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

In Response Refer To:
2005/07418

SEP 1 2006

Michael Finan
Chief, Delta Office
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Mr. Finan:

This letter transmits NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Enclosure 1) based on our review of Mountain House Community Services District's (MHCSD) proposed Mountain House Wastewater Treatment Plant (MHWWTP) expansion project in San Joaquin 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 (DPS) 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 September 4, 2002. Habitat restoration activities on Mountain House Creek originally were part of the proposed project. A response was sent to the U.S. Army Corps of Engineers (Corps) on October 21, 2002, indicating that we could not proceed with this consultation as described until additional information regarding the MHWWTP outfall diffuser design and effects of facility operation were more thoroughly developed. NMFS requested additional information from the Corps describing any fisheries impacts and water quality monitoring that would be included in the project's operation. NMFS met with representatives of the applicant (Trimark Communities) from October 2002 through early spring of 2003 to discuss the project and its potential impacts on listed fish species. In February 2003, the applicant decided to separate the components of the project into the Mountain House Creek restoration component and the MHWWTP expansion component. The Corps issued a letter in April 2003 indicating that the project was being split into the two components although both components still were being considered under one permit. On May 23, 2003, NMFS concurred with the Corps' determination that the Mountain House Creek restoration portion of the project was not likely to adversely affect Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and threatened Central Valley steelhead, or the designated critical habitat for these species. The southern DPS of North American green sturgeon was not listed under the ESA at that time. Consultation on the MHWWTP expansion portion of the project was suspended until a biological assessment (BA) for this component could be developed. The final version of the BA was received by NMFS on November 4, 2005.

This biological opinion is based on information provided in the November 4, 2005, section 7 consultation package which included the biological assessment (BA) for the proposed project and supplemental information to the BA (*i.e.*, dilution studies and sediment testing protocols); letters and e-mails regarding the proposed project received by NMFS staff; meetings held December 10, 2004, and May 5, June 27, August 31, September 8, and November 4, 2005, regarding the project and agency concerns; 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 MHWWTP 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 incidental take associated with the project 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)* 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 MHWWTP 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

cc: James Starr, California Department of Fish and Game, 4001 North Wilson Way, Stockton, CA 94205

Ryan Olah, U.S. Fish and Wildlife Service, 2800 Cottage Way, Room W-2605, Sacramento, CA 95825

Barry Hilton, Central Valley Regional Water Quality Board, Sacramento Main Office, 11020 Sun Center Drive, Suite #200, Rancho Cordova, CA 95670-6114

Copy to File: ARN 151422SWR2002SA8308

BIOLOGICAL OPINION

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

ACTIVITY: Mountain House Wastewater Treatment Plant Expansion

CONSULTATION CONDUCTED BY: Southwest Region, National Marine Fisheries Service

FILE NUMBER: 151422SWR2002SA8308:JSS

I. CONSULTATION HISTORY

On September 4, 2002, NOAA's National Marine Fisheries Service (NMFS) received a request for consultation under section 7 of the Endangered Species Act (ESA) from the U.S. Army Corps of Engineers, Sacramento District (Corps) on the proposed Mountain House Development plan in San Joaquin County, California. The proposed project involves the construction and operation of a new wastewater treatment plant outfall that would discharge to Old River, and the restoration of the Mountain House Creek channel and floodplain within the footprint of the Mountain House Community development.

On October 15, 2002, Jeffrey Stuart of NMFS met with Eric Teed-Bose (Trimark Communities) and Tom Skordal (Gibson and Skordal) to discuss the restoration plan for Mountain House Creek as well as potential alternatives to the wastewater treatment plant outfall. It was agreed that alternatives to the outfall would be investigated and followed by the development of more complete plans for the project.

On October 21, 2002, NMFS sent a letter to the Corps indicating that consultation would be suspended until complete plans for the wastewater treatment plant's outfall could be developed.

In February 2003, Trimark Communities provided NMFS with a description of the preferred alternative resulting from the discussions held the previous October. Trimark Communities decided to continue pursuing the outfall structure in Old River as the discharge point for its Mountain House wastewater treatment plant. At this time, Trimark Communities also decided to separate the components of the initial Corps permit application into two separate projects, so as to continue meeting its timeline for the construction of the housing development project.

On April 7, 2003, the Corps sent a letter to NMFS indicating that they considered the creek restoration project and wastewater treatment plant outfall as two separate projects under the one permit application. The Corps requested that separate consultations be carried out for the two projects.

On May 23, 2003, NMFS concurred with the Corps' determination that the proposed Creek Restoration and Crossings phase of the Mountain House Development project was not likely to adversely affect 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*), or the designated critical habitat for these species. The wastewater treatment plant outfall portion of the consultation was suspended until Trimark Communities could finish the design and modeling required to continue with the formal consultation.

On December 10, 2004, meetings were held between NMFS and consultants representing Trimark Communities (Robertson-Bryan, Inc.) to initiate technical discussions of the outfall design and water quality requirements for the formal consultation.

On May 5, 2005, a meeting was held between NMFS and Robertson-Bryan, Inc. to discuss potential adverse effects of the project, assessment methodologies to be used in modeling the outfall effects, and associated technical information.

On June 27, 2005, telephone discussions were held between NMFS and Robertson-Bryan, Inc. to discuss outfall diffuser design alternatives which would maximize fish migration zones of passage.

On August 31, 2005, NMFS received a draft biological assessment (BA; Robertson-Bryan, Inc. 2005) for the proposed construction and operation of the Mountain House Community Services District's (MHCSD) Wastewater Treatment Plant outfall in Old River.

On September 8, 2005, NMFS provided comments on the draft BA to Robertson-Bryan, Inc.

On November 4, 2005, NMFS received a copy of the revised BA from Robertson-Bryan, Inc. which incorporated NMFS' earlier comments on the draft BA.

On June 29, 2006, NMFS received a copy of the draft National Pollution Discharge Elimination System (NPDES) permit for the proposed action.

II. DESCRIPTION OF THE PROPOSED ACTION

The Mountain House Wastewater Treatment Plant (MHWWTP) expansion project will entail increasing the current volume of treated effluent from 0.45 million gallons per day (mgd) to 3.0 mgd annual average dry-weather flow (AADF) to meet the future needs of the 4,784 acre master planned community of Mountain House in San Joaquin County, California (see Appendix B, Figures 1 and 2). The ultimate design capacity for the facility is 5.4 mgd. As part of the facility upgrades and expansion, MHCSD has designed a direct discharge diffuser pipeline for the outfall structure to be placed in the channel of Old River. This diffuser array will replace the current dry land spray irrigation of wastewater effluent from the MHWWTP on upland areas owned by MHCSD adjacent to the current location of the wastewater treatment facility (Robertson-Bryan, Inc. 2005).

A. Existing Facilities

The MHWWTP expansion project is to be divided into three phases. The project is currently in phase I, with the current volume of treated effluent (*i.e.*, AADF of 0.45 mgd) intended to meet only preliminary-phase flows from the Mountain House community at its current level of buildout. The phase I treatment process includes influent screening, aerated treatment ponds, flocculators, dissolved air flotation, clarifiers, sand filters, and chlorine disinfection systems. Effluents from the current MHWWTP operations are discharged to dry-land fields adjacent to the plant.

B. Proposed Facilities

The MHCSD proposed phase II facility, which currently is being constructed, will treat upwards of 3.0 mgd AADF of wastewater (5.4 mgd under the ultimate design capacity of phase III) from the Mountain House planned community. The phase II plant will utilize two hybrid sequencing batch reactors (SBRs) which employ activated sludge wastewater technology. The treatment process is designed to meet or exceed California Title 22 requirements for unrestricted reuse of effluent. Treatment processes for phase II also will entail influent screening and grit removal, biological oxygen demand (BOD) reduction and nitrification/denitrification, clarification, tertiary disk filtration, and ultraviolet (UV) disinfection of the effluent. The UV system will provide a level of disinfection so that total coliform concentrations are less than 2.2 most probable number (MPN)/100ml (7-day median) and at no time will total coliform counts exceed 23 MPN/100ml in any single sample each month. The treatment train will also include sludge storage and treatment, capable of compliance with the U.S. Environmental Protection Agency's (EPA) Class "B" bio-solids standards for offsite disposal.

Under the phase II facilities upgrades, the tertiary treated effluent will be discharged to the waters of Old River adjacent to the MHWWTP. Effluent will be pumped via a 36-inch polyvinyl chloride (PVC) pipeline to the levee adjacent to the Old River channel where it will be directed over the levee embankment and into a 24-inch high density polyethylene (HDPE) diffuser pipeline placed along the bottom of the channel. The MHCSD proposes to build two diffuser outfalls: a primary diffuser to be used for near term operation and a secondary diffuser for potential future use. The diffuser pipelines will be buried along the bottom of the Old River channel. Multiple diffuser ports will be positioned every 10 feet and extend 12-inches above grade along the channel bottom. Each diffuser port will be equipped with a gooseneck check valve to prevent back flow into the diffuser port. The pipelines will be held in place by concrete ballasts positioned along the length of the pipeline. The pipeline trenches will be backfilled with native material and contoured to the original bottom topography (see appendix B Figures 3 and 4). The primary diffuser will be located approximately 200 feet downstream of Wicklund Cut. The secondary diffuser will be located approximately 2,500 feet downstream in Old River from the primary diffuser. The secondary diffuser is intended to be used only if the NPDES permit issued by the Central Valley Regional Water Quality Control Board (Regional Board) requires an additional location to meet the permit water quality requirements (Robertson Bryan, Inc. 2005).

The excavation of the trenches along the bottom of the Old River channel will require dredging of the bottom substrate from the channel. The plans for the trenches indicate that each trench will be 10 feet wide, and excavated to a depth of 4 feet. The approximate lengths of the excavated trenches will be 225 feet for the primary diffuser and 170 feet for the secondary diffuser, and excavation will require the removal of 200 cubic yards and 170 cubic yards of material, respectively. Dredging is anticipated to be done by a hydraulic cutterhead dredge and will take less than a week to complete.

C. Conservation Measures

The MHCSD 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 MHCSD has designed the WWTP and the effluent diffusers to comply with the anticipated water quality measures defined in the future NPDES permit for discharge to Old River. The effluent will meet Title 22 discharge requirements and Water Quality Control Plan criteria for wastewater discharges. The MHCSD has incorporated the following construction related conservation measures into their proposed project plans (Robertson-Bryan, Inc. 2005):

1. In-channel construction will be limited to the period between July 1 and December 31 to minimize potential for adversely affecting federally listed anadromous salmonids during their emigration period.

2. 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.

3. Design of the diffuser will allow a 50-foot zone of passage on the far bank (northern bank).

4. Dredging of the trench into which the new diffuser pipeline will be buried will be conducted by a cutterhead suction dredge. Suction dredges contribute less turbidity to the overlying water column than other methods of dredging.

5. Fish exclusion "rakers" will be attached to the end of the cutterhead to minimize the likelihood of entraining listed species of fish, particularly green sturgeon.

6. The rate of swing of the cutterhead arm and the method of operating the cutterhead will be done in the following fashion to minimize impacts to listed fish species:

    a. *Reduce cutterhead rotational speed* – reducing cutterhead rotational speed will reduce the potential for sidecasting of sediment form the cutterhead.

    b. *Reduce swing speed* – reducing swing speed ensures that the dredge does not move through the cut faster than the sediment can be hydraulically pumped.

c. *Eliminate bank undercutting* – using shallower cuts to reduce the potential for undercutting and cut-face sloughing. The dredge head will cut no deeper than 80 percent of the diameter of the cutterhead.

7. A spill prevention plan will be prepared describing measures to be taken to minimize the risk of fluids or other materials used during construction (oils, transmission and hydraulic fluids, cement, fuel, *etc.*) from entering Old River or contaminating riparian areas adjacent to the river itself. In addition to a spill prevention plan, a cleanup protocol will be developed and implemented in case of a spill.

8. Construction Best Management Practices (BMPs) for off-channel staging and storage of equipment and vehicles will be implemented to minimize the risk of contamination of the waters of Old River by spilled materials.

9. Following construction and placement of the diffusers, the bottom topography of the Old River channel will be returned to pre-project conditions so that no predator holding habitat is created by the project actions.

10. Disturbance of riparian vegetation will be avoided to the greatest extent practicable. Any riparian vegetation removed or damaged will be replaced at a 3:1 ratio within the immediate area of the disturbance to maintain habitat quality.

11. In compliance with the NPDES General Construction Permits, standard construction site BMPs to minimize erosion and stormwater runoff at the construction site will be implemented.

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

In addition to the aforementioned conservation measures, the Regional Board requires sediment sampling prior to the dredging action. If the sediment testing reveals that the sediments are contaminated with chemicals of concern, then special actions such as silt curtains, capping of sediment horizons, or incremental dredging may be employed.

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 action area for the purposes of this biological opinion includes those portions of Old River located from ½ mile northwest of the mouth of Mountain House Creek to ½ mile southeast of Wicklund Cut near the community of Mountain House in San Joaquin County, California. The affected area equals approximately 2 river miles along the channel of Old River. 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.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species (Evolutionarily Significant Units [ESUs] or Distinct Population Segments [DPSs]) and designated critical habitat occurs in the action area and may be affected by the proposed project:

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

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

Central Valley steelhead DPS
Listed as threatened (71 FR 834, January 5, 2006), see also
(70 FR 52488, September 2, 2005 - critical habitat)

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

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 (70 FR 37160). On January 5, 2006, NMFS published a final listing determination for ten 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 ESA, 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 population has been included in the listed 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 (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. The critical habitat designation identifies those physical and biological features of the habitat that are essential to the conservation of the species and that may require special management consideration and protection. Within the Sacramento River this includes the river water, river bottom (including those areas and associated gravel used by winter-run Chinook salmon as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing. In the areas west of Chipps Island, including San Francisco Bay to the Golden Gate Bridge, this designation includes the estuarine water column, essential foraging habitat, and food resources utilized by winter-run Chinook salmon as part of their juvenile outmigration or adult spawning migrations. As governed by the critical habitat definition for winter-run Chinook salmon, critical habitat does not occur within the action area.

Central Valley spring-run Chinook salmon were listed as threatened on September 16, 1999 (50 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 as of 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 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 in the listed population of steelhead as of 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 in the action area. No critical habitat has been designated or proposed 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 streamflows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate streamflows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38 °F to 56 °F (Bell 1991, California Department of Fish and Game (CDFG) 1998). Adult winter-run Chinook salmon enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate past Red Bluff Diversion Dam (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. Adult spring-run Chinook salmon enter the Delta from the Pacific Ocean beginning in January and enter natal streams from March to July (Myers *et al.* 1998). In Mill Creek, Van Woert (1964) noted that of 18,290 spring-run Chinook salmon observed from 1953 to 1963, 93.5 percent were counted between April 1 and July 14, and 89.3 percent were counted between April 29 and June 30. 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.

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 (U.S. Fish and Wildlife Service (FWS) 1995). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. Bell (1991) identifies the preferred water temperature for adult spring-run Chinook salmon migration as 38 °F to 56 °F. Boles (1988) recommends water temperatures below 65 °F for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70 °F, and that fish can become stressed as temperatures approach 70 °F. The Bureau of Reclamation (Reclamation) reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60 °F; although salmon can tolerate temperatures up to 65 °F before they experience an increased susceptibility to disease. The upper preferred water temperature for spawning Chinook salmon is 55 °F to 57 °F (Chambers 1956, Bjornn and Reiser 1995). Winter-run Chinook salmon 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 winter-run Chinook salmon spawners are three years old. Physical Habitat Simulation Model (PHABSIM) results (FWS 2003a) indicate winter-run Chinook salmon suitable spawning velocities in the upper Sacramento River are between 1.54 feet per second (ft/s) and 4.10 ft/s, and suitable spawning substrates are between 1 and 5 inches in diameter. Initial habitat suitability curves (HSCs) show spawning suitability rapidly decreases for water depths greater than 3.13 feet (FWS 2003a). 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). PHABSIM results indicate spring-run Chinook salmon suitable spawning velocities in Butte Creek are between 0.8 ft/s and 3.22 ft/s, and suitable spawning substrates are between 1 and 5 inches in diameter (FWS 2004). The initial HSC showed suitability rapidly decreasing for depths greater than 1.0 feet, but this effect was most likely due to the low availability of deeper water in Butte Creek with suitable velocities and substrates rather than a selection by spring-run Chinook salmon of only shallow depths for spawning (FWS 2004).

The optimal water temperature for egg incubation is 44 °F to 54 °F (Rich 1997). Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel percolation, and poor water quality. Studies of Chinook salmon egg survival to hatching conducted by Shelton (1995) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The length of time required for eggs to develop and hatch is dependent on water temperature and is quite variable. Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 61 °F and 37 °F, respectively, when the incubation temperature was held constant.

Winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence occurring generally at night. Spring-run Chinook salmon fry emerge from the gravel from November to March and spend about 3 to 15 months in freshwater habitats prior to emigrating to the ocean (Kjelson *et al.* 1981). 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 small insects and crustaceans.

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). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration. Emigration of juvenile 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). From 1995 to 1999, all winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). The emigration timing of Central Valley spring-run Chinook salmon is 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). The emigration period for spring-run Chinook salmon extends from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period (CDFG 1998).

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

As Chinook salmon fry and fingerlings mature, they prefer to rear further downstream where ambient salinity may reach 1.5 to 2.5 parts per thousand (Healy 1980, 1982; Levings *et al.* 1986). Juvenile winter-run Chinook salmon occur in the Delta from October through early May based on data collected from trawls, beach seines, and salvage records at the Central Valley Project (CVP) and State Water Project (SWP) pumping facilities (CDFG 1998). The peak of listed juvenile salmon arrivals in the Delta generally occurs from January to April, but may extend into June. Upon arrival in the Delta, winter-run Chinook salmon spend the first 2 months rearing in the more upstream, freshwater portions of the Delta (Kjelson *et al.* 1981, 1982). Data from the CVP and SWP salvage records indicate that most spring-run Chinook salmon smolts are present in the Delta from mid-March through mid-May depending on flow conditions (CDFG 2000).

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, 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.* (1986) 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. Winter-run Chinook salmon fry remain in the estuary (Delta/Bay) until they reach a fork length of about 118 mm (*i.e.*, 5 to 10 months of age) and then begin emigrating to the ocean perhaps as early as November and continuing through May (Fisher 1994, Myers *et al.* 1998). Little is known about estuarine residence time of spring-run Chinook salmon. 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. Spring-run yearlings are larger in size than fall-run yearlings and are ready to smolt upon entering the Delta; therefore, they are believed to spend little time rearing in the Delta.

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

Following the construction of Shasta Dam, the number of winter-run Chinook salmon initially declined but recovered during the 1960s. The initial recovery was followed by a steady decline from 1969 through the late 1980s following the construction of the RBDD. Since 1967, the estimated adult winter-run Chinook salmon population ranged from 117,808 in 1969, to 186 in 1994 (FWS 2001a,b; CDFG 2002a). The population declined from an average of 86,000 adults in 1967 to 1969 to only 1,900 in 1987 to 1989, and continued to remain low, with an average of 2,500 fish for the period from 1998 to 2000 (see Appendix B: Figure 5). Between the time Shasta Dam was built and the listing of winter-run Chinook salmon as endangered, major impacts to the population occurred from warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, acid mine drainage from Iron Mountain Mine, and entrainment at a large number of unscreened or poorly-screened water diversions (NMFS 1997, 1998).

Population estimates in 2001 (8,224), 2002 (7,441), 2003 (8,218), 2004 (7,701) and 2005 (15,730) show a recent increase in the escapement of winter-run Chinook salmon. The 2005 run was the highest since the listing. Winter-run Chinook salmon abundance estimates and cohort replacement rates since 1986 are shown in Table 1. The population estimates from the RBDD counts has increased since 1986 (CDFG 2004a), there is an increasing trend in the 5 year moving average since 1997, and the 5 year moving average of cohort replacement rates has increased and appears to have stabilized over the same period (Table 1).

Table 1. Winter-run Chinook salmon population estimates from RBDD counts, and corresponding cohort replacement rates for the years since 1986 (CDFG 2004a, Grand Tab CDFG February 2005).

Year	Population Estimate (RBDD)	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	2,596	-	-	-	
1987	2,186	-	-	-	
1988	2,885	-	-	-	
1989	696	-	0.27	-	
1990	433	1,759	0.20	-	
1991	211	1,282	0.07	-	40,100
1992	1,240	1,092	1.78	-	273,100
1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1,297	664	1.05	0.94	338,107
1996	1,337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	3,002	1,340	2.31	2.48	454,792
1999	3,288	1,961	2.46	2.80	289,724
2000	1,352	1,972	1.54	2.90	370,221
2001	8,224	3,349	2.74	2.76	1,864,802
2002	7,441	4,661	2.26	2.22	2,136,747
2003	8,218	5,705	6.08	3.02	1,896,649
2004	7,701	6,587	0.94	2.71	881,719
2005	15,730	9,463	2.11	2.83	3,831,286
median	1,769	1,550	1.78	2.49	338,107

[a]JPE estimates were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers.

c. *Status - Sacramento River Winter-run Chinook Salmon*

Numerous factors have contributed to the decline of winter-run Chinook salmon through degradation of spawning, rearing and migration habitats. The primary impacts include blockage of historical habitat by Shasta and Keswick Dams, warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, heavy metal contamination from Iron Mountain Mine, high ocean harvest rates, and entrainment in a large number of unscreened or poorly screened water diversions within the Central Valley. Secondary factors include smaller water manipulation facilities and dams, loss of rearing habitat in the lower Sacramento River and Delta from levee construction, marshland reclamation, and interactions with, and predation by, introduced non-native species (NMFS 1997, 1998).

Since the listing of winter-run Chinook salmon, several habitat problems that led to the decline of the species have been addressed and improved through restoration and conservation actions. The impetus for initiating restoration actions stem primarily from the following: (1) ESA section 7 consultation Reasonable and Prudent Alternatives (RPAs) on temperature, flow, and operations of the CVP and SWP; (2) Regional Board decisions requiring compliance with Sacramento River water temperatures objectives which resulted in the installation of the Shasta Temperature Control Device in 1998; (3) a 1992 amendment to the authority of the CVP through the Central Valley Improvement Act (CVPIA) to give fish and wildlife equal priority with other CVP objectives; (4) fiscal support of habitat improvement projects from the California Bay Delta Authority (CBDA) Bay-Delta Program (*e.g.*, installation of a fish screen on the Glenn-Colusa Irrigation District (GCID) diversion); (5) establishment of the CBDA Environmental Water Account (EWA); (6) Environmental Protection Agency (EPA) actions to control acid mine runoff from Iron Mountain Mine; and (7) ocean harvest restrictions implemented in 1995.

The susceptibility of winter-run Chinook salmon to extinction remains linked to the elimination of access to most of their historical spawning grounds and the reduction of their population structure to a small population size. Recent trends in winter-run Chinook salmon abundance and cohort replacement are positive and may indicate some recovery since the listing. Although NMFS recently proposed that this ESU be upgraded from endangered to threatened status, it made the decision in its Final Listing Determination (June 28, 2005, 70 FR 37160) to continue to list the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the recovery goals established for the run (NMFS 1997, 1998) and the naturally spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the recovery criteria for 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.

d. *Population Trend – Central Valley Spring-run Chinook Salmon*

Historically, the predominant salmon run in the Central Valley was the spring-run Chinook salmon, which 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).

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 are not temporally separated in the hatchery, spring-run and fall-run Chinook salmon are 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 two 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 (NMFS 2003, 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.

Since 1969, the Central Valley spring-run Chinook salmon ESU (excluding Feather River fish) has displayed broad fluctuations in abundance ranging from 25,890 in 1982 to 1,403 in 1993 (CDFG unpublished data). Even though the abundance of fish may increase from one year to the next, the overall average population trend has a negative slope during this time period (see Appendix B: Figure 6). The average abundance for the ESU was 12,499 for the period of 1969 to 1979, 12,981 for the period of 1980 to 1990, and 6,542 for the period of 1991 to 2001. In 2002 and 2003, total run size for the ESU was 13,218 and 8,775 adults respectively, well above the 1991-2001 average.

Evaluating the ESU as a whole masks significant changes that are occurring among basin metapopulations. For example, while the mainstem Sacramento River population has undergone a significant decline, the tributary populations have demonstrated substantial increases. The average population abundance of Sacramento River mainstem spring-run Chinook salmon has recently declined from a high of 12,107 fish for the period 1980 to 1990, to a low of 609 for the period between 1991 and 2001, while the average abundance of Sacramento River tributary populations increased from a low of 1,227 to a high of 5,925 over the same period. Although tributaries such as Mill and Deer Creeks have shown positive escapement trends since 1991, recent escapements to Butte Creek, including 20,259 in 1998, 9,605 in 2001 and 8,785 in 2002, are responsible for the overall increase in tributary abundance (CDFG 2002b, 2004b; CDFG, unpublished data). The Butte Creek estimates, which account for the majority of this ESU, do not include prespawning mortality. In the last several years as the Butte Creek population has increased, mortality of adult spawner has increased from 21 percent in 2002 to 60 percent in 2003 due to over-crowding and diseases associated with high water temperatures. This trend may indicate that the population in Butte Creek may have reached its carrying capacity (Ward *et al.* 2003) or has reached historical population levels (*i.e.*, Deer and Mill creeks). Table 2 shows the population trends from the three tributaries since 1986, including the moving 5 year average, cohort replacement rate, and estimated JPE.

