 2009, 2010, and 2011 show a precipitous decline in escapement numbers based on redd counts and carcass counts. Estimates place the adult escapement numbers for 2007 at 2,542 fish, 2,830 fish for 2008, 4,658 fish for 2009, 1,596 fish for 2010, and 827 fish for 2011 (DFG Grand Tab 2012).

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 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 population size of 3,782,476.

Based on the RBDD counts, the population has been growing rapidly since the 1990's with positive short-term trends (excluding the 2007-2010 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 *et al*. (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

TABLE 6: 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]	Medium	Medium	High	Medium	Medium	Medium	Medium					Medium
Sac. River[b]	Medium	Medium	Medium	Medium	Medium	Medium					Medium	Medium

b) Juvenile migration

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

KL = Knights Landing

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

Sources: aYoshiyama *et al*. (1998); Moyle (2002); bMyers *et al*. (1998) ; Vogel and Marine(1991); cMartin *et al*. (2001); dSnider and Titus (2000); eUSFWS (2001a, 2001b)

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 4 years 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 current winter-run Chinook salmon JPE for 2011 is only 332,012 fish entering the Delta, a substantial decline from the previous JPE values seen in the last decade. Recently, 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 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 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's assessment in 2007 did not include the recent declines in adult escapement abundance which may modify the conclusion reached in 2007. 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 reestablished 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).

TABLE 7: WINTER-RUN CHINOOK SALMON POPULATION ESTIMATES FROM RBDD COUNTS (1986 TO 2001) AND CARCASS COUNTS (2001 TO 2011), AND CORRESPONDING COHORT REPLACEMENT RATES FOR THE YEARS SINCE 1986 (DFG GRAND TAB FEBRUARY 2011).

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	3,556,995
2006	17,296	11,333	2.10	2.71	3,890,534
2007	2,542	10,353	0.32	2.32	1,100,067
2008	2,830	9,275	0.18	1.14	1,152,043
2009	4,537	8,609	0.26	1.00	1,144,860
2010	1,596	5,760	0.63	0.70	332,012
2011	824	2,466	0.29	0.34	162,051
Median	2,364	2,218	1.05	2.26	370,221
Mean	3,814	4,113	1.63	1.90	969,186

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 CRR using spawning population of a given year, divided by the spawning population 3 years prior.
c JPE estimates were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers.

VIABLE SALMONID POPULATION SUMMARY FOR SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

ABUNDANCE. During the first part of last 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, 2008, 2009, 2010, and 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. 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, 5-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, with declining escapement estimates for the years 2007 through 2011. However, 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 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 mainstem Sacramento River below Keswick Dam. Based on Reasonable and Prudent Alternative actions described in the 2009 OCAP BiOp, 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.

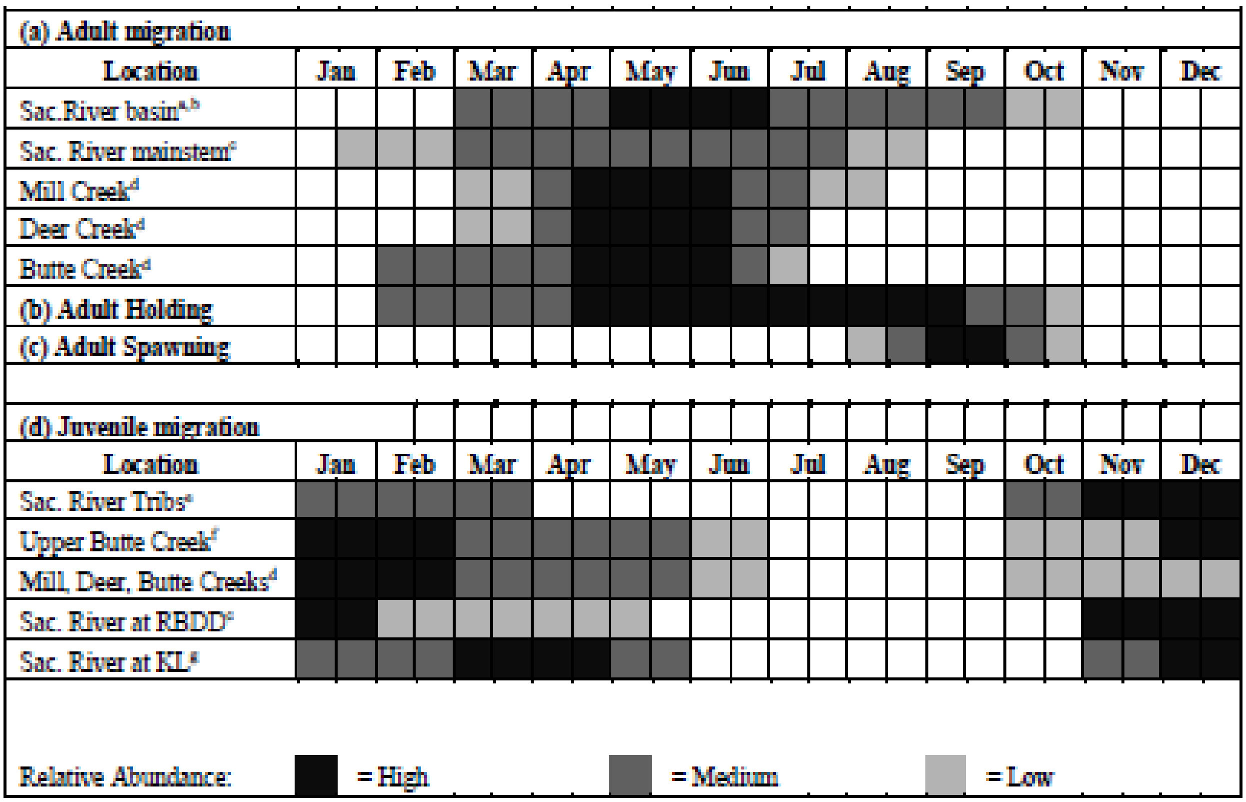
Historically the spring-run Chinook salmon were the second most abundant salmon run in the Central Valley (DFG 1998). These fish occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most 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 (DFG 1998). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (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 (DFG 1998). Adult Central Valley spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (DFG 1998) and enter the Sacramento River between March and September, primarily in May and June (see Table 8 in text; Yoshiyama *et al.* 1998, Moyle 2002). Lindley *et al*. (2007) 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*. 2007). 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*. 2007).

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 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).

TABLE 8: 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.



Note: Yearling spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Young-of-the-year spring-run Chinook salmon emigrate during the first spring after they hatch.
Sources: [a] Yoshiyama *et al*. (1998); [b] Moyle (2002); [c] Myers *et al*. (1998); [d] Lindley *et al*. (2007); [e] CDFG (1998); [f] McReynolds *et al*. (2005); Ward *et al*. (2002, 2003); [g] Snider and Titus (2000)

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRH. In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is 11 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 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, thus compromising the genetic integrity of the spring-run Chinook salmon stock. 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 above, the Feather River spring-run Chinook population numbers 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 1,404 in 1993 to 24,903 in 1998 (see Table 9). 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. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995. 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. 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 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" 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 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.

TABLE 9: CENTRAL VALLEY SPRING-RUN CHINOOK SALMON POPULATION ESTIMATES FROM CDFG GRANDTAB (FEBRUARY 2011) 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	17,598	4,135	13,463	10,372	0.54	1.93	14,757	0.56	1.27
2002	17,419	4,189	13,230	12,710	2.08	2.23	17,202	1.72	1.45
2003	17,691	8,662	9,029	9,536	1.62	2.04	14,410	1.91	1.42
2004	13,982	4,212	9,770	10,216	0.73	1.72	15,187	0.79	1.35
2005	16,126	1,774	14,352	11,969	1.08	1.21	16,563	0.93	1.18
2006	10,948	2,181	8,767	11,030	0.97	1.29	15,233	0.62	1.20
2007	9,974	2,674	7,300	9,844	0.75	1.03	13,744	0.71	0.99
2008	6,420	1,624	4,796	8,997	0.33	0.77	11,490	0.40	0.69
2009	3,801	989	2,812	7,605	0.32	0.69	9,454	0.35	0.60
2010	3,792	1,661	2,131	5,161	0.29	0.53	6,987	0.38	0.49
2011	4,967	1,900	3,067	4,021	0.64	0.47	5,791	0.77	0.52
Median	10,037	3,655	6,727	8,262	0.73	1.70	12,386	0.79	1.27
Mean	11,647	3,621	8,026	7,708	1.29	1.48	11,585	1.08	1.21

a NMFS included both the escapement numbers from the Feather River Fish Hatchery (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

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 FRH 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. In contrast to the first half of the decade, the last 6 years of adult returns indicate that population abundance is declining 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 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. Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in the past several years is nearly sufficient to classify it as a high extinction risk based on this criteria. Some tributaries, such as Clear Creek and Battle Creek have seen population gains, but the overall abundance numbers are still low. The recent increases in Battle Creek would qualify this population as being at a moderate risk of extinction. The Yuba River also has a spring-run population. The annual run size on the Yuba River generally ranges from a few hundred fish to several thousand fish, with the annual trends closely following the annual abundance trend of the Feather River Hatchery spring-run Chinook salmon population. 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.

PRODUCTIVITY. The 5-year geometric mean for the extant Butte, Deer, and Mill Creek spring-run Chinook salmon populations ranges from 491 to 4,513 fish (Good *et al.* 2005), indicating increasing productivity over the short-term and was projected to likely continue into the future (Good *et al.* 2005). However, as mentioned in the previous paragraph, the last 5 years of adult escapement to these tributaries has seen a cumulative decline in fish numbers and the CRR has declined in concert with the population declines. In the past decade (2001 to 2011), the 10 year average annual spring-run escapement for Mill, Deer, and Butte creeks has been 875, 1,235, and 5,419 fish, respectively. The average for the last 6 years for Mill, Deer, and Butte creeks has decreased to 559, 660, and 3,134 fish, respectively. Over the past 3 years the average escapement has declined further to 356, 249, and 1,783 fish for Mill, Deer, and Butte creeks, respectively (GrandTab February 2011, CDFG survey data 2011). The productivity of the Feather River and Yuba River 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 likely be reintroduced into the San Joaquin River below Friant Dam as part of the San Joaquin River Settlement Agreement if NMFS finds that a permit can be issued to do so. 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 and Northwestern California Coastal Range diversity group areas.

DIVERSITY. The Central Valley spring-run Chinook salmon ESU is comprised of 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 FRH 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 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.

CALIFORNIA CENTRAL VALLEY STEELHEAD

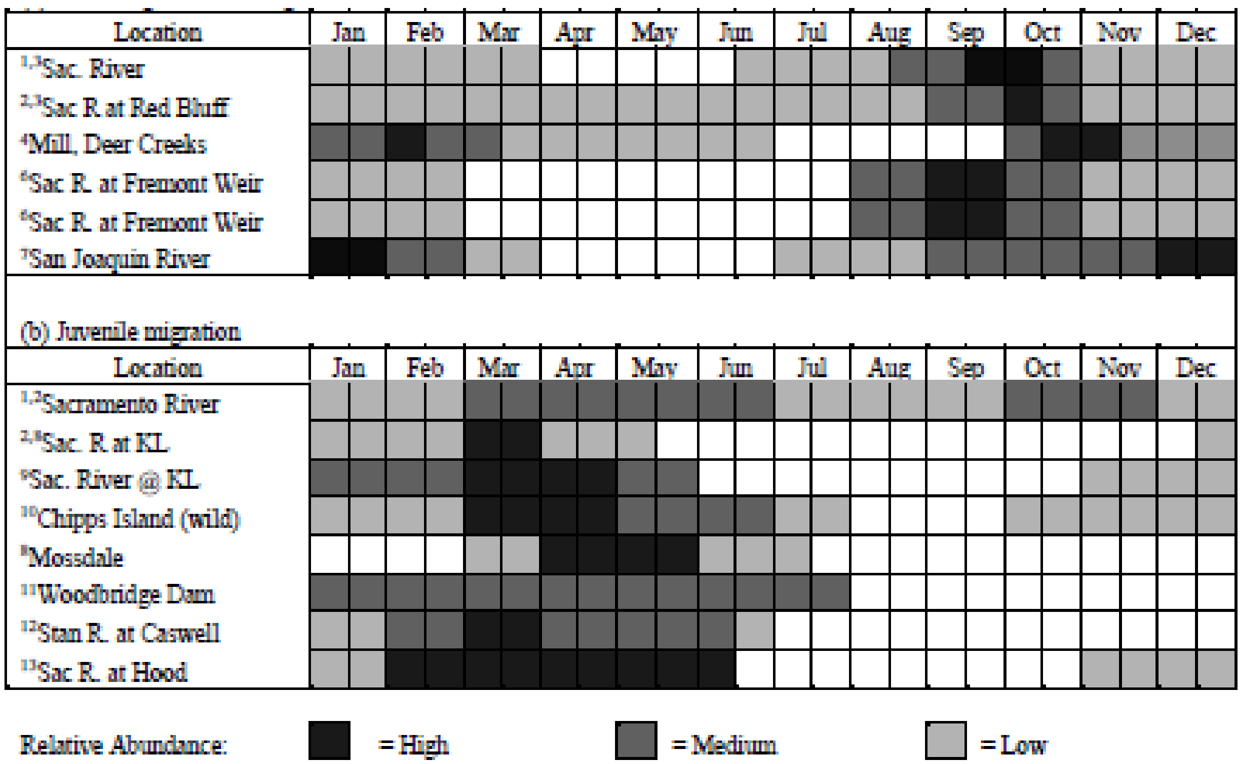
Steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Only winter-run steelhead currently are found in Central 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; see Table 10 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). 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 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 (2003) also have verified these temporal findings based on analysis of captures at Chipps Island.

TABLE 10: THE TEMPORAL OCCURRENCE OF ADULT (A) AND JUVENILE (B) CALIFORNIA CENTRAL VALLEY STEELHEAD IN THE CENTRAL VALLEY. DARKER SHADES INDICATE MONTHS OF GREATEST RELATIVE ABUNDANCE.



Sources: [1]Hallock 1961; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFG 1995; [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 2003; [11]Jones & Stokes Associates, Inc., 2002; [12]S.P. Cramer and Associates, Inc. 2000 and 2001; [13]Schaffter 1980, 1997.

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 (see Appendix B: Figure 3). 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 (2003) 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). Recent 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 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). California Department of Fish and Game (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" (Letter from Dean Marston, CDFG, to Michael Aceituno, NMFS, 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.

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.

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, one million in-DPS hatchery steelhead smolts and another half million out-of-DPS hatchery steelhead smolts are released annually in the Central Valley. The estimated ratio of nonclipped to clipped steelhead has decreased from 0.3 percent to less than 0.1 percent, 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.

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 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 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 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 *O. mykiss* populations.

SOUTHERN DISTINCT POPULATION SEGMENT OF NORTH AMERICAN GREEN STURGEON

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). During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett *et al.* 1991, Moser and Lindley 2007). 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, and Beamesderfer *et al.* 2007). Lindley *et al.* (2008) reported that green sturgeon make seasonal migratory movements along the west coast of North America, overwintering north of Vancouver Island and south of Cape Spencer, Alaska. Individual fish from the Southern DPS of green sturgeon have been detected in these seasonal aggregations. Information regarding the migration and habitat use of the Southern DPS of green sturgeon has recently emerged. 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). To date, the data indicates 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 green sturgeon includes all green sturgeon populations south of the Eel River, with the only known spawning population being in the Sacramento River. 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 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 (Beamesderfer *et al.* 2007). 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 than those of white sturgeon (Kynard *et al.* 2005, Van Eenennaam *et al.* 2009). Adults begin their upstream spawning migrations into freshwater in late February with spawning occuring between March and July (CDFG 2002. Heublin 2006, Heublin *et al.* 2009, Vogel 2008). Peak spawning is believed to occur between April and June in deep, turbulent, mainstem channels over large cobble and rocky substrates with crevices and interstices. 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, Heublin *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. Although no historical accounts exist for identified green sturgeon spawning occuring 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 Dam on the Yuba River. 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 in the western side of the San Joaquin Valley. Green sturgeon have recently been identified by UC 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 mainstem San Joaquin River (2007 sturgeon report card - CDFG 2008)

Kelly *et al.* (2007) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn (see Table 11). 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. Recent acoustical 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 (> 5m), 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 Heublin (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 (Heublin 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.

Currently spawning appears 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). 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 12.5mm to 14.5 mm in length and have a large ovoid yolk sac that supplies nutritional energy until exogenous feeding occurs. These yolksac 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 behavioral 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. This data suggests 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 bioenergetic 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 mainstem (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 rotary screw trap, 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 rotary-screw trap 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 Harvey O. Banks Pumping Plant and the John E. Skinner Fish Collection Facility (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 green sturgeon likely hold in the mainstem Sacramento River, as suggested by Kynard *et al.* (2005).

Population abundance information concerning the Southern DPS green sturgeon is described in the NMFS status reviews (Adams *et al*. 2002, NMFS 2005a). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures, CDFG 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. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al*. 2002). The only existing information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001. The average number of North American green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386, April 6, 2005). For the Tracy Fish Collection Facility, 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 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. Catches of subadult 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 portion of 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 North American green sturgeon. 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).

As described previously, the majority of spawning by green sturgeon in the Sacramento River system appears to take place above the location of RBDD. This is based on the length and estimated age of larvae captured at RBDD (approximately 2–3 weeks of age) and GCID (downstream, approximately 3–4 weeks of age) indicating that hatching occurred above the sampling location. Note that there are many assumptions with this interpretation (*i.e*., equal sampling efficiency and distribution of larvae across channels) and this information should be considered cautiously. Available information on green sturgeon indicates that, as with winter-run Chinook salmon, the mainstem Sacramento River may be the last viable spawning habitat (Good *et al.* 2005) for the Southern DPS of 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 green sturgeon has not been assessed, NMFS believes that the extinction risk has increased because there is only one known population, that which is spawning within the mainstem Sacramento River.

TABLE 11: THE TEMPORAL OCCURRENCE OF (A) ADULT, (B) LARVAL (C) JUVENILE AND (D) SUBADULT COASTAL MIGRANT SOUTHERN DPS OF GREEN STURGEON. LOCATIONS EMPHASIZE THE CENTRAL VALLEY OF CALIFORNIA. DARKER SHADES INDICATE MONTHS OF GREATEST RELATIVE ABUNDANCE.

(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

* Fish Facility salvage operations

Sources: [a]USFWS (2002); [b]Moyle *et al.* (1992); [c]Adams *et al*. (2002) and NMFS (2005a); [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)

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 the status and viability as has been done in recent efforts for Central Valley salmonid populations (Lindley *et al*. 2006, Good *et al.* 2005). NMFS assumes that the general categories for assessing salmonid population viability will also be useful in assessing the viability of the Southern DPS of 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 is also lacking. Fishery data collected at Federal and State pumping facilities in the Delta indicate a decreasing trend in abundance between 1968 and 2006 (70 FR 17386). Captures of larval green sturgeon in the RBDD rotary screw traps 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 rotary screw trap have been substantially higher than in previous years. 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 will be a strong year class.

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 indicates that the Southern DPS of North American green sturgeon is made up 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 mainstem 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 that river, at least during wet years with sustained high flows. Likewise, observations of several adult green sturgeons congregating below Daguerre Dam on the Yuba River suggests 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.

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.

DEFINITION OF CRITICAL HABITAT CONDITION AND FUNCTION FOR SPECIES' CONSERVATION

CRITICAL HABITAT FOR 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 CENTRAL VALLEY SPRING-RUN CHINOOK SALMON AND CALIFORNIA 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. Following are the inland habitat types used as PCEs for Central Valley spring-run Chinook salmon and California Central Valley steelhead, and as physical habitat elements for Sacramento River winter-run Chinook salmon.

PCEs for Central Valley Spring-run Chinook salmon and California Central Valley steelhead include:

SPAWNING HABITAT

Freshwater spawning sites are those with 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 mainstem 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 mainstem 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

Freshwater rearing sites are those with 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 outmigration. 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.

FRESHWATER MIGRATION CORRIDORS

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 mainstems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant 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

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.

CRITICAL HABITAT FOR THE 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 Sacramento – San Joaquin River 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 Feather River Fish Hatchery. Coastal Marine areas include waters out to a depth of 60 meters from Monterey Bay, California, to the Juan De Fuca Straits in 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 elements:

FOOD RESOURCES

Abundant food items within estuarine habitats and substrates for juvenile, subadult, and adult life stages are required for the proper functioning of this PCE for green sturgeon. Prey species for juvenile, subadult, 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, subadult, and adult green sturgeon within the bays and estuaries.

WATER FLOW

Within bays and estuaries adjacent to the Sacramento River (*i.e.*, the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco bays), sufficient 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.

WATER QUALITY

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 (75oF). 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 parts per thousand - 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 subadults and adults tolerate a wide range of salinities (Kelly *et al.* 2007). Subadult 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 mg O2 hr-1 kg-1, 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 subadult or adult stages.

MIGRATORY CORRIDOR

Safe and unobstructed migratory pathways 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 subadults 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 subadult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage back out into the ocean.

WATER DEPTH

A diversity of depths is necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Tagged adults and subadults 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

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.

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

The action area functions primarily as a migratory corridor for adult and juvenile California Central Valley steelhead. All adult California Central Valley steelhead originating in the San Joaquin River watershed will have to migrate through the action area in order to reach their spawning grounds and to return to the ocean following spawning. Likewise, all California Central Valley steelhead smolts originating in the San Joaquin River watershed will also have to pass through the action area during their emigration to the ocean. The waterways in the action area also are expected to provide some rearing benefit to emigrating steelhead smolts as they move through the action area. The action area also provides some use as a migratory corridor and rearing habitat for juveniles of the Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon ESUs that are drawn into the south Delta by the actions of the CVP and SWP water diversion facilities. The action area also functions as migratory, holding and rearing habitat for adult and juvenile Southern DPS of North American green sturgeon.

SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

The temporal occurrence of Sacramento River winter-run Chinook salmon smolts and juveniles in the action area are best described by the salvage records of the CVP and SWP fish handling facilities. Based on salvage records covering the last 10 years at the CVP and SWP, Sacramento River winter-run Chinook salmon are typically present in the south Delta 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 (50.4 percent). 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. The presence of juvenile Sacramento River winter-run Chinook salmon in the south Delta is a function of river flows on the Sacramento River, where the fish are spawned, and the demands for water diverted by the SWP and CVP facilities. When conditions on the Sacramento River are conducive to stimulating outmigrations of juvenile Sacramento River winter-run Chinook salmon, the draw of the CVP and SWP pumping facilities pulls a portion of these emigrating fish through the waterways of the central and southern Delta from one of the four access points originating on the Sacramento River (Georgiana Slough, the Delta Cross Channel, Three Mile Slough, and the San Joaquin River via Broad Slough). The combination of pumping rates and tidal flows moves these fish towards the southwestern corner of the Delta and into the action area. When the combination of pumping rates and fish movements are high, significant numbers of juvenile Sacramento River winter-run Chinook salmon are drawn into the south Delta.

CENTRAL VALLEY SPRING-RUN CHINOOK SALMON

Like the Sacramento River winter-run Chinook salmon, the presence of juvenile Central Valley spring-run Chinook salmon in the action area is under the influence of the CVP and SWP water diversions and the flows on the Sacramento River and its tributary watersheds. Currently, all known populations of Central Valley spring-run Chinook salmon inhabit the Sacramento River watershed. The San Joaquin River watershed populations have been extirpated, with the last known runs on the San Joaquin River being extirpated in the late 1940s and early 1950s by the construction of Friant Dam and the opening of the Kern-Friant irrigation canal.

Juvenile Central Valley spring-run Chinook salmon first begin to appear in the action area in January. A significant presence of fish does not occur until March (17.2 percent of average annual salvage) and peaks in April (65.9 percent of average annual salvage). By May, the salvage of Central Valley spring-run Chinook salmon juveniles declines sharply (15.5 percent of average annual salvage) and essentially ends by the end of June (1.2 percent of average annual salvage).

CALIFORNIA CENTRAL VALLEY STEELHEAD

The California Central Valley steelhead DPS occurs in both the Sacramento River and the San Joaquin River watersheds, although the spawning population of fish is much greater in the Sacramento River watershed (Good *et al.* 2005) . Like Sacramento River Chinook salmon, Sacramento River steelhead can be drawn into the south Delta by the actions of the CVP and SWP water diversion facilities. 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 proximity, similar habitats, and historical presence. 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. 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 CDFG on the mainstem of the San Joaquin River just above the HOR during the VAMP experimental period routinely catch low numbers of outmigrating steelhead smolts from the San Joaquin Basin. Monitoring is less frequent prior to the VAMP, therefore emigrating steelhead smolts have a lower probability of being detected. The Rotary Screw Trap (RST) monitoring on the Stanislaus River at Caswell State Park and further upriver near the City of Oakdale indicate that smolt-sized fish start emigrating downriver in January and can continue through late May. Fry sized fish (30 to 50 mm) are captured at the Oakdale RST starting as early as April and continuing through June. Adult escapement numbers have been monitored for the past several years with the installation of an Alaskan style weir on the lower Stanislaus River between Ripon and Riverbank. Typically, very few adult *O. mykiss* have been observed moving upstream past the weir due to the removal of the structure at the end of December. However, in 2006 to 2007, the weir was left in through the winter and spring and seven adult steelhead were counted moving upstream. In 2008-2009, 15 adult *O. mykiss* moved upstream past the weir. The weir counts indicate that at least some *O. mykiss* adults are moving upstream from the lower Stanislaus River into upstream areas. These fish, due to their migratory behavior, timing of entrance, and typically larger size would be considered potential steelhead returning to the tributary.

SOUTHERN DPS OF NORTH AMERICAN GREEN STURGEON

Adult green sturgeon use the upper Sacramento River for spawning from February through July (U.S. Fish and Wildlife Service 1995), and spend most of their lives in the ocean when not spawning (Moyle 2002). Thus, as supported by the historical record, adults are rare in the interior Delta, and are not expected to be present near the temporary barriers during the spring barrier installation period. Juveniles or sub-adults, however, may be present as they rear year round in the Delta. There are no estimates of the number of individuals rearing in the south Delta (National Marine Fisheries Service 2009b), however, DFG sturgeon report card data reports only 6 green sturgeon captures in the San Joaquin River upstream of Stockton and no green sturgeon captures in Old River from 2007-2011. Juvenile green sturgeon are routinely collected at the SWP and CVP salvage facilities throughout the year (National Marine Fisheries Service 2009b). Salvage records indicate that sub-adult green sturgeon may be present during any month of the year, but are especially prevalent in July and August; these fish range in size from 136 millimeters (mm) to 744 mm (National Marine Fisheries Service 2009b). Although there could be green sturgeon in the vicinity of the TBP construction, the likelihood is extremely low.

STATUS OF CRITICAL HABITAT WITHIN THE ACTION AREA

The action area is within the San Joaquin Delta subbasin (hydrologic unit [HU] # 5544) and is included in the critical habitat designated for California Central Valley steelhead. The San Joaquin Delta HU is in the southwestern portion of the California Central Valley steelhead DPS range and includes portions of the south and central Delta channel complex. The San Joaquin Delta HU encompasses approximately 628 square miles, with 455 miles of stream channels (at 1:100,000 hydrography). The critical habitat analytical review team (CHART) identified approximately 276 miles of occupied riverine/estuarine habitat in this hydrologic subunit area (HSA) and that it contained one or more PCEs for the California Central Valley steelhead DPS (NMFS 2005b). The PCEs of steelhead 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 the California Central Valley steelhead DPS 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 nutrients 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 juveniles and smolts and for adult freshwater migration. No spawning of California Central Valley steelhead occurs within the action area. In regards to the designated critical habitat for the Southern DPS of 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, subadults, 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 substantial degradation over time of several of the essential critical elements has diminished the function and condition of the freshwater rearing and migration habitats in the action area. It has only rudimentary functions compared to its historical status. The channels of the south 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 cleared for farming. Little riparian vegetation remains in the south Delta, limited mainly to tules growing along the foot of artificial levee banks. Numerous artificial channels also have been created to bring water to irrigated lands that historically did not have access to the river channels (*i.e.*, Victoria Canal, Grant Line Canal, Fabian and Bell Canal, Woodward Cut, *etc*.). These artificial channels have disturbed the natural flow of water through the south Delta. As a byproduct of this intensive engineering of the Delta's hydrology, numerous irrigation diversions have been placed along the banks of the flood control levees to divert water from the area's waterways to the agricultural lands of the Delta's numerous "reclaimed" islands. Most of these diversions are not screened adequately to protect migrating fish from entrainment. Sections of the south Delta have been routinely dredged by DWR to provide adequate intake depth to these agricultural water diversions. Shallow water conditions created by the actions of the SWP and CVP enhance the probability of pump cavitation or loss of head on siphons. NMFS has issued a biological opinion that assesses the impacts DWR's South Delta Diversions Dredging and Modification Program (October 27, 2003; SWR-02-SA-6433:JSS). That biological opinion included NMFS' terms and conditions to avoid and minimize incidental take of listed species in the south Delta. That biological opinion expired at the end of 2008.

