UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

SEP 25 2008

In Response Refer To:
2008/00396

Kathleen Dadey, Ph.D.
Chief, Central California Valley
South Branch
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Dr. Dadey:

This letter transmits NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Enclosure 1) based on our review of the Ironhouse SanitaryDistrict Wastewater Treatment Plant (ISD WWTP) expansion project in Contra Costa County, California, and its effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), threatened Southern distinct population segment of North American green sturgeon (*Acipenser medirostris*), and designated critical habitat for Central Valley steelhead in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Critical habitat for the Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon does not occur within the action area of the project. Your initial request for section 7 consultation on this project was received on February 1, 2008. The U.S. Army Corps of Engineers (Corps) has assigned identification number (SPK-2005-00054) to this project. The initiation package contained a biological assessment for the proposed project (Vinnedge Environmental Consulting 2007) and a copy of the draft Supplemental Environmental Impact Report for the proposed project (Jones and Stokes 2006).

Staff from NMFS and the consulting firms representing ISD (Vinnedge Environmental Consulting, Biota Pacific Environmental Sciences, and Robertson-Bryan, Inc) conferred several times in April and May 2008 via phone and email to complete the biological assessment to NMFS satisfaction. A final biological assessment (BA) was provided to NMFS on June 6, 2008.

This biological opinion is based on information provided in the February 1, 2008, section 7 consultation package which included the biological assessment for the proposed project and supplemental information to the BA (*i.e.*, Addendum to the Biological Assessment, June 6, 2008); phone conversations and e-mails regarding the proposed project received by NMFS staff; and, numerous scientific articles and reports from both the peer reviewed literature and agency "gray literature." A complete administrative record of this consultation is on file at the Sacramento Area Office of NMFS.

Based on the best available scientific and commercial information, the biological opinion concludes that the ISD WWTP expansion project, as presented by the Corps, is not likely to jeopardize the continued existence of the listed species or destroy or adversely modify designated critical habitat. NMFS also has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor project related incidental take of listed salmonids. The section 9 prohibitions against taking of listed species and the terms and conditions in the Incidental Take Statement of this biological opinion will not apply to North American green sturgeon until the final section 4(d) ruling under the ESA has been published in the Federal Register.

This letter also transmits NMFS' Essential Fish Habitat (EFH) conservation recommendations for Pacific salmon (*O. tshawytscha*) and starry flounder (*Platichthys stellatus*) as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.*; Enclosure 2). The document concludes that the ISD WWTP expansion project will adversely affect the EFH of Pacific salmon in the action area and adopts certain terms and conditions of the incidental take statement and the ESA conservation recommendations of the biological opinion as the EFH conservation recommendations.

The Corps has a statutory requirement under section 305(b)(4)(B) of the MSA to submit a detailed response in writing to NMFS within 30 days of receipt of these conservation Recommendations that includes a description of the measures proposed for avoiding, mitigating, or offsetting the impact of the activity on EFH (50 CFR 600.920 (j)). If unable to complete a final response within 30 days, the Corps should provide an interim written response within 30 days before submitting its final response.

Please contact Mr. Jeffrey Stuart in our Sacramento Area Office at (916) 930-3607 or via e-mail at J.Stuart@noaa.gov if you have any questions regarding this response or require additional information.

Sincerely,

for Rodney R. McInnis
Regional Administrator

Enclosures (2)
1. Biological Opinion
2. Essential Fish Habitat Conservation Recommendations

Copy to File: ARN 151422SWR2008SA00041
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Enclosure 1

BIOLOGICAL OPINION

ACTION AGENCY: U.S. Army Corps of Engineers, Sacramento District

ACTIVITY: Ironhouse Sanitary District Wastewater Treatment Plant Expansion Project

CONSULTATION CONDUCTED BY: Southwest Region, National Marine Fisheries Service

FILE NUMBER: **151422SWR2008SA00041**

I. CONSULTATION HISTORY

On February 1, 2008, NOAA's National Marine Fisheries Service (NMFS) received a letter from the United States Army Corps of Engineers (Corps) requesting initiation of formal section 7 consultation under the Endangered Species Act (ESA) for the proposed Ironhouse Sanitary District Wastewater Treatment Plant Expansion Project. The Corps has been requested to issue Nationwide Permits (NWP) for utility line activities (NWP 12), bank stabilization (NWP 13), and temporary construction, access, and dewatering (NWP 33). The Corps has assigned identification number (SPK-2005-00054) to this project. The initiation package contained a biological assessment (BA) for the proposed project (Vinnedge Environmental Consulting 2007) and a copy of the draft Supplemental Environmental Impact Report (EIR) for the proposed project (Jones and Stokes 2006).

During April and May 2008, staff from NMFS conferred with the consultants representing the applicant, Ironhouse Sanitary District (ISD), to discuss additional information needs required for the consultation. NMFS requested additional information be provided for the project's anticipated impacts to the recently listed Southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*) and the designated critical habitat for Central Valley steelhead (*Oncorhynchus mykiss*). This information was missing from the original biological assessment provided in the consultation package.

On June 6, 2008, NMFS received an addendum to the BA (Vinnedge Environmental Consulting and Robertson-Bryan, Inc. 2008) addressing NMFS' comments on the draft BA and requests for additional information via e-mail. A hard copy of the BA addendum was logged into the NMFS Sacramento office on June 16, 2008.

On June 20, 2008, subsequent to the completion of the addendum to the BA (Vinnedge Environmental Consulting and Robertson-Bryan, Inc. 2008), NMFS received updated information and figures regarding the in-water site preparation, assembly and placement of the pipeline and diffuser.

II. DESCRIPTION OF THE PROPOSED ACTION

The ISD Wastewater Treatment Plant (WWTP) expansion project will entail the construction of an upgraded and expanded facility. The project will increase the permitted capacity of the WWTP from its current capacity of 2.7 million gallons per day (mgd) to 4.3 mgd average dry weather flow (ADWF) in the initial phase of expansion, and to 8.6 mgd ADWF at buildout to accommodate growth-related demands in the ISD service area and to meet the level of treatment necessary to meet regulatory discharge requirements. Under the proposed project, discharge of treated effluent would be a combination of direct discharge into the San Joaquin River off the north shore of Jersey Island, application of recycled water onto a maximum of 380 acres of agricultural lands on Jersey Island, use of on-site storage of 80 million gallons of recycled water and 34 million gallons for storage of non-compliant water, and development, to the extent practicable, of industrial re-use water. As part of the facility upgrades and expansion, the ISD has designed a direct discharge diffuser pipeline with the outfall structure placed just off the north shore of Jersey Island in the San Joaquin River.

A. Existing Facilities

The existing wastewater treatment facilities were upgraded in the mid-1990s to treat 3.0 mgd ADWF at 188 milligrams per liter (mg/l) influent biochemical oxygen demand (BOD) concentration. Currently the influent BOD concentration is greater (210 mg/l) than the design influent BOD, which reduces the wastewater treatment capacity to 2.7 mgd. Treatment facilities consist of a 9-inch Parshall flume, two channel grinders, two 42-inch-diameter screw pumps, and two parallel two-stage aerated ponds with return sludge capability. In this two-stage aerated pond system, the first aerated pond is a completely mixed basin with a 1.7 million gallon (MG) volume and five 20-horsepower (hp) floating aerators. The second pond has a 2.4 MG volume and six 10-hp floating aerators.

The current ISD disposal process includes storage of effluent in ponds, disinfection, and application to the District's 542 acres of agricultural lands on its mainland property and on Jersey Island. The storage ponds have a 350 acre-foot (ac-ft) (114 MG) capacity when taking into account 3 feet of freeboard. Following treatment, the effluent is stored in the ponds and disinfected with sodium hypochlorite prior to land application of the recycled water on 162 acres of mainland property and 380 acres on Jersey Island.

B. Proposed Facilities

A tertiary treatment facility, including an effluent pump station, would be constructed in two phases within a 6.5-acre footprint on ISD's "mainland" property. The initial phase would be designed for an ADWF of 4.3 mgd. The second phase would expand the treatment plant to a design flow of 8.6 ADWF. For the purposes of this assessment, the full build-out discharge rate of 8.6 ADWF was used to evaluate potential water quality effects on aquatic life. A membrane bioreactor treatment facility with membrane filtration would be used to treat effluent, and ultraviolet irradiation would be used to disinfect effluent prior to discharge. The treatment process will produce a nitrified, denitrified, disinfected tertiary effluent that meets Title 22 requirements for unrestricted reuse.

Land application of treated effluent would continue to occur on up to 380 acres of agricultural land on Jersey Island. Once land application is maximized and the existing storage pond is fully utilized, treated effluent would be discharged to the San Joaquin River by means of an effluent pump station, which would pump from the proposed wastewater treatment plant, through an extended 24-inch pipeline, to a 30-inch outfall pipe. Construction of the new treatment facility would require site preparation and earthwork, including excavation. Excess material not suitable for backfill would be used to grade existing lands ISD owns to minimize the need to transport materials off site.

A new influent treatment pipeline would be constructed to connect the existing wastewater treatment plant to the new wastewater treatment plant. An existing 24-inch diameter effluent pipeline on Jersey Island would also be extended to facilitate surface water discharge. The effluent pipeline alignment would generally follow Jersey Island Road, as shown in Appendix B, Figure 1. It would begin at the existing 24-inch diameter pipeline near the south end of Jersey Island, would extend to the north end of the island, and continue into a new 30-inch-diameter outfall. Both the influent and effluent pipelines would be installed in open trenches using traditional cut and cover construction techniques at depths up to 6 feet and widths averaging 6 feet. Dewatering activities may be necessary during pipeline placement due to high groundwater elevations on the mainland and Jersey Island properties. Pipeline dewatering water would be disposed of on adjacent lands owned by ISD.

A discharge pipeline, outfall, and diffuser would be installed in the vicinity of the Jersey Island north levee (Appendix B, Figure 1). The entire assembly would be placed perpendicular to the shore, and would extend approximately 550 feet offshore and at a river depth of 20 feet or greater (Appendix B, Figure 2). The discharge pipeline and outfall would encompass the first 400 feet and would be buried 5 feet below the riverbed to minimize the potential for damage to the pipeline from vessel traffic in the San Joaquin River, and to maximize the dilution ratio from the diffuser (Appendix B, Figure 3). The diffuser would extend the final 150 feet (beginning at approximately 400 feet from the shoreline) and also would be buried below the riverbed with the discharge ports extending outward into the water column (Appendix B, Figure 4). The discharge ports would be the only portion of the diffuser exposed in the water column (i.e., the diffuser pipeline would be buried below the riverbed).

In general, the diffuser would minimize the zone of initial dilution and provide at least a 20:1 dilution of the effluent. The diffuser would consist of 16 ports, alternating between downstream and upstream positions, spaced 10 feet apart, and oriented at approximately 30 degrees from the bottom of the streambed (Appendix B, Figure 4). Twelve-inch flexible rubber diffuser ports (Tideflex Technologies ®) would be used to maintain a jet velocity of approximately 5 feet per second (fps) from the diffuser, at a flow discharge rate of slightly less than 1 cubic feet per second (cfs) when the ISD discharge reaches 8.6 mgd. The effective diameter of the ports would be about 6 inches (0.2 ft^2 area). Discharge of treated effluent into the San Joaquin River would only occur once land application is maximized and the north effluent storage pond is fully utilized, but could occur year-round.

Installation of the discharge pipeline, outfall and diffuser would involve four steps: (1) installation of the discharge pipeline up, through, and down the levee; (2) preparation of the riverbed for placement of the outfall and diffuser; (3) assembly and installation of the outfall and diffuser; and (4) restoration of the streambed and site to preconstruction contours.

Installation of Discharge Pipeline. The portion of discharge pipeline installed on the landside, within, and on the waterside of the levee would be fitted as welded steel. The discharge pipeline would be exposed on the land and water sides of the levee. The section of pipe that would go through the levee would be placed such that the invert of the pipe would be 1 foot above the 100-year flood elevation. A minimum of 2 feet of backfill would be placed over this section of the discharge pipeline. An excavator, crane, and roller/compactor would be used to assemble and install the pipeline through the levee. Existing riprap, in a 20-foot-wide area, on the waterside of the levee, could be temporarily displaced to allow placement of the pipeline, then returned to position on the levee.

In-Water Site Preparation. As described above, the discharge pipeline would be buried 5 feet below the riverbed to minimize the potential for damage to the pipeline from vessel traffic in the San Joaquin River. A hydraulic suction dredge would remove materials within an approximately 36-foot-wide area along a distance of approximately 550 feet from the shoreline to accommodate the discharge pipeline, outfall, and diffuser. Use of a hydraulic suction dredge would reduce water quality effects at the cutterhead location, including increases in turbidity. Materials removed from the dredge area would be transported via a discharge line over the levee onto Jersey Island and disposed of at an approved disposal site on Jersey Island.

Assembly and In-Water Placement. Prior to placement in the San Joaquin River, the outfall pipeline and diffuser would be assembled on land. The assembly method could involve either joining the pipeline in convenient lengths for handling and launching on land, or assembling the pipeline on land and launching it in the water as it is joined. Concrete ballast weights (4 feet by 4 feet by 1.3 feet) could be added either after the pipeline had been placed in the water, or after joining the pipeline and before the pipeline is launched in the water. The latter approach would require a ramp or a skid to move the assembled pipeline into the water. In either case, concrete ballast weights would be buried with the discharge pipeline, as described above.

The pipeline would be temporarily anchored in place during the launching operation using either guide cables, temporary block anchors with tethers to the pipeline, or temporary piles driven into the river bed with tethers to the pipeline. If temporary piles are used to anchor the pipeline, up to 20 pilings would be installed and removed using a vibratory hammer. Regardless of methodology, any temporary anchoring device would be removed after the pipeline had been secured.

Layout of the alignment of the outfall pipeline would be facilitated by a survey boat and divers. A floating barge with a crane would be used to move the pipeline into place, and other barges and boats would be used to assist in laying and sinking the outfall pipeline. The outfall pipeline would be sunk into place by filling the pipeline with river water at a controlled rate.

Restoration of the Site to Preconstruction Contours. After the pipeline has been sunk, clean gravel and rock would be placed to restore depths to preconstruction contours. In addition, the area of levee disturbed to place the pipeline would be backfilled, and riprap replaced on the water side of the levee.

All in-water work would occur between August 1 and October 15 to meet in-water work windows for delta smelt, Chinook salmon and steelhead populations. This timeframe is intended to avoid the majority of the adult and juvenile migration of listed anadromous species, as well as meet conditions stipulated in the United States Fish and Wildlife Service's (USFWS) Programmatic biological opinion for delta smelt (USFWS 2004).

C. Conservation Measures

The ISD has incorporated the following conservation measures into the project design to avoid or minimize potential adverse effects of the proposed project upon listed salmonids and green sturgeon. These include water quality and construction-related measures. The ISD has designed the WWTP and the effluent diffusers to comply with the anticipated water quality measures defined in its NPDES permit for discharge to the lower San Joaquin River. The effluent will meet Title 22 discharge requirements and Water Quality Control Plan criteria for wastewater discharges. The ISD has incorporated the following construction-related conservation measures into their proposed project plans (Vinnedge Environmental Consulting and Robertson-Bryan, Inc. 2008):

1. To avoid or minimize the direct loss or injury to salmon and steelhead, in-channel construction shall be conducted after August 1 and before October 15. Noise associated with installation of the discharge pipeline, outfall, and diffuser, including pile driving, would be temporary (lasting approximately 2 to 3 weeks) and limited in scope; approximately 20 piles would be secured during construction and pilings would be put in place using a vibratory hammer.

2. Any construction within San Joaquin River, on adjacent levees, or upland areas with the potential for erosion into the river shall be conducted under a Stormwater Pollution Prevention Plan (SWPPP) and a Spill Prevention Plan (SPP). The plans will be prepared to minimize the risk of stormwater, oils, fuels and/or other material from entering project area water bodies. The SPP will also describe clean-up measures to be implemented in the unlikely event that a spill occurs.

3. In-channel construction, including dredging and diffuser placement will be limited to daylight hours during weekdays, leaving a nighttime and weekend period of passage for federally listed fish species.

4. Design of the diffuser allows a zone of fish passage through the northern half of the San Joaquin River channel.

5. Construction Best Management Practices (BMPs) shall be implemented to reduce direct loss or injury to federally listed fish species within the project area during construction activities. Implementation of BMPs will minimize the potential for re-suspension of

sediments, turbidity, and the potential for contaminant spills. Examples of typical construction BMPs incorporated into the project design will include such actions as placement of sediment traps and barriers (*i.e.*, straw wattle rolls and storm fencing) along open cuts in the upland areas during placement of the pipeline from the treatment plant to the diffuser location on the San Joaquin River, control of excavation and exposure of open cuts on the levee face during placement of the discharge pipeline to reduce or eliminate affects of inclement weather exposure, and routing of stormwater to settling basins prior to discharge to remove suspended sediments during and following precipitation events. Detailed descriptions of construction industry standard BMPs can be found in documents such as the California Department of Transportation's (2003) Project Planning and Design Guide which describes the appropriate BMPs to incorporate into construction projects to minimize construction related impacts to the environment. The applicant has indicated that they will incorporate such standard practices into their project.

6. Fueling, cleaning, and maintenance of vehicles and construction equipment shall not occur within wetted channel areas or on adjacent riverbanks. Vehicles and construction equipment shall be fueled, maintained, and cleaned on upland staging areas and/or at approved waterside fueling locations/facilities, if necessary, away from the adjacent irrigation channels and riverbanks.

7. Dredging of the trench into which the new pipeline and diffuser is to be buried will be conducted utilizing cutterhead suction dredging. Suction dredging is considered the least environmentally harmful dredging alternative, where a dredge sediment loss rate of less than 1% of total dredge volume is estimated compared to dredge sediment loss rates several times greater, and as much as 10% with a conventional bucket dredge.

8. The rate and method of dredging will be controlled to minimize the re-suspension of sediments and to minimize the risk of fish being entrained in the suction head. Accordingly, the dredging contractor shall implement the following measures as recommended by the Corps (2000):

    a) *Reduce cutterhead rotation speed*. Reducing cutterhead rotation speed can reduce the potential for side-casting of sediment from the suction entrance. Rotation speed shall be set to the lowest speed practicable given the compactness of the dredged material.

    b) *Reduce swing speed*. Reducing the cutterhead swing speed ensures that the dredge does not move through the cut faster than it can hydraulically pump the sediment. Swing speed shall be reduced to the maximum extent practicable to maximize suction efficiency.

    c) *Eliminate bank undercutting*. Using shallower cuts can reduce the potential for undercutting and cut-face sloughing. The dredge cut shall be no deeper than approximately 80% of the cutterhead diameter.

9. Following construction, the stream bottom topography will be returned to its pre-construction topography to prevent creation of additional predator holding habitat.

10. Monitoring of the effluent and receiving water, in accordance with the Monitoring and Reporting Program associated with the National Pollution Discharge Elimination System (NPDES) permit, will be conducted to verify that the discharge does not cause exceedance of the California Toxics Rule (CTR) aquatic life criteria and Basin Plan Objectives in the receiving water. Whole effluent toxicity (WET) test monitoring data will be evaluated to determine whether the discharge is causing toxicity in the receiving water. If the collective data verify that there is substantial evidence that the discharge could cause acute or chronic toxicity to aquatic organisms in the receiving water, ISD would coordinate further actions, possibly including a Toxicity Reduction Evaluation (TRE) with the RWQCB based upon results of monitoring data.

11. Disturbance of streamside vegetation will be minimized to the maximum extent practicable. It is not expected that any large, shade-providing trees will be removed; however, in the unforeseen circumstance that a large tree(s) must be removed, three trees will be planted at a nearby, undisturbed location for each tree removed.

12. A qualified fisheries biologist will be on-site during construction initiation, mid-way through construction, and at the close of construction to monitor implementation of conservation measures and water quality.

D. Action Area

The action area is defined as all of the 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 affected area equals approximately 10 river miles along the channel of the San Joaquin River and adjacent nearby channels, including False River, Dutch Slough Taylor Slough, and Three Mile Slough. This corresponds to the expected extent of tidal mixing of the effluent from the wastewater outfall structures where discharges from the outfall could be detected under normal operating conditions.

The portion of the San Joaquin River to be affected by the proposed discharge is defined by the tidal exchange and mixing zone characteristics in the San Joaquin River and greater western Delta. On a near-field basis, water in the San Joaquin River in the vicinity of the outfall is conveyed approximately 5 miles upstream and downstream during the daily diurnal tidal exchange periods. Thus, the near-field exchange zone affects the San Joaquin River primarily, and to a lesser extent the other channels surrounding Jersey Island (False River, Dutch Slough, Taylor Slough, and Three Mile Slough). The majority of the mixing and dispersion of the effluent discharge would occur within this near-field jet and tidal mixing area. Far-field modeling analysis conducted for the Draft Supplemental Environmental Impact Report for Ironhouse Sanitary District Wastewater Treatment Plant Expansion (Supplemental EIR) (Jones & Stokes 2006) using the Department of Water Resources (DWR) Delta Simulation Model 2 (DSM2) indicated that the dilution of effluent in the tidal mixing zone would, on average, be 500:1 and would always be at least 200:1.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species evolutionarily significant units (ESU) or distinct population segments (DPS) and designated critical habitat occur in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
Listed as endangered (June 28, 2005, 70 FR 37160)

Central Valley spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
Listed as threatened (June 28, 2005, 70 FR 37160)

Central Valley steelhead DPS (*Oncorhynchus mykiss*) Listed as threatened (January 5, 2006, 71 FR 834)

Central Valley steelhead designated critical habitat
(September 2, 2005, 70 FR 52488)

Southern DPS of North American green sturgeon (*Acipenser medirostris*)
Listed as threatened (April 7, 2006, 71 FR 17757)

Southern DPS of North American green sturgeon proposed critical habitat
(Proposed September 8, 2008, 73 FR 52084)[1]

A. Species and Critical Habitat Listing Status

NMFS has recently completed an updated status review of 16 salmon ESUs, including Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon, and concluded that the species' status should remain as previously listed (June 28, 2005, 70 FR 37160). On January 5, 2006, NMFS published a final listing determination for 10 steelhead DPSs, including Central Valley steelhead. The new listing concludes that Central Valley steelhead will remain listed as threatened (71 FR 834).

Sacramento River winter-run Chinook salmon were originally listed as threatened in August 1989, under emergency provisions of the Endangered Species Act of 1973, as amended, and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper Sacramento River in California's Central Valley. The Livingston Stone National Fish Hatchery (LSNFH) population has been included in the listed

[1] On September 8, 2008, NMFS published the proposed rule for designated critical habitat for the threatened Southern Distinct Population Segment of North American green sturgeon in the Federal Register (73 FR 52084). This opinion was already in final review at the time of the publication and therefore does not address this proposed rule. Due to the time sensitive nature of this opinion, further revision of the document to incorporate the proposed critical habitat would have resulted in unacceptable delays. NMFS considers the safeguards incorporated into the terms and conditions to protect designated critical habitat for Central Valley steelhead in the action area to be sufficient to protect proposed critical habitat for Southern DPS green sturgeon in the action area. Future opinions will consider the proposed designated critical habitat in their analysis.

Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. Critical habitat was delineated as the Sacramento River from Keswick Dam at river mile (RM) 302 to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta (Delta), including Kimball Island, Winter Island, and Brown's Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge. Critical habitat for Sacramento River winter-run Chinook salmon does not occur within the action area.

Central Valley spring-run Chinook salmon were listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Hatchery (FRH) spring-run Chinook salmon population has been included as part of the Central Valley spring-run Chinook salmon ESU in the most recent modification of the Central Valley spring-run Chinook salmon listing status (June 28, 2005, 70 FR 37160). Critical habitat was designated for Central Valley spring-run Chinook salmon on September 2, 2005 (70 FR 52488), but does not occur in the action area for the proposed ISD WWTP Expansion Project.

Central Valley steelhead were listed as threatened under the ESA on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River (inclusive of and downstream of the Merced River) basins in California's Central Valley. The Coleman National Fish Hatchery and FRH steelhead populations have been included as part of the Central Valley steelhead DPS in the most recent modification of the Central Valley steelhead listing status (January 5, 2006, 71 FR 834). These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for steelhead in the Central Valley on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches such as those of the American, Feather, and Yuba Rivers, and Deer, Mill, Battle, Antelope, and Clear Creeks in the Sacramento River basin; the Calaveras, Mokelumne, Stanislaus, and Tuolumne Rivers in the San Joaquin River basin; and, the Sacramento and San Joaquin Rivers and Delta. Designated critical habitat for the Central Valley steelhead is found within the action area.

The Southern DPS of North American green sturgeon was listed as threatened on April 7, 2006 (71 FR 17757). The Southern DPS presently contains only a single spawning population in the Sacramento River, and rearing individuals may occur within the action area. Critical habitat has been proposed, but not yet designated for the Southern DPS of North American green sturgeon.

B. Species Life History and Population Dynamics

1. Chinook Salmon

a. *General Life History*

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. 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 mainstem 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 ºF to 56 ºF (Bell 1991, CDFG 1998). Boles (1988) recommends water temperatures below 65 ^{o}F for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70 ^{o}F, and that fish can become stressed as temperatures approach 70 ^{o}F. The U.S. Bureau of Reclamation (Reclamation) reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60 ^{o}F; although salmon can tolerate temperatures up to 65 ^{o}F before they experience an increased susceptibility to disease.

Information on the migration rates of adult 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 on their upstream migration (California Bay-Delta Authority (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 redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 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 ^{o}F to 57 ^{o}F (Chambers 1956, Smith 1973, Bjornn and Reiser 1991, and Snider 2001).

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 other micro-crustaceans. 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 actively migrate, or 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 along the way for a period of time ranging from weeks to a year (Healey 1991).

Rearing fry 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 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 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).

Similar to adult movement, juvenile salmonid downstream movement is primarily crepuscular. Martin *et al.* (2001) found 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 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 ºF to 57 ºF (Brett 1952) and impairment of smoltification occurs at temperatures greater than 64^{o} F (Marine and Cech 2004) . In Suisun and San Pablo Bays water temperatures reach 54 ºF by February in a typical year. Other portions of the Delta (*i.e*., South Delta and Central Delta) can reach 70 ºF by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended. Thereafter, elevated temperatures may cause less than optimal conditions for juvenile salmonids and contribute to the lack of young salmon in the estuary during the summer (Kjelson *et al.* 1982).

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

b. *Sacramento River Winter-run Chinook salmon*

The distribution of winter-run Chinook salmon spawning and rearing historically was limited to the upper Sacramento River and its tributaries, where spring-fed streams provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963, Yoshiyama *et al.* 1998). The 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 historical 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 (Table 1; 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 millimeters (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).

Table 1. 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

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[1]	Medium/Medium	Medium/Medium	High/High	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium					Medium/Medium
Sac. River[2]	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium					Medium/Medium	Medium/Medium

b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River @ Red Bluff[3]	Low/Low						Low/Medium	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium
Sac. River @ Red Bluff[2]	Medium/Medium	Medium/Medium					Low/Low	High/High	High/High	High/High	Medium/Medium	Medium/Medium
Sac. River @ Knights L.[4]	Medium/Medium	Medium/Medium	Medium/Medium	Low/Low				Low/Low	Low/Low	Low/Low	Medium/Medium	Medium/Medium
Lower Sac. River (seine)[5]	High/High	High/High	Medium/Medium	Low/–					Low/Low	Low/Low	Medium/Medium	High/High
West Sac. River (trawl)[5]	Low/Low	High/High	High/High	High/High							Low/Low	Medium/Medium

Source: [1]Yoshiyama *et al.* 1998; Moyle 2002; [2]Myers *et al.* 1998; [3]Martin *et al.* 2001; [4]Snider and Titus 2000; [5]USFWS 2001a, b

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

Historical Sacramento River winter-run Chinook salmon population estimates, which included males and females, reached approximately 100,000 fish in the 1960s, but declined to under 200 fish in the 1990s (Good *et al.* 2005). Population estimates in 2003 (8,135), 2004 (7,784), 2005 (15,730) and 2006 (17,205) show a recent increase in the population size (CDFG GrandTab, February 2007) and a 3-year average of 13,573 (2004 through 2006) (see Table 2 in text and Appendix B Figure 5). The 2006 run was the highest since the 1994 listing. Overall, abundance measures over the last decade suggest that the abundance is increasing (Good *et al*. 2005). However, escapement estimates for 2007 show a precipitous decline in escapement numbers based on redd counts and carcass counts. Escapement estimates place the adult escapement numbers for 2007 at 2,488 fish (CDFG GrandTab, 2008). The saltwater life history traits and habitat requirements of winter-run Chinook salmon and fall-run Chinook salmon are similar. Therefore, the unusually poor ocean conditions that are suspected to have contributed to the drastic decline in returning fall run Chinook salmon populations coast wide in 2007 (Varanasi and Bartoo 2008) are likely to have also contributed to the observed decrease in the winter-run Chinook salmon spawning population in 2007.

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.

Table 2. Winter-run Chinook salmon population estimates from RBDD counts (1986 to 2001) and carcass counts (2001 to 2007), and corresponding cohort replacement rates for the years since 1986 (CDFG 2004, CDFG Grand Tab February 2008).

Year	In-River Population Estimate	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated Juvenile Production Estimate (JPE)[a]
1986	2,566				
1987	2,165				
1988	2,857				
1989	649		0.25		
1990	411	1,730	0.19		
1991	177	1,252	0.06		40,025
1992	1,203	1,059	1.85		272,032
1993	378	564	0.92	0.66	85,476
1994	144	463	0.81	0.77	32,562
1995	1,166	614	0.97	0.92	263,665
1996	1,012	781	2.68	1.45	228,842
1997	836	707	5.81	2.24	189,043
1998	2,903	1,212	2.49	2.55	656,450
1999	3,264	1,836	3.23	3.03	738,082
2000	1,263	1,856	1.51	3.14	285,600
2001	8,120	3,277	2.80	3.17	1,836,160
2002	7,360	4,582	2.25	2.46	1,664,303
2003	8,133	5,628	6.44	3.25	1,839,100
2004	7,784	6,532	0.96	2.79	1,760,181
2005	15,730	9,425	2.14	2.92	3,556,995
2006	17,205	11,242	2.12	2.78	3,890,534
2007	2,488	10,268	0.32	2.39	562,607
Median	2,327	1,783	1.85	2.55	562,607
Average	3,992	3,502	1.99	2.30	1,053,039
Gmean[b]	1,907	2,074	1.22	2.09	479,040

[a]JPE estimates were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers.
[b]Gmean is the geometric mean of the data set in that column.