Table 2. Spring-run Chinook salmon population estimates from CDFG Grand Tab (February 2005) 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	1,623	7,855	0.13	-	294,124
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	1,431	3,581	0.56	2.13	259,329
1998	24,725	8,245	2.52	2.58	4,480,722
1999	6,069	8,950	2.25	2.72	1,099,838
2000	5,457	8,077	3.81	2.21	988,930
2001	13,326	10,202	0.54	1.94	2,414,969
2002	13,218	12,559	2.18	2.26	2,395,397
2003	8,902	9,9394	1.63	2.08	1,613,241
2004	9,872	10,155	0.74	1.78	1,789,027
2005	14,312	11,926	1.08	1.23	2,593,654
median	7,994	9,172	1.33	1.74	1,448,601

[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.

The extent of spring-run Chinook salmon spawning in the mainstem of the upper Sacramento River is unclear. Very few spring-run Chinook salmon redds (less than 15 per year) were observed from 1989 through 1993, and none in 1994, during aerial redd counts (FWS 2003a). Recently, the number of redds in September has varied from 29 to 105 during 2001 though 2003 depending on the number of survey flights (CDFG, unpublished data). In 2002, based on RBDD ladder counts, 485 spring-run Chinook salmon adults may have spawned in the mainstem Sacramento River or entered upstream tributaries such as Clear or Battle Creek (CDFG 2004b). In 2003, no adult spring-run Chinook salmon were believed to have spawned in the mainstem Sacramento River. Due to geographic overlap of ESUs and resultant hybridization since the construction of Shasta Dam, Chinook salmon that spawn in the mainstem Sacramento River during September are more likely to be identified as early fall-run rather than spring-run Chinook salmon.

e. *Status of Spring-run Chinook Salmon*

The initial factors that led to the decline of spring-run Chinook salmon in the Central Valley were related to the loss of upstream habitat behind impassable dams. Since this initial loss of habitat, other factors have contributed to the instability of the spring-run Chinook salmon population and have negatively affected the ESU's ability to recover. These factors include a combination of physical, biological, and management factors such as climatic variation, water management activities, hybridization with fall-run Chinook salmon, predation, and over-harvesting (CDFG 1998). Since spring-run Chinook salmon adults must hold over for months in small tributaries before spawning, they are much more susceptible to the effects of high water temperatures.

During the drought from 1986 to 1992, Central Valley spring-run Chinook salmon populations declined substantially. Reduced flows resulted in warm water temperatures that impacted adults, eggs, and juveniles. For adult spring-run Chinook salmon, reduced instream flows delayed or completely blocked access to holding and spawning habitats. Water management operations (*i.e.*, reservoir release schedules and volumes) and the unscreened and poorly-screened diversions in the Sacramento River, Delta, and tributaries compounded drought-related problems by reducing river flows, elevating river temperatures, and entraining juveniles into the diversions.

Several actions have been taken to improve habitat conditions for spring-run Chinook salmon, including: improved management of Central Valley water (*e.g.*, 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. Because the Central Valley spring-run Chinook salmon ESU is confined to relatively few remaining watersheds and continues to display broad fluctuations in abundance, the population is at a moderate risk of extinction.

2. Steelhead

a. *General Life History*

Steelhead can be divided into two life history types, 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. Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature and spawn, whereas ocean-maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two life history types are more commonly referred to by their season of freshwater entry (*i.e.*, summer (stream-maturing) and winter (ocean-maturing) steelhead). 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).

Winter steelhead generally leave the ocean from August through April, and spawn between December and May (Busby *et al.* 1996). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. In general, the preferred water temperature for adult steelhead migration is 46 °F to 52 °F (McEwan and Jackson 1996, Myrick 1998, and Myrick and Cech 2000). Thermal stress may occur at temperatures beginning at 66 °F and mortality has been demonstrated at temperatures beginning at 70 °F, although some races of steelhead may have higher or lower temperature tolerances depending upon their evolutionary history. Lower latitudes and elevations would tend to favor fish tolerant of higher ambient temperatures (see Matthews and Berg (1997) for discussion of *O. mykiss* from Sespe Creek in Southern California). The preferred water temperature for steelhead spawning is 39 °F to 52 °F, and the preferred water temperature for steelhead egg incubation is 48 °F to 52 °F (McEwan and Jackson 1996, Myrick 1998, Myrick and Cech 2000). The minimum stream depth necessary for successful upstream migration is 13 cm (Thompson 1972). Preferred water velocity for upstream migration is in the range of 40-90 cm/s, with a maximum velocity, beyond which upstream migration is not likely to occur, of 240 cm/s (Thompson 1972, Smith 1973).

Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Nickelson *et al.* 1992, 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, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams. Most steelhead spawning takes place from late December through April, with peaks from January though March

(Hallock *et al.* 1961). Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity, and may spawn in intermittent streams as well (Everest 1973, Barnhart 1986).

The length of the incubation period for steelhead eggs is dependent on water temperature, dissolved oxygen (DO) concentration, and substrate composition. In late spring and following yolk sac absorption, fry emerge from the gravel and actively begin feeding in shallow water along stream banks (Nickelson *et al.* 1992).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. 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 (Shirvell 1990, Meehan and Bjornn 1991). Some older juveniles move downstream to rear in large tributaries and mainstem rivers (Nickelson *et al.* 1992). Juveniles feed on a wide variety of aquatic and terrestrial insects (Chapman and Bjornn 1969), and older juveniles sometimes prey upon emerging fry.

Steelhead generally spend two years in freshwater before emigrating downstream (Hallock *et al.* 1961, Hallock 1989). Rearing steelhead juveniles prefer water temperatures of 45 °F to 58 °F and have an upper lethal limit of 75 °F. They can survive up to 81 °F with saturated DO conditions and a plentiful food supply. Reiser and Bjornn (1979) recommended that DO concentrations remain at or near saturation levels with temporary reductions no lower than 5.0 mg/l for successful rearing of juvenile steelhead. During rearing, suspended and deposited fine sediments can directly affect salmonids by abrading and clogging gills, and indirectly cause reduced feeding, avoidance reactions, destruction of food supplies, reduced egg and alevin survival, and changed rearing habitat (Reiser and Bjornn 1979). Bell (1973) found that silt loads of less than 25 mg/l permit good rearing conditions for juvenile salmonids.

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. 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. Barnhart (1986) reported that steelhead smolts in California range in size from 140 to 210 mm (fork length). 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.

b. *Population Trends – Central Valley Steelhead*

Steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996). Steelhead were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems (now inaccessible due to extensive alterations from numerous water diversion projects) and in both east and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). The present distribution has been greatly reduced (McEwan and Jackson 1996). The California Advisory Committee on Salmon and Steelhead (1988) reported a reduction of steelhead habitat from 6,000 miles historically to 300 miles currently. Historically, steelhead probably ascended Clear Creek past the French Gulch area, but access to the upper basin was blocked by Whiskeytown Dam in 1964 (Yoshiyama *et al.* 1996).

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 draft *Updated Status Review of West Coast Salmon and Steelhead* (NMFS 2003), 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".

The only consistent data available on steelhead numbers in the San Joaquin River basin come from CDFG mid-water trawling samples collected on the lower San Joaquin River at Mossdale. These data (see Appendix B, Figure 8) indicate a decline in steelhead numbers in the early 1990s, which have remained low through 2002 (CDFG 2003). In 2003, a total of 12 steelhead smolts were collected at Mossdale (CDFG, unpublished data).

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, FWS, pers. comm. 2002, as reported in NMFS 2003, Good *et al.* 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, 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, Calaveras, 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 (Demko *et al.* 2000). After 4 years of operating a fish counting weir on the Stanislaus River only two adult steelhead have been observed moving upstream, although several large rainbow trout have washed up on the weir in late winter (S.P. Cramer 2005). 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, if not abundant, throughout accessible streams and rivers in the Central Valley (NMFS 2003, Good *et al.* 2005).

c. *Status - Central Valley Steelhead*

Both the BRT (NMFS 2003, Good *et al.* 2005) and the Artificial Propagation Evaluation Workshop (69 FR 33102) concluded that the Central Valley steelhead DSP presently is "in danger of extinction". Steelhead have been extirpated from most of their historical range in this region. Habitat concerns in this DSP focus on the widespread degradation, destruction, and blockage of freshwater habitat within the region, and water allocation problems. Widespread hatchery steelhead production within this DSP also raises concerns about the potential ecological interactions between introduced stocks and native stocks. Because the Central Valley steelhead population has been fragmented into smaller isolated tributaries without any large source population and the remaining habitat continues to be degraded by water diversions, the population remains at an elevated risk for future population declines.

3. <u>North American Green Sturgeon</u>

a. *General Life History*

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 1980, Moyle *et al.* 1992). It is believed that 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 and then southwards to Japan. They have been recorded from at least six different countries:

Mexico, United States, Canada, Russia (Sakhalin Island), Japan and Korea (Emmett *et al.* 1991, Moyle *et al.* 1992). Although widely distributed, they are not very abundant in comparison to the sympatric white sturgeon (*Acipenser transmontanus*).

(1) ***Adult Distribution and Feeding***. 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. Spawning has only been reported in one Asian river, the Tumin River in eastern Asia. 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). 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). Recent acoustical tagging studies on the Rogue River (Erickson *et al.* 2002) have shown that adult green sturgeon will hold for as much as 6 months in deep (> 5m), low gradient reaches or off channel sloughs or coves of the river during summer months when water temperatures were between 15 ^{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.

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 sturgeon caught in Washington state waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

(2) ***Spawning***. Adult green sturgeon are gonochoristic (sex genetically fixed), oviparous and iteroparous. They are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (10 to 15 years based on sympatric white sturgeon sexual maturity). Younger females may not spawn the first time they undergo oogenesis and reabsorb their gametes. Adult female green sturgeon produce between 60,000 and 140,000 eggs, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van Eenennaam *et al.* 2001). They have the largest egg size of any sturgeon, and the volume of yolk ensures an ample supply of energy for the developing embryo. The eggs themselves are slightly adhesive, much less so than the sympatric white sturgeon, and are more dense than than those of white sturgeon (Kynard *et al.* 2005). Adults begin their upstream spawning migrations into freshwater in late February with spawning occuring between March and July. Peak spawning is believed to occur between April and June in deep, turbulent, mainstem channels over large cobble and rocky substrates with crevices and interstices. Females broadcast spawn their eggs over this substrate, and the fertilized eggs sink into the interstices of the substrate where they develop further (Kynard *et al.* 2005).

(3) ***Egg Development.*** 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), which is similar to the sympatric white sturgeon development rate (176 hours). Studies conducted at the University of California, Davis by Van Eenennaam *et al.* (2005) indicated that an optimum

range of water temperature for egg development ranged between 14 °C and 17 °C. Temperatures over 23 °C resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5 °C and 22 °C resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14 °C, hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so.

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

Olfactory and auditory vesicles are present while the mouth and respiratory structures are only shallow clefts on the head. At 10 days of age, the yolk sac has become greatly reduced in size and the larvae initiates exogenous feeding through a functional mouth. The fin folds have become more developed and formation of fin rays begins to occur in all fin tissues. By 45 days of age, the green sturgeon larvae have completed their metamorphosis, which is characterized by the development of dorsal, lateral, and ventral scutes, elongation of the barbels, rostrum, and caudal peduncle, reabsorption of the caudal and ventral fin folds, and the development of fin rays. The juvenile fish resembles the adult form, including the dark olive coloring, with a dark mid-ventral stripe (Deng *et al.* 2002).

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 behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al.*'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 8 °C, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds.

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance (*i.e.*, growth, food conversion, swimming ability) between 15 °C and 19 °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 °C to approximately 24 °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 (Whiskeytown, Oroville, Folsom, and Nimbus dams).

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). This latter study also indicated that the lowered turbidity found in tailwater streams and rivers due to dams increased the effectiveness of sculpin predation on sturgeon larvae under laboratory conditions.

b. *Population Trends –Southern DPS of North American Green Sturgeon*

Known historic and current spawning occurs in the Sacramento River (Adams *et al.* 2002, Beamesderfer *et al.* 2004). Currently, upstream migrations of sturgeon are halted by Keswick and Shasta Dams on the mainstem of the Sacramento 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 constructed on the river.

Spawning on the Feather River is suspected to have occurred in the past due to the continued presence of adult green sturgeon in the river below Oroville Dam. This continued presence of adults below the dam suggests that fish are trying to migrate to upstream spawning areas now blocked by the dam which was constructed in 1968.

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 over the past two centuries.

The size of the population of green sturgeon is difficult to estimate due to a lack of data specific for this fish. Ratios of tagged white to green sturgeon in San Pablo Bay have generated population estimates averaging 12,499 sub-adult and adult green sturgeon. Captures of juvenile and sub-adult green sturgeon passing Red Bluff Diversion Dam have exceeded 2,000 individuals in some years. Inferences from the commercial and sport fisheries harvest can be used to estimate population trends over time. Based on the harvest numbers, green sturgeon catch has decreased from a high of 9,065 in 1986 to 512 in 2003. The greatest decreases in harvest were for commercial gears in the Columbia River, Willapa Bay, and Greys Harbor. The decrease was attributed to changes in the regulatory statutes for sturgeon harvest (Adams *et al.* 2002). Catch rates for the Hoopa and Yurok tribal harvests remained unchanged during this same period and accounted for approximately 59 percent of the total harvest in 2003 (NMFS 2005a). Entrainment numbers at the SWP and CVP pumping facilities in the south Delta have been consistently lower than their levels in the mid -1970s (SWP) and the mid-1980s (CVP). Prior to 1986, the SWP (1968 -2001) averaged 732 green sturgeon salvaged per year, which dropped to 47 per year after 1986. The CVP (1980-2001) showed similar declines in its salvage rate for green sturgeon, 889 per year prior to 1986 and 32 per year after 1986.

c. *Status –Southern DPS of North American Green Sturgeon*

The southern DPS of North American green sturgeon historically was smaller than the sympatric population of white sturgeon in the San Francisco Bay estuary and its associated tributaries. The population has apparently been declining over the past several decades based on harvest numbers from the California sturgeon sport fishery in the San Francisco Bay estuary and the Sacramento – San Joaquin Delta as well as the Northwestern commercial sturgeon fisheries in the Columbia River estuary, where significant numbers of the southern DPS of green sturgeon congregate. These fisheries capture segments of this DPS as incidental bycatch while targeting the more desired white sturgeon. In addition, the numbers of green stugeon entrained at the CVP and SWP pumping facilities have shown consistent reductions in the total number of sturgeon entrained by the pumping actions over the past several years without a concurrent reduction in the pumping rates. The principle factor for this decline is the reduction of green sturgeon spawning habitat to a limited area below Keswick Dam on the Sacramento River. The construction of impassable barriers, particularly large dams, has greatly reduced the access of green sturgeon to their historical spawning areas. These barriers and their manipulation of the normal hydrograph for the river also have had detrimental effects on the natural life history of green sturgeon. Reduced flows have corresponded with weakened year class recruitment in the sympatric white sturgeon population and it is believed to have the same effect upon green sturgeon recruitment. Obstruction of natural sedmiment recruitment below large impoundments potentially has increased predation on larval and juvenile sturgeon due to a reduction in turbidity and loss of larger diameter substrate. In addition to the adverse effects of impassable barriers, numerous agricultural water diversions exist in the Sacramento River and the Delta along the migratory route of larval and juvenile sturgeon. Entrainment, or, if equipped with a fish screen, impingement are considered serious threats to sturgeon during their downstream migration. Fish screens have not been designed with criteria that address sturgeon behavior or swimming capabilities. The benthic oriented sturgeon are also more susceptible to contaminated sediments through dermal contact and through their feeding behavior of ingesting prey along with contaminated sediments before winnowing out the sediment. Their long life spans allow them to accumulate high body burdens of contaminants, that potentially will reach concentrations with deleterious physiological effects.

C. Habitat Condition and Function for Species' Conservation

The freshwater habitat of salmon, steelhead, and sturgeon in the Sacramento River, San Joaquin River, and Suisun Marsh watershed drainages varies in function depending on location. Spawning areas are located in accessible, upstream reaches of the Sacramento or San Joaquin Rivers and their watersheds where viable spawning gravels and water quality are found. Spawning habitat condition is strongly affected by water flow and quality, especially temperature, DO, and silt load, all of which can greatly affect the survival of eggs and larvae.

High quality spawning habitat is now inaccessible behind large dams in these watersheds, which limits salmonids to spawning in marginal tailwater habitat below the dams. Despite often intensive management efforts, the existing spawning habitat below dams is highly susceptible to inadequate flows and high temperatures due to competing demands for water, which impairs the habitat function.

Migratory corridors are downstream of the spawning area and include the Delta and Suisun Marsh. These corridors allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat conditions are impaired in each of these drainages by the presence of barriers, which can include dams, unscreened or poorly-screened diversions, inadequate water flows, and degraded water quality.

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 by salmonids, but such use has not been documented for sturgeon. Rearing habitat condition is strongly affected by habitat complexity, food supply, and presence of predators of juvenile salmonids and sturgeon. Some complex, productive habitats with floodplains remain in the Sacramento and San Joaquin River systems (*e.g.*, the lower Cosumnes River, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa) and the Yolo and Sutter bypasses). However, the channelized, leveed, and rip-rapped river reaches and sloughs that are common in the Delta and Suisun Marsh systems typically have lower habitat complexity, lower abundance of food organisms, and offer little protection from either fish or avian predators.

IV. ENVIRONMENTAL BASELINE

A. Factors Affecting the Species and Habitat

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley and Suisun Marsh. For example, NMFS prepared range-wide status reviews for West coast Chinook salmon (Myers *et al.* 1998), steelhead (Busby *et al.* 1996) and green sturgon (Adams *et al.* 2002, NMFS 2005a). Also, the NMFS BRT published a draft updated status review for West coast Chinook salmon and steelhead in November 2003 (NMFS 2003) and a final review in June 2005 (Good *et al.* 2005). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*e.g.*, 58 FR 33212, 59 FR 440, 62 FR 24588, 62 FR 43937, 63 FR 13347, 64 FR 24049, 64 FR 50394, 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Bay-Delta Program (CALFED 1999), and the Final Programmatic EIS for the CVPIA (Department of Interior (DOI) 1999), provide an excellent summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley.

The following general description of the factors affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, North American green sturgeon and their habitat is based on a summary of these documents.

In general, the human activities that have affected the listed anadromous salmonids and their habitats consist of: (1) dam construction that blocks previously accessible habitat; (2) water development and management activities that affect water quantity, flow timing, quality, and stream function; (3) land use activities such as agriculture, flood control, urban development, mining, road construction, and logging that degrade aquatic and riparian habitat; (4) hatchery operation and practices; (5) harvest activities; and (6) ecosystem restoration actions.

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.

In general, large dams on every major tributary to the Sacramento River, the San Joaquin River, and the Delta block access to the historical spawning reaches in the upper portions of these watersheds for listed salmon, steelhead and green stugeon in the Central Valley. On the Sacramento River, Keswick Dam blocks passage to historic spawning and rearing habitat in the upper Sacramento, McCloud, and Pit Rivers. Whiskeytown Dam blocks access to the upper watershed of Clear Creek. Oroville Dam and associated facilities block passage to the upper Feather River watershed. Nimbus Dam blocks access to most of the American River basin. Friant Dam construction in the mid-1940s has been associated with the elimination of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River (DOI 1999). On the Stanislaus River, construction of Goodwin Dam (1912), Tulloch Dam (1957), and New Melones Dam (1979) blocked both spring- and fall-run Chinook salmon (CDFG 2001) as well as Central Valley steelhead. Similarly, La Grange Dam (1893) and New Don Pedro Dam (1971) blocked upstream access to salmonids on the Tuolumne River. Upstream migration on the Merced River was blocked in 1910 by the construction of Merced Falls and Crocker-Huffman Dams and later New Exchequer Dam (1967) and McSwain Dam (1967). These dams also had the potential to block any spawning populations of green sturgeon in these tributaries.

As a result of the dams, winter-run Chinook salmon, spring-run Chinook salmon, and steelhead populations on these rivers 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 a major stressor to adults and juvenile salmonids. Green sturgeon populations would be similarly affected by these barriers and alterations to the natural hydrology.

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 have delayed or blocked passage of adult Chinook salmon migrating upstream (Edwards *et al.* 1996, Tillman *et al.* 1996, California Department of Water Resources (DWR) 2002). The effects of the SMSCG on sturgeon is 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 streamflows 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 foodweb processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement (Mount 1995, Ayers and Associates 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.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Hundreds of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, 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 (FWS 2003b). However, since the 2001 paper by Herren and Kawasaki, the largest diversion facilities in the Central Valley have been targeted for installation of modern fish screens under the Anadromous Fish Screen Program, and most have been screened or have pending plans for screens in place (Steve Thomas, NMFS, personal communication). The remaining unscreened diversions are typically smaller in size and divert considerably less water than the larger diversions.

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP/SWP. 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. 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). 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 degradation and fragmentation of riparian habitat had resulted mainly from flood control and bank protection projects, together with the conversion of riparian land to agriculture. Removal of snags and driftwood in the Sacramento and San Joaquin River basins has reduced sources of LWD needed to form and maintain stream habitat that salmon depend on in their various life stages.

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is one of the primary causes of salmonid habitat degradation (NMFS 1996). 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 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 (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 1998). 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).

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).

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 bedload 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.

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.

4. 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 waterbody having elevated levels of chlorpyrifos, dichlorodiphenyltrichlor (*i.e.* DDT), diazinon, electrical conductivity, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (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.

Sediments can either act as a sink or as a source of contamination depending on hydrological conditions and the type of habitat the sediment occurs in. Sediment provides habitat for many aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into the surface waters. 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 (EPA 1994). 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 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 3).

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). As the river water and its constituents move downstream from the San Joaquin River channel to the DWSC, the channel depth increases from approximately 8 to 10 feet to over 35 feet. The water column is no longer mixed adequately to prevent DO from decreasing by contact with the air–water interface only. Photosynthesis by suspended algae is diminished by increased turbidity and circulation below the photosynthetic compensation depth. This is the depth to which light penetrates with adequate intensity to carry on photosynthesis in excess of the oxygen demands of respiration. As the oxygen demand from respiration, defined as biological oxygen demand, exceeds the rate at which oxygen can be produced by photosynthesis and mixing, then the level of DO in the water column will decrease. Additional demands on oxygen are also exerted in non-biological chemical reactions in which compounds consume oxygen in an oxidation-reduction reaction.

5. 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 (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.

6. Commercial and Sport Harvest

a. *Ocean Harvest*

(1) *Chinook salmon*. Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the 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 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 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 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.

Ocean fisheries have affected the age structure of spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). There are limited data on spring-run Chinook salmon ocean harvest rates. An analysis of 6 tagged groups of FRH spring-run Chinook salmon by Cramer and Demko (1997) indicated that harvest rates of 3-year-old fish ranged from 18 percent to 22 percent, 4-year-old fish ranged from 57 percent to 84 percent, and 5-year-olds ranged from 97 percent to 100 percent. The almost complete removal of 5-year-olds from the population effectively reduces the age structure of the species, which reduces its resiliency to factors that may impact a particular year class (*e.g.*, pre-spawning mortality from lethal instream water temperatures).

(2) ***Green sturgeon.*** Ocean harvest of green sturgeon occurs primarily along the Oregon and Washington coasts and within their coastal estuaries. A commercial fishery for sturgeon still exists within the Columbia River, where they are caught in gill nets along with the more commercially valuable white sturgeon. Since the southern population of green sturgeon migrates along the western coast of the United States and Canada, individuals of this DPS can be found along the entire coastline and thus are susceptible to commercial harvest in the waters of the northwest. A relatively significant proportion of the Columbia River population of green sturgeon has their origins in the southern population spawning areas, as determined by genetic markers. Green sturgeon are also caught by recreational fisherman, and it is the primary bottomfish landed in Willapa Bay, Washington. Within the San Francisco Bay 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).

b. *Freshwater Sport Harvest*

(1) ***Chinook salmon.*** Historically in California, almost half of the river sportfishing 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 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 winter-run Chinook salmon are ascending the Sacramento River to their spawning grounds. These closures have virtually eliminated impacts on 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 spring-run Chinook salmon throughout the species' range. During the summer, holding adult 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 spring-run Chinook salmon in Mill, Deer, Butte and Big Chico creeks were added to the existing CDFG regulations in 1994. The current regulations, including those developed for winter-run Chinook salmon; provide some level of protection for spring-run fish (CDFG 1998).

(2) ***Steelhead.*** 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. Staley (1975) estimated the harvest rate in the American River during the 1971-1972 and 1973-1974 seasons to be 27 percent. 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 (CDFG 2004c). Overall, this regulation has greatly increased protection of naturally produced adult steelhead.

(3) ***Green sturgeon.*** Green sturgeon are caught incidentally by sport fisherman targeting the more highly desired white sturgeon within the Delta waterways and the Sacramento River. As of March 2006, no green sturgeon may be retained by fisherman in California waters. In July 2006 the CDFG reversed their earlier prohibition on the take of green sturgeon in California waters by sportfisherman. Currently the slot limits for sturgeon caught by sportfisherman in California waters are 46 to 72 inches with a daily bag limit of one fish. This protects the stocks of green sturgeon that are found within the same waters as the targeted white sturgeon.

7. <u>Predation</u>

Accelerated predation also may be a factor in the decline of winter-run Chinook salmon and spring-run Chinook salmon, and to a lesser degree 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 diversion dam, GCID's diversion dam, areas where rock revetment has replaced natural riverbank 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 factors such as water quality and 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 (Vogel *et al.* 1988). 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.

FWS 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).

Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the State and Federal 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 (NMFS 1997).