Water flow through the south Delta is highly manipulated to serve human purposes. Rainfall and snowmelt is captured by reservoirs in the upper watersheds, from which its release is dictated primarily by downstream human needs. The SWP and CVP pumps draw water towards the southwest corner of the Delta which creates a net upstream flow of water towards their intake points. Fish, and the forage base they depend upon for food, represented by free floating phytoplankton and zooplankton, as well as larval, juvenile, and adult forms, are drawn along with the current towards these diversion points. In addition to the altered flow patterns in the south Delta, numerous discharges of treated wastewater from sanitation wastewater treatment plants (*e.g.*, Cities of Tracy, Stockton, Manteca, Lathrop, Modesto, Turlock, Riverbank, Oakdale, Ripon, Mountain House, and the Town of Discovery Bay) and the untreated discharge of numerous agricultural wasteways are emptied into the waters of the San Joaquin River and the channels of the south Delta. This leads to cumulative additions to the system of thermal effluent loads as well as cumulative loads of potential contaminants (*i.e.*, selenium, boron, endocrine disruptors, pesticides, biostimulatory compounds, *etc*.).

The installation of the temporary rock barriers has been an ongoing action since 1991. Installation of the HOR fall barrier has occurred intermittently since the early 1960s to enhance water quality downstream in the Port of Stockton and the DWSC. These barriers have altered the hydrology of the south Delta each time they have been installed by redirecting flows and increasing water elevation behind the barriers.

Even though the habitat has been substantially altered and its quality diminished through years of human actions, its conservation value remains high for San Joaquin River basin steelhead. This segment of the Central Valley steelhead DPS must pass through the San Joaquin Delta HSA to reach their upstream spawning and freshwater rearing areas on the tributary watersheds and to pass through the region again during the downstream migrations of both adult runbacks and juvenile smolts. Therefore, it is of critical importance to the long-term viability of the San Joaquin River basin portion of the California Central Valley steelhead DPS to maintain a functional migratory corridor and freshwater rearing habitat through the action area and the San Joaquin Delta HSA.

FACTORS AFFECTING THE SPECIES AND HABITAT IN THE ACTION AREA

The action area encompasses a small portion of the area utilized by the California Central Valley steelhead DPS as well as the Southern DPS of North American green sturgeon. Many of the range-wide factors affecting these two species are discussed in the *Status of the Species and Critical Habitat* section of this biological assessment, and are considered the same in the action area. This section will focus on the specific factors in the action area that are most relevant to the proposed TBP.

The magnitude and duration of peak flows during the winter and spring, which affects listed salmonids in the action area, are reduced by water impoundment in upstream reservoirs. 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 low lying terraces under cultivation (*i.e.*, orchards and row crops) in the natural floodplain along the basin tributaries. Consequently, managed flows in the main stem of the river often truncate the peak of the flood hydrograph and extended the reservoir releases over a protracted period. These actions reduce or eliminate the scouring flows necessary to mobilize sediments and create natural riverine morphological features within the action area. Furthermore, the unimpeded river flow in the San Joaquin River basin is severely reduced by the combined storage capacity of the different reservoirs located throughout the basin's watershed. Very little of the natural hydrologic input to the basin is allowed to flow through the reservoirs to the valley floor sections of the tributaries leading to the Delta. Most is either stored or diverted for anthropogenic uses. Elevated flows on the valley floor are typically only seen in wet years or flood conditions, when the storage capacities of the numerous reservoirs are unable to contain all of the inflow from the watersheds above the reservoirs.

High water temperatures also limit habitat availability for listed salmonids in the San Joaquin River and the lower portions of the tributaries feeding into the main stem of the river. High summer water temperatures in the lower San Joaquin River frequently exceed 72 °F, and create a thermal barrier to the migration of adult and juvenile salmonids (CDEC database). 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. 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 cumulative impacts to ecosystem functions and processes that accrue from multiple bank protection sites within a given river reach (USFWS 2000). Armored 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).

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 for extended periods 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 near shore refuge areas.

Point source (PS) and non-point source (NPS) pollution from agricultural discharge and urban and industrial development occur upstream of, and within the action area. The effects of these impacts are discussed in detail in the *Status of the Species and Critical Habitat in the Action Area* section. Environmental stresses 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 Central Valley watersheds (USFWS 1995b). Other impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, water quality, *etc.*, are discussed in the *Status of the Species and Critical Habitat in the Action Area* section.

CUMULATIVE EFFECTS

For purposes of the ESA, cumulative effects are defined as the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultations pursuant to section 7 of the ESA.

AGRICULTURAL PRACTICES

Agricultural practices in the Delta may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the Delta entrain fish including juvenile salmonids and green sturgeon. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Delta. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003).

INCREASED URBANIZATION

The Delta, East Bay, and Sacramento regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties, are expected to increase in population by nearly 3 million people by the year 2020. Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. For example, the General Plans for the cities of Stockton, Brentwood, Lathrop, Tracy and Manteca and their surrounding communities anticipate rapid growth for several decades to come. 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 which are situated away from waterbodies, will not require Federal permits, and thus will not undergo review through the ESA section 7 consultation process with NMFS.

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. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and green sturgeon moving through the system. 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.

GLOBAL CLIMATE CHANGE

The world is about 1.3 °F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may rise by two or more degrees in the 21st century (Intergovernmental Panel on Climate Change [IPCC] 2001). Much of that increase likely will occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes 1998). Using objectively analyzed data Huang and Liu (2000) estimated a warming of about 0.9 °F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 to 1.0 meters in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding, and permanent inundation of low-lying natural ecosystems (*e.g.*, salt marsh, riverine, mud flats) affecting salmonid PCEs. Increased winter precipitation, decreased snow pack, permafrost degradation, and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions, and destroy fish and wildlife habitat, including salmon-spawning streams. Glacier reduction could affect the flow and temperature of rivers and streams that depend on glacier water, with negative impacts on fish populations and the habitat that supports them.

Summer droughts along the South Coast and in the interior of the northwest Pacific coastlines will mean decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to overtake native fish species and impact predator-prey relationships (Peterson and Kitchell 2001, Stachowicz *et al.* 2002).

In light of the predicted impacts of global warming, the Central Valley has been modeled to have an increase of between 2 °C and 7 °C by 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, Dettinger 2005), with a drier hydrology predominated by precipitation rather than snowfall. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold-water conditions exist 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 snow pack 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 the dam over the summer and fall periods.

Within the context of the brief period over which the proposed project is scheduled to be constructed, the near term effects of global climate change are unlikely to result in any perceptible declines to the overall health or distribution of the listed populations of anadromous fish within the action area that are the subject of this consultation.

EFFECTS OF THE ACTION

This section describes the anticipated effects of implementing the 2013-2017 TBP on the species and habitats listed in Table 1.

CONSTRUCTION IMPACTS ON FISH

CHINOOK SALMON AND CENTRAL VALLEY STEELHEAD

TEMPORARY ROCK BARRIERS

Adult migrating winter-run Chinook salmon are unlikely to be adversely affected by construction activities associated with implementing the 2013-2017 TBP. This salmon race spawns only in the Sacramento River basin and, therefore, is unlikely to use the south Delta as a migration corridor. Additionally, CDFG fish monitoring data suggests that adult salmon are rare in the south Delta. Large mesh drift nets were used to monitor the presence of fall- and late fall-run adult Chinook salmon during September 1997 and 1998 at Grant Line Canal, Middle River, and Old River at Tracy. In over 74 hours of sampling, only one adult Chinook salmon was captured

Currently, spring-run Chinook salmon also spawn only in the Sacramento River basin, however, an experimental reintroduction of juvenile spring-run salmon is proposed for the San Joaquin River.

Planned releases from 2013-2017 are:

- 2013 - surplus yearling broodstock
- 2014 - 6,000-18,000 hatchery smolts plus surplus yearling broodstock
- 2015 - 37,500-62,500 hatchery smolts and 600-1,800 hatchery yearlings
- 2016 - 60,000-125,000 hatchery smolts and 3,000-6,000 hatchery yearlings
- 2017 - 130,000-200,000 hatchery smolts and 6,000-12,000 hatchery yearlings

No adult spawners are expected to return until 2015 at the earliest and the numbers of returning adults would be very low until 2017 when the first returns from 2014 hatchery smolt releases are expected. Migration paths of the returning adult spring-run salmon from this experimental reintroduction are uncertain, however, some may migrate through the south Delta. Adult migrations of Spring-run Chinook in the Sacramento River begin in Late January and early February, peak in May and June and finish in September. These migration timings are likely to be similar for the reintroduced San Joaquin River population and would coincide with barrier construction which is typically from March to November. The construction of the barriers may take adult spring-run Chinook salmon, however, take is expected to be low because:

- no adult spring-run Chinook salmon are expected to be in this area during construction from 2013 to 2014 as juveniles from the first release would not yet be returning to spawn;
- few adult spring-run Chinook salmon are expected to be in this area during construction from 2015 to 2016 as returning adults would be comprised of the surviving individuals from surplus yearly broodstock released in 2013 and 2014 and of these most are likely to migrate up the San Joaquin river;
- few adult spring-run Chinook salmon are expected to be in this area during construction in 2017 as returning adults would be comprised of the surviving individuals from surplus yearly broodstock released from 2013 to 2015 and of surviving individuals from the 2014 releases of hatchery smolts. Of these few returning adults, most are likely to migrate up the San Joaquin river;
- the effects would be temporary (not to exceed 24 working days for construction at any one barrier);
- 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; and
- most fish are expected to move away from the area of disturbance.

Migration of adult Spring-run Chinook salmon through the south Delta may be temporarily impeded by both the ag-barriers and the spring HOR rock barrier. While passage at the ag-barriers would be stopped during low tides on low flow years, passage over and through the barriers would occur during high tide events. During years with higher flows, migration may not be impeded at all by the ag-barriers as water flows over the barriers at most times. At the spring HOR rock barrier, culverts are in place at all times and are not anticipated to be physically blocked; however, high flows through the culverts may prevent fish passage. Unanticipated maintenance needs, including debris removal, may require slide gate closures. Velocity through the culverts varies based on tide with higher velocities at low tides and lower velocities at high tides. In 2007, water velocity through the barrier culverts was monitored with readings every 15 minutes. Measured water velocities ranged from around 3 ft/s up to 8 ft/s and daily fluctuations were as high as 3 ft/s. 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 could swim through the culverts at all typical velocities, although they may be more likely to swim through at lower velocities.

Juvenile spring-run Chinook salmon migration in the Sacramento River begins in October, peaks from December to February and extends through May. Salvage records from the Delta indicate that approximately 66 percent of the annual spring-run Chinook salmon salvage occurs in April and falls to approximately 15.5 percent of the annual salvage total by May (National Marine Fisheries Service 2008). These migration timings are likely to be similar for the reintroduced San Joaquin River population and this period would coincide with the construction and removal of the barriers. As no naturally produce juvenile spring-run Chinook salmon are likely to be in the San Joaquin River until 2017, migration timing will likely depend on when hatchery-raised smolts and yearlings are released. If migrating juveniles are present in the area during construction activities, take could occur. Construction activities could harm migrating juveniles through actual injury or death from rock placement as well as by limiting migration paths through the south Delta and harassment could occur from construction activities.

The spring installation of the temporary barriers coincides with the peak of the Sacramento River population of Central Valley spring-run Chinook salmon smolt outmigration in the Delta, which occurs primarily in April and May. CVP and SWP salvage records also indicate that Sacramento River winter-run Chinook salmon juveniles are present in the south Delta during early through late spring, with nearly 97 percent of the annual winter-run Chinook salmon salvage occurring in the south Delta by April (National Marine Fisheries Service 2008). Approximately 31 percent of the total annual Central Valley steelhead smolt outmigration takes place during March falling to eight percent in April, as indicated by these salvage data, and incidental catches in salmon monitoring programs indicate that adult Central Valley steelhead may also be present in the south Delta during the spring (California Department of Water Resources 2000b), and most would be located in the San Joaquin River (California Department of Water Resources 2007). Juvenile Central Valley fall-run Chinook salmon are likely to be in the south Delta during the spring barrier installation period, although, based on salvage records the peak salvage occurs in May (Greene 1992). Late fall–run Chinook salmon are likely to be in the south Delta during the fall barrier removal period (Greene 1992).

Heavy earthmoving equipment (e.g., excavators, dozers, and track loaders) would be used on the banks of the rivers and levees to move rock and gravel needed for the construction of the barriers. This type of activity would generate noise that could potentially disturb fish in the immediate area. In addition, the placement of rock below the waterline would also generate noise as well as create a physical disturbance that could potentially harass, injure, kill or displace fish, however, sound monitoring conducted during the 2012 season (Shields, 2012; Appendix C) showed sound levels caused by construction activities were below NMFS adverse behavioral effects thresholds (National Marine Fisheries Service 2009c), therefore, sound impacts are expected to be minimal. Excavating the channel bottom with a dragline and 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 fish populations 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 minimal because they would be temporary, only small areas of the four subject channels would be disturbed or affected by construction, and most fish are expected to move away from the area of disturbance.

Because the MRB weir would be raised in mid-June or early July, it is likely that the majority of outmigrating juvenile Central Valley spring-run and fall-run, as well as Sacramento River winter-run Chinook salmon would have already passed through the TBP area. However, several monitoring programs, including salvage operations at the SWP and CVP facilities, the Mossdale Trawl and incidental catches in salmon monitoring programs, indicate that both adult and juvenile Central Valley steelhead may be present in the south Delta in mid-June and early July when the MRB weir would be raised (California Department of Water Resources 2000b). It is likely, however, that most steelhead would be travelling primarily through the San Joaquin River because the DFG TBP Fish Monitoring Program has not observed a single steelhead outside of the San Joaquin River in over eight years of sampling (California Department of Water Resources 2007). However, due to the lack of information on adult steelhead migration routes and timing, the presence of steelhead near the MRB during the period when the weir is raised cannot be ruled out. SWP salvage records indicate that juvenile steelhead presence in the south Delta peaks in January through May, and then declines significantly into the summer (California Department of Water Resources 2000b).

Construction activities associated with increasing the height of the weir have the potential to harass and displace fish that may be present in the immediate area of the MRB. Construction activities would also generate noise, which could harass fish if they were in the area. It is anticipated that these potential effects would be minimal because:

- few juvenile Chinook salmon or juvenile and adult steelhead are expected to be in this area during construction;
- the effects would be temporary (not to exceed 2 days for construction);
- 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; and
- most fish are expected to move away from the area of disturbance.

NON-PHYSICAL BARRIER

In the years in which DWR opts to install the NPB in place of the spring HORB, the installation and removal of up to eight, 8- or 12-inch diameter steel piles and the bubble curtain structure at the head of Old River has the potential to harass and displace fishes present in the general area of the construction activity. NMFS has established interim criteria for evaluating underwater noise impacts from pile driving on fish. These criteria are defined in the document entitled "Agreement in Principal for Interim Criteria for Injury to Fish from Pile Driving Activities" dated June 12, 2008 (National Marine Fisheries Service 2008). This agreement identifies a peak sound pressure level of 206 decibels (dB) and an accumulated sound exposure level (SEL)[1] of 187 dB as thresholds for

[1] Sound exposure level (SEL) is defined as the constant sound level acting for one second, which has the same amount of acoustic energy as the original sound. Expressed another way, the sound exposure level is a measure of

injury to fish. For fish less than 2 g, the accumulated SEL threshold is reduced to 183 dB. Although there has been no formal agreement on a "behavioral" threshold, NMFS uses 150 dB-RMS as the threshold for adverse behavioral effects (National Marine Fisheries Service 2009c).

Pile driving noise modeling, using NMFS Underwater Noise Calculation Spreadsheet model (National Marine Fisheries Service 2009c), indicates that the installation of the piles would not result in peak sounds greater than 171 dB. The Compendium of Pile Driving Sound Data (California Department of Transportation 2007) provides sound level data on a variety of pile sizes and driver types. Data on vibratory driving of 12-inch piles is available but none is available for 8-inch piles. The 12-inch pile data is considered to be representative for both of the potential sizes of piles (8" or 12") to be used and indicates the following source levels as measured at 10 meters from the pile:

- Peak[2] = 171 dB
- RMS = 155 dB
- Sound exposure level (SEL [for 1 second of vibratory driving]) = 155 dB.

In the absence of site-specific data, NMFS recommends using an underwater attenuation rate of 4.5 dB per doubling of distance (National Marine Fisheries Service 2009c). It also supports the notion that sound levels of less than 150 dB do not contribute the accumulated SEL for the purposes of assessing injury (National Marine Fisheries Service 2009c). Using this assumption and attenuation rate the calculated distance to each of the applicable thresholds is as follows:

- Distance to 206 dB-peak = less than 1 meter
- Distance to 150 dB-RMS = 22 meters
- Distance to 187 dB-$SEL_{accumulated}$ = 21 meters (for fish > 2 g)
- Distance to 183 dB-$SEL_{accumulated}$ = 22 meters (for fish < 2 g)

Results of sound monitoring conducted for a similar project at Georgiana Slough in the Delta have shown that distances to 183 dB- $SEL_{accumulated}$ were significantly less than sounds predicted for HOR (i.e <10 m; Shields, 2012, Appendix C). These low numbers are despite the fact that piles driven at Georgiana Slough are driven deeper than those at HOR (a maximum of 25 feet vs 20 feet deep) and that the substrate at Georgiana Slough was more difficult for the piles to penetrate than the substrate at HOR (Per. Com John Personeni). The 12" piles at Georgiana Slough took from 55 seconds to 490 seconds to place and one to ten piles were placed per day. Accumulated SEL's for stationary fish 10 meters from the pile driving at Georgiana Slough never exceeded 175 dB.

The increased turbidity levels associated with construction may negatively impact fish populations temporarily through reduced availability of food, reduced feeding efficiency, and exposure to toxic sediment released into the water column. These potential effects would be minimal because:

- the effects would be temporary (10 in-water days for installation and 5 in-water days for removal);

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the sound energy in a single pile driver strike. Accumulated SEL (SEL accumulated) is the cumulative SEL resulting from successive pile strikes. $SEL_{accumulated}$ is based on the number of pile strikes and the SEL per strike; the assumption is made that all pile strikes are of the same SEL.

[2] Peak sound pressure refers to the highest absolute value of a measured waveform (i.e., sound pressure pulse as a function of time).

- a vibratory method of pile installation would be used which minimizes disturbances to fish over other impact-type pile driving methods;
- for most activities, the effects of pile driving noise on fish would likely be limited to avoidance behavior in response to movements, noises, and shadows caused by construction personnel and equipment operating in or adjacent to the water body. Additionally, the duration of pile driving would be minimal and would require less than 80 minutes to complete;
- only a very small channel area would be disturbed or affected by construction; and
- most fish are expected to move away from the area of disturbance.

The placement of the NPB with the signage, concrete anchors and pier blocks associated with it will temporarily impact a maximum of 288 ft^2 of the river bed (8-12" piles, 30-2'x2' pier blocks and 40-2'x2' concrete anchors). These temporary impacts from the placement of this equipment will be placed for no more than 5 months and the substrate is expected to return to pre-project conditions after removal of the anchors, stands and piles.

BARRIER CULVERT REPLACEMENT

Juvenile spring-run and winter-run Chinook salmon and Central Valley steelhead could potentially occur in the project area during the necessary replacement of the GLC and MR barrier culverts and associated structures. The effects of construction-related activities associated with the replacement of the barrier culverts and associated structures on Chinook salmon and steelhead would be similar to that described above for the installation of the temporary rock barriers. These potentially adverse effects would be minimal because:

- The culverts only need replacement every 10 to 15 years and will not likely be replaced from 2013-2017;
- few Spring-run or Winter-run Chinook salmon or steelhead are expected to be in this area while construction activities are taking place;
- culverts would be replaced by completely removing the barrier, culverts and abutments in October and November along with the regular barrier removal. The following year new culverts and abutments would be placed immediately preceding the barrier construction;
- the effects would be temporary;
- only a relatively small area of the channel would be disturbed or affected by construction;
- 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; and
- most fish are expected to move away from the area of disturbance.

SOUTHERN DPS OF NORTH AMERICAN GREEN STURGEON

Adult green sturgeon use the upper Sacramento River for spawning from February through July (U.S. Fish and Wildlife Service 1995), and spend most of their lives in the ocean when not spawning (Moyle 2002). Thus, as supported by the historical record, adults are rare in the interior Delta, and are not expected to be present near the temporary barriers during the spring barrier installation period. Juveniles or sub-adults, however, may be present as they rear year-round in the Delta. There are no estimates of the number of individuals rearing in the south Delta (National Marine Fisheries Service 2009b), however, DFG sturgeon report card data reports only 6 green sturgeon captures in the San Joaquin River upstream of Stockton and no green sturgeon captures in Old River from 2007-2011. Juvenile green sturgeon are routinely collected at the SWP and CVP salvage facilities throughout the year (National Marine Fisheries Service 2009b), however, these salvage rates are extremely low (66 total individuals since 1993). Salvage records indicate that sub-adult green sturgeon may be present during any month of the year, but are especially prevalent from July through October; these fish range in size from 42 millimeters (mm) to 744 mm. Although there could be green sturgeon in the vicinity of the TBP construction, the likelihood is extremely low.

The effects on green sturgeon of construction-related activities associated with the installation of the temporary rock barriers (including the MRB raise) and the NPB, as with the replacement of the GLC barrier culverts, 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, minimal, if any, adverse effects are expected to negatively impact green sturgeon for the reasons previously described for salmonid species.

TEMPORARY BARRIERS PROJECT FISH STUDY

Impacts from the TBP fish study will be relatively small in area and will be comprised of placement of up to 50 anchors made from sections of railroad track, up to 10 weighted stands and one scientific pile. These anchors will be used for placing equipment such as hydrophones, ADCP's and DIDSON cameras. Each railroad track anchor is approximately 24 inches x 6 inches, each weighted stand is approximately 3 feet by 3 feet and the scientific pile would be at most a 12 inch diameter steel pipe. The total substrate impacted by the placement of the maximum number of all of these structures would be 141 ft^2 and all structures would temporarily affect the river bottom at the location placed. The placement of the scientific equipment on these anchors will have no effects on listed fish species as they will be affixed to the anchors so they would point in a specific direction (ADCP's and DIDSON cameras) or float freely in the water column (Hydrophones). As no impacts from the scientific equipment are anticipated, other different technologies may be utilized if the need arises to obtain data on and improve the understanding of listed species or predatory fish in the vicinity of the TBP. Scientific equipment will be placed for no more than five months and the substrate is expected to return to pre-project conditions after removal of the anchors, stands and pile. The scientific pile will only be placed in years that the NPB is installed and impacts associated with the vibratory driving have been assessed in the "Non-Physical Barrier" effects section of this document.

ELECTROFISHING IMPACTS ON FISH

CHINOOK SALMON AND CENTRAL VALLEY STEELHEAD

As previously described, there is the potential for juveniles from the Central Valley spring- and fall-run, and Sacramento River winter-run Chinook salmon ESUs, adults from the San Joaquin river experimental Central Valley spring-run Chinook Salmon population (2017 only), as well as juvenile and adult Central Valley steelhead to be present in the predator fish sampling areas near the temporary barriers during the 3-month spring sampling period. Should adult or juvenile Chinook salmon or steelhead be inadvertently shocked by the electrofishing equipment, incidental take would occur. However, the likelihood of take is low because:

- prior to the start of sampling each day, water temperature and conductivity measurements will be taken to evaluate electroshocker settings and adjustments will be made if necessary;
- electrofishing would not be conducted when EC is above 1500 µS/cm;
- electrofishing would not occur when 600 Volts (V) produces less than 6 amps;
- in areas where large amounts of aquatic vegetation interfere with the electrical field, electrofishing would range from 200 V to 600 V at 60 pulses per second and settings would be adjusted to maintain approximately 8 amps;
- in areas without large amounts of aquatic vegetation electrofishing would range from 200 V to 400 V at 60 pulses per second and settings would be adjusted to maintain approximately 6 amps;
- the electrofishing equipment would target large fish using pulse DC (PDC) only;
- it is unlikely that juvenile Chinook salmon or juvenile steelhead would be in the immediate vicinity of the predatory fish as salmonid smolts tend to quickly move through areas while predatory fish tend to find favorable currents where they can catch prey as it passes by;
- it is unlikely that adult steelhead would be in the immediate vicinity of the predatory fish due to extremely low densities of steelhead. Mossdale Trawl data from 1994 to 2011 showed captures of only 139 steelhead;
- if present, juvenile Chinook salmon are unlikely to be affected by the electrofishing equipment because the voltage drop on small smolts is much less than that of large predatory fish;
- electrofishing would be conducted only occasionally, occurring at most once per week near each of the study areas for a three-month period.

If adult or juvenile Chinook salmon or steelhead were inadvertently shocked by the electrofishing equipment measures will be put in place to reduce mortality of these individuals. These measures are:

- field staff will be trained to quickly identify listed species and would release live fish to minimize handling stress;
- any listed species will be measured, recorded and released at the location caught.
- adult steelhead or Chinook salmon will be held under the water until they recover and then they will be released; and
- juvenile steelhead or Chinook salmon will be placed in a bucket full of water until they recover and then they will be released.

SOUTHERN DPS OF NORTH AMERICAN GREEN STURGEON

As previously described, it is unlikely that adult green sturgeon would be in the fish sampling areas near the temporary barriers and the possibility of juvenile and sub-adults being present during the 3-month spring sampling period is low.

Should juvenile or sub-adult green sturgeon be inadvertently shocked by the electrofishing equipment, incidental take would occur. However, the likelihood of take is low because:

- prior to the start of sampling each day, water temperature and conductivity measurements will be taken to evaluate electroshocker settings and adjustments will be made if necessary;
- electrofishing would not be conducted when EC is above 1500 µS/cm;
- electrofishing would not occur when 600 Volts (V) produces less than 6 amps;
- in areas where large amounts of aquatic vegetation interfere with the electrical field, electrofishing would range from 200 V to 600 V at 60 pulses per second and settings would be adjusted to maintain approximately 8 amps;
- in areas without large amounts of aquatic vegetation electrofishing would range from 200 V to 400 V at 60 pulses per second and settings would be adjusted to maintain approximately 6 amps;
- densities of green sturgeon in the south Delta and San Joaquin riverare so low that individuals are highly unlikely to be in the sampling areas during sampling;
- electrofishing would be conducted only occasionally, occurring at most once per week near each of the study areas for a three-month period.

Mortality of green sturgeon from electrofishing is highly unlikely to occur as it is unlikely that green sturgeon will be in vicinity of the electrofishing and as white sturgeon shocked in Suison Marsh at 8 amps have recovered quickly (pers com. M. Young). If green sturgeon were inadvertently shocked by the electrofishing equipment measures will be put in place to reduce mortality of these individuals. These measures are:

- field staff will be trained to quickly identify listed species and would release live fish to minimize handling stress;
- any listed species will be measured, recorded and released at the location caught.
- the electrofishing equipment would use pulse DC (PDC) only; and
- green sturgeon will be held under the water until they recover and then they will be released.

FYKE NETTING IMPACTS ON FISH

CHINOOK SALMON AND CENTRAL VALLEY STEELHEAD

As previously described, there is the potential for juveniles from the Central Valley spring- and fall-run, and Sacramento River winter-run Chinook salmon ESUs, adults from the San Joaquin river experimental Central Valley spring-run Chinook Salmon population (2017 only), as well as juvenile and adult Central Valley steelhead to be present in the predator fish sampling areas near the temporary barriers during the 3-month spring sampling period. Should adult or juvenile Chinook salmon or steelhead be trapped by fyke netting equipment, incidental take would occur. If listed salmonids are trapped efforts would be made to minimize trapping and handling mortality by:

- following procedures used by the DFG Adult Striped Bass Monitoring Project;
- removing accumulated debris from the fyke net;
- using a live well, coolers, or quickly sorting fish into wet containers;
- making efforts to remove listed salmonids before other non-listed fish;
- measuring and immediately releasing listed salmonids trapped in the fyke nets to minimize handling stress;
- keeping hands or surgical gloves wet to minimize disruption of the mucous layer;
- soaking fyke traps for less than 24 hours before retrieving the catch; and
- leaving a portion of the fyke net in the water to minimize fish stress during catch processing.