Based on the RBDD counts, the population has been growing rapidly since the 1990s with positive short-term trends (excluding the 2007 preliminary 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 the Sacramento River winter-run Chinook salmon population appears to be improving, 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).

This population remains below the draft recovery goals established for the run (NMFS 1997, 1998b) and the naturally-spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the draft recovery criteria for Sacramento River winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females with a concurrent geometric mean of the cohort replacement rate greater than 1.0 (NMFS 1997). Recent trends in Sacramento River winter-run Chinook salmon abundance and cohort replacement remain positive, indicating some recovery since the listing. However, the population remains well below the recovery goals of the draft recovery plan, and is particularly susceptible to extinction because of the reduction of the genetic pool to one population.

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

Abundance. Redd and carcass surveys, and fish counts, suggest that the abundance of winter-run Chinook salmon has been increasing. The depressed 2007 abundance estimate is an exception to this trend and may represent a new cycle of poor ocean productivity. 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).

Productivity. ESU productivity has been positive over the short term, and adult escapement and juvenile production have been increasing annually (Good *et al.* 2005). The long-term trend for the ESU remains negative, however, as it consists of only one population that is subject to possible impacts from environmental and artificial conditions. The most recent cohort replacement rate (CRR) estimate suggests a reduction in productivity for the 1998-2001 cohorts.

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 habitat and must be artificially maintained in the Sacramento River by a regulated, finite cold water pool from 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.

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 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; 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. If this proportion of hatchery origin fish from the LSNFH exceeds 15 percent in 2006-2007, Lindley *et al*. (2007) recommends 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.

c. *Central Valley Spring-Run Chinook salmon*

Historically the spring-run Chinook salmon were the second most abundant salmon run in the Central Valley (CDFG 1998). These fish occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit Rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). 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 (CDFG 1998).

Adult Central Valley spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (Table 3; 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 (YOY) 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 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 during the following winter and 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 YOY migration and an earlier yearling migration (Lindley *et al*. 2007).

Table 3. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2]Sac.River basin			Medium	Medium	High	High	Medium	Medium	Medium			
[3]Sac. River			Medium	Medium	Medium	Medium	Medium					
[4]Mill Creek			Low	Medium / High	High	High / Medium	Medium / Low	Low / –				
[4]Deer Creek			Low	Medium / High	High	High / Medium	Medium / –					
[4]Butte Creek		Medium	Medium	Medium	Medium	Medium	Medium					

(b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]Sac. River Tribs	Medium	Medium	Medium							Medium	High	High
[6]Upper Butte Creek	High	High	Medium	Medium	Medium	Low				Low	Low	Medium
[4]Mill, Deer, Butte Creeks	High	High	Medium	Medium	Medium	Low				Low	Low	Low
[3]Sac. River at RBDD	High	Low	Low	Low	Low / –						High	High
[7]Sac. River at Knights Landing (KL)	Medium	Medium	High	High	Medium						Medium	High

Source:[1]Yoshiyama *et al*. 1998; [2]Moyle 2002; [3]Myers *et al*. 1998; [4]Lindley *et al*. 2007; [5]CDFG 1998; [6]McReynolds *et al*. 2005; Ward *et al*. 2002, 2003; [7]Snider and Titus 2000

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

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 YOY 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).

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 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag (CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to 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 1,403 in 1993 to 24,725 in 1998 (see Table 4 in text and Appendix B Figure 6). 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 recent trends are 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. Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21^{o}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.

Several actions have been taken to improve habitat conditions for Central Valley spring-run Chinook salmon, including: improved management of Central Valley water (*i.e.*, through use of CALFED EWA and CVPIA (b)(2) water accounts); implementing new and improved screen and ladder designs at major water diversions along the mainstem Sacramento River and tributaries; and, changes in ocean and inland fishing regulations to minimize harvest. Although protective measures likely have contributed to recent increases in spring-run Chinook salmon abundance, the ESU is still below levels observed from the 1960s through 1990. Threats from hatchery production (*i.e.*, competition for food between naturally spawned and hatchery fish, run hybridization and genomic homogenization), climatic variation, high temperatures, predation, and water diversions still persist.

There have been significant habitat improvements (including the removal of several small dams and increases in summer flows) in Central Valley spring-run Chinook salmon watersheds, as well as reduced ocean fisheries and a favorable terrestrial and marine climate. It appears that the three independent spring-run Chinook salmon populations in the Central Valley are growing (Good *et al*. 2005). All three spring-run Chinook salmon populations show signs of positive long- and short-term mean annual population growth rates. Although Central Valley spring-run Chinook salmon have some of the highest population growth rates in the Central Valley, other than Butte Creek and the hatchery-influenced Feather River, population sizes are relatively small compared to fall-run Chinook salmon populations (Good *et al*. 2005). Because the Central Valley spring-run Chinook salmon ESU is spatially confined to relatively few remaining streams, continues to display broad fluctuations in abundance, and a large proportion of the population (*i.e.*, in Butte Creek) faces the risk of high mortality rates, the population remains at a moderate to high risk of extinction.

Table 4. Central Valley Spring-run Chinook salmon population estimates from CDFG Grand Tab (February 2007) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated JPE[a]
1986	24,263	-	-	-	4,396,998
1987	12,675	-	-	-	2,296,993
1988	12,100	-	-	-	2,192,790
1989	7,085	-	0.29	-	1,283,960
1990	5,790	12,383	0.46	-	1,049,277
1991	1,624	7,855	0.13	-	294,305
1992	1,547	5,629	0.22	-	280,351
1993	1,403	3,490	0.24	0.27	254,255
1994	2,546	2,582	1.57	0.52	461,392
1995	9,824	3,389	6.35	1.70	1,780,328
1996	2,701	3,604	1.93	2.06	489,482
1997	1,433	3,581	0.56	2.13	259,692
1998	24,725	8,246	2.52	2.58	4,480,722
1999	6,104	8,957	2.26	2.72	1,106,181
2000	5,577	8,108	3.89	2.23	1,010,677
2001	13,563	10,280	0.55	1.96	2,457,919
2002	13,220	12,638	2.17	2.28	2,395,759
2003	8,902	9,474	1.60	2.09	1,614,329
2004	9,774	10,208	0.72	1.78	1,771,267
2005	14,346	11,962	1.09	1.22	2,599,816
2006	8,700	10,990	0.98	1.31	1,576,634
2007	7,819	9,909	0.80	1.04	1,416,977
Median	8,260	9,692	1.03	1.58	1,496,806
Average	8,897	9,088	1.58	1.61	1,612,277
Gmean[b]	6,460	8,049	1.02	1.39	1,170,650

[a]NMFS calculated the spring-run JPE using returning adult escapement numbers to the Sacramento River basin prior to the opening of the RBDD for spring-run migration, and then escapement to Mill, Deer, and Butte Creeks for the remaining period, and assuming a female to male ratio of 6:4 and pre-spawning mortality of 25 percent. NMFS utilized the female fecundity values in Fisher (1994) for spring-run Chinook salmon (4,900 eggs/female). The remaining survival estimates used the winter-run values for calculating JPE.
[b]Gmean is the geometric mean of the data set in that column.

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

Abundance. 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 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.

Productivity. The 5-year geometric mean for the extant Butte, Deer, and Mill Creek spring-run populations ranges from 491 to 4,513 fish (Good *et al.* 2005), indicating increasing productivity over the short-term and projected as likely to continue (Good *et al.* 2005). 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 cohorts have recently utilized all available habitat in the creek; the population cannot expand further and it is unknown if individuals have opportunistically migrated to other systems. The spatial structure of the spring-run ESU has been reduced with the extirpation of all San Joaquin River basin spring-run populations.

Diversity. The Central Valley spring-run ESU is comprised of two genetic complexes. Analysis of natural and hatchery spring-run Chinook salmon stocks in the Central Valley indicates that the southern Cascades spring-run population complex (Mill, Deer, and Butte creeks) retains genetic integrity. The genetic integrity of the Sierra Nevada spring-run population complex has been somewhat compromised. The Feather River spring-run have introgressed with the fall-run, and it appears that the Yuba River population may have been impacted by FRH fish straying into the Yuba River. Additionally, the diversity of the spring-run ESU has been further reduced with the loss of the San Joaquin River basin spring-run populations.

2. 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 steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer 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 steelhead are found only in

North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

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 though March in small streams and tributaries where cool, well oxygenated water is available year-round (Hallock *et al.* 1961, McEwan and Jackson 1996; Table 5). 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.

Table 5. The temporal occurrence of adult (a) and juvenile (b) Central Valley steelhead in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1,3]Sac. River	L	L	L	L	L	L						L	L	L	L	M	M	H	H	M	L	L	L	L
[2,3]Sac R at Red Bluff	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	M	H	M	L	L	L	L
[4]Mill, Deer Creeks			H	M	M	L	L	L	L	L	L	L								H	H	M	M	M
[6]Sac R. at Fremont Weir	L	L	L	L											M	M	H	H	M	M	L	L	L	L
[6]Sac R. at Fremont Weir	L	L	L	L											M	M	H	H	M	M	L	L	L	L
[7]San Joaquin River													L	L	L	L	M	M	M	M	M	M	H	H

(b) Juvenile

Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1,2]Sacramento River	L	L	L	L	M	M	M	M	M	M	M	M	L	L	L	L	L	L	M	M	M	M	L	L
[2,8]Sac. R at Knights Land	L	L	L	L	H	H	L	L	L															L
[9]Sac. River @ KL	M	M	M	M	H	H	H	H	M	M											L	L	L	L
[10]Chipps Island (wild)	L	L	L	L	H	H	H	H	M	M	M	M	L	L					L	L	L	L	L	L
[8]Mossdale							H	H	H	H														
[11]Woodbridge Dam	M	M	M	M	M	M	M	M	M	M	M	M	M	M										
[12]Stan R. at Caswell	L	L	M	M	H	H	M	M	M	M	M	L												
[13]Sac R. at Hood	L	L	H	H	H	H	H	H	H	H	H	H									L	L	L	L

Source: [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.

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

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 YOY 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 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 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.

Historic 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 7). 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, 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 otilith microchemistry.

It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005). CDFG staff has prepared catch summaries for juvenile migrant 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 Central Valley steelhead on the Tuolumne, Merced, and lower San Joaquin Rivers are severely depressed (see Appendix B: Figure 8).

Lindley *et al*. (2006a) indicated that prior population census estimates completed in the 1990s found the 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). Central Valley steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates.

Viable Salmonid Population Summary for CV Steelhead

Abundance. All indications are that natural Central Valley steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005); the long-term trend remains negative. There has been little steelhead population monitoring despite 100 percent marking of hatchery steelhead since 1998. Hatchery production and returns are dominant over natural fish and include significant numbers of non-DPS-origin Eel River steelhead stock.

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).

Spatial Structure. Steelhead appear to be well-distributed where found throughout the Central Valley (Good *et al.* 2005). 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 and Calaveras rivers.

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 not included in the Central Valley steelhead DPS.

3. <u>Southern Distinct Population Segment of North American Green Sturgeon</u>

The North American green sturgeon have morphological characteristics of both cartilaginous fish and bony fish. The fish has some morphological traits similar to sharks, such as a cartilaginous skeleton, heterocercal caudal fin, spiracles, spiral valve intestine, electro-sensory pores on its snout and an enlarged liver. However, like more modern teleosts, it has five gill arches contained within one branchial chamber, covered by one opercular plate and a functional swim bladder for bouyancy control. Adult green sturgeon have a maximum fork length of 2.3 meters and 159 kg body weight (Miller and Lee 1972, Moyle *et al*. 1992). Green sturgeon can live at least 60 years, based on data from the Klamath River (Emmett *et al.* 1991).

The green sturgeon is the most widely distributed of the *acipenseridae*. They are amphi-Pacific and circumboreal, ranging from the inshore waters of Baja California northwards to the Bering Sea (Moyle 2002). Although widely distributed, they are not very abundant in comparison to the sympatric white sturgeon (*Acipenser transmontanus*). Similar species occur in northern Asiatic river systems and their relatedness to green sturgeon has been discussed in Artyukhin *et al.* (2007).

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 (NMFS 2005a). 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 2006). Particularly large concentrations occur in the Columbia River estuary, Willapa Bay, and Grays Harbor, with smaller aggregations in San Francisco and San Pablo Bays (Emmett *et al* 1991, Moyle *et al.* 1992, Beamesderfer *et al.* 2004). 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. Southern DPS green sturgeon have been detected in these seasonal aggregations.

Two green sturgeon DPSs were identified based on evidence of spawning site fidelity (indicating multiple DPS tendencies), and on the preliminary genetic evidence that indicates differences at least between the Klamath River and San Pablo Bay samples (Adams *et al*. 2002, 2007). The Northern DPS includes all green sturgeon populations starting with the Eel River and extending northward. The Southern DPS would include all green sturgeon populations south of the Eel River with the only known spawning population being in the Sacramento River.

The Southern DPS of North American green sturgeon life cycle can be broken into four distinct phases based on developmental stage and habitat use: (1) adult females greater than or equal to 13 years of age and males greater than or equal to 9 years of age, (2) larvae and post-larvae less than 10 months of age, (3) juveniles less than or equal to 3 years of age, and (4) coastal migrant females between 3 and 13, and males between 3 and 9 years of age (Nakamoto *et al*. 1995).

Information regarding the migration and habitat use of the Southern DPS of North American green sturgeon has recently emerged. Lindley (2006b) presents preliminary results of large-scale green sturgeon migration studies. Lindley's analysis verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. It appears North American green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia. This information also agrees with the results of green sturgeon tagging studies completed by CDFG where they tagged a total of 233 green sturgeon in the San Pablo Bay estuary between 1954 and 2001. A total of 17 tagged fish were ultimately 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 Estuary (CDFG 2002). In addition, recent analysis by Israel (2006a) indicates a substantial component of the population (*i.e.*, 50-80 percent) of Southern DPS North American green sturgeon to be present in the Columbia estuary.

Kelley *et al.* (2007) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn. 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 the authors surmised they are related to foraging behavior (Kelley *et al*. 2007). Recent acoustical tagging studies on the Rogue River (Erickson *et al*. 2002) have shown that adult green sturgeon will hold for as long 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 ^{o}C and 23 ^{o}C. When ambient temperatures in the river dropped in autumn and early winter (<10 ^{o}C) and flows increased, fish moved downstream and into the ocean. Similar behavior is exhibted by adult green sturgeon on the Sacramento River based on captures of adult green sturgeon in holding pools on the Sacramento River above the Glen-Colusa Irrigation District (GCID) diversion (RM 205). It appears adult green sturgeon could possibly utilize a variety of freshwater and brackish habitats for up to 9 months of the year in the Sacramento River watershed.

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966, J. Stuart, unpublished data). Adult green sturgeon caught in Washington state waters have also been found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

Adults of the Southern DPS of North American green sturgeon begin their upstream spawning migrations into the San Francisco Bay by at least March, reach Knights Landing during April, and spawn between March and July (Heublein *et al*. 2006). Peak spawning is believed to occur between April and June (Table 6) and thought to occur in deep turbulent pools (Adams *et al*. 2002, 2007). Spawning females broadcast their eggs over suitable substrate which can range from clean sand to bedrock but is thought to predominately consist of large cobbles (USFWS 2002). According to Heublein (2006), all adults leave the Sacramento River prior to September.

Green sturgeon larvae hatched from fertilized eggs after approximately 169 hours at a water temperature of 15 ^{o}C (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). 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 14 ^{o}C and 17 ^{o}C. Temperatures over 23 ^{o}C resulted in 100 percent mortality of fertilized eggs before hatching.

Green sturgeon larvae do not exhibit the initial pelagic swim–up behavior characteristic of other *acipenseridae*. The are strongly oriented to the bottom and exhibit nocturnal activity patterns. After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile fish continue to exhibit nocturnal behavior beyond the metamorphosis from larvae to juvenile stages. Kynard *et al*.'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 8 ^{o}C, downstream migrational behavior diminished and holding behavior increased. These data suggest that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. During these early life stages, larval and juvenile green sturgeon are subject to predation by both native and introduced fish species. Smallmouth bass (*Micropterus dolmoides*) have been recorded on the Rogue River as preying on juvenile green sturgeon, and prickly sculpin (*Cottus asper*) have been shown to be an effective predator on the larvae of sympatric white sturgeon (Gadomski and Parsley 2005).

Table 6. The temporal occurrence of adult (a) larval and post-larval (b) juvenile (c) and coastal migrant (d) Southern DPS of North American green sturgeon. Locations emphasize the Central Valley of California. Darker shades indicate months of greatest relative abundance.

(a) Adult (≥13 years old for females and ≥9 years old for males)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2,3]Upper Sac. River			M	M/H	H	H/M	M	M	M	M	M	
[4,8]SF Bay Estuary			M	M	M	M	M	M	M			
(b) Larval and post-larval (≤10 months old)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]RBDD, Sac River					M	H	H	M				
[5]GCID, Sac River					M	H	H	M	L	L		
(c) Juvenile (> 10 months old and ≤3 years old)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[6]South Delta*	M	M	M	M	M	M	M	M	M	M	M	M
[6]Sac-SJ Delta	M	M	M	M	M	M	M	M	M	M	M	M
[5]Sac-SJ Delta				M	M	M	M	M	M	M		
[5]Suisun Bay	M	M	M	M	M	M	M	M	M	M	M	M
(d) Coastal migrant (3-13 years old for females and 3-9 years old for males)												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[3,7]Pacific Coast	M	M	M	M	M	M	M	M	M	M	M	M
Source: [1]USFWS 2002; [2]Moyle et al. 1992; [3]Adams et al. 2002 and NMFS 2005a; [4]Kelley et al. 2007; [5]CDFG 2002; [6]Interagency Ecological Program Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [7]Nakamoto et al. 1995; [8]Heublein et al. 2006												
* Fish Facility salvage operations												
Relative Abundance:	H = High				M = Medium				L = Low			

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance (*i.e.*, growth, food conversion, swimming ability) between 15 ^{o}C and 19 ^{o}C 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 4 ^{o}C to approximately 24 ^{o}C. 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 (Oroville, Englebright, Folsom, and Nimbus Dams).

Known historic and current spawning occurs in the Sacramento River (Adams *et al.* 2002 and 2007, Beamesderfer *et al.* 2004). 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 based on habitat assessments done for Chinook salmon, the geographic extent of spawning has been reduced due to the impassable barriers.

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.

Spawning in the San Joaquin River system has not been recorded historically or observed recently, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the european settlement of the region. During the later 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. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of european influence, based on past use of the region by populations of Central Valley spring-run Chinook salmon and steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin, and it is reasonable to assume that green sturgeon have suffered a similar fate.

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 (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures, CDFG provided 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, 2007). 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 (see Appendix A Table 7 and Appendix B Figure 9). 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 (April 5, 2005 70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (April 5, 2005 70 FR 17386). In light of the increase in exports at these facilities since 1986, which should have resulted in increased captures of North American green sturgeon, it is clear that the abundance of the Southern DPS of North American green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (April 5, 2005 70 FR 17386). Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the 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).

Based on the length and estimated age of post-larvae captured at RBDD (approximately 2 weeks of age) and GCID (downstream; approximately 3 weeks of age), it appears the majority of Southern DPS North American green sturgeon spawn above RBDD. Note, there are many assumptions with this interpretation (*i.e*., equal sampling efficiency and distribution of post-larvae across channels) and this information should be considered cautiously.

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

The Southern DPS of North American green sturgeon was not included or analyzed in recent efforts to characterize the status and viability of Central Valley salmonid populations (Lindley *et al*. 2006a; Good *et al.* 2005). However, 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).

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 comprised of a single spawning population in the Sacramento River. Although some individuals have been observed in the Feather and Yuba Rivers, it is not yet known if these fish represent separate spawning populations. Therefore, the apparent presence of a single reproducing population puts the DPS at risk, due to extremely tenuous spatial structure.

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

C. Critical Habitat Condition and Function for Species' Conservation

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 was designated for Central Valley spring-run Chinook salmon and 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 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 Central Valley steelhead, and as physical habitat elements for Sacramento River winter-run Chinook salmon.

Critical habitat for the Southern DPS of the North American green sturgeon was proposed on September 8, 2008 (73 FR 52084), and includes the waters of the legal Delta, the Sacramento River below Keswick Dam, the Feather River below Oroville Dam to its confluence with the Sacramento River, the Yuba River below Daguerre Dam to its confluence with the Feather River, Suisun Bay, San Pablo Bay, and San Francisco Bay as well as specific coastal and marine waters along the west coast of the United States. Due to the recent publication of the proposal, analysis of the critical habitat for green sturgeon was not conducted for this opinion (see footnote 1, page 8).

1. 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 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.

2. 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. Juvenile life stages of salmonids are dependant on the function of this habitat for successful survival and recruitment.

3. 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. The survival of anadromous salmonids is dependant on freshwater migration corridors to provide adequate passage from the ocean to the spawning habitat and back again.

4. 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 extremely important to anadromous species because they act as a transitional zone between the freshwater and ocean environments.

D. Factors Impacting Listed Species

1. Habitat Blockage

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat was actually available before dam construction and mining, and concluded that 82 percent is not accessible today.

As a result of migrational barriers, winter-run Chinook salmon, spring-run Chinook salmon, and steelhead populations have been confined to lower elevation mainstems that historically only were used for migration. Population abundances have declined in these streams due to decreased quantity and quality of spawning and rearing habitat. Higher temperatures at these lower elevations during late-summer and fall are also a major stressor to adult and juvenile salmonids. According to Lindley *et al.* (2004), of the four independent populations of Sacramento River winter-run Chinook salmon that occurred historically, only one mixed stock of winter-run Chinook salmon remains below Keswick Dam. Similarly, of the 18 independent populations of Central Valley spring-run Chinook salmon that occurred historically, only three independent populations remain in Deer, Mill, and Butte Creeks. Dependent populations of Central Valley spring-run Chinook salmon continue to occur in Big Chico, Antelope, Clear, Thomes, and Beegum Creeks and the Yuba River, but are thought to rely on the three extant independent populations for their continued survival. Central Valley steelhead historically had at least 81 independent populations based on Lindley *et al.*'s (2006a) analysis of potential habitat in the Central Valley. However, due to dam construction, access to 38 percent of all spawning habitat has been lost as well as access to 80 percent of the historically available habitat. Green sturgeon populations were likely also affected by barriers and alterations to the natural hydrology. In particular, the RBDD blocked all access to the primary spawning habitat in the Sacramento River for many years under the old operational procedures, and continues to block a significant portion of the adult spawning run under current operational procedures. Under current operations, approximately 50 percent of the spawning migration of green sturgeon to the upper reaches of the Sacramento River above the RBDD is blocked after the May 15 closure of the radial gates. The partial opening of the gates allows for downstream movement of green sturgeon beneath the gates which were successful in migrating past the RBDD before the May 15 closure, but due to high water velocities through the narrow gap between the bottom of the radial gate and the dam's concrete apron, upstream movement of fish is unlikley after May 15.

The Suisun Marsh Salinity Control Gates (SMSCG), located on Montezuma Slough, were installed in 1988, and are operated with gates and flashboards to decrease the salinity levels of managed wetlands in Suisun Marsh. The SMSCG are known to block or delay passage of adult Chinook salmon migrating upstream (Edwards *et al.* 1996, Tillman *et al.* 1996, DWR 2002). The effects of the SMSCG on sturgeon are unknown at this time.

2. Water Development

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted stream flows and altered the natural cycles by which juvenile and adult salmonids base their migrations. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta have been diverted for human uses. Depleted flows have contributed to higher temperatures, lower DO levels, and decreased recruitment of gravel and large woody debris (LWD). More uniform flows year round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation. These stabilized flow patterns have reduced bed load movement (Mount 1995, Ayers 2001), caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams. The storage of unimpeded runoff in these large reservoirs also has altered the normal hydrograph for the Sacramento and San Joaquin River watersheds. Rather than seeing peak flows in these river systems following winter rain events (Sacramento River) or spring snow melt (San Joaquin River), the current hydrology has truncated peaks with a prolonged period of elevated flows (compared to historical levels) continuing into the summer dry season.

Water withdrawals, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months, and in some cases, have been of a sufficient magnitude to result in reverse flows in the lower San Joaquin River (Reynolds *et al*. 1993). Direct relationships exist between water temperature, water flow, and juvenile salmonid survival (Brandes and McLain 2001). Elevated water temperatures in the Sacramento River have limited the survival of young salmon in those waters. Juvenile fall-run Chinook salmon survival in the Sacramento River is also directly related with June stream flow and June and July Delta outflow (Dettman *et al*. 1987).

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento and San Joaquin Rivers, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). Most of the 370 water diversions operating in Suisun Marsh are unscreened (Herren and Kawasaki 2001).

Outmigrant juvenile salmonids in the Delta are subjected to adverse environmental conditions created by water export operations at the CVP and SWP facilities. Specifically, juvenile salmonid survival has been reduced by the following: (1) water diversion from the mainstem Sacramento River into the Central Delta via the Delta Cross Channel; (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.).

3. Water Conveyance and Flood Control

The development of the water conveyance system in the Delta has resulted in the construction of more than 1,100 miles of channels and diversions to increase channel elevations and flow capacity of the channels (Mount 1995). Levee development in the Central Valley affects spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As Mount (1995) indicates, there is an "underlying, fundamental conflict inherent in this channelization." Natural rivers strive to achieve dynamic equilibrium to handle a watershed's supply of discharge and sediment (Mount 1995). The construction of levees disrupts the natural processes of the river, resulting in a multitude of habitat-related effects.

Many of these levees use angular rock (riprap) to armor the bank from erosive forces. The effects of channelization, and riprapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006). These changes affect the quantity and quality of nearshore habitat for juvenile salmonids and have been thoroughly studied (USFWS 2000, Schmetterling *et al.* 2001, Garland *et al*. 2002). Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

Prior to the 1970s, there was so much debris resulting from poor logging practices that many streams were completely clogged and were thought to have been total barriers to fish migration. As a result, in the 1960s and early 1970s it was common practice among fishery management agencies to remove woody debris thought to be a barrier to fish migration (NMFS 1996b). However, it is now recognized that too much LWD was removed from the streams resulting in a loss of salmonid habitat and it is thought that the large scale removal of woody debris prior to 1980 had major, long-term negative effects on rearing habitats for salmonids in northern California (NMFS 1996b). Areas that were subjected to this removal of LWD are still limited in the recovery of salmonid stocks; this limitation could be expected to persist for 50 to 100 years following removal of debris.

Large quantities of downed trees are a functionally important component of many streams (NMFS 1996b). LWD influences stream morphology by affecting channel pattern, position, and geometry, as well as pool formation (Keller and Swanson 1979, Bilby 1984, Robison and Beschta 1990). Reduction of wood in the stream channel, either from past or present activities, generally reduces pool quantity and quality, alters stream shading which can affect water temperature regimes and nutrient input, and can eliminate critical stream habitat needed for both vertebrate and invertebrate populations. Removal of vegetation also can destabilize marginally stable slopes by increasing the subsurface water load, lowering root strength, and altering water flow patterns in the slope.

In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting salmonid food supply.

4. Land Use Activities

Land use activities continue to have large impacts on salmonid habitat in the Central Valley watershed. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). Starting with the gold rush, these vast riparian forests were cleared for building materials, fuel, and to clear land for farms on the raised natural levee banks. The degradation and fragmentation of riparian habitat continued with extensive flood control and bank protection projects, together with the conversion of the fertile riparian lands to agriculture outside of the natural levee belt. By 1979, riparian habitat along the Sacramento River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The clearing of the riparian forests removed a vital source of snags and driftwood in the Sacramento and San Joaquin River basins. This has reduced the volume of LWD input needed to form and maintain stream habitat that salmon depend on in their various life stages. In addition to this loss of LWD sources, removal of snags and obstructions from the active river channel for navigational safety has further reduced the presence of LWD in the Sacramento and San Joaquin Rivers, as well as the Delta.

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is one of the primary causes of salmonid habitat degradation (NMFS 1996a). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity (Cordone and Kelley 1961), and affecting intergravel permeability and DO levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995).

Land use activities associated with road construction, urban development, logging, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality through the alteration of stream bank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and removal of riparian vegetation, resulting in increased stream bank erosion (Meehan 1991). Urban stormwater and agricultural runoff may be contaminated with herbicides and pesticides, petroleum products, sediment, *etc*. Agricultural practices in the Central Valley have eliminated large trees and logs and other woody debris that would otherwise be recruited into the stream channel (NMFS 1998a).

Since the 1850s, wetlands reclamation for urban and agricultural development has caused the cumulative loss of 79 and 94 percent of the tidal marsh habitat in the Delta downstream and upstream of Chipps Island, respectively (Conomos *et al.* 1985, Nichols *et al.* 1986, Wright and Phillips 1988, Monroe *et al.* 1992, Goals Project 1999). Prior to 1850, approximately 1400 km^2 of freshwater marsh surrounded the confluence of the Sacramento and San Joaquin Rivers, and another 800 km^2 of saltwater marsh fringed San Francisco Bay's margins. Of the original 2,200 km^2 of tidally influenced marsh, only about 125 km^2 of undiked marsh remains today. In Suisun Marsh, saltwater intrusion and land subsidence gradually has led to the decline of agricultural production. Presently, Suisun Marsh consists largely of tidal sloughs and managed wetlands for duck clubs, which first were established in the 1870s in western Suisun Marsh (Goals Project 1999). Even more extensive losses of wetland marshes occurred in the Sacramento and San Joaquin River Basins. Little of the extensive tracts of wetland marshes that existed prior to 1850 along the valley's river systems and within the natural flood basins exist today. Most has been "reclaimed" for agricultural purposes, leaving only small remnant patches.

Dredging of river channels to enhance inland maritime trade and to provide raw material for levee construction has significantly and detrimentally altered the natural hydrology and function of the river systems in the Central Valley. Starting in the mid-1800s, the Corps and other private consortiums began straightening river channels and artificially deepening them to enhance shipping commerce. This has led to declines in the natural meandering of river channels and the formation of pool and riffle segments. The deepening of channels beyond their natural depth also has led to a significant alteration in the transport of bed load in the riverine system as well as the local flow velocity in the channel (Mount 1995). The Sacramento Flood Control Project at the turn of the nineteenth century ushered in the start of large scale Corps actions in the Delta and along the rivers of California for reclamation and flood control. The creation of levees and the deep shipping channels reduced the natural tendency of the San Joaquin and Sacramento Rivers to create floodplains along their banks with seasonal inundations during the wet winter season and the spring snow melt periods. These annual inundations provided necessary habitat for rearing and foraging of juvenile native fish that evolved with this flooding process. The armored riprapped levee banks and active maintenance actions of Reclamation Districts precluded the establishment of ecologically important riparian vegetation, introduction of valuable LWD from these riparian corridors, and the productive intertidal mudflats characteristic of the undisturbed Delta habitat.