8. 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.

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 subadult life stage.

Salmon and steelhead are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Predation rates on juvenile and adult green sturgeon have not been adequately studied to date. Ocean predation may also contribute to significant natural mortality, although it is not known to what extent. In general, salmonids are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the rebound of seal and sea lion populations following their protection under the Marine Mammal Protection Act of 1972 has increased the number of salmonid deaths. This may be further exacerbated by the decline of other fisheries stocks (*i.e.* haddock, Pollock, and members of the genus *Sebastes*) which provided alternative forage resources to marine mammals.

Finally, unusual drought conditions may warrant additional consideration in California. Flows in 2001 were among the lowest flow conditions on record in the Central Valley. The available water in the Sacramento watershed and San Joaquin watershed was 70 percent and 66 percent of normal, according to the Sacramento River Index and the San Joaquin River Index, respectively. Back-to-back drought years could be catastrophic to small populations of listed salmonids that are dependent upon reservoir releases for their success (*e.g.*, winter-run Chinook salmon). Therefore, reservoir carryover storage (usually referred to as end-of-September storage) is a key element in providing adequate reserves to protect salmon and steelhead during extended drought periods. In order to buffer the effect of drought conditions and over allocation of resources, NMFS in the past has recommended that minimum carryover storage be maintained in Shasta and other reservoirs to help alleviate critical flow and temperature conditions in the fall. Green sturgeon's need for appropriate water temperatures would also benefit from river operations that maintain a suitable temperature profile for this species.

The future effects of global warming are of key interest to salmonid and green sturgeon survival. It is predicted that Sierra snow packs will dwindle with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains. 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 rationally 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.* winter-run Chinook salmon and Central Valley steelhead) that must hold below the dam over the summer and fall periods. Similar, although potentially to a lesser degree, declines in green sturgeon populations are anticipated with reduced cold water flows. Green sturgeon egg and larval development are optimized at water temperatures that are only slightly higher than those for salmonids. Lethal temperatures are similar to salmonids, although slightly higher than those for salmonids.

9. <u>Ecosystem Restoration</u>

a. *California Bay-Delta Authority*

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. 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. This program is in the development stage and the benefits to listed salmonids are not yet clear. Clear Creek is one of five 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. 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.

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*

EPA'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 Appendix J, Reclamation 2004). 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 Chapter 15, Reclamation 2004).

The Spring-run Salmon Increased Protection Project provides overtime wages for CDFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1996. Through the Delta-Bay Enhanced Enforcement Program, initiated in 1994, a team of 10 wardens focus their enforcement efforts on salmon, steelhead, and other species of concern from the San Francisco Bay Estuary upstream into the Sacramento and San Joaquin River basins. These two enhanced enforcement programs have had significant, but unquantified benefits; to spring-run Chinook salmon attributed by CDFG (see Chapter 15, Reclamation 2004).

The Mill and Deer Creek Water Exchange projects are designed to provide new wells that enable diverters to bank groundwater in place of stream flow, thus leaving water in the stream during critical migration periods. On Mill Creek several agreements between Los Molinos Mutual Water Company (LMMWC), Orange Cove Irrigation District (OCID), CDFG, and DWR allows DWR to pump groundwater from two wells into the LMMWC canals to pay back LMMWC water rights for surface water released downstream for fish. Although the Mill Creek Water Exchange project was initiated in 1990 and the agreement allows for a well capacity of 25 cfs, only 12 cfs has been developed to date (Reclamation and OCID 1999). In addition, it has been determined that a base flow of greater than 25 cfs is needed during the April through June period for upstream passage of adult spring-run Chinook salmon in Mill Creek (Reclamation and OCID 1999). In some years, water diversions from the creek are curtailed by amounts sufficient to provide for passage of upstream migrating adult spring-run Chinook salmon and downstream migrating juvenile steelhead and spring-run Chinook salmon. However, the current arrangement does not ensure adequate flow conditions will be maintained in all years. DWR, CDFG, and FWS have developed the Mill Creek Adaptive Management Enhancement Plan to address the instream flow issues. A pilot project using 1 of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Future testing is planned with implementation to follow.

10. Non-native Invasive Species

As currently seen in the San Francisco estuary, non-native invasive species (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.

11. 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) have been agreed upon but have yet to be implemented in the field. Benefits to listed salmonids from the EWA have been smaller than anticipated.

Similar to the listed salmonids, the southern DPS of North American green sturgeon have been negatively impacted by hydroelectric and water storage operations in the Central Valley which ultimately affect the hydrology and accessibility 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.

B. Existing Monitoring Programs

Salmon-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 4 (Appendix A) by geographic area and target species. Information for this summary was derived from a variety of sources:

- 1999 IEP Steelhead Project Work Team report on monitoring, assessment, and research on steelhead: status of knowledge, review of existing programs, and assessment of needs (IEP Steelhead Project Work Team 1999);
- 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 the 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 the fish are also being conducted to better understand the fish's niche in the aquatic system.

C. Presence of Listed Salmonids in the Action Area

Based on fish monitoring studies, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead juveniles and smolts from the Sacramento River watershed frequently enter into the south Delta system based on river flows and SWP and CVP pumping rates. Fish from the Sacramento River can access the south Delta via the Old River and Middle River channels from the north. These river channels merge with the San Joaquin River, which in turn connects with the Sacramento River system further north at several points: the Delta Cross Channel via the North and South Forks of the Mokelumne River, Georgiana Slough, Three Mile Slough, and the mouth of the San Joaquin River near Antioch and Sherman Island. Central Valley steelhead emigrating downstream in the San Joaquin River system have a high potential to move through the action area due to the flow split at the Head of Old River, the timing of their emigration in relation to the installation of the Head of Old River barrier (HORB), and the pumping activities of the CVP pulling water through the Old River channel towards that facility.

The action area for the MHWWTP expansion project is an approximately two-mile section of Old River just upstream (southeast) of the CVP intake facilities. All three listed salmonid species are captured and salvaged at the CVP and SWP fish collection facilities. The potential for winter-run and spring-run Chinook salmon and Sacramento River basin steelhead occurring upstream of the collection facilities are lower than the potential for occurrence at the collection facilities due to the overlying hydrodynamics of the channels during the emigration periods of these fish. Higher flows out of the San Joaquin River basin during the emigration period should push fish away from the action area and downstream. However, during each high tide, tidal hydraulics could push fish upstream of the pumping facilities and into the action area. This is especially likely on a strong spring tide when net tidal flow is greater than the volume of water entering from the upstream side of the action area from the San Joaquin River.

D. Presence of Green Sturgeon in the Action Area

Although the Sacramento River watershed is the identified migration route and spawning area for green sturgeon, both adult and juvenile green sturgeon are known to occur within the lower reaches of the San Joaquin River and into the south Delta. Juveniles have been captured in the vicinity of Santa Clara Shoals, Brannan Island State Recreational Area and in the channels of the south Delta (Moyle *et al.* 1992, Beamesderfer *et al.* 2004). Green sturgeon also have been recovered at both the SWP and CVP pumping facilities on Old River near Tracy, indicating that they must have transited through one of the many channels of the south Delta to reach that location. Both adult and juvenile green sturgeon may use the Delta as a migratory, resting, or rearing habitat. Presence in the Delta could occur in any month, as juveniles may reside there during their first few years of growth. Adults are likely to be present in the winter and early spring as they move through the Delta towards their spawning grounds in the upper Sacramento River watershed. Following spawning, the fish will pass through the Delta again on their way back to the ocean, but the duration and timing of this event is not well understood in the Sacramento River system.

V. EFFECTS OF THE ACTION

Pursuant to section 7(a)(2) of the Endangered Species Act (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. This biological opinion assesses the effects of the MHWWTP expansion project on the endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, threatened Central Valley steelhead, the southern DPS of North American green sturgeon, and designated critical habitat for Central Valley steelhead. The MHWWTP expansion project is likely to adversely affect listed species and critical habitat primarily through discharge of wastewater effluent to waters of the Delta. In the *Description of the Proposed Action* section of this Opinion, NMFS (NMFS) provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this 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.

Regulations that implement section 7(b)(2) of the ESA require that biological opinions 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 also requires biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536).

NMFS generally approaches "jeopardy" 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; among 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.

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat found at 50 CFR 402.02, which has been invalidated by the courts. 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.

A. Approach to Assessment

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 Delta Simulation Model Version 2 (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. In addition to the DSM2 model runs for mixing and dilution, NMFS was provided with the results of a dye tracer study within the Old River channel adjacent to the diffuser site. However, the diffuser will emit a continuous stream of effluent rather than a single point injection of material. The level of dilution from a continuous infusion of material may not be adequately modeled by the single point injection used in the characterization studies of mixing and dilution. Because of the above modeling uncertainties, NMFS has assumed that listed fish occurring near the MHWWTP outfall may be exposed to higher concentrations of wastewater effluent (*i.e.*, undiluted effluent) than predicted by the above studies.

B. Assessment

The MHWWTP expansion project will result in a new wastewater discharge to Old River. The effects of the proposed project will fall into two main categories: short-term construction related effects and 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 July 1 through December 31 and the transitory nature of the construction process for the installation of the diffuser pipeline, which is projected to last no more than 2 weeks. This work window will avoid the vast majority of listed salmonids that have the potential to be present in the channel of Old River during their migration through the Sacramento-San Joaquin Delta but will overlap with the potential presence of 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 Old River year-round. Some pollutants are expected to cause mainly sublethal effects to listed salmonids, particularly (1) Central Valley steelhead originating from the San Joaquin River drainage which will have a greater likelihood of occurring in Old River, and (2) North American green sturgeon which, as indicated above, may be present year-round. NMFS expects that a dilution plume radiating from the diffuser array will have an oscillatory behavior due to natural tidal and river flow variables. Overlap of the dilution plume with listed fish is expected to be related in part to the effect of SWP and CVP water diversions on flow in the Old River channel, as well as the operations of the temporary and proposed permanent barriers in the South Delta.

1. Construction Effects

a. *Hydraulic Dredging*

(1) Entrainment of Fish and Invertebrates. The applicant plans to utilize hydraulic dredging to excavate the two trenches required to position the outfall diffuser pipes along the bottom of the Old River channel. The primary diffuser will require a total of 200 cubic yards to be excavated. An additional 170 cubic yards of material will be dredged for the secondary diffuser alignment. 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. Based on the shallow water depths found in the action area (less than 4 meters at high tide), and the relatively constricted width of the river channel (less than 300 feet at high tide, less than 170 feet at low tide), salmonids may be present throughout the entire water column and thus are vulnerable to entrainment if they are present in the channel during dredging actions. Similarly, if green sturgeon are present in the channel during dredging operations, they are vulnerable to entrainment due to their demersal behavior. This bottom-oriented behavior puts them in close proximity to the channel bottom and the cutterhead assembly during dredging operations. Most entrained fish would be expected to be injured and likely die. 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 2006a).

The applicant has stated in their project description that they will limit hydraulic dredging to the period between July 1 and December 31. This work window should avoid almost all migrating listed salmonids from both the Sacramento River watershed as well as the San Joaquin River watershed. There is a low probability of exposing emigrating Sacramento River winter-run

Chinook salmon and Central Valley steelhead during the latter portion of the work window (October through December) based on salvage records at the CVP and SWP, with the majority of these fish arriving in the south Delta channels in December. However, even in these later months, exposed fish numbers are expected to be very low due to the location of the action area in the south Delta being well separated from the major migratory paths of Sacramento River winter-run Chinook salmon, Central Valley steelhead, and North American green sturgeon.

In addition to a small number of juvenile salmonids and green sturgeon, other organisms are expected to be entrained by the hydraulic suction dredge, particularly small demersal fish and benthic invertebrates. Reine and Clark (1998) estimated that the mean entrainment rate of a typical benthic invertebrate, represented by the grass shrimp, when the cutterhead of a suction dredge was positioned at or near the bottom was 0.69 shrimp/cubic yard. The entrainment rate rose sharply to 3.4 shrimp/cubic yard 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 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. 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 minor due to the small area of the dredging impact (0.09 acres).

NMFS believes, based on the analysis of previous hydraulic dredging projects, that the entrainment risk to juvenile salmonids is low. A healthy salmonid smolt should have sufficient burst swimming speed at 10 body lengths per second to overcome the water flow velocity surrounding the intake of the cutterhead (see the technical memorandum to the administrative file for this project and NMFS 2005b for a more complete review of hydraulic dredging effects on salmonids). Although adult Central Valley steelhead from the San Joaquin River basin may move through the south Delta during the latter portion of the dredging work window, it is anticipated that adults will be able to avoid the effects of the entraining suction flow to the dredge cutterhead.

NMFS anticipates that green sturgeon will be present within the channels of the Delta region on a year round basis, both as adults and juveniles. The channels of the South Delta are known to have the potential for the presence of green sturgeon, based on the reported take of green sturgeon in the fish salvage operations of the CVP and SWP pumping facilities (Adams *et al.* 2002). However, the population size of green sturgeon is small. The applicant has stated in their project description that conservation measures will include the installation of fish exclusion devices to prevent the entrainment of green sturgeon by the dredge cutterhead. These exclusion devices will take the form of "rakers" or "cages" attached to the cutterhead to minimize or avoid the entrainment of sturgeon. The "rakers" or "cages" will create a physical barrier that will cause fish resting on the bottom to move out of the way of the dredge as it approaches. In addition to these exclusion devices, the small footprint of the diffuser pipe trench will reduce the time needed to complete the dredging operation. The applicant has stated that approximately 4,000 square feet of river bottom will be disturbed, 2,250 square feet for the primary diffuser alignment, and 1,700 square feet for the secondary diffuser alignment. Therefore, the expected dredging operation should not take more than 1 to 2 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 resuspends 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 2000 hp 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 resuspension 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 resuspended 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).

Resuspension 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 polyaromatic 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 4,000 square feet (0.09 acres) with dredging and construction operations lasting no more than 2 weeks. The estimated volume of material to be removed from the primary diffuser alignment is 200 cubic yards, while the secondary diffuser site will have a slightly lower volume of 170 cubic yards removed. Given the range of sediment resuspension associated with dredging, the anticipated volume of sediment injected into the overlying water column by the dredging action is expected to fall between 3.7 cubic yards and 37 cubic yards. 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 south Delta; therefore, NMFS does not anticipate any significant adverse effects to be associated with the short-term increase in turbidity associated with the dredging and construction phase of the diffuser installation. Also, turbidity conditions are expected to return to ambient levels within a week of the termination of dredging and construction (likely much sooner). Based on the timing of the dredging actions (July 1 through December 31), NMFS expects the majority of the direct impacts created by these activities to be experienced by adult Central Valley steelhead migrating upstream to the watersheds of the San Joaquin River (*i.e.* Stanislaus, Tuolumne and Merced Rivers) which have the highest potential to be in the Old River channel during the dredging window. Exposures to other Chinook salmon ESUs or Central Valley steelhead originating in other watersheds in the Central Valley are not expected due to the timing and duration of the dredging actions and the location and hydrology of the south Delta action area. The presence of winter-run and spring-run Chinook salmon juveniles in this portion of the south Delta is unlikely until January. The probability of occurrence peaks several months later in March and April, when peak emigration rates and pumping increases overlap. This draws fish into the south Delta under the influence of CVP and SWP water diversions and into the action area.

The exposure risk to green sturgeon is less clear. It can be anticipated that juvenile and adolescent green sturgeon could be found year-round in the central Delta, particularly in the deeper sections of the Old River channel based on sturgeon behavior and their preference for deep holes in river channels. Such areas occur near the intakes for the SWP and CVP. Presence on the shallower margins of the river is likely to occur at night, when fish are foraging in those areas. Therefore, the elevated turbidity levels created by the dredging and sheet pile installation during the daylight construction period may not persist into the night when sturgeon could be anticipated to move into the work area, thus reducing their exposure potential.

Sediment composition data was not included with the biological assessment (October 2005) but will be completed prior to the NPDES discharge permit issued by the Regional Board and the Corps 404 permit. NMFS anticipates that the chemical composition of the sediment within the proposed dredging footprint will meet water quality guidelines set forth in the Basin Plan for the Central Valley and the sediment quality guidelines proposed in Buchman (1999) and MacDonald *et al.* (2000).

(3) Acoustic Impacts. High levels of underwater acoustic noises have been shown to have adverse impacts upon fish within close proximity of the noise source. 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. The applicant has indicated that the dredging action will operate continuously for 1 to 2 days at each site and the entire dredging and construction phase of the project should not last more than 1 to 2 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 will continue on a 24-hour cycle such as cleaning the cutterhead, repositioning the dredge itself, and conducting maintenance work. The action area is located in a fairly narrow section of the Old River channel, ranging from 300 feet at high tide to less than 180 feet at low tide.

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 from the dredging activity. The sound energy peaked at a level of 100 to 110 dB (presumably at a reference pressure of 1µPascal (re:1µPa), 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, the closest distance would be 40 meters (131 feet) (based on the hopper dredge measurements). Based on this distance, the calculated point source level of sound energy is 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 is 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.

Recent studies by 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 the 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:1µPa), 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:1µPa) 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. Exposures of these other fish species can serve as surrogates for salmonids. Adverse effects were measured in these surrogates following as little as 2 hours of exposure to 142 dB (re:1μPa) sound energy.

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. NMFS believes the proposed project may result in salmonids 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 piscine predators either by reducing the sensitivity of the auditory response in the exposed salmonid or masking the noise of an approaching predator. Disruption of the exposed salmonid's ability to maintain position or swim with the school will enhance its potential as a target for predators. Unusual behavior or swimming characteristics single out an individual fish and allow a predator to focus its attack upon that fish more effectively. There is little data in general concerning green sturgeon physiology and hearing, and NMFS could not find information concerning the potential for hearing degradation from anthropogenic sources in the literature for this species. Therefore, NMFS will assume that some hearing degradation will occur in sturgeon if they are within close proximity to the dredge, 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 listed salmonids and green sturgeon may be exposed to the adverse effects of noise created during dredging activities. As stated above, a small number of emigrating Sacramento River winter-run Chinook salmon and Central Valley steelhead may be exposed during the latter portion of the work window (October through December) based on salvage records at the CVP and SWP, with the majority of these fish arriving in the south Delta channels in December. However, even in these later months, exposed fish numbers are expected to be very low due to the location of the action area in the south Delta and off the major migratory paths of winter-run Chinook salmon, Central Valley steelhead, and green sturgeon. Green sturgeon potentially may be present year-round, but the population is believed to be small, which decreases the likelihood of individual fish encountering the activities which are expected to be of limited duration and affect a small area.

b. *Degradation of Habitat*

Approximately 0.09 acres (4,000 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 recolonization 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 spawning cycles of invertebrate populations in the area. The areal extent of the dredging for the placement of the diffusers pipelines is relatively small (two sites with approximately 10 feet by 200 feet footprints). Suitable stocks of organisms and vegetation to serve as "seed" stock for the recolonization are present in the channel surrounding the action area. Typically recolonization 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 impacted compared to its overall availability, NMFS believes that adverse effects to listed salmonids and green sturgeon will be minor.

Approximately 600 square feet of levee face will be disturbed by the placement of the diffuser pipelines into the channel of Old River. Currently most of these levee surfaces are vegetated with non-native ruderal (weedy) plants, some of which overhang the waters of the channel. Although not high quality habitat, this vegetation can provide some shade and cover during high tides and high water events and thus may be used as cover by listed salmonids. It also may serve as a source of terrestrial insects for salmonids foraging along the margins of the river channel. The removal of all vegetation along these portions of the levee face for pipeline installation will degrade the already diminished riparian habitat even further than is currently present. The applicant has stated that they will replace trees at a 3 to 1 ratio for any that are removed during the pipeline installation. Due temporary nature of the disturbance and the small amount of levee face that will be affected compared to its overall availability, NMFS believes that adverse effects of this disturbance to listed salmonids and green sturgeon will be minor.

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, several thousand feet of trench will be dug along the levee crown. A ductile iron pipeline will be placed in this trench to carry effluent to the diffuser outfalls. 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 Old River 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. 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. Therefore, NMFS does not anticipate that listed salmonids and green sturgeon are likely to be adversely affected by construction spills.

2. <u>Long-term Operational Effects</u>

a. Habitat Alterations

The installation of subsurface structures in the channel of Old River has the potential to create holding habitat for predatory fish (*i.e.*, striped bass, largemouth bass, catfish (*Ictalurus* spp.), *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 indicate 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 (Tidalflex®) that will extend approximately 12-inches above grade along the bottom. The specifications for the diffuser indicate that the valves will be placed every 10-feet along the diffuser pipeline for a total of 10 Tidalflex® valves per a diffuser outfall (20 total). NMFS believes that these small structures will not create sufficient 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 effects of the project are expected to result from the MHWWTP effluent discharge to Old River. In particular, the discharge is expected to contain low levels of certain pollutants, and increase the water temperature and reduce the DO level in Old River near the outfall, which are likely to contribute to chronic, sub-lethal effects on listed fish. The discharge will occur year-round, and therefore all migrating salmonids that occur in Old River near the MHWWTP may be exposed to the adverse effects of project operation. Salmonids are expected to occur in the Delta from November 1 through June 30. Outmigrating 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 most likely to be exposed. Overall, the numbers of listed fish that will be adversely affected by the MHWWTP effluent discharge are expected to be low because Old River is not part of a major migration route for salmonids.

Adequate function of the MHWWTP within NPDES permit limits requires dilution of the effluent by the waters of Old River. However, dilution of the effluent discharged to Old River is expected to vary due to the influences of tides (*i.e.*, the tidal range is approximately 4 feet) and seasonal outflow, which may have competing or complimentary effects. Dilution also is expected to be affected by agricultural diversion of water and the installation of flow barriers in the south Delta, which also vary seasonally. The influence of these factors on the flow characteristics of Old River is explained in detail in a technical memorandum to the administrative file (NMFS 2006). Despite modeling efforts and because the dilution characteristics of the diffuser array are uncertain and fish may occur very close to the outfall, the following analysis assumes that listed fish may be exposed to undiluted effluent as a simple worst case scenario.

The applicant used effluent from its current wastewater treatment facility to generate the chemical profile of its discharge for the future facility. Of the 300 chemical constituents looked at in the analysis, 18 were detected for which water quality criteria are listed (see Table 5, Appendix A). Of these 18 chemical constituents, NMFS used EPA-recommended statistical criteria (*i.e.*, within 2 standard deviations of the maximum reported value) to determine that 7 (aluminum, ammonia, chromium VI, copper, cyanide, heptachlor, and selenium) have the potential to exceed water quality criteria promulgated in either the California Toxics Rule (CTR) or the EPA National Recommended Water Quality Criteria. A subset of these seven (aluminum, ammonia, cyanide, and heptachlor) also were identified by the applicant as having the reasonable potential to exceed water quality standards. However, ammonia was indicated as likely to meet aquatic life criteria due to the upgraded treatment system of the new facility, with concentrations not expected to exceed 11 nanograms per liter. In contrast, the draft NPDES permit NMFS received on June 29, 2006, indicated that the permitted limits to the average monthly and daily discharges of ammonia from the MHWWTP would be much greater (*i.e.*, 1.0 and 3.0 mg/l, respectively). Therefore, the following assessment includes discussion of the potential adverse effects of all seven chemical constituents identified above on listed fish. Additionally, we also assess the potential adverse effects of discharging pharmaceuticals and personal care products (PPCPs, which often have no water quality criteria) to the receiving waters of Old River, and expected increases in water temperature and decreases in DO.

NMFS also expects local benthic invertebrate fauna to be affected by the chemical constituents contained in the discharge of the WWTP effluent. These invertebrate populations are typically exposed for much greater periods of time then the listed fish and are relatively non-motile in comparison to them. Therefore accumulations of contaminants in the sediments surrounding the diffuser outfalls expose these invertebrate populations to higher levels of contaminants than are typically seen in the overlying water column (EPA 1994, Ingersoll 1995). These populations of invertebrates are important to the successful rearing of the listed fish within the action area by providing a suitable forage base for their nutritional needs. Diminishment in their population numbers or changes in the community structure to less desirable prey species can have significant detrimental effects on rearing salmonids and green sturgeon in the action area which depend upon them for their forage base.

(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, cited in Laws 1993). Impairment of fish growth has been attributed to aluminum concentrations as low as 100 μg/l. (Cronan and Schofield 1979, cited in Laws 1993).

The 1-hour maximum exposure limit for freshwater aquatic organisms (CMC), according to both the EPA National Recommended Water Quality Criteria and the CTR, is 750 μg/l. The 4-day maximum continuous concentration (CCC) for aluminum is 87 μg/l according to the EPA and California standards. The maximum aluminum concentration in the outfall effluent is 200 μg/l according to data supplied by the applicant. NMFS believes that aluminum concentrations present in the MHWWTP effluent will contribute to impaired gill function and reduced growth of listed salmonids and green sturgeon that are exposed. This ultimately may reduce the efficiency of oxygen uptake, increase the vulnerability of affected individuals to predators, and reduce the likelihood of survival. However, 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, and because the buffering capacity (*i.e.*, ambient pH greater than 7) of the receiving waters should reduce the intensity of the adverse effects.

Sublethal or nonlethal endpoints don't require that mortality be absent; rather it indicates that death is not the primary toxic endpoint being examined. Rand (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, may diminish the ability of the salmonids to find food or escape from predators and may ultimately result in 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

(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 3 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 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 EPA National Recommended Water Quality Criteria and the CTR standards promulgate a CMC of 2.89 mg/l and a CCC of 2.54 mg/l for ammonia. The draft NPDES permit for the proposed project allows average monthly and daily discharge concentrations of ammonia to be 1.0 and 3.0 mg/l, respectively. NMFS believes that ammonia concentrations present in the MHWWTP effluent will 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 that are exposed. 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. The limits to ammonia concentrations reported in the draft NPDES permit indicate that potentially lethal levels may be reached in the undiluted effluent. Lower concentrations below the lethal thresholds are expected to cause effects that are chronic and sub-lethal because the movement of fish should limit their exposure to concentrated effluent from the project outfall.