Although every effort may be made to return all fish back to the site alive, some mortality is inevitable, however, fyke netting has been shown to cause significantly less stress to fish than other netting methods such as gill netting (Hopkins, 2011). Fyke netting mortality to striped bass from the past five years of the DFG Adult Striped Bass Monitoring Project ranged between 0 to 16 fish per year, which is a 0% to 0.24% mortality rate. It was noted that salmonid bycatch was 45 Chinook salmon and 2 steelhead in 2008, 2 chinook salmon in 2009, 1 Chinook Salmon in 2010, 6 Chinook salmon in 2011 and 37 Chinook salmon and 1 steelhead in 2012. Salmonids were caught throughout the sampling season with their condition varying from good to excellent. Capture and mortality to listed salmonids will be documented and reported to the NMFS and all sampling will stop when take levels are reached.

SOUTHERN DPS OF NORTH AMERICAN GREEN STURGEON

As previously described, it is unlikely that adult green sturgeon would be in the fish sampling areas near the temporary barriers and the possibility of juvenile and sub-adults being present during the 3-month spring sampling period is low. Should juvenile or sub-adult green sturgeon be trapped by fyke netting equipment, incidental take would occur. If green sturgeon are trapped, efforts would be made to minimize trapping and handling mortality by:

- removing accumulated debris from the fyke net;
- using a live well, coolers, or quickly sorting fish into wet containers;
- making efforts to remove green sturgeon before other non-listed fish;
- measuring and immediately releasing green sturgeon trapped in the fyke nets to minimize handling stress;
- keeping hands or surgical gloves wet to minimize disruption of the mucous layer;
- soaking fyke traps for less than 24 hours before retrieving the catch; and
- leaving a portion of the fyke net in the water to minimize fish stress during catch processing.

Although every effort may be made to return all fish back to the site alive, some mortality is inevitable, however, fyke netting has been shown to cause significantly less stress to fish than other netting methods such as gill netting (Hopkins, 2011). Fyke netting mortality to striped bass from the past five years of the DFG Adult Striped Bass Monitoring Project ranged between 0 to 16 fish per year, which is a 0% to 0.24% mortality rate. It was noted that DFG captured only 4 green sturgeon in 2008, 0 from 2009-2011 and 1 in 2012 in the fyke nets placed for the DFG Adult Striped Bass Monitoring Project and all were released alive. These nets were placed in the Sacramento River where green sturgeon are much more likely to occur. Capture and mortality to green sturgeon will be documented and reported to the NMFS and all sampling will stop when take levels are reached.

HOOK AND LINE FISHING IMPACTS ON FISH

CHINOOK SALMON AND CENTRAL VALLEY STEELHEAD

As previously described, there is the potential for juveniles from the Central Valley spring- and fall-run, and Sacramento River winter-run Chinook salmon ESUs, adults from the San Joaquin river experimental Central Valley spring-run Chinook Salmon population (2017 only), as well as juvenile and adult Central Valley steelhead to be present in the predator fish sampling areas near the temporary barriers during the 3-month spring sampling period. Should adult or juvenile Chinook salmon or steelhead be captured during hook and line sampling, incidental take would occur. Capture rates of listed salmonids would likely be extremely low because:

- Fishing methods will be chosen to target larger predatory fish;
- Adult Chinook salmon tend to not feed when migrating to their spawning grounds;
- Juvenile Chinook salmon and most of the juvenile steelhead would be too small to bite the types of lures and bait used; and
- Hook and line sampling has been conducted for the past 3 years at the head of Old river and no listed salmonids were captured.

SOUTHERN DPS OF NORTH AMERICAN GREEN STURGEON

As previously described, it is unlikely that adult green sturgeon would be in the fish sampling areas near the temporary barriers and the possibility of juvenile and sub-adults being present during the 3-month spring sampling period is low. Should juvenile or sub-adult green sturgeon be captured by hook and line fishing, incidental take would occur. Capture rates of green sturgeon would likely not occur because:

- Fishing methods will be chosen to target larger predatory fish and to avoid capture of green sturgeon;
- Hook and line sampling has been conducted for the past 3 years at the head of Old river and no green sturgeon were captured; and
- DFG sturgeon report card data suggests that fisherman rarely catch green sturgeon in the vicinity of the TBP.

IMPACTS ON CRITICAL HABITAT

CENTRAL VALLEY STEELHEAD

NMFS designated critical habitat for Central Valley steelhead September 2, 2005 (70 FR 52488). The Delta was included in the designated critical habitat area. In general, critical habitat is defined as specific areas that contain the primary constituent elements (PCEs) and habitat elements essential to the conservation of the species. PCEs for the Central Valley steelhead include the following four elements: spawning habitat; freshwater rearing habitat; freshwater migration corridors; and estuarine areas. The south Delta provides primarily rearing habitat and freshwater migration corridors for steelhead (National Marine Fisheries Service 2009b).

TEMPORARY ROCK BARRIERS AND NPB

The effects of rock barrier installation and removal on physical habitat would be limited to the footprint area of each of the four rock barriers as shown in Table 12. Although the replacement of the GLC barrier culverts are not likely to occur from 2013 to 2017 and sediment removal does not occur in most years, it is expected that the effects associated with replacement and GLC sediment removal on physical habitat would be limited to the 0.34 acres and 0.1 acres, respectively.

The duration of the physical covering of the channel bottom by the rocks of the three agricultural barriers lasts approximately eight months each year. The spring HORB is in place for an approximate 60-day period, and the fall HORB may remain in the channel for up to 60 days. Disturbance of the channel substrate due to the annual installation and removal of the temporary barriers, and, to a lesser extent, due to any periodic sediment removal activities, would likely prevent the establishment of a normal climax benthic community within the four barriers' footprints, and non-native species, capable of rapidly colonizing the disturbed substrate, would be favored.

TABLE 12: BARRIER FOOTPRINTS

Barrier	Footprint (acres)
Spring Head of Old River[1]	0.44
Old River at Tracy	0.34
Grant Line Canal	0.34
Middle River	0.31
Total	**1.43**

[1] The footprint of the fall HORB is approximately 0.34 acres.

The installation of the NPB would temporarily impact up to 0.01 acre of channel bottom. The surface area affected by the piles would account for up to 8 square feet of channel substrate and the additional impacts will be due to concrete anchor blocks (40 x 4 ft^2 = 160 ft^2) and concrete pier blocks (30 x 4 ft^2 = 120 ft^2) that will be temporarily set on top of the substrate in order to fasten down the BAFF and other related equipment. The barrier would only impact channel habitat for up to three months, after which, the barrier, piles and concrete anchors would be removed. As such, there would be no substantial effects on steelhead critical habitat.

The installation of the temporary rock barriers would likely affect approximately 25 miles of waterways lying between the four barriers. The changes in the length of the period of inundation during each tidal cycle, as reflected by the differences between barrier installation season and the no-barriers condition in winter, would likely affect the natural communities (e.g., vegetation community) in the subject south Delta channels. When the rock barriers are in place, the tidal range is muted, and the lower end of the range is held artificially high (3.3 NAVD88). The intertidal range is reduced and vegetation that is typically exposed under normal low tide becomes submerged during the period when the barriers are operating. Additionally, hydrological changes would affect the ability of migrating salmonids to freely pass through the area due to flow impediments created by the rock barriers. The rock barriers also create impediments to free movement of fish within the channels of the south Delta. They may also 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 steelhead critical habitat in the south 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. 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).

TEMPORARY BARRIERS PROJECT FISH STUDY

Impacts from the TBP fish study will be relatively small in area and will be comprised of placement of up to 50 anchors made from sections of railroad track, up to 10 weighted stands and one scientific pile. These anchors will be used for placing equipment such as hydrophones, ADCP's and DIDSON cameras. Each railroad track anchor is approximately 24 inches x 6 inches, each weighted stand is approximately 3 feet by 3 feet and the scientific pile would be at most a 12 inch diameter steel pipe. The total substrate impacted by the placement of the maximum number of all of these structures would be 141 ft^2 and all structures would temporarily affect the river bottom at the location placed. The placement of the scientific equipment on these anchors will have no effects on Central Valley steelhead Critical Habitat as they will be affixed to the anchors so they would point in a specific direction (ADCP's and DIDSON cameras) or float freely in the water column (Hydrophones). As no impacts from the scientific equipment are anticipated, other different technologies may be utilized if the need arises to obtain data on and improve the understanding of listed species or predatory fish in the vicinity of the TBP. Scientific equipment will be placed for no more than five months and the substrate is expected to return to pre-project conditions after removal of the anchors, stands and pile.

ELECTROFISHING

Electrofishing for predatory fish in areas near the temporary barriers is not expected to have an adverse effect on these PCEs. This activity would be conducted only occasionally, occurring at most once per week near each of the study sites for a three-month period.

SOUTHERN DPS OF NORTH AMERICAN GREEN STURGEON

TEMPORARY ROCK BARRIERS AND NPB

NMFS designated critical habitat for North American green sturgeon (southern DPS) on October 9, 2009 (74 FR 52300). The Delta was included in the designated critical habitat area. PCEs for the southern DPS of green sturgeon include the following six elements: food resources; water flow; water quality; migratory corridors; water depth; and sediment quality. The south Delta includes PCEs concerned with: food resources; water flows sufficient to allow adults, sub-adults, and juveniles to orient to flows for migration; migratory corridors for all life-stages using the Delta; water depths to accommodate the needs of different life-stages in the estuary; and sediment with adequately low contaminant loads (National Marine Fisheries Service 2009b).

As previously described, water quality, hydrodynamics, and passage could potentially be affected by 2013-2017 TBP project construction. However, these effects are expected to have minimal impact 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 (National Marine Fisheries Service 2008) 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 from construction would be minimal.

TEMPORARY BARRIERS PROJECT FISH STUDY

Impacts from the TBP fish study will be relatively small in area and will be comprised of placement of up to 50 anchors made from sections of railroad track, up to 10 weighted stands and one scientific pile. These anchors will be used for placing equipment such as hydrophones, ADCP's and DIDSON cameras. Each railroad track anchor is approximately 24 inches x 6 inches, each weighted stand is approximately 3 feet by 3 feet and the scientific pile would be at most a 12 inch diameter steel pipe. The total substrate impacted by the placement of the maximum number of all of these structures would be 141 ft^2 and all structures would temporarily affect the river bottom at the location placed. The placement of the scientific equipment on these anchors will have no effects on southern DPS of North American green sturgeon Critical Habitat as they will be affixed to the anchors so they would point in a specific direction (ADCP's and DIDSON cameras) or float freely in the water column (Hydrophones). As no impacts from the scientific equipment are anticipated, other different technologies may be utilized if the need arises to obtain data on and improve the understanding of listed species or predatory fish in the vicinity of the TBP. Scientific equipment will be placed for no more than five months and the substrate is expected to return to pre-project conditions after removal of the anchors, stands and pile.

ELECTROFISHING

Electrofishing for predatory fish in areas near the temporary barriers is not expected to have an adverse effect on these PCEs. This activity would be conducted only occasionally, occurring at most once per week near each of the study sites for a three-month period.

IMPACTS 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.

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 the south Delta area where 2013-2017 TBP would be implemented.

TEMPORARY ROCK BARRIERS AND NPB

The effects of the proposed action on salmonid habitat have been described previously, and generally are expected to apply to Chinook salmon EFH. Installation of the temporary rock barriers may degrade certain functional habitat characteristics of the starry flounder (i.e., free movement of fish, passage obstructions, alterations of water quality parameters, and creation of lentic conditions) during the eight months the barriers are in place annually. The remaining four months of the year (December through March) would allow for some recovery of habitat conditions, including free movement of fish through the channels of the south Delta, and enhancement of water quality parameters related to flow patterns and tidal exchange. The changes in habitat associated with the installation and operation of the NPB, in the years in which it would be installed, would be temporary, lasting up to 60 days and would be limited to a very small area of the total habitat area for these two species. Passage of starry flounder migrating in south Delta channels would be affected should they approach the NPB. However, they could continue their migration in and out of the south Delta using other channels. Sediment removal at the barrier sites would be periodic, and would disturb a relatively small area of the channel bottom, as previously described. The northern anchovy and starry flounder are primarily marine and estuarine species. There are no records of northern anchovy salvage at the CVP or SWP fish salvage facilities and, as such, no impacts to northern anchovy EFH are anticipated to result from the construction of the 2013-2017 TBP. However, CVP and SWP salvage data indicates that salvage of starry flounder does occur. Most salvage occurs in May through July, and the majority of the salvaged flounder are young-of-the-year (U.S. Department of the Interior 2008). Effects of the 2013-2017 TBP on starry flounder EFH would be minimal.

TEMPORARY BARRIERS PROJECT FISH STUDY

Impacts from the TBP fish study will be relatively small in area and will be comprised of placement of up to 50 anchors made from sections of railroad track, up to 10 weighted stands and one scientific pile. These anchors will be used for placing equipment such as hydrophones, ADCP's and DIDSON cameras. Each railroad track anchor is approximately 24 inches x 6 inches, each weighted stand is approximately 3 feet by 3 feet and the scientific pile would be at most a 12 inch diameter steel pipe. The total substrate impacted by the placement of the maximum number of all of these structures would be 141 ft^2 and all structures would temporarily affect the river bottom at the location placed. The placement of the scientific equipment on these anchors will have no effects on Essential Fish Habitat as they will be affixed to the anchors so they would point in a specific direction (ADCP's and DIDSON cameras) or float freely in the water column (Hydrophones). As no impacts from the scientific equipment are anticipated, other different technologies may be utilized if the need arises to obtain data on and improve the understanding of listed species or predatory fish in the vicinity of the TBP. Scientific equipment will be placed for no more than five months and the substrate is expected to return to pre-project conditions after removal of the anchors, stands and pile.

ELECTROFISHING

Effects on the EFH for starry flounder, northern anchovy, and Chinook salmon would be minimal. The changes in habitat, which would be limited to a relatively small area in the water to which an electric current is applied, would be temporary and would be limited to a very small fraction of the total habitat area for these species. Passage of anchovy or starry flounder through the south Delta is unlikely to be affected by electrofishing in the area of the temporary barriers. As previously described, the electrofishing equipment would be programmed to target fish significantly larger than anchovy, and generally, starry flounder found as far upstream as the south Delta are young-of-the-year (Moyle 2002), and therefore would likely be smaller than the predatory fish targeted during electrofishing. Similarly, as described above, outmigration of juvenile Chinook salmon is unlikely to be affected by electrofishing for predatory fish due to their relatively small size and the low likelihood that they would be holding in the immediate vicinity of predatory fish. Moreover, electrofishing would occur at most only once per week near each of the study sites for a three-month period. As such, there would be no substantial changes in EFH.

CONSERVATION MEASURES

CONTINUE EXISTING MEASURES

DWR will continue implementation of all applicable monitoring, avoidance, minimization, and compensation measures required as part of the Action-Specific Implementation Plan (ASIP) BIOPs issued in 2001 for the TBP and referenced by the recent BIOPs (U.S. Fish and Wildlife Service 2008, 2009a, and 2009b; National Marine Fisheries Service 2008, 2009a, 2009b, and 2011).

PREVIOUS CONSERVATION

In accordance with requirements issued in the 2011 ITP (ITP # 2801-2011-019-03) DWR purchased 6.0 acres of shallow water habitat credits for the South Delta TBP. DWR utilized a credit of 1.25 acres left over from the Kimball Island Mitigation Bank and an additional 4.75 acres of shallow water habitat credits was purchased at the Liberty Island Conservation Bank. DWR also purchased 1.0 acre of Floodplain Riparian Habitat credit at the Cosumnes Floodplain Mitigation Bank to mitigate impacts to Swainson's Hawks.

WORKER ENVIRONMENTAL AWARENESS PROGRAM

Construction personnel will participate in a NMFS-approved worker environmental awareness program as has been done in previous years (Appendix D). Under this program, workers will be informed about the presence of NMFS-listed fish species and habitat associated with the species and that unlawful take of the animal or destruction of its habitat is a violation of the ESA. Prior to construction activities, a qualified biologist(s) approved by NMFS will instruct all construction personnel about the life history of Chinook salmon, Central Valley steelhead, and the North American green sturgeon southern DPS. Proof of this instruction will be submitted to the NMFS Sacramento Office.

CONDUCT PILE DRIVING WITH A VIBRATORY DRIVER

DWR is committed to conducting all 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 reduces the distance that noise exceeds NMFS thresholds by almost 1,000 feet from the area of impact, substantially reducing or avoiding the potential to cause take of listed species.

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 while the barriers are installed. In addition, DWR will place sand bags, bio-logs, 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 rivers or channels.

TEMPORARY BARRIERS PROJECT FISH STUDY

The fish study will be developed to avoid take of listed fish. Consistent with the previous Fish Monitoring Programs, the following measures will be used to minimize the effects of loss and disturbance of habitat on Chinook salmon, Central Valley steelhead, and the southern DPS of the North American green sturgeon:

- Any listed species caught alive will be handled as little as possible, have length and condition/coloration estimated visually and recorded, and immediately released at the location caught;
- Any dead listed species will be disposed according to procedures listed under the take authorization. Take information will be reported as a supplemental report at the end of the sampling period;
- Field staff will be trained to quickly identify listed species and release live fish to minimize handling stress.

Measures to minimize take of listed fish during passive sampling, i.e., fyke trapping will follow procedures used by the DFG Adult Striped Bass Monitoring Project. These measures include:

- Soaking fyke traps for less than 24 hours before retrieving the catch;
- Ensuring that a portion of the fyke trap remains in the water to minimize fish stress during catch processing;

If sampling is likely to produce a variance of expected take, project staff will notify and consult with the appropriate regulatory agencies (NMFS and DFG). If actual take exceeds estimated take, project staff will cease sampling and await ESA consultation.

CONCLUSION

Based on the information presented within this BA, the California Department of Water Resources has determined that the Temporary Barriers Project, with all of the components described in the "Description of Proposed Action" section of this document is likely to have the following effects on NMFS regulated ESA listed species and their Critical Habitats:

TABLE 13: EFFECT DETERMINATIONS OF NMFS REGULATED SPECIES FOR THE TEMPORARY 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
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

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.

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APPENDIX A: FIGURES

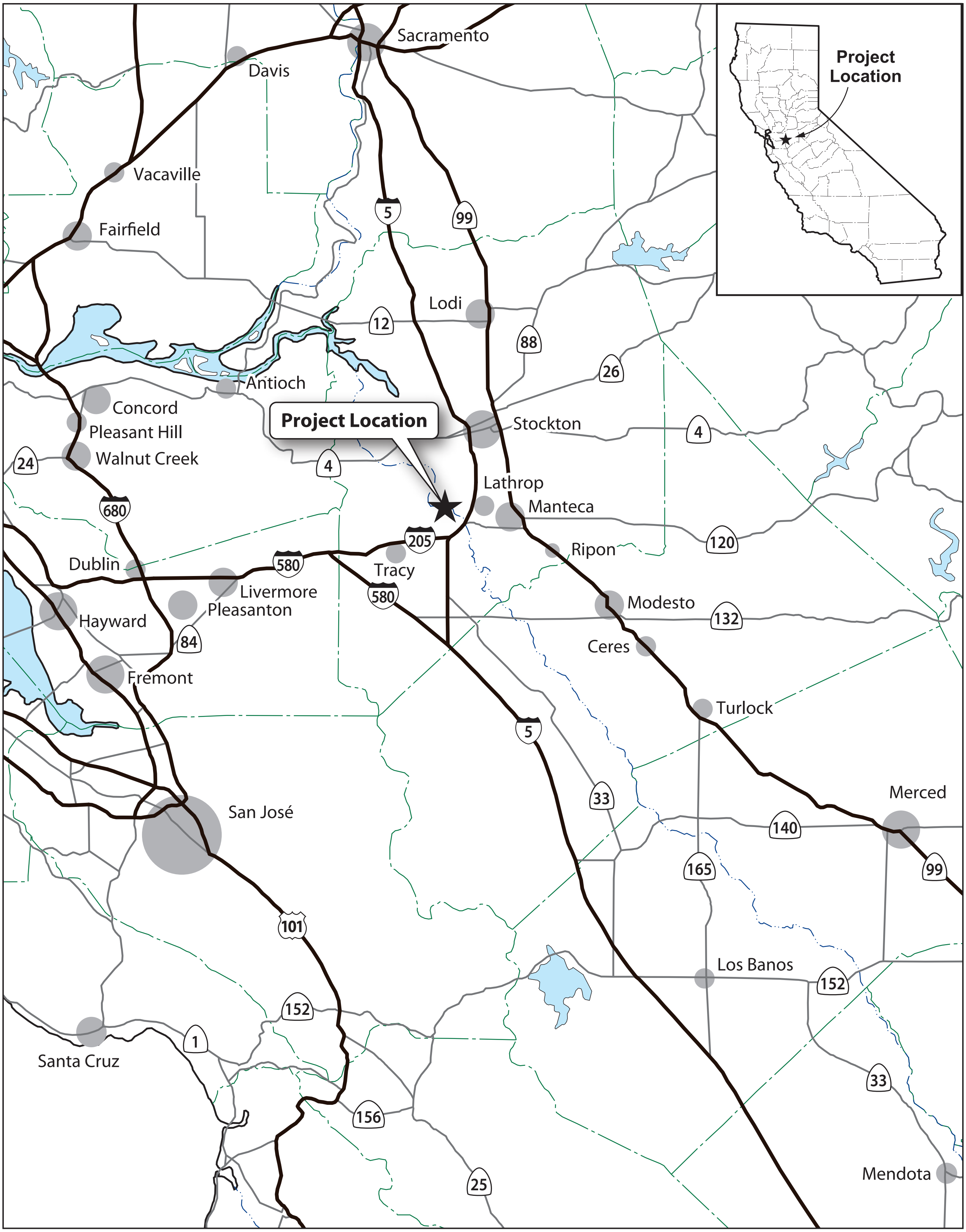
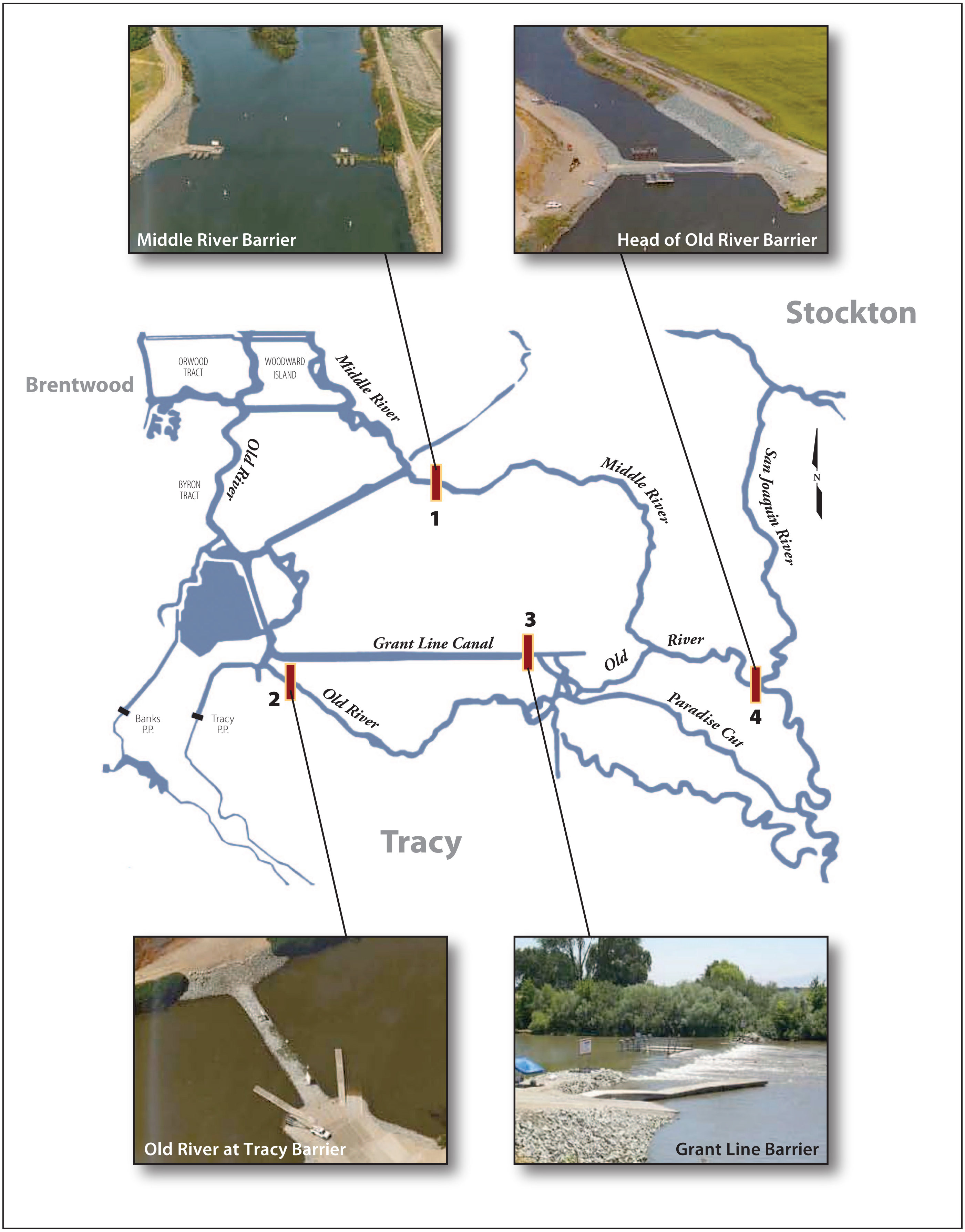


Figure 1
Project Vicinity

Graphics/Projects/00135.10 Permitting TBP (11-11) JD



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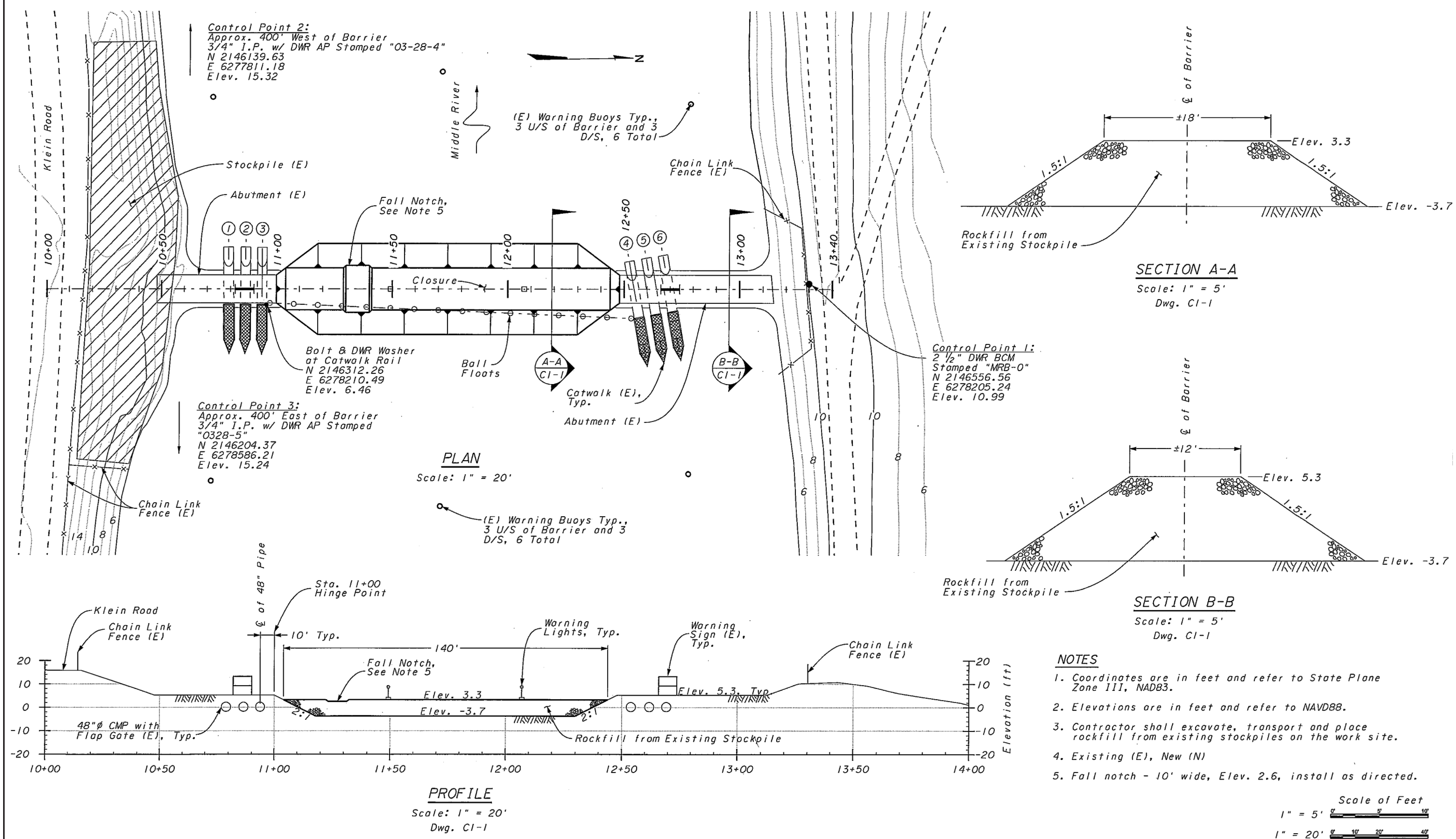
ICF INTERNATIONAL