Urban stormwater and agricultural runoff may be contaminated with pesticides, oil, grease, heavy metals, polycyclic aromatic hydrocarbons (PAHs), and other organics and nutrients (California Regional Water Quality Control Board-Central Valley Region [Regional Board] 1998) they can potentially destroy aquatic life necessary for salmonid survival (NMFS 1996a, b). Point source (PS) and non-point source (NPS) pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e.*, concrete, asphalt, and buildings) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996a, b). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. In addition to the PS and NPS inputs from urban runoff, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges.

Past mining activities routinely resulted in the removal of spawning gravels from streams, the straightening, and channelization of the stream corridor from dredging activities, and the leaching of toxic effluents into streams from mining operations. Many of the effects of past mining operations continue to impact salmonid habitat today. Current mining practices include suction dredging (sand and gravel mining), placer mining, lode mining and gravel mining. Present day mining practices are typically less intrusive than historic operations (hydraulic mining); however, adverse impacts to salmonid habitat still occur as a result of present-day mining activities. Sand and gravel are used for a large variety of construction activities including base material and asphalt, road bedding, drain rock for leach fields, and aggregate mix for concrete to construct buildings and highways.

Most aggregate is derived principally from pits in active floodplains, pits in inactive river terrace deposits, or directly from the active channel. Other sources include hard rock quarries and mining from deposits within reservoirs. Extraction sites located along or in active floodplains present particular problems for anadromous salmonids. Physical alteration of the stream channel may result in the destruction of existing riparian vegetation and the reduction of available area for seedling establishment (Stillwater Sciences 2002). Loss of vegetation impacts riparian and aquatic habitat by causing a loss of the temperature moderating effects of shade and cover, and habitat diversity. Extensive degradation may induce a decline in the alluvial water table, as the banks are effectively drained to a lowered level, affecting riparian vegetation and water supply (NMFS 1996b). Altering the natural channel configuration will reduce salmonid habitat diversity by creating a wide, shallow channel lacking in the pools and cover necessary for all life stages of anadromous salmonids. In addition, waste products resulting from past and present mining activities, include cyanide (an agent used to extract gold from ore), copper, zinc, cadmium, mercury, asbestos, nickel, chromium, and lead.

Juvenile salmonids are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. Studies by DWR on water quality in the Delta over the last 30 years show a steady decline in the food sources available for juvenile salmonids and sturgeon and an increase in the clarity of the water due to a reduction in phytoplankton and zooplankton. These conditions have contributed to increased mortality of juvenile Chinook salmon, steelhead, and sturgeon as they move through the Delta.

5. Water Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. The Regional Board, in its 1998 Clean Water Act §303(d) list characterized the Delta as an impaired water body having elevated levels of chlorpyrifos, dichlorodiphenyltrichlor (*i.e.* DDT), diazinon, electrical conductivity, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor,

heptachlor epoxide, hexachlorocyclohexanes [including lindane], endosulfan and toxaphene), mercury, low DO, organic enrichment, and unknown toxicities (Regional Board 1998, 2001).

In general, water degradation or contamination can lead to either acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically, when concentrations are lower, to chronic or sublethal effects that reduce the physical health of the organism, and lessens its survival over an extended period of time. Mortality may become a secondary effect due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. For example, increased levels of heavy metals are detrimental to the health of an organism because they interfere with metabolic functions by inhibiting key enzyme activity in metabolic pathways, decrease neurological function, degrade cardiovascular output, and act as mutagens, teratogens or carcinogens in exposed organisms (Rand *et al*. 1995, Goyer 1996). For listed species, these effects may occur directly to the listed fish or to its prey base, which reduces the forage base available to the listed species.

In the aquatic environment, most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in sediment (Ingersoll 1995). Direct exposure to contaminated sediments may cause deleterious effects to listed salmonids or the threatened green sturgeon. This may occur if a fish swims through a plume of the resuspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gills. Elevated contaminant levels may be found in localized “hot spots” where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations (Environmental Protection Agency 1994a). However, the more likely route of exposure to salmonids or sturgeon is through the food chain, when the fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore, the degree of exposure to the salmonids and green sturgeon depends on their trophic level and the amount of contaminated forage base they consume. Response of salmonids and green sturgeon to contaminated sediments is similar to water borne exposures.

Low DO levels frequently are observed in the portion of the Stockton deep-water ship channel (DWSC) extending from Channel Point, downstream to Turner and Columbia Cuts. Over a 5-year period, starting in August 2000, a DO meter has recorded channel DO levels at Rough and Ready Island (Dock 20 of the West Complex). Over the course of this time period, there have been 297 days in which violations of the 5 mg/l DO criteria for the protection of aquatic life in the San Joaquin River between Channel Point and Turner and Columbia Cuts have occurred during the September through May migratory period for salmonids in the San Joaquin River. The data derived from the California Data Exchange Center files indicate that DO depressions occur during all migratory months, with significant events occurring from November through March when listed Central Valley steelhead adults and smolts would be utilizing this portion of the San Joaquin River as a migratory corridor (see Appendix A, Table 8).

Potential factors that contribute to these DO depressions are reduced river flows through the ship channel, released ammonia from the City of Stockton Wastewater Treatment Plant, upstream contributions of organic materials (*e.g.*, algal loads, nutrients, agricultural discharges) and the increased volume of the dredged ship channel. During the winter and early spring emigration period, increased ammonia concentrations in the discharges from the City of Stockton Waste Water Treatment Facility lowers the DO in the adjacent DWSC near the West Complex. In addition to the adverse effects of the lowered DO on salmonid physiology, ammonia is in itself toxic to salmonids at low concentrations. Likewise, adult fish migrating upstream will encounter lowered DO in the DWSC as they move upstream in the fall and early winter due to low flows and excessive algal and nutrient loads coming downstream from the upper San Joaquin River watershed. Levels of DO below 5 mg/L have been reported as delaying or blocking fall-run Chinook salmon in studies conducted by Hallock *et al.* (1970).

6. Hatchery Operations and Practices

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels (Department of the Interior [DOI] 1999). For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that early fall- and spring-run Chinook salmon were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. The FRH spring-run Chinook salmon have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of fall-run Chinook salmon, an indication that FRH spring-run Chinook salmon may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of spring-run Chinook salmon spawning in the Feather River and counted at RBDD contain hybridized fish.

The management of hatcheries, such as Nimbus Hatchery and FRH, can directly impact spring-run Chinook salmon and steelhead populations by oversaturating the natural carrying capacity of the limited habitat available below dams. In the case of the Feather River, significant redd superimposition occurs in-river due to hatchery overproduction and the inability to physically separate spring- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run Chinook salmon often limits the amount if water available for steelhead spawning and rearing the rest of the year.

The increase in Central Valley hatchery production has reversed the composition of the steelhead population, from 88 percent naturally produced fish in the 1950s (McEwan 2001) to an estimated 23 to 37 percent naturally produced fish currently (Nobriga and Cadrett 2001). The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001).

Hatcheries also can have some positive effects on salmonid populations. Artificial propagation has been shown to be effective in bolstering the numbers of naturally spawning fish in the short term under specific scenarios. Artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally spawned populations at critically low abundance levels, as was the case with the Sacramento River winter-run Chinook salmon population during the 1990s. However, relative abundance is only one component of a viable salmonid population.

7. <u>Over Utilization</u>

a. *Ocean Commercial and Sport Harvest – Chinook Salmon and Steelhead*

Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the Northern and Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement. CWT returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

Since 1970, the CVI for Sacramento River winter-run Chinook salmon generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run Chinook salmon was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest rate was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of Sacramento River winter-run Chinook salmon. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996). In 1996 and 1997, NMFS issued a biological opinion which concluded that incidental ocean harvest of Sacramento River winter-run Chinook salmon represented a significant source of mortality to the endangered population, even though ocean harvest was not a key factor leading to the decline of the population. As a result of these opinions, measures were developed and implemented by the PFMC, NMFS, and CDFG to reduce ocean harvest by approximately 50 percent. In 2001 the CVI dropped to 0.27, most likely due to the reduction in harvest and the higher abundance of other salmonids originating from the Central Valley (Good *et al*. 2005).

Ocean fisheries have affected the age structure of Central Valley spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). Ocean harvest rates of Central Valley spring-run Chinook salmon are thought to be a function of the CVI (Good *et al*. 2005). Harvest rates of Central Valley spring-run Chinook salmon ranged from 0.55 to nearly 0.80 between 1970 and 1995 when harvest rates were adjusted for the protection of Sacramento River winter-run Chinook salmon. The drop in the CVI in 2001 as a result of high fall-run escapement to 0.27 also reduced harvest of Central Valley spring-run Chinook salmon. There is essentially no ocean harvest of steelhead.

b. *Inland Sport Harvest –Chinook Salmon and Steelhead*

Historically in California, almost half of the river sport fishing effort was in the Sacramento-San Joaquin River system, particularly upstream from the City of Sacramento (Emmett *et al.* 1991). Since 1987, the Fish and Game Commission has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for Sacramento River winter-run Chinook salmon. Present regulations include a year-round closure to Chinook salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to Chinook salmon fishing on the Sacramento River between the Deschutes River Bridge and the Carquinez Bridge. The rolling closure spans the months that migrating adult Sacramento River winter-run Chinook salmon are ascending the Sacramento River to their spawning grounds. These closures have virtually eliminated impacts on Sacramento River winter-run Chinook salmon caused by recreational angling in freshwater. In 1992, the California Fish and Game Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run Chinook salmon caused by trout anglers. That same year, the Commission also adopted regulations which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality.

In-river recreational fisheries historically have taken Central Valley spring-run Chinook salmon throughout the species' range. During the summer, holding adult Central Valley spring-run Chinook salmon are easily targeted by anglers when they congregate in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate; however, the significance of poaching on the adult population is unknown. Specific regulations for the protection of Central Valley spring-run Chinook salmon in Mill, Deer, Butte, and Big Chico Creeks and the Yuba River have been added to the existing CDFG regulations. The current regulations, including those developed for Sacramento River winter-run Chinook salmon provide some level of protection for spring-run fish (CDFG 1998).

There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from

1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams. Overall, this regulation has greatly increased protection of naturally produced adult steelhead; however, the total number of Central Valley steelhead contacted might be a significant fraction of basin-wide escapement, and even low catch-and-release mortality may pose a problem for wild populations (Good *et al*. 2005).

c. *Green Sturgeon*

Commercial harvest of white sturgeon results in the incidental bycatch of green sturgeon primarily along the Oregon and Washington coasts and within their coastal estuaries. Oregon and Washington have recently prohibited the retention of green sturgeon in their waters for commercial and recreational fisheries. Adams *et al*. (2002, 2007) reported harvest of green sturgeon from California, Oregon, and Washington between 1985 and 2001. Total captures of green sturgeon in the Columbia River Estuary by commercial means ranged from 240 fish per year to 6,000. Catches in Willapa Bay and Grays Harbor by commercial means combined ranged from 9 fish to 2,494 fish per year. Emmett *et al*. (1991) indicated that averages of 4.7 to 15.9 tons of green sturgeon were landed annually in Grays Harbor and Willapa Bay respectively. Overall, captures appeared to be dropping through the years; however, this could be related to changing fishing regulations. Adams *et al*. (2002, 2007) also reported sport fishing captures in California, Oregon, and Washington. Within the San Francisco Estuary, green sturgeon are captured by sport fisherman targeting the more desirable white sturgeon, particularly in San Pablo and Suisun bays (Emmett *et al*. 1991). Sport fishing in the Columbia River, Willapa Bay, and Grays Harbor captured from 22 to 553 fish per year between 1985 and 2001. Again, it appears sport fishing captures are dropping through time; however, it is not known if this is a result of abundance, changed fishing regulations, or other factors. Based on new research by Israel (2006a) and past tagged fish returns reported by CDFG (2002), a high proportion of green sturgeon present in the Columbia River, Willapa Bay, and Grays Harbor (as much as 80 percent in the Columbia River) may be Southern DPS North American green sturgeon. This indicates a potential threat to the Southern DPS North American green sturgeon population. Beamesderfer *et al.* (2007) estimated that green sturgeon will be vulnerable to slot limits (outside of California) for approximately 14 years of their life span. Fishing gear mortality presents an additional risk to the long-lived sturgeon species such as the green sturgeon (Boreman 1997). Although sturgeon are relatively hardy and generally survive being hooked, their long life makes them vulnerable to repeated hooking encounters, which leads to an overall significant hooking mortality rate over their lifetime. An adult green sturgeon may not become sexually mature until they are 13 to 18 years of age for males (152-185cm), and 16 to 27 years of age for females (165-202 cm) (Van Eenennaam 2006). Even though slot limits "protect" a significant proportion of the life history of green sturgeon from harvest, they do not protect them from fishing pressure.

Green sturgeon are caught incidentally by sport fisherman targeting the more highly desired white sturgeon within the Delta waterways and the Sacramento River. New regulations which went into effect in March 2007, reduced the slot limit of sturgeon from 72 inches to 66 inches, and limit the retention of white sturgeon to one fish per day with a total of 3 fish retained per year. In addition, a non-transferable sturgeon punch card with tags must be obtained by each angler fishing for sturgeon. All sturgeon caught must be recorded on the card, including those released. All green sturgeon must be released unharmed and recorded on the sturgeon punch card by the angler.

Poaching rates of green sturgeon in the Central Valley are unknown; however, catches of sturgeon occur during all years, especially during wet years. Unfortunately, there is no catch, effort, and stock size data for this fishery which precludes making exploitation estimates (USFWS 1995a). Areas just downstream of Thermalito Afterbay outlet and Cox's Spillway, and several barriers impeding migration on the Feather River may be areas of high adult mortality from increased fishing effort and poaching. The small population of sturgeon inhabiting the San Joaquin River experiences heavy fishing pressure, particularly regarding illegal snagging and it may be more than the population can support (USFWS 1995a).

8. <u>Disease and Predation</u>

Infectious disease is one of many factors that influence adult and juvenile salmonid survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS 1996a, 1996b, 1998a). Specific diseases such as bacterial kidney disease, C*eratomyxosis shasta* (C-shasta), columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect steelhead and Chinook salmon (NMFS 1996a, 1996b, 1998a). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that wild fish tend to be less susceptible to pathogens than are hatchery-reared fish. Nevertheless, wild salmonids may contract diseases that are spread through the water column (*i.e*., waterborne pathogens) as well as through interbreeding with infected hatchery fish. The stress of being released into the wild from a controlled hatchery environment frequently causes latent infections to convert into a more pathological state, and increases the potential of transmission from hatchery reared fish to wild stocks within the same waters.

Accelerated predation also may be a factor in the decline of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon, and to a lesser degree Central Valley steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961, Decato 1978, Vogel *et al.* 1988, Garcia 1989).

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson-Cottonwood Irrigation District's (ACID) diversion dam, GCID's diversion facility, areas where rock revetment has replaced natural river bank vegetation, and at South Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run Chinook salmon is believed to be higher than normal due to flow dynamics associated with the operation of this structure. Due to their small size, early emigrating winter-run Chinook salmon may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall. In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters. The Sacramento pikeminnow is a species native to the Sacramento River basin and has co-evolved with the anadromous salmonids in this system. However, rearing conditions in the Sacramento River today (*e.g.*, warm water, low-irregular flow, standing water, and water diversions) compared to its natural state and function decades ago in the pre-dam era, are more conducive to warm water species such as Sacramento pikeminnow and striped bass than to native salmonids. Tucker *et al.* (1998) reported that predation during the summer months by Sacramento pikeminnow on juvenile salmonids increased to 66 percent of the total weight of stomach contents in the predatory pikeminnow. Striped bass showed a strong preference for juvenile salmonids as prey during this study. This research also indicated that the percent frequency of occurrence for juvenile salmonids nearly equaled other fish species in the stomach contents of the predatory fish. Tucker *et al.* (2003) showed the temporal distribution for these two predators in the RBDD area were directly related to RBDD operations (predators congregated when the dam gates were in, and dispersed when the gates were removed).

USFWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally eroding banks (Michny and Hampton 1984). From October 1976 to November 1993, CDFG conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 percent to 99 percent. Predation by striped bass is thought to be the primary cause of the loss (Gingras 1997).

Predation on juvenile salmonids has increased as a result of water development activities which have created ideal habitats for predators and non-native invasive species (NIS). Turbulent conditions near dam bypasses, turbine outfalls, water conveyances, and spillways disorient juvenile salmonid migrants and increase their predator avoidance response time, thus improving predator success. Increased exposure to predators has also resulted from reduced water flow through reservoirs; a condition which has increased juvenile travel time. Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the CVP and SWP Fish Facilities, and the SMSCG. Predation on salmon by striped bass and pikeminnow at salvage release sites in the Delta and lower Sacramento River has been documented (Orsi 1967, Pickard *et al.* 1982); however, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (Edwards *et al.* 1996, Tillman *et al.* 1996, NMFS 1997).

Avian predation on fish contributes to the loss of migrating juvenile salmonids by constraining natural and artificial production. Fish-eating birds that occur in the California Central Valley include great blue herons (*Ardea herodias*), gulls (*Larus spp*.), osprey (*Pandion haliaetus*), common mergansers (*Mergus merganser*), American white pelicans (*Pelecanus erythrorhynchos*), double-crested cormorants (*Phalacrocorax spp*.), Caspian terns (*Sterna caspia*), belted kingfishers (*Ceryle alcyon*), black-crowned night herons (*Nycticorax nycticorax*), Forster's terns (*Sterna forsteri*), hooded mergansers (*Lophodytes cucullatus*), and bald eagles

(*Haliaeetus leucocephalus*) (Stephenson and Fast 2005). These birds have high metabolic rates and require large quantities of food relative to their body size.

Mammals can also be an important source of predation on salmonids within the California Central Valley. Predators such as river otters (*Lutra canadensis*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) are common. Other mammals that take salmonid include: badger (*Taxidea taxus*), bobcat (*Linx rufis*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), long-tailed weasel (*Mustela frenata*), mink (*Mustela vison*), mountain lion (*Felis concolor*), red fox (*Vulpes vulpes*), and ringtail (*Bassariscus astutus*). These animals, especially river otters, are capable of removing large numbers of salmon and trout from the aquatic habitat (Dolloff 1993). Mammals have the potential to consume large numbers of salmonids, but generally scavenge post-spawned salmon. In the marine environment, pinnipeds, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Steller's sea lions (*Eumetopia jubatus*) are the primary marine mammals preying on salmonids (Spence *et al*. 1996). Pacific striped dolphin (*Lagenorhynchus obliquidens*) and killer whale (*Orcinus orca*) can also prey on adult salmonids in the nearshore marine environment, and at times become locally important. Although harbor seal and sea lion predation primarily is confined to the marine and estuarine environments, they are known to travel well into freshwater after migrating fish and have frequently been encountered in the Delta and the lower portions of the Sacramento and San Joaquin Rivers. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable, such as the large water diversions in the South Delta.

9. Environmental Variation

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al*. 1999, Mantua and Hare 2002). This phenomenon has been referred to as the Pacific Decadal Oscillation. In addition, large-scale climatic regime shifts, such as the El Niño condition, appear to change productivity levels over large expanses of the Pacific Ocean. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American west. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the west coast.

"El Niño" is an environmental condition often cited as a cause for the decline of West Coast salmonids (NMFS 1996b). El Niño is an unusual warming of the Pacific Ocean off South America and is caused by atmospheric changes in the tropical Pacific Ocean (Southern Oscillation-ENSO) resulting in reductions or reversals of the normal trade wind circulation patterns. The El Niño ocean conditions are characterized by anomalous warm sea surface temperatures and changes to coastal currents and upwelling patterns. Principal ecosystem alterations include decreased primary and secondary productivity in affected regions and changes in prey and predator species distributions. Cold-water species are displaced towards higher latitudes or move into deeper, cooler water, and their habitat niches occupied by species tolerant of warmer water that move upwards from the lower latitudes with the warm water tongue.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival in the ocean is driven largely by events occurring between ocean entry and recruitment to a sub-adult life stage.

NMFS issued a statement dated February 2, 2008 (NMFS 2008) which assessed potential causes for the reduced escapement of adult Chinook salmon and coho salmon (*O. kisutch*) in California. In this document, NMFS found that poor ocean conditions were the primary causative factor for the low escapement numbers in 2007-2008. This finding was based on the spatial extent of the low returns along the coast of California which includes both Central Valley stocks of Chinook salmon and coastal stocks of coho salmon. NMFS' analysis found that ocean conditions were poor for salmon growth and survival during the spring-summer seasons of both 2005 and 2006. The Wells Ocean Productivity Index (WOPI), a composite index of 13 oceanographic variables and indices, weighted heavily by sea level height, sea surface temperature, upwelling index, and surface wind stress has been used successfully to track several other biological parameters including ocean productivity and rockfish juvenile production. In both of the spring-summer seasons of 2005 and 2006, the WOPI values were at some of their lowest levels ever for waters along the California coast. Only WOPI values during the El Niño years (1982-83, 1992-93, and 1999) had lower values. The WOPI index is also predicting that the 2008 salmon escapement numbers are likely to be low. Further discussions of climate related effects are addressed within the *Cumulative Effects* section of this opinion.

10. Ecosystem Restoration

a. *California Bay-Delta Authority (CBDA)*

Two programs included under CBDA; the Ecosystem Restoration Program (ERP) and the EWA, were created to improve conditions for fish, including listed salmonids, in the Central Valley (CALFED 2000). Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for steelhead and spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by the CBDA-ERP Program have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids. Similar habitat restoration is imminent adjacent to Suisun Marsh (*i.e.*, at the confluence of Montezuma Slough and the Sacramento River) as part of the Montezuma Wetlands project, which is intended to provide for commercial disposal of material dredged from San Francisco Bay in conjunction with tidal wetland restoration.

A sub-program of the ERP called the Environmental Water Program (EWP) has been established to support ERP projects through enhancement of instream flows that are biologically and ecologically significant in anadromous reaches of priority streams controlled by dams. This program is in the development stage and the benefits to listed salmonids are not yet clear. Clear Creek is one of five priority watersheds in the Central Valley that has been targeted for action during Phase I of the EWP.

The EWA is designed to provide water at critical times to meet ESA requirements and incidental take limits without water supply impacts to other users, particularly South of Delta water users. In early 2001, the EWA released 290 thousand acre feet of water from San Luis Reservoir at key times to offset reductions in South Delta pumping implemented to protect winter-run Chinook salmon, delta smelt, and splittail. However, the benefit derived by this action to winter-run Chinook salmon in terms of number of fish saved was very small. The anticipated benefits to other Delta fisheries from the use of the EWA water are much higher than those benefits ascribed to listed salmonids by the EWA release.

Currently, the EWA program is authorized through 2010 and is scheduled to be reduced in its scope. Future EWA operations will be considered to have limited assets and will primarily be utilized only during the VAMP pumping reductions in April and May to offset the "uncompensated losses" to CVP and SWP contractors for fisheries related actions. The primary source of EWA assets through 2015 will come from the 60,000 acre feet of water transferred to the State under the Yuba Accord annually.

b. *Central Valley Project Improvement Act*

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward recovery of all anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the DOI's ability to meet regulatory water quality requirements. Water has been used successfully to improve fish habitat for spring-run Chinook salmon and steelhead by maintaining or increasing instream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

c. *Iron Mountain Mine Remediation*

Environmental Protection Agency's Iron Mountain Mine remediation involves the removal of toxic metals in acidic mine drainage from the Spring Creek Watershed with a state-of-the-art lime neutralization plant. Contaminant loading into the Sacramento River from Iron Mountain

Mine has shown measurable reductions since the early 1990s (see Reclamation 2004 Appendix J). Decreasing the heavy metal contaminants that enter the Sacramento River should increase the survival of salmonid eggs and juveniles. However, during periods of heavy rainfall upstream of the Iron Mountain Mine, Reclamation substantially increases Sacramento River flows in order to dilute heavy metal contaminants being spilled from the Spring Creek debris dam. This rapid change in flows can cause juvenile salmonids to become stranded or isolated in side channels below Keswick Dam.

d. *State Water Project Delta Pumping Plant Fish Protection Agreement (Four-Pumps Agreement)*

The Four Pumps Agreement Program has approved about $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since the agreement inception in 1986. Four Pumps projects that benefit spring-run Chinook salmon and steelhead include water exchange programs on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Bay upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead (see Reclamation 2004 Chapter 15).

11. Non-Native Invasive Species

As currently seen in the San Francisco estuary, NIS can alter the natural food webs that existed prior to their introduction. Perhaps the most significant example is illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis*. The arrival of these clams in the estuary disrupted the normal benthic community structure and depressed phytoplankton levels in the estuary due to the highly efficient filter feeding of the introduced clams (Cohen and Moyle 2004). The decline in the levels of phytoplankton reduces the population levels of zooplankton that feed upon them, and hence reduces the forage base available to salmonids transiting the Delta and San Francisco estuary which feed either upon the zooplankton directly or their mature forms. This lack of forage base can adversely impact the health and physiological condition of these salmonids as they emigrate through the Delta region to the Pacific Ocean.

Attempts to control the NIS also can adversely impact the health and well-being of salmonids within the affected water systems. For example, the control programs for the invasive water hyacinth and *Egeria densa* plants in the Delta must balance the toxicity of the herbicides applied to control the plants to the probability of exposure to listed salmonids during herbicide application. In addition, the control of the nuisance plants have certain physical parameters that must be accounted for in the treatment protocols, particularly the decrease in DO resulting from the decomposing vegetable matter left by plants that have died.

12. Summary

For Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, the construction of high dams for hydropower, flood control, and water supply resulted in the loss of vast amounts of upstream habitat (*i.e.*, approximately 80 percent, or a minimum linear estimate of over 1,000 stream miles), and often resulted in precipitous declines in affected salmonid populations. For example, the completion of Friant Dam in 1947 has been linked with the extirpation of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River within just a few years. The reduced populations that remain below Central Valley dams are forced to spawn in lower elevation tailwater habitats of the mainstem rivers and tributaries that were previously not used for this purpose. This habitat is entirely dependent on managing reservoir releases to maintain cool water temperatures suitable for spawning, and/or rearing of salmonids. This requirement has been difficult to achieve in all water year types and for all life stages of affected salmonid species. Steelhead, in particular, seem to require the qualities of small tributary habitat similar to what they historically used for spawning; habitat that is largely unavailable to them under the current water management scenario. All salmonid species considered in this consultation have been adversely affected by the production of hatchery fish associated with the mitigation for the habitat lost to dam construction (*e.g.*, from genetic impacts, increased competition, exposure to novel diseases, *etc*.).

Land-use activities such as road construction, urban development, logging, mining, agriculture, and recreation are pervasive and have significantly altered fish habitat quantity and quality for Chinook salmon and steelhead through alteration of streambank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and removal of riparian vegetation resulting in increased streambank erosion. Human-induced habitat changes, such as: alteration of natural flow regimes; installation of bank revetment; and building structures such as dams, bridges, water diversions, piers, and wharves, often provide conditions that both disorient juvenile salmonids and attract predators. Harvest activities, ocean productivity, and drought conditions provide added stressors to listed salmonid populations. In contrast, various ecosystem restoration activities have contributed to improved conditions for listed salmonids (*e.g.*, various fish screens). However, some important restoration activities (*e.g.*, Battle Creek Restoration Project) have not yet been implemented and benefits to listed salmonids from the EWA have been less than anticipated.

Similar to the listed salmonids, the Southern DPS of North American green sturgeon has been negatively impacted by hydroelectric and water storage operations in the Central Valley which ultimately affect the hydrology and accesibility of Central Valley rivers and streams to anadromous fish. Anthropogenic manipulations of the aquatic habitat, such as dredging, bank stabilization, and waste water discharges have also degraded the quality of the Central Valley's waterways for green sturgeon.

F. Existing Monitoring Programs

Salmonid-focused monitoring efforts are taking place throughout the Sacramento and San Joaquin River basins, and the Suisun Marsh. Many of these programs incidentally gather information on steelhead but a focused, comprehensive steelhead monitoring program has not been funded or implemented in the Central Valley. The existing salmonid monitoring efforts are summarized in Table 9 (Appendix A) by geographic area and target species. Information for this summary was derived from a variety of sources:

- IEP's (1999) Steelhead Project Work Team report on monitoring, assessment, and research on steelhead: status of knowledge, review of existing programs, and assessment of needs;
- CDFG Plan;
- U.S. Forest Service Sierra Nevada Framework monitoring plan;
- ESA section 10 and section 4(d) scientific research permit applications;
- Trinity River Restoration Program biological monitoring; and
- Suisun Marsh Monitoring Program.

Studies focused on the life history of green sturgeon are currently being implemented by researchers at academic institutions such as University of California, Davis. Future plans include radio-telemetry studies to track the movements of green sturgeon within the Delta and Sacramento River systems. Additional studies concerning the basic biology and physiology of green sturgeon are also being conducted to better understand the fish's niche in the aquatic system.

IV. 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).

A. Status of the Species and Critical Habitat in the Action Area

1. Status of the Species within the Action Area

The action area functions primarily as a migratory corridor for adult and juvenile Central Valley steelhead. All adult 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 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, Central Valley spring-run Chinook salmon ESUs, and Central Valley steelhead from the Sacramento River watershed that are drawn into the Central and South Delta by the actions of the CVP and SWP water diversion facilities and must therefore emigrate towards the ocean through the lower San Joaquin River system. The action area also functions as migratory, holding, and rearing habitat for adult and juvenile Southern DPS of North American green sturgeon.

a. *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 8 years at the CVP and SWP, Sacramento River winter-run Chinook salmon are typically present in the Western and Central 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 (48.8 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 (see Appendix A, Table 10.). The presence of juvenile Sacramento River winter-run Chinook salmon in the Western and Central 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 one of the four access points on the Sacramento River (Georgiana Slough, the Delta Cross Channel, Three Mile Slough, and the San Joaquin River via Broad Slough) into the channels of the Western and Central Delta, including the lower sections of the San Joaquin River. The combination of pumping rates and tidal flows moves these fish towards the action area adjacent to Jersey Island. 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 action area.

b. *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 (20.1 percent of average annual salvage) and peaks in April (66.8 percent of average annual salvage) (see Appendix A Table 10). By May, the salvage of Central Valley spring-run Chinook salmon juveniles declines sharply (11.5 percent of average annual salvage) and essentially ends by the end of June (1.3 percent of average annual salvage).

c. *Central Valley Steelhead*

The Central Valley steelhead DPS occurs in both the Sacramento River and the San Joaquin River watersheds. However the spawning population of fish is much greater in the Sacramento River watershed and accounts for nearly all of the DPS' population. Like Sacramento River

Chinook salmon, Sacramento River steelhead can be drawn into the Central and Western Delta by the actions of the CVP and SWP water diversion facilities. Small, remnant populations of 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, historical presence, and recent otilith chemistry studies verifying at least one steelhead in the limited samples collected from the river. 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 (see Appendix A Table 10). Their presence increases through December and January (22.5 percent of average annual salvage) and peaks in February (34.6 percent) and March (31.6 percent) before rapidly declining in April (7.8 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.