(3) *Chromium VI.* Chromium salts are generally derived from industrial sources, particularly electroplating, production of cleaning agents, wood preservatives, and paints. Hexavalent chromium is a carcinogen, renal toxin, and has epidermal effects which would erode gill epithelia in fish. Early research (Olson and Foster 1956) reported that inhibition of growth occurred in Chinook salmon exposed to 16 µg/l hexavalent chromium and in rainbow trout (*O. mykiss*) exposed to 21 µg/l hexavalent chromium.

Current EPA National Recommended Water Quality Criteria and the CTR standards promulgate a CMC of 16 µg/l and a CCC of 11 µg/l for hexavalent chromium. The applicant's discharge data indicates that the maximum effluent concentration of hexavalent chromium was 10 µg/l. NMFS believes that hexavalent chromium concentrations present in the MHWWTP effluent will 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 that are exposed. 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, 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.

(4) *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 threshold of sublethal toxicity was 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.

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 EPA National Recommended Water Quality Criteria and the CTR standards promulgate a CMC of 16 μg/l and a CCC of 11 μg/l for copper. The applicant's discharge data indicates that the maximum effluent concentration of copper was 6.8 μg/l. NMFS believes that copper concentrations present in the MHWWTP effluent will contribute to adverse effects such as habitat avoidance and reduced olfactory function of listed salmonids and green sturgeon that are exposed. This ultimately may increase the vulnerability of affected individuals to predators, reduce feeding efficiency, and reduce the likelihood of successful migration. However, 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.

(5) *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 mitochondrial 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 50μg/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 EPA 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 8.9 μg/l. NMFS believes that cyanide concentrations present in the MHWWTP effluent will contribute to adverse effects ranging from slowed reactions to stimuli (*e.g.*, food or predators) to reduced reproductive output. 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.

(6) *Heptachlor*. Heptachlor is an organochlorine pesticide which affects the neurological functioning of the exposed organism. It was used as an insecticide to control termites, ants and other soil dwelling insects. In 1978, the EPA began to phase out the use of heptachlor in the United States and banned its use outright in 1988. It belongs to the cyclodiene class of organochlorine pesticides and primarily affects the chloride ion (Cl^-) channels of neurons by blocking the gamma amino butyric acid (GABA) receptor on the neuron. When GABA is blocked, the neuron remains in a state of partial repolarization, which results in uncontrolled excitation of the neuron. Cyclodienes are also potent inhibitors of Na^+ - K^+ ATPase, and more importantly of the Ca^{2+}, Mg^{2+} - ATPase that is essential for the uptake and release of calcium across membranes. Inhibition of this transporter in the terminal ends of neurons in synaptic membranes results in an accumulation of intracellular free calcium ions with the promotion of calcium induced release of neurotransmitters from storage vesicles and the subsequent depolarization of adjacent neurons and the propagation of the stimuli throughout the central nervous system (Ecobichon 1996). Studies have shown that the average LC_{50} for Chinook salmon exposed to heptachlor is approximately 24 µg/l, whereas rainbow trout have an average LC_{50} value of 10 to 15 µg/l (pesticideinfo.org 2006). Heptachlor also is considered to be an endocrine disruptor, and like other cyclic polychlorinated compounds, mimics reproductive hormones in exposed organisms (Ecobichon 1996).

The water quality criteria for heptachlor promulgated by the EPA (National Recommended Water Quality Criteria) are 0.52µg/l (CMC) and 0.0038µg/l (CCC). The CTR has the same values for waters in California. The data provided by the applicant indicates that the effluent discharge has a maximum heptachlor concentration of 0.023 µg/l. NMFS believes that heptachlor concentrations present in the MHWWTP effluent will contribute to adverse effects based on reduced neurological function of listed salmonids and green sturgeon that are exposed, which may in turn impair their ability to feed, swim, avoid predators, *etc.* Endocrine disruption may reduce the likelihood of successful reproduction. 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.

(7) *Selenium.* Sulfur to sulfur bonds (ionic disulfide bonds) are important in creating the unique secondary, tertiary, and quaternary structures of proteins and enzymes that give them their specificity. When excess selenium is present, it interferes with the proper formation of sulfur to sulfur bonds (Lemly 2002), rendering the protein dysfunctional. This leads to malformations of protein structures (*e.g.*, gill lamellae or cartilage) or abnormal enzyme functions. Selenium toxicity has been linked to pathologies in the structure and function of gill lamellae, white and red blood cells, hepatocytes, kidney tissue, cardiac tissue, ovarian follicles, and eyes, and has been linked to increases of teratogenic deformities in fish and wildlife. Lemly (1999a, b) has indicated that selenium is tightly cycled in natural aquatic systems, continually re-exposing the aquatic life in the affected system for several decades following contamination. Selenium is bioconcentrated in animal and plant tissues and is then biomagnified as it passes up the food chain. Selenium is also passed from the mother through her eggs to the developing embryo. It is this characteristic that is very damaging to aquatic life. Low levels of selenium are bioconcentrated in the adult life form, generally without gross physical toxicity, but cause reproductive failure in the developing eggs. Exposed fish frequently fail to have successful recruitment of young, due to early mortality of the embryos or recently hatched offspring.

Recent research indicates that the current EPA water quality criteria of 5µg/l selenium may not be sufficiently protective of aquatic biota, and that adverse effects to fish and wildlife can occur as low as 2 µg/l (Hamilton 2004). The current EPA chronic standard for selenium (CCC) is 5 µg/l, while the CTR standards are 5µg/l for the CCC and 20 µg/l for the CMC. The applicant's effluent data indicates that the maximum selenium concentration measured in the effluent was 2.8 µg/l. NMFS believes that selenium concentrations present in the MHWWTP effluent will contribute to adverse effects such as reduced reproductive success of listed salmonids and green sturgeon that are exposed. 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.

(8) *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 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 MHWWTP effluent and the surrounding ambient South Delta waters are unknown; however, NMFS believes that PPCP concentrations present in the MHWWTP effluent will contribute to adverse effects such as reduced growth, impaired transition to the saltwater environment, and reduced reproductive output of listed salmonids and green sturgeon that are exposed. 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 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.

(9) ***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 daily water temperature differentials of nearly 20 °F can occur during most of 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 for the period between November and January were approximately 15 °F while the differentials for February through April were approximately 10 °F. The end of the pipe discharge temperatures are not anticipated to reach incipient lethal temperatures 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 and 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. Based on the modeled DO levels for winter, the end of the pipe DO levels are expected to be adequate for survival of listed salmonids, and reductions to ambient winter DO levels in Old River will be small and not likely to adversely affect listed salmonids and North American green sturgeon.

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.

Non-Federal actions that may affect the action area include ongoing agricultural activities and increased urbanization. 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,b).

The Delta and East Bay 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. The General Plans for the cities of Stockton, Brentwood, Lathrop, Tracy and Manteca and their surrounding communities anticipate rapid growth for several decades to come. The anticipated growth will occur along both the I-5 and US-99 transit corridors in the east, and Highway 205/120 in the south and west.

Increased urbanization also is expected to result in increased wave action and propeller wash in Delta waterways due to increased recreational boating activity. 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. Increased recreational boat operation in the Delta is anticipated to result in more contamination from the operation of engines on powered craft entering the water bodies of the Delta. In addition to recreational boating, commercial vessel traffic is expected to increase with the redevelopment plans of the Port of Stockton. Portions of this redevelopment plan have already been analyzed by NMFS for the West Complex (formerly Rough and Ready Island) but the redevelopment of the East Complex, which currently does not have a Federal action associated with it, will also increase vessel traffic as the Port becomes more modernized. Commercial vessel traffic is expected to create substantial entrainment of aquatic organisms through ship propellers as the vessels transit the shipping channel from Suisun Bay to the Port and back again. In addition, the hydrodynamics of the vessel traffic in the confines of the channel will create sediment resuspension, and localized zones of high turbulence and shear forces. These physical effects are expected to adversely affect aquatic organisms, including both listed salmonids and North American green sturgeon resulting in death or injury.

VII. INTEGRATION AND SYNTHESIS

A. Effects on Listed Species

This biological opinion assesses the effects of the MHWWTP expansion project on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the southern DPS of North American green sturgeon. NMFS believes that the short-term construction related effects will be minor due to the application of the work window of July 1 through December 31 and the transitory nature of the construction process for the installation of the diffuser pipeline, which is projected to last no more than 2 weeks. This work window will avoid the vast majority of listed salmonids that have the potential to be present in the channel of Old River during their migration through the Sacramento-San Joaquin Delta but will overlap with the potential presence of green sturgeon in the Delta, which are believed to reside there year-round. Construction effects will include entrainment of fish and invertebrates, increased turbidity, and noise impacts, but are expected to be minor and affect a small number of fish.

The greatest effects of the project are expected to occur over the long term, and result from the MHWWTP effluent discharge to Old River. In particular, the discharge is expected to contain low levels of certain pollutants (*i.e.*, aluminum, ammonia, chromium VI, copper, cyanide, heptachlor, and selenium, and PPCPs) in Old River near the outfall, which are likely to contribute to primarily chronic, sub-lethal effects on listed fish (*e.g.*, impaired ability to feed, swim, avoid predators, *etc.*). The discharge will occur year-round, and therefore all migrating salmonids that occur in Old River near the MHWWTP may be exposed to the adverse effects of the WWTP operation. Outmigrating 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 most likely to be exposed. Overall, the numbers of listed fish that will be adversely affected by the MHWWTP effluent discharge are expected to be low because Old River is not part of a major migration route for salmonids.

In addition to the direct exposure of the listed fish species, exposure of the local benthic invertebrate population to the contaminants will lead to indirect adverse effects upon these fish by diminishing the value of the forage base in the action area. NMFS anticipates that there will be a direct change in the invertebrate population numbers and community structure within the action area as a result of the WWTP discharge. These changes will have corresponding effects upon the listed salmonid species and the green sturgeon rearing in the action area.

B. Effects on Species Likelihood of Survival and Recovery

1. Sacramento River Winter-run Chinook salmon

NMFS does not anticipate that Sacramento River winter-run Chinook salmon adults will occur within the action area. The migratory path followed by winter-run adults lies to the north along the Sacramento River channel. Some straying or milling behavior may occur within the lower San Joaquin River system in the western and central portions of the Delta, but adults are not expected to stray as far south as the outfall sites in the Old River channel. Therefore, the effects of the project on adult winter-run Chinook salmon are expected to be discountable. Also, NMFS does not expect that large numbers of juvenile winter-run Chinook salmon will be present in the action area. Some fish may be carried past the CVP and SWP diversions on the incoming flood tide and make it to the MHWWTP outfall diffuser sites on Old River. NMFS anticipates that the potential number of fish exposed to the effluent plume will not be greater than the number of winter-run fish that are entrained at the CVP and SWP facilities. NMFS has previously calculated that the number of winter-run juveniles entrained by the SWP and CVP diversions amounts to no more than 1 or 2 percent of the emigrating juvenile winter-run population in a given year. Those fish that are present in the south Delta adjacent to the action area are from the same "pool" of fish that are considered to be affected by the operations of the water diversions by state and federal facilities (*i.e.* SWP and CVP). NMFS has previously determined that the amount of take associated with the operations of the SWP and CVP diversions did not constitute a jeopardy conclusion (NMFS 2004).

The loss of these few Sacramento River winter-run Chinook salmon smolts is not expected to decrease the number of returning adults, because of the large number of smolts that are produced by the population. Since no spawning or major freshwater rearing habitat will be affected by the proposed activities, impacts on spawning survival and survival from egg to smolt are not expected.

2. Central Valley Spring-run Chinook salmon

NMFS does not anticipate that Central Valley spring-run Chinook salmon adults will occur in the action area and thus are not likely to be adversely affected by the project. As previously explained for the spawning migration of adult Sacramento River winter-run Chinook salmon, spring-run Chinook salmon adults would tend to follow the same migratory pathways along the Sacramento River to their upstream spawning reaches in the tributaries to the Sacramento River, north of Sacramento. Some milling or holding in the Central Delta is possible due to the mixing of Sacramento River water with the waters of the San Joaquin River in the Central Delta, but it is unlikely that adult fish will be drawn into the south Delta. Therefore, the effects of the project on adult spring-run Chinook salmon are expected to be discountable. Yearling fish may appear in the lower San Joaquin River as early as late October, but are not likely to occur in any substantial numbers until after February when the pulse of emigrating juvenile spring-run Chinook salmon begin to enter the Delta. It is during these periods of out migrations that spring-run Chinook are pulled into the south Delta by the water diversion activities of the SWP and CVP. The exposure potential of spring-run Chinook salmon to the effluent water is expected to be low and involves relatively few fish as compared to the entire juvenile production that emigrates downstream in the Sacramento River. NMFS anticipates that the potential number of fish exposed to the effluent plume will not be greater than the number of spring-run fish that are entrained at the CVP and SWP facilities for the same reasons given above for the juvenile winter-run Chinook salmon migrants.

As with Sacramento River winter-run Chinook salmon, no spawning or major freshwater rearing habitat will be affected by the proposed activities, so impacts on spawning survival and survival from egg to smolt are not expected. The very small loss of spring-run smolts anticipated would be unlikely to result in a change in adult returns, because the number expected to be lost is small in comparison to the number of smolts produced and likely to survive to become adults.

3. Central Valley Steelhead

NMFS anticipates that the proposed project will result in the exposure of a small number of adult and juvenile Central Valley steelhead to increased levels of toxic chemicals including metals, cyanide, and organochlorine pesticides. The exposures to toxic chemicals may delay or impede fish migration causing increased energy expenditure by the affected individuals delayed by the effluent. The elevated stress levels and toxics may degrade the fish's health, energy levels, and the reproductive potential of adults, and increase the potential of juveniles to be preyed upon by striped bass or other large predators due to impaired behavioral and physiological responses. Individuals that appear different in their behavior attract predators, and thus experience higher mortality due to predator attacks. Prolonged exposure to even low levels of toxics, as would occur in low-flow conditions when water residence time in the affected channel may be on the order of several days due to tidal oscillations and barrier operations would enhance the potential uptake of metals and other contaminants by feeding juveniles.

Since the populations of adult steelhead from the San Joaquin River basin are considered to be quite small, even the loss of a few adult fish may have substantial adverse effects on juvenile age class sizes in succeeding years. Estimates of adult escapement of steelhead to the watersheds of the basin are typically only a few dozen or so. This is reflected by the low number of smolts captured by monitoring activities throughout the year in different tributaries (*i.e.*, rotary screw traps on the Stanislaus, Tuolumne, and Merced Rivers, and the Mossdale trawls on the San Joaquin River below the confluence of these three east side tributaries) in which only a few dozen smolts to several hundred smolts are collected each year (Marston 2004, S.P. Cramer 2005). These capture numbers have been extrapolated to estimate an annual population of only a few thousand juvenile steelhead smolts basin-wide in the San Joaquin River region. The Stanislaus River weir, which is used to count adult steelhead passing through the counting chamber or dead carcasses floating back onto the weir, has only recorded a few adult fish each year it has been in use. This is indicative of the low escapement numbers for adult steelhead in this watershed (S.P. Cramer 2005). The other watersheds are thought to have similar or even lower numbers based on the superiority of the Stanislaus River in terms of habitat and water quality for Central Valley steelhead.

The loss of one individual female's reproductive capacity either through mortality or reproductive degradation related to toxicant exposure can have a relatively high impact on a given watershed's potential population if the number of adults returning to each stream is low. Loss of one female with an expected egg capacity of 5,000 eggs represents approximately 50 to 100 smolts returning to the ocean (NMFS 2003, Good *et al.* 2005). Even though the loss of a few steelhead adults from the San Joaquin River basin watersheds could have significant impacts to future juvenile steelhead year classes in these systems, this is not expected to reduce the likelihood of survival and recovery of the Central Valley steelhead DPS. This is due to the relatively small contribution that these watersheds make to the entire Central Valley steelhead DPS. Straying of adults from other watersheds may help to sustain these small runs over the long term, replacing fish lost to natural and anthropogenic causes.

4. <u>Southern DPS of North American Green Sturgeon</u>

Sturgeon are expected to be more vulnerable to the adverse effects of the MHWWTP outfall effluent compared to salmon and steelhead. Their "inactive" resting behavior on the bottom puts them in dermal contact with contaminated sites surrounding outfalls where materials have precipitated out of solution. This can eventually lead to lesions and the production of tumors from materials in the substrate if the exposure is lengthy. Sturgeon are also benthic invertebrate feeders that forage on organisms that can sequester contaminants at much higher levels than the ambient water or sediment content, such as the Asian clams *Corbicula* and *Potamocorbula* that are prevalent in the Delta. The great longevity of sturgeons also places them at risk for the bioaccumulation of contaminants to levels that create physiologically adverse conditions within the body of the fish. Because they prefer deep pools, green sturgeon may have some reduced risk of exposure to effluent from the outfall sites, since the waters of the south Delta river channel at the location of the outfall are quite shallow and therefore would appear to be less attractive to sturgeon as holding water.

Little is known about the migratory habits and patterns of either adult or juvenile green sturgeon in the Delta region. The basic pattern described for adult green sturgeon migrations into the Delta region from the San Francisco Bay estuary is that fish enter the Delta region starting in late winter or early spring and migrate upstream towards the stretch of the Sacramento River between Red Bluff and Keswick Dam. After spawning, adults return downstream and re-enter the Delta towards late summer and fall (based on behavior of sturgeon in the Klamath and Rogue River systems). Juvenile and larval green sturgeon begin to show up in rotary screw trap catches along the Sacramento River starting in summer (Beamesderfer *et al.* 2004) and could be expected to reach the Delta by fall. The extent and duration of rearing in the Delta is unclear (*i.e.*, months to years), but NMFS believes that juvenile green sturgeon, including sub-adults, could be found during any month of the year within the waters of the Delta. Therefore, both adult and juvenile green sturgeon have the potential to be adversely affected by chronic exposure to low levels of toxic chemicals released in the effluent of the outfall. However, because green sturgeon apparently spawn only in the Sacramento River, relatively few green sturgeon are expected to be in the San Joaquin River drainage and the channels of the south Delta and thus few should be exposed to the adverse effects of the project.

C. Effects of the Proposed Action on Critical Habitat

The MHWWTP expansion project will affect only the designated critical habitat of the Central Valley steelhead DPS, which includes the channels of the south Delta where the outfall diffusers are to be built. Effects to critical habitat will be related primarily to the discharge of treated effluent, which will not enhance water quality within the action area and may even potentially degrade it. The maximum level of degradation will be centered on the point of discharge, and then diminish with increasing distance from the discharge point due to the eventual mixing and dilution by tidal and river flows. The zone of mixing will cover the entire width of the Old River channel due to tidal flow of water back and forth across the diffuser outfall.

The Old River channel currently has marginal habitat quality due to anthropogenic alterations committed over the previous 150 years. These alterations include extensive levee construction, installation of rock slope protection on the levee faces (riprapping) which typically requires the removal of riparian vegetation, dredging of channels to enhance water diversions for agricultural and municipal purposes, straightening of channels to enhance water flow for flood control and water diversion purposes, and the discharge of agricultural and municipal waste effluents into the river channel at numerous locations within the channels of the south Delta.

In July, 2005, NMFS' critical habitat analytical review teams (CHARTs) issued their final assessments of critical habitat for 7 listed salmon and steelhead ESUs in California (NMFS 2005d). This included critical habitat descriptions for the Central Valley spring-run Chinook salmon ESU and the Central Valley steelhead DPS. Section 3 of the ESA (16 U.S.C. 1532(5)) defines critical habitat as "(i) the specific areas within the geographic area occupied by the species, at the time of the listing * * * on which are found those physical and biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection". These features include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, and rearing of offspring; and habitats that are protected from disturbance or are representative of the historical geographical and ecological distribution of the species. After considering the above features, the CHARTs considered the principal biological and physical constituent elements that are essential to the conservation of the species, known as PCEs. The specific PCEs considered in determining the critical habitat for listed salmonids in California include (NMFS 2005d):

(1) **Freshwater spawning sites** with sufficient water quantity and quality and adequate substrate to support spawning, incubation and larval development.

(2) **Freshwater rearing sites** with sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions and allow salmonid development and mobility; sufficient water quality to support growth and development; food and nutrient resources such as terrestrial and aquatic invertebrates and forage fish; and natural cover

such as shade, submerged and overhanging large woody debris, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

(3) **Freshwater migration corridors** free of obstruction and excessive predation with adequate water quantity to allow for juvenile and adult mobility; cover, shelter, and holding areas for juveniles and adults; and adequate water quality to allow for survival.

(4) **Estuarine areas** that provide uncontaminated water and substrates; food and nutrient sources to support growth and development; and connected shallow water areas and wetlands to cover juveniles.

(5) **Marine areas** with sufficient water quality to support salmonid growth, development, and mobility; food and nutrient resources such as marine invertebrates and forage fish; and nearshore marine habitats with adequate depth, cover, and marine vegetation to provide cover and shelter.

The CHART indicated in their review (NMFS 2005d) that the San Joaquin Delta sub-basin encompasses an area of approximately 628 square miles with 455 miles of stream channels. Of this, fish distribution and habitat use occur in approximately 276 miles of occupied riverine/estuarine habitat for Central Valley steelhead and 142 miles for the Central Valley spring-run Chinook salmon. The CHART concluded that these occupied areas contained one or more PCEs (*i.e.*, freshwater rearing and migratory habitat and estuarine areas) and described the San Joaquin Delta as having a high conservation value, primarily due to its use as a rearing and migratory corridor for listed steelhead and spring-run Chinook salmon in the Central Valley.

The river channel within the action area is primarily used as a migratory corridor by the small number of Central Valley steelhead moving downstream out of the San Joaquin River watershed. These fish move through the channels of the San Joaquin Delta to the lower reaches of the Delta and the marine waters beyond. Due to the loss of riparian habitat and tidal flats resulting from decades of dredging and riprapping, the ecological value of the Old River channel as a rearing habitat has been greatly diminished from historical conditions, although rearing is still considered to occur in the channel. The CHART has determined that the waterways of the south Delta are necessary for connecting the freshwater spawning habitats upstream in the San Joaquin River watershed with the downstream waterways leading to the ocean and thus have a high conservation value. The project itself will not significantly diminish the value of the waterway as a migratory corridor compared to its current condition. The effluent that is discharged should not cause acute conditions that will lead to direct mortality of fish passing through the mixing zone or create an impassable barrier. If such conditions were to occur, the discharge would be out of compliance with state and federal water quality laws, and thus any take of fish occurring due to these violations or subsequent loss of aquatic habitat would not be subject to the conditions of this biological opinion and its incidental take statement. Incidental take of listed species can only be given for lawful actions. The lawful discharges from the MHWWTP to the waters of Old River should maintain the current level of water quality when mixed with the receiving waters. The receiving waters are currently listed as impaired under the 303(d) section of the Clean Water Act, and thus the discharge is regulated at the end of the pipe with more stringent water quality criteria than would be seen in "cleaner" receiving waters where assimilative capacity is assumed to exist.

Although the discharge will not improve the quality of the receiving waters contained in the channel of Old River, it should not demonstrably diminish the current water quality to the point where acute lethal take occurs, or preclude the ability of the aquatic habitat to support passage and rearing of the listed steelhead. Therefore, given the current status of water quality in the channel of Old River and the quality of the aquatic habitat within the same area, the effects associated with the discharge of the treated effluent would be difficult to separate from the current conditions found in the baseline. If the receiving waters had been more pristine and the aquatic habitat less degraded, the addition of the effluent stream would have presented a much clearer diminishment of the habitat quality within the action area. However, the habitat in the action area has been significantly disturbed by anthropogenic inputs for decades, and the resulting biotic and abiotic indicators (*i.e.* water quality indices, non-native invasive species infestations, extensive water diversions) are indicative of a highly disturbed environment. The addition of the MHWWTP effluent, as controlled by the water quality parameters of its discharge permits, should not result in any further adverse modifications of this already highly impacted waterway.

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 MHWWTP expansion project, and the cumulative effects, it is NMFS' biological opinion that the MHWWTP 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 intended as part 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 (ITS).

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 issued to the applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered in this ITS. If the Corps: (1) fails to assume and implement the terms and conditions of the ITS; and/or (2) fails to require the agents of the Corps to adhere to the terms and conditions of the ITS 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 the Corp's agents must report the progress of the action and its impact on the species to NMFS as specified in this ITS (50 CFR §402.14[i][3]).

Although some measures described below are expected and intended to avoid, minimize, or monitor the take of North American green sturgeon, the section 9 prohibitions against taking of listed species and the terms and conditions of the incidental take statement in 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.