Figure 2
Project Location Map

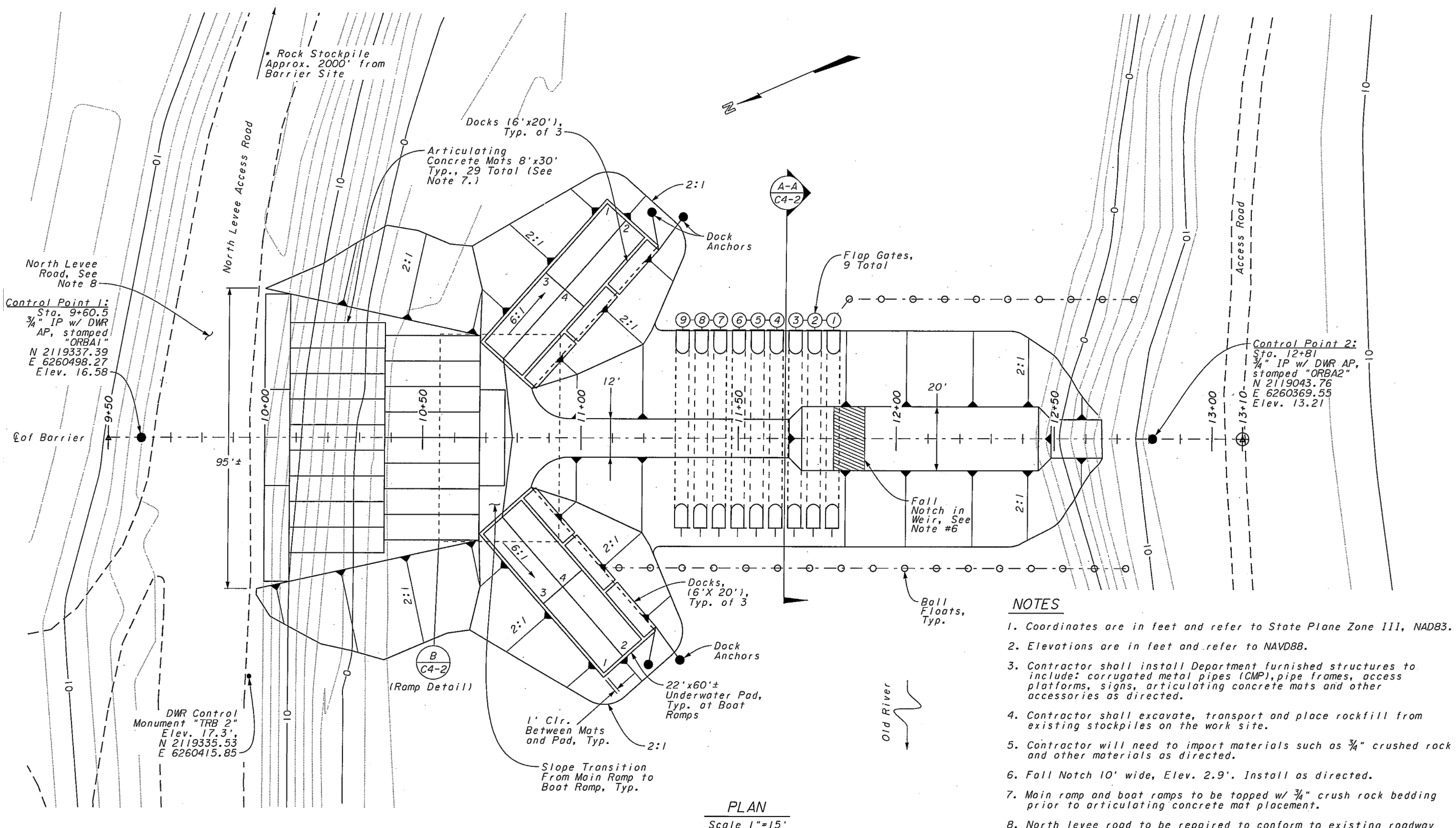


NOTES

1. Coordinates are in feet and refer to State Plane Zone III, NAD83.
2. Elevations are in feet and refer to NAVD88.
3. Contractor shall excavate, transport and place rockfill from existing stockpiles on the work site.
4. Existing (E), New (N)
5. Fall notch - 10' wide, Elev. 2.6, install as directed.

Graphics...00135.10 Permits TPB (11-2011) JD

Figure 3
Middle River Barrier
Plan, Profile, and Sections



PLAN
Scale 1"=15'

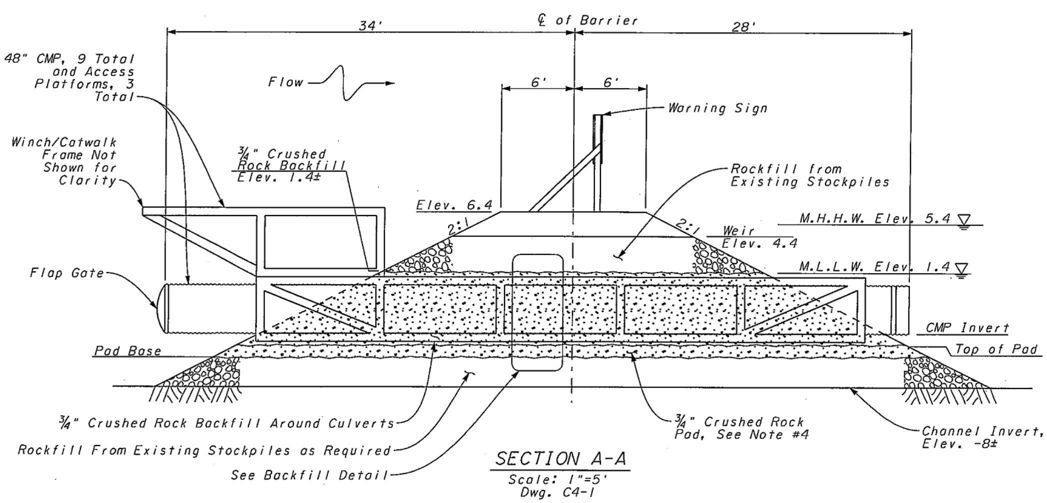
NOTES

1. Coordinates are in feet and refer to State Plane Zone III, NAD83.
2. Elevations are in feet and refer to NAVD88.
3. Contractor shall install Department furnished structures to include: corrugated metal pipes (CMP), pipe frames, access platforms, signs, articulating concrete mats and other accessories as directed.
4. Contractor shall excavate, transport and place rockfill from existing stockpiles on the work site.
5. Contractor will need to import materials such as ¾" crushed rock and other materials as directed.
6. Fall Notch 10' wide, Elev. 2.9'. Install as directed.
7. Main ramp and boat ramps to be topped w/ ¾" crush rock bedding prior to articulating concrete mat placement.
8. North levee road to be repaired to conform to existing roadway 75' upstream and 75' downstream of barrier centerline, as directed.

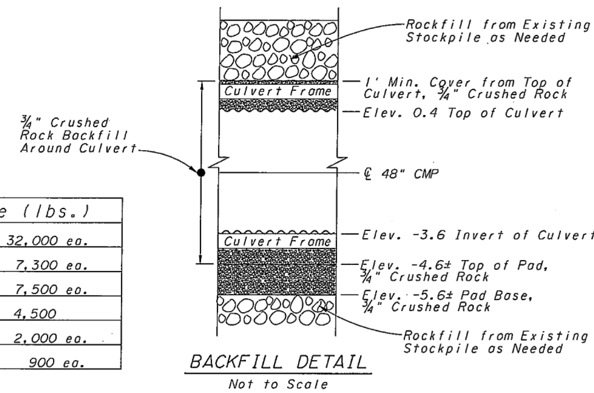
Scale of Feet
1"=15' 0' 15' 30'

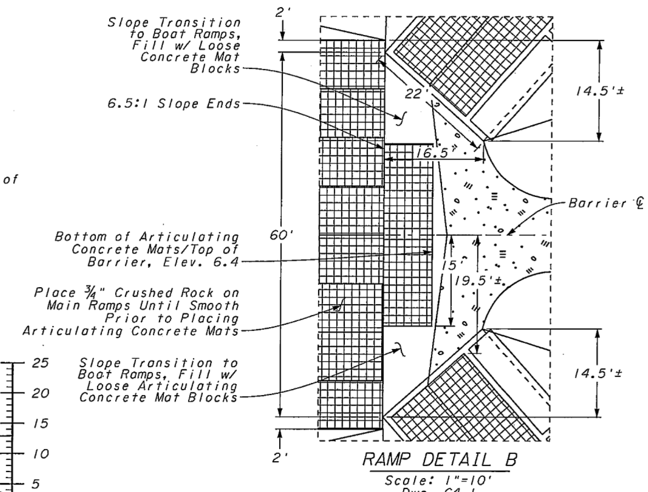
Graphics...00135.10 Permits TBP (11-2011) JD

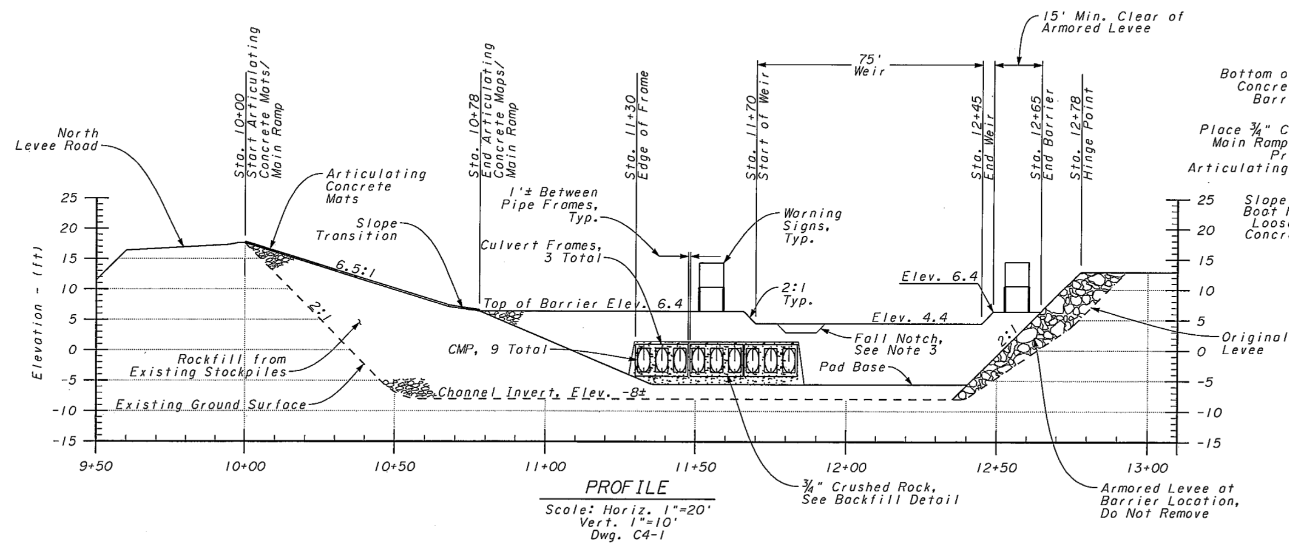
Figure 4a
Old River Near Tracy Barrier
Plan



Weight Table (lbs.)	
Culvert Frame	32,000 ea.
Catwalk	7,300 ea.
Articulating Mats	7,500 ea.
Mat Spreader Bar	4,500
Docks	2,000 ea.
Dock Anchors	900 ea.







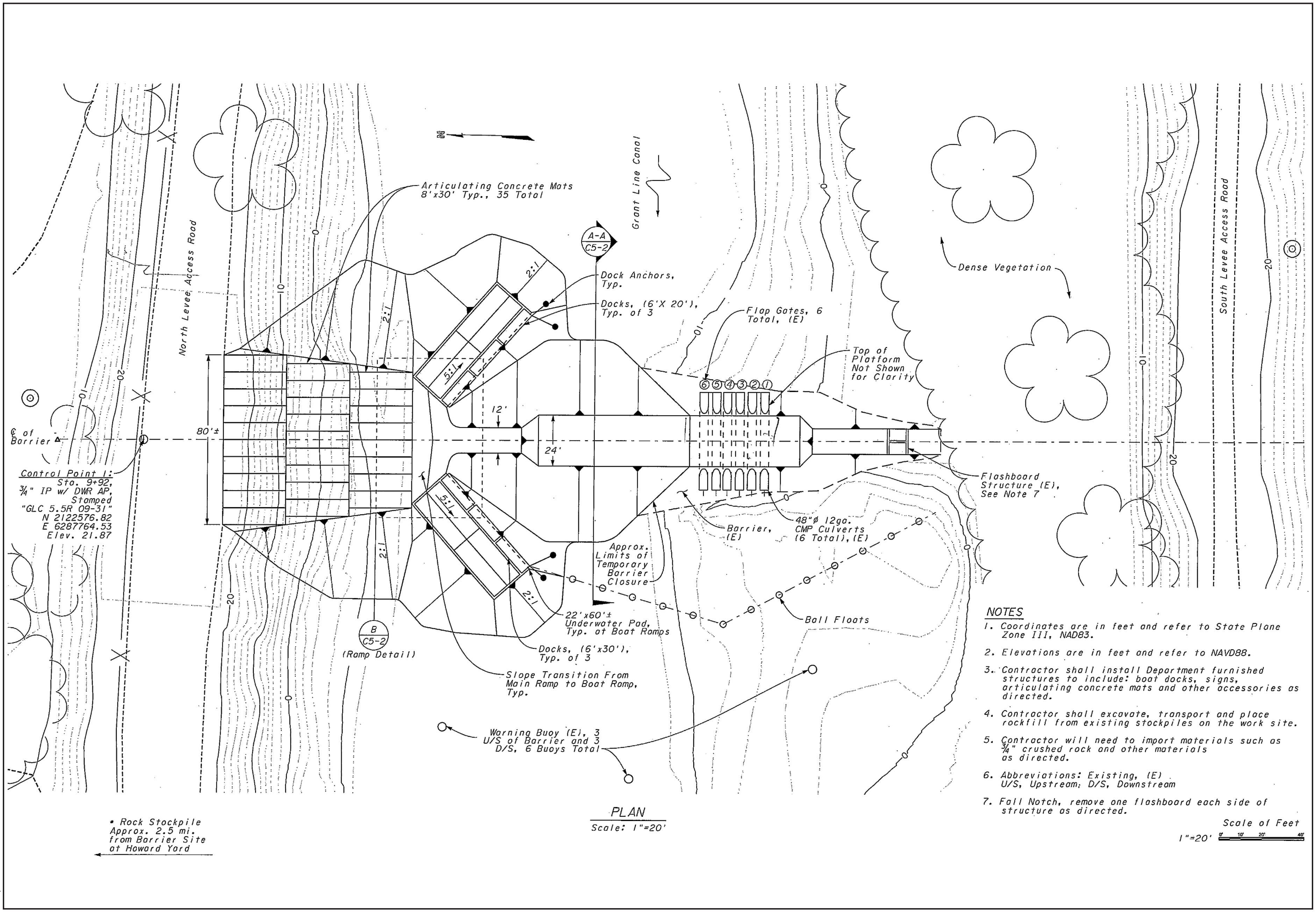
NOTES

1. All elevations are in feet and refer to NAVD88.
2. Abbreviations:
   M.H.H.W. - Mean High High Water
   M.L.L.W - Mean Low Low Water.
3. Fall Notch 10' wide, Elev. 2.9', Install as directed.
4. ¾" crushed rock pad to be leveled and tamped with an excavator bucket.

Scale of Feet
1"=20' 0' 10' 20' 40'
1"=5' 0' 5' 10'

Figure 4b
Old River Near Tracy Barrier
Profile, Section and Details

Graphics...00135.10 Permits TBP (11-2011) JD

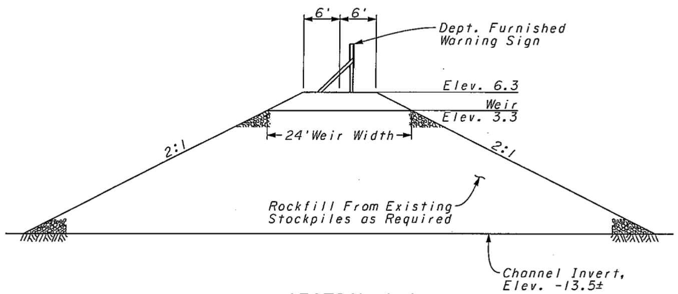


NOTES

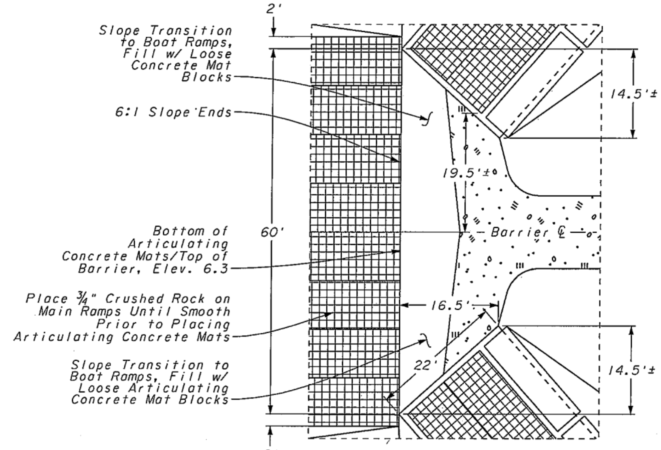
1. Coordinates are in feet and refer to State Plane Zone III, NAD83.
2. Elevations are in feet and refer to NAVD88.
3. Contractor shall install Department furnished structures to include: boat docks, signs, articulating concrete mats and other accessories as directed.
4. Contractor shall excavate, transport and place rockfill from existing stockpiles on the work site.
5. Contractor will need to import materials such as ¾" crushed rock and other materials as directed.
6. Abbreviations: Existing, (E) U/S, Upstream; D/S, Downstream
7. Fall Notch, remove one flashboard each side of structure as directed.

Graphics...00135.10 Permits TBP (11-2011) JD

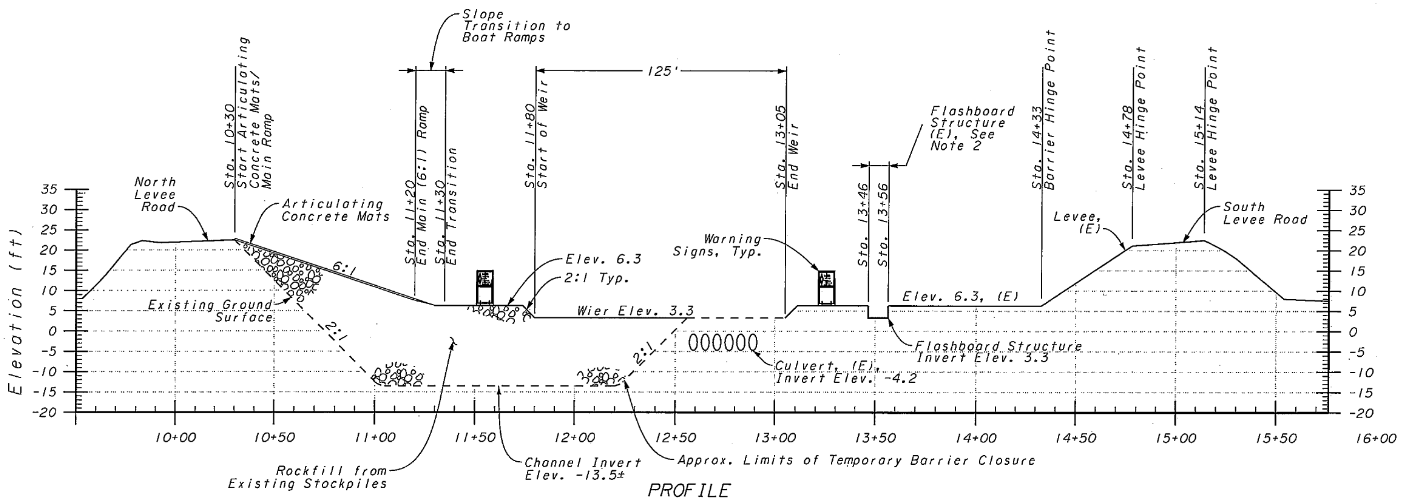
Figure 5a
Grant Line Canal Barrier
Plan



SECTION A-A
Scale: 1"=10'
Dwg. C5-1



RAMP DETAIL B
Scale: 1"=10'
Dwg. C5-1



PROFILE
Scale: Horiz. 1"=30'
Vert. 1"=15'
Dwg. C5-1

NOTES

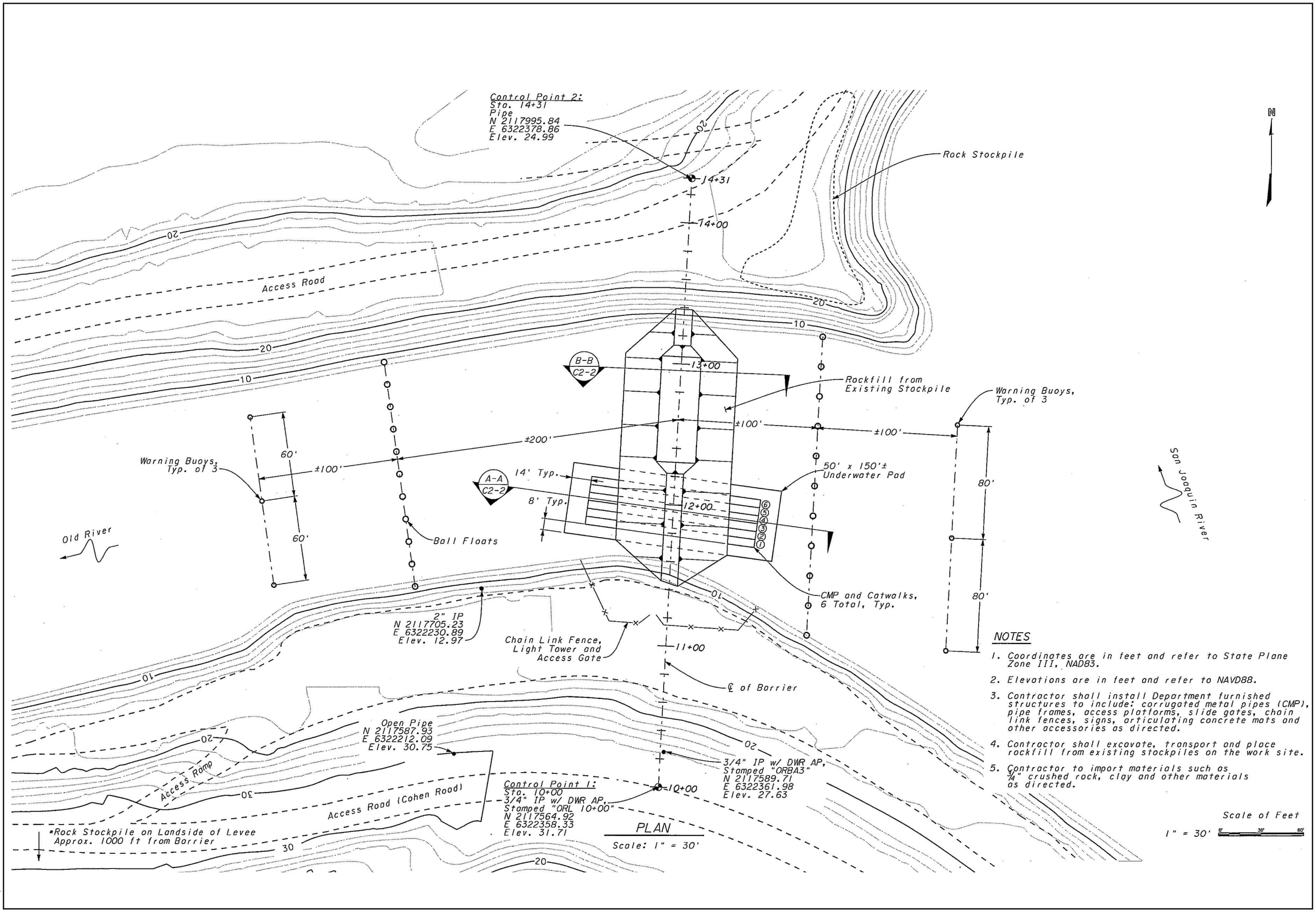
1. All elevations are in feet and refer to NAVD88.
2. Fall Notch, remove one flashboard each side, as directed.

Weight Table (lbs.)	
Articulating Mats	7,500 ea.
Mat Spreader Bar	4,500
Dock Sections	2,000 ea.
Dock Anchors	900 ea.

