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August 30, 2010

Jeffrey Shu, State Water Resources Control Board
Division of Water Quality
P.O. Box 100
Sacramento, CA 95812-0100

VIA ELECTRONIC AND U.S. MAIL: jshu@waterboards.ca.gov

RE: **Notice of Public Solicitation of Water Quality Data and Information for 2012 California Integrated Report [Clean Water Act Sections 305(b) and 303(d)]**

Dear Mr. Shu:

The undersigned organizations have been active for many years on programs and issues affecting the quality and flow of the waters of the State. Our organizations have performed water monitoring and watershed surveys, and conducted outreach among a diverse group of citizens around California, to determine the most pressing issues for state waterway health. We welcome the opportunity to submit these comments in light of these significant and ongoing efforts.

We present in this letter two general themes of proposed listings. First, we highlight some examples of traditional "pollutant"-based "Category 5"[1] listings that are being proposed to you separately. This Category of listings has been the focus of the State Water Resources Control Board's (State Board) 303(d) list to date. We urge the State Board's careful attention to these and the other Category 5 listings proposed by the identified commenters as well as the undersigned organizations and others. The adoption of such proposed listings will help ensure clean, healthy waterways throughout the State.

Second, we highlight additional groups of listings that also identify impaired and threatened waters that should be listed under Category 4 (particularly 4C) or Category 5. Our analysis reveals three such groups that regularly impair designated beneficial uses but that have received inadequate attention in the state's 303(d) process to date. These are: altered natural flows in surface waters, groundwater contamination and excessive groundwater withdrawals that impact surface water health, and anthropogenic climate change-caused impacts to surface waters. Impaired and threatened waterways from these groups of listings must be included in the 2012 303(d) list to ensure compliance with the Clean Water Act, and to achieve full restoration of the health of the waters of the state.

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[1] Category references from U.S. EPA, "Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act" (July 29, 2005), available at: http://www.epa.gov/owow/tmdl/2006IRG/report/2006irg-report.pdf (2006 Guidance), and SWRCB, "Staff Report: 2010 Integrated Report Clean Water Act Sections 303(d) and 305(b)" (April 19, 2010) (2010 Integrated Report Staff Report), available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/2010ir0419.pdf.

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I. FEDERAL AND STATE MANDATES REQUIRE 303(D) LIST IDENTIFICATION OF ALL IMPAIRED AND THREATENED CALIFORNIA WATER BODIES.

A. Impaired or Threatened Water Bodies Must Be Identified on the 303(d) List Regardless of Whether Impacted by "Pollutants" or "Pollution."

Section 303(d) of the Federal Clean Water Act represents the Act's "safety net."[2] It is the bedrock component of the Clean Water Act, the backstop to ensure that the goals of the Act can be achieved when initial efforts fail. At the advent of implementation of Section 303(d) in the late 1990s, U.S. EPA Assistant Administrator for Water Robert Perciasepe called the TMDL program "crucial to success because it brings rigor, accountability, and statutory authority to the process."[3]

Section 303(d) requires states to address comprehensively all human activities that affect the chemical, physical, and biological integrity of the nation's waters.[4] Section 303(d) is widely recognized as an essential means to achieving the Clean Water Act's goal of restoring waters so that they are safe for swimming, fishing, drinking, and other "beneficial uses" that citizens enjoy, or used to be able to enjoy.[5]

Section 303(d) first requires the State Water Board to identify waters that do not meet, or are not expected to meet by the next listing cycle, water quality standards after the application of certain technology-based controls. Specifically, Section 303(d)(1)(A) states as follows:

> Each State shall identify those waters within its boundaries for which the effluent limitations required by section 1311(b)(1)(A) and section 1311(b)(1)(B) of this title are not stringent enough to implement any water quality standard applicable to such waters. The State shall establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters.

In other words**,** if a water body's standards are not being met in the water body, then it *must* be listed under the state's Section 303(d) list. This is a separate and distinct task from the effort of determining whether or not total maximum daily loads (TMDLs) are required, as discussed in CWA Section 303(d)(1)(C):

> Each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those

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[2] Houck, Oliver A., *The Clean Water Act TMDL Program* 49 (Envtl. Law Inst. 1999).
[3] Memorandum from Robert Perciasepe, Assistant Administrator for Water, U.S. EPA, to Regional Administrators and Regional Water Division Administrators, U.S. EPA, "New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs)" (August 8, 1997).
[4] *See* 33 U.S.C. §§ 1251 *et seq.* and 33 U.S.C. § 1313(d).
[5] 33 U.S.C. § 1313(d)(1) and (2); *see also* 40 C.F.R. § 130.7(b)(1). California law defines an existing use as one that has occurred since 1975 and recognizes 23 designated or beneficial uses for water bodies, including uses such as freshwater replenishment, and migration of aquatic organisms. (2002 California 305(b) Report on Water Quality, Appendix A, State Water Resources Control Board, August, 2003. Available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/305b.shtml.