Steelhead smolt production originating in the San Joaquin River basin (all natural) is monitored by Kodiak trawls conducted by the USFWS and CDFG on the mainstem of the San Joaquin River just above the Head of Old River Barrier during the VAMP experimental period. These efforts 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. 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 near Riverbank. Typically, very few adult steelhead have been observed moving upstream past the weir. However, in 2006 to 2007, the weir was left in through the winter and spring and seven adult steelhead were counted moving upstream. Natural steelhead production also occurs on the Calaveras River, with empties into the San Joaquin River in the City of Stockton. Monitoring is conducted by RSTs in the upper reaches of the river below New Hogan Dam. Emigration of smolts from this watershed is highly correlated with stream flow conditions, and passage of smolts through the valley floor section of the watercourse is predicated on the river maintaining connectivity with the Delta. Steelhead smolt migrations are likewise monitored at several sites on the Sacramento River by the USFWS and CDFG. An important monitoring station for tracking smolt numbers is the Chipps Island station in the western Delta. This monitoring site collects steelhead smolts produced within the entire Central Valley basin.

d. *Southern DPS of North American Green Sturgeon*

Juvenile green sturgeons from the Southern DPS are routinely collected at the SWP and CVP salvage facilities throughout the year. However, numbers are considerably lower than for other species of fish monitored at the facilities. Based on the salvage records from 1981 through 2007, green sturgeon may be present during any month of the year, and have been particularly prevalent during July and August (see Appendix B Figure 9). The sizes of these fish are less than 1 meter and average 330 mm with a range of 136 mm to 774 mm. The size range indicates that these are sub-adult fish rather than adult or larval/juvenile fish. It is believed that these sub-adult fish utilize the Delta for rearing for up to a period of approximately 3 years. The proximity of the CVP and SWP facilities to the action area would indicate that sub-adult green sturgeons have a strong potential to be present within the action area during the installation of the pipeline in the San Joaquin River. Juvenile green sturgeon have also previously been captured at Santa Clara Shoals during fish monitoring studies (Moyle 2002).

2. 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 Central Valley steelhead. The San Joaquin Delta HU is in the southwestern portion of the Central Valley steelhead DPS range and includes portions of the south, central and western 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) that contained one or more PCEs for the 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 essential features of these PCEs included 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, natural levels of 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 Central Valley steelhead juveniles and smolts and for adult upstream migration. No spawning of Central Valley steelhead occurs within the action area.

The general condition and function of freshwater rearing and migration habitats has already been described in the *Status of the Species and Critical Habitat* section of this biological opinion. The substantial degradation over time of several of the essential features of these PCEs has diminished the function and condition of the habitats in the action area. This area currently provides only rudimentary functions compared to its historical status. The channels of the Delta have been heavily riprapped with coarse rock slope protection on artificial levee banks and these channels have been straightened to facilitate water conveyance through the system. The extensive riprapping and levee construction has precluded river channel migrations and the formation of natural riverine/estuarine features 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 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 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 Delta have been routinely dredged by DWR to provide adequate intake depth for these agricultural water diversions, particularly in the South Delta. Likewise, the main channel of the San Joaquin River has been routinely dredged by the Corps to create an artificially deep channel to provide passage for ocean going commercial shipping to the Port of Stockton.

Water flow through the 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, are drawn along with the current towards these diversion points. In addition to the altered flow patterns in the 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 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*.).

Those members of the Central Valley steelhead DPS that spawn in the San Joaquin system must pass through the San Joaquin Delta HSA to reach their upstream spawning and freshwater rearing areas on the tributary watersheds. Therefore, it is of critical importance to the long-term viability of the San Joaquin River basin portion of the Central Valley steelhead DPS to maintain a functional migratory corridor and freshwater rearing habitat through the action area and the San Joaquin Delta HSA.

B. Factors Affecting the Species and Habitat in the Action Area

The action area encompasses a small portion of the area utilized by the Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon ESUs, Central Valley steelhead DPS, and the Southern DPS of North American green sturgeon. Many of the range-wide factors affecting these species are discussed in the *Status of the Species and Critical Habitat* section of this biological opinion, 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 ISD wastewater treatment plant expansion project.

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 often truncate the peak of the flood hydrographs and extended the releases from basin reservoirs 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.

Tidal action in the action area frequently has a much greater effect on river hydrodynamics than riverine flows. Only during high winter and spring runoff events do the effects of the river flow compensate for the tidal actions in the area. Under natural conditions, flood flows were substantially higher than seen in the currently managed system. This pushed the tidal effects in the western Delta farther to the west, and created a much greater expanse of freshwater dominated habitat. Under the current water management operations, summer flows are higher and more uniform than those that naturally occurred. These conditions extend freshwater habitat farther downstream than under the natural conditions of low summer flows that historically occurred.

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 mainstem of the river. High summer water temperatures in the lower San Joaquin River frequently exceed 72 ^{o}F (CDEC database), and create a thermal barrier to the migration of adult and juvenile salmonids.

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). Revetted embankments result in loss of sinuosity and braiding and reduce the amount of aquatic habitat. Impacts at the reach level result primarily from halting erosion and controlling riparian vegetation. Reach-level impacts which cause significant impacts to fish are reductions in new habitats of various kinds, changes to sediment and organic material storage and transport, reductions of lower food-chain production, and reduction in 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 nearshore refuge areas.

PS and NPS of pollution resulting 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* 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, NIS, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

V. EFFECTS OF THE ACTION

A. Approach to the Assessment

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA and its implementing regulations also require biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536). This biological opinion does not rely on the regulatory definition of “destruction or adverse modification” of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species. This biological opinion assesses the effects of the proposed action on endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, threatened Central Valley steelhead, their designated critical habitat, and the threatened Southern DPS of North American green sturgeon.

In the *Description of the Proposed Action* section of this biological opinion, NMFS provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this biological opinion, NMFS provided an overview of the threatened and endangered species and critical habitat that are likely to be adversely affected by the activity under consultation.

NMFS generally approaches the "jeopardy" and critical habitat modification analyses in a series of steps. First, NMFS evaluates the available evidence to identify direct and indirect physical, chemical, and biotic effects of the proposed action on individual members of listed species or aspects of the species’ environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species’ environment - such as reducing a species’ prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species’ environment - such as introducing exotic competitors or a sound). Once NMFS has identified the effects of the action, the available evidence is evaluated to identify a species’ probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species’ reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; and others). The available evidence is then used to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

1. Information Available for the Assessment

To conduct the assessment, NMFS examined evidence from a variety of sources. Detailed background information on the status of these species and critical habitat has been published in a number of documents, including peer-reviewed scientific journals, primary reference materials, governmental and non-governmental reports, and scientific meetings as well as the supporting information supplied with the action's environmental documents.

2. Assumptions Underlying This Assessment

In the absence of definitive data or conclusive evidence, NMFS must make a logical series of assumptions to overcome the limits of the available information. These assumptions will be made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning will be stated for each assumption, and supporting evidence cited.

NMFS was provided with modeling results describing the dilution and mixing characteristics of the effluent leaving the outfall diffuser. The dilution models used in this analysis were based on the DSM2, a water quality and tidal hydraulic computer simulation developed by DWR. Several critical inputs for the DSM2 model are developed from the outputs of the water conveyance model developed by DWR called CALSIM, which has not gained unanimous support from the hydrology and aquatic resources community for its use outside of water conveyance modeling, particularly when trying to gather definitive hydrology outputs rather than generalized conditions. Because of these modeling uncertainties, and to err on the side of the species, NMFS has assumed that listed fish occurring near the ISD WWTP outfall may be exposed to higher concentrations of wastewater effluent (i.e., undiluted effluent) than predicted by the above studies.

B. Assessment

1. Overview

The ISD WWTP expansion project will result in a new wastewater discharge to the lower San Joaquin River. The effects of the proposed project will fall into two main categories: (1) short-term construction related effects, and (2) persistent long-term effects of the wastewater treatment plant's operations. NMFS believes that the short-term construction related effects will be minor due to the application of the work window of August 1 through October 15, and the transitory nature of the construction process for the installation of the diffuser pipeline, which is projected to last approximately 2 weeks. This work window will avoid the vast majority of listed salmonids that have the potential to be present in the channel of the lower San Joaquin River during their migration through the Sacramento-San Joaquin Delta, but will overlap with the potential presence of Southern DPS green sturgeon in the Delta, which are believed to reside there year-round. Construction effects primarily will be related to the disruption of the benthic and riparian habitat in the action area due to the installation of the pipeline, including the hydraulic suction dredging required to excavate the trench for pipeline placement.

The long-term operation of the wastewater discharge diffuser array is expected to contribute low levels of pollutants to the lower San Joaquin River on a year-round basis. Some pollutants are expected to adversely affect listed fish, particularly (1) Central Valley steelhead originating from the upper San Joaquin River drainage, and (2) North American green sturgeon which, as indicated above, may be present year-round. Individuals from the Sacramento River winter-run Chinook salmon ESU and the Central Valley spring-run Chinook salmon ESU may also experience these adverse effects if present in the action area during effluent discharges. These adverse effects are believed to result in mainly sublethal changes in the physiology of the exposed fish and may not result in mortality as their final endpoint. NMFS expects that a dilution plume radiating from the diffuser array will have an oscillatory behavior due to natural tidal and river flow variables. This tidal oscillation creates a repeating superimposition of the dilution plume back upon itself during each tidal change. Eventually the amount of wastewater effluent moved downstream out of the system will come to equilibrium with the amount of new effluent being discharged into the system, giving a demonstrable dilution pattern surrounding the outfall.

2. <u>Construction Effects</u>

a. *Hydraulic Dredging*

(1) Entrainment of Fish and Invertebrates. The applicant plans to utilize hydraulic dredging to excavate a trapezoidal trench to position the outfall diffuser pipe along the bottom of the San Joaquin River channel. The trench will measure 4 feet wide at the base and 8 feet deep with the side slope ratio and the width of the trench at the mudline to be determined by the dredging contractor's determination of slope stability, although initial analysis indicates that the width of the trench at the mudline will be approximately 36 feet wide. The trench will extend approximately 580 feet offshore from the levee transition site on Jersey Island. Dredging of this trench will require excavation of approximately 3,700 cubic yards (cy) of material.

Hydraulic dredging has the potential to entrain juvenile salmonids and green sturgeon if the individual fish enter the zone of inflow around the hydraulic cutterhead. The hydraulic cutterhead dredge operates by pulling water through the cutterhead assembly, upwards through the intake pipeline, past the hydraulic pump and down the outflow pipeline to the DMD site on Jersey Island. The suction creates a field of influence around the head of the dredge intake pipe. The size of the field of influence surrounding the cutterhead is dependent on the diameter of the pipeline, the power of the pump, and how deep the cutterhead is extended into the sediment layer. However, based on the timing of the proposed dredging (*i.e.*, August 1 through October 15) and the short duration of the expected in-water work, it is unlikely that salmonids will be present in this reach of the river during this period and, thus, the likelihood of entrainment is low. Furthermore, NMFS believes, based on the analysis of previous hydraulic dredging projects in the Delta, that the entrainment risks to healthy juvenile salmonid smolts are low. A healthy salmonid smolt should have sufficient burst swimming speed at 10 body lengths/second to overcome the water flow velocity surrounding the intake of the cutterhead dredge and swim out of the zone of entrainment surrounding the dredge intake (see NMFS 2005c for a more complete review of hydraulic dredging effects on salmonids).

However, the demersal behavior of green sturgeon and their assumed presence in the action area during the dredging actions increases their risk of entrainment by the dredge. This bottom-oriented behavior puts them in close proximity to the channel bottom and thus the flow field surrounding the cutterhead assembly during the dredging operations. Should an individual fish be entrained, it is highly likely that it will be injured and killed. The vulnerability of juvenile salmonids and green sturgeon to entrainment in hydraulic dredges is comprehensively discussed in a technical memorandum to the administrative file (NMFS 2006). The velocity of the flow field surrounding the cutterhead assembly rapidly diminishes with distance from the actual orifice of the intake of the cutterhead. Healthy fish should be able to swim against the velocity of the intake current and escape the effects of the dredge's suction, thus avoiding entrainment. Furthermore, the disturbance from the cutterhead assembly is believed to "alert" any fish within close proximity to the cutterhead of its imminent approach, thereby allowing sufficient time and distance to avoid entrainment. However, there is no guarantee that all fish will make the appropriate avoidance response to avoid entrainment, and some may become entrained into the suction pipe of the hydraulic dredge.

In addition to salmonids, other organisms would be entrained by the hydraulic suction dredge, particularly small demersal fish and benthic invertebrates. The Corps report (Reine and Clark 1998) estimated that the mean entrainment rate of a typical benthic invertebrate, represented by the grass shrimp (*Crangon* spp.), was 0.69 shrimp/cy when the cutterhead was positioned at or near the bottom but rose sharply to 3.4 shrimp/cy when the cutterhead was raised above the substrate to clean the pipeline and cutterhead assembly. Likewise, benthic infauna, such as clams, would be entrained by the suction dredge in rates equivalent to their density on the channel bottom, as they have no ability to escape the zone of entrainment surrounding the dredge's cutterhead. The loss of benthic food resources for juvenile steelhead, salmon, and green sturgeon such as amphipods or isopods, could be significant, depending on the density of the animal assemblages on the channel bottom. NMFS believes that small invertebrates such as annelids, crustaceans (amphipods, isopods), and other benthic fauna would be unable to escape the suction of the hydraulic dredge and be lost to the system. The timing of the dredging cycle (summer-fall) would preclude forage base replacement by recruitment from surrounding populations prior to the following winter and spring migration period of juvenile steelhead and Chinook salmon through the dredging action area (Nightingale and Simenstad 2001). Likewise, forage base for green sturgeon would be compromised within the action area until the disturbed substrate is recolonized from surrounding invertebrate populations.

The loss of benthic food resources, such as amphipods or isopods, could reduce fish growth rates and increase the energy expended searching for food, depending on the density of the animal assemblages on the channel bottom. This would be more likely to affect sturgeon, which are specialized benthic feeders, but also could affect juvenile salmon and steelhead, which feed on isopods and amphipods (particularly *corophium* amphipods) that are present in this region of the

Delta. NMFS believes that although small invertebrates such as annelids, crustaceans (amphipods, isopods), and other benthic fauna would be unable to escape the suction of the hydraulic dredge and would be lost to the system, the scale of impacts to the forage base of salmonids and green sturgeon will be negligible overall due to the small area of the dredging impact (0.45 acres) relative to the size of the action area (10 rivers miles). The action area is itself a very small percentage of the available Delta through which listed fish may move. It has been stated that the delta has over 1,000 miles of waterways (Department of Water Resources – Delta Atlas 1995).

To help ameliorate the potential for entrainment of listed fish, the applicant has stated in their project description that conservation measures will be incorporated into the dredging plan. These include: (1) the presence of a qualified fisheries biologist on-site to monitor all in-channel dredging activities when dredging is occurring, and (2) employing a controlled rate of suction dredging, as recommended by the Corps (2000), to provide any fish in the direct path of the cutterhead ample opportunity to escape. In addition to these conservation measures, the small footprint of the diffuser pipe trench will reduce the time needed to complete the dredging operation. The applicant has stated that approximately 19,800 square feet of river bottom will be disturbed. Therefore, the expected dredging operation should take approximately 2 to 3 weeks to complete. NMFS expects that this short period of time will significantly minimize the exposure of fish to the effects of dredging entrainment.

(2) Water Quality and Turbidity. Hydraulic dredging re-suspends bottom sediments during the dredging process. The rotating blades of the cutterheads located at the intake end of the dredge ladder excavate substrate by mechanically disturbing the sediment horizon. The disturbed sediment is then pulled into the orifice of the intake pipe by the force of the water flow created by the suction pump aboard the dredge. Suspension of sediment may result from the rotating cutterhead throwing material into the water column above the intake zone of the suction pipe, the rate of swing of the dredge ladder across the dredging arc in front of the dredge, and the depth of the cutterhead into the bottom sediment layer. The amount of sediment re-suspension can be reduced by using the appropriate cutterhead rotation speed for the sediment composition, adjusting the relationship between the cutterhead rotational speed and the hydraulic suction force at the intake orifice, reducing the horizontal swing rate of the dredge ladder, or using hooded intakes around the cutterhead intake. Based on studies by the Corps of Engineers (Corps 2000), hydraulic cutterhead dredges typically produce less than 10 percent re-suspended sediments, and frequently can reach levels as low as 1 percent loss of the total dredged volume.

Suspended sediments can adversely affect salmonids in the area by clogging sensitive gill structures (Nightingale and Simenstad 2001) but are generally confined to turbidity levels in excess of 4,000 mg/l. Based on the best available information, NMFS does not anticipate that turbidity levels associated with the dredging action itself will increase to these deleterious levels. However, responses of salmonids to elevated levels of suspended sediments often fall into three major categories: physiological effects, behavioral effects, and habitat effects (Bash et al. 2001). The severity of the effect is a function of concentration and duration (Newcombe and MacDonald 1991, Newcombe and Jensen 1996) so that low concentrations and long exposure periods are frequently as deleterious as short exposures to high concentrations of suspended sediments. A review by Lloyd (1987) indicated that several behavioral characteristics of salmonids can be altered by even relatively small changes in turbidity (10 to 50 NTUs). Salmonids exposed to slight to moderate increases in turbidity exhibited avoidance, loss of station in the stream, reduced feeding rates and reduced use of overhead cover. Reaction distances of rainbow trout to prey were reduced with increases of turbidity of only 15 NTUs over an ambient level of 4 to 6 NTUs in experimental stream channels (Barret *et al*. 1992). Increased turbidity, used as an indicator of increased suspended sediments, also is correlated with a decline in primary productivity, a decline in the abundance of periphyton, and reductions in the abundance and diversity of invertebrate fauna in the affected area (Lloyd 1987, Newcombe and MacDonald 1991).

Re-suspension of contaminated sediments may have adverse effects upon salmonids or green sturgeon that encounter the sediment plume, even at low turbidity levels. Lipophilic compounds in the fine organic sediment, such as toxic polycyclic aromatic hydrocarbons (PAHs), can be preferentially absorbed through the lipid membranes of the gill tissue, providing an avenue of exposure to salmonids or green sturgeon experiencing the sediment plume (Newcombe and Jensen 1996). Similarly, charged particles such as metals (e.g., copper), may interfere with ion exchange channels on sensitive membrane structures like gills or olfactory rosettes and increases in ammonia from the sediment may create acutely toxic conditions for salmonids or green sturgeon present in the channel's margins.

The expected total surface area of channel bottom to be dredged is approximately 19,800 square feet (0.45 acres) with dredging and construction operations lasting approximately 2 to 3 weeks. The estimated volume of material to be removed is 3,700 cubic yards. When cutterhead suction dredging is conducted properly, re-suspension of sediments is typically limited to the immediate vicinity of the cutterhead and sediment loss rates are typically less than 1 percent of the dredge volume, although these loss rates may be as high as 10 percent under certain conditions (Corps 2000). Therefore, the anticipated volume of sediment injected into the overlying water column by the dredging action is expected to range between 37 cubic yards (1 percent loss) to 370 cubic yards (10 percent loss). This will create a temporary elevation in the local water column turbidity within the action area, but is expected to remain well within the normal ranges of turbidity for the West Delta except within the immediate vicinity of the dredge when in operation. Strong tidal currents within the action area on the ebb and flood tides are also expected to disperse the turbidity plume created within the immediate area of the dredging action. This will reduce the intensity of the plume over a relatively short distance to negligible levels.

Therefore, NMFS does not anticipate that the dredging operations will create a significant increase in turbidity levels within the action area that would result in identifiable adverse effects. Increases in ambient turbidity will be highest immediately around the dredger head, but hydrologic conditions (*i.e.*, tidal and river flow and dispersion in the surrounding water mass) should quickly reduce these turbidity levels to background levels in the San Joaquin River. Furthermore, turbidity conditions are expected to return to ambient levels within hours to days of the termination of dredging and construction actions (likely much sooner) due to the flushing effect of the tides and river flow. Moreover, based on the timing of the dredging actions (August 1 through October 15), NMFS does not expect listed salmonids to be present in the action area during construction with the exception of a small number of Central Valley steelhead adults that may stray into the action area from the Sacramento River during their upstream spawning migration. Green sturgeon, which can occupy waters containing variable levels of suspended sediment and thus turbidity, are not expected to be impacted by the slight increase in the turbidity levels anticipated in the dredging action as explained above.

(3) Acoustic Impacts. High levels of underwater acoustic noises have been shown to have adverse impacts upon fish. Adverse effects can range from physical damage to the exposed fish, sometimes resulting in death, to lesser impacts, such as behavioral modifications or increased susceptibility to predation, which do not necessarily result in death or long term adverse impacts by themselves. The applicant has indicated that the dredging and construction phase of the project should last approximately 2 to 3 weeks. Even though the suction dredge may not be in constant operation (typically 8 to 10 hours daily based on previous consultations), other activities aboard the dredge may continue on a 24-hour cycle such as cleaning the cutterhead, repositioning the dredge itself, and conducting maintenance work on the dredger itself. In addition, the applicant has indicated that up to 20 pilings may need to be driven into the San Joaquin River channel bottom to temporarily anchor the diffuser and discharge pipeline during its placement into the dredged trench. If used, the pilings would be installed and later removed using a vibratory pile-driving hammer. Noise generated from the installation and removal of these pilings may adversely affect fish by altering their migration behavior, reducing their hearing, and/or direct injury or lethality to fish within the immediate vicinity of the construction activities. As previously mentioned, the in-channel area to be directly affected by the dredging and piling installation consists of an approximately 36-foot wide by approximately 550-foot long corridor extending into the San Joaquin River from the northwest shore of Jersey Island. The San Joaquin River channel at this location is approximately 3,300 feet wide.

Studies conducted by the Corps (Clarke et al. 2002) measured sounds produced by different dredging methods, including hydraulic cutterhead dredges. Clarke et al. (2002) measured sound energy in the 70 to 1,000 Hz range emanating from the dredging activity. The sound energy peaked at a level of 100 to 110 decibel (dB) (presumably at a reference pressure of 1 μPascal (re: l μPa), although it was not cited in the report text) at an unspecified distance from the dredge. Assuming that the measurements for the cutterhead hydraulic dredge were made at similar distances as the other dredge methods examined, the closest distance would be 40 meters (based on the hopper dredge measurements). Based on this distance, the calculated point source level of sound energy would be equal to 153 dB. Conversely, based on the finding that the sounds emitted by the hydraulic dredge were barely detectable at 500 meters (Clarke et al. 2002), then the point source noise energy would be equal to 125 dB assuming that the background noise is between 50 and 60 dB. Transient noise associated with machinery and deck activities may be substantially above these energy levels, as indicated by the bucket dredge data. Sounds created from topside activities can be easily and efficiently transferred through the barge hull to the surrounding water column, particularly from metal to metal contact.

Scholik and Yan (2002) studied the effects of boat engine noise on the auditory sensitivity of the fathead minnow. The majority of noise generated from a motor is derived from the cavitation of the propeller as it spins in the water. Fish were exposed to a recording of the noise generated by a 55-hp outboard motor over a period of 2 hours. The noise level was adjusted to 142 dB (re: l μPa), which was equivalent to the noise levels measured at 50 meters from a 70 hp outboard motor. The experimental fish suffered a drop in hearing sensitivity over the range of frequencies normally associated with their hearing capabilities. These responses were measured using electrophysiological responses of their auditory nerves under general anesthesia. Studies by McCauley et al. (2003) on the marine pink snapper, indicated that high-energy noise sources (approximately 180 dB (re: 1 μPa) maximum) can damage the inner ears of aquatic vertebrates by ablating the sensory hairs on their inner ear epithelial tissue as revealed by electron microscopy. Damage remained apparent in fish held up to 58 days after exposure to the intense sound. Although little data from studies utilizing salmonids is available, NMFS assumes that some level of adverse impacts to salmonids can be inferred from the above results. Results of exposure of these other fish species can serve as surrogates for salmonids and green sturgeon since the general inner ear anatomy and hearing physiology of fish is highly conserved phylogenetically. Adverse effects were measured in these surrogates following as little as 2 hours of exposure to 142 dB (re: 1 μPa) sound energy.

Vibratory pile driving is accomplished by attaching a variable eccentric vibrator to the head of the pile to drive the pile into the substrate. The specific effects of pile driving on fish depend on a wide range of factors including the type of pile, type of hammer, fish species, and environmental setting. As summarized in *Effects of Sound on Fish* (Hastings and Popper 2005), there have been five recent experimental studies that have examined the effects of pile driving on fish (Abbott and Bing-Sawyer 2002; Nedwell et al. 2003; Abbott 2004). The results of these studies have varied, and have indicated that the effects of pile driving may range from fish mortality to a loss of hearing capabilities for some fish species (Hastings and Popper 2005).

The scientific and regulatory communities continue to work to develop noise exposure criteria for the onset of injury, behavioral disturbance, and other auditory effects, such as noise interference with hearing (masking) and temporary loss of hearing. Popper et al. (2006) found that a series of metrics should be examined for setting protective criteria. Specifically, they recommended that the interim criteria for pile driving be set at a sound exposure level (SEL) of 187 dB re: 1 μPa^2 •sec *and* a peak sound pressure level of 208 dB re: 1 μPa_{peak} in any single strike. Although the criteria in that study were specific to percussive pile driving, which involves the repeated striking of the head of a piling by a hydraulic hammer, they serve as a guideline for noise thresholds for the proposed project, which is using a vibratory pile-driving hammer. Sound energy, as measured by decibels, does not differentiate between the sources of the acoustic energy and the perceived intensity (loudness) of that energy. Therefore, the biological effects elicited by the sound energy are primarily dependent on the magnitude of the acoustic energy and not so much as to the source of the acoustic energy. Other parameters that are important in determining the biological effects of acoustic energy include the wave form and time to rise to the peak energy level.

The loss of hearing sensitivity may adversely affect a salmonid's ability to orient itself (i.e., due to vestibular damage), detect predators, locate prey, or sense their acoustic environment. Fish also may exhibit noise-induced avoidance behavior that causes them to move into less suitable habitat or avoid passing the source of the noise. Although NMFS believes that the potential for salmonids, including adult Central Valley steelhead, being present in the action area during construction is very low, the proposed project may result in a very small number of adult steelhead fleeing the dredging associated noises and delaying passage around the dredge until the noise abates. Likewise, chronic noise exposure can reduce their ability to detect predators either by reducing the sensitivity of the auditory response in the exposed steelhead or masking the noise of an approaching predator. Disruption of the exposed steelhead's ability to maintain position or engage in schooling behavior will enhance its potential as a target for predators, such as seals and sea lions in the Delta. Unusual behavior or swimming characteristics single out an individual fish and allow a predator to focus its attack upon that fish more effectively. As mentioned previously, there is little data in general concerning green sturgeon hearing and their physiological response to sound exposure. Therefore, based on the information from surrogate fish species, NMFS will assume that some hearing degradation could potentially occur in sturgeon if they are within close proximity to the dredge or pile drivers, but the degree to which the loss occurs remains unknown at the present time.

Based on the short duration of the dredging and construction phase of this project and the timing of the work window, NMFS anticipates that a small number of green sturgeon may be exposed to the adverse effects of noise created during construction activities. Green sturgeon have the potential to be present year-round in the action area, but the population density in the action area is believed to be low (based on data from bottom trawl monitoring studies conducted for Corps dredging projects in the San Joaquin River Deep Water Ship Channel). The low density decreases the likelihood of large numbers of individual fish encountering the dredging activities, which are expected to be of limited duration and affect a small area of the river channel in relation to the total area available in the affected reach. Furthermore, the number of listed salmonids (*i.e.*, adult Central Valley steelhead) that would be exposed to the adverse effects of construction noise is expected to be very low due to the timing of the work window (August 1 to October 15) coinciding with the low point of salmonid migration through this reach of the San Joaquin River.

b. *Degradation of Habitat*

Approximately 0.45 acres (19,800 square feet) of benthic substrate will be removed and subsequently replaced with gravel and clean fill to cover the diffuser pipe alignments. This new substrate will be devoid of benthic invertebrates, which may be used as food by listed species, and vegetation, which may be used as cover for resting and protection from predators. NMFS believes that re-colonization of this "virgin" material with invertebrates and vegetation will occur relatively quickly following completion of the diffuser pipeline installation, perhaps as quickly as within 1 year depending on the reproductive cycles of invertebrate populations in the area. The areal extent of the dredging for the placement of the diffusers pipelines is very small (approximately 36 feet by 550 feet) relative to the size of the action area and the lower San Joaquin River as a whole. Suitable stocks of organisms and vegetation to serve as "seed" stock for the re-colonization are present in the channel surrounding the action area. Typically re-colonization of new substrate occurs when these drifting invertebrate larvae and plants encounter open substrate as they are dispersed into the barren fill area by tidal and river currents sweeping through the channel. Although initially the community composition of the newly colonized substrate is likely to be different than the surrounding channel, a mature benthic community resembling the surrounding area is expected to form with the passage of time if the substrate does not encounter any further disturbances. Due to the temporary nature of the disturbance and the small amount of benthic substrate that will be affected compared to its overall availability in the action area, NMFS believes that adverse effects to listed salmonids and green sturgeon are likely to be discountable or negligible. Therefore, NMFS does not anticipate that listed salmonids and green sturgeon are likely to be adversely affected by the degradation of habitat resulting from the limited dredging area.