Scale of Feet
1"=10' 0' 10' 20'
1"=30' 0' 30' 60'

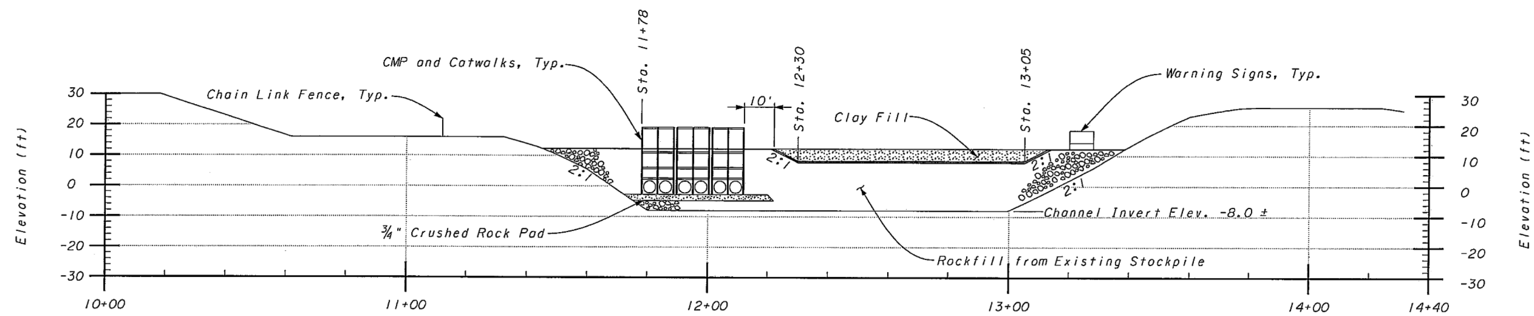
Graphics...00135.10 Permits TBP (11-2011) JD

Figure 5b
Grant Line Canal Barrier
Profile, Section and Details

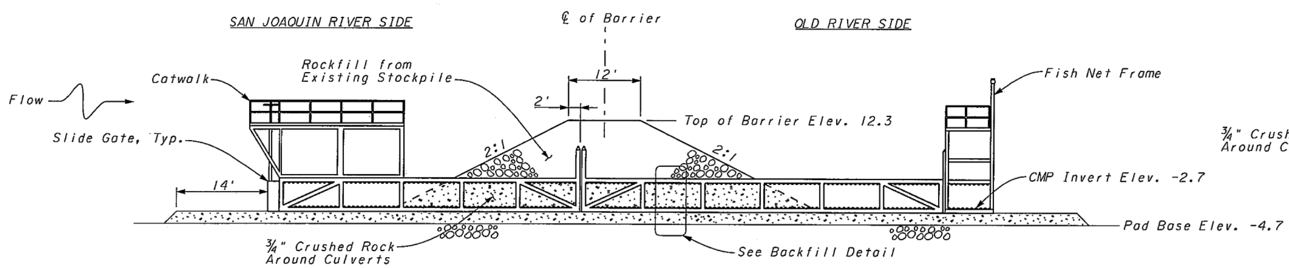


Graphics... 00135.10 Permits TBP (11-2011) JD

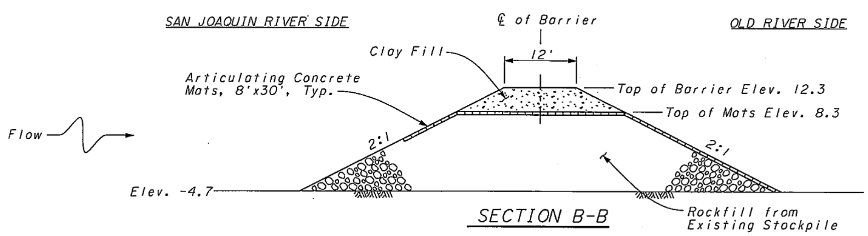
Figure 6a
Head of Old River Barrier (Spring)
Plan



PROFILE
Scale: 1" = 20'
Dwg. C2-1

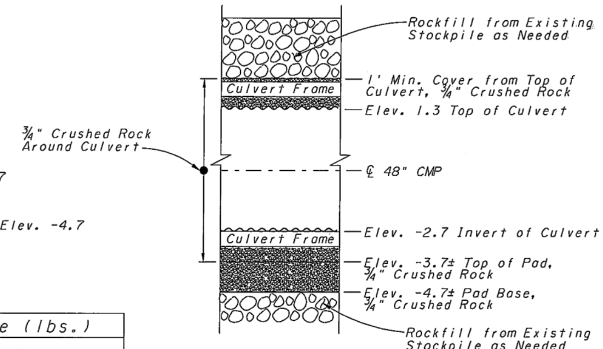


SECTION A-A
Scale: 1" = 10'
Dwg. C2-1



SECTION B-B
Scale: 1" = 10'
Dwg. C2-1

Weight Table (lbs.)	
U/S Culvert Frame	18,000 ea.
D/S Culvert Frame	20,000 ea.
U/S Riser Section	3,800 ea.
U/S Catwalk	2,500 ea.
D/S Fish Net Frame	7,000 ea.
Slide Gate Valve	900 ea.
Articulating Mats	7,500 ea.
Mat Spreader Bar	4,500



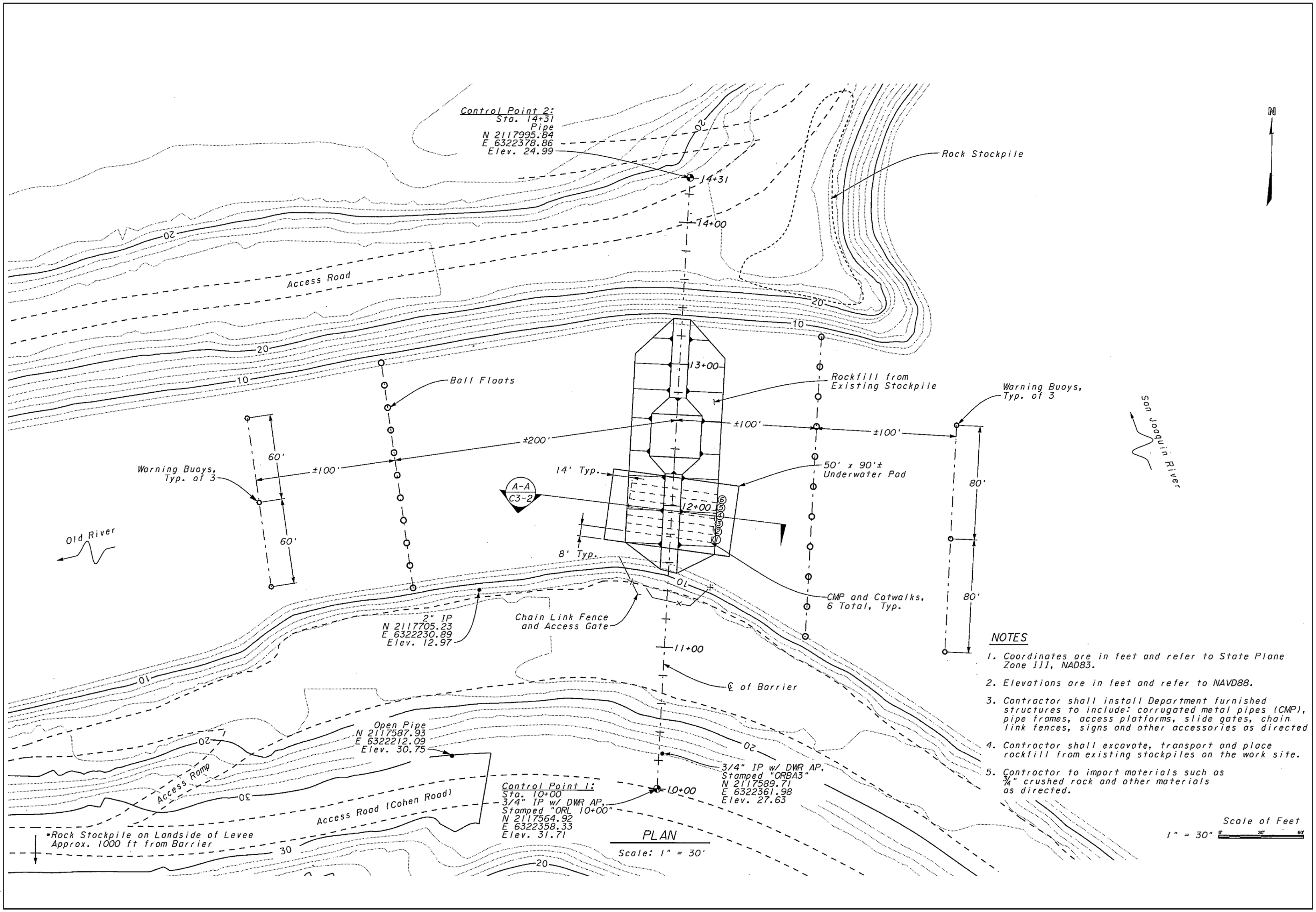
BACKFILL DETAIL
Not to Scale

NOTES
1. Elevations are in feet and refer to NAVD88.
2. Upstream (U/S), Downstream (D/S)

Scale of Feet
1" = 10' 0' 10' 20'
1" = 20' 0' 10' 20' 40'

Figure 6b
Head of Old River (Spring)
Profile, Section and Details

Graphics... 00135.10 Permits TBP (11-2011) JD

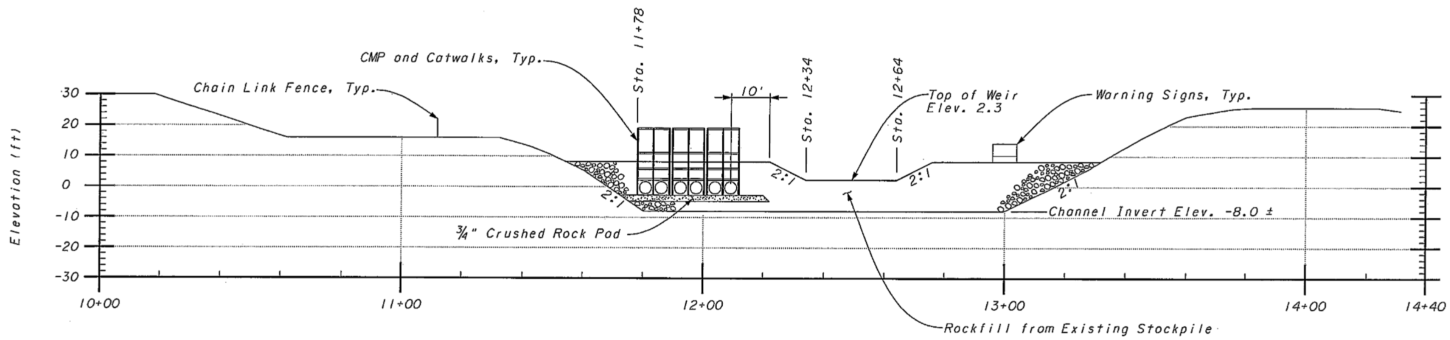


NOTES

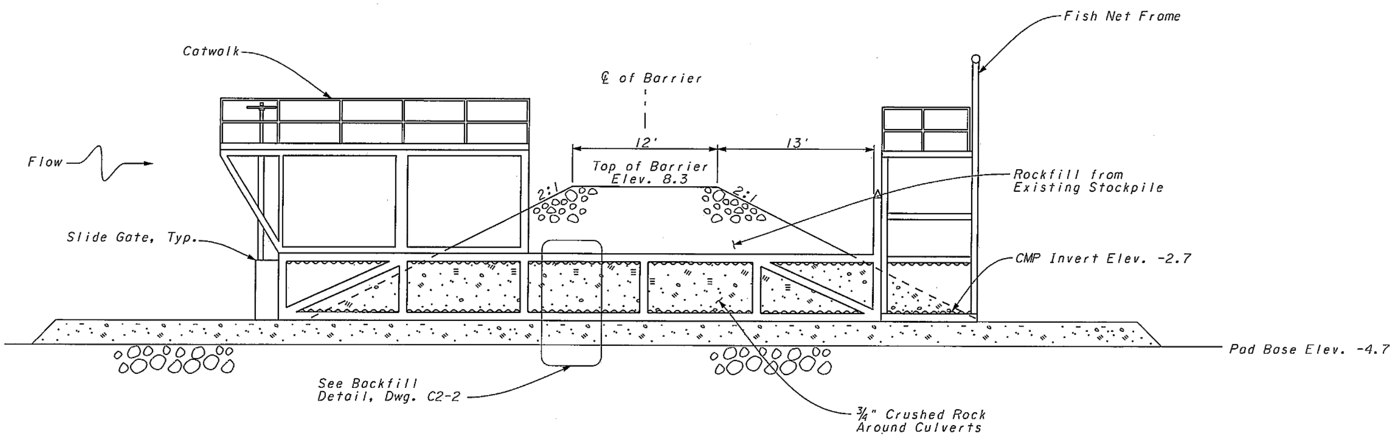
1. Coordinates are in feet and refer to State Plane Zone III, NAD83.
2. Elevations are in feet and refer to NAVD88.
3. Contractor shall install Department furnished structures to include: corrugated metal pipes (CMP), pipe frames, access platforms, slide gates, chain link fences, signs and other accessories as directed
4. Contractor shall excavate, transport and place rockfill from existing stockpiles on the work site.
5. Contractor to import materials such as ¾" crushed rock and other materials as directed.

Graphics... 00135.10 Permits TBP (11-2011) JD

Figure 7a
Head of Old River Barrier (Fall)
Plan



PROFILE
Scale: 1" = 20'
Dwg. C3-1



SAN JOAQUIN RIVER SIDE

SECTION A-A
Scale: 1" = 5'
Dwg. C3-1

OLD RIVER SIDE

Weight Table (lbs.)	
U/S Culvert Frame	18,000 ea.
U/S Riser Section	3,800 ea.
U/S Catwalk	2,500 ea.
D/S Fish Net Frame	7,000 ea.
Slide Gate Valve	900 ea.
Articulating Mats	7,500 ea.
Mat Spreader Bar	4,500

NOTES

1. Elevations are in feet and refer to NAVD88.
2. Upstream (U/S), Downstream (D/S)

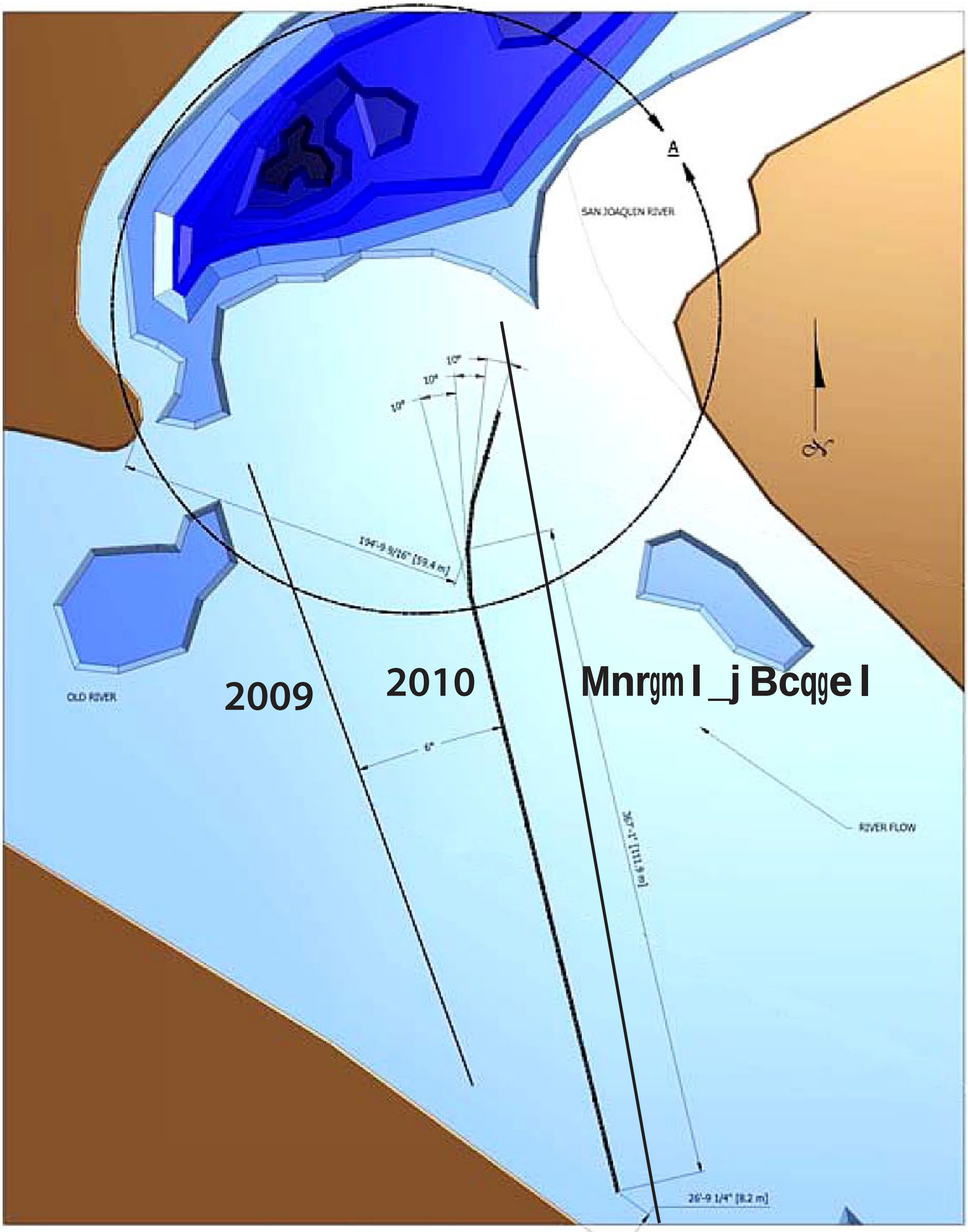
Scale of Feet

1" = 5' 0' 5' 10'

1" = 20' 0' 10' 20' 40'

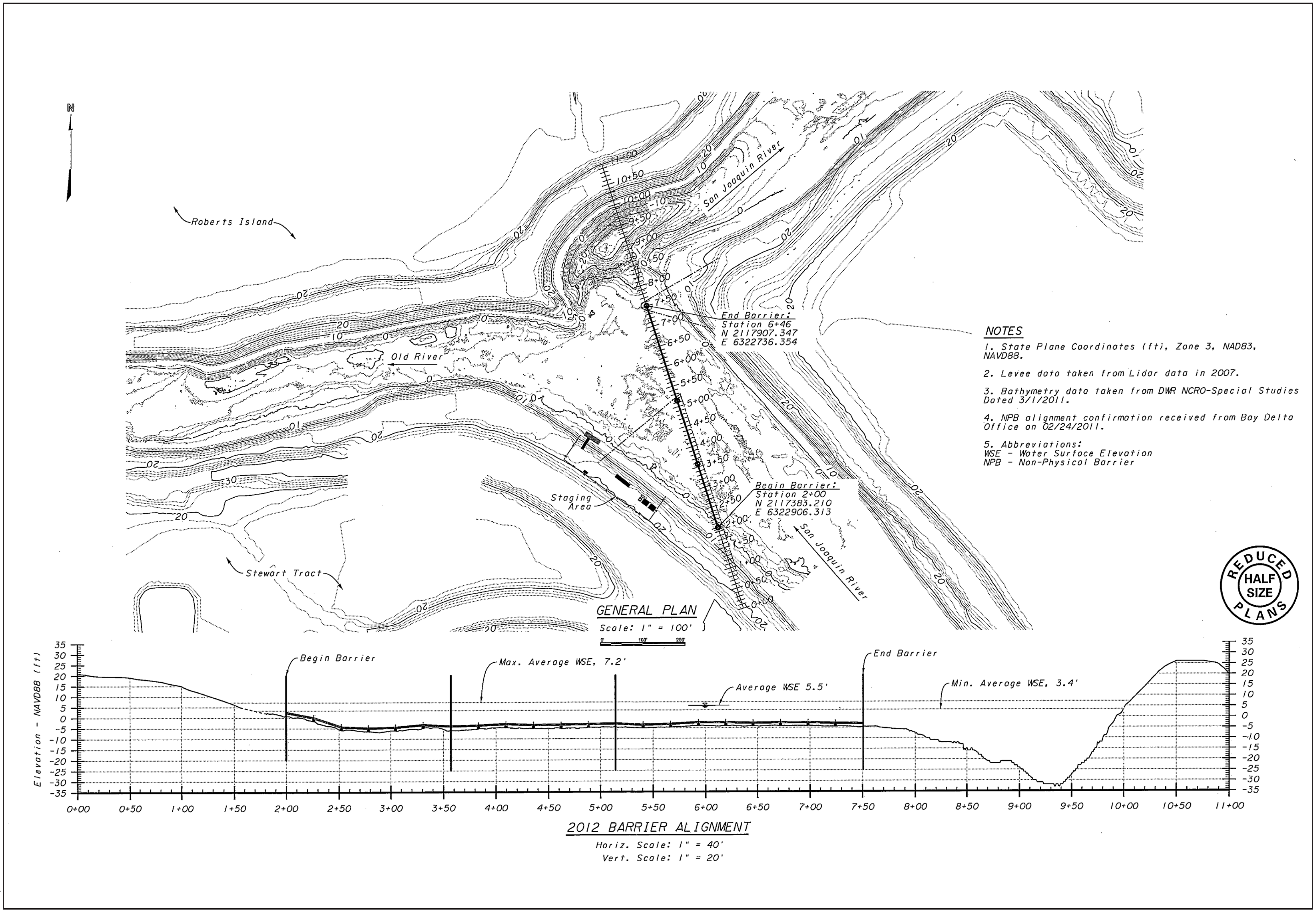
Graphics... 00135.10 Permits TBP (11-2011) JD

Figure 7b
Head of Old River (Fall)
Profile and Section



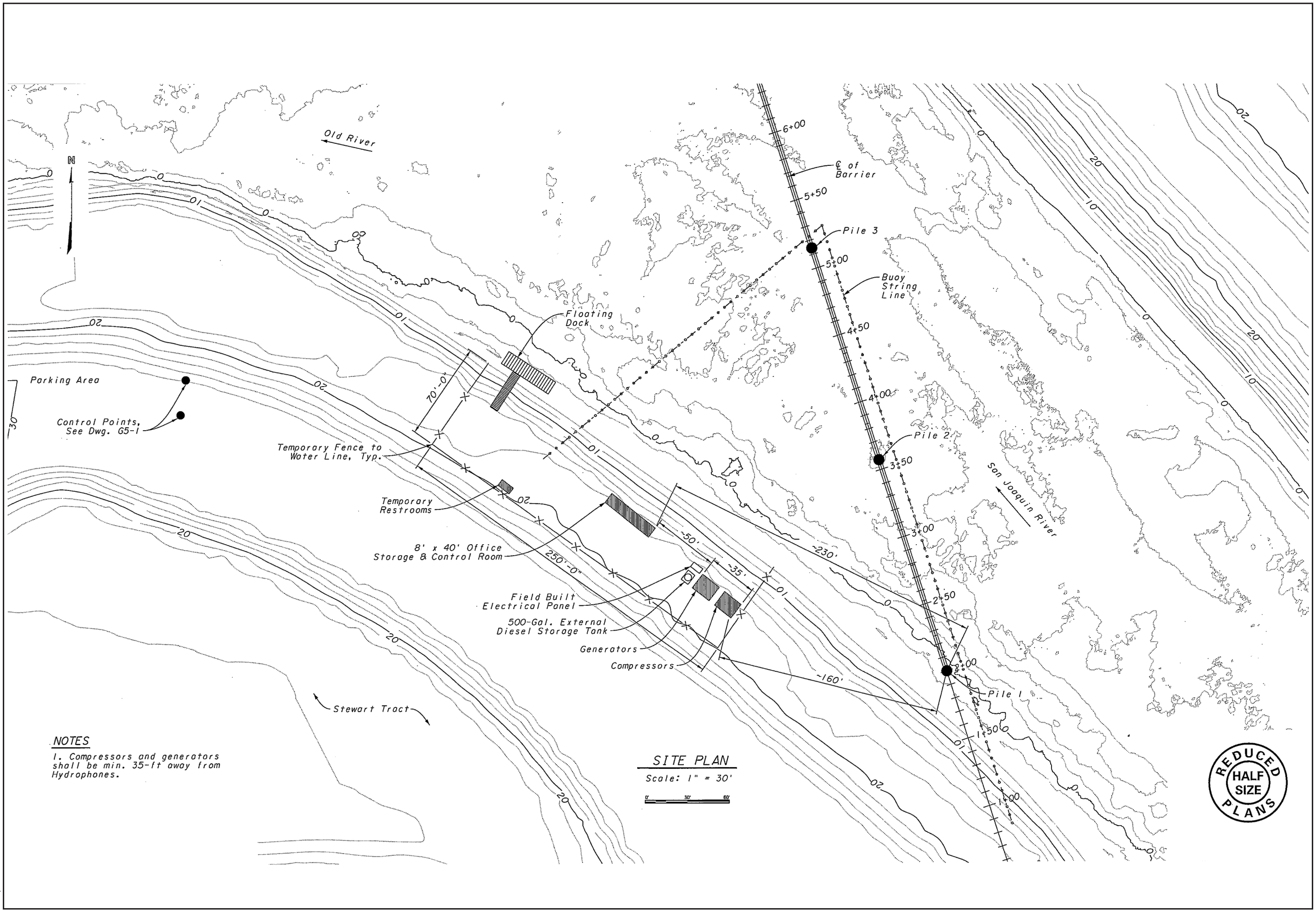
Graphics/Projects/00135.10 Permitting TBP (11-11) JD

Figure 8
2009, 2010 and Mnrgml_j Barrier Comparison



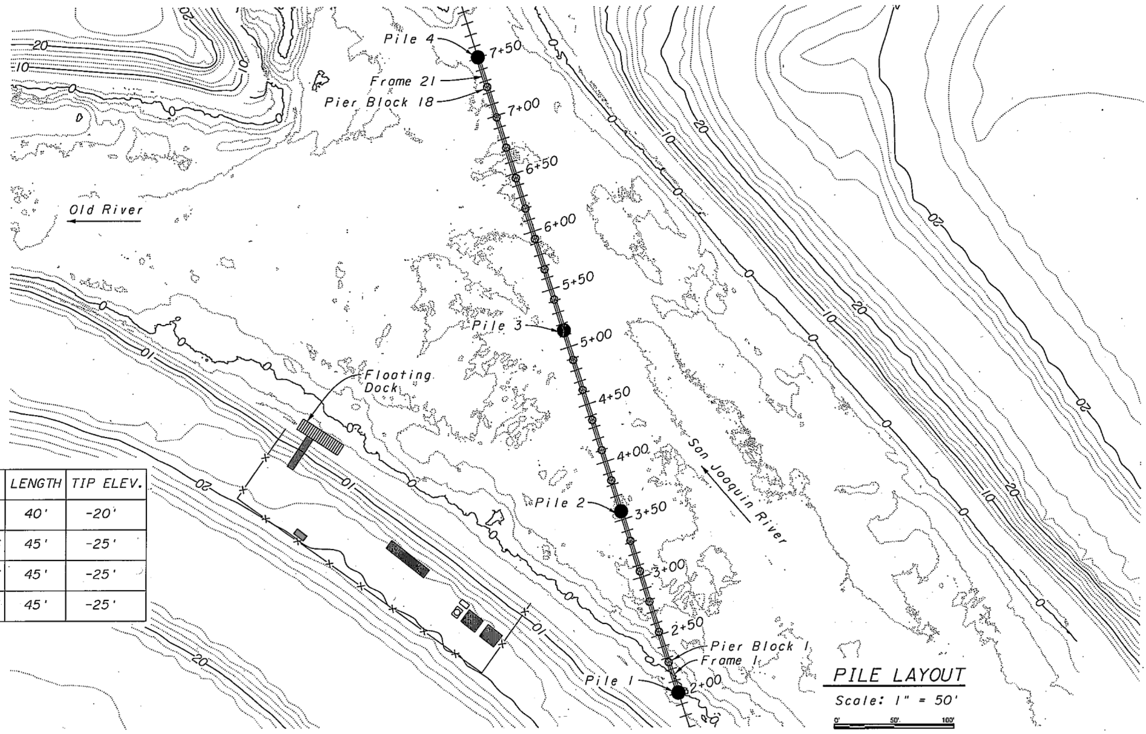
Graphics... 00135.10 Permits TPB (11-2011) JD

Figure 9a
Head of Old River Non-Physical Barrier
Plan and Profile



Graphics... 00135.10 Permits TPB (11-2011) JD

Figure 9b
Head of Old River Non-Physical Barrier
Staging Area - Plan



PILE No.	STATION	NORTHING	EASTING	LENGTH	TIP ELEV.
1	2+00.0	2117383.21	6322906.31	40'	-20'
2	3+57.0	2117532.50	6322857.86	45'	-25'
3	5+14.4	2117682.27	6322809.26	45'	-25'
4	7+50.6	2117906.92	6322736.35	45'	-25'

NOTES

1. State Plane Coordinates (ft), Zone 3, NAD83, NAVD88.

2. Pile Material Specifications:
Pipe 8 Std.: fy=35ksi; O.D. 8.625"; t=0.322; ASTM A53

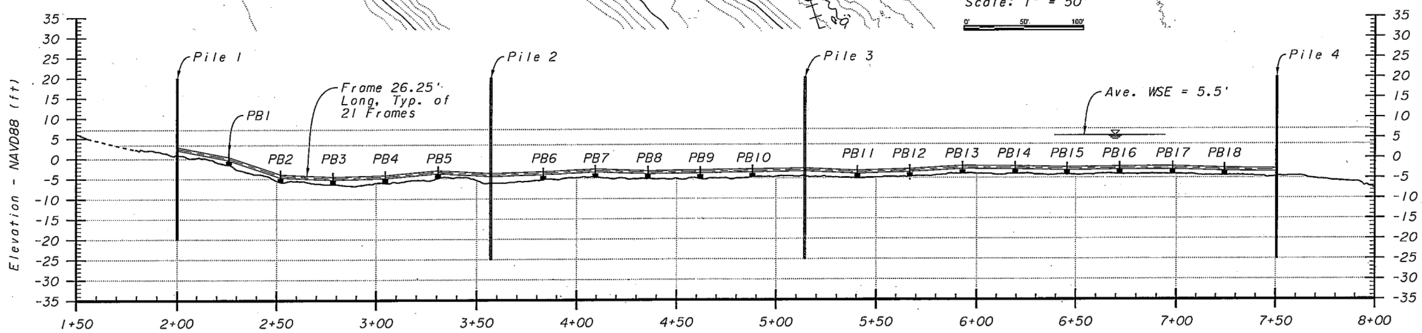
3. Pier blocks to be located between adjoining frames, except where pile is located.

4. Data collected from CDEC station "OHI" and analyzed from April-May of 2010:

Flow Range:
Minimum 1200 cfs
Maximum 3748 cfs

Stage Data:
Max WSE= 7.2'
Min WSE= 3.4'
Ave Max WSE= 5.9'
Ave Min WSE= 5.1'5.