> pollutants which the Administrator identifies under section 1314(a)(2) of this title as suitable for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

This means that a water body is listed on the 303(d) list if beneficial uses are being impaired, and a TMDL is developed if they are being impaired by a "pollutant" (including a combination of pollutants and pollution).

"Pollutant" is defined in CWA Section 502(6).[6] Courts have interpreted the definition of "pollutant" expansively, stating that it "encompass[es] substances not specifically enumerated but subsumed under the broad generic terms" listed in Section 502(6).[7] Similarly, courts have stated that the definition of pollutant is "meant to leave out very little."[8]

"Pollution" is also defined in CWA Section 502, as "the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." U.S. EPA has found that "pollution" must result in a 303(d) listing if it results in impairment, and will result in a TMDL if pollutants are also present:

> In some cases, the pollution is caused by the presence of a pollutant and a TMDL is required. In other cases, pollution does not result from a pollutant and a TMDL is not required. States should schedule these segments for monitoring to confirm that there continues to be no pollutant associated with the failure to meet the water quality standard and to support water quality management actions necessary to address the cause(s) of the impairment.[9]

The mandate to list impaired waterways under Section 303(d)(1)(A) regardless of the cause of impairment is consistent with the reasoning of *Pronsolino v. Nastri*.[10] The Ninth Circuit Court of Appeals found that the source of the impairment at issue is irrelevant to listing, and that decisionmakers may consider only the issue of whether the water body is impaired in determining whether to list it. This position is also supported by the National Research Council (NRC), which found that the TMDL program "should encompass all stressors, <u>both pollutants</u>

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[6] The definition of "pollutant" in Section 502(6) includes: "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water." Several other items are specifically excluded; flow alteration is not one of those items.

[7] *U.S. PIRG v. Atlantic Salmon of Maine* (U.S. Dist. Ct. Maine, Aug. 2001), available at http://www.med.uscourts.gov/Site/opinions/kravchuk/2001/MJK_08282001_1-00cv150_USPIRG_v_Heritage.pdf, citing *United States v. Hamel*, 551 F.2d 107 (6th Cir. 1977).

[8] *Id.*, citing *Sierra Club, Lone Star Chapter v. Cedar Point Oil Co.*, 73 F.3d 546, 566-568 (5th Cir. 1996), *cert. denied*, 519 U.S. 811 (1996).

[9] 2006 Guidance at 56.

[10] *Pronsolino v. Nastri*, 291 F.3d 1123, 1137-38 (9th Cir. 2002), cert. denied, 123 S. Ct. 2573 (2003) ("Water quality standards reflect a state's designated *uses* for a water body and do not depend in any way upon the source of pollution").

and pollution, that determine the condition of the waterbody."[11] The NRC found this step to be important in part because "activities that can overcome the effects of 'pollution' and bring about water body restoration – such as habitat restoration and channel modification – should not be excluded from consideration during TMDL plan implementation."[12]

In its 2006 Guidance informing states on how to prepare their biennial report on water quality (the states' "305(b)/303(d) Integrated Report"), U.S. EPA recommended a division of impaired water body segments into Categories as follows:[13]

- Category 4: Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed;
- Category 5: Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.

California adopted the following, similar state categories for impaired waterways:[14]

- Category 4a: A water segment for which ALL its 303(d) listings are being addressed; and 2) at least one of those listings is being addressed by a USEPA approved TMDL.
- Category 4b: A water segment for which ALL its 303(d) listings are being addressed by action(s) other than TMDL(s).
- Category 4c: A water segment that is impaired or affected by non-pollutant related [*i.e.*, "pollution"] cause(s).
- Category 5: A water segment where standards are not being met and a TMDL is required but not yet completed for at least one of the pollutants being listed for this segment.

Categories "4" and "5" together represent the state's "303(d) List," as *both* categories encompass the total of the state's impaired or threatened waterways under Section 303(d)(1)(A). Category 5 waters require a TMDL. This Category includes waters impaired only by pollutants and those impaired both by pollutants and "pollution" (in which case consideration of the "pollution" would be given in the TMDL development for the waterway). Category 4 also includes impaired waters, but categorizes them as not requiring development of a TMDL,[15] though other actions may be taken to improve their health, as noted below.