Existing riprap along a 20 linear foot area (180 cubic yards) on the water side of the south levee of the San Joaquin River at Jersey Island would be temporarily displaced during construction to allow placement of the discharge pipeline. None of the displaced riprap would be located below the ordinary high water mark (OHWM). Currently, most of the levee surfaces along the north shore of Jersey Island are heavily riprapped with little overhanging or shade-providing vegetation. It is not anticipated that any trees will need to be removed to facilitate placement of the discharge pipeline and diffuser; however, the applicant has stated that they will replace trees at a 3 to 1 ratio in the event that any trees are removed during the pipeline installation. Due to the temporary nature of the disturbance, the low habitat value for listed fishes, and the small amount of levee face that will be affected compared to its overall availability, NMFS believes that any effects to listed salmonids and green sturgeon related to this disturbance will be discountable or negligible and will not reach the level of take. Therefore, NMFS does not anticipate that listed salmonids and green sturgeon are likely to be adversely affected by habitat disturbance from dredging or construction activities on the levee.

c. *Construction Spills*

The applicant has indicated that heavy construction equipment will be used to construct and place the outfall pipeline and diffuser. As part of the construction plan, an existing 24-inch-diameter pipeline on the south end of Jersey Island would be extended northwards along Jersey Island Road and would merge into a new 30-inch-diameter outfall. The new pipeline would be installed in open trenches using traditional cut and cover techniques at depths up to 6 feet and widths averaging 6 feet. The types of equipment needed to install this pipeline have the potential to leak lubricating oils, gasoline or diesel fuels, hydraulic fluids, or other related organic compounds into the San Joaquin channel or onto adjacent upland soils. The applicant has indicated that construction BMPs and a spill prevention plan (SPP) will be developed and implemented to control any spills or construction related discharges (see *Section II.C. Conservation Measures* above for more detail) to the river or upland areas. In addition to the BMPs and SPP, a trained fisheries biologist will have oversight of the construction activities to assure compliance with the BMPs and SPP and to immediately report and institute any of the necessary response plans should a spill occur. Based on these preventative measures, NMFS believes that any effects to listed salmonids and green sturgeon related to the potential spills entering the river channel will be discountable or negligible and will not result in take of listed species. Therefore, NMFS does not anticipate that listed salmonids and green sturgeon are likely to be adversely affected from spills occurring within the action area resulting from construction activities.

2. Long-term Operational Effects

a. *Habitat Alterations*

The installation of subsurface structures in the channel of the San Joaquin has the potential to create holding habitat for predatory fish (*i.e*., striped bass, largemouth bass, other centrarchids, catfish (*Ictalurus* spp.), Sacramento pike minnow, *etc*.) by creating alterations in the bathymetry and underwater topography of the receiving water body. These changes in the bottom profile may create holding habitat or velocity refugia for piscine predators. However, the design criteria for the diffuser pipeline indicates that following the installation of the buried diffuser pipeline, bottom topography and bathymetry will be returned to the original pre-construction conditions. Also, the amount of structure created above the bottom surface will be minimized. The diffuser will have small gooseneck valves (Tideflex®) that will extend above grade along the bottom. The discharge ports would be the only portion of the diffuser array exposed within the water column. The specifications for the diffuser indicate that the valves will be placed every 10 feet along the diffuser pipeline for a total of 16 Tideflex® valves on the diffuser outfall. NMFS believes that these small structures will not create sufficient holding habitat to encourage predators to congregate in the area in numbers greater than that which already occurs naturally. Therefore, NMFS does not expect predator density within the action area to increase due to the construction of the diffuser outfalls.

b. *Effluent Discharge*

The greatest potential effects of the project are expected to result from the ISD WWTP effluent discharge to the lower San Joaquin River. In particular, the discharge is expected to contain low levels of certain pollutants and increase the water temperature in the lower San Joaquin River in the immediate vicinity of the outfall, which could contribute to chronic, sub-lethal effects on listed fish if they are exposed to the effluent plume for a sufficient duration. The discharge will occur year-round and, therefore, all migrating salmonids that occur in the lower San Joaquin River near the ISD WWTP outfall may be exposed to the adverse effects of project operations. Salmonids are expected to primarily occur in the Delta from November 1 through June 30. Emigrating juveniles may rear and migrate in the Delta for up to 3 months, and are more likely to be adversely affected than adults which tend to migrate quickly to their spawning grounds upstream. Central Valley steelhead from the San Joaquin River drainage, and North American green sturgeon which may occur year-round in the Sacramento-San Joaquin Delta, are those fish groups that are most likely to be exposed to the outfall discharge. However, as previously mentioned, Sacramento River winter-run and Central Valley spring-run Chinook salmon can also occur within the action area during their migrations through the Delta. Although several thousand fish may move through the San Joaquin River adjacent to the outfall each year, the overall numbers of listed fish that will be adversely affected by the ISD WWTP effluent discharge are expected to be low due to the advanced level of treatment at the new ISD facility, the design of the outfall, the diffuser's distance offshore, the depth of the diffuser, and the large amount of dilution that will occur as the effluent mixes with receiving water, in both the near-field and far-field portions of the action area.

Dilution of the effluent discharged to the San Joaquin River off Jersey Island is expected to vary due to the influences of tides (i.e., the tidal range is approximately 3 feet) and seasonal outflow, which may have competing or complimentary effects. The influences of these factors on the flow characteristics of the San Joaquin River are explained in detail in the project's supporting environmental documents (the Antidegradation Analysis (Robertson-Bryan 2008) and in the Supplemental EIR (Jones and Stokes 2006)). The BA addendum (Vinnedge Environmental Consulting and RBI 2008) states that for an 8.6 mgd discharge, the maximum concentration of effluent under acute and chronic worst-case conditions is 5.4% and 3.7%, respectively. These effluent percentages correspond to a maximum worst-case dilution of 18.6:1 for acute criteria and 45.5:1 for chronic criteria and are calculated at a distance of 150 feet from the diffuser. Because the dilution characteristics of the unconstructed diffuser array are not verified and fish may occur very close to the outfall, the following analysis screens for potential chemical constituents of concern by assuming that listed fish may be exposed to undiluted effluent as a simple worst case scenario. Such a scenario could occur during the slack tide conditions that occur during each turn of the tide when water velocity sweeping past the diffuser site falls to zero as the tidal flow balances the river flow. For the assessment of individual chemical constituent effects, this assessment considers available dilution based on diffuser design, San Joaquin River flow, and background concentrations.

The applicant used influent to its current wastewater treatment facility to generate the chemical profile of its discharge for the future facility. Of the 183 chemical constituents looked at in the analysis, 36 were detected for which water quality criteria are listed (see Table 11 Appendix A). The applicant assessed average treatment removal performance for four constituents (aluminum, copper, lead, and zinc) based on measurements collected at eleven tertiary treatment facilities in California that are similar to the proposed ISD WWTP treatment train (Ironhouse Sanitary District 2007). The applicant also provided supplemental information to NMFS that presented the projected maximum concentrations of cadmium and silver in ISD WWTP effluent based on measured data from five similar tertiary facilities (Bryan, pers. comm., 2008). In addition, ammonia was indicated to meet aquatic life criteria based on the design performance of the upgraded treatment system of the new facility, with concentrations not expected to exceed 0.5 mg/l (Robertson-Bryan 2008). Of these 37 chemical constituents (including ammonia), USEPA-recommended statistical criteria (i.e., within 2 standard deviations of the maximum reported value) was used to determine that 8 constituents (aluminum, ammonia, cadmium, chloride, copper, cyanide, lead, and zinc) have the potential in undiluted effluent to exceed aquatic life water quality criteria promulgated in either the CTR or the U.S. Environmental Protection Agency (USEPA) National Recommended Water Quality Criteria. A subset of these 8 (aluminum and copper) also were identified by the applicant as having the reasonable potential in undiluted effluent to exceed water quality standards. For ammonia, NMFS based its analysis on the NPDES permit adopted on April 25, 2008 which indicated that the permitted limits for the average monthly and daily discharges of ammonia from the ISD WWTP would be 1.1 and 2.1 mg/l, respectively. In addition, the applicant assessed the potential adverse effects of discharging pharmaceuticals and personal care products (PPCPs- which have no adopted water quality criteria) to the receiving waters of the San Joaquin River, the expected increases in water temperature, and the decreases in DO within the receiving waters affected by the ISD WWTP discharges. Therefore, the following assessment includes discussion of the potential adverse effects of all nine chemical constituents identified above on listed fish. Additionally, the potential adverse effects of PPCPs, the expected increases in water temperature, and decreases in DO are assessed and discussed.

NMFS expects that most of the effects associated with the effluent discharge from the ISD WWTP outfall will be classified as "sublethal" or "nonlethal." Sublethal or nonlethal endpoints do not require that mortality be absent; rather it indicates that death is not the primary toxic endpoint being examined. Rand *et al.* (1995) states that the most common sublethal endpoints in aquatic organisms are behavioral (e.g., swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (e.g., growth, reproduction, and development), biochemical (e.g., blood enzyme and ion levels), and histological changes. Some sublethal effects may indirectly result in mortality. Changes in certain behaviors, such as swimming or olfactory responses (i.e., taste and smell), may diminish the ability of the salmonids to find food or escape from predators and may ultimately result in their death. Some sublethal effects may have little or no long-term consequences to the fish because they are rapidly reversible or diminish and cease with time. Individual fish of the same species may exhibit different responses to the same concentration of toxicant. The individual condition of the fish can significantly influence the outcome of the toxicant exposure. Fish with greater energy stores will be better able to survive a temporary decline in foraging ability, or have sufficient metabolic stores to swim to areas with better environmental conditions. Fish that are already stressed are more susceptible to the deleterious effects of contaminants, and may succumb to toxicant levels that are considered sublethal to a healthy fish. In addition, contaminated food resources can create additional metabolic stressors in the exposed fish. Calories that would normally be used for basic metabolic needs (*i.e.*, growth, locomotion, basal metabolism, *etc*.) would need to be redirected to detoxifying the ingested contaminants through biotransformation of the toxic compounds and "packaging" it for excretion. Additional energy would then be required to repair any cellular or genetic damage created by the contaminant prior to its excretion. If the damage is of sufficient magnitude, the organism may be unable to repair it and could eventually die or be compromised in its normal physiologic capacities.

(1) Aluminum. For aquatic organisms, aluminum bioavailability and toxicity are intimately related to ambient pH; such that changes in ambient acidity may affect aluminum solubility, dissolved aluminum speciation, and organism sensitivity to aluminum. At moderate acidity (pH 5.5 to 7.0), fish, and invertebrates may be stressed due to aluminum adsorption onto gill surfaces and subsequent asphyxiation. At a pH of 4.5 to 5.5, aluminum can impair ion regulation and augment the toxicity of hydrogen ions (H^+). At lower pHs, elevated aluminum can temporarily ameliorate the toxic effects of acidity by competing for binding sites with H^+. Aluminum toxicity can cause erosion of the gill epithelium and death in fish (Cronan and Schofield 1979). Impairment of fish growth has been attributed to aluminum concentrations as low as 100 µg/l (Cronan and Schofield 1979).

The 1-hour maximum exposure limit for freshwater aquatic organisms (criteria maximum concentration - CMC), according to the USEPA National Recommended Water Quality Criteria, is 750 µg/l (USEPA 2008). According to the USEPA, the 4-day maximum continuous concentration (criteria continuous concentration - CCC) for aluminum is 87 µg/l. Neither the Central Valley Basin Plan nor the CTR have adopted criteria for aluminum; therefore, publicly owned treated works facilities (POTWs) are regulated based on EPA recommended criteria. The maximum aluminum concentration in the outfall effluent is 155 µg/l according to data supplied by the applicant. NMFS believes that aluminum concentrations present in the ISD WWTP effluent could potentially contribute to impaired gill function and reduced growth of listed salmonids and green sturgeon that are exposed to undiluted effluent for an extended period. This ultimately may reduce the efficiency of oxygen uptake, increase the vulnerability of affected individuals to predators, and reduce the likelihood of survival. However, NMFS anticipates that the effects attributable to the proposed action will be chronic and sub-lethal in nature. Furthermore, the criteria are developed for waters that are more acidic and have less dissolved minerals present (*i.e.*, soft water). Therefore, the adverse effects of the different aluminum chemical species present in the effluent discharge may be attenuated by the more basic and harder waters of the Delta, which reduce toxicity. Additionally, it is highly unlikely that fish will be exposed to undiluted effluent within the river due to the ambient river and tidal flows present in the San Joaquin and the design of the diffuser to quickly dissipate the discharge plume.

A recalculation of USEPA's recommended criteria for aluminum was developed by the Arid West Water Quality Research Project, funded by USEPA Region IX (Parametrix *et al.* 2006). The recalculation was based on an updated acute and chronic toxicity dataset collected since 1988 and newly derived aluminum toxicity–hardness relationships. Utilizing the Arid West Study relationships results in a CCC of 442 µg/l which incorporates the water hardness values present at the discharge site. It should also be noted that the background aluminum concentrations in the San Joaquin River average 285 µg/l (n = 4). As such, the discharge of treated effluent from the ISD facility will often reduce slightly, rather than increase, the river's total aluminum concentration at the discharge site.

The form of aluminum, and the chemistry of the water, dictates whether a given concentration of aluminum will be toxic to aquatic life. As stated in EPA's National Recommended Water Quality Criteria: 2002 document (EPA-822-R-02-047) footnote "L,": "*EPA is aware of field data indicating that many high quality waters in the U.S. contain more than 87* µg/l *aluminum/L, when either total recoverable or dissolved is measured*." This is the case in the San Joaquin River.

U.S. EPA further states that a water-effect ratio (WER) may be appropriate to adjust aluminum criteria for site-specific water quality conditions. A WER adjustment to criteria accounts for the site water chemistry conditions and the form of the aluminum present in the water column, which together dictates the relative biological availability or "bioavailability" of aluminum to aquatic life. Bioavailability refers to the degree to which a trace metal is available for uptake by movement into or onto an aquatic organism, such as a fish or macroinvertebrate.

Several dischargers in the Central Valley have preliminary WER results for aluminum that range from about 23 to >200. Application of these WERs to the U.S. EPA-recommended chronic aluminum criterion of 87 µg/l result in WER-adjusted chronic criteria of approximately 2,000 µg/l or greater (Cities of Manteca, Modesto, and Yuba City; unpublished data). These studies used *Ceriodaphnia dubia* as the test species, the species found by EPA to be the most sensitive to aluminum effects. The test results indicate that aluminum levels in treated wastewater are not toxic to *Ceriodaphnia dubia* because the aluminum is in a non-bioavailable form and thus cannot be taken up by the organism. Much of the river's total aluminum is in the form of silica associated with clay particles, which is not bioavailable.

Based on these findings, the discharge of treated effluent from the ISD facility is not expected to alter ambient river aluminum levels or alter the ratio of different aluminum species in a manner that would demonstrably have adverse affects on anadromous salmonids or green sturgeon within the action area.

(2) Ammonia. Salmonids are very sensitive to the level of un-ionized ammonia in the aqueous environment. Thurston and Russo (1983) found median acute toxicity levels of NH_3 in rainbow trout (*O. mykiss*) to range from 0.16 to 1.1 mg/liter in 96-hour exposures. The exposed fish ranged from 1-day old fry (<0.1 g) to 4-year old adults (2.6 kg). Sensitivity to NH_3 decreased as the fish developed from fry to juveniles, and then subsequently increased as fish matured. Sensitivity to ammonia as measured by the concentration lethal to 50 percent of the exposed population (LC_{50}) (Rand *et al.* 1995) did not appreciably change in concurrent exposures for 12- and 35-day test by the same authors. Thurston *et al.* (1984) measured chronic toxicity of rainbow trout to several low dose concentrations of ammonia (0.01-0.07 mg/l un-ionized ammonia) over a 5-year period, exposing three successive generations of trout to the toxicant. The trout exhibited dose dependent changes in the level of ammonia in their blood, and fish exposed to ammonia concentrations of 0.04 mg/l or higher of un-ionized ammonia exhibited pathological lesions in their gills and kidneys. There were no gross signs of toxicity at any of the test dose exposures, even though the histological examinations indicated abundant sublethal pathologies.

Lesions within the gill tissues create adverse conditions for oxygen exchange in exposed fish. Common types of pathologies observed in chronically exposed trout were “clumping” of gill filaments, separation of epithelial cells from their underlying basement membranes, and micro-aneurisms (Thurston *et al.* 1984). The resulting abnormalities in the gill tissues can be expected to reduce the efficiency of oxygen transfer across the gill epithelial cells, which may reduce the energy available for feeding, migration, and reproduction. In addition, the injured tissues are more susceptible to pathogens and increase the likelihood of morbidity in exposed fish.

Lesions in the renal (kidney) tissues of the exposed fish can be expected to impair blood flow and filtration, and eventually induce renal failure. In an anadromous fish, such as Chinook salmon or steelhead, a properly functioning renal system is imperative for osmotic regulation in its freshwater life stages. The renal system produces the dilute urine necessary to maintain the proper level of hydration.

Current USEPA National Recommended Water Quality Criteria for ammonia are temperature and pH based (USEPA 2008). The adopted NPDES permit for the proposed project allows average monthly and daily discharge concentrations of ammonia to be 1.1 and 2.1 mg/l, respectively. NMFS believes that extended exposure to ammonia concentrations present in ISD WWTP effluent at the “end-of-the-pipe” would contribute to adverse effects such as reduced renal function, which is important for osmoregulation; impaired gill function; and reduced growth of listed salmonids and green sturgeon. This ultimately may impair the ability of smolts in their transition to the saltwater environment, reduce the efficiency of oxygen uptake, increase the vulnerability of affected individuals to predators, and reduce the likelihood of survival.

However, NMFS anticipates that such adverse effects are not likely to occur to significant numbers of listed fish in the action area. NMFS finds that the movements of fish into and out of the immediate zone of dilution surrounding the outfall pipeline diffuser should limit the extent of the exposure to the ammonia levels present at the end of the pipe. Based on the rate of movements observed in radio tagged Chinook salmon in the Delta, fish move at approximately 0.5 to 1.0 mile per hour (Vogel 2004, 2008) during their downstream emigration. However, the fine scale spatial movements of fish are unknown, and fish may loiter in any given area before volitionally moving out of that area or forced out by some other factor, such as the presence of predators. Ammonia concentrations are anticipated to quickly fall to levels that pose little threat to listed fish outside of the initial zone of dilution. Furthermore, ISD's planned WWTP will fully nitrify and dentrify the effluent, thus producing effluent low in nitrogen compounds. The design for the treatment train for the ISD WWTP predicts that ammonia levels will be below 0.5 mg/l following full tertiary treatment of the waste stream. Ambient river ammonia levels are below criteria and large dilution effect will occur in both the near-filed and far-field areas around the outfall. Consequently, with the planned discharge, ammonia levels within the action area are expected to change little in both the near-field and far-field areas of the action area. Based on the expected ammonia levels in the tertiary treatment train effluent and the ambient ammonia levels in the river, NMFS does not anticipate that anadromous salmonids or green sturgeon in the action area will be exposed to permanently deleterious levels of ammonia.

(3) Cadmium. Salmonids are more acutely sensitive to cadmium than any other freshwater species with species mean acute values (SMAV) of 2.108 µg/l for rainbow trout and 4.30 µg/l for Chinook salmon at a total hardness of 50 mg/l (as $CaCO_3$) (USEPA 2001). The recommended USEPA cadmium CMC was derived from the value for rainbow trout (2.108 µg/l). Both acute and chronic toxicity are generally recognized to decrease with increasing hardness (USEPA 2001). The species mean chronic values (SMCV) used in the development of USEPA's cadmium CCC include 1.31 µg/l for rainbow trout and 2.6 µg/l for Chinook salmon (Brown *et al*. 1994; Chapman 1975; Eaton *et al.* 1978; Benoit *et al*. 1976). The cadmium chronic toxicity–hardness relationship was determined, in part, with data for brown trout (Eaton *et al*. 1978; Brown *et al.* 1994). The final dissolved chronic value (FCV) for cadmium of 0.15 µg/l is lower than all the reported genus mean chronic values (GMCV) and all the reported salmonid SMCVs. Reported chronic effects in salmonids include increased gill diffusion (Hughes *et al.* 1979); undefined physiological effects (Majewski and Giles 1984), and reduced growth (Woodworth and Pascoe 1982).

Recently updated USEPA National Recommended Water Quality Criteria (USEPA 2008) state a CMC of 0.9 µg/l and a CCC of 0.14 µg/l for cadmium. These new national criteria are lower than the current CTR criteria for cadmium. The applicant's supplemental data from similar Central Valley wastewater treatment facilities indicates that the maximum effluent concentration of total cadmium was 0.081 µg/l. NMFS believes that cadmium concentrations present in the ISD WWTP effluent could contribute to adverse chronic and sub-lethal effects of impaired gill diffusion and reduced growth for the listed salmonids and green sturgeon should prolonged exposures occur to the end-of-the-pipe concentrations. However, based on the expected dilution effects attributable to the proposed diffuser design, the concentration of water borne cadmium outside of the zone of initial dilution is not expected to result in adverse effects in fish exposed to the outfall plume. Furthermore, adverse effects (*i.e.*, sublethal) should be reduced even more due to the inherent movement of fish into and out of the action area during their migrations, and the volitional movements of individual fish within the immediate vicinity of the dilution plume discharging from the diffuser array, thereby reducing the duration of their exposure. Finally, river cadmium levels (0.05 µg/l) are below the effects criteria, and the diffuser design provides for rapid mixing and dilution of effluent cadmium concentrations in the ambient river water column.

(4) Chloride. Rainbow trout are among the least sensitive species used to develop the recommended chloride criteria with LC_{50} of 3,336 mg/l and 6,743 mg/l (Kostechi and Jones 1983, Spehar 1987). Early life stages of rainbow trout were more sensitive with 54 percent survival at 1,324 mg/l and 97 percent survival or greater at chloride concentrations of 643 mg/l or less (Spehar 1987). The mean difference in body weight for survivors exposed at 1,324 mg/l versus 643 mg/l (or less) was 5 percent. The SMAV used for the current USEPA criteria was 6,743 mg/l for rainbow trout (USEPA 1988). Cladocerans, snails, clams, and aquatic insects were all more sensitive to chloride than rainbow trout. The species mean chronic value used in the development of USEPA criteria was 922 mg/l for rainbow trout and the acute-to-chronic ratio was 7.3 (USEPA 1988). Chlorinity is closely related to salinity, and thus can adversely affect osmotic potential in anadromous fish as life stages pass between freshwater and seawater (Rand *et al.* 1995).

Current USEPA National Recommended Water Quality Criteria promulgate a CCC of 230 mg/l and CMC of 860 mg/l for chloride. The applicant's discharge data indicates that the maximum effluent concentration of chloride was 160 mg/l. Chloride concentrations in the San Joaquin River at Jersey Point are influenced by seawater intrusion, hydrodynamic forces, and water conveyance and diversion operations in the Delta (*i.e*., Delta outflows, pumping withdrawals, agricultural return flows). Average chloride concentrations at Jersey Point, based on intensive historical monitoring data by DWR during the years of 1980-1995, are less than 150 mg/l during the months of March through June. Chloride concentrations increase in the summer and fall months when Delta outflows are reduced (e.g., maximum average monthly chloride of 500 mg/l in December). NMFS believes that chloride concentrations present in the ISD WWTP effluent will contribute minimally to adverse effects influencing osmotic regulation in exposed fish. In addition, during periods of time when no assimilation capacity for salinity exists in the vicinity of the proposed outfall, ISD would not discharge effluent to comply with water quality restrictions.

The effects attributable to the proposed action primarily are expected to be chronic and sub-lethal because the movement of fish should limit their exposure to concentrated effluent from the project outfall. Furthermore, river chloride levels are typically below the CCC during most of the year and are expected to always be less than the CMC. The diffuser design provides for rapid mixing and dilution of effluent chloride concentrations in the ambient river water.

(5) Copper. Pacific salmonids (*Oncorhynchus* spp.) are very susceptible to copper toxicity, having the lowest LC_{50} threshold of any group of freshwater fish species tested by the EPA in their Biotic Ligand Model (BLM; EPA 2003) with a Genus Mean Acute Value (GMAV) of 29.11 µg/l of copper. In comparison, fathead minnows (*Pimephales promelas*), the standard EPA test fish for aquatic toxicity tests, have a GMAV of 72.07 µg/l of copper. Hansen *et al.* (2002) exposed rainbow trout to sub-chronic levels of copper in water with nominal water hardness of 100 mg/l (as $CaCO_3$). Growth, whole body copper concentrations, and mortality were measured over an 8-week trial period. Significant mortality occurred in fish exposed to 54.1 µg/l Cu (47.8 percent mortality) and 35.7 µg/l Cu (11.7 percent mortality). Growth and body burden of copper were also dose dependent with a 50 percent depression of growth occurring at 54.0 µg/l, but with significant depressions in growth still occurring at copper doses as low as 14.5 µg/l after the 8 week exposure.

In a separate series of studies, Hansen *et al.* (1999a, b) examined the effects of low dose copper exposure to the electrophysiological and histological responses of rainbow trout and Chinook salmon olfactory bulbs, and the two fish species behavioral avoidance response to low dose copper. Chinook salmon were shown to be more sensitive to dissolved copper than rainbow trout and avoided copper levels as low as 0.7 µg/l copper (water hardness of 25 mg/l), while the rainbow trout avoided copper at 1.6 µg/l. Diminished olfactory (*i.e.*, taste and smell) sensitivity reduces the ability of the exposed fish to detect predators and to respond to chemical cues from the environment, including the imprinting of smolts to their home waters, avoidance of chemical contaminants, and diminished foraging behavior (Hansen *et al.* 1999b). The olfactory bulb electroencephalogram (EEG) responses to the stimulant odor, L-serine (10^{-3} M), were completely eliminated in Chinook salmon exposed to ≥50 µg/l and in rainbow trout exposed to ≥200 µg/l within 1 hour of exposure. Following copper exposure, the EEG response recovery to the stimulus odor were slower in fish exposed to higher copper concentrations. Histological examination of Chinook salmon exposed to 25 µg/l copper for 1 and 4 hours indicated a substantial decrease in the number of receptors in the olfactory bulb due to cellular necrosis. Similar receptor declines were seen in rainbow trout at higher copper concentrations during the one hour exposure, and were nearly identical after four hours of exposure. A more recent olfactory experiment (Baldwin *et al.* 2003) examined the effects of low dose copper exposure on coho salmon (*O. kisutch*) and their neurophysiological response to natural odorants. The inhibitory effects of copper (1.0 to 20.0 µg/l) were dose dependent and were not influenced by water hardness. Declines in sensitivity were apparent within 10 minutes of the initiation of copper exposure and maximal inhibition was reached in 30 minutes. The experimental results from the multiple odorants tested indicated that multiple olfactory pathways are inhibited and that the thresholds of sublethal toxicity were only 2.3 to 3.0 µg/l above the dissolved copper background. The results of these experiments indicate that even when copper concentrations are below lethal levels, substantial adverse effects occur to salmonids exposed to these low levels. Reduction in olfactory response is expected to increase the likelihood of morbidity and mortality in exposed fish by impairing their homing ability and consequently migration success, as well as by impairing their ability to detect food and predators (Also see the technical white paper on copper toxicology issued by NMFS (Hecht *et al.* 2007)).

In addition to these physiological responses to copper in the water, Sloman *et al.* (2002) found that the adverse effect of copper exposure was also linked to the social interactions of salmonids. Subordinate rainbow trout in experimental systems had elevated accumulations of copper in both their gill and liver tissues, and the level of adverse physiological effects were related to their social rank in the hierarchy of the tank. The increased stress levels of subordinate fish, as indicated by stress hormone levels, is presumed to lead to increased copper uptake across the gills due to elevated ion transport rates in chloride cells. Furthermore, excretion rates of copper may also be inhibited, thus increasing the body burden of copper. Sloman *et al.* (2002) concluded that not all individuals within a given population will be affected equally by the presence of waterborne copper, and that the interaction between dominant and subordinate fish will determine, in part, the physiological response to the copper exposure.

Current USEPA National Recommended Water Quality Criteria and the CTR standards promulgate a CMC of 5.9 μg/l and a CCC of 4.3 μg/l for copper. The applicant's preliminary data indicates that the ISD influent to the current plant has an average copper concentration of 31 μg/l. The draft supplemental EIR for the ISD WWTP expansion project (Jones and Stokes 2006) estimates that the concentration of copper in the effluent after treatment with the membrane reactor (MBR) technology will be 11.8μg/l. Subsequent analysis of the MBR removal efficiency for copper suggests that this earlier estimate was too high. The information contained in the addendum to the biological assessment reduces this estimated concentration for copper in the effluent to 2.1 μg/l based on a removal efficiency of 91.3 percent by the MBR treatment technology.

NMFS believes that copper concentrations present in the ISD WWTP effluent will contribute to adverse effects such as habitat avoidance and reduced olfactory function of listed salmonids and green sturgeon should these fishes be exposed to copper concentrations 2–3μg/l above river background. This ultimately may increase the vulnerability of affected individuals to predators, reduce feeding efficiency, and reduce the likelihood of successful migration. However, any effects attributable to the proposed action primarily are expected to be chronic and sub-lethal because the movement of fish and rapid diffuser dilution should limit exposure to concentrated effluent from the project outfall. Estimations of the effluent concentrations may at times exceed the measured copper concentrations in the San Joaquin River. Table 7-2 in the Draft Supplemental Environmental Impact Report (EIR) for the ISD WWTP expansion states that ambient copper concentrations in the San Joaquin River at Jersey Point have a minimum of 1.22 μg/l and a maximum observed concentration of 2.94 μg/l, with an average of 1.82 μg/l (Jones and Stokes 2006). Maximum copper concentrations in the river (3.2 μg/l) according to the Antidegradation Analysis for the Ironhouse Sanitary District Waste Water Treatment Plant (Robertson-Bryan, Inc. 2008) can exceed expected effluent concentrations, and indicate the effluent may, at times, not cause increases in river copper concentrations. Based on the large dilution that ISD discharges will receive, and expected effluent copper concentrations, the project is not expected to increase copper concentrations in the farfield mixing zone to the extent that lethal or permanent damage will occur to exposed fish. NMFS is concerned that short term, temporary adverse affects may occur to salmonids or green sturgeon that are in close proximity to the outfall diffuser array, particularly during the “slack tide” periods when water flow is negligible past the diffuser array and dilution is minimized. As indicated above, loss of olfactory response can occur from as little as 10 minutes of exposure to copper concentrations as low as 2 μg/l above background copper concentrations. Such a situation appears to have a high potential of occurring based on the modeling results (see NMFS technical white paper on copper toxicity (Hecht *et al*. 2007)). The duration of the slack tide period (approximately 15 to 30 minutes) will provide sufficient exposure time for the adverse effects of copper exposure to manifest themselves. The other contaminants discussed in this biological opinion require longer exposure times for adverse effects to become evident at the concentrations anticipated in the effluent.