5. Abbreviations:
PB - Pier Block
ASTM - American Society for Testing & Materials
WSE - Water Surface Elevation
O.D. - Outside Diameter
t - Thickness

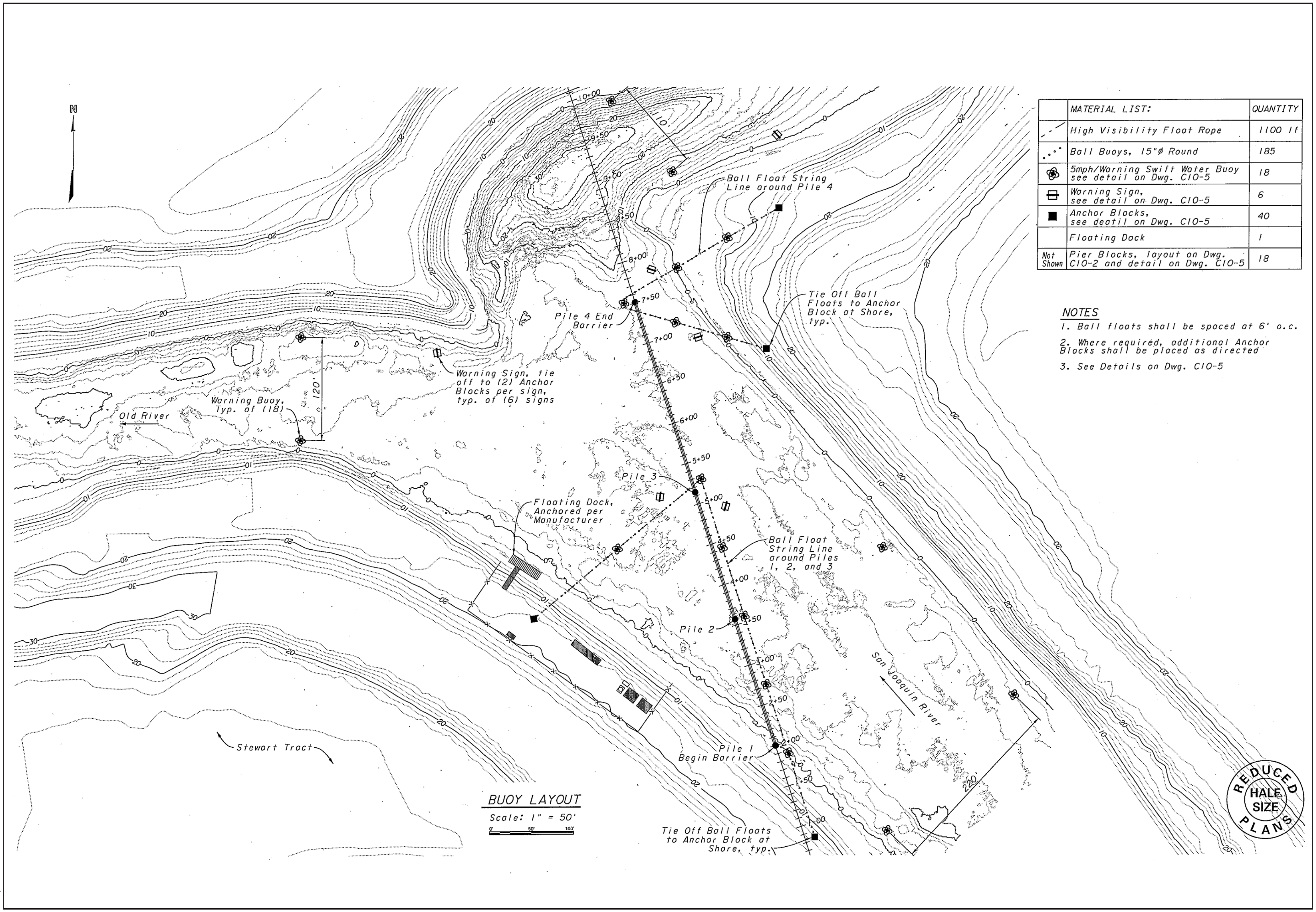


2012 BARRIER ALIGNMENT
Horiz. Scale: 1" = 30'
Vert. Scale: 1" = 15'

REDUCED PLANS HALF SIZE

Graphics... 00135.10 Permits TPB (11-2011) JD

Figure 9c
Head of Old River Non-Physical Barrier
Pile and Pier Block Layout - Plan and Profile



Graphics... 00135.10 Permits TPB (11-2011) JD

Figure 9d
Head of Old River Non-Physical Barrier
Buoy Layout - Plan

Supplier	MATERIAL LIST:	QUANTITY
Cal-Nevo	Sound Projector Cable 12GA / 3C	3135' (Total)
	Line 1, Frames 1-2	226'
	Line 2, Frames 3-4	223'
	Line 3, Frames 5-6	232'
	Line 4, Frames 7-8	178'
	Line 5, Frames 9-10	206'
	Line 6, Frames 11-12	263'
	Line 7, Frames 13-14	285'
	Line 8, Frames 15-16	310'
	Line 9, Frames 17-18	359'
	Line 10, Frames 19-20	413'
	Line 11, Frame 21	440'
Cal-Nevo	Intense Light Power Cable 6GA / 3C	932' (Total)
	Line 1, Frames 1-6	156'
	Line 2, Frames 7-12	156'
	Line 3, Frames 13-18	235'
	Line 4, Frames 19-21	385'
OVIVO	Intense Light Signal Cable (no specification provided)	840' (Total)

CABLE NOTES

1. All cable lengths are measured as shown on the drawing from the barrier to the control room.

3. Approximate distance from control room to pile 1 is shown on Dwg. C10-1.

4. Intense Light Signal Cable is suppled by OVIVO Water. Intense Light Signal Cable Length from Control Room to Start of barrier is Approximately 220' as shown.

Supplier	MATERIAL LIST:	QUANTITY
Cal-Nevo	2" PVC, Schedule 40	1159' (Total)
	Line 1, Pile 1 to shore	185'
	Line 2, Frames 1-6	161'
	Line 3, Frames 7-12	163'
	Line 4, Frames 13-17	255'
	Line 5, Frames 18-21	395'

PVC NOTES

1. All PVC lengths are measured as shown on the drawing from the barrier to the compressor.

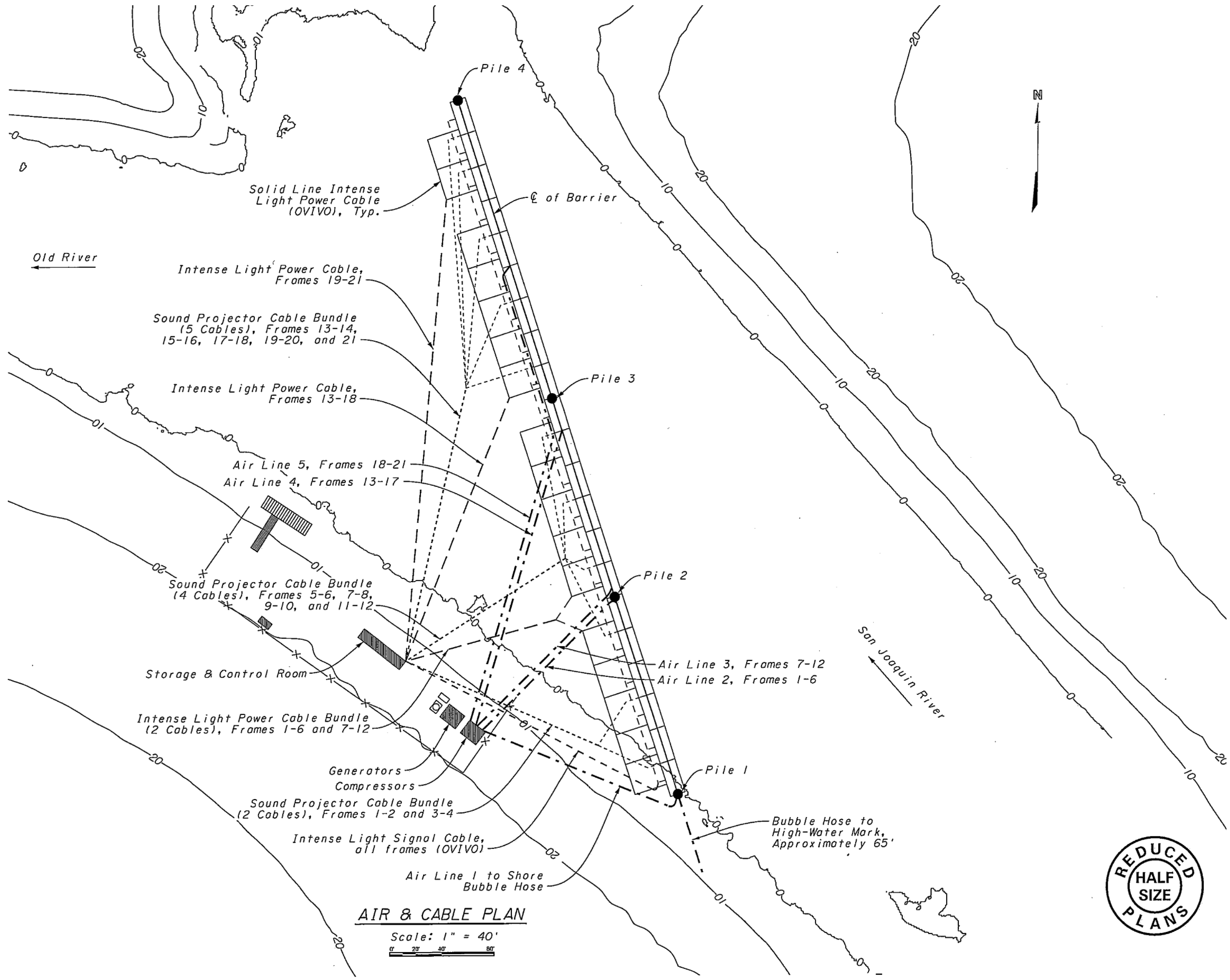
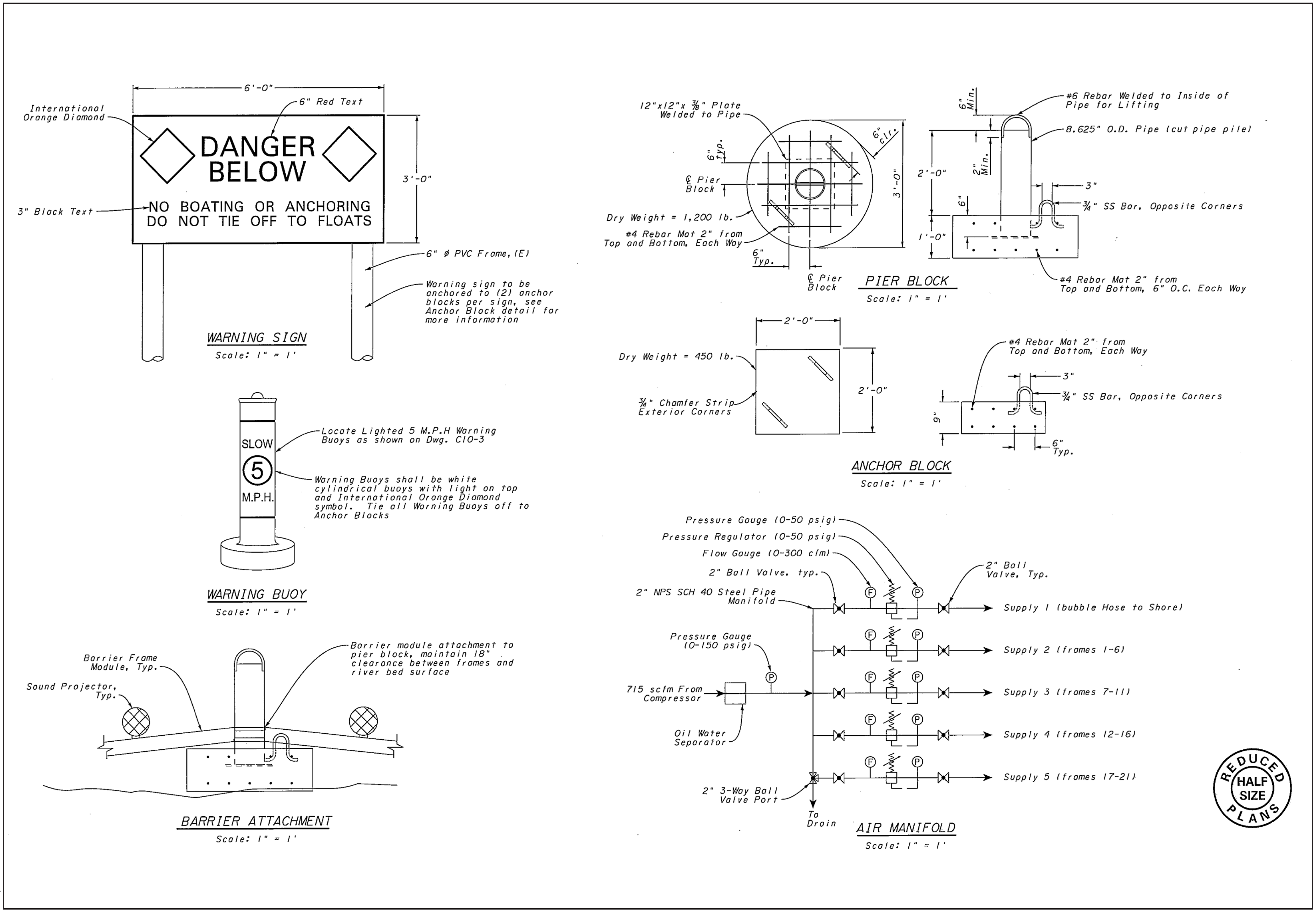


Figure 9e
Head of Old River Non-Physical Barrier
Air and Cable Schematic - Plan



Graphics...00135.10 Permits TPB (11-2011) JD

Figure 9f
Head of Old River Non-Physical Barrier
Pier and Anchor Blocks, Signs, and Buoy - Detail

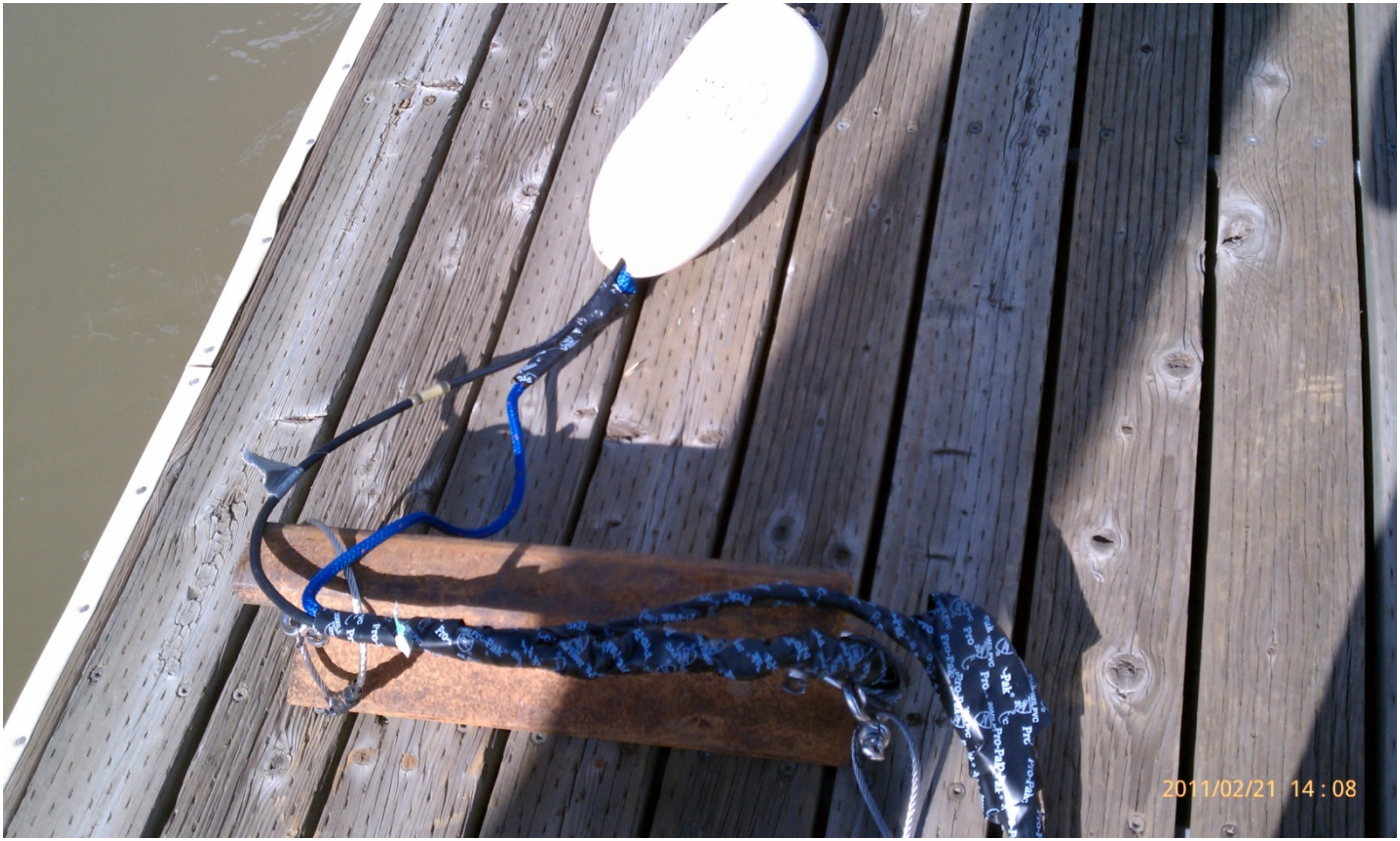


Figure 10: Photo of a railroad track anchor, line and buoy setup used to deploy a hydrophone.

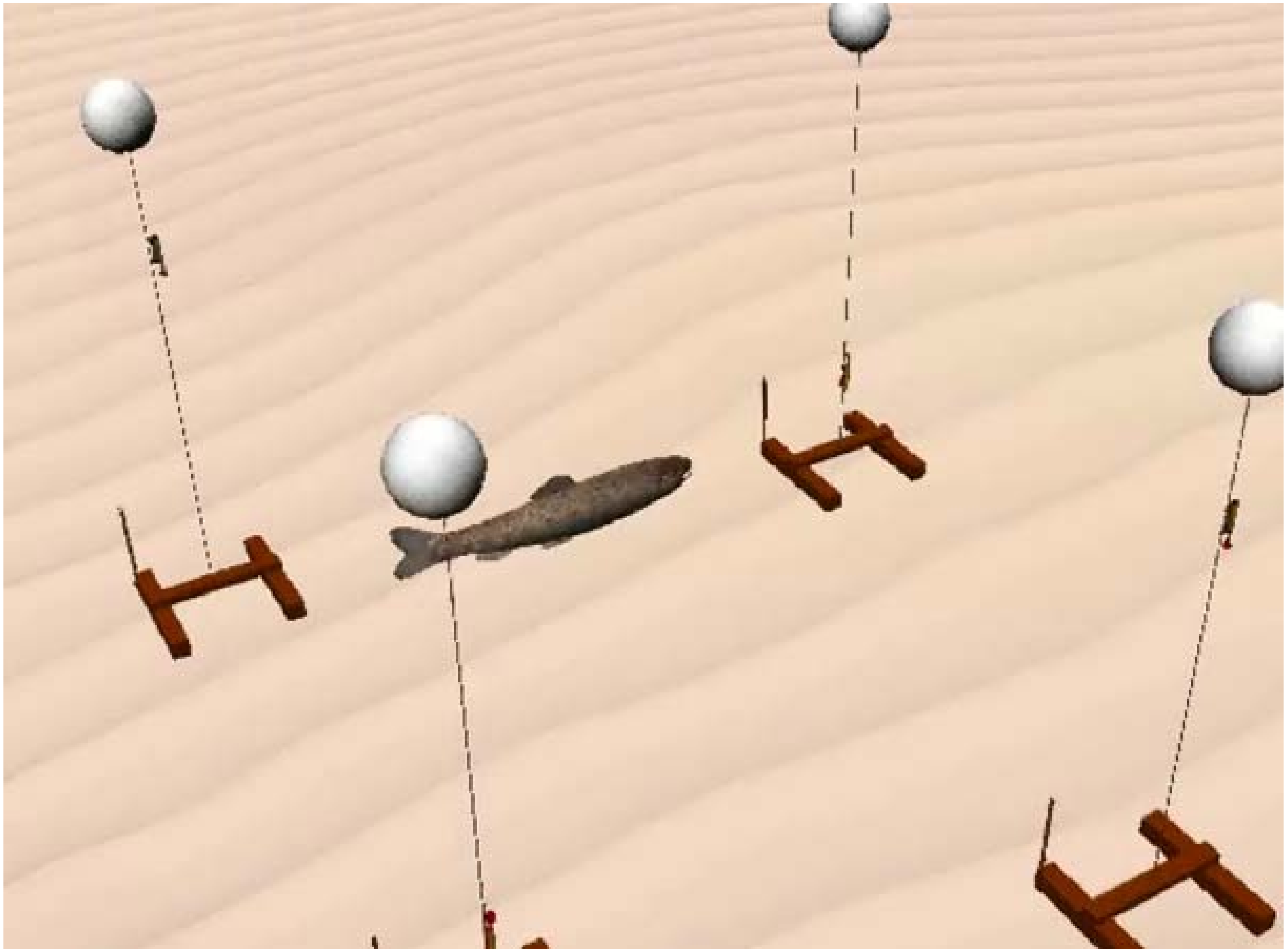


Figure 11: Example of hydrophone bottom mounts with tensioned lines used for the 2-D hydroacoustic study and the HOR.

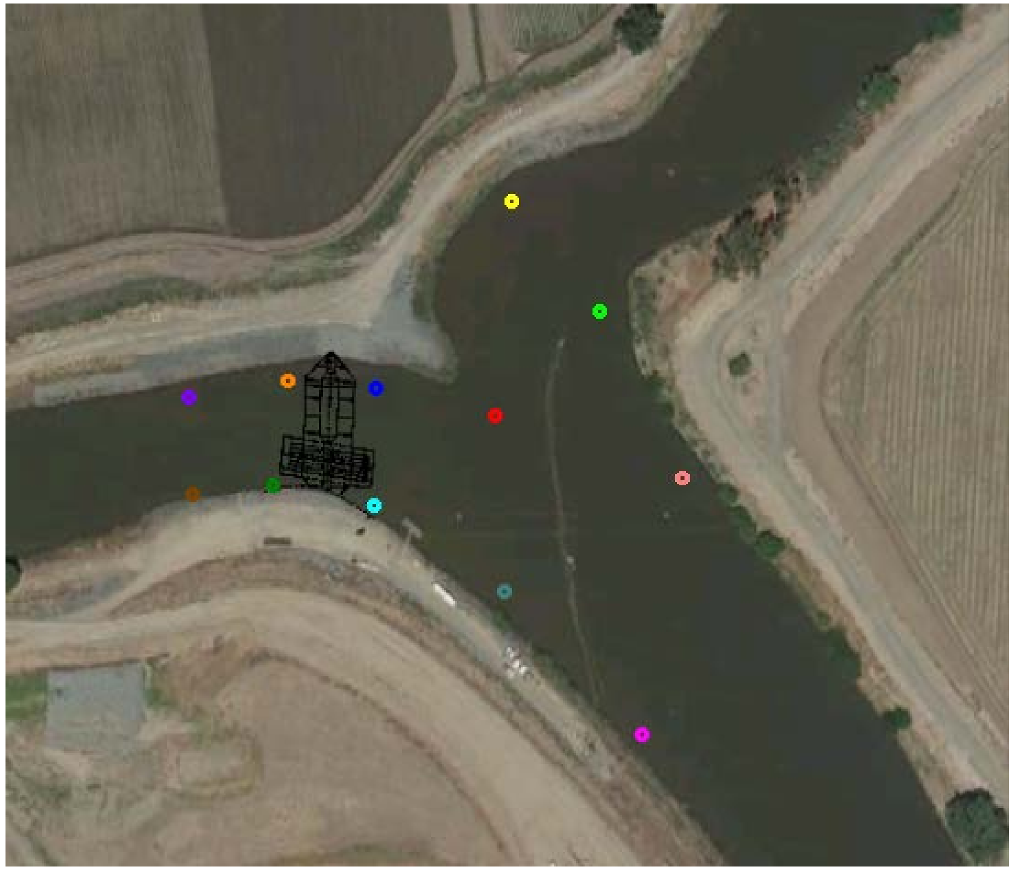


Figure 12: Example of hydrophone layout for a 2-D array around the HOR barrier.

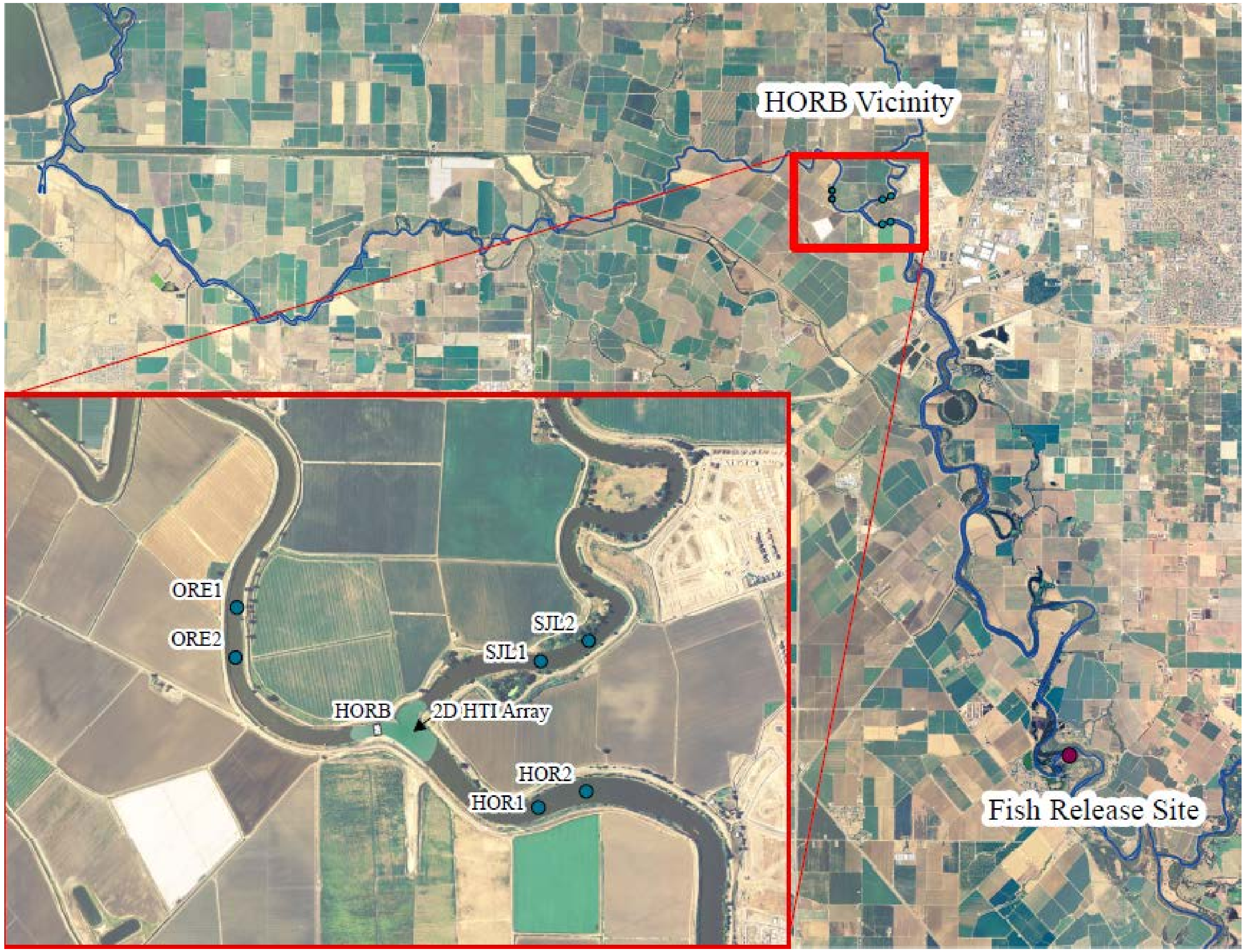


Figure 13: Example of peripheral node placement around the HORB showing a potential upstream tagged salmonid smolt release site.