A. Amount or Extent of Take

NMFS anticipates that the proposed MHWWTP expansion project and the associated discharge of effluent into the channel of Old River will result in the incidental take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon. The incidental take is expected to be in the form of death, harm, and harassment of juvenile Sacramento River winter-run Chinook salmon and juvenile and adult Central Valley steelhead during the month of December, and North American green sturgeon from July through December from hydraulic suction dredging; temporary loss of riparian vegetation from construction activities occurring on levee banks; long-term reduction of water quality in the Old River channel adjacent to the outfall resulting in exposure to low levels of contaminants by juvenile and adult listed salmonids from November 1 through June 30, which includes the entire period when individuals from one or more of the listed ESUs or DPSs may be expected to occur in the action area; and exposure to low levels of contaminants by North American green sturgeon year-round. The numbers of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon taken are expected to be low and will be difficult to quantify because dead, injured, or impaired individuals will be difficult to detect and recover. However, incidental take is expected to include:

1. All juvenile Sacramento River winter-run Chinook salmon, juvenile or adult Central Valley steelhead, and juvenile or adult North American green sturgeon harmed, harassed, or killed from hydraulic suction dredging over an area of Old River not expected to exceed 4,000 square feet; excavation of material not expected to exceed a total of 370 cubic yards; and disturbance of the Old River levee face not expected to exceed 600 square feet. Hydraulic dredging is anticipated to occur for a total of 2 weeks during the

period from July 1 through December 31; incidental take of winter-run Chinook salmon and steelhead is anticipated to occur only during the month of December.

2. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon harmed, harassed, or killed as a result of exposure to chronic, sublethal concentrations of toxic compounds discharged as part of the MHWWTP outfall effluent. The draft NPDES permit limits may allow exposure to lethal concentrations of ammonia. NMFS anticipates that adverse effects may occur in up to 2 river miles of the Old River channel adjacent to the outfall. Incidental take of adult Sacramento River winter-run Chinook salmon or Central Valley spring-run Chinook salmon is not anticipated, because NMFS considers it unlikely that these fish will be present in the areas where the effluent of the outfall is of sufficient concentration to cause adverse effects. Adult Central Valley steelhead originating from the San Joaquin River drainages may be exposed to sufficient effluent concentrations from the MHWWTP to cause adverse effects as they migrate through the waters of the Old River channel in the south Delta. Due to the small number of adults present in the San Joaquin River drainage and because Old River is not a major migration route, NMFS expects one adult Central Valley steelhead to be adversely affected per year by the proposed project. The numbers of juvenile Sacramento River winter-run, Central Valley spring-run Chinook salmon, and Central Valley steelhead that utilize the Delta waterways within the action area are hard to estimate due to the high levels of uncertainty surrounding their density in these waters. For the past 6 years, estimates of the population of winter-run sized Chinook salmon juveniles entering the fish collection facilities at the CVP and SWP have averaged 7,700 fish annually with a high of 20,000 in 2002 and a low of 1,400 in 2005. Therefore, NMFS anticipates that an equivalent number of fish will be present in the waters of Old River within the action area. Approximately 7,700 winter-run Chinook salmon are expected to be exposed to the effluent from the MHWWTP outfall, of which NMFS expects 1 percent (77 fish) will be exposed to chronic, sublethal concentrations of toxic compounds sufficient to cause adverse effects. The 1 percent susceptibility rate of exposed fish is a two orders of magnitude reduction in the number of fish exposed to the toxicants in the water. This represents a proportion of the population which has an enhanced susceptibility to the toxicant which is then reflected in the presentation of adverse effects. During the same 6-year period, approximately 25,000 spring-run sized Chinook salmon juveniles were salvaged annually at the CVP and SWP fish collection facilities, with a high of 43,000 fish collected in 2003 and a low of 11,600 fish in 2004. Using the same rationale, NMFS expects that 1 percent (250 fish) of these spring-run Chinook salmon will be exposed to sublethal concentrations of toxic compounds from the MHWWTP effluent sufficient to cause adverse effects. Salvage data from the CVP and SWP indicate that approximately 7,400 Central Valley steelhead smolts will move through the south Delta annually, with the majority of fish migrating in March. NMFS expects that 1 percent (74 fish) will be exposed to sublethal concentrations of toxic compounds from the MHWWTP effluent sufficient to cause adverse effects. NMFS recently completed a conference opinion assessing the impacts of the IEP fish sampling activities on North American green sturgeon (NMFS 2005c). A total of 265 juvenile or adult North American green sturgeon are anticipated to be taken by 4 of 15 fisheries-related studies. Two of the studies have

sampling sites in the Central and South Delta (*i.e.*, Clifton Court Forebay) or the lower San Joaquin River; one of the studies involves year-round sampling. In the absence of definitive data, NMFS estimates that the number of North American green sturgeon taken by the proposed MHWWTP expansion project will be 5 percent of the IEP take, which corresponds with the approximate proportion of sampling effort by the IEP in the Central and South Delta or San Joaquin River drainage. Therefore, annual incidental take is estimated to be 14 juvenile, sub-adult, or adult North American green sturgeon per year.

The total incidental take associated with this project is expected to be as follows:

ESU/DPS	Juveniles			Adults	
	Number	Percent of ESU/DPS		Number	Percent of ESU/DPS
Sacramento River winter-run Chinook salmon	77	0.02		0	0
Central Valley spring-run Chinook salmon	250	0.02		0	0
Central Valley steelhead	74	0.04		1	0.05
North American green sturgeon	14 adult and juveniles combined				

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 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 MHWWTP outfall upon listed salmonids and their habitat.

3. Measures shall be taken to avoid, minimize, and monitor the impacts of the effluent from the MHWWTP outfall on the benthic invertebrate community surrounding the outfall diffuser.

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(s), the applicant will measure the dilution characteristics of the continuous discharge *in situ* over a complete monthly tidal cycle, including the spring, neap, and one or more intermediate tidal stages. Time points shall include at the minimum: the flood, ebb, and slack tide portions of the tidal cycle for each day that tidal samples are taken. Water quality measurements will be taken at the point of discharge, and 1 meter, 5 meters, 10 meters, 25 meters, 50 meters, and 100 meters from the point of discharge. Measurements will also be made to ascertain the latitudinal dispersion as well as the longitudinal dispersion of the plume following discharge from the diffuser array. Water velocity and water depth of the channel at the point of measurement will be included in the data recorded.

   b. Within the first 2 years following the initiation of discharge of wastewater effluent from the diffuser array(s), the applicant will measure the dilution characteristics of the discharge *in situ* with respect to changes in river flow, agricultural diversions, CVP and SWP pumping and the operation of the barriers at the tidal stage from 1(a) that produced the least effective level of dilution utilizing the same measurement locations as 1(a).

   c. All experimental protocols will be sent to NMFS for review and approval at least 45 days prior to implementing them 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 MHWWTP outfall upon listed salmonids and their habitat.**

   a. For the first 5 years of operation of the MHWWTP 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 they are produced.

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

d. The applicant shall have the ability to divert river discharges to the currently existing, permanent emergency storage basins located on the MHWWTP site, during a facility upset or malfunction to avoid or minimize discharges to the waters of Old 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 Old River and adversely affecting listed fish species during periods of noncompliance. Maximal use of the emergency storage basins, 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 Old River for data gathering purposes only, which should include at the least, levels of steroidal estrogens such as 17 □-estradiol (E_2), estrone (E_1) and 17 □-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 MHWWTP 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 period of three years following its initiation.

3. **Measures shall be taken to avoid, minimize, and monitor the impacts of the effluent from the MHWWTP outfall on the benthic invertebrate community surrounding the outfall diffuser.**

a. Prior to the disturbance of the channel bottom by the construction phase of the project and the implementation of effluent discharges, surveys of the benthic fauna inhabiting the area of the outfall placement location as well as a control site located outside of the area of influence will be completed. These surveys will provide pre-project baseline data points for determining the initial status of the benthic community in the action area and adjacent waterways.

b. Following the initiation of discharges from the outfall, subsequent surveys of the benthic fauna surrounding the outfall structure and the control site will be conducted at 6 months, 1 year, and 2 years. Comparisons with the pre-project community data will be made to determine the relative changes in the benthic community structure due to the project's influence.

c. Sediment chemical profiles will be made at the same time as the benthic fauna surveys for comparative purposes. At a minimum, the chemical constituent profiles that were analyzed to obtain the initial dredging permit for the diffuser placement should be tested for in the sediment samples in order to determine if accumulation of these constituents is occurring in the sediments subjected to the outfall plume in Old River

d. Data and a summary report will be developed and sent to NMFS at the address in 1(c) following the completion of the surveys, but no later than 30 months after the initiation of discharge from the outfall. Following review of the summary report, NMFS may require that the effluent discharge be modified to protect benthic invertebrate communities in the surrounding channel if adverse impacts are detected. A process of adaptive management will be implemented based on discussions between the applicant and NMFS. The goal of the adaptive management will be the protection of the invertebrate communities which provide forage for rearing salmonids and green sturgeon within the action area.

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) 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 salmon and steelhead.

2. The Corps should support anadromous salmonid monitoring programs throughout the Delta and Suisun Bay to improve the understanding of migration and habitat utilization by salmonids 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 MHWWTP 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: (1) 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.

XII. REFERENCES

Adams, P.B., C.B. Grimes, J.E. Hightower, S.T. Lindley, and M.L. Moser. 2002. Status review for North American green sturgeon, *Acipenser medirostris*. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California. 49 pages.

Alderdice, D.F. and F.P.J. Velsen. 1978. Relation between temperature and incubation time for eggs of Chinook salmon (*Oncorhynchus tshawytscha*). Journal of the Fisheries Research Board of Canada 35(1):69-75.

Allen, M.A., and T.J. Hassler. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific southwest), Chinook salmon. U.S. Fish and Wildlife Service Report 82(11.49). U.S. Army Corps of Engineers, TR EL-82-4. 26 pages.

Ayers and Associates. 2001. Two-dimensional modeling and analysis of spawning bed mobilization, lower American River. Prepared for the U.S. Army Corps of Engineers, Sacramento District Office.

Baldwin, D.H., J.F. Sandahl, J.S. Labenia, and N.L. Scholz. 2003. Sublethal effects of copper on coho salmon: impacts on nonoverlapping receptor pathways in the peripheral olfactory nervous system. Environmental Toxicology and Chemistry 22(10):2266-2274.

Barnhart, R.A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific southwest), steelhead. U.S. Fish and Wildlife Service Biological Report 82(11.60), U.S. Army Corps of Engineers, TR EL-82-4. 21 pages.

Barrett, J.C., G.D. Grossman, J. Rosenfeld. 1992. Turbidity-induced changes in reactive distance of rainbow trout. Transactions of the American Fisheries Society 121:437-443.

Bash, J. C. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. Center for steamside studies, University of Washington, Seattle, WA. 74 pages. Found at: http://depts.washington.edu/cssuw/Publications/Salmon%20and%20Turbidity.pdf

Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko. 2004. Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin Rivers and tributaries. Prepared for State Water Contractors by S.P. Cramer and Associates, Inc., Gresham, Oregon. 46 pages.

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, Portland, OR.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria (third edition). U.S. Army Corps of Engineers, Portland, OR.

Bilby R.E. 1984. Removal of woody debris may affect stream channel stability. Journal of Forestry 82:609-613.

Bjornn, T.C., and D.W. Reiser. 1995. Habitat requirements of salmonids in streams. Pages 83-138 *in*: W. Meehan, editor. Influences of forest and rangeland management on salmonids fishes and their habitat. American Fisheries Society Special Publication 19. Bethesda, Maryland.

Boles, G. 1988. Water temperature effects on Chinook salmon (*Oncorhynchus tshawytscha*) with emphasis on the Sacramento River: a literature review. Report to the California Department of Water Resources, Northern District, 43 pages.

Brett, J.R. 1952. Temperature tolerance of young Pacific salmon, genus *Oncorhynchus*. Journal of the Fisheries Research Board of Canada 9:265-323.

Buchman, M.F. 1999. Screening quick reference tables, NOAA HAZMAT report 99-1. Seattle, Washington. Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12 pages.

Busby, P.J., T.C. Wainright, G.J. Bryant, L. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon and California. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-27, 261 pages.

CALFED Bay-Delta Program. 1999. Ecosystem Restoration Program Plan, Volumes I and II. Technical Appendix to Draft PEIS/EIR, June 1999.

California Advisory Committee on Salmon and Steelhead. 1988. Restoring the Balance, a report to the Legislature and the Department of Fish and Game, #124-J, 84 Pages.

California Commercial, Industrial and Residential Real Estate Services Directory. Available: http://www.ured.com/citysubweb.html. (April 2002).

California Department of Fish and Game. 1998. Report to the Fish and Game Commission. A status review of the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River Drainage. Candidate species status report 98-01. Sacramento, 394 pages.

California Department of Fish and Game. 2000. Spring-run Chinook salmon annual report. Prepared for the California Fish and Game Commission. Habitat Conservation Division, Native Anadromous Fish and Watershed Branch. Sacramento, 19 pages.

California Department of Fish and Game. 2001. Contributions to the Biology of Central Valley Salmonids. Containing 17 selected papers edited by R. L. Brown. Fish Bulletin 179. Vol. I and II. Sacramento, CA.

California Department of Fish and Game. 2002a. Sacramento River winter-run Chinook Salmon biennial report 2000-2001. Prepared for the California State Fish and Game Commission. Habitat Conservation Division, Native Anadromous Fish and Watershed Branch. Sacramento, 25 pages.

California Department of Fish and Game. 2002b. Spring-run Chinook salmon annual report. Prepared for the California Fish and Game Commission. Habitat Conservation Division, Native Anadromous Fish and Watershed Branch. Sacramento, 29 pages.

California Department of Fish and Game. 2003. Memorandum to Madelyn Martinez (NMFS) regarding steelhead populations in the San Joaquin River basin. 4 pages.

California Department of Fish and Game. 2004a. Sacramento River winter-run Chinook salmon 2002-2003 biennial report. Prepared for the California Fish and Game Commission. Habitat Conservation Division, Native Anadromous Fish and Watershed Branch. Sacramento, 22 pages.

California Department of Fish and Game. 2004b. Sacramento River spring-run Chinook salmon 2002-2003 biennial report. Prepared for the California Fish and Game Commission. Habitat Conservation Division, Native Anadromous Fish and Watershed Branch. Sacramento, 35 pages.

California Department of Fish and Game. 2004c. Freshwater Sport Fishing Regulations 2004-2006. California Fish and Commission and Department of Fish and Game, Sacramento, California, 64 pages.

California Department of Water Resources. 2002. Suisun Marsh Salinity Control Gates salmon passage evaluation report. Environmental Services Office, Sacramento, 19 pages.

California Regional Water Quality Control Board-Central Valley Region. 1998. Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins, fourth edition. Available: http://www.swrcb.ca.gov/~CRWQCB5/home.html

California Regional Water Quality Control Board-Central Valley Region. 2001. Draft staff report on recommended changes to California's Clean Water Act, section 303(d) list. Available: http://www.swrcb.ca.gov/CRWQCB5/tmdl/

California Resources Agency. 1989. Upper Sacramento River fisheries and riparian management plan. Prepared by an Advisory Council established by SB1086, authored by State Senator Jim Nielson. 157 pages.

Calkins, R.D., W.F. Durand, and W.H. Rich. 1940. Report of the Board of Consultants on the fish problem of the upper Sacramento River. Stanford University, Stanford, CA, 34 pages.

Chambers, J. 1956. Fish passage development and evaluation program. Progress Report No. 5. U.S. Army Corps of Engineers, North Pacific Division, Portland, OR.

Chapman, D.W., and T.C. Bjornn. 1969. Distribution of salmon in streams, with special reference to food and feeding. *In* T. G. Northcote (editor), Symposium on salmon and trout in streams, pages 153-176. University of British Columbia, Institute of Fisheries, Vancouver.

Clark, G.H. 1929. Sacramento-San Joaquin salmon (*Oncorhynchus tshawytscha*) fishery of California. Calif. Div. of Fish and Game, Fish Bull. No.17:73.

Clarke, D., C. Dickerson, and K. Reine. 2002. Characterization of underwater sounds produced by dredges. *In* Specialty Conference on Dredging and Dredged Material Disposal – Orlando, Florida, 14 pages. American Society of Civil Engineers.

Cohen, A.N. and P.B. Moyle. 2004. Summary of data and analyses indicating that exotic species have impaired the beneficial uses of certain California waters: a report submitted to the State Water Resources Control Board on June 14, 2004. 25 pages.

Conomos, T.J., R.E. Smith, and J.W. Gartner. 1985. Environmental settings of San Francisco Bay. Hydrobiologia 129: 1-12.

Cordone, A.J. and D.W. Kelley. 1961. The influences of inorganic sediment on the aquatic life of streams. California Fish and Game 47:89-228.

Cramer, S.P. 2005. Stanislaus River rotary screw trap monitoring data. Available at: http://spcramer.com/spcramer.html

Cramer, S.P., and D.B. Demko. 1997. The status of late-fall and spring Chinook salmon in the Sacramento River Basin regarding the Endangered Species Act. S.P. Cramer and Associates. Gresham, OR.

Cronan, C.S., and C.L. Schofield. 1979. Aluminum leaching response to acid precipitation: effects on high-elevation watersheds in the northeast. Science 204:304-305.

Daughton, C.G. 2002. Environmental stewardship and drugs as pollutants. Lancet. 360:1035-1036.

Daughton, C.G. 2003a. Cradle-to-cradle stewardship of drugs for minimizing their environmental disposition while promoting human health. I. Rationale for and avenue toward a green pharmacy. Environmental Health Perspectives 111:757-774.

Daughton, C.G. 2003b. Cradle-to-cradle stewardship of drugs for minimizing their environmental disposition while promoting human health. II. Drug disposal, waste reduction and future directions. Environmental Health Perspectives 111:775-785.

Daughton, C.G. and T.A. Ternes. 1999. Pharmaceuticals and personal care products in the environment: Agents of subtle change. Environmental Health Perspectives. 107(supplement 6):907-938.

Decato, R.J. 1978. Evaluation of the Glenn-Colusa Irrigation District fish screen. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 78-20.

Demko, D.B., C. Gemperle, A. Phillips, and S.P. Cramer. 2000. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River, Caswell State Park site, 1999. Prepared for U.S. Fish and Wildlife Service. Prepared by S.P. Cramer and Associates, Inc. Gresham, OR. 146 pp plus appendices.

Deng, X., J.P. Van Eenennaam, and S.I. Doroshov. 2002. Comparison of early life stages and growth of green sturgeon and white sturgeon. Pages 237-248 *in* W. Van Winkle, P.J. Anders, D.H. Secor, and D.A. Dixon, editors. Biology, management, and protection of North American sturgeon. American Fisheries Society, Symposium 28, Bethesda, Maryland.

Dubrovsky, N.M., C.R. Kratzer, L.R. Brown, J.M. Gronberg, and K.R. Burow. 2000. Water quality in the San Joaquin-Tulare basins, California, 1992-95. U.S. Geological Survey Circular 1159.

Dubrovsky, N.M., D.L. Knifong, P.D. Dileanis, L.R. Brown, J.T. May, V. Connor, and C.N. Alpers. 1998. Water quality in the Sacramento River basin. U.S. Geological Survey Circular 1215.

Dunford, W.E. 1975. Space and food utilization by salmonids in marsh habitats in the Fraser River Estuary. M.S. Thesis. University of British Colombia, Vancouver, B.C., 81 pages.

Ecobichon, D.J. 1996. Toxic effects of Pesticides *In*: Casarett & Doull's Toxicology: The Basic Science of Poisons, Fifth Edition. Curtiss D. Klassen, editor. McGraw Hill. New York. Pp. 643-690.

Edwards, G.W., K.A.F. Urquhart, and T.L. Tillman. 1996. Adult salmon migration monitoring, Suisun Marsh Salinity Control Gates, September-November 1994. Technical Report 50. Interagency Ecological Program for the San Francisco Bay/Delta Estuary, 27 pages.

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in West coast estuaries, Volume II: Species life history summaries. ELMR Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, MD, 329 pages.

Erickson, D.L., J.A. North, J.E. Hightower, J. Weber, L. Lauck. 2002. Movement and habitat use of green sturgeon *Acipenser medirostris* in the Rogue River, Oregon, USA. Journal of Applied Ichthyology 18:565-569.

Everest, F.H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Commission. Fishery Research Report 7. 48 pages.

Fisher, F.W. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology 8:870-873.

Fry, D.H. 1961. King salmon spawning stocks of the California Central Valley, 1940-1959. California Fish and Game 47:55-71.

Gadomski, D.M. and M.J. Parsely. 2005. Effects of turbidity, light level, and cover on predation of white sturgeon larvae by prickly sculpins. Transactions of the American Fisheries Society 134:369-374.

Garcia, A. 1989. The impacts of squawfish predation on juvenile Chinook salmon at Red Bluff Diversion Dam and other locations in the Sacramento River. U.S. Fish and Wildlife Service Report No. AFF/FAO-89-05.

Gingras, M. 1997. Mark/recapture experiments at Clifton Court Forebay to estimate pre-screen loss of juvenile fishes: 1976-1993. Interagency Ecological Program Technical Report No. 55.

Goals Project. 1999. Baylands ecosystem habitat goals: A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco. San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESU of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-66, 598 p.

Goyer, R.A. 1996. Toxic effects of metals. Pages 691-736 *in*: C.D. Klassen, editor. Casarett & Doull's toxicology: the basic science of poisons, fifth edition. McGraw Hill. New York.

Hallig-Sørenson, S. Nors Nielsen, P.F. Lanzky, F. Ingerslev, H.C. Holten Lützhøft and S.E. Jørgensen. 1998. Occurrence, fate, and effects of pharmaceutical substances in the environment - a review. Chemosphere. 36(2):357-393.

Hallock, R.J. 1989. Upper Sacramento River steelhead (*Oncorhynchus mykiss)* 1952-1988. Prepared for the U.S. Fish and Wildlife Service. California Department of Fish and Game, Sacramento, CA.

Hallock, R.J. and F.W. Fisher. 1985. Status of winter-run Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento River. Report to the California Department of Fish and Game, Anadromous Fisheries Branch, Sacramento, CA.

Hallock, R.J., R.F. Elwell, and D.H. Fry, Jr. 1970. Migrations of adult king salmon, *Oncorhynchus tshawytscha*, in the San Joaquin Delta. California Fish and Game 151. Sacramento. 92 p.

Hallock, R.J., W.F. Van Woert, and L. Shapavalov. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout (*Salmo gairdneri gairdneri*) in the Sacramento River system. California Fish and Game 114:73.

Hamilton, S.J. 2004. Review of selenium toxicity in the aquatic food chain. Science of the Total Environment 326: 1-31.

Hansen, J.A., J. Lipton, P.G. Welsh, J. Morris, D. Cacela, and M.J. Suedkamp. 2002. Relationship between exposure duration, tissue residues, growth, and mortality in rainbow trout (*Oncorhynchus mykiss*) juveniles sub-chronically exposed to copper. Aquatic Toxicology 58:175-188.

Hansen, J.A., J.C.A. Marr, J. Lipton, D. Cacela, and H.L. Bergman. 1999a. Differences in neurobehavioral responses of Chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout (*Oncorhynchus mykiss*) exposed to copper and cobalt: Behavioral avoidance. Environmental Toxicology and Chemistry 18(9):1972-1978.

Hansen, J.A., J.D. Rose, R.A. Jenkins, K.G. Gerow, and H.L. Bergman. 1999b. Chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout (*Oncorhynchus mykiss*) exposed to copper: neurophysiological and histological effects on the olfactory system. Environmental Toxicology and Chemistry 18(9):1979-1991.

Hare, S.R., N.J. Mantua, and R.C. Frances. 1999. Inverse production regimes: Alaska and west coast Pacific salmon. Fisheries 24(1):6-14.

Healey, M.C. 1980. Utilization of the Nanaimo River estuary by juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Fishery Bulletin 77:653-668.

Healey, M.C. 1982. Juvenile Pacific salmon in estuaries: the life support system. *In* V.S. Kennedy (editor), Estuarine Comparisons, pages 315-341. Academic Press. New York, N.Y.

Healey, M.C. 1991. Life history of Chinook salmon. *In* C. Groot and L. Margolis (editors), Pacific Salmon Life Histories, pages 213-393. Univ. of British Columbia Press, Vancouver, British Columbia.

Herren, J.R., and S.S. Kawasaki. 2001. Inventory of water diversions in four geographic areas in California's Central Valley. Pages 343-355 in: R.L. Brown, editor. Fish Bulletin 179: Contributions to the Biology of Central Valley Salmonids. Vol. 2. California Department of Fish and Game. Sacramento.

Ingersoll, C.G. 1995. Sediment tests. *In* G.M. Rand (editor), Fundamentals of aquatic toxicology: effects, environmental fate, and risk assessment, second edition, pages 231-255. Taylor and Francis, Bristol, Pennsylvania.

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, assessment, and research on Central Valley steelhead: Status of knowledge, review existing programs, and assessment needs. In Comprehensive Monitoring, Assessment, and Research Program Plan, Technical Appendices VII-11.

Jobling, S., M. Nolan, C.R. Tyler, G. Brighty, and J.P. Sumpter. 1998. Widespread sexual disruption in wild fish. Environmental Science and Technology 32:2498-2506.

Katzenellenbogen, J.A. 1995. The structural pervasiveness of estrogenic activity. Environmental Health Perspectives. 103(supplement 7):99-101.

Keller, E.A., and F.J. Swanson. 1979. Effects of large organic material on channel form and fluvial processes. Earth Surface Processes 4:361-380.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1981. Influences of freshwater inflow on Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin Estuary. *In* R.D. Cross and D.L. Williams (editors), Proceedings of the National Symposium on Freshwater Inflow to Estuaries, pages 88-108. U.S. Fish and Wildlife Service, FWS/OBS-81-04.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin estuary, California. *In* V.S. Kennedy (editor), Estuarine comparisons, pages 393-411. Academic Press, New York, NY.