(6) Cyanide. Cyanide's toxicity primarily is due to the inhibition of the cellular respiration through the binding of cyanide with enzymes such as cytochrome oxidase. This prevents the transfer of electrons to oxygen in the mitochondria1 electron transport chain, and greatly diminishes the formation of high-energy compounds (*i.e*., ATP) for cellular metabolism. Therefore, the energy available for activities such as feeding, migration, and reproduction is reduced which may impair growth, likelihood of survival, and reproductive output. When comparing the lethal toxicity of cyanide among different fish species, the salmonids exhibited the greatest susceptibility to cyanide toxicity with LC_{50} values less than 100 µg/l for acute toxicity and chronic toxicities of less than 50 µg/l. The toxicity of cyanide is exacerbated in low DO conditions due to the inhibition of the electron transport chain and the reduction of metabolic energy production.

Current USEPA National Recommended Water Quality Criteria and the CTR standards promulgate a CMC of 22 µg/l and a CCC of 5.2 µg/l for cyanide. The applicant's discharge data indicates that the maximum effluent concentration of total cyanide was 2.3 µg/l. NMFS believes that cyanide concentrations present in the ISD WWTP effluent will contribute to adverse effects ranging from slowed reactions to stimuli (e.g., food or predators) to reduced reproductive output should sufficient exposure to undiluted effluent occur. The effects attributable to the proposed action primarily are expected to be chronic and sub-lethal because the movement of fish should limit their exposure to concentrated effluent from the project outfall. Furthermore, river cyanide levels are below criteria, and the diffuser design provides rapid mixing and dilution of effluent cyanide concentrations with ambient river water.

(7) Lead. Salmonids are among the most sensitive of aquatic species used in the promulgation of current USEPA National Recommended Water Criteria for lead. The SMAVs for rainbow trout and fathead minnow used for the current USEPA criteria were identical at 158 µg/l at a total hardness of 50 mg/l (as $CaCO_3$) (USEPA 1980). SMAVs for goldfish and bluegills were considerably higher, and brook trout, cladocerans, and amphipods were among the most sensitive organisms to lead concentrations. Acutely toxic levels of total lead for Pacific salmon are reported as 600 µg/l total lead for a 4-day LC_{50} (Chapman 1975). The species mean chronic value used in the development of USEPA criteria was 62 µg/l for rainbow trout (USEPA 1980). Chronic toxicity values for rainbow trout used in development of the USEPA criteria were 62 µg/l (Davies et al. 1976) and 102 µg/l (Sauter et al. 1976). Both acute and chronic toxicity are generally recognized to decrease with increasing hardness (USEPA 1980). Chronic effects observed in studies with rainbow trout included inhibition of delta – amino levulinic acid dehydratase (ALA-D) activity and blackened tails (Hodson et al. 1977), abnormal curvature of the spine (*i.e.*, lordosis, scoliosis or kyphosis) (Davies *et al*. 1976), and decreased blood iron content.

Current USEPA National Recommended Water Quality Criteria and the CTR standards promulgate a CMC of 25 µg/l and a CCC of 0.97 µg/l for lead. The applicant's discharge data indicates that the maximum effluent concentration of total lead was 0.86 µg/l. NMFS believes that lead concentrations present in the ISD WWTP effluent could contribute to adverse chronic effects ranging from reduced stamina to spinal deformities. However, such effects attributable to the proposed action are not expected because the movement of fish should limit their exposure to concentrated effluent from the project outfall. Furthermore, river lead levels (0.37 µg/l) are below criteria, and the diffuser design provides rapid mixing and dilution of effluent lead concentrations in the ambient river water column.

(8) Zinc. Salmonids are among the freshwater animal species most sensitive to zinc toxicity. Zinc SMAVs for salmonids used in developing the current USEPA National Recommended Aquatic Life Criteria include 446 µg/l for Chinook salmon; 689 µg/l for rainbow trout; and 1,628 µg/l for coho salmon at a total hardness of 50 mg/l (as $CaCO_3$) (USEPA 1987). As a group, only cladocerans were more sensitive than salmonids to zinc concentrations. Both acute and chronic toxicity are generally recognized to decrease with increasing hardness (USEPA 1987). The Arid West Water Quality Research Project (Parametrix *et al*. 2006) recalculated USEPA criteria by updating the national zinc acute and chronic toxicity databases, including the acute toxicity–hardness relationship. The Arid West Study included additional rainbow and brook trout toxicity data and new acute and chronic toxicity data for cutthroat and brown trout (Brinkmann and Hansen 2004; Davies and Brinkmann 1999; Davies *et al*. 2000). The recalculated CMC was less restrictive while the CCC was similar. The Arid West Study SMAVs for salmonids were similar at 449 µg/l for Chinook salmon and 582 µg/l for rainbow trout. Substantial data exist that document the chronic effects in rainbow trout at moderate-concentration exposures including avoidance behavior (Sprague 1968), damaged gills (Brown *et al*. 1968), hyperglycemia (Wagner and McKeown 1982), and damaged hepatocytes (Leland 1983).

Current USEPA National Recommended Water Quality Criteria and the CTR standards promulgate a CMC and CCC of 57µg/l for zinc. The applicant's discharge data indicates that the maximum effluent concentration of total zinc was 28 µg/l. NMFS believes that zinc concentrations present in the ISD WWTP effluent could potentially contribute to adverse effects to gills, liver cells, and glucose regulation in listed salmonids and green sturgeon should sufficient exposure to undiluted effluent occur. However, such effects attributable to the proposed action are not expected because the movement of fish should limit their exposure to concentrated effluent from the project outfall. Furthermore, river zinc levels (8.0 µg/l) are below criteria, and the diffuser design provides rapid mixing and dilution of effluent zinc concentrations with ambient river water.

(9) Pharmaceuticals and Personal Care Products (PPCPs). The byproduct of increased domestic use of PPCPs is the increased propensity for drugs and their metabolites to enter the environment, usually through treated and untreated sewage (Katzenellenbogen 1995; Sumpter and Jobling 1995; Hallig-Sørenson *et al.* 1998; Daughton and Ternes 1999; Rodgers-Gray *et al.* 2000; Daughton 2002, 2003a, 2003b, Pawlowski *et al.* 2003). Many classes of drugs have been identified as common trace environmental pollutants in surface and ground waters. Although the half-lives of most PPCPs are far shorter than those of other more well known pollutants, the continual environmental introduction of drugs by sewage effluent makes them "pseudopersistant" pollutants with physiological consequences for exposed aquatic organisms (Daughton and Ternes 1999). The U.S. Geological Survey (USGS) conducted a nationwide survey in 139 streams across 30 states during 1999 to 2000 and analyzed these water samples for organic wastewater contaminants (OWCs), which include some, but not all PPCPs. The USGS found that OWCs were prevalent in 80 percent of the streams sampled during this study. Although some of the compounds screened have numerical water quality criteria under State or Federal guidelines, many do not. The frequency of occurrence ranged from a median value of 7 compounds per a sample to as many as 38 OWCs in a given sample (Kolpin *et al.* 2002). Adverse effects of these compounds on fish include decreased growth, increased mortality, and impaired transition to the saltwater environment. In the case of compounds that mimic estrogens, feminization of males and potential alteration of population sex-ratios can occur

(Sumpter and Jobling 1995; Jobling *et al.* 1998). A high incidence of male Chinook salmon that have the appearance of females has been reported for fish from both the Sacramento and San Joaquin River drainages (Williamson and May 2002).

The levels of PPCPs in the ISD WWTP effluent and the surrounding ambient South Delta waters are unknown. Both adult and juvenile fish migrating through the waters of the Delta and the watersheds of the Sacramento and San Joaquin Rivers have been exposed to numerous WWTP outfalls during their movements upstream and downstream. Each of these outfalls is expected to have PPCPs associated with their effluent stream. Therefore, chronic exposure to some underlying level of PPCPs in the waterways is almost certain for these migrating fish. NMFS believes that PPCP concentrations present in the ISD WWTP effluent will contribute to the adverse effects created by PPCP exposure, such as reduced growth, impaired transition to the saltwater environment, and reduced reproductive output of listed salmonids and green sturgeon. This ultimately may increase the vulnerability of affected individuals to predators, and reduce the likelihood of survival and reproduction. However, the effects attributable to the proposed action individually are difficult to quantify, given the history of exposure to similar PPCPs from other outfalls in the system.

(10) Water Temperature and Dissolved Oxygen. The applicant has modeled the water temperatures of the effluent discharge using the DSM2 and CALSIM modeling programs. The modeled data indicates that worst-case daily water temperature differentials of approximately 20 ºF can occur during the winter months (November through April) between the ambient river water and the end of the pipe discharge. Increases in water temperature are primarily a concern for listed salmonids. The median differentials between the undiluted effluent and ambient receiving water for the period between November and January were approximately 14.8 ºF while the differentials for February through April were approximately 10.8 ºF. However, the temperature differentials would be decreased to 1.4 ºF or less, even under worst-case conditions, under the 20:1 dilution that would occur within 40 feet of the diffuser. Furthermore, the end of the pipe discharge temperatures are not anticipated to reach incipient lethal temperature levels for salmonids; in contrast, the creation of a warm water zone around the diffuser unit may create an attractive refuge during periods of colder ambient water conditions in the winter months. These conditions would then serve to congregate fish within the mixing zone, where they would be subject to higher contaminant loads than expected by the modeling. The attraction of the fish to the temperature zone around the diffuser array has been shown to occur at other outfalls, and likely increases both the amount of time fish are exposed and the concentration of the effluent to which they are exposed. Otherwise, the expected increases in water temperature are not likely to adversely affect listed salmonids or North American green sturgeon.

Reductions in DO levels are primarily a concern for listed salmonids when they will be present in the late fall, winter, and spring. Elevated biological oxygen demand (BOD) and ammonia from the ISD discharge may impart a small and localized oxygen demand within the near-field mixing zone. Based on near-field and far-field dilution, any effect of ISD discharge on river DO levels is expected to be small. Moreover, dissolved oxygen levels in the lower San Joaquin River are typically above 7.0 mg/l, which are adequate for survival and passage of listed salmonids and green sturgeon. Based on the large assimilative capacity of the lower San Joaquin River and the small volume of the discharge, reductions to ambient winter DO levels in the lower

San Joaquin River will be small and not likely to adversely affect listed salmonids or North American green sturgeon.

3. Summary of Project Effects

a. *Effects to Listed Species*

The construction phase of the proposed ISD WWTP expansion project will temporarily impact the waters of the western Delta. Of the listed species NMFS has jurisdiction over in the western Delta, only the Southern DPS of green sturgeon (juveniles and sub-adults) are expected to be present in the action area during the construction phase. The listed salmonids (*i.e.*, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead) will have completed their migration through the delta as smolts prior to the onset of construction activities in August. The schedule for the installation of the pipeline outfall and diffuser array indicates that in-water work should be done prior to the initiation of adult upstream spawning migrations by these listed salmonids in late fall. Few listed salmonids start their upstream spawning migrations prior to the end of October. The one group of listed salmonids that may have adults venturing into the Delta this early is the central Valley steelhead DPS. Adults entering into the Sacramento River side of the western Delta are known to enter the system in late summer prior to moving upriver (see Appendix A, Table 5- steelhead life history). Therefore, it is not impossible for adult steelhead to be in the lower San Joaquin River at this time too.

The incorporation of the conservation measures discussed in *Section II. C.* of this document will greatly reduce or eliminate any potential adverse impacts to the listed fish species associated with the construction techniques and actions proposed, particularly salmonids. NMFS does not anticipate the short term effects of the construction actions will adversely affect listed salmonids in the action area. Listed green sturgeon may be present in the action area during construction activities, but the conservation measures should be protective of these fish during the dredging actions and pipeline installation work.

NMFS does expect that the long term operation of the outfall and its discharge of tertiary treated wastewater will have some measure of negative impacts to the species. As discussed in *Section V.B.2* of this document, the effects of the wastewater discharge is unlikely to ever result in acutely toxic conditions in the river. Therefore project effects resulting in dead fish within close proximity of the diffuser are highly unlikely to be observed. Rather, the effects will be more subtle, as is typical of sublethal effects. Given the uncertainty of fish behavior and fine scale movements, it is impossible to completely predict the level of exposure to fish occupying the different zones of dilution (*i.e.,* nearfield and farfield dilution zones). Fish may move into and out of these zones in an apparently random fashion with different levels and durations of exposure based on their own volitional behavior, tides, river flows, and other environmental variables present. Nevertheless, NMFS uses the precautionary approach in its evaluation, and believes that some level of adverse effects will occur due to exposure to the ISD WWTP outfall. Most of these effects, such as behavioral alterations or biochemical changes will be short lived and will rectify themselves once the fish enters "cleaner" water. However, some proportion of the exposed fish will be more sensitive and may succumb to the toxicity of the outfall's chemical constituents directly, or more likely, fall prey to local predators who take advantage of the fish's altered physiological or behavioral condition.

b. *Effects to Critical Habitat*

The installation of the pipeline and diffuser array will temporarily disturb approximately 23,200 square feet (580 feet by 40 feet) of channel bottom in the San Joaquin River. This section of the San Joaquin is designated as critical habitat for the Central Valley steelhead DPS. NMFS expects the disturbance of the benthic substrate to be short lived. The ISD WWTP expansion project requires that the disturbance of the channel bottom resulting from the dredging and pipeline installation be remediated upon completion of the project. The applicant has stated that the pipeline trench will be filled in and re-contoured back to the original conditions, removing all mounds, trenches, or other "breaks" in the bottom topography created by the pipeline installation. As stated above, NMFS expects the disturbed area of river bottom to become colonized by benthic invertebrates within a short time, but the composition of the benthic invertebrate community may be different than surrounding areas until a stable climax community has developed. NMFS is unable to determine this time period due to a lack of appropriate data in these river areas.

The long term operations of the diffuser may eventually lead to changes in the sediment contaminant profile for heavy metals. As dissolved metals are discharged to the overlying water column from the diffuser, a fraction will combine with chemical or organic constituents in the water and form precipitates. These precipitates, whether comprised of inorganic or organic compounds, are expected to fall out of solution and settle to the bottom. Tides and river currents may carry these precipitates considerable distances from the site of the outfall. However, NMFS expects to see a gradient extending outwards from the diffuser location in both an upstream and downstream direction. The concentration of metals in the sediment is expected to be highest near the pipeline and decrease with distance from the pipeline. Based on the concentrations of metals in the effluent discharge water, the elevation in sediment metals may take decades to rise to levels that create adverse effects in the benthic invertebrate fauna and the fish that feed upon them.

VI. 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.

1. 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. 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 2003a).

2. 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 (California Commercial, Industrial, and Residential Real Estate Services Directory 2002). 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, Oakley, Lathrop, Tracy and Manteca and their surrounding communities anticipate rapid growth for several decades to come. City of Manteca (2007) anticipates 21 percent annual growth through 2010 reaching a population of approximately 70,000 people. City of Lathrop (2007) expects to double its population by 2012, from 14,600 to approximately 30,000 residents. The anticipated growth will occur along both the I-5 and US-99 transit corridors in the east, Highway 205/120 in the south, and the Highway 4 corridor in Contra Costa County. 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 or "avoid" listed species of animals or plants, will not require Federal permits, and thus will not undergo review through the 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. Increased commercial shipping has already been the subject of a section 7 consultation.

3. 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 over take 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 ^{o}C and 7 ^{o}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 Central Valley steelhead) that must hold below the dam over the summer and fall periods.

VII. INTEGRATION AND SYNTHESIS

This section integrates the current conditions described in the environmental baseline with the effects of the proposed action and the cumulative effects of future actions. The purpose of this synthesis is to develop an understanding of the likely short-term and long-term responses of listed species and critical habitat to the proposed project.

The San Joaquin River basin historically contained numerous independent populations of Central Valley steelhead and spring-run Chinook salmon (Lindley *et al*. 2006a, 2007). Potentially, Southern DPS green sturgeon were also present in these watersheds prior to anthropogenic changes. The suitability of these watersheds to support these runs of fish changed with the onset of human activities in the region. Human intervention in the region initially captured mountain runoff in foothill reservoirs which supplied water to farms and urban areas. As demand grew, these reservoirs were enlarged or additional dams were constructed higher in the watershed to capture a larger fraction of the annual runoff. San Joaquin Valley agriculture created ever greater demands on the water captured by these reservoirs, diminishing the flow of water remaining in the region's rivers, and negatively impacting regional populations of salmonids (and likely green sturgeon, too). Reclamation actions eliminated vast stretches of riparian habitat and seasonal floodplains from the San Joaquin River watershed and Delta through the construction of levees and the armoring of banks with rock riprap for flood control. Construction of extensive water conveyance systems and water diversions altered the flow characteristics of the Delta region. These anthropogenic actions resulted in substantial degradation of the functional characteristics of the aquatic habitat in the watershed upon which the region's salmonids (and potentially green sturgeon) depended to maintain healthy populations. Likewise, portions of the Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon populations that originate in the watersheds of the Sacramento River make use of the lower San Joaquin River as a migratory corridor and rearing habitat. These fish enter through one of the interconnecting waterways between the Sacramento River and the San Joaquin River and follow the San Joaquin River westwards towards Suisun Bay. The degradation of these San Joaquin River habitats affects their survival and viability too.

Presently, Central Valley spring-run Chinook salmon have been functionally extirpated from the San Joaquin River basin. Populations of Central Valley steelhead in the San Joaquin River basin have been substantially diminished to only a few remnant populations in the lower reaches of the Stanislaus, Tuolumne, and Merced Rivers below the first foothill dams. Southern DPS green sturgeon have not been documented utilizing the San Joaquin River as a spawning river in recorded history but human alterations, which have been ongoing for over 100 years in the watershed, may have extirpated these populations before accurate records were maintained. However, fish survey records indicate that juvenile and sub-adult green sturgeon make use of the lower San Joaquin River for rearing purposes during the first several years of their life. Since the viability of small remnant populations of Central Valley steelhead in the San Joaquin River basin is especially tenuous and such populations are susceptible to temporally rapid decreases in abundance and possess a greater risk of extinction relative to larger populations (Pimm *et al.* 1988, Berger 1990, Primack 2004), activities that reduce quality and quantity of habitats, or that preclude formation of independent population units (representation and redundancy rule cited by Lindley *et al*. 2007), are expected to reduce the viability of the overall ESU if individual populations within the larger metapopulation become extinct (McElhany *et al.* 2000). Therefore, if activities have significant impacts on steelhead populations or destroy necessary habitat, including designated critical habitat, within these San Joaquin populations, they could have significant implications for the DPS as a whole.

A. Summary of Effects of the Environmental Baseline

The evidence presented in the Environmental Baseline section indicates that past and present activities within the San Joaquin River basin and waters of the Delta have caused significant habitat loss and fragmentation. This has significantly reduced the quality and quantity of the remaining freshwater rearing sites and the migratory corridors within the action area for the Central Valley steelhead populations of the San Joaquin River basin (primarily) and for the Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon populations as well as Southern DPS green sturgeon that utilize this area.

Regulation of dam discharges has reduced the extent of natural variability in the extent of saline water intrusion and flows in the action area and the rest of the western Delta on both a seasonal and yearly basis. Alterations in the geometry of the Delta channels, removal of riparian vegetation and shallow water habitat, construction of armored levees for flood protection, changes in river flow created by demands of water diverters (including pre-1914 riparian water right holders, CVP and SWP contractors, and municipal entities), and the influx of contaminants from agricultural and urban dischargers have substantially reduced the functionality of the action area's waterways.

The Stockton DWSC upstream of the project location currently experiences episodes of low DO in the channel's water column from Channel Point westwards to Turner and Columbia Cuts. These DO depressions can occur throughout the year, but are more likely in the late summer and early fall periods when temperatures are high and natural flow in the river is typically at its lowest. As cited by Hallock (1970), the low DO levels are believed to act as barriers to salmonids migrating upstream into the San Joaquin River Basin in fall and have at other times of the year created "fish kills" in the DWSC due to the low ambient DO levels. Previous actions in the delta region have included the ongoing installation of a fall barrier at the Head of Old River to redirect the majority of the San Joaquin River downstream past the Port of Stockton, rather than splitting the flow and having some of it enter into the South Delta. In addition, the fall release of additional water from San Joaquin River tributaries (the pulse flow) is intended to attract fish into the system and to reduce the adverse water quality conditions found in the DWSC adjacent to the Port of Stockton. To further alleviate the poor DO conditions in the DWSC, an aerator has been operated at Channel Point for several years, first by the U.S. Army Corps of Engineers, and more recently by the Port of Stockton, in an attempt to mitigate for the additional dredging required to deepen the DWSC to minus 37 feet. A new aerator is currently being tested at Dock 20 of the West Complex to further mitigate the effects of the DO sag.

B. Summary of Effects Resulting from the Proposed Action

The current action, the operation of the ISD WWTP outfall pipeline and diffuser in the San Joaquin River near Jersey Point, is intended to allow the applicant, ISD, to expand the capacity of its current waste water treatment plant from 2.7 mgd to 4.3 mgd and eventually 8.6 mgd at full capacity build out.

With regards to Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon ESUs, and Central Valley steelhead DPS (from both the San Joaquin River and Sacramento River watersheds), the project poses a minimal threat to these populations. As previously described, the construction actions of this project will have negligible effects upon listed salmonids. The August 1 through October 15 in-water work window will avoid the majority of the adult and juvenile salmonid migrations through the Western Delta. Only adult steelhead entering the Sacramento River watershed typically enter the system during this time frame, and they are expected to primarily stay within the Sacramento River channel to the north of the action area. A small fraction of this run may enter the Sacramento watershed through the western Delta and San Joaquin River channel before entering one of interconnecting waterways to the Sacramento River (Threemile Slough, Georgiana Slough, and Mokelumne River via the DCC) and making their way upriver.

Green sturgeon are likely to be present in the Western Delta, as this is an area believed to be utilized for rearing by juveniles and sub-adults on a year-round basis prior to migrating to the ocean. Numerous conservation measures have been integrated into the proposed project and will be implemented by the applicant during the dredging and pipeline installation phases of the project. These safety measures are designed primarily to protect salmonids, but are expected to protect green sturgeon in the action area as well. It is unlikely that any salmonids will be entrained by the dredging actions due to the timing of the activity but it is possible that some green sturgeon may be entrained during this work. Based on the monitoring studies employed during other Delta area dredging actions, NMFS believes that the numbers of green sturgeon entrained by the dredge will be extremely low and possibly none. However, encounters between the cutterhead of the dredge and green sturgeon cannot be completely ruled out.

With regard to Central Valley steelhead critical habitat, the effects of the proposed ISD WWTP expansion project are expected to have minimal adverse effects upon the functionality or conservation values of the freshwater rearing and migratory corridors designated in the San Joaquin Delta HSA. Impacts to the designated critical habitat within the action area that are related to the construction actions are temporary, lasting only as long as the dredging and pipeline installation and the time needed for benthic invertebrates to colonize the disturbed channel bottom. The construction actions are not expected to impede or prevent migratory potential in the channel of the San Joaquin River due to numerous factors, including: timing of work, width of the channel at the action area (approximately 85 percent of channel will be unaffected), and numerous protective measures employed to minimize impacts to the river during construction (*i.e.*, construction BMPs). Temporary loss of foraging habitat is minimal, given the small footprint of the pipeline alignment compared to the available habitat and the eventual re-establishment of benthic invertebrates in the disturbed alignment area.

As described in previous sections, long term impacts to designated critical habitat occur due to the discharge of potential contaminants to the river in the effluent stream. NMFS believes that acute toxicity, resulting in mortality to fish or blockage of the migratory corridor to the ocean, is unlikely to occur. Rather, the anticipated impact is exposure to sublethal levels of contaminants that have the potential to lower physiological status or impair normal behavioral responses to environmental stimuli. These responses may enhance predation or reduce migrational ability, but are expected to be generally temporary in their effects. Once fish move out of the areas with elevated levels of contaminants, normal behaviors and physiological capacities are expected to return in a short amount of time. Loss of forage base due to sediment contaminant loads is not likely to occur. Based on sediment analysis done for other dredge sites in the general area, the sediments in the lower San Joaquin River have a high content of mineral sands. This type of substrate does not sequester heavy metals or organic contaminants readily. NMFS anticipates that sediment contamination related to the outfall would take decades to reach levels of concern, if at all, and that episodic floods and extreme flows are likely to redistribute the sandy channel substrate over wide areas, thereby preventing contaminant buildup around the outfall.

C. Combined Effects

The conditions associated with the environmental baseline (*i.e.*, the effects of past and ongoing activities) are expected to be minimally affected by the proposed project. The construction of the outfall pipeline and diffuser will have negligible effects upon listed salmonids species due to their absence from the action area during the construction window. Impacts to green sturgeon are expected to be higher than those experienced by listed salmonids due to their year round presence in the action area, however the risk of entrainment or injury due to pile driving and laying of the pipeline is considered low due to the conservation measures to be employed during the construction phase.

However, the long term operation of the outfall will add constituents to the Delta that can cause deleterious effects to aquatic organisms and their habitats, although these constituents will be added at low levels. The Delta has previously been listed as a degraded water body under the 303(d) listing process for water quality and recently has seen declines in key pelagic species (referred to as the pelagic organism decline or POD). The continual use of the Delta as a vehicle to dilute wastewater treatment effluent will ultimately add to the already degraded status of the Delta and will increase the potential for adverse effects to listed fish and critical habitat. Although the new ISD WWTP will use technology designed to meet or exceed current regulations (*i.e.*, Title 22 requirements for unrestricted reuse of the treated water), it does not completely remove all constituents of concern. Therefore, it will ultimately add to the cumulative burden of natural and anthropogenic compounds affecting water quality in the Delta, although at a slower rate than previous regional dischargers. NMFS recognizes the advanced treatment technology implemented by the Ironhouse SanitaryDistrict and the significant reduction in constituents of concern in its effluent stream compared to its influent and commends them for their efforts. Nonetheless, NMFS at the same time recognizes the potential for future reductions in any discharge to natural water bodies and the opportunity for constructive reuse of the wastewater in other venues rather than discharging to the San Joaquin River.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the Southern DPS of North American green sturgeon, the environmental baseline, the effects of the proposed Ironhouse Wastewater Treatment Plant

Expansion Project, and the cumulative effects, it is NMFS' biological opinion that the Expansion Project, as proposed, is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead or the Southern DPS of North American green sturgeon, nor will it result in the destruction or adverse modification of designated critical habitat for Central Valley steelhead in the San Joaquin Delta.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the Corps so that they become binding conditions of any grant or permit, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require ISD to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps and/or ISD must report the progress of the action and its impact on the species to NMFS as specified in the incidental take statement (50 CFR §402.14(i)(3)).

A. Amount or Extent of Take

NMFS anticipates that the proposed action will result in the incidental take of individuals from the Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon ESUs, the Central Valley steelhead DPS, and the Southern DPS of North American green sturgeon. Incidental take associated with this action is expected to be in the form of mortality, harm, or harassment of juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead and juveniles and sub-adults from the Southern DPS of North American green sturgeon, resulting from the effluent discharged from the ISD diffuser array exposing fish to contaminants within the San Joaquin River channel. Incidental take of juvenile Sacramento River winter-run Chinook salmon, juvenile Central Valley spring-run Chinook salmon, and juvenile Central Valley steelhead is expected to occur during the period from approximately November 1 to June 30, when individuals from these

Chinook salmon ESUs and the steelhead DPS could potentially be present in the action area. Similarly, adult Central Valley steelhead are expected to be present during the September through October time period when fall spawning migrations are possible. Juveniles and sub-adults from the Southern DPS of North American green sturgeon are expected to be present in the action area year round and their presence would overlap with any discharge from the ISD WWTP outfall into the San Joaquin River. There is also a low potential for juvenile and/or sub-adult green sturgeon to be entrained by the hydraulic dredge during it s operation. However, the quantification of this potential is functionally impossible due to a lack of empirical data concerning the density of green sturgeon in the action area and the actual behavioral response of green sturgeon to the dredger equipment *in situ*.

NMFS cannot, using the best available information, accurately quantify the anticipated incidental take of individual listed fish because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the ISD WWTP expansion project area. However, it is possible to designate ecological surrogates for the extent of take anticipated to be caused by the Expansion Project, and to monitor those surrogates to determine the level of take that is occurring. The three most appropriate ecological surrogates for the extent of take caused by the Expansion Project are: (1) the period of time that the in-water construction actions will occur, (2) the area of the channel bottom disturbed by the in-water footprint of the outfall pipe and diffuser, and (3) the operational constraints of the ISD WWTP as described in the project description of the Biological Assessment (Vinnedge Environmental Consulting 2007) and the Addendum to the Biological Assessment (Vinnedge Environmental Consulting and Robertson-Bryan, Inc. 2008).

Ecological Surrogates

- The analysis of the effects of the proposed ISD WWTP Expansion Project anticipates that the installation of the outfall pipeline and diffuser array will take place during the in-water work window between August 1 and October 15, during daylight hours on the weekdays. No in-water construction activities will take place at night or on weekends, thus allowing for a period of unimpaired passage for listed fish. In-water work beyond October 15 will be considered as take, unless extensions to this construction work window have been expressly authorized by NMFS.

- The analysis of the effects of the proposed ISD WWTP Expansion Project anticipates that the footprint of the in-water work will be as follows. The outfall pipe and diffuser array will total 550 feet in length from the toe of the levee to its farthest extent offshore. An additional 30 feet is allowed for the slope of the dredging trench at the terminus of the pipeline, giving a total length of the project equal to 580 feet. The width of the dredging action to create the trench for the pipeline will be nominally 40 feet wide to allow for the slope of the cut and a depth of 96 inches (30-inch diameter pipe plus 60-inches of soil coverage plus 6 inches of base below the pipeline). The total disturbed area along the channel bottom of the San Joaquin River is anticipated to be approximately 23,200 square feet. If the project footprint, as defined by the dimensions described above, is surpassed, then NMFS authorized take will have been exceeded for the project.

- The analyses of the effects of the proposed action were based on information supplied by the applicant to describe the ISD WWTP expansion project. NMFS based its analysis on a maximum volume of treated wastewater discharged per day of 8.6 mgd, the effluent concentrations reported by the applicant (listed in Appendix A: Table 11), and the conservation measures described in the project description of the Addendum to the Biological Assessment (Vinnedge Environmental Consulting and Robertson-Bryan, Inc. 2008). If discharge volumes surpass 8.6 mgd, then incidental take will have been exceeded. If effluent concentrations reported in Table 11 are surpassed, then incidental take for the effluent will have been exceeded. If the conservation measures described in the project description are not implemented, then incidental take will have been exceeded.

If these ecological surrogates are not maintained within the parameters described above, the proposed ISD WWTP Expansion Project will be considered to have exceeded anticipated take levels, triggering the need to reinitiate consultation on the ISD WWTP Expansion Project.

B. Effect of the Take

In the accompanying biological opinion, NMFS determined that this level of anticipated take is not likely to result in jeopardy to the species or the destruction or adverse modification of critical habitat.