APPENDIX B: HISTORICAL TBP SCHEDULE DATA

Year	Old River near Tracy (ORT)						
	Installation			Notched	Removal		
	Started	Closed	Completed		Started	Breached	Completed
1987							
1988							
1989							
1990							
1991	14-Aug		30-Aug		28-Sep		13-Oct (i)
1992	15-Apr boat port on		01-May 09-May boat port on		30-Sep		09-Oct (ii)
1993	12-May		1-Jun		27-Sep		6-Oct
1994	22-Apr boat port on All culverts tied open (5/18-6/1)		April-24 May-01		26-Sep		10-Oct
1995	3-Aug		8-Aug		27-Sep		6-Oct
1996	12-May		10-Jun (iii)		29-Sep		16-Oct
1997	8-Apr		17-Apr		30-Sep		7-Oct
1998	(vii)						
1999	15-May		28-May		28-Sep		8-Oct
2000	4-Apr		16-Apr		1-Oct		7-Oct
2001	23-Apr		26-Apr		13-Nov	14-Nov	26-Nov
2002	1-Apr		18-Apr		16-Nov	16-Nov	29-Nov
2003	1-Apr	14-Apr	22-Apr	17-Sep	13-Nov	15-Nov	25-Nov
2004	1-Apr	15-Apr	20-Apr	10-Sep	8-Nov	8-Nov	1-Dec
2005	9-May	31-May	6-Jun	15-Sep	8-Nov	10-Nov	30-Nov
2006	7-Jul	17-Jul	31-Jul	1-Oct	13-Nov	16-Nov	8-Dec
2007	2-Apr	18-Apr	23-Apr	21-Sep	5-Nov	7-Nov	18-Nov
2008	12-May	4-Jun	19-Jun	10-Sep	3-Nov	4-Nov	25-Nov
2009	18-May	23-Jun	3-Jul	12-Sep	2-Nov	4-Nov	19-Nov
2010	10-May	3-Jun	8-Jun	15-Sep	19-Oct	20-Oct	4-Nov
2011	27-May	10-Jun	15-Jun	15-Sep	10-Oct	11-Oct	31-Oct
2012	15-Mar	31-Mar	6-Apr				

Year	Spring Head of Old River					
	Installation			Removal		
	Started	Closed	Completed	Started	Breached	Completed
1987						
1988						
1989						
1990						
1991						
1992	15-April boat port on		23-April @ 4 ft 26-April @ 6 ft 01-May	02-Jun		08-Jun
1993						
1994	21-April boat port on		23-April @ 10 ft 01-May	18-May		20-May
1995			(vii)			
1996	6-May		11-May	16-May		03-Sep (iv)
1997	9-Apr		16-Apr	15-May		19-May
1998	(vii)					
1999	(vii)					
2000	5-Apr		16-Apr	19-May		2-Jun
2001	17-Apr		6-Apr	23-May		30-May
2002	2-Apr		18-Apr	22-May	24-May	7-Jun
2003	1-Apr	15-Apr	21-Apr	16-May	18-May	3-Jun
2004	1-Apr	15-Apr	21-Apr	19-May	24-May	10-Jun
2005	(xi)	(xi)	(xi)	(xi)	(xi)	(xi)
2006	(xi)	(xi)	(xi)	(xi)	(xi)	(xi)
2007	11- Apr	20- Apr	26- Apr	19- May	22- May	6- Jun
2008	(xiv)	(xiv)	(xiv)	(xiv)	(xiv)	(xiv)
2009	(xv)	(xv)	(xv)	(xv)	(xv)	(xv)
2010	5-Apr (xv)	(xv)	16-Apr (xv)	(xv)	(xv)	(xv)
2011	(xvii)	(xvii)	(xvii)	(xvii)	(xvii)	(xvii)
2012	15-Mar	1-Apr	11-Apr	-	-	-

Year	Fall Head of Old River (v)						
	Installation			Notched	Removal		
	Started	Closed	Completed		Started	Breached	Completed
1968(ix)	30-Sep		3-Oct		15-Nov		21-Nov
1969							
1970	1-Oct		6-Oct		13-Nov		14-Nov
1971	24-Sep		1-Oct		8-Nov		12-Nov
1972	25-Sep		29-Sep		7-Nov		10-Nov
1973	1-Oct		5-Oct		14-Nov		15-Nov
1974	12-Sep		18-Sep		1-Nov		9-Nov
1975	17-Sep		26-Sep		1-Nov		4-Nov
1976	28-Oct		1-Nov		22-Nov		23-Nov
1977			27-Oct				5-Dec
1978							
1979			1-Oct				29-Nov
1980							
1981			15-Oct				25-Nov
1982							
1983							
1984	5-Sep		8-Sep				19-Oct
1985							
1986							
1987	9-Sep		11-Sep				28-Nov
1988	22-Sep		28-Sep				2-Dec
1989	27-Sep		28-Sep		27-Nov		30-Nov
1990	10-Sep		11-Sep				27-Nov
1991	9-Sep		13-Sep		22-Nov		27-Nov
1992	8-Sep		11-Sep		30-Nov		4-Dec
1993	08-Nov (vi)		11-Nov		3-Dec		7-Dec
1994	6-Sep		8-Sep		28-Nov		30-Nov
1995	(vii)						
1996	30-Sep		3-Oct		18-Nov		22-Nov
1997							
1998	(vii)						
1999	(viii)						
2000	27-Sep		7-Oct		27-Nov		8-Dec
2001	24-Sep		6-Oct		22-Nov	22-Nov	2-Dec
2002	24-Sep		4-Oct		11-Nov	12-Nov	21-Nov
2003	2-Sep	15-Sep	18-Sep	16-Sep	3-Nov	4-Nov	13-Nov
2004	7-Sep	27-Sep	29-Sep	28-Sep	1-Nov	2-Nov	12-Nov
2005	19-Sep	28-Sep	30-Sep	29-Sep	7-Nov	8-Nov	15-Nov
2006	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2007	5-Oct	17-Oct	18-Oct	18-Oct	9-Nov	10-Nov	29-Nov
2008	1-Oct	16-Oct	16-Oct	16-Oct	3-Nov	3-Nov	9-Nov
2009	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2010	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2011	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)	(xiii)
2012	-	-	-		-	-	-

Year	Middle River						
	Installation			Notched	Removal		
	Started	Closed	Completed		Started	Breached	Completed
1987			15-May		End of Sep		End of Sep
1988	26-May		28-May		23-Sep		23-Sep
1989			12-Apr		26-Sep		26-Sep
1990			16-Apr		29-Sep		29-Sep
1991	4-Apr		5-Apr		27-Sep		27-Sep
1992	8-Apr		10-Apr		28-Sep		29-Sep
1993	14-Jun		17-Jun		23-Sep		24-Sep
1994	23-Apr		25-Apr		29-Sep		5-Oct
1995	8-Aug		11-Aug		10-Oct		10-Oct
1996	18-May		20-May		29-Sep		29-Sep
1997	3-Apr		7-Apr		27-Sep		28-Sep
1998	(vii)						
1999	15-May		18-May		29-Sep		2-Oct
2000	4-Apr		6-Apr		1-Oct		7-Oct
2001	20-Apr		23-Apr		12-Nov	18-Nov	17-Nov
2002	10-Apr		15-Apr		20-Nov	20-Nov	23-Nov
2003	12-Apr	15-Apr	23-Apr	17-Sep	7-Nov	8-Nov	10-Nov
2004	9-Apr	12-Apr	13-Apr	23-Sep	9-Nov	10-Nov	12-Nov
2005	10-May	12-May	17-May	15-Sep	7-Nov	8-Nov	9-Nov
2006	5-Jul	7-Jul	8-Jul	1-Oct	17-Nov	18-Nov	20-Nov
2007	7-Apr	10-Apr	10-Apr	21-Sep	19-Nov	20-Nov	29-Nov
2008	19-May	21-May	23-May	10-Sep	5-Nov	5-Nov	9-Nov
2009	19-May	19-Jun	14-Jul	12-Sep	16-Nov	17-Nov	19-Nov
2010	18-May	24-May	24-May	15-Sep	28-Oct	28-Oct	2-Nov
2011	1-Jun	6-Jun	6-Jun	15-Sep	10-Oct	11-Oct	18-Oct
2012	12-Mar	16-Mar	17-Mar				

Year	Grant Line Canal							
	Installation			Removal				
	Started	Closed	Completed	Flashboards Adjusted (x)	Notched	Started	Breached	Completed
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996	17-Jun		10-Jul			2-Oct		15-Oct
1997	21-May		4-Jun			26-Sep		15-Oct
1998	(vii)							
1999	15-May		3-Jun			23-Sep		5-Oct
2000	19-May		1-Jun			1-Oct		7-Oct
2001	2-May		6-May			11-Nov	12-Nov	18-Nov
2002	1-Apr		12-Jun			14-Nov	16-Nov	25-Nov
2003	1-Apr (Partial) 9-Jun (Full)	11-Jun	23-Apr (Partial) 17-Jun (Full)	16-Sep		10-Nov	13-Nov	25-Nov
2004	1-Apr (Partial) 2-Jun (Full)	9-Apr (Partial) 5-Jun (Full)	28-Apr (Partial) 9-Jun (Full)	9-Sep		11-Nov	12-Nov	6-Dec
2005	2-May (xii)	14-Jul	18-Jul	14-Jul & 14-Sep		7-Nov	15-Nov	30-Nov
2006	7-Jul (xii)	20-Jul	26-Jul	20-Jul & 1-Oct		14-Nov	21-Nov	6-Dec
2007	9-Apr (Partial) 27-Apr (Full)	17-Apr (Partial) 10-May (Full)	17-Apr (Partial) 11-May (Full)	17-Apr (Partial) 10-May (Full)	21-Sep	6-Nov	8-Nov	29-Nov
2008	19-May (Partial) 23-May (Full)	2-Jun (Partial) 26-Jun (Full)	2-Jun (Partial) 27-Jun (Full)	10-Sep	10-Sep	8-Nov	11-Nov	24-Nov
2009	29-May	24-Jun (Partial) 1-Jul (Full)	3-Jul	7-Jul	12-Sep	28-Oct	30-Oct	13-Nov
2010	16-May	7-Jul	9-Jul	7-Jul	15-Sep	11-Oct	14-Oct	19-Nov
2011	10-Jun (xviii)	14-July (xix)	2-Aug (xx)	(xxi)	(xxi)	17-Oct	19-Oct	4-Nov
2012	5-Apr	19-Apr (Partial) 5-May (Full)	7-May					

(i) Barrier notched on Sept. 28, 1991. Construction resumed on Oct. 10 and finished on Oct. 13.

(ii) Barrier notched on Sept. 30, 1992. Construction resumed on Oct. 2 and finished on Oct. 9.

(iii) Construction was delayed on 5/17 and resumed on 6/5 due to high flows.

(iv) Barrier was breached on 5/ 16 on an emergency basis, but complete removal wasn't done until 9/3, after Corps demanded permit compliance of complete removal.

(v) Barrier was installed in previous years.

(vi) Installation delayed due to high flows.

(vii) Not intalled due to high San Joaquin River flows.

(viii) Not installed upon DFG's request.

(ix) In 1963 and 1964 an old rock barge was intentionally flooded and sunk at the head of Old River in an experiment to see if it could serve as a temporary barrier. Results were not promising and rock was placed directly for the 1968 barrier. No barriers were in place in 1965, 1966 or 1967.

(x) Flashboards adjusted to allow minimum 6-inches flow for fish passage.

(xi) Spring Head of Old River not installed due to high flows in the San Joaquin River.

(xii) Only above water portion of boat ramps constructed due to hgh flows. North abutment not installed until full closure of barrier. No "partial" barrier configuration for 2005.

(xiii) Fall Head of Old River not installed because existing flows and dissolved oxygen levels in the San Joaquin River were sufficient for Chinook Salmon.

(xiv) Not installed in accordance with Wanger decision to protect Delta Smelt.
(xv) Non Physical "Bubble Barrier" installed as a pilot test to prevent salmon from entering Old River.

(xvi) Includes installation of new culverts in the Middle River barrier north and south abutments.

(xvii) The Non-Physical Barrier was planned but could not be installed due to high velocity currents in the San Joaquin River that posed excessively dangerous conditions for divers and ruled out the possibility of installing the necessary equipment on the channel bottom.

(xviii) Started Grantline Canal barrier south abutment construction to replace culverts, using barge and crane from shoreline.

(xix) Due to high flows the Grantline Canal barrier fish flashboard structure washed out and will be re-constructed at a later date. The weir section elevation had to be reduced to accommodate the high flow. All 6 culverts were in tidal position (closed).

(xx) The Grantline Canal barrier weir section was completed back to its designed weir elevation (1.0 ft NGVD) and all 6 culvert flap-gates were tied open.

(xxi) The Grantline Canal flashboard structure was washed out earlier in the year and the California Department of Fish and Game did not require a notch this year due to high flows.

APPENDIX C: 2012 TBP AND GS SOUND MONITORING MEMO'S

Memo

To:	Jacob McQuirk (DWR)		
From:	Chris Shields	**Email:**	chris.shields@atkinsglobal.com
Phone:	916-325-1424	**Date:**	April 17, 2012
Ref:	100026852	**cc:**	Chris Fitzer (AECOM)
Subject:	Underwater Noise Monitoring Results During Vibratory Pile Installation of the Georgiana Slough Non-Physical Barrier		

Introduction

This technical memorandum presents results of short-term underwater noise measurements conducted at the Georgiana Slough Non-Physical Barrier (GSNPB) construction site from February 15 through February 27, 2012. The purpose of the noise measurements was to monitor the underwater noise levels generated by vibratory pile-driving activities during the GSNPB construction as a condition of the Biological Opinion (BO) issued by the National Marine Fisheries Service (NMFS) on February 11, 2011 (NMFS 2011). The GSNPB site is located in the north Sacramento–San Joaquin Delta in unincorporated Sacramento County, at the divergence of the Sacramento River and Georgiana Slough, just downstream of Walnut Grove.

Construction involving vibratory pile driving is generally described as continuous operation of the hammer to seat the pile. To install the project piles, the pile would be hoisted into position with a crane and stabilized by a deck-mounted jig, or template, on the working barge. The vibratory hammer is mounted on the crane. The hammer would then attach to the pile. The pile would be driven for a short period until the pile sinks a couple of feet into the substrate, where it would no longer require the support of the jig. The hammer would pause for the jig to be removed and then operate continuously until the pile is driven down to the final depth. The final depth of some of the piles would be below the surface of the river, requiring an extension arm to be attached to the hammer. The underwater noise analysis discussed in the 2011 BO assumed that 20 piles would be installed in 2 days and that each pile would require up to 10 minutes to be installed. Assuming each second represents a single hammer strike, 6,000 strikes per day or 12,000 strikes for all piles to be installed would be required to complete the project. Under these assumptions, the NMFS Underwater Noise Calculation Spreadsheet modeled the daily accumulated sound exposure level ($SEL_{accumulated}$) to be 198 decibels (dB) at 10 meters (33 feet) for 10 piles using a reference peak sound pressure level of 171 dB at 10 meters for a 12-inch steel pile. The 2012 construction year includes additional piles for scientific purposes and a total pile count of 23.

MONITORING METHODOLOGY

The NMFS criteria for underwater noise levels were established specifically for impact pile driving and were not intended to be applied to vibratory driving. However, conservative thresholds for underwater noise levels for vibratory pile driving were established for the GSNPB project. The following thresholds were applied to the project's pile-driving activities at 10 meters:

- Peak sound pressure = 171 dB
- RMS (Root Mean Square)= 155 dB,
- SEL = 155 dB, and
- $SEL_{accumulated}$ = 198 dB.

Memo

Short-term underwater noise levels of vibratory pile-driving activities were measured from February 15 through February 27, 2012, by an Atkins acoustics specialist. Short-term underwater noise levels were measured using a Larson Davis Laboratories (LDL) Model 831 precision integrating sound level meter (SLM) with a Reson TC4013 omni-directional hydrophone. The SLM was calibrated before and after use with a G.R.A.S. Pistonphone Type 42AF to ensure that the measurements would be accurate. All underwater measurements were taken at 10 meters away from where the pile was installed and at varying depths based on the depth of the river channel at each pile location. The meter was programmed to collect peak sound pressure levels every 1 second. As stated in the BO, sound levels of less than 150 dB were not considered to contribute to the accumulated SEL for the purposes of assessing injury; therefore, strikes that measured less than 150 dB were not counted as strikes or included in accumulated SEL calculations. Using the varying 1 second peak sound pressure levels measured between strikes, peak sound-pressure levels were logarithmically averaged and the mean peak sound-pressure level was applied to the NMFS Underwater Noise Calculation Spreadsheet to determine the daily accumulated SEL.

RESULTS

A description of pile-driving activities is presented below and Table 1 presents noise monitoring results. The Attachment presents the NMFS Underwater Noise Calculation Spreadsheet for each day of monitoring.

Pile 22 was the first pile to be installed. The pile location is adjacent to River Road in Walnut Grove and upstream from the BAFF. The hydrophone was located 10 meters from the pile and measurements were taken from the CS Marine working barge. The pile came in contact with riprap, resulting in longer installation time. Pile 22 required 490 strikes to be seated.

Pile 15 was installed in 127 strikes with the vibratory hammer. The resulting peak sound pressure levels were relatively low, with an average 1-second peak sound pressure level of 158 dB. It should be noted that Pile 15 was installed much faster than in the previous year and the barrier mounting bracket was not attached for this pile or any others during the 2012 construction year because of the high peak sound pressure levels that were observed during the 2011 construction year.

Piles 12 through 14 and 21 required between 108 and 135 strikes to be seated. The average peak sound pressure levels ranged between 166 dB and 168 dB, and the peak sound pressure levels ranged between 174 dB and 183 dB for the highest peak sound pressure level measured while the piles were being installed.

Pile driving activities ceased after the sixth pile (Pile 21) was installed. As shown in Table 1 the $SEL_{Accumulated}$ resulted in 175 dB for stationary fish. The $SEL_{Accumulated}$ for moving fish did not result in a calculated number due to the low peak sound pressure levels measured throughout the day.

Piles 18 through 20 and 5 through 11 were installed on the second day of monitoring. Again, fish barrier mounting brackets were not preinstalled on these piles or the remaining piles for the fish barrier. Pile 20 required the most number of strikes (245) to be seated. The number of strikes to seat the piles decreased dramatically, allowing more piles to be installed for the day. Average peak sound pressure levels ranged from 158 dB to 177 dB with the highest peak sound pressure level measuring 187.2 dB.

Piles 1 through 4 and 17 were installed on the third day of monitoring, February 17, 2012. The highest peak sound pressure level measured during installation was 187.6 dB and the average peak sound pressure level was 174 dB, with 399 total strikes for the day of pile driving activities. As shown in Table 1 the $SEL_{Accumulated}$ resulted in 175 dB for stationary fish.

Memo

Pile 23 was installed on the last day of monitoring, February 27, 2012. A total of 317 strikes were required to seat this pile. Pile 23 is one of the new scientific piles for the 2012 study year. The average peak sound pressure level was 175 dB, as shown in Table 1 below. The highest peak sound pressure level measured was 187.6 dB.

CONSCLUSION

Daily underwater noise monitoring of pile driving activities associated with Georgiana Slough Non-Physical Barrier construction are shown in Table 1 below and demonstrate that the daily $SEL_{accumulated}$ threshold was not exceeded on any one full day of pile driving.

REFERENCE

National Marine Fisheries Service (NMFS). 2009. Pile driving calculation spreadsheet. Available at: http://www.wsdot.wa.gov/Environment/Bioloby/BA/BAguidance.thm. Accessed: November 4, 2008.

Table 1
Underwater Noise Level Measurements of Vibratory Hammer Pile Driving
(at 10 meters from pile)

Date	Time of Day		Pile	Depth (feet)[1]	Number of Strikes	Peak[2] (dB)	Average Peak[3] (dB)	Daily Number of Strikes	Daily Average Peak[3] (dB)	SELaccumulated (dB)	
	Start	End								Stationary Fish	Moving Fish
2-15-2012	10:02:42	10:20:36	22	5	490	184.8	172	1102	170	175	--
	11:55:00	11:58:11	15	5	127	155.1	158				
	13:20:15	13:23:38	14	5	130	183.3	168				
	14:07:03	14:12:52	13	8	135	175.5	168				
	14:47:08	14:51:44	12	8	110	175.3	169				
	15:34:04	15:51:20	21	10	108	174.2	166				
2-16-2012	09:52:34	10:03:13	20	10	245	170.9	158	1192	169	175	--
	10:37:30	10:39:51	11	10	137	183.6	167				
	11:06:47	11:10:10	10	10	102	181.3	166				
	11:36:35	11:37:32	9	10	57	179.3	173				
	12:42:19	12:44:23	8	10	65	178.1	171				
	13:19:17	13:30:37	19	10	166	179.7	168				
	13:57:41	14:01:54	7	10	133	182.3	177				
	14:38:56	14:42:26	18	10	85	181.3	167				
	15:23:54	15:27:22	6	10	124	175.9	164				
	16:00:40	16:01:46	5	10	66	187.2	164				
2-17-2012	09:20:15	09:21:15	4	8	61	172.5	160	399	174	175	--
	09:53:25	09:54:19	3	8	55	178.8	169				
	10:27:42	10:28:52	2	5	71	178.8	170				
	11:01:49	11:04:03	1	5	108	185.0	176				
	11:38:12	11:42:24	17	10	104	187.6	177				
2-27-2012	08:24:14	10:34:54	23	8	317	187.6	175	317	175	175	167

Notes: dB = decibel; SELaccumulated = daily accumulated sound exposure level.
[1] Depth of hydrophone in water body.
[2] Peak sound pressure refers to the highest absolute value of a measured waveform.
[3] Average of peak sound pressure levels measured during pile installation.
Source: Underwater measurements conducted by Atkins in 2012, National Marine Fisheries Service Underwater Noise Calculation Spreadsheet 2012.

Memo

To:	Jacob McQuirk-DWR		
From:	Chris Shields	**Email:**	Chris.Shields@atkinsglobal.com
Phone:	916-325-1424	**Date:**	11 May 2012
Ref:		**cc:**	Roy Leidy-AECOM
Subject:	2012 South Delta Temporary Barriers Project		

Introduction

The South Delta Temporary Barriers Project (TBP) is an ongoing project that calls for the seasonal construction of temporary rock barriers to ensure that local agricultural diverters within the South Delta Water Agency do not experience adverse water level and circulation impacts caused by the State Water Project (SWP) and the Central Valley Project (CVP). The temporary rock barriers are designed to function as flow control structures that trap tidal waters behind them during high tide, improving water levels and circulation for local south Delta farmers, as well as improve migration of Central Valley fall-run Chinook salmon originating in the San Joaquin River watershed by blocking movements into the Old River Channel from the mainstem San Joaquin River, reducing potential entrapment within the SWP and CVP pumps. Temporary rock barriers were installed at Middle River, Old River near Tracy and Head of Old River.

Adhering to the project description provided to the National Marine Fisheries Service (NMFS) for the purposes of Section 7 consultation, the amount of sound generated in the aquatic environment during construction of temporary rock barriers installed would be monitored. The ecological surrogate identified in the Biological Opinion for 2012 South Delta Temporary Barriers Project regarding underwater noise monitoring is as follows:

- Ecological Surrogates

  The analysis of the effects of the proposed TBP anticipates that the construction and removal of each barrier will result in acoustic noise generated in the aquatic environment that exceeds typical ambient background conditions for the action area. Based on the types of vehicles and equipment to be used, the methods described for construction and removal of the barriers, and the effects analysis conducted for this consultation, the amount of sound generated in the aquatic environment associated with the construction and removal of each barrier shall not exceed 150 dB at a distance of 100 meters from the source activity at any time.

MONITORING METHODOLOGY

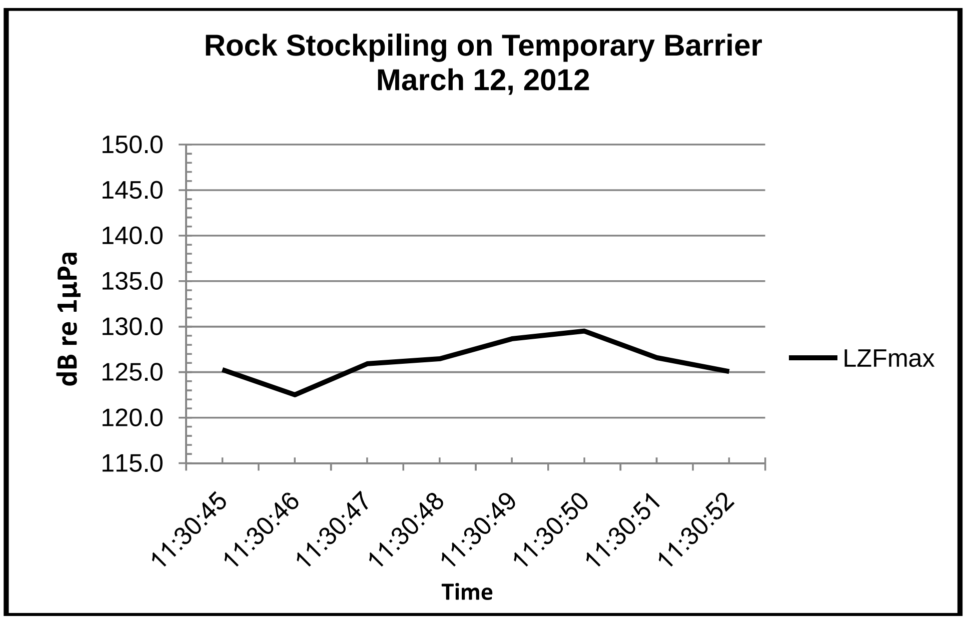
Underwater noise levels were measured using a Larson Davis Laboratories (LDL) Model 831 precision integrating sound level meter (SLM) with a Reson TC4013 omni-directional hydrophone. The SLM was calibrated with a G.R.A.S. Pistonphone Type 42AF to ensure that the measurements would be accurate. All underwater measurements were taken at a distance of 100 meters from in-stream temporary rock barrier construction locations. The SLM was manually operated. The SLM logged data every second of activation recording the date, time, and maximum underwater noise level. The SLM was activated during rock placement and piling on top of the temporary barrier, while rock piles were pushed into the river and in-stream rock placement by clam-bucket. The monitoring of underwater noise levels focused on the aquatic noise levels generated during rock placement, specifically, noise levels generated during rock placement within the water channel. Instantaneous maximum underwater noise levels are denoted as dB LZFmax in this memo and are relative to dB re 1µPa.

RESULTS

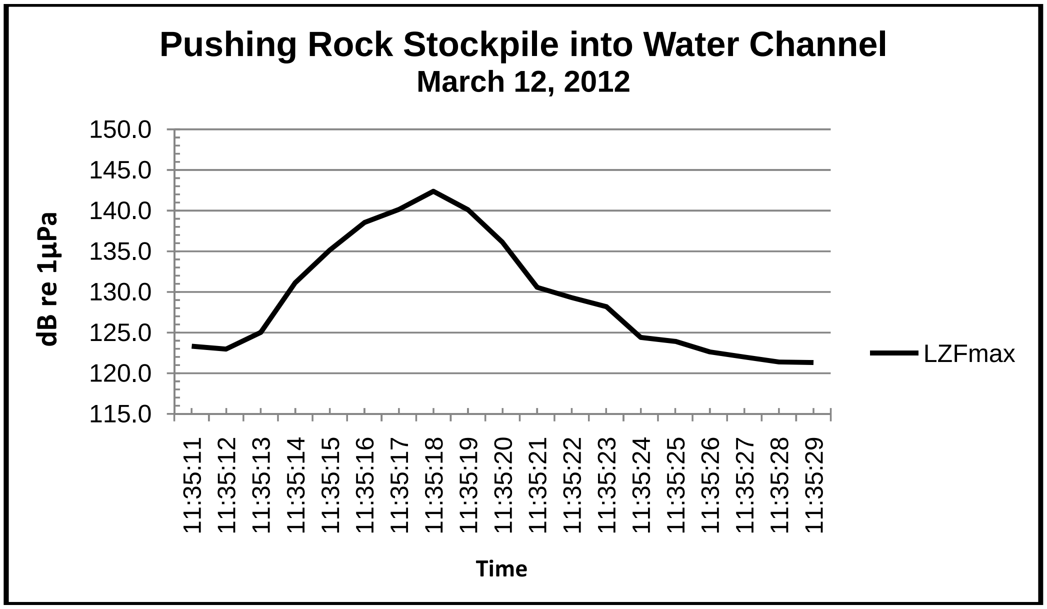
Middle River

Underwater noise levels attributable to the construction of the temporary rock barrier at Middle River were monitored on March 12 and 13, 2012. The Middle River temporary barrier was constructed utilizing one dozer, one excavator and several rock delivery trucks. Rock was stockpiled on the levee road adjacent to the temporary rock barrier construction site by trucks. The excavator would then re-position the rocks down the levee slope and at the levee toe so that the dozer could access the rock. The dozer would scoop rock into the bucket and transport the rock to the edge of the temporary rock barrier, originating from the levee toe and into the channel, for placement and stockpiling. Rock would be stockpiled at the end of the forming temporary rock barrier before being pushed into the channel. This method was repeated throughout the day as the temporary rock barrier construction continued into the water channel. The results are summarized below and complete data sheets are included in the Appendix A:

- Ambient noise level: 115-120 dB LZFmax
- Rock stockpiling: 119-143 dB LZFmax - A graphical representation of typical underwater noise levels due to rock stockpiling on the temporary rock barrier is shown below.