Kolpin, D.W., E.T. Furlong, M.T. Meyer, E.M. Thurman, S.D. Zaugg, L.B. Barber, and H.T. Buxton. 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: a national reconnaissance. Environmental Science and Technology. 36(6):1202-1211.

Kynard, B., E. Parker, and T. Parker. 2005. Behavior of early life intervals of Klamath River green sturgeon, *Acipenser medirostris*, with note on body color. Environmental Biology of Fishes 72:85-97.

Laws, E.A. 1993. Aquatic pollution. An introductory text (second edition). John Wiley and Sons, Inc. New York, NY. 611 pages.

Lemly, A.D. 1999a. Selenium impacts on fish: an insidious time bomb. Human and Ecological Risk Assessment 5(6): 1139-1151.

Lemly, A.D. 1999b. Selenium transport and bioaccumulation in aquatic ecosystems: a proposal for water quality criteria based on hydrological units. Ecotoxicology and Environmental Safety 42: 150-156.

Lemly, A.D. 2002. Symptoms and implications of selenium toxicity in fish: the Belews Lake case example. Aquatic Toxicology 57: 39-49.

Levings, C.D. 1982. Short term use of low-tide refugia in a sand flat by juvenile chinook, (*Oncorhynchus tshawytscha*), Fraser River estuary. Canadian Technical Reports of Fisheries and Aquatic Sciences, Number 1111. 7 pages.

Levings, C.D., C.D. McAllister, and B.D. Chang. 1986. Differential use of the Campbell River estuary, British Columbia, by wild and hatchery-reared juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 43:1386-1397.

Levy, D.A., and T.G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. Canadian Journal of Fisheries and Aquatic Sciences 39:270-276.

Lindley, S.T., R. Schick, B.P. May, J.J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams. 2004. Population structure of threatened and endangered Chinook salmon ESU in California's Central Valley basin. Public review draft. NMFS Southwest Science Center. Santa Cruz, CA.

Lloyd, D.S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. North American Journal of Fisheries Management 7:34-45.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater systems. Archives of Environmental Contamination and Toxicology 39:20-31.

MacFarlane, B.R., and E.C. Norton. 2002. Physiological ecology of juvenile Chinook salmon at the southern end of their distribution, the San Francisco Estuary and Gulf of Farallones, California. California Department of Fish and Game, Fish Bulletin 100:244-257.

Mantua, N.J. and S.R. Hare. 2002. The Pacific decadal oscillation. Journal of Oceanography. 58:35-44.

Marston, D. 2004. Letter to Mike Aceituno regarding steelhead smolt recoveries for the San Joaquin River Basin.

Martin, C.D., P.D. Gaines, and R.R. Johnson. 2001. Estimating the abundance of Sacramento River juvenile winter Chinook salmon with comparisons to adult escapement. Red Bluff Research Pumping Plant Report Series, Volume 5. U.S. Fish and Wildlife Service. Red Bluff, CA.

Maslin, P., M Lennox, and W. McKinney. 1997. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*). California State University, Chico, Department of Biological Sciences. 89 pages.

Matthews, K.R. and N.H. Berg. 1997. Rainbow trout responses to water temperature and dissolved oxygen stress in two southern California stream pools. Journal of Fish Biology. 50:50-67.

Mayfield, R.B. and J.J. Cech, Jr. 2004. Temperature Effects on green sturgeon bioenergetics. Transactions of the American Fisheries Society 133:961-970.

McCauley, R.D., J. Fewtrell, and A.N. Popper. 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113:638-642.

McDonald, J. 1960. The behavior of Pacific salmon fry during the downstream migration to freshwater and saltwater nursery areas. Journal of the Fisheries Research Board of Canada 17:655-676.

McEwan, D. 2001. Central Valley steelhead. *In* R .L. Brown (editor), Contributions to the Biology of Central Valley Salmonids, Volume 1, pages 1-44. California Department of Fish and Game, Fish Bulletin 179.

McEwan, D., and T.A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California. Department of Fish and Game, Sacramento, California, 234 pages.

McGill, R.R. Jr. 1987. Land use changes in the Sacramento River riparian zone, Redding to Colusa. A third update: 1982-1987. Department of Water Resources, Northern District, 19 pages.

Meehan, W.R. 1991. Introduction and overview. *In* W.R. Meehan (editor), Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19, pages 1-16. American Fisheries Society, Bethesda, MD.

Meehan, W.R. and T.C. Bjornn. 1991. Salmonid distributions and life histories. *In* W.R. Meehan (editor), Influences of forest and rangeland management on salmonid fishes and their habitats, pages 47-82. American Fisheries Society Special Publication 19. American Fisheries Society, Bethesda, MD.

Michny, F., and M. Hampton. 1984. Sacramento River Chico Landing to Red Bluff project, 1984, Juvenile salmon study. U.S. Fish and Wildlife Service, Division of Ecological Services. Sacramento, CA.

Miller, D.J. and R.N. Lee. 1972. Guide to the coastal marine fishes of California. California Department of Fish and Game, Fish Bulletin 157.

Monroe, M., J. Kelly, and N. Lisowski. 1992. State of the estuary, a report of the conditions and problems in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. June 1992. 269 pages.

Mount, J.F. 1995. California Rivers and Streams: The conflict between fluvial process and land use. University of California Press, Berkeley.

Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Report prepared for the Resources Agency, California Department of Fish and Game, Rancho Cordova. 222 pages.

Moyle, P.B., P.J. Foley, and R.M. Yoshiyama. 1992. Status of green sturgeon, *Acipenser medirostris*, in California. Final report submitted to National Marine Fisheries Service, Terminal Island, California. 11 pages. University of California, Davis, California.

Moyle, P.B., R.A. Daniels, B. Herbold, and D.M. Baltz. 1986. Patterns in distribution and abundance of a non-coevolved assemblage of estuarine fishes in California. Fishery Bulletin 84:105-117.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-35. 443 pages.

Myrick, C.A, and J.J. Cech. 2000. Growth and thermal biology of Feather River steelhead under constant and cyclical temperatures. Department of Wildlife, Fish, and Conservation Biology, University of California. Davis, California.

Myrick, C.A. 1998. Temperature, genetic, and ration effects on juvenile rainbow trout (*Oncorhynchus mykiss*) bioenergetics. Ph.D. dissertation. University of California. Davis. 165 pages.

National Marine Fisheries Service. 1996. Making Endangered Species Act determinations of effect for individual or group actions at the watershed scale. Prepared by NMFS, Environmental and Technical Services Branch, Habitat Conservation Branch. 31pages.

National Marine Fisheries Service. 1997. National Marine Fisheries Service Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon. NMFS, Southwest Region, Long Beach, California, 217 pages with goals and appendices.

National Marine Fisheries Service. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.

National Marine Fisheries Service. 2003. Preliminary conclusions regarding the updated status of listed ESU of West Coast salmon and steelhead. Draft report February 2003. West

Coast Salmon Biological Review Team. U.S. Department of Commerce, National Marine Fisheries Service-Northwest Fisheries Science Center.

National Marine Fisheries Service. 2004. Biological Opinion for the Long Term Central Valley Project and State Water Project Operations, Criteria, and Plan (OCAP). October 22, 2004. 291 pages.

National Marine Fisheries Service. 2005a. Green sturgeon (*Acipenser medirostris*) status review update, February 2005. Biological review team, Santa Cruz Laboratory, Southwest Fisheries Science Center. 31 pages.

National Marine Fisheries Service. 2005b. Biological and conference opinion on the Port of Stockton, West Complex Dredging project. July 19, 2005. 135 pages.

National Marine Fisheries Service. 2005c. Addendum to the Central Valley programmatic biological opinion for scientific research, northern and central coast programmatic biological opinion for scientific research, and conference opinion for the southern distinct population segment of North American green sturgeon: Research permit 1440, concerning the Interagency Ecological Program monitoring activities in the San Francisco Estuary and Sacramento-San Joaquin Delta. November 29, 2005. 71 pages.

National Marine Fisheries Service. 2005d. Final Assessment of the National Marine Fisheries Services's Critical Habitat Analytical Review Teams (CHARTs) for seven salmon and steelhead evolutionarily significant units (ESUs) in California. July 2005..

National Marine Fisheries Service. 2006. Comments to the Administrative File for the Mountain House Wastewater Treatment Plant (MHWWTP) expansion Project.

National Marine Fisheries Service and California Department of Fish and Game. 2001. Final report on anadromous salmon fish hatcheries in California. Prepared by Joint Hatchery Review Committee. June 27, 2001.

Newcombe, C.P., and J.O. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693-727.

Newcombe, C.P., and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. North American Journal of Fisheries Management 11:72-82.

Nichols, F.H., J.E. Cloern, S.N. Louma, and D.H. Peterson. 1986. The modification of an estuary. *Science* 231: 567-573.

Nickelson, T.E., J.W. Nicholas, A.M. McGie, R.B. Lindsay, D.L. Bottom, R.J. Kaiser, and S.E. Jacobs. 1992. Status of anadromous salmonids in Oregon coastal basins. Oregon Department of Fish and Wildlife, Research Development Section and Ocean Salmon Management, 83 pages

Nightingale, B., and C.A. Simenstad. July 2001. Dredging Activities: Marine Issues. Research Project T1803, Task 35, Whitepaper. Found at: http://www.wa.gov/wdfw/hab/ahg/ahgwhite.htm

Nobriga, M., and P. Cadrett. 2003. Differences among hatchery and wild steelhead: evidence from Delta fish monitoring programs. Interagency Ecological Program for the San Francisco Estuary Newsletter 14:3:30-38.

Olson, P.A., and R.F. Foster. 1956. Effect of chronic exposure to sodium dichromate on young Chinook salmon and rainbow trout. Hanford Biological Research Annual Report 1955. Atomic Energy Commission HW 41500. Richland, WA.

Orsi, J. 1967. Predation study report, 1966-1967. California Department of Fish and Game

Pacific Fisheries Management Council. 2002. Review of 2002 ocean salmon fisheries. Available: http://www.pcouncil.org/salmon/salsafe02/salsafe02.html.

Pacific Fishery Management Council. 2004. Review of 2003 Ocean Salmon Fisheries. Available: www.pcouncil.org

Pawlowski, S., T. Ternes, M. Bonerz, T. Kluczka, B. van der Burg, H. Nau, L. Erdinger, and T. Braunbeck. 2003. Conbined *in situ* and *in vitro* assessment of the estrogenic activity of sewage and surface water samples. Toxicological sciences 75: 57-65.

Phillips, R.W., and H.J. Campbell. 1961. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. Annual Report to Pacific Marine Fisheries Commission 14:60-73.

Pickard, A., A. Grover, and F. Hall. 1982. An evaluation of predator composition at three locations on the Sacramento River. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary. Technical Report No. 2, 20 pages.

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin delta, Part II. Pages 115-119 *In*: S.L. Turner and D.W. Kelley (eds.), California Fish and Game Bulletin 136.

Rand, G.M., P.G. Wells, and L.S. McCarty. 1995. Introduction to aquatic toxicology. Pages 3-66 *in*: G.M. Rand, editor. Fundamentals of aquatic toxicology: effects, environmental fate, and risk assessment, second edition. Taylor and Francis. Bristol, Pennsylvania.

Reine, K., and D. Clarke. 1998. Entrainment by hydraulic dredges–A review of potential impacts. Technical Note DOER-E1. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. *In* W.R. Meehan, editor. Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. USDA, Forest Service General Technical Report PNW-96.

Rich, A.A. 1997. Testimony of Alice A. Rich, Ph.D., regarding water rights applications for the Delta Wetlands Project, proposed by Delta Wetlands Properties for Water Storage on Webb Tract, Bacon Island, Bouldin Island, and Holland Tract in Contra Costa and San Joaquin Counties. July 1997. California Department of Fish and Game Exhibit CDFG-7. Submitted to State Water Resources Control Board.

Robertson – Bryan, Inc. 2005. Biological Assessment for the proposed construction and operation of the Mountain House Community Services District Wastewater Treatment Plant outfall in Old River. 89 pages plus appendices.

Robison, G.E., and Beschta, R.L. 1990. Identifying trees in riparian areas that can provide coarse woody debris to streams. Forest Service 36:790-801.

Rodgers-Gray, T.P., S. Jobling, S. Morris, C. Kelley, S. Kirby, A. Janbakhsh, J.E. Harries, M.J. Waldock, J.P. Sumpter and C.R. Tyler. 2000. Long-term temporal changes in the estrogenic composition of treated sewage effluent and its biological effects on fish. Environmental Science and Technology. 34(8):1521-1528.

Rutter, C. 1904. Natural history of the quinnat salmon. Investigations on Sacramento River, 1896-1901. Bull. U.S. Fish Comm. 22:65-141.

Scholik, A.R., and H.Y. Yan. 2002. Effects of boat engine noise on the auditory sensitivity of the fathead minnow, *Pimephales promelas*. Environmental Biology of Fishes 63:203-209.

Shapovalov, L., and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. California Department of Fish and Game, Fish Bulletin 98, 375 pages.

Shelton, J. M. 1995. The hatching of Chinook salmon eggs under simulated stream conditions. Progressive Fish-Culturist 17:20-35.

Shirvell, C.S. 1990. Role of instream rootwads as juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*) cover habitat under varying streamflows. Canadian Journal of Fisheries and Aquatic Sciences 47:852-860.

Slater, D.W. 1963. Winter-run Chinook salmon in the Sacramento River, California, with notes on water temperature requirements at spawning. U.S. Fish and Wildlife Service, Special Science Report Fisheries 461:9.

Sloman, K.A., D.W. Baker, C.M. Wood, and G. McDonald. 2002. Social interactions affect physiological consequences of sublethal copper exposure in rainbow trout, *Oncorhynchus mykiss*. Environmental Toxicology and Chemistry. 21(6):1255-1263.

Smith, A.K. 1973. Development and application of spawning velocity and depth criteria for Oregon salmonids. Transactions of the American Fisheries Society 10:312-316.

Snider, B. 2001. Evaluation of effects of flow fluctuations on the anadromous fish populations in the lower American River. California Department of Fish and Game, Habitat Conservation Division. Stream Evaluation Program. Tech. Reports No. 1 and 2 with appendices 1-3. Sacramento, California.

Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58:325-333.

Staley, J.R. 1975. American River steelhead (*Salmo gairdnerii gairdnerii*) management, 1956-1974. California Department of Fish and Game, Region 2, Inland Fisheries, Anadromous Branch, Administrative Report No. 76-2.

Stevens, D.E. 1961. Food habits of striped bass, *Roccus saxatilis* (Walbaum) in the Rio Vista area of Sacramento River. Master's Thesis. University of California. Berkeley, California.

Stone, L. 1874. Report of operations during 1872 at the U.S. salmon-hatching establishment on the McCloud River, and on the California Salmonidae generally; with a list of specimens collected. Report to U.S. Commissioner of Fisheries for 1872-1873, 2:168-215.

Sumpter, J.P., and S. Jobling. 1995. Vitellogenesis as a biomarker for estrogenic contamination of the aquatic environment. Environmental Health Perspectives. 103(supplement 7):173-178.

Thompson, K. 1972. Determining stream flows for fish life. *In* Proceedings, Instream Flow Requirement Workshop, pages 31-50. Pacific Northwest River Basin Commission, Vancouver, Washington.

Thurston, R.V., and R.C. Russo. 1983. Acute toxicity of ammonia to rainbow trout. Transactions of the American Fisheries Society 112:696-704.

Thurston, R.V., R.C. Russo, R.J. Luedtke, C.E. Smith, E.L. Meyn, C. Chakoumakos, K.C. Wang, and C.J.D. Brown. 1984. Chronic toxicity of ammonia to rainbow trout. Transactions of the American Fisheries Society 113:56-73.

Tillman, T.L., G.W. Edwards, and K.A.F. Urquhart. 1996. Adult salmon migration during the various operational phases of Suisun Marsh Salinity Control Gates in Montezuma Slough: August-October 1993. Agreement to California Department of Water Resources, Ecological Services Office by California Department of Fish and Game, Bay-Delta and Special Water Projects Division, 25 pages.

U.S. Army Corps of Engineers. 2000. Draft long-term management strategy-management plan. Appendix I. Dredging Best Management Practices. Prepared by the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission and the San Francisco Bay Regional Water Quality Control Board. June 2000. San Francisco, CA.

U.S. Bureau of Reclamation and Orange Cove Irrigation District. 1999. Draft Environmental Assessment/Initial Study for Mill Creek Anadromous Fish Adaptive Management Enhancement Plan. August 1999.

U.S. Bureau of Reclamation. 2004. Long-term Central Valley Project and State Water Project Operating Criteria and Plan. Biological Assessment for ESA section 7(a)(2) consultation. Mid-Pacific Region. Sacramento, California.

U.S. Department of Interior. 1999. Final Programmatic Environmental Impact Statement for the Central Valley Project Improvement Act. October 1999. Technical Appendix, 10 volumes.

U.S. Environmental Protection Agency. 1994. Water Quality Standards Handbook: Second Edition. EPA 823-B-94-005a.

U.S. Environmental Protection Agency. 2003. 2003 Draft Update of Ambient Water Quality Criteria for Copper. EPA 822-R-03-026. Washington, D.C.

U.S. Fish and Wildlife Service. 1995. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. Portland, OR.

U.S. Fish and Wildlife Service. 2001a. Abundance and seasonal, spatial, and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Draft Progress Report for Red Bluff Research Pumping Plant, Vol.14. Prepared by Philip Gaines and Craig Martin for the U.S. Bureau of Reclamation. Red Bluff, CA.

U.S. Fish and Wildlife Service. 2001b. Abundance and survival of juvenile Chinook salmon in the Sacramento-San Joaquin Estuary: 1997 and 1998. Annual progress report. 131 pages.

U.S. Fish and Wildlife Service. 2003a. Flow-habitat relationships for steelhead and fall, late-fall, and winter-run Chinook salmon spawning in the Sacramento River between Keswick Dam and Battle Creek. Sacramento, CA. 76 pages.

U.S. Fish and Wildlife Service. 2003b. Abundance and survival of juvenile Chinook salmon in the Sacramento-San Joaquin Estuary: 1999. Annual progress report. 70 pages.

U.S. Fish and Wildlife Service. 2004. Draft adult spring Chinook salmon monitoring in Clear Creek, California, 1999-2002. Prepared by J.M. Newton and M.R. Brown. Red Bluff, CA.

Van Eenennaam, J.P., J. Linares-Casenave, X. Deng, and S.I. Doroshov. 2005. Effect of incubation temperature on green sturgeon embryos, *Acipenser medirostris*. Environmental Biology of Fishes 72:145-154.

Van Eenennaam, J.P., M.A.H. Webb, X. Deng, S.I. Doroshov, R.B. Mayfield, J.J. Cech, Jr., D.C. Hillemeir and T.E. Willson. 2001. Artificial spawning and larval rearing of Klamath River green sturgeon. Transactions of the American Fisheries Society 130:159-165.

Van Woert, W. 1964. Mill Creek counting station. Office memorandum to Eldon Hughes, May 25, 1964. California Department of Fish and Game, Water Projects Branch, Contract Services Section.

Vogel, D.A., and K.R. Marine. 1991. Guide to upper Sacramento River Chinook salmon life history. Prepared for the U.S. Bureau of Reclamation, Central Valley Project, 55 pages.

Vogel, D.A., K.R. Marine, and J.G. Smith. 1988. Fish passage action program for Red Bluff Diversion Dam. Final report on fishery investigations. Report No. FR1/FAO-88-19. U.S. Fish and Wildlife Service, Northern Central Valley Fishery Resource Office. Red Bluff, CA.

Waples, R.S. 1991. Pacific Salmon, *Oncorhynchus spp*., and the definition of "species" under the Endangered Species Act. Marine Fisheries Review 53:11-21.

Ward, P.D., T.R. Reynolds and C.E. Garman. 2003. Butte Creek spring-run Chinook salmon *Oncorhynchus tshawytscha*, pre-spawn mortality evaluation. California Department of Fish and Game, Inland Fisheries, Administrative Report No. 2004-5. Chico, CA.

Waters, T.F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7.

Williamson, K.S., and B. May. 2002. Incidence of phenotypic female Chinook salmon positive for the male Y-chromosome-specific marker *OtY1* in the Central Valley, California. Journal of Aquatic Animal Health 14:176-183.

Wright, D.A., and D.J. Phillips. 1988. Chesapeake and San Francisco Bays: A study in contrasts and parallels. Marine Pollution Bulletin 19 (9): 405-413.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of Chinook salmon in the Central Valley Drainage of California. *In* Sierra Nevada Ecosystem Project, Final Report to Congress, Volume III. Assessments, Commissioned Reports, and Background Information. Centers for Water and Wildland Resources, University of California. Davis, California.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley Drainage of California. *In* R.L. Brown (editor), Contributions to the Biology of Central Valley Salmonids, pages 71-176. California Department of Fish and Game, Fish Bulletin 179, Volume 1.

Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management 18:487-521.

Appendix A: Tables

Table 3:

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 4. 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
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

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		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	FRH	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 Camanche 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 Camanche 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
		Mokelumne River	Angler survey	Lower Mokelumne River below Camanche Dam to Lake Lodi	In-river harvest rates	Various, year-round	EBMUD
Central Valley	***Chinook salmon, Steelhead, Continued***	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

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		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 Steelhead	Sacramento River	Angler Survey	RBDD to Redding	In-river harvest	Random Days, Jul 15 - Mar 15	CDFG
		Battle Creek	Hatchery counts	CNFH	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
		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
<u>Central Valley</u>	***Central Valley Steelhead Continued***	Battle Creek	Otolith analysis	CNFH	Determine anadromy or freshwater residency of fish returning to hatchery	Variable, dependent on return timing	FWS
		Feather River	Hatchery coded wire tagging	FRH	Return rate, straying rate, and survival	Daily, Jul - Apr	DWR

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		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
		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 oumigration	Variable, Jan-Jun	Natural Resource Scientists, Inc.
Central Valley	***Central Valley Steelhead Continued***	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

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		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
	Sacramento River 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	Colemen National Fish Hatchery	Hatchery contribution	Variable	FWS, CDFG
		Sacramento River	Ladder counts	RBDD	Run-size above RBDD	Daily, Mar 30- Jun 30	FWS
		Pacific Ocean	Ocean Harvest	California ports south of Point Arena	Ocean landings	May 1- Sept 30 (commercial), Feb 15 - Nov 15 (sport)	CDFG
	Central Valley 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	UC Davis
		Suisun Marsh	Gill netting	Suisun Marsh Salinity Control Gates	Fish passage	Variable, Jun - Dec	CDFG

Table 5: Chemical Constituents of the MHWWTP Effluent[1]

		Effluent Concentrations in ug/l	
Constituent	Maximum Effluent Concentration	CCC 4 Day concentration[2]	CMC 1 hour concentration[3]
Aluminum	200	87	750
Antimony	0.55		
Arsenic	2	150	340
Chromium (total)	3.3		
Chromium 6	10	11	16
Copper	6.8	11	16
Lead	1	3.1	79
Mercury	0.0047	0.77	1.4
Nickel	5.8	56	510
Selenium	2.8	5	20
Thallium	0.005		
Zinc	10	130	130
Cyanide (total)	8.9	5.2	22
Tributyltin	0.008	0.063	0.46
Ammonia nitrogen	0.011	2.89	2.54
Aldrin	0.005	4	
Heptachlor	0.023	0.0038	0.52
Pentachlorophenol	0.065	12	16

(1) Constituents are projected maximum concentrations for the future wastewater outfall effluent based on current chemical constituent concentrations in the MHWWTP dry land disposal effluent. The current MHWWTP 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)