C. Reasonable and Prudent Measures

NMFS believes that the following reasonable and prudent measures are necessary and appropriate to minimize take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon resulting from implementation of the action. These reasonable and prudent measures also would minimize adverse effects on designated critical habitat:

1. Measures shall be taken to verify the assumptions made in the modeling of the dissipation zone for the outfall with data taken in the field.

2. Measures shall be taken to avoid, minimize, and monitor the impacts of the effluent discharge from the ISD WWTP outfall upon listed salmonids, green sturgeon, and their habitats.

D. Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the action must be implemented in compliance with the WDRs issued by the Regional Board and the following terms and conditions, which implement the reasonable and prudent measures described above for each category of activity. These terms and conditions are non-discretionary.

1. Measures shall be taken to verify the assumptions made in the modeling of the dissipation zone for the outfall with data taken in the field.

a. Within the first 2 years following the initiation of discharge of wastewater effluent from the diffuser array, the applicant will develop, in coordination with NMFS staff, a study protocol to examine the *in situ* dilution characteristics of the proposed outfall and diffuser. The goal of the study is to verify the results of the modeling efforts previously completed with field data and to more thoroughly define the near field dilution patterns in the San Joaquin River channel under different ambient flows and tidal conditions immediately surrounding the location of the outfall pipeline.

b. Within 1 year of finalizing the study plan in 1(a), the applicant will measure the dilution characteristics of the discharge *in situ* with respect to changes in river flow and tides according to the study plan. A final report will be submitted to NMFS within 6 months of completion of the studies.

c. All experimental protocols and reports will be sent to NMFS for review and comment at the following address:

Attn: Supervisor
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento, California 95814-4706

Office: (916) 930-3601
Fax: (916) 930-3629

2. Measures shall be taken to avoid, minimize, and monitor the impacts of the effluent discharge from the ISD WWTP outfall upon listed salmonids and their habitat.

a. For the first 5 years of operation of the ISD WWTP outfall, water quality measurements for contaminants of concerns will be made in accordance with the Central Valley Regional Water Quality Board's discharge permit.

b. All data and reports generated by the applicant to reach compliance with the Regional Board's permit will be sent to NMFS at the address in 1(c) as soon as possible after they are produced.

c. Should concentrations of contaminants of concern exceed the effluent limitations set forth in the Regional Board's discharge permit or in the applicant's estimates of effluent concentrations in Table 11 of this opinion, NMFS will be notified within 24 hours at the phone numbers in 1(c).

d. The applicant shall maintain and exercise their ability to divert river discharges to the currently existing, permanent emergency storage basins located on the ISD WWTP site, during a facility upset or malfunction to avoid or minimize discharges to the waters of the lower San Joaquin River during periods of noncompliance with the waste discharge permit. This will avoid or minimize the likelihood of noncompliant effluent being discharged to the waters of the lower San Joaquin River and adversely affecting listed fish species during periods when the effluent is not in compliance with permit requirements. Appropriate use of the emergency storage basins to avoid non-compliant discharges to the San Joaquin River during periods of facility upset or malfunction, shall be described in monthly monitoring reports submitted to the Regional Board and NMFS.

e. The applicant shall develop a reconnaissance level monitoring plan for PPCPs in the wastewater discharge stream and the lower San Joaquin River for data gathering purposes only, which should include at the least, levels of steroidal estrogens such as 17 β-estradiol (E_2), estrone (E_1) and 17 α-ethinylestradiol (EE_2) and estrogen–like compounds such as nonylphenol. This plan shall be delivered to NMFS for review and approval within the first 6 months following commencement of operation of the ISD WWTP outfall project at the address in section 1(c) above. Following approval by NMFS, data collected for PPCPs shall be included with the chemical constituents report described in 2(a, b). This monitoring shall continue for a minimum of three years following its initiation.

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(l) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat or regarding the development of pertinent information.

1. The Corps should support and promote aquatic and riparian habitat restoration within the Delta region, and encourage its contractors to modify operation and maintenance procedures through the Corps' authorities so that those actions avoid or minimize negative impacts to listed species.

2. The Corps should support anadromous salmonid and green sturgeon monitoring programs throughout the Delta and Suisun Bay to improve the understanding of migration and habitat utilization by these species in this region.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

XI. REINITIATION OF CONSULTATION

This concludes formal consultation on the actions outlined in the request for consultation received from the Corps for the ISD WWTP outfall. As provided for in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (I) the amount or extent of taking specified in any incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion, or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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Appendix A: Tables

Table 7: The annual occurrence of juvenile Southern DPS of North American green sturgeon at the CVP and SWP fish collection facilities in the South Delta. (Adams et al, (2007), CDFG 2002)

Year	State Facilities		Federal Facilities	
	Salvage Numbers	Numbers per 1000 acre feet	Salvage Numbers	Numbers per 1000 acre feet
1968	12	0.0162		
1969	0	0		
1970	13	0.0254		
1971	168	0.2281		
1972	122	0.0798		
1973	140	0.1112		
1974	7313	3.9805		
1975	2885	1.2033		
1976	240	0.1787		
1977	14	0.0168		
1978	768	0.3482		
1979	423	0.1665		
1980	47	0.0217		
1981	411	0.1825	274	0.1278
1982	523	0.2005	570	0.2553
1983	1	0.0008	1475	0.653
1984	94	0.043	750	0.2881
1985	3	0.0011	1374	0.4917
1985	0	0	49	0.0189
1987	37	0.0168	91	0.0328
1988	50	0.0188	0	0
1989	0	0	0	0
1990	124	0.0514	0	0
1991	45	0.0265	0	0
1992	50	0.0332	114	0.0963
1993	27	0.0084	12	0.0045
1994	5	0.003	12	0.0068
1995	101	0.0478	60	0.0211
1996	40	0.0123	36	0.0139
1997	19	0.0075	60	0.0239
1998	136	0.0806	24	0.0115
1999	36	0.0133	24	0.0095
2000	30	0.008	0	0
2001	54	0.0233	24	0.0106
2002	12	0.0042	0	0
2003	18	0.0052	0	0
2004	0	0	0	0
2005	16	0.0044	12	0.0045
2006	39	0.0078	324	0.1235

Table 8: Monthly Occurrences of Dissolved Oxygen Depressions below the 5mg/L Criteria in the Stockton Deepwater Ship Channel (Rough and Ready Island DO monitoring site) Water Years 2000 to 2004

			Water Year			
Month	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**Monthly Sum**
September	0	26**	30**	16**	30**	102
October	0	0	7	0	4	11
November	0	0	12	0	3	15
December	6	4*	13	2	13	38
January	3	4	19	7	0	33
February	0	25	28	13	0	66
March	0	7	9	0	0	16
April	0	4	4	0	0	8
May	2*	0	2	4	0	8
Yearly Sum	11	70	124	42	50	**Total=297**

* = Suspect Data – potentially faulty DO meter readings

** = Wind driven and photosynthetic daily variations in DO level; very low night-time DO levels, high late afternoon levels

Table 9. Salmon and Steelhead monitoring programs in the Sacramento - San Joaquin River basins, and Suisun Marsh.

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***Chinook Salmon, Steelhead***	Sacramento River	Scale and otolith collection	Coleman National Hatchery, Sacramento River and tributaries	Scale and otolith microstructure analysis	Year-round	CDFG
		Sacramento River and San Joaquin River	Central Valley angler survey	Sacramento and San Joaquin rivers and tributaries downstream to Carquinez	In-river harvest	8 or 9 times per month, year round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at Balls Ferry and Deschutes Road Bridge	Juvenile emigration timing and abundance	Year round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at RBDD	Juvenile emigration timing and abundance	Year round	FWS
		Sacramento River	Ladder counts	Upper Sacramento River at RBDD	Escapement estimates, population size	Variable, May - Jul	FWS
		Sacramento River	Beach seining	Sacramento River, Caldwell Park to Delta	Spatial and temporal distribution	Bi-weekly or monthly, year-round	FWS
		Sacramento River	Beach seining, snorkel survey, habitat mapping	Upper Sacramento River from Battle Creek to Caldwell Park	Evaluate rearing habitat	Random, year-round	CDFG
		Sacramento River	Rotary screw trap	Lower Sacramento River at Knight's Landing	Juvenile emigration and post-spawner adult steelhead migration	Year-round	CDFG
		Sacramento-San Joaquin basin	Kodiak/Midwater trawling	Sacramento river at Sacramento, Chipps Island, San Joaquin River at Mossdale	Juvenile outmigration	Variable, year-round	FWS
		Sacramento-San Joaquin Delta	Kodiak trawling	Various locations in the Delta	Presence and movement of juvenile salmonids	Daily, Apr - Jun	IEP
		Sacramento-San Joaquin Delta	Kodiak trawling	Jersey Point	Mark and recapture studies on juvenile salmonids	Daily, Apr - Jun	Hanson Environmental Consultants

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	*Chinook Salmon, Steelhead, Continued*	Sacramento-San Joaquin Delta	Salvage sampling	CVP and SWP south delta pumps	Estimate salvage and loss of juvenile salmonids	Daily	USBR/CDFG
		Battle Creek	Rotary screw trap	Above and below Coleman Hatchery barrier	Juvenile emigration	Daily, year-round	FWS
		Battle Creek	Weir trap, carcass counts, snorkel/ kayak survey	Battle Creek	Escapement, migration patterns, demographics	Variable, year-round	FWS
		Clear Creek	Rotary screw trap	Lower Clear Creek	Juvenile emigration	Daily, mid Dec- Jun	FWS
		Feather River	Rotary screw trap, Beach seining, Snorkel survey	Feather River	Juvenile emigration and rearing, population estimates	Daily, Dec - Jun	DWR
		Yuba River	Rotary screw trap	lower Yuba River	Life history evaluation, juvenile abundance, timing of emergence and migration, health index	Daily, Oct - Jun	CDFG
		Feather River	Ladder at hatchery	Feather River Hatchery	Survival and spawning success of hatchery fish (spring-run Chinook salmon), determine wild vs. hatchery adults (steelhead)	Variable, Apr - Jun	DWR, CDFG
		Mokelumne River	Habitat typing	Lower Mokelumne River between Comanche Dam and Cosumnes River confluence	Habitat use evaluation as part of limiting factors analysis	Various, when river conditions allow	EBMUD
		Mokelumne River	Redd surveys	Lower Mokelumne River between Comanche Dam and Hwy 26 bridge	Escapement estimate	Twice monthly, Oct 1- Jan 1	EBMUD
		Mokelumne River	Rotary screw trap, mark/recapture	Mokelumne River, below Woodbridge Dam	Juvenile emigration and survival	Daily, Dec- Jul	EBMUD

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	*Chinook Salmon, Steelhead, Continued*	Mokelumne River	Angler survey	Lower Mokelumne River below Comanche Dam to Lake Lodi	In-river harvest rates	Various, year-round	EBMUD
		Mokelumne River	Beach seining, electrofishing	Lower Mokelumne	Distribution and habitat use	Various locations at various times throughout the year	EBMUD
		Mokelumne River	Video monitoring	Woodbridge Dam	Adult migration timing, population estimates	Daily, Aug - Mar	EBMUD
		Calaveras River	Adult weir, snorkel survey, electrofishing	Lower Calaveras River	Population estimate, migration timing, emigration timing	Variable, year-round	Fishery Foundation
		Stanislaus River	Rotary screw trap	lower Stanislaus River at Oakdale and Caswell State Park	Juvenile outmigration	Daily, Jan - Jun, dependent on flow	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel surveys, hook and line survey, beach seining, electrofishing	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence and distribution, habitat use, and abundance	Variable, Mar- Jul	CDFG
Central Valley	***CV Steelhead***	Sacramento River	Angler Survey	RBDD to Redding	In-river harvest	Random Days, Jul 15 - Mar 15	CDFG
		Battle Creek	Hatchery counts	Coleman National Fish Hatchery	Returns to hatchery	Daily, Jul 1 - Mar 31	FWS
		Clear Creek	Snorkel survey, redd counts	Clear Creek	Juvenile and spawning adult habitat use	Variable, dependent on river conditions	FWS
		Mill Creek, Antelope Creek, Beegum Creek	Spawning survey - snorkel and foot	Upper Mill, Antelope, and Beegum Creeks	Spawning habitat availability and use	Random days when conditions allow, Feb - Apr	CDFG
		Mill Creek, Deer Creek, Antelope Creek	Physical habitat survey	Upper Mill, Deer, and Antelope Creeks	Physical habitat conditions	Variable	USFS

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***CV Steelhead Continued***	Dry Creek	Rotary screw trap	Miner and Secret Ravine's confluence	Downstream movement of emigrating juveniles and post-spawner adults	Daily, Nov- Apr	CDFG
		Dry Creek	Habitat survey, snorkel survey, PIT tagging study	Dry Creek, Miner and Secret Ravine's	Habitat availability and use	Variable	CDFG
		Battle Creek	Otolith analysis	Coleman Hatchery	Determine anadromy or freshwater residency of fish returning to hatchery	Variable, dependent on return timing	FWS
		Feather River	Hatchery coded wire tagging	Feather River Hatchery	Return rate, straying rate, and survival	Daily, Jul - Apr	DWR
		Feather River	Snorkel survey	Feather River	Escapement estimates	Monthly, Mar to Aug (upper river), once annually (entire river)	DWR
		Yuba River	Adult trap	lower Yuba River	Life history, run composition, origin, age determination	Year-round	Jones and Stokes
		American River	Rotary screw trap	Lower American River, Watt Ave. Bridge	Juvenile emigration	Daily, Oct- Jun	CDFG
		American River	Beach seine, snorkel survey, electrofishing	American River, Nimbus Dam to Paradise Beach	Emergence timing, juvenile habitat use, population estimates	Variable	CDFG
		American River	Redd surveys	American River, Nimbus Dam to Paradise Beach	Escapement estimates	Once, Feb - Mar	CDFG, BOR
		Mokelumne River	Electrofishing, gastric lavage	Lower Mokelumne River	Diet analysis as part of limiting factor analysis	Variable	EBMUD
		Mokelumne River	Electrofishing, hatchery returns	Lower Mokelumne River, Mokelumne River hatchery	O. Mykiss genetic analysis to compare hatchery returning steelhead to residents	Variable	EBMUD

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***CV Steelhead Continued***	Calaveras River	Rotary screw trap, pit tagging, beach seining, electrofishing	lower Calaveras River	Population estimate, migration patterns, life history	Variable, year-round	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel survey, hook and line survey, beach seining, electrofishing, fish traps/weirs	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence, origin, distribution, habitat use, migration timing, and abundance	Variable, Jun - Apr	CDFG
		Merced River	Rotary screw trap	Lower Merced River	Juvenile outmigration	Variable, Jan-Jun	Natural Resource Scientists, Inc.
		Central Valley-wide	Carcass survey, hook and line survey, electrofishing, traps, nets	Upper Sacramento, Yuba, Mokelumne, Calaveras, Tuolumne, Feather, Cosumnes and Stanislaus Rivers, and Mill, Deer, Battle, and Clear Creeks	Occurrence and distribution of *O. Mykiss*	Variable, year-round	CDFG
		Central Valley - wide	Scale and otolith sampling	Coleman NFH, Feather, Nimbus, Mokelumne River hatcheries	Stock identification, juvenile residence time, adult age structure, hatchery contribution	Variable upon availability	CDFG
		Central Valley - wide	Hatchery marking	All Central Valley Hatcheries	Hatchery contribution	Variable	FWS, CDFG
	SR Winter-run Chinook salmon	Sacramento River	Aerial redd counts	Keswick Dam to Princeton	Number and proportion of reds above and below RBDD	Weekly, May 1-July 15	CDFG
		Sacramento River	Carcass survey	Keswick Dam to RBDD	In-river spawning escapement	Weekly, Apr 15-Aug 15	FWS, CDFG
		Battle Creek	Hatchery marking	Coleman National Fish Hatchery	Hatchery contribution	Variable	FWS, CDFG
		Sacramento River	Ladder counts	RBDD	Run-size above RBDD	Daily, Mar 30- Jun 30	FWS

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***SR Winter-run Chinook salmon***	Pacific Ocean	Ocean Harvest	California ports south of Point Arena	Ocean landings	May 1- Sept 30 (commercial), Feb 15 - Nov 15 (sport)	CDFG
	CV Spring-run Chinook salmon	Mill, Deer, Antelope, Cottonwood, Butte, Big Chico Creeks	Rotary screw trap, snorkel survey, electrofishing, beach seining	upper Mill, Deer, Antelope, Cottonwood, Butte, and Big Chico creeks	Life history assessment, presence, adult escapement estimates	Variable, year-round	CDFG
		Feather River	Fyke trapping, angling, radio tagging	Feather River	Adult migration and holding behavior	Variable, Apr-June	DWR
		Yuba River	Fish trap	lower Yuba River, Daguerre Point Dam	Timing and duration of migration, population estimate	Daily, Jan - Dec	CDFG
Suisun Marsh	***Chinook salmon***	Suisun Marsh	Otter trawling, beach seining	Suisun Marsh	Relative population estimates and habitat use	Monthly, year-round	UCDavis
		Suisun Marsh	Gill netting	Suisun Marsh Salinity Control Gates	Fish passage	Variable, Jun - Dec	CDFG

Table 10: Salvage rates at the CVP and SWP Fish Collection Facilities for listed Salmonids. (Data from CVO web site)

Sacramento River Winter-run Chinook Salmon

Water Year	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Sum
2006-2007	0	0	87	514	1678	2730	330	0	0	NA	NA	NA	5339
2005-2006	0	0	649	362	1016	1558	249	27	208	NA	NA	NA	4069
2004-2005	0	0	228	3097	1188	644	123	0	0	NA	NA	NA	5280
2003-2004	0	0	84	640	2812	4865	39	30	0	NA	NA	NA	8470
2002-2003	0	0	1261	1641	1464	2789	241	24	8	NA	NA	NA	7401
2001-2002	0	0	1326	478	222	1167	301	0	0	NA	NA	NA	3494
2000-2001	0	0	384	1302	6014	15379	259	0	0	NA	NA	NA	23338
1999-2000	0	0	NA	NA0	NA	1592	250	0	0	NA	NA	NA	1842
Sum	0	0	4019	8007	14394	30724	1792	81	216	0	0	0	59233
Avg	0	0	574	1144	2056	3841	224	10	27	0	0	0	7876
% WR/Total	0	0	9.5	22.5	12.5	29.5	0.4	0.0	0.1	0.0	0.0	0.0	
% WR	0	0	7.290	14.523	26.109	48.763	2.844	0.129	0.343	0.000	0.000	0.000	

Central Valley Spring-run Chinook Salmon

Water Year	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Sum
2006-2007	0	0	0	0	7	190	4700	3656	0	NA	NA	NA	5262
2005-2006	0	0	0	0	104	1034	8315	3521	668	NA	NA	NA	13642
2004-2005	0	0	0	0	0	1856	10007	1761	639	NA	NA	NA	14263
2003-2004	0	0	0	25	50	4646	5901	960	0	NA	NA	NA	11582
2002-2003	0	0	0	46	57	11400	27977	2577	0	NA	NA	NA	42057
2001-2002	0	0	0	21	8	1245	10832	2465	19	NA	NA	NA	14590
2000-2001	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
1999-2000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Sum	0	0	0	92	226	20371	67732	11649	1326	0	0	0	101396
Avg	0	0	0	15	38	3395	11289	1942	221	0	0	0	16899
SR/Total	0.0	0.0	0.0	0.3	0.2	26.1	21.1	2.4	0.8	0.0	0.0	0.0	
% SR	0.00	0.000	0.000	0.091	0.223	20.091	66.799	11.489	1.308	0.000	0.000	0.000	

Central Valley Steelhead
(Clipped and Unclipped)

Water Year	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Sum
2006-2007	0	0	10	81	1643	4784	2689	113	20	NA	NA	NA	9340
2005-2006	0	0	0	129	867	3942	337	324	619	NA	NA	NA	6218
2004-2005	0	20	70	120	1212	777	687	159	116	NA	NA	NA	3161
2003-2004	0	12	40	613	10598	4671	207	110	0	NA	NA	NA	16521
2002-2003	0	0	413	13627	3818	2357	823	203	61	NA	NA	NA	21302
2001-2002	0	0	3	1169	1559	2400	583	37	42	NA	NA	NA	5793
2000-2001		0	89	543	5332	5925	720	69	12	NA	NA	NA	12690
1999-2000	3	60	NA	NA	NA	1243	426	87	48	NA	NA	NA	1867
Sum	3	92	625	16282	25029	26099	6472	1102	918	0	0	0	76622
Avg	0	12	89	2326	3576	3262	809	138	115	0	0	0	10327
% SH	0.0	0.1	0.9	22.5	34.6	31.6	7.8	1.3	1.1	0.0	0.0	0.0	

Total Chinook salmon entrained by month at the CVP and SWP Facilities (average)

Facility	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept
CVP	2031	1227	1152	1918	13571	8842	35192	49892	18299	719	42	121
SWP	1628	1531	4891	3165	2883	4182	18435	30009	11037	474	95	76
Sum	3659	2758	6044	5083	16454	13024	53627	79901	29336	1193	137	197

Table 11: Chemical Constituents of the ISD WWTP Effluent

Constituent	Maximum Effluent Concentration[1]	Units	CCC 4 Day Concentration[2]	CMC 1 Hour Concentration[3]
1,2,3,4,6,7,8-HpCDD	0.408	µg/l		
1,2,3,4,6,7,8-HpCDF	0.228	µg/l		
1,4-Dichlorobenzene	3.1	µg/l		
Aluminum (Total)	155	µg/l	87	750
Ammonia	0.5	mg/l	1.13	2.14
Antimony (Total)	0.2	µg/l		
Arsenic (Total)	2.2	µg/l	150	340
Bis (2-Ethylhexyl)phthalate	2.1	µg/l		
Cadmium (Total)	0.08	µg/l	0.14	0.9
Chloride	160	mg/l	230	860
Chloroform	1.1	µg/l		
Chromium (Total)	2.5	µg/l	11	16
Copper (Total)	2.1	µg/l	4.3	5.9
Cyanide	2.3	µg/l	5.2	22
Diethyl phthalate	14	µg/l		
Dioxins TEQ	0.049	µg/l		
EC	1505	µmhos/cm		440 (4)
Fluoride	1000	µg/l		
Hardness (as $CaCO_3$)	180	mg/l		
Iron (Total EFF; diss RW)	137	µg/l	1000	
Lead (Total)	0.86	µg/l	0.97	25
Manganese (dissolved)	21.4	µg/l		
MBAS	1.93	mg/l		
Mercury (Total)	0.005	µg/l	0.77	1.7
Nickel (Total)	4.1	µg/l	25	220
OCDD	0.0385	µg/l		
OCDF	0.0068	µg/l		
Phenol	13	µg/l		
Selenium (Total)	1	µg/l	2	
Silver	0.32	µg/l		0.72
Sulfate	71	mg/l		
Sulfide	1.2	mg/l		
Sulfite	1	mg/l		
Thallium (Total)	0.1	µg/l		
Toluene	2.2	µg/l		
Zinc	28	µg/l	57	57

(1) Constituents are projected maximum concentrations for the future wastewater outfall effluent based on current chemical constituent concentrations in the influent to the existing facility and known, or best professional judgement analysis of, constituent removal performance of similar treatment facilities. The current ISD WWTP does not utilize the same treatment train as the proposed facility.
(2) Criteria Continuous Concentration (averaged over 4 days)
(3) Criteria Maximum Concentration (1-hour average)
(4) Basin Plan objective for striped bass

Appendix B: Figures

Figure 1: Location of the proposed Ironhouse SanitaryDistrict Wastewater Treatment Plant Outfall.

Figure 2: Plan and Profile of diffuser outfall pipeline for the ISD WWTP

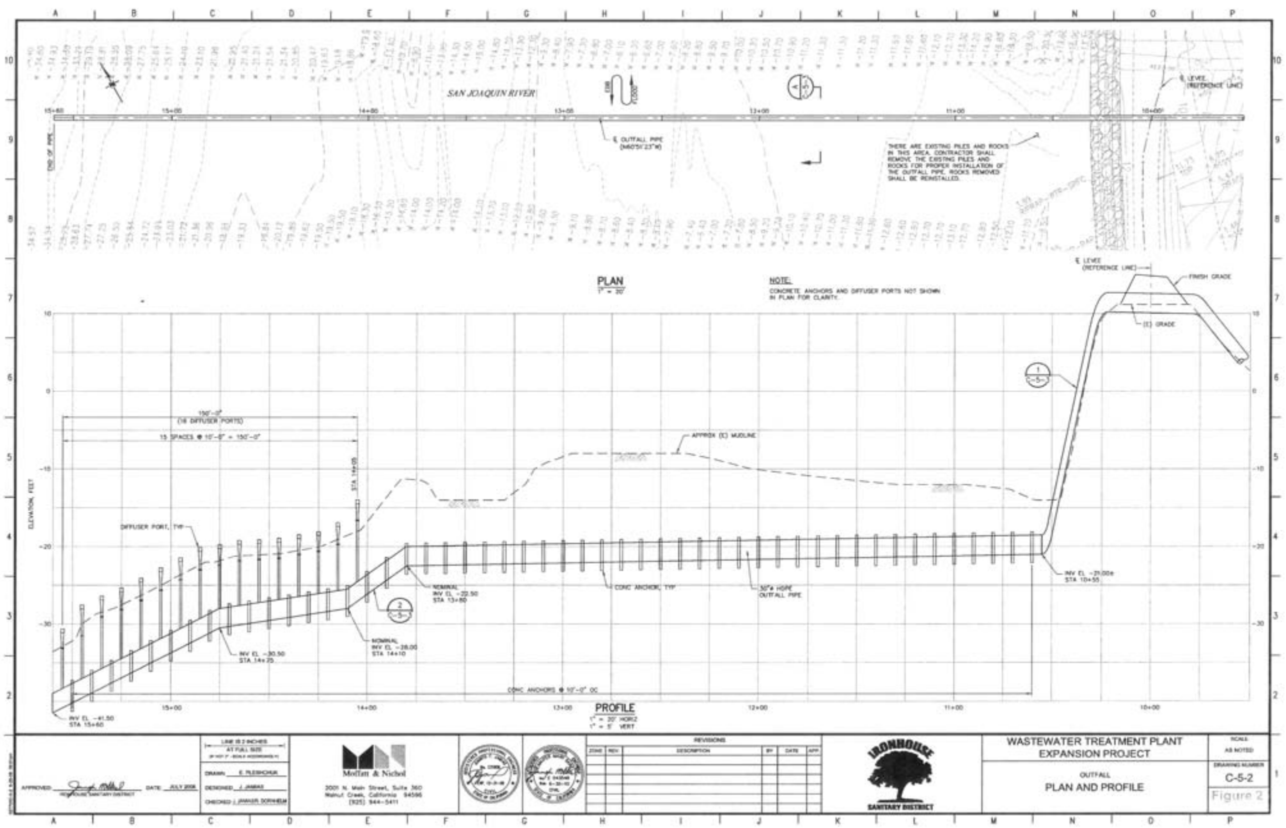


Figure 3: Sections and Details of the outfall pipeline for the ISD WWTP.

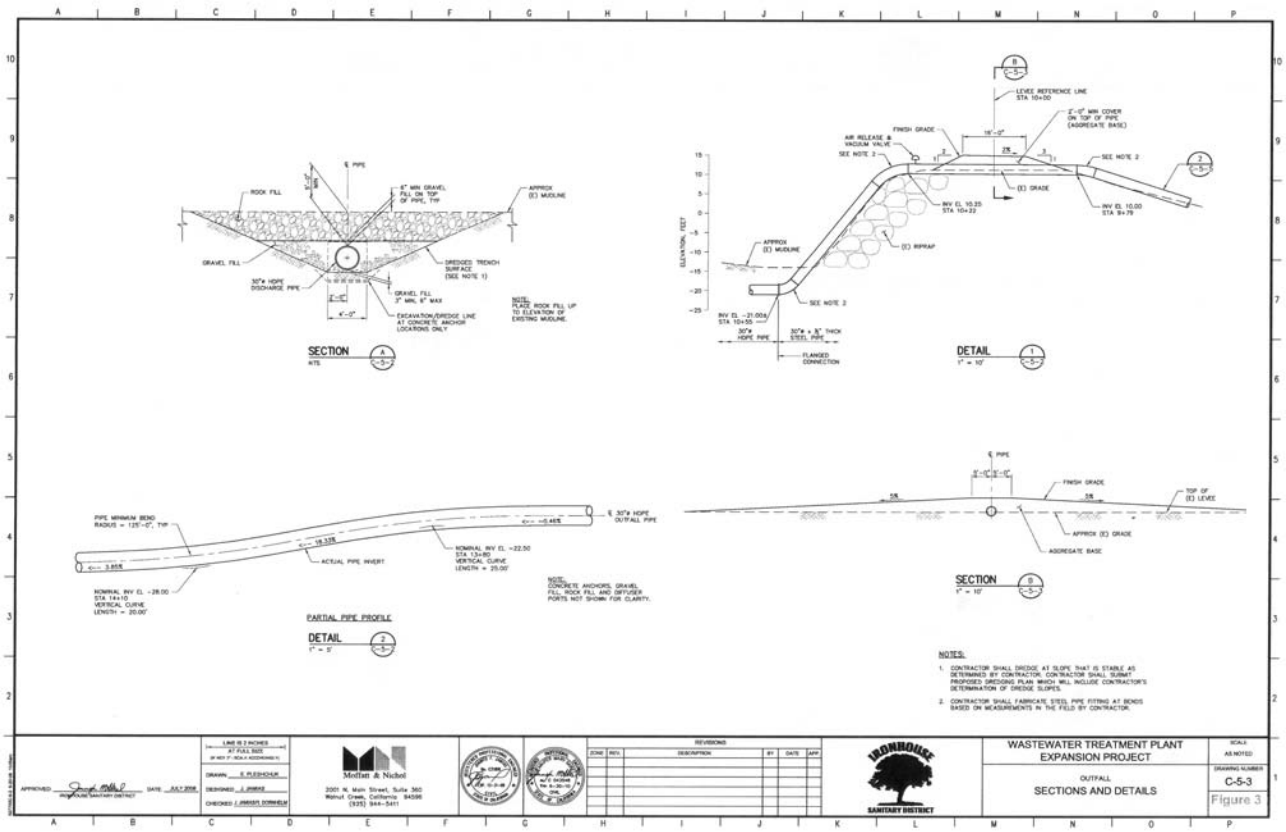


Figure 4: Pipe and Diffuser Details for the ISD WWTP outfall pipeline.