- Pushing rock stockpile into water channel: 130-148 dB LZFmax - A graphical representation of typical underwater noise levels due to pushing stockpiled rock on the temporary rock barrier into the water channel is shown below.

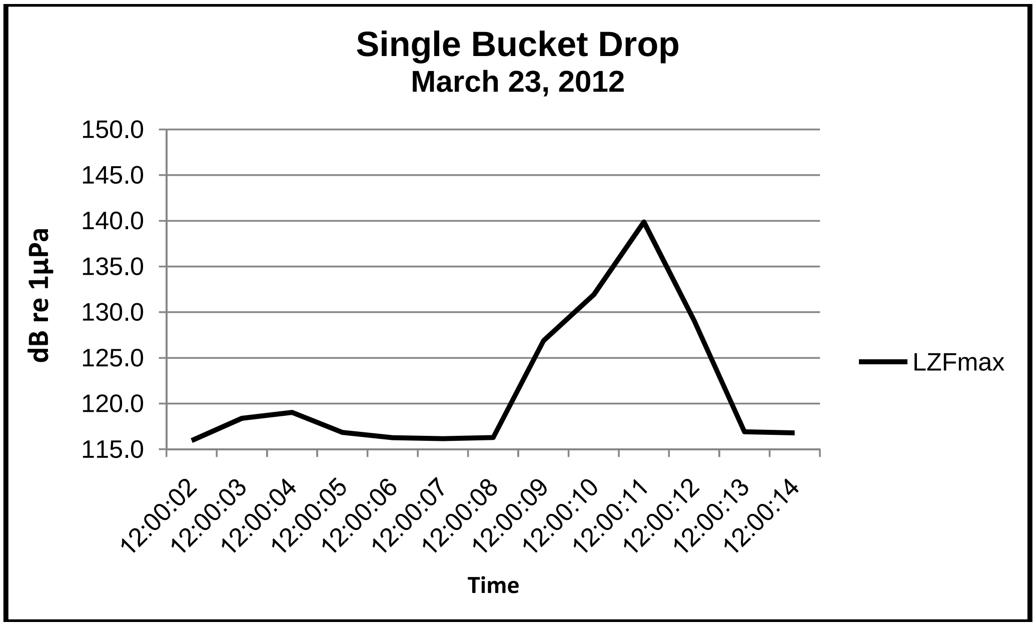


Head of Old River

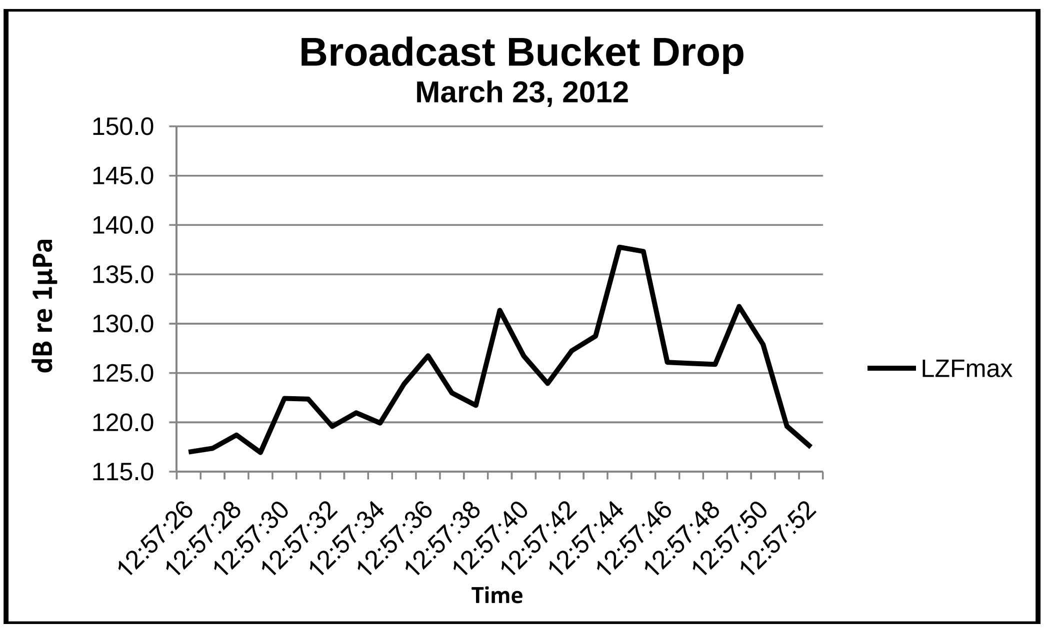
Underwater noise levels attributable to the construction of the temporary rock barrier at Head of Old River were monitored on March 22 and 23, 2012. The Head of Old River temporary barrier was constructed utilizing one dozer, one barge calm bucket and several rock delivery trucks. Rock was stockpiled on the water side of the levee along the river bank adjacent to the temporary rock barrier construction site by trucks. The dozer would then re-position the rocks at the edge of the river bank so that the barge excavator could access the rock. The barge excavator would scoop rock into the bucket and swing the rock over the temporary rock barrier for placement. Rock was deposited in a single bucket drop, spread over an area of the rock barrier in a broadcasting motion, or by a submerged bucket drop. The majority of rock deposits consisted of the bucket dropping in a freefall with a full load of rock onto the temporary barrier, and then the bucket would be dragged along the length of the submerged rock barrier. The bucket was dragged along the rock barrier to locate gaps or to evenly spread the rock along the barrier when the barrier was near the desired elevation. These events varied in duration. These methods were repeated throughout the day as the temporary rock barrier construction continued into the water channel. The results are summarized below and complete data sheets are included in the Appendix B:

- Ambient noise level: 115-121 dB LZFmax

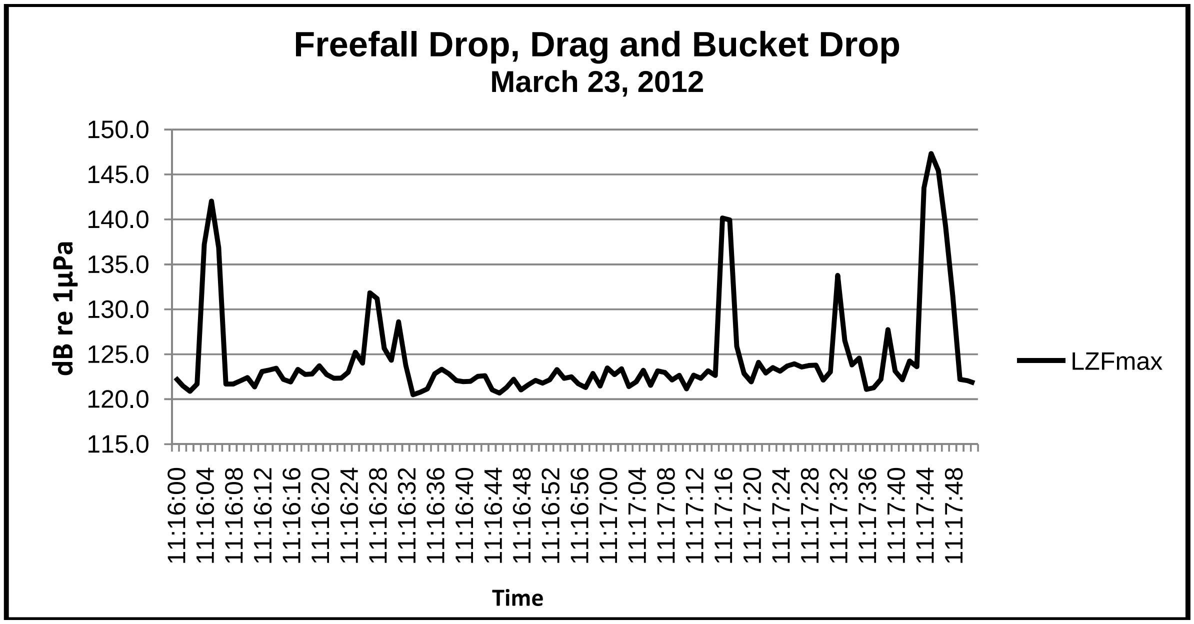
- Single bucket drop: 135-140 dB LZFmax - A graphical representation of typical underwater noise levels due to a single bucket drop on the temporary rock barrier is shown below.



- Broadcast bucket drop: 125-138 dB LZFmax - A graphical representation of typical underwater noise levels due to a broadcast bucket drop on the temporary rock barrier is shown below.



- Freefall drop, drag and bucket drop: 131-147 dB LZFmax - A graphical representation of typical underwater noise levels due to a freefall drop, drag and bucket drop on the temporary rock barrier is shown below.



Old River near Tracy

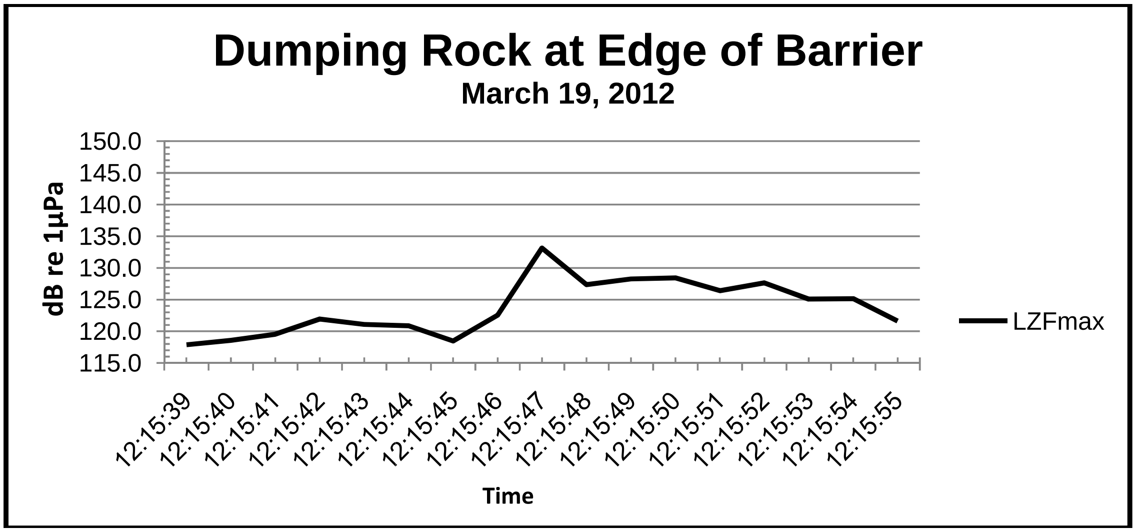
Underwater noise levels attributable to the construction of the temporary rock barrier at Old River near Tracy were monitored on March 19, 20 and 26, 2012. The Old River near Tracy temporary barrier was constructed utilizing one dozer, one excavator, one clam bucket and one rock delivery truck on March 19 and 20. Rock was stockpiled on agricultural property to the east of the temporary rock barrier construction site and loaded onto the truck using the excavator. Rock was transported to the site with the truck and dumped at the edge of the rock barrier adjacent to the levee, forming the boat launch pad. Rock was either stockpiled along the edge of the temporary barrier with some errant rocks entering the water or dumped directly into the water channel. After stockpiling a considerable amount of rock, the dozer would then push the stockpiled rock into the water channel. The dozer would make several short back and forth movements on the forming launch pad as it was pushing the rock into the water channel.

Construction practices changed on March 26, a clam bucket was used as the barrier moved further into the water channel from the formed boat launch pad. Rock was transported by truck and stockpiled on the boat launch pad. Clam bucket work activities were similar to the Head of Old River clam bucket activities described above. There were full bucket drops, broadcasting of full bucket drops, full bucket freefall drop followed by bucket drop broadcast over the barrier and full bucket freefall drop, broadcast, removal of some rock followed by another drop. These methods were repeated throughout each day as the temporary rock barrier construction continued into the water channel and varied in duration. The results are summarized below and complete data sheets are included in the Appendix C:

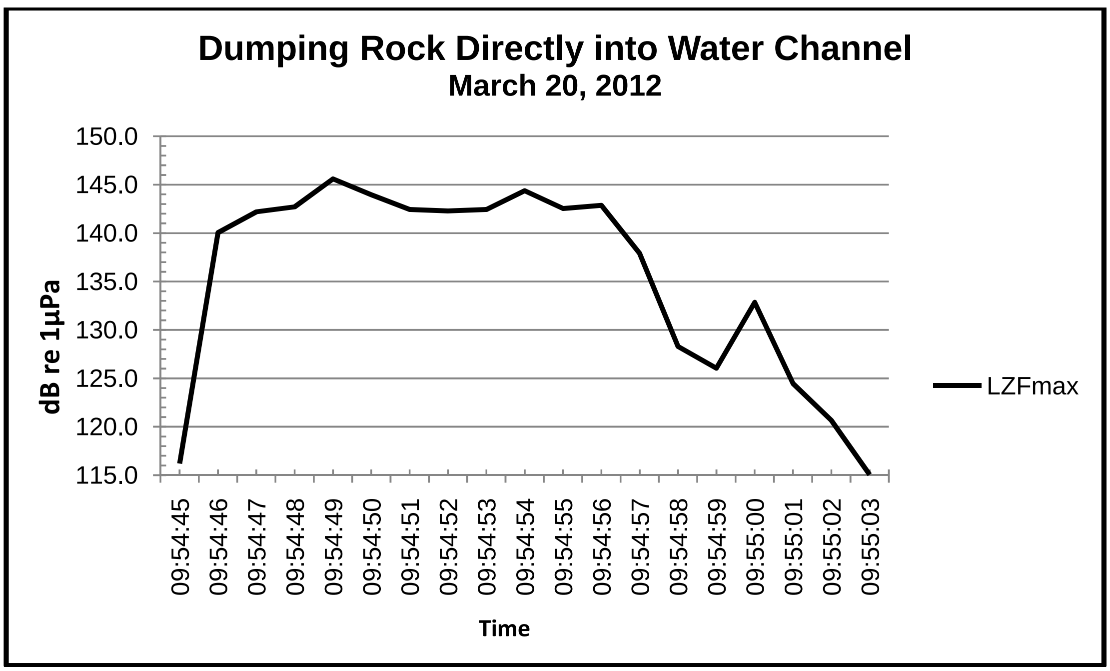
- Ambient noise level: 113-114 dB LZFmax

- Stockpiling rock, no rock entering the water: 115-119 dB LZFmax

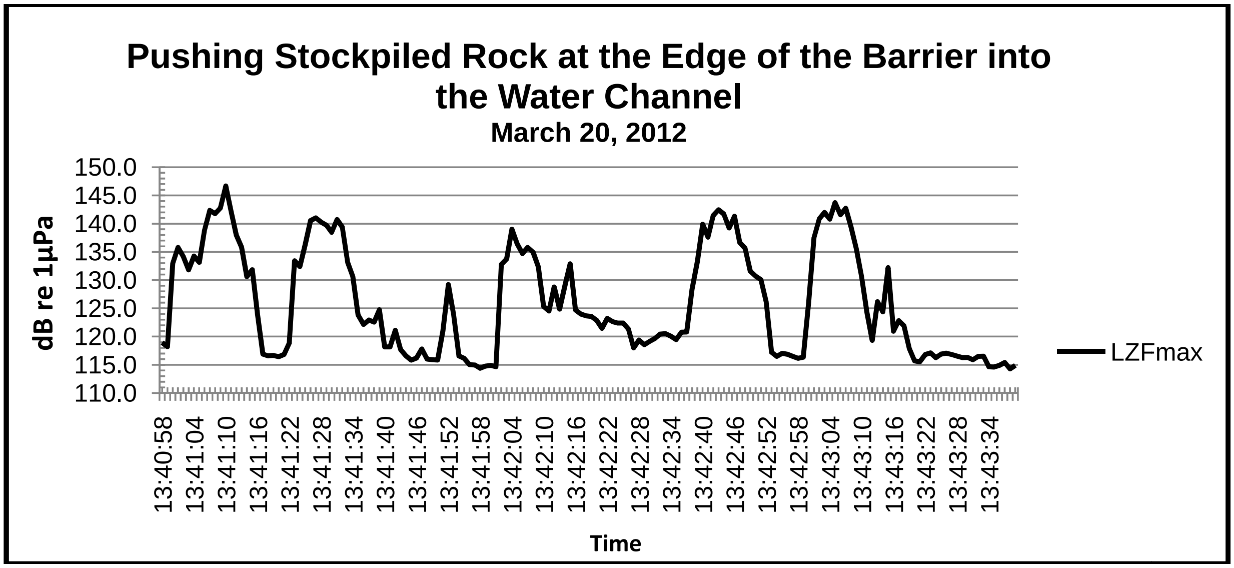
- Dumping rock at edge of barrier with some rocks entering water: 120-133 dB LZFmax- A graphical representation of typical underwater noise levels due to dumping rock at the edge of the temporary rock barrier is shown below.



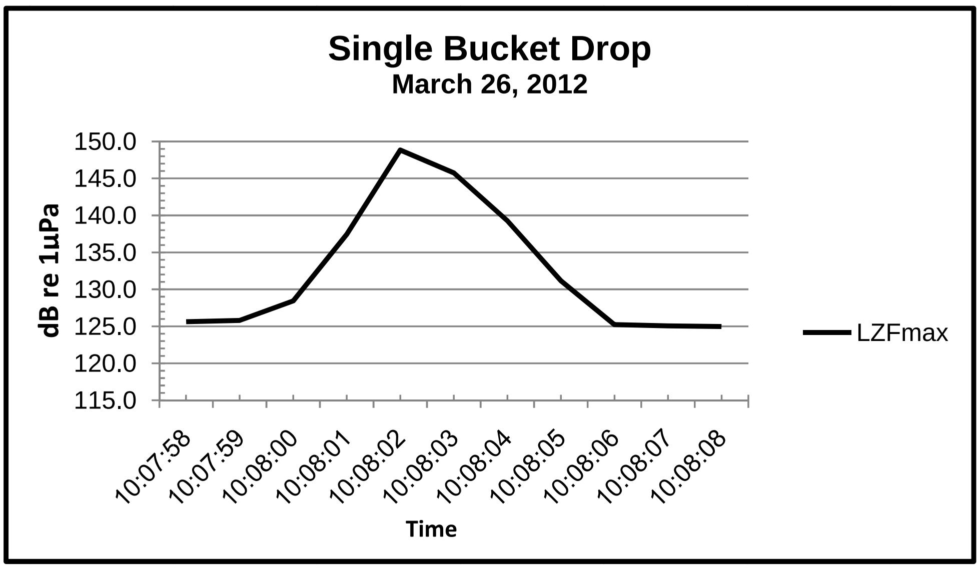
- Dumping rock directly into water channel: 125-147 dB LZFmax - A graphical representation of typical underwater noise levels due to dumping rock directly into the water channel is shown below.



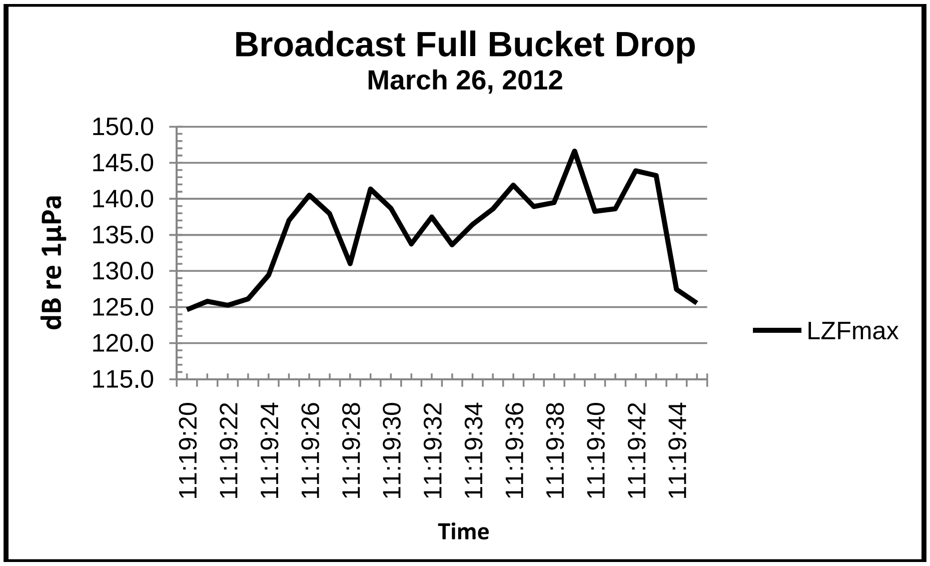
- Pushing stockpiled rock at edge of barrier into the water channel: 129-147 dB LZFmax - A graphical representation of typical underwater noise levels due to pushing stockpiled rock at the edge of the barrier into the water channel is shown below.



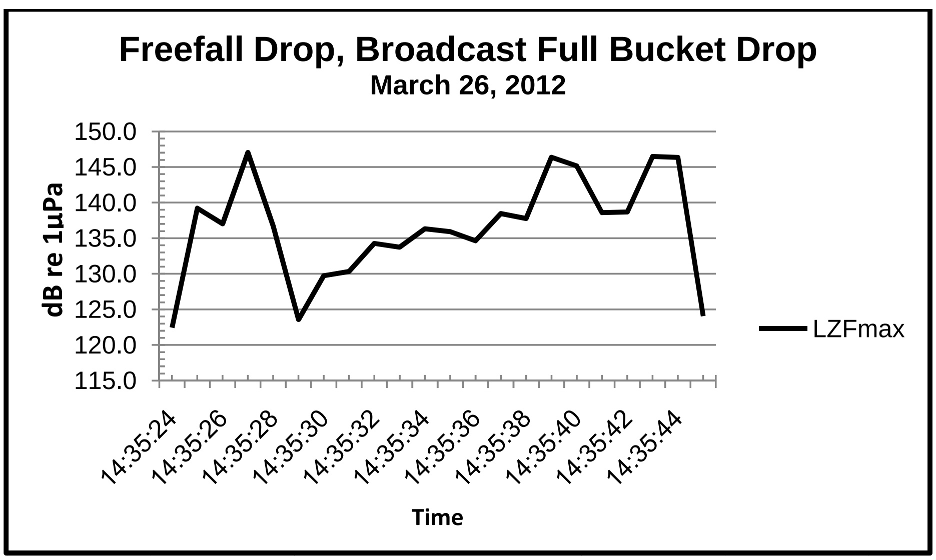
- Single bucket drop: 140-149 dB LZFmax - A graphical representation of typical underwater noise levels due to a single bucket drop on the temporary rock barrier is shown below.



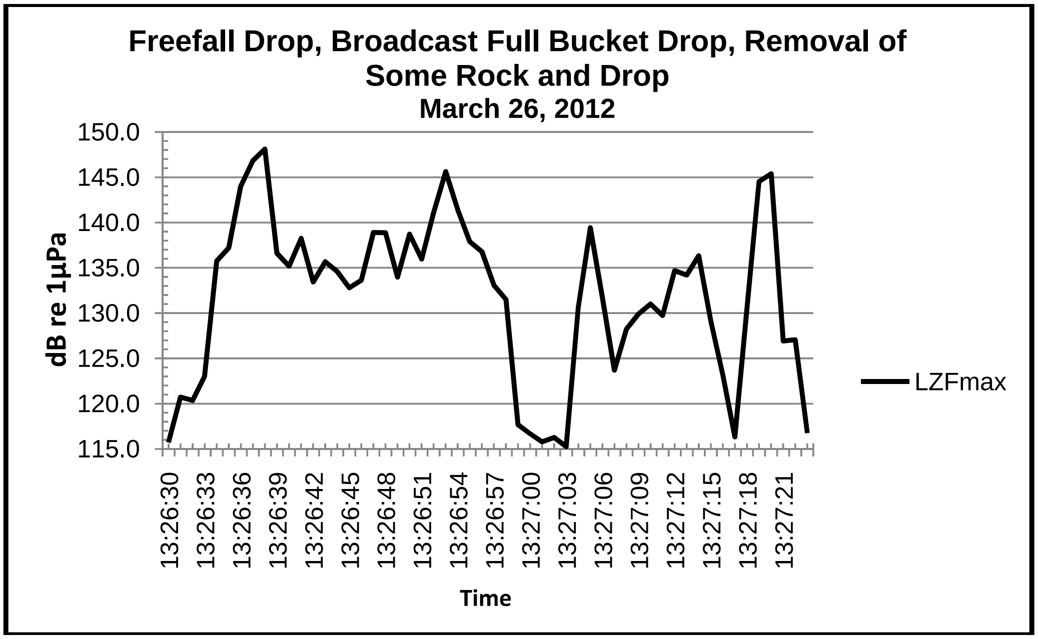
- Broadcast full bucket drop: 141-147 dB LZFmax - A graphical representation of typical underwater noise levels due to a broadcast bucket drop on the temporary rock barrier is shown below.



- Freefall drop, broadcast full bucket drop: 142-147 dB LZFmax - A graphical representation of typical underwater noise levels due to a freefall drop, broadcast full bucket drop on the temporary rock barrier is shown below.



- Freefall drop, broadcast full bucket drop, removal of some rock and drop: 138-147 dB LZFmax - A graphical representation of typical underwater noise levels due to a freefall drop, broadcast full bucket drop, removal of some rock and drop on the temporary rock barrier is shown below.



CONCLUSION

The monitoring conducted at Middle River, Head of Old, and Old River near Tracy properly characterizes the underwater noise level trends attributable to temporary rock barrier construction at each site. Based on the underwater noise levels measured and observed during the monitoring, the ecological surrogate threshold was not exceeded and it was determined that monitoring was no longer warranted.

APPENDIX D: ENVIRONMENTAL AWARENESS TRAINING INFORMATION

Worker Environmental Awareness Program

Training will be done by a qualified biologist for all workers at the job site.

Species List for WEAP Training – Handout attachment 1

Winter and Spring Run Chinook Salmon

Central Valley Steelhead

North American Green Sturgeon

Delta Smelt Longfin

Smelt Swainson's

Hawk Western Pond

Turtle

Best Management Practices

1. No pets, camping, firearms, or any other use of the right of way area will be allowed. The Contractor's employees will not be allowed at the work site during nonworking hours.

2. Any sightings, trappings, injuries, or fatalities to animals that occur as a result of project-related activities shall be reported immediately to the Engineer.

3. Food-related trash, such as wrappers, cans, bottles, scraps, shall be placed in closed containers and removed daily from work sites. Trash or garbage shall be removed to a county approved disposal site at least weekly by the Contractor. The right of way shall be policed daily by the Contractor's personnel.

4. Review of the potential penalties for taking a listed wildlife species will be described.

5. Protocol to follow if sensitive species are encountered, including appropriate contact points, such as the Engineer or designated representative, inspectors, and environmental personnel.

6. Fact sheets or cards will be available to the Contractor's employees.

7. Traffic shall be restricted to existing roads and flagged right of way or temporary construction easement.

Follow-up meetings to present additional topics pertaining to the above subjects as they occur or are brought to the attention of the Engineer or the Contractor during construction.

WEAP Handout

Temporary Barriers Project

Worker Environmental Awareness Training

Delta Smelt

Hypomesus transpacificus

Threatened – State and Federal

- Migrate from SF Bay to Delta
- Spawn from Jan. to Jul. mostly in the Delta.
- Eat microscopic crustaceans

Longfin Smelt

Spirinchus thaleichthys

Species of Concern

- Migrate from SF Bay through Delta
- Spawn in late winter to Spring in the Delta
- Eat microscopic crustaceans

Rainbow Trout (Steelhead)

Oncorhynchus gairdneri

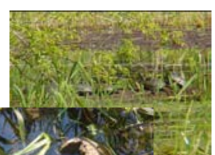
Endangered – Federal

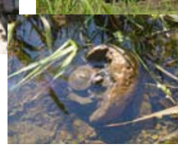
Migrate from fresh to salt water and back

Spawn in fresh water from Dec. to Apr.

Western Pond Turtle

State-Species of Concern





Nests Mar. to Aug. along waterways

Basks on logs and beaches

Chinook Salmon

Oncorhynchus tshawytscha

Federal
Spring = Threatened
Winter = Endangered

Migrate from fresh to salt water

Spawn in fresh water

Delta is a migratory path

Juveniles migrate through the Delta year round

Migration route affects survival

Green Sturgeon

Acipenser medirostris

Threatened - Federal

Long-lived, slow growing fish

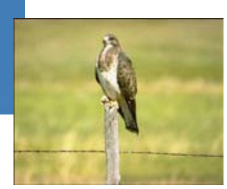
Adults are mostly marine

Spawn in fresh water

Young migrate to salt water

Swainson's Hawk

State-Threatened



Nest from Mar to May

Protected from construction impacts within a ¼ mile of nests