CENTRAL VALLEY PROJECT (U.S. BUREAU OF RECLAMATION)
CHINOOK SALMON SALVAGE

WATER YEAR TYPE SACRIVER	SJRIVER	(Calendar Year)	Month Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Annual OCAP Loss	Total (Take)
AN	BN	1957	0	0	3288	116684	85407	11600	512	312	192	0	0	0	217995	128318	341953
W	W	1958	0	0	0	0	0	0	528	48	0	0	0	0	576	339	904
BN	D	1959	0	0	29088	46476	19812	5148	276	84	48	0	0	0	100932	59411	158325
D	C	1960	0	0	8868	26340	25140	105584	432	48	0	0	0	0	166412	97955	261038
D	C	1961	0	0	4512	21444	25380	18792	408	72	0	0	0	0	70608	41562	110758
BN	BN	1962	0	0	0	20424	58032	13944	312	48	0	0	0	0	92760	54601	145506
W	AN	1963	0	0	0	0	14040	8196	336	48	60	0	0	0	22680	13350	35576
D	D	1964	0	372	1776	30144	57936	39864	888	0	108	0	0	0	131088	77162	205628
W	W	1965	0	0	2052	6864	232616	87072	3264	84	192	12	0	0	332158	195518	521029
BN	BN	1968	0	0	11028	68556	23844	14568	288	84	72	96	0	0	118536	69774	185939
W	W	1967	0	0	4476	4140	29340	15900	3408	360	24	72	0	0	57720	69774	185939
BN	D	1968	1236	48657	36768	54312	47256	8584	0	48	1020	4008	6228	744	208861	122941	327625
W	W	1969	6328	1152	660	12828	36566	7032	504	0	132	744	0	0	65946	38818	103445
W	AN	1970	0	25621	57100	135348	26022	17050	180	0	324	276	60	0	261981	154209	410951
W	BN	1971	0	1200	21504	92700	193116	119156	3456	24	0	144	3360	7464	442124	260246	693528
BN	D	1972	0	5184	22692	59664	149352	56140	60	12	2680	684	0	0	298668	175804	468499
AN	AN	1973	0	1868	4242	78480	78816	12096	144	0	0	34308	11856	1932	223742	131701	350968
W	W	1974	0	980	25444	43476	166916	31668	2328	24	36	1168	0	0	272040	124813	332618
W	W	1975	672	2184	8736	35760	51756	13404	432	122	60	252	121	38	113537	66831	178097
C	C	1976	0	876	13487	33516	51216	15900	0	216	24	216	240	312	116003	68283	181965
C	C	1977	2232	1044	204	1920	5448	1800	0	0	0	0	0	108	12756	7509	20009
AN	W	1978	0	0	360	984	4332	4260	192	0	0	26592	2448	3480	42648	25104	66899
BN	AN	1979	2784	169	1056	62304	40100	5458	0	0	184	0	745	0	112800	66397	176941
AN	W	1980	0	125	299	93825	50063	7320	1187	0	0	316	1328	308	154771	91102	242788
D	D	1981	95	0	1709	28907	28975	5458	0	0	0	2360	488	6872	74864	44067	117434
W	W	1982	2911	5414	13170	6535	95864	68290	295	233	0	0	14635	12814	220161	129593	345351
W	W	1983	5952	4110	6149	47667	112807	31935	928	0	0	2302	459	66	212375	125010	333137
W	AN	1984	162	0	8461	86803	81617	1904	990	0	0	10714	6671	5009	202331	119098	317382
D	D	1985	0	7319	4540	46780	59700	1633	103	0	0	8053	3898	5060	137086	80693	215037
W	W	1986	1810	401293	34136	67614	189070	46166	10257	0	0	642	75	966	752029	442665	1179653
D	C	1987	306	504	718	47962	39077	0	0	0	0	0	0	2395	90962	53543	142685
C	C	1988	3726	2196	1484	24196	22219	205	57	0	0	0	0	302	54385	32013	85310
D	C	1989	73	0	6151	13539	20685	2489	0	0	0	0	0	0	42937	25274	67352
C	C	1990	92	103	71	2085	2840	916	0	0	0	0	0	0	6107	3595	9580
C	C	1991	0	198	2527	18360	7006	292	0	0	0	0	2705	138	31226	18380	48982
C	C	1992	510	3907	18002	17349	1893	0	0	0	0	0	0	24	41685	24537	65388
AN	W	1993	36	360	360	5364	11724	1020	0	0	0	12	492	1134	20502	12068	32160
C	C	1994	256	2796	1668	4293	888	36	0	0	0	12	0	2262	12211	7188	19155
W	W	1995	3852	816	684	9390	24516	23820	1044	0	0	144	0	132	64398	37906	101018
W	W	1996	864	1044	96	19068	15486	3072	0	0	0	24	192	72	39918	23497	62616
W	W	1997	192	12	16296	19728	13260	3860	12	12	24	48	48	341	53833	31688	84444
W	W	1998	49512	37752	11002	12552	43872	12816	180	0	0	0	84	0	167770	98754	263169
W	AN	1999	2196	38148	9773	33354	36851	12252	36	36		12	96	132	132686	78220	208449
AN	AN	2000	1212	27472	7296	30024	9846	1872	36	0	204	36	48	168	78214	46039	122689
D	D	2001	276	1176	2977	21804	2550	516	0	12	0	0	0	168	29479	17352	46252
D	D	2002	936	204	1839	9274	1766	660	12	12	0	160	155	555	15573	9167	24428
		SUM	86221	624256	406749	1618837	2295018	841748	33085	1939	5584	93407	56432	52996	6118272	3601383	9597289
		MONTHLY MEAN	1917.85	13570.8	8842.37	35192.1	49891.7	18298.9	719.239	42.1522	121.391	2030.59	1226.78	1152.09	133006	78291	208637

Table 6

WATER YEAR TYPE			STATE WATER PROJECT (DEPARTMENT OF WATER RESOURCES) CHINOOK SALMON SALVAGE												Annual		
			Month														
SACRIVER	SJRIVER	(Calendar Year)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	OCAP Loss	Total (Take)
AN	BN	1957	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1958	0	0	0	0	0	0	0	0	0	0	0	0			
BN	D	1959	0	0	0	0	0	0	0	0	0	0	0	0			
D	C	1960	0	0	0	0	0	0	0	0	0	0	0	0			
D	C	1961	0	0	0	0	0	0	0	0	0	0	0	0			
BN	BN	1962	0	0	0	0	0	0	0	0	0	0	0	0			
W	AN	1963	0	0	0	0	0	0	0	0	0	0	0	0			
D	D	1964	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1965	0	0	0	0	0	0	0	0	0	0	0	0			
BN	BN	1966	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1967	0	0	0	0	0	0	0	0	0	0	0	0			
BN	D	1968	0	0	3446	10548	13980	1632	120	60	72	300	2772	2556	35486	20888	55664
W	W	1969	3420	275	284	14868	24124	3394	212	0	24	136	12	277	47026	27681	73766
W	AN	1970	1093	1574	1189	10831	12764	6220	2100	540	12	0	3168	14052	53543	31517	83989
W	BN	1971	223	1431	5528	3892	6012	776	0	0	0	0	0	312	18174	10698	28508
BN	D	1972	548	150	4822	13520	43387	19540	0	0	385	1407	8588	5390	97737	425482	521264
AN	AN	1973	1648	667	1814	6534	22334	3917	0	0	0	699	1463	3150	42226	183824	225205
W	W	1974	907	927	4008	13106	67567	44662	3597	0	1	91	4528	2408	141802	617311	756277
W	W	1975	1743	1650	4404	5508	15161	663	27	60	402	2516	3569	2858	38561	167669	205659
C	C	1976	961	1005	10287	3040	13688	1602	114	251	24	139	128	642	31881	138789	170032
C	C	1977	2224	983	593	68	4522	612	0	0	0	0	269	19068	28339	123369	151141
AN	W	1978	45621	6668	511	19	3200	12400	632	0	21	37139	653	3736	110600	481479	589867
BN	AN	1979	2399	1187	2304	28993	59790	9533	5647	359	70	1516	5392	5249	122439	533018	653008
AN	W	1980	5968	383	188	18668	27041	22836	725	725	931	966	943	1462	80836	351906	431125
D	D	1981	1756	3504	6327	55039	19115	352	0	85	0	395	2937	12095	101605	442320	541893
W	W	1982	6700	26805	22973	28353	110299	24446	0	0	0	0	6086	52757	278419	1212051	1484961
W	W	1983	12509	12758	4796	0	1138	37445	134	0	0	0	162	0	68942	300128	367691
W	AN	1984	0	80	1659	27260	40078	46130	3	575	0	10514	8859	9883	145041	631412	773552
D	D	1985	121	847	2261	28246	96273	8768	408	0	19	719	1099	1952	140713	612571	750469
W	W	1986	1639	13422	18900	133773	176557	90240	0	0	0	0	153	549	435233	1894714	2321243
D	C	1987	63	405	4316	40804	95002	9783	573	69	83	2	16	26764	177880	774371	948693
C	C	1988	2943	4235	3905	44736	71008	21453	1781	308	24	39	460	1016	151908	661306	810176
D	C	1989	2592	170	8319	49525	42859	602	0	122	0	38	755	1277	106259	462581	566715
C	C	1990	2463	1103	4668	17377	8964	595	75	0	0	9	0	42	35296	153655	188245
C	C	1991	91	99	4765	19904	12268	680	0	0	0	72	1282	9	39170	1705520	208907
C	C	1992	904	8445	9255	1058	2365	0	0	0	6	0	0	160	22193	96614	118363
AN	W	1993	1622	956	136	1487	2626	728	8	84	0	22	77	901	8647	37643	46117
C	C	1994	193	209	283	269	1787	20	0	0	0	0	10	707	3478	15141	18549
W	W	1995	5048	1389	18	14	3505	8994	184	12	0	0	0	0	19164	83427	102208
W	W	1996	3013	280	444	2637	6586	1583	14	0	10	3	112	46	14728	64116	78549
W	W	1997	18	35	1674	6014	2963	635	30	0	9	8	4	463	11853	51600	63216
W	W	1998	352	108	4	0	1713	1610	120	0	0	27	10	12	3956	17222	21099
W	AN	1999	34	844	1974	23609	23654	458	48	44	42	6	39	59	50811	221197	270992
AN	AN	2000	615	6825	3355	20690	9144	3951	33	15	526	227	52	180	45613	198569	219457
D	D	2001	263	1220	6422	13223	6747	0	0	0	0	0	0	452	28327	123317	151077
D	D	2002	1083	272	524	1606	2096	32	0	15	0	0	4	716	6348	27635	33856
		SUM	110777	100911	146356	645219	1050317	386292	16585	3324	2661	56990	53602	171200	2744234	1.3E+07	14031533
		MONTHLY MEAN	3165	2883	4182	18435	30009	11037	474	95	76	1628	1531	4891	78407	368598	400901

Table 7:

CENTRAL VALLEY PROJECT (U.S. BUREAU OF RECLAMATION)
STEELHEAD SALVAGE (Calendar Year)

WATER YEAR TYPE			Month												Annual	
SACRIVER	SJRIVER	(Calendar Year)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	OCAP Loss	Total (Take)
AN	BN	1957	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1958	0	0	0	0	0	0	0	0	0	0	0	0			
BN	D	1959	0	0	0	0	0	0	0	0	0	0	0	0			
D	C	1960	0	0	0	0	0	0	0	0	0	0	0	0			
D	C	1961	0	0	0	0	0	0	0	0	0	0	0	0			
BN	BN	1962	0	0	0	0	0	0	0	0	0	0	0	0			
W	AN	1963	0	0	0	0	0	0	0	0	0	0	0	0			
D	D	1964	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1965	0	0	0	0	0	0	0	0	0	0	0	0			
BN	BN	1966	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1967	0	0	0	0	0	0	0	0	0	0	0	0			
BN	D	1968	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1969	0	0	0	0	0	0	0	0	0	0	0	0			
W	AN	1970	0	0	0	0	0	0	0	0	0	0	0	0			
W	BN	1971	0	0	0	0	0	0	0	0	0	0	0	0			
BN	D	1972	0	0	0	0	0	0	0	0	0	0	0	0			
AN	AN	1973	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1974	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1975	0	0	0	0	0	0	0	0	0	0	0	0			
C	C	1976	0	0	0	0	0	0	0	0	0	0	0	0			
C	C	1977	0	0	0	0	0	0	0	0	0	0	0	0			
AN	W	1978	0	0	0	0	0	0	0	0	0	0	0	0			
BN	AN	1979	492	372	444	1080	0	0	0	0	0	0	0	0	2388	1406	3746
AN	W	1980	0	0	90	743	126	0	0	0	0	0	0	252	1211	713	1900
D	D	1981	248	1258	1008	168	267	0	0	0	0	0	0	0	2949	1736	4626
W	W	1982	0	0	0	0	297	0	0	0	0	0	0	1980	2277	1340	3572
W	W	1983	0	0	0	0	0	0	0	0	0	0	14	0	14	8	22
W	AN	1984	0	0	146	187	70	0	0	0	0	0	0	0	403	237	632
D	D	1985	0	83	134	127	101	0	0	0	0	0	0	0	445	262	698
W	W	1986	26	524	127	505	238	46	45	0	0	0	0	0	1511	889	2370
D	C	1987	143	112	718	776	275	0	0	0	0	0	0	0	2024	1191	3175
C	C	1988	248	0	491	1039	1646	0	0	0	0	0	0	139	3563	2097	5589
D	C	1989	0	252	5051	3139	1212	0	0	0	0	0	0	0	9654	5683	15144
C	C	1990	0	1085	2139	786	0	0	0	0	0	0	0	0	4010	2360	6290
C	C	1991	95	109	4412	1263	98	0	0	0	0	0	0	0	5977	3518	9376
C	C	1992	4216	1788	2716	342	0	0	0	0	0	0	0	0	9062	5334	14215
AN	W	1993	0	3480	3060	684	84	24	0	0	0	0	0	12	7344	4323	11520
C	C	1994	30	676	336	127	36	12	0	0	0	0	0	48	1265	745	1984
W	W	1995	12	276	648	228	108	72	0	0	0	0	0	0	1344	791	2108
W	W	1996	1008	838	24	264	84	12	0	0	0	0	0	24	2254	1327	3536
W	W	1997	12	0	168	396	60	36	12	0	0	0	0	12	696	410	1092
W	W	1998	300	180	120	36	48	12	168	0	0	0	12	0	876	516	1374
W	AN	1999	96	324	395	508	161	24	0	0	0	0	24	24	1556	916	2441
AN	AN	2000	444	1822	396	204	60	0	0	0	0	0	12	12	2950	1736	4627
D	D	2001	156	2388	1517	468	12	12	0	0	0	0	0	0	4553	2680	7142
D	D	2002	96	402	847	203	0	24	0	0	0	0	0	84	1656	975	2598
		SUM	7622	15969	24987	13273	4983	274	225	0	0	0	62	2587	69982	41193	109777
		MONTHLY MEAN	318	665	1041	553	208	11	9	0	0	0	3	108	2916	1716	4574

Table 8:

STATE WATER PROJECT (DEPARTMENT OF WATER RESOURCES)
STEELHEAD SALVAGE (Calendar Year)

WATER YEAR TYPE			Month													Annual	
SACRIVER	SJRIVER	(Calendar Year)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	OCAP Loss	Total (Take)
AN	BN	1957	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1958	0	0	0	0	0	0	0	0	0	0	0	0			
BN	D	1959	0	0	0	0	0	0	0	0	0	0	0	0			
D	C	1960	0	0	0	0	0	0	0	0	0	0	0	0			
D	C	1961	0	0	0	0	0	0	0	0	0	0	0	0			
BN	BN	1962	0	0	0	0	0	0	0	0	0	0	0	0			
W	AN	1963	0	0	0	0	0	0	0	0	0	0	0	0			
D	D	1964	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1965	0	0	0	0	0	0	0	0	0	0	0	0			
BN	BN	1966	0	0	0	0	0	0	0	0	0	0	0	0			
W	W	1967	0	0	0	0	0	0	0	0	0	0	0	0			
BN	D	1968	0	0	766	744	348	84	0	0	12	0	12	24	1990	1171	3172
W	W	1969	36	13	55	9	20	60	0	0	0	0	24	120	337	198	529
W	AN	1970	170	13	25	242	0	0	24	0	0	0	0	48	522	307	819
W	BN	1971	36	96	384	348	72	0	0	0	0	0	12	0	948	558	1487
BN	D	1972	48	60	1813	710	141	0	0	0	0	0	0	105	2877	12525	15344
AN	AN	1973	41	72	46	76	40	259	0	0	0	0	0	0	534	2325	2848
W	W	1974	0	59	879	141	11	480	0	0	21	1	0	0	1592	6931	8491
W	W	1975	0	436	2404	1116	229	40	0	0	12	8	120	0	4365	19002	23280
C	C	1976	62	264	1696	341	96	0	0	0	8	8	7	2	2504	10901	13355
C	C	1977	6	169	428	123	222	2	1230	0	0	0	5	2268	4453	19386	23749
AN	W	1978	390	6107	254	86	85	436	0	0	0	0	0	0	7358	32032	39243
BN	AN	1979	15	25	454	1011	969	0	0	0	0	0	20	23	2517	10957	13424
AN	W	1980	381	835	74	118	210	80	0	0	0	33	0	25	1756	7644	9365
D	D	1981	119	1509	3088	4902	0	0	0	0	0	0	0	309	9927	43216	52944
W	W	1982	792	1432	1110	10965	2441	179	0	0	0	17	0	0	16936	73728	90325
W	W	1983	280	89	0	0	256	0	0	0	0	0	0	0	625	2721	3333
W	AN	1984	0	0	41	357	18	0	0	0	0	0	0	22	438	1907	2336
D	D	1985	0	325	1221	1165	647	0	0	0	0	0	0	0	3358	14618	17909
W	W	1986	0	139	54	1328	446	0	0	0	0	0	0	1268	3235	14083	17253
D	C	1987	0	69	3387	976	446	0	0	0	0	0	0	172	5050	21984	26933
C	C	1988	88	2403	823	2116	426	25	0	0	0	0	0	0	5881	25602	31365
D	C	1989	46	499	4767	2105	404	0	0	0	0	0	0	0	7821	34047	41712
C	C	1990	0	1317	2195	1039	19	0	0	0	0	0	0	0	4570	19895	24373
C	C	1991	22	23	5799	91	0	0	0	0	0	92	489	0	6516	28366	34752
C	C	1992	148	5418	3867	201	33	0	0	0	0	0	0	16	9683	42153	51643
AN	W	1993	1330	8561	792	353	200	0	0	0	0	0	0	0	11236	48914	59925
C	C	1994	21	107	154	22	61	0	15	0	0	2	0	4	386	1463	1796
W	W	1995	360	362	78	6	86	117	30	0	0	4	0	0	1043	4541	5563
W	W	1996	2009	597	190	192	151	7	0	0	0	0	17	17	3180	13844	16960
W	W	1997	0	9	88	101	23	0	0	0	0	28	0	30	279	1215	1488
W	W	1998	52	16	0	0	0	6	0	0	0	39	0	0	113	492	603
W	AN	1999	13	7	177	587	195	42	6	4	0	6	36	3	1076	4684	5739
AN	AN	2000	721	4405	791	231	27	56	6	0	0	3	54	173	6467	28153	34491
D	D	2001	387	2932	4468	258	57	0	0	0	0	0	0	2	8104	35279	43221
D	D	2002	612	537	656	159	22	18	12	0	0	0	0	165	2181	9495	11632
		SUM	8185	38925	43024	32219	8401	1891	1323	4	53	241	796	4796	139858	594337	731402
		MONTHLY MEAN	234	1112	1229	921	240	54	38	0	2	7	23	137	3996	16981	20897

Table 9:

Note:

For tables 6 through 9 the following abbreviations are used for the water type years:

W	Wet
AN	above normal rainfall
BN	below normal rainfall
D	Dry
C	Critically dry

SACRIVER refers to the Sacramento River watershed basin, SJRIVER refers to the San Joaquin River watershed basin.

The monthly salvage numbers reflect the sum of the expanded fish counts recorded daily at each facility. These daily counts are conducted during finite periods of time during the day and night (*i.e.* 10 minute counts every 4 hours). This salvage number is further expanded to account for the loss of fish through the fish screen louvers (screen efficiency), predation occurring in the fish screen system, and loss in the handling and trucking of salvaged fish prior to release to give a total loss value (*i.e.* OCAP Loss). The two numbers are summed to give the total number of fish that are affected directly by the fish screen operations (the incidental take).