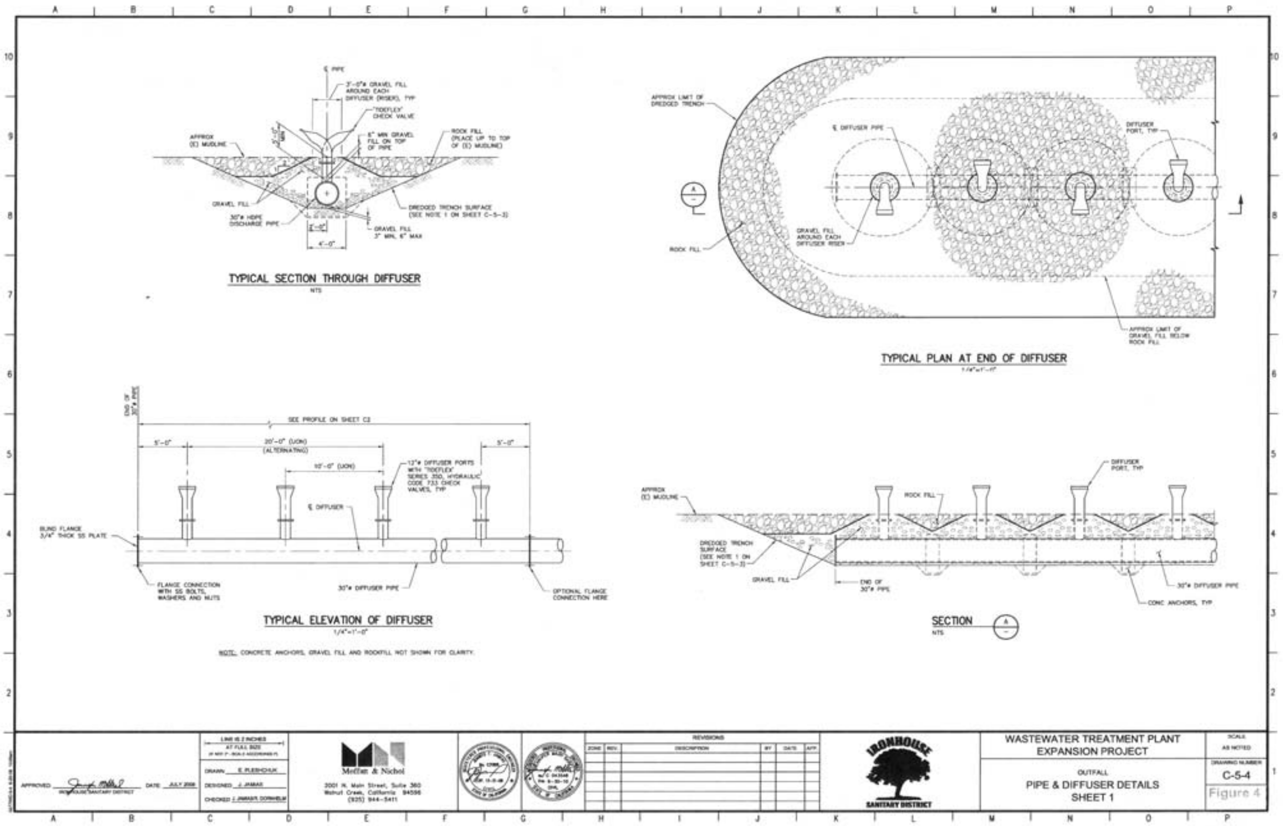


Figure 5:
Annual estimated Sacramento River winter-run Chinook salmon escapement population.
Sources: PFMC 2002, 2004, CDFG 2004a, NMFS 1997
Trendline for figure 5 is an exponential function: $Y=24.765\ e^{-0.0789x}$, $R^2=0.2788$.

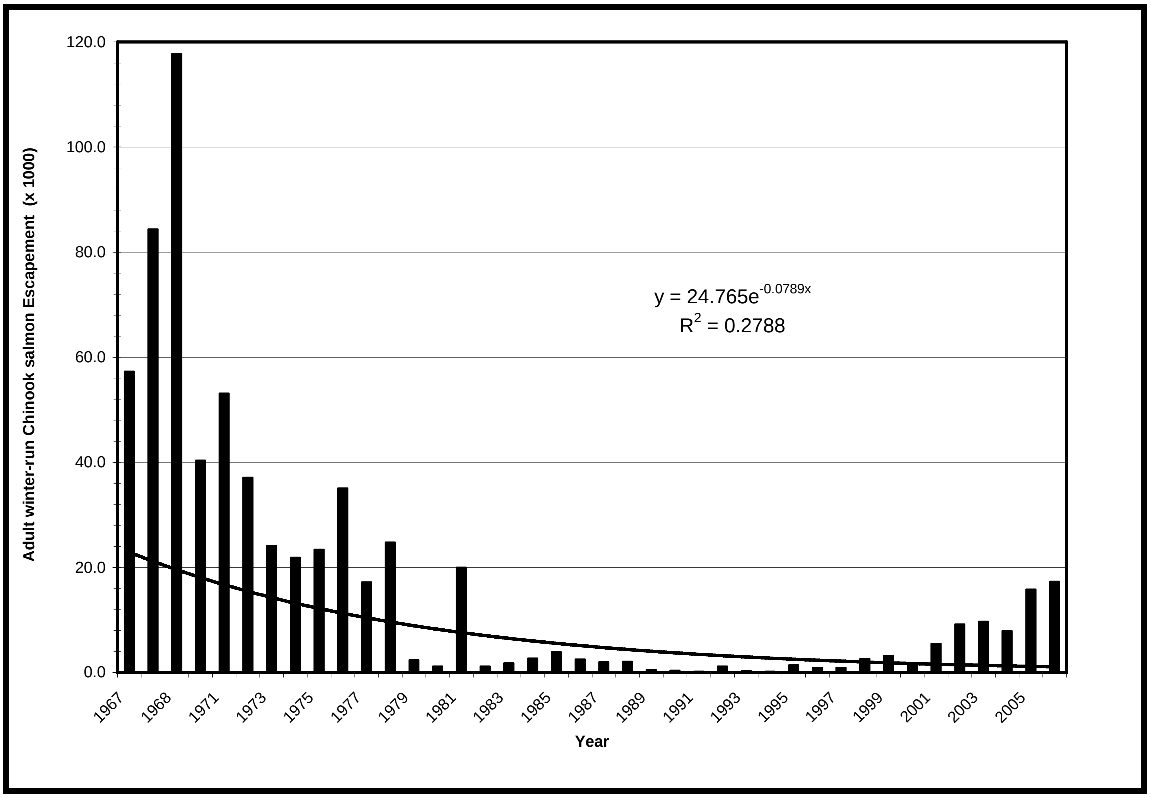


Figure 6:
Annual estimated Central Valley spring-run Chinook salmon escapement population for the Sacramento River watershed for years 1967 through 2003.
Sources: PFMC 2002, 2004, CDFG 2004b, Yoshiyama 1998, GrandTab 2006.
Trendline for figure 6 is an exponential function: $Y=11909\ e^{-0.0187x}$, $R^2 = 0.0629$.

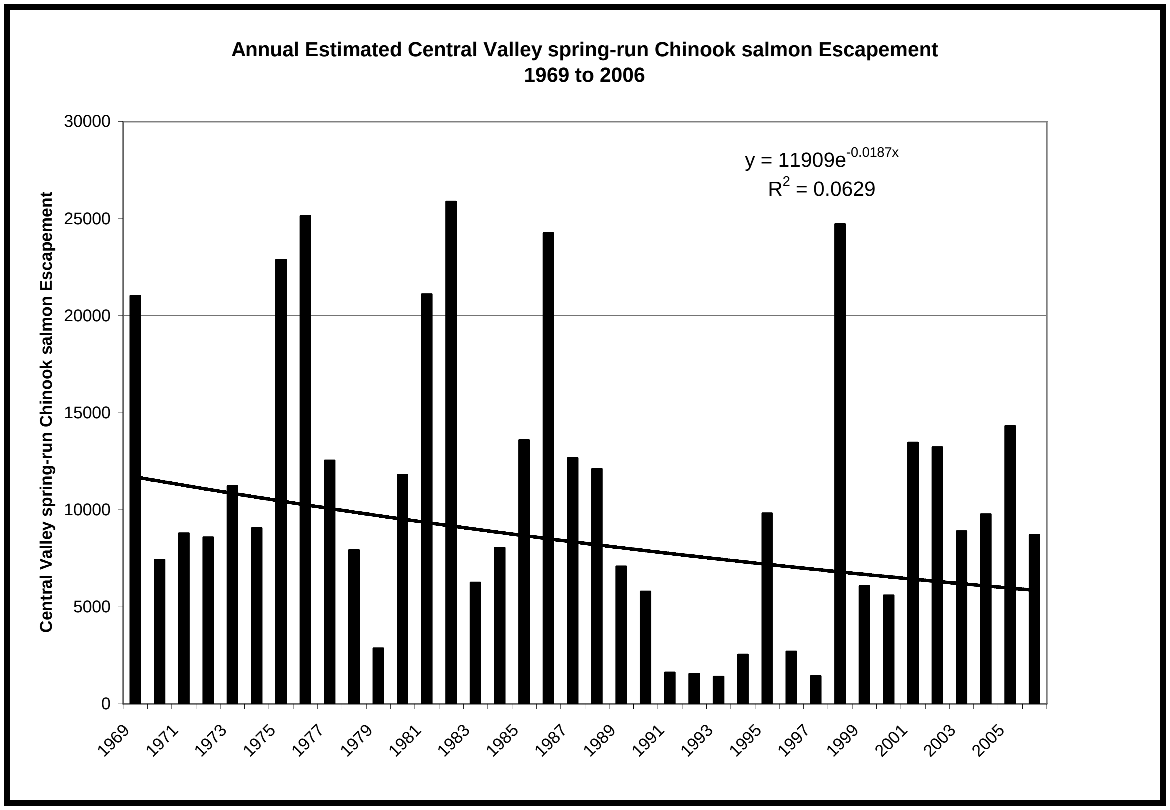
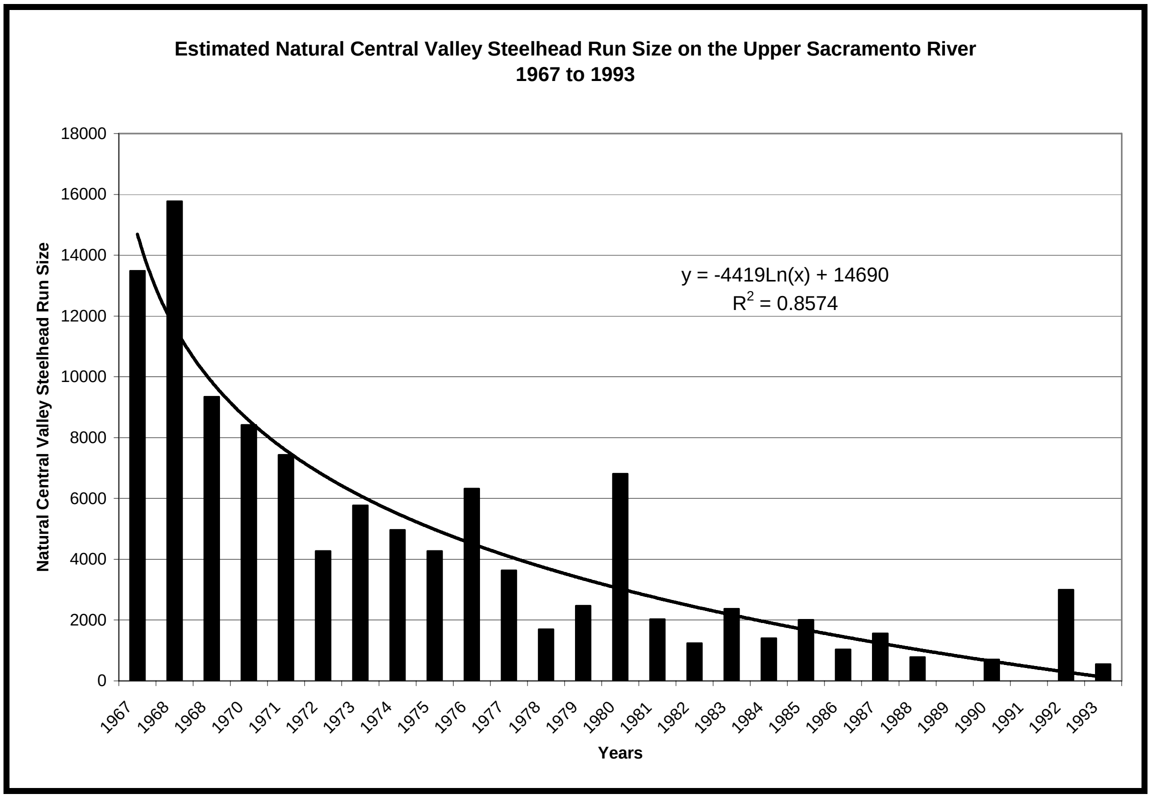


Figure 7:
Estimated Central Valley natural steelhead escapement population in the upper Sacramento River based on RBDD counts.
Source: McEwan and Jackson 1996.
Trendline for Figure 7 is a logarithmic function: Y= -4419 Ln(x) + 14690 R^2= 0.8574



Note: Steelhead escapement surveys at RBDD ended in 1993

Figure 8:
Annual number of Central Valley steelhead caught while Kodiak trawling at the Mossdale monitoring location on the San Joaquin River (Marston 2004, SJRG 2007).

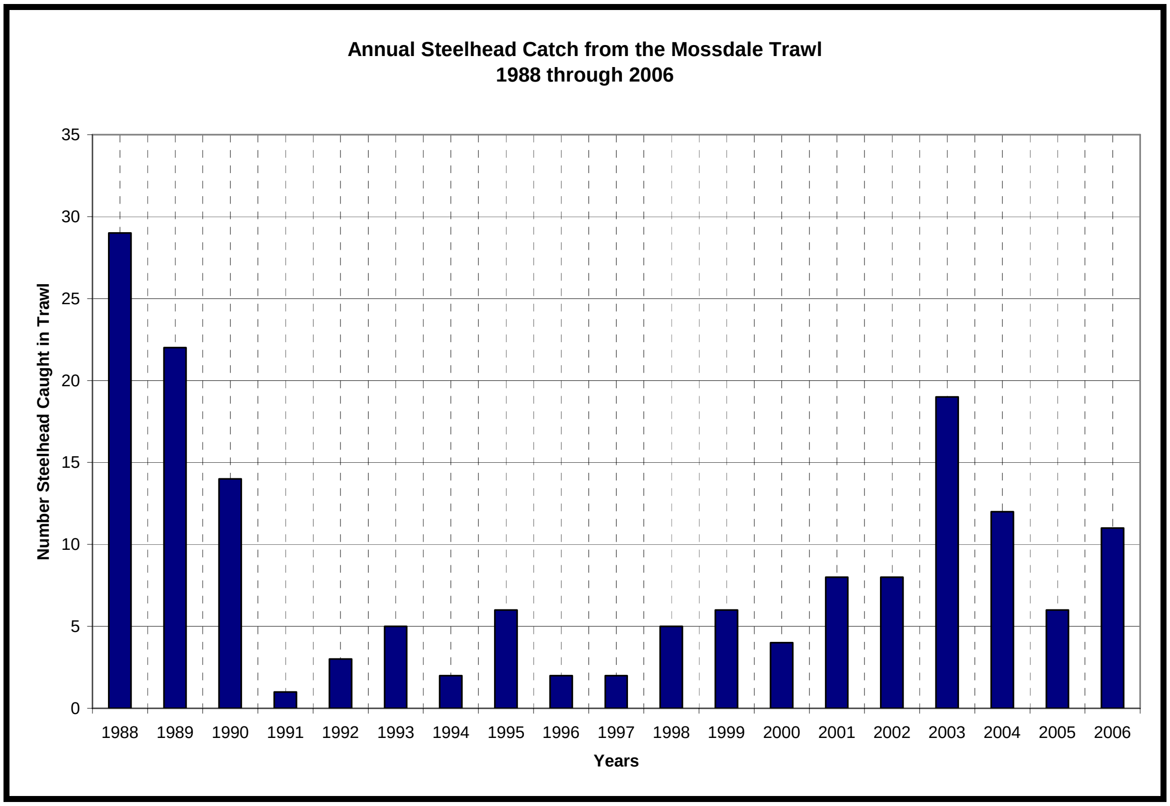


Figure 9a:
Estimated number of North American green sturgeon (Southern DPS) salvaged from the State Water Project and the Central Valley Project fish collection facilities.
Sources: Beamesderfer et al., 2007, CDFG 2002, Adams et al. 2007.

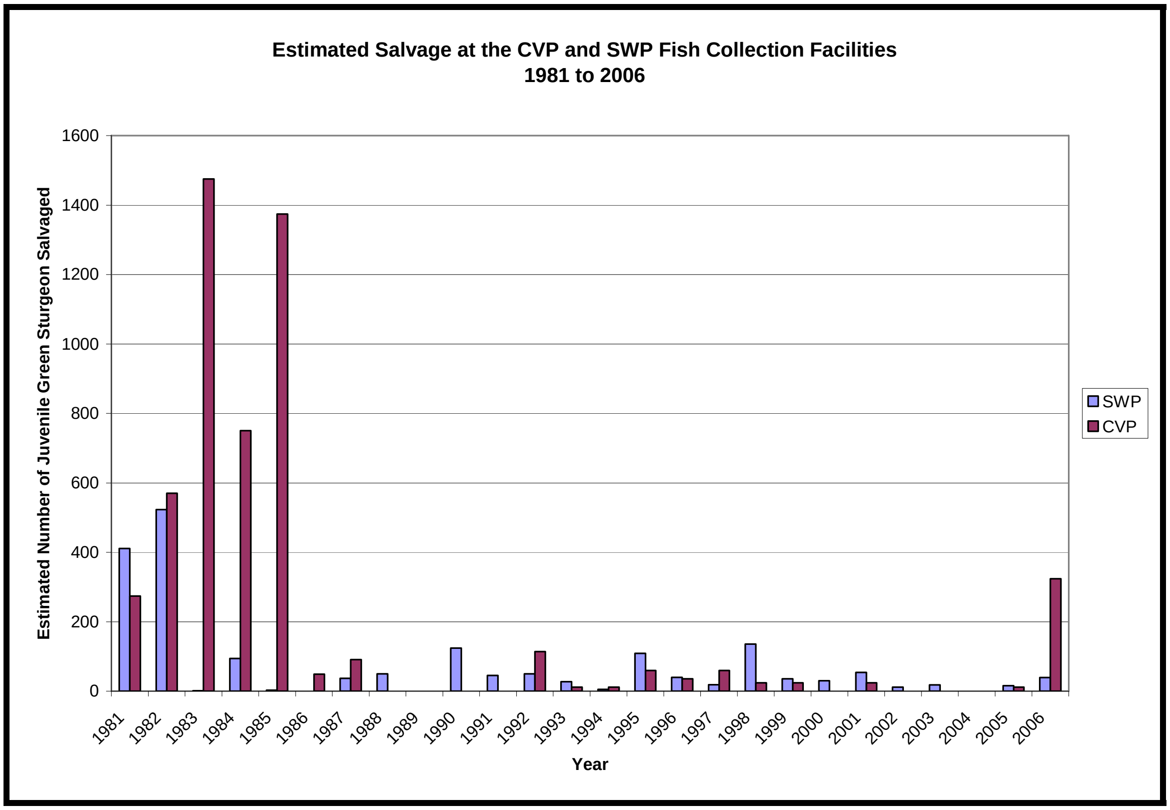
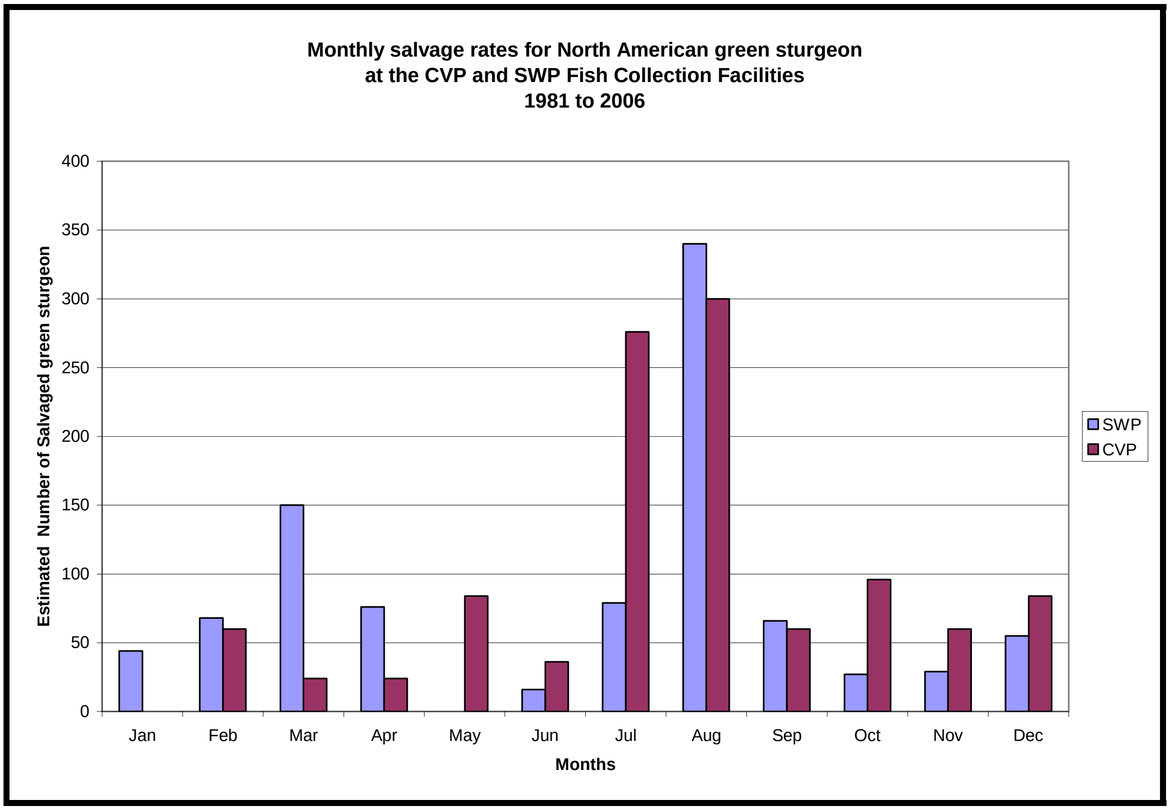


Figure 9b:
Estimated number of North American green sturgeon (Southern DPS) salvaged monthly from the State Water Project and the Central Valley Project fish collection facilities.
Source: CDFG 2002, unpublished CDFG records.



Enclosure 2

<u>Magnuson-Stevens Fishery Conservation and Management Act</u>

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended (U.S.C. 180 *et seq.*), requires that Essential Fish Habitat (EFH) be identified and described in Federal fishery management plans (FMPs). Federal action agencies must consult with NOAA's National Marine Fisheries Service (NMFS) on any activity which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies.

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purposes of interpreting the definition of EFH, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle. The proposed project site is within the region identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon FMP and for starry flounder (*Platichthys stellatus*) and English sole (*Parophrys vetulus*) in Amendment 11 to the Pacific Coast Groundfish FMP.

The Pacific Fishery Management Council (PFMC) has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 14 to the Pacific Coast Salmon FMP (PFMC 1999). The proposed project site is within the region identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon FMP and for starry flounder (*Platichthys stellatus*) in Amendment 11 to the Pacific Coast Groundfish FMP. Freshwater EFH for Pacific salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers *et al.* (1998), and includes the San Joaquin Delta (Delta) hydrologic unit (*i.e.*, number 18040003. Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Salmon Plan that occur in the Delta unit.

Factors limiting salmon populations in the Delta include periodic reversed flows due to high water exports (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversions, predation by introduced species, and reduction in the quality and quantity of rearing habitat due to channelization, pollution, riprapping, *etc*. (Dettman *et al.* 1987;

California Advisory Committee on Salmon and Steelhead Trout 1988, Kondolf *et al.* 1996a, 1996b). Factors affecting salmon populations in Suisun Bay include heavy industrialization within its watershed and discharge of wastewater effluents into the bay. Loss of vital wetland habitat along the fringes of the bay reduce rearing habitat and diminish the functional processes that wetlands provide for the bay ecosystem.

A. Life History and Habitat Requirements

Pacific Salmon

General life history information for Central Valley Chinook salmon is summarized below. Information on Sacramento River winter-run and Central Valley spring-run Chinook salmon life histories is summarized in the preceding biological opinion for the proposed project (Enclosure 1). Further detailed information on Chinook salmon Evolutionarily Significant Units (ESUs) are available in the NMFS status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers *et al.* 1998), and the NMFS proposed rule for listing several ESUs of Chinook salmon (63 FR 11482).

Adult Central Valley fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from July through December and spawn from October through December while adult Central Valley late fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from October to April and spawn from January to April (U.S. Fish and Wildlife Service [FWS] 1998). Chinook salmon spawning generally occurs in clean loose gravel in swift, relatively shallow riffles or along the edges of fast runs (NMFS 1997).

Egg incubation occurs from October through March (Reynolds *et al.* 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and into the San Francisco Bay and its estuarine waters (Kjelson *et al.* 1982). The remaining fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, aquatic and riparian vegetation, logs, and undercut banks provide habitat for food organisms, shade, and protect juveniles and smolts from predation. These smolts generally spend a very short time in the Delta and estuary before entry into the ocean. Whether entering the Delta or estuary as fry or juveniles, Central Valley Chinook salmon depend on passage through the Delta for access to the ocean.

2. Starry Flounder

The starry flounder is a flatfish found throughout the eastern Pacific Ocean, from the Santa Ynez River in California to the Bering and Chukchi Seas in Alaska, and eastwards to Bathurst inlet in Arctic Canada. Adults are found in marine waters to a depth of 375 meters. Spawning takes place during the fall and winter months in marine to polyhaline waters. The adults spawn in shallow coastal waters near river mouths and sloughs, and the juveniles are found almost exclusively in estuaries. The juveniles often migrate up freshwater rivers, but are estuarine dependent. Eggs are broadcast spawned and the buoyant eggs drift with wind and tidal currents. Juveniles gradually settle to the bottom after undergoing metamorphosis from a pelagic larva to a demersal juvenile by the end of April. Juveniles feed mainly on small crustaceans, barnacle larvae, cladocerans, clams and dipteran larvae. Juveniles are extremely dependent on the condition of the estuary for their health. Polluted estuaries and wetlands decrease the survival rate for juvenile starry flounder. Juvenile starry flounder also have a tendency to accumulate many of the anthropogenic contaminants found in the environment.

II. PROPOSED ACTION

The proposed action is described in section II (*Description of the Proposed Action*) of the preceding biological opinion for endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, Central Valley steelhead (*O. mykiss*), threatened southern DPS of North American green sturgeon, and critical habitat for Central Valley steelhead (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on salmonid habitat are described at length in section V (*Effects of the Action*) of the preceding biological opinion, and generally are expected to apply to Pacific salmon EFH. The effects on EFH for the one species of flatfish is expected to be similar to those for salmon.

IV. CONCLUSION

Based on the best available information, NMFS believes that the proposed Ironhouse SanitaryDistrict Wastewater Treatment Plant Expansion Project may adversely affect EFH for Pacific salmon and groundfish during its initial and normal long-term operations.

V. EFH CONSERVATION RECOMMENDATIONS

NMFS recommends that the following conservation measures be implemented in the project action area, as addressed in Appendix A of Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999). NMFS anticipates that implementing those conservation measures intended to minimize disturbance and sediment and pollutant inputs to waterways would benefit groundfish as well.

Riparian Habitat Management–In order to prevent adverse effects to riparian corridors, the U.S. Army Corps of Engineers (Corps) should:

- Maintain riparian management zones of appropriate width along Old River;
- Reduce erosion and runoff into waterways within the project area; and
- Minimize the use of chemical treatments within the riparian management zone to manage nuisance vegetation along the levee banks.

Bank Stabilization–The installation of riprap or other streambank stabilization devices can reduce or eliminate the development of side channels, functioning riparian and floodplain areas and off channel sloughs. In order to minimize these impacts, the Corps should:

- Use vegetative methods of bank erosion control whenever feasible. Hard bank protection should be a last resort when all other options have been explored and deemed unacceptable;
- Determine the cumulative effects of existing and proposed bio-engineered or bank hardening projects on salmon EFH, including prey species, before planning new bank stabilization projects; and
- Develop plans that minimize alterations or disturbance of the bank and existing riparian vegetation.

Conservation Measures for Construction/Urbanization–Activities associated with urbanization (*e.g.*, building construction, utility installation, road and bridge building, and storm water discharge) can significantly alter the land surface, soil, vegetation, and hydrology and subsequently adversely impact salmon EFH through habitat loss or modification. In order to minimize these impacts, the Corps and the applicant should:

- Plan development sites to minimize clearing and grading;
- Use Best Management Practices in building as well as road construction and maintenance operations such as avoiding ground disturbing activities during the wet season, minimizing the time disturbed lands are left exposed, using erosion prevention and sediment control methods, minimizing vegetation disturbance, maintaining buffers of vegetation around wetlands, streams and drainage ways, and avoid building activities in areas of steep slopes with highly erodible soils. Use methods such as sediment ponds, sediment traps, or other facilities designed to slow water runoff and trap sediment and nutrients; and
- Where feasible, reduce impervious surfaces.

Wastewater/Pollutant Discharges–Water quality essential to salmon and their habitat can be altered when pollutants are introduced through surface runoff, through direct discharges of pollutants into the water, when deposited pollutants are resuspended (*e.g.*, from dredging), and when flow is altered. Indirect sources of water pollution in salmon habitat includes run-off from streets, yards, and construction sites. In order to minimize these impacts, the Corps and the applicant should:

- Monitor water quality discharge following National Pollution Discharge Elimination System requirements from all discharge points;

- For those waters that are listed under Clean Water Act section 303 (d) criteria (*e.g.*, the Delta), work with State and Federal agencies to establish total maximum daily loads and develop appropriate management plans to attain management goals; and

- Establish and update, as necessary, pollution prevention plans, spill control practices, and spill control equipment for the handling and transport of toxic substances in salmon EFH (*e.g.*, oil and fuel, organic solvents, raw cement residue, sanitary wastes, *etc.*). Consider bonds or other damage compensation mechanisms to cover clean-up, restoration, and mitigation costs.

VI. STATUTORY REQUIREMENTS

Section 305 (b) 4(B) of the MSA requires that the Federal lead agency provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the lead agency for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR §600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreement with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

VII. LITERATURE CITED

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