Appendix B: Figures

Figure 1: Project Site for the MHWWTP Diffuser Outfalls - Regional

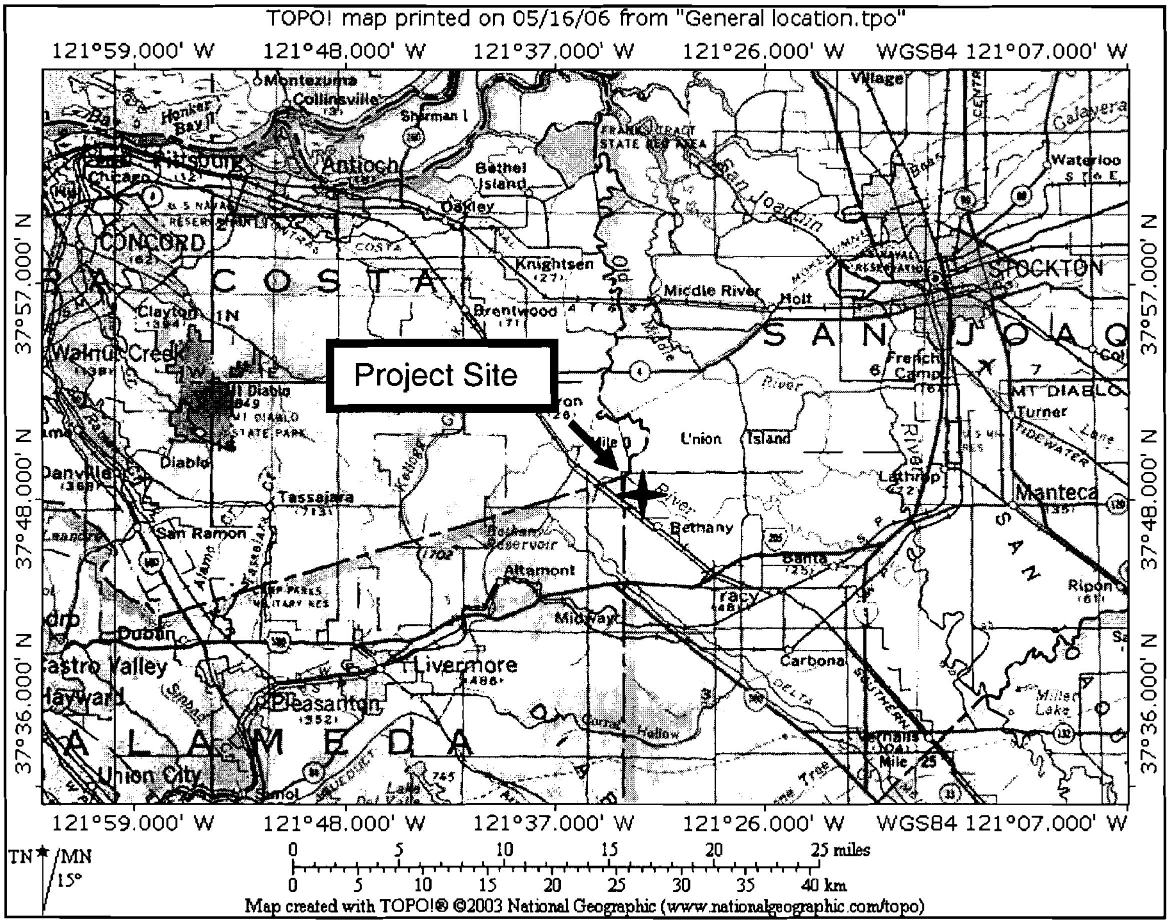


Figure 2: Project Site for the MHWWTP Outfall Diffusers - Local

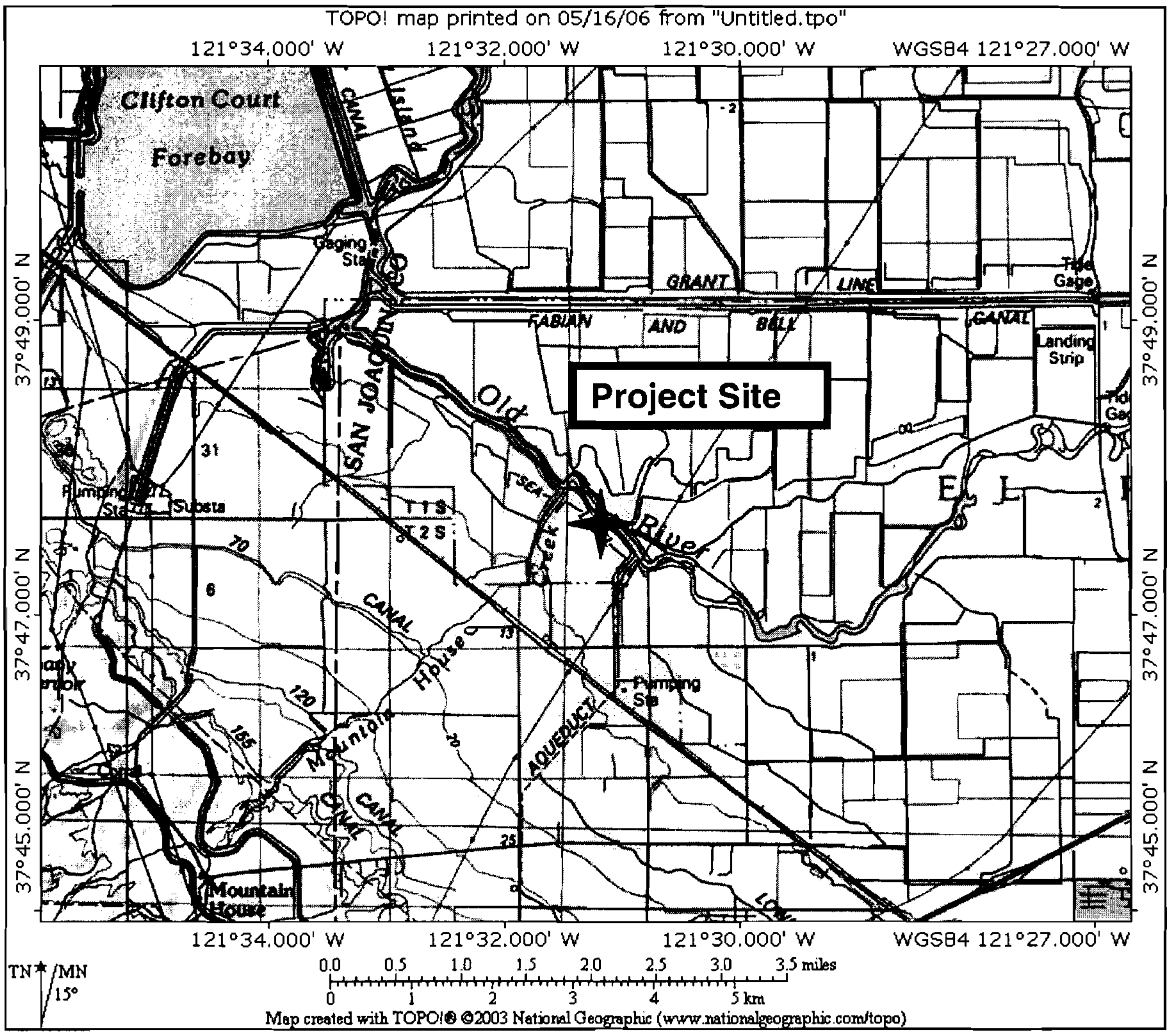


Figure 3: Primary Diffuser Schematics for the MHWWTP Outfall

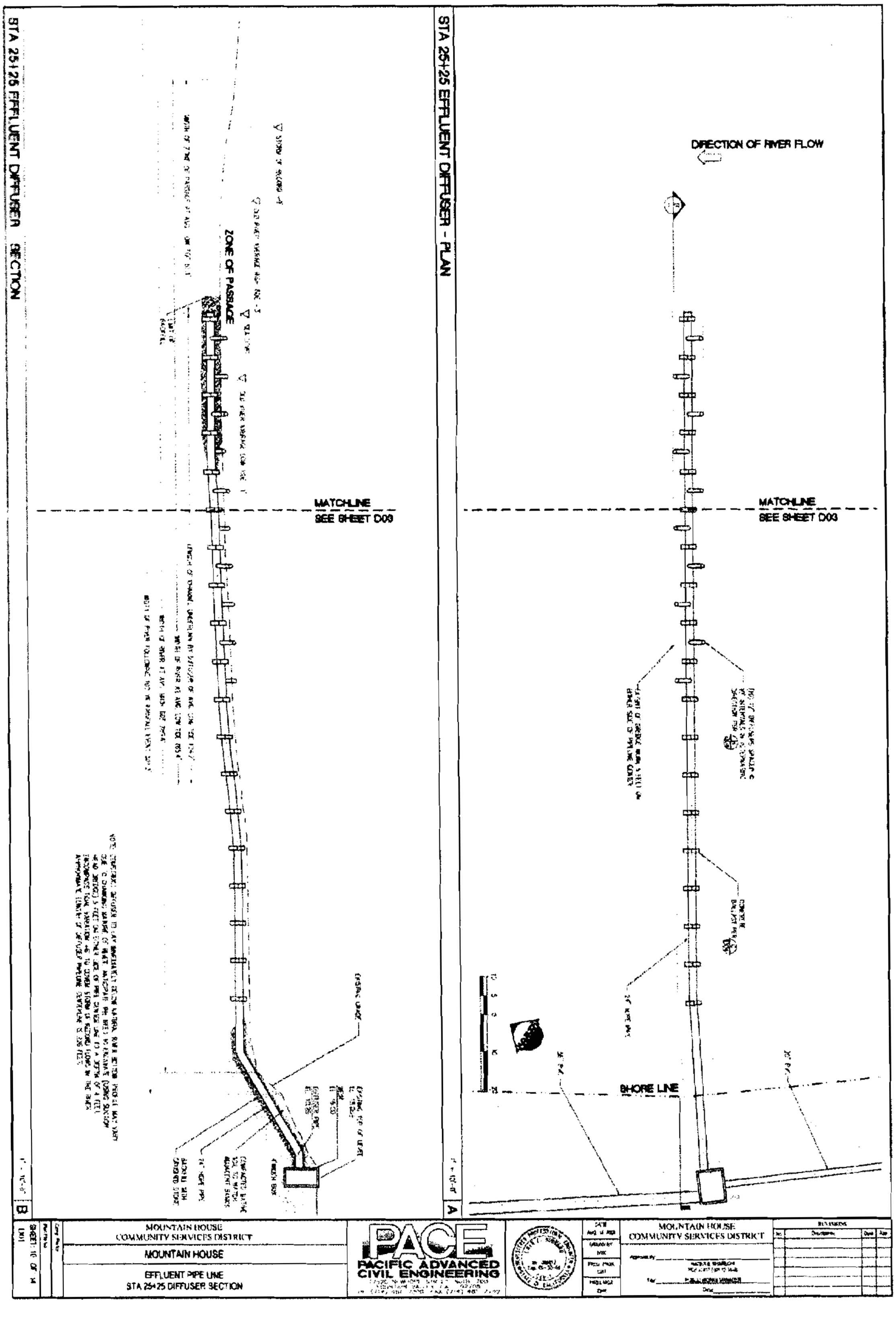
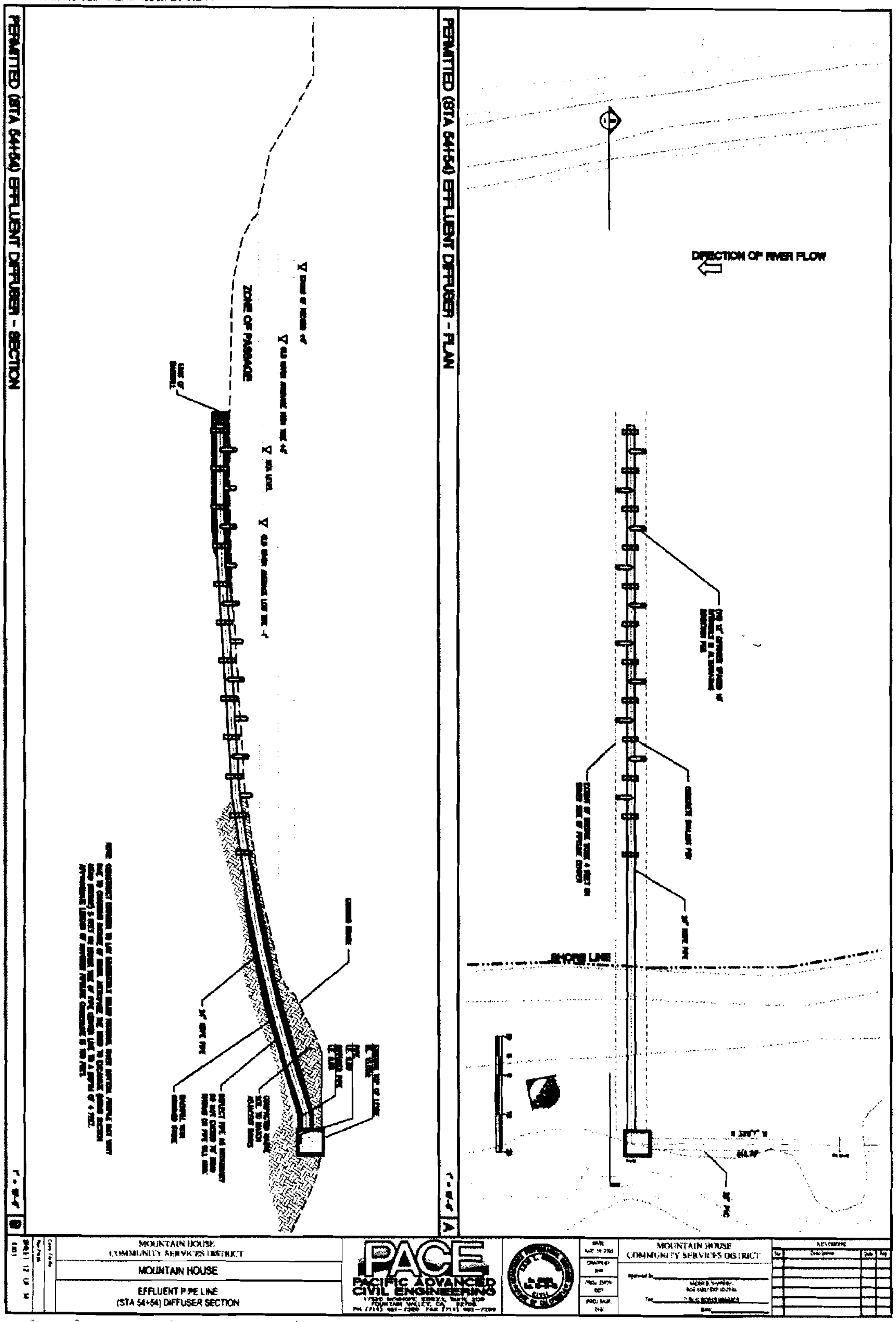


Figure 4: Secondary Diffuser Schematic for the MHWWTP Outfall



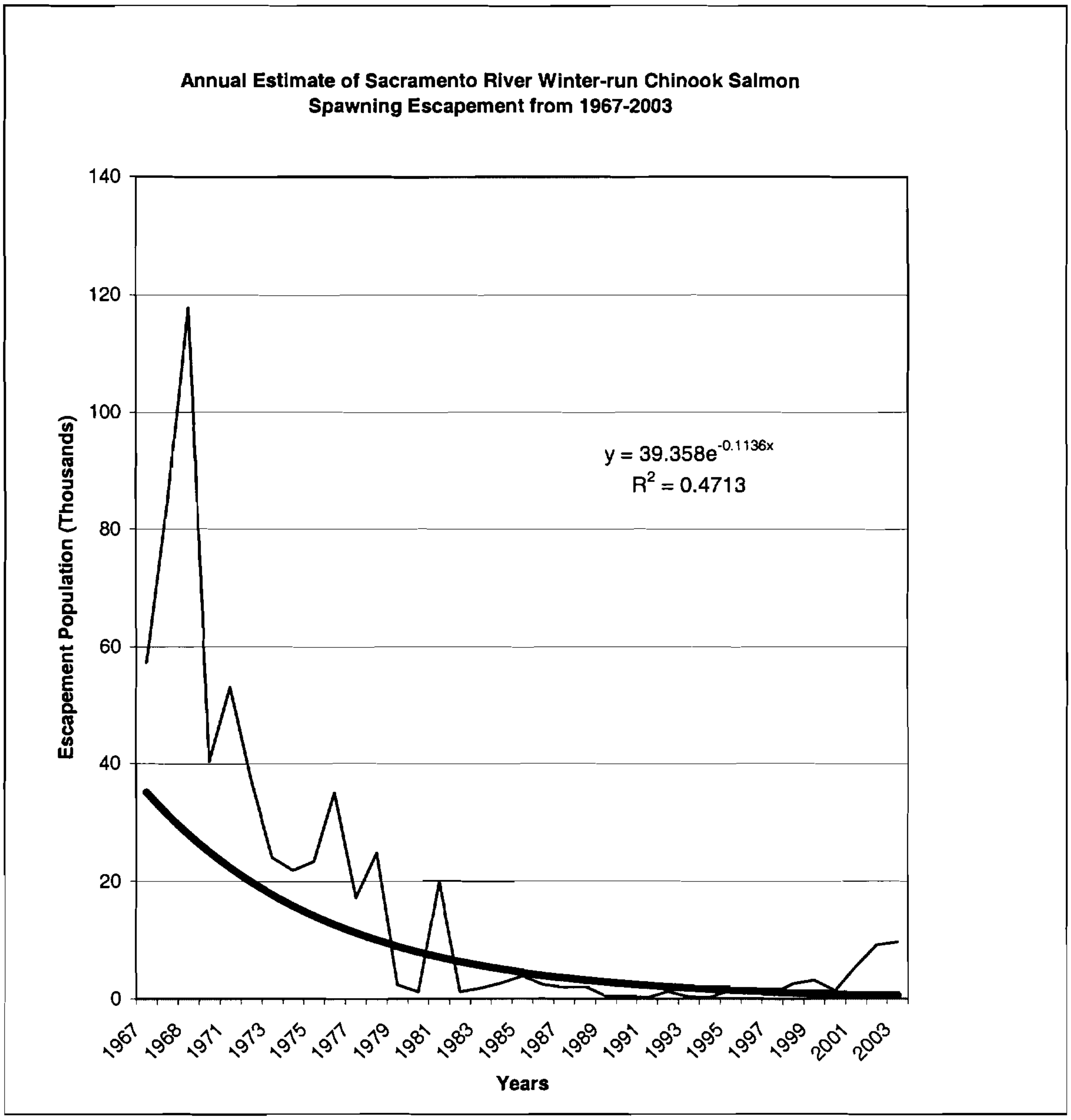


Figure 5:
Annual estimated Sacramento River winter-run Chinook salmon escapement population.
Sources: PFMC 2002, 2004, DFG 2004a, NMFS 1997
Trendline for figure 5 is an exponential function: $Y=39.358\ e^{-0.1136x}$, $R^2=0.4713$.

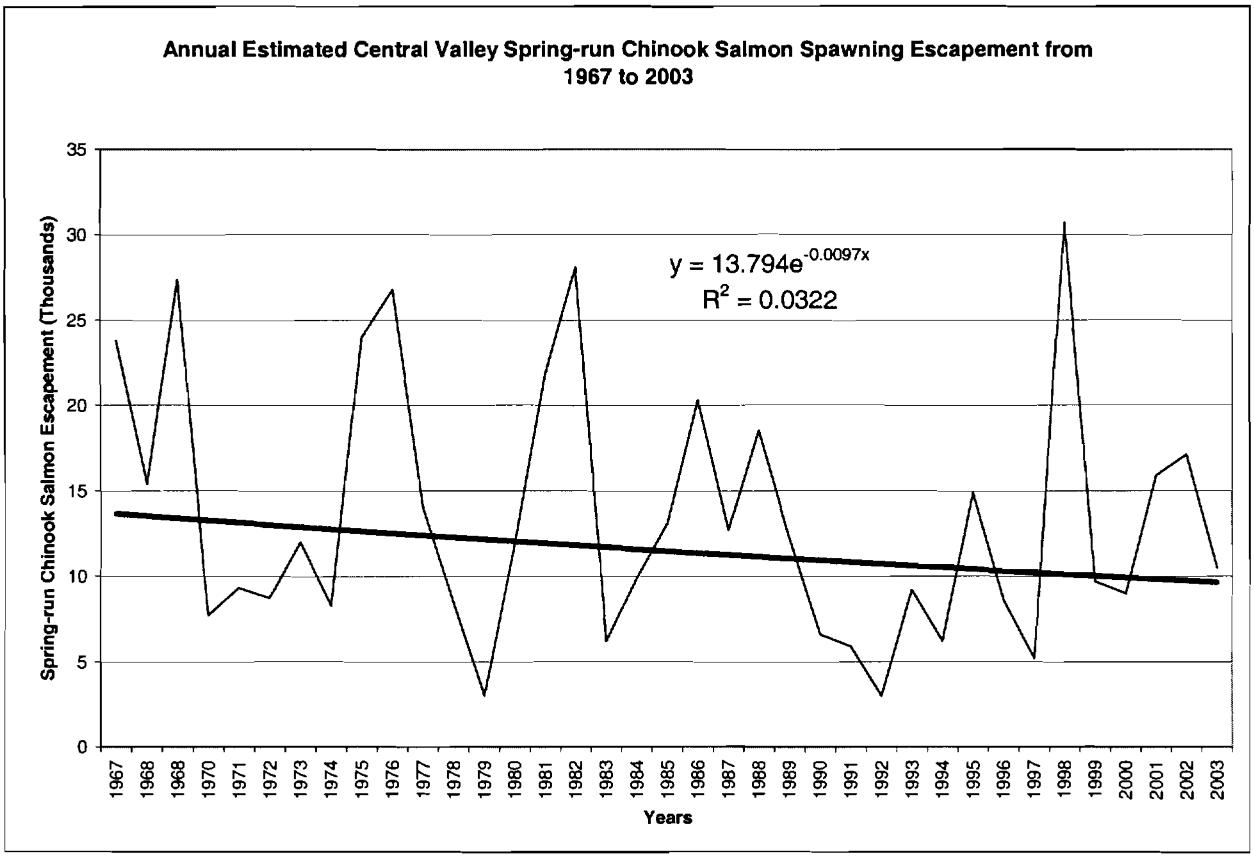
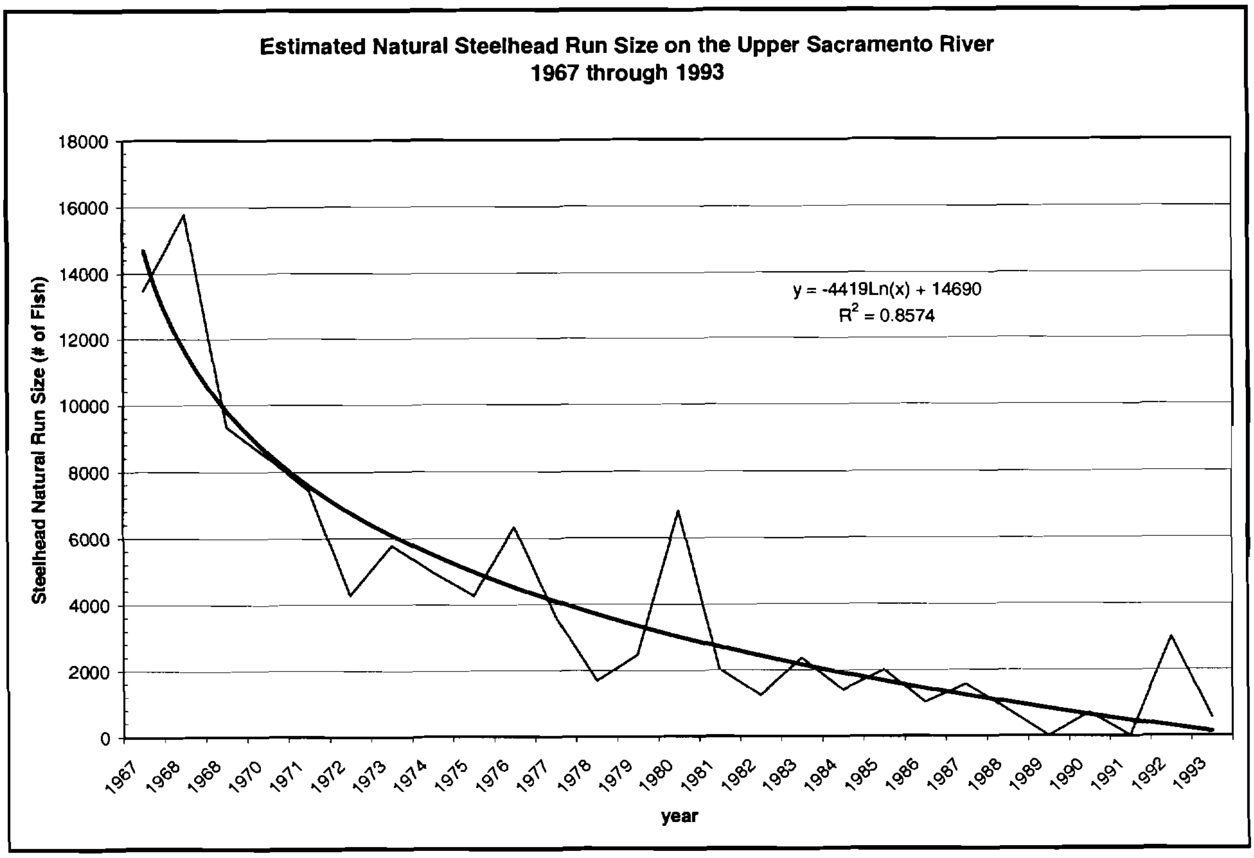


Figure 6:

Annual estimated Central Valley spring-run Chinook salmon escapement population for the Sacramento River watershed for years 1967 through 2003.

Sources: PFMC 2002, DFG 2004b, Yoshiyama 1998.

Trendline for figure 6 is an exponential function: $Y=13.794\ e^{-0.0097}$, $R^2 = 0.0322$.



Note: Steelhead escapement surveys at RBDD ended in 1993

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

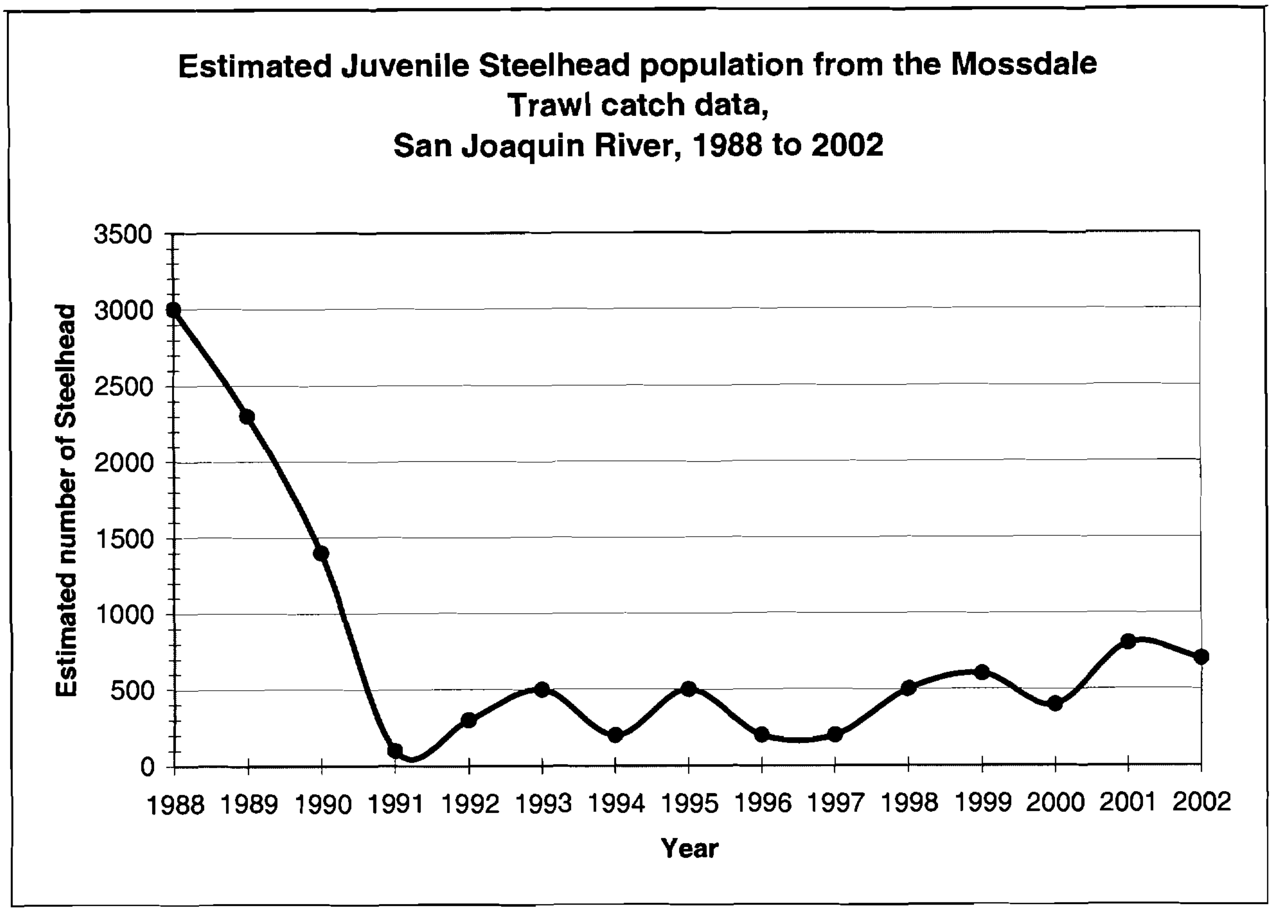


Figure 8:
Estimated number of juvenile Central Valley steelhead derived from the Mossdale trawl surveys on the San Joaquin River from 1988 to 2002.
Source: Marston (DFG), 2003.

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.

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). 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.

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.

IV. CONCLUSION

Based on the best available information, NMFS believes that the proposed Mountain House Wastewater Treatment Plant expansion project may adversely affect EFH for Pacific salmon during its 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).

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

California Advisory Committee on Salmon and Steelhead Trout. 1998. Restoring the balance. California Department of Fish and Game, Inland Fisheries Division, Sacramento, California, 84 pages.

Dettman, D.H., D.W. Kelley, and W.T. Mitchell. 1987. The influence of flow on Central Valley salmon. Prepared by the California Department of Water Resources. Revised July 1987. 66 pages.

Healey, M.C. 1991. Life history of Chinook salmon. *In* C. Groot and L. Margolis (editors) Pacific salmon life histories, pages 213-393. University of British Columbia Press, Vancouver.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California. *In* V.S. Kennedy (editor), Estuarine comparisons, pages 213-393. Academic Press, New York, New York.

Kondolf, G.M., J C. Vick, and T.M. Ramirez. 1996a. Salmon spawning habitat rehabilitation in the Merced, Tuolumne, and Stanislaus Rivers, California: an evaluation of project planning and performance. University of California Water Resources Center Report No. 90, ISBN 1-887192-04-2, 147 pages.

Kondolf, G.M., J.C. Vick, and T.M. Ramirez. 1996b. Salmon spawning habitat on the Merced River, California: An evaluation of project planning and performance. Transactions of the American Fisheries Society 125:899-912.

Lister, D.B., and H.S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Big Qualicum River, British Columbia. Journal of the Fisheries Research Board of Canada 27:1215-1224.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-35, 443 pages.

National Marine Fisheries Service. 1997. Proposed recovery plan for the Sacramento River winter-run Chinook salmon. National Marine Fisheries Service, Southwest Region, Long Beach, California, 288 pages plus appendices.

Pacific Fishery Management Council. 1999. Description and identification of essential fish habitat, adverse impacts and recommended conservation measures for salmon.

Amendment 14 to the Pacific Coast Salmon Plan, Appendix A. Pacific Fisheries Management Council, Portland, Oregon.

Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley streams: A plan for action. California Department of Fish and Game, Sacramento, California, 129 pages.

U.S. Fish and Wildlife Service. 1998. Central Valley Project Improvement Act tributary production enhancement report. Draft report to Congress on the feasibility, cost, and desirability of implementing measures pursuant to subsections 3406(e)(3) and (e)(6) of the Central Valley Project Improvement Act. U.S. Fish and Wildlife Service, Central Valley Fish and Wildlife Restoration Program Office, Sacramento, California.