California's 2008/2010 303(d) list of impaired waters, adopted by the State Water Board on August 4, 2010, contains Category 4A, 4B, and Category 5 waters. However, **the state's 2008/2010 303(d) list fails to include *any* Category 4C waters**, a glaring omission given the numerous pollution-related impairments facing many of the state's threatened and impaired waterways. The State Board must rectify this oversight in the state's 2012 303(d) list.

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[11] National Research Council, "Assessing the TMDL Approach to Water Quality Management," p. 4 (Nat'l Academy Press, Wash. D.C., 2001) (emphasis added).
[12] *Id.*
[13] 2006 Guidance at pp. 46 *et seq.* (emphasis added).
[14] *See* 2010 Integrated Report Staff Report at 20 (emphasis added).
[15] As noted below, we would argue that flow alterations can and should require development of a TMDL even if present without pollutants; there is precedent for this position in California.

In sum, the 2012 303(d) list must identify *all* impaired and threatened waters, whether impaired by pollutants and/or pollution – not only so that they may be addressed as required by the TMDL process,[16] but also so they may be restored to health as well through other programs and policies. For example, California's Porter-Cologne Water Quality Control Act requires that Basin Plans include a program of implementation that describes how water quality standards will be attained.[17] Where standards are not being attained – such as where flow alterations have been identified as impairing waterway beneficial uses – these implementation plans must incorporate strategies for achieving waterway health. Implementation of this state mandate, along with the TMDL program mandates where applicable, will ensure that water bodies whose health is threatened and impaired – in Categories 4(a)-(c) *and* Category 5 – are restored to health.

B. The State Must Use and Consider All Readily Available Information

The body of regulations and guidance that bear on 303(d) listing are unambiguous about the information that should be considered in making listing decisions: *all of it*. Federal regulations state clearly that "[e]ach State shall assemble and evaluate all existing and readily available water quality-related data and information to develop the [303(d)] list."[18] The regulations further mandate that local, state and federal agencies, members of the public, and academic institutions "should be *actively* solicited for research they may be conducting or reporting."[19] Furthermore, EPA's 2006 Guidance explicitly states that U.S. EPA's review of California's list will include an "assess[ment of] whether the state conducted an adequate review of all existing and readily available water quality-related information."[20] To that end, the 2006 Guidance also requires states to provide "[r]ationales for any decision to not use any existing and readily available data and information."[21]

Accordingly, and the State Board's data solicitation notice notwithstanding,[22] any and all existing and readily available data and information must be considered to determine the health of the state's increasingly-degraded water bodies.

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[16] *See supra* n. 15 regarding TMDLs for flow-related impairments in California, and *see infra* regarding requirements to develop TMDLs that consider flows when waterways are also listed due to pollutant impairments. *See also* SWRCB, "A Process for Addressing Impaired Waters in California" (July 2005), available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/docs/iw_guidance.pdf.

[17] Water Code Section 13241 reads: "Each regional board shall establish such water quality objectives in water quality control plans as in its judgment will ensure the reasonable protection of beneficial uses and the prevention of nuisance…." Section 13242 follows that: "The program of implementation for achieving water quality objectives shall include, but not be limited to:

(a) A description of the nature of actions which are necessary to achieve the objectives, including recommendations for appropriate action by any entity, public or private.

(b) A time schedule for the actions to be taken.

(c) A description of surveillance to be undertaken to determine compliance with objectives."

It is both the law and good public policy for the state to take action to ensure that waterways identified as impaired, including those impaired by pollution, are restored to health.

[18] 40 C.F.R. § 130.7(b)(5).

[19] 40 C.F.R. § 130.7(b)(5)(iii) (emphasis added).

[20] 2006 Guidance at 29.

[21] *Id.* at 18.

[22] SWRCB, "Notice of Public Solicitation of Water Quality Data and Information for 2012 California Integrated Report – Surface Water Quality Assessment and List of Impaired Waters" (Jan. 10, 2010; updated May 24, 2010), http://www.waterboards.ca.gov/water_issues/programs/tmdl/docs/data_solicitation_ir2012v2.pdf.

II. THE UNDERSIGNED ORGANIZATIONS URGE THE STATE WATER BOARD TO LIST ALL WATERWAYS IMPAIRED BY "POLLUTANTS."

The 2008/2010 303(d) list adopted by the State Board on August 4, 2010 shows a 64% increase from the number of listings in 2006. This number likely reflects both a growing number of severely polluted waterways in California and an improvement in the Board's ability to assess a larger number of waterways and pollutants. We applaud the State Water Board for its efforts to assess a larger number of waterways and sources and causes of impairments and expect to see the 2012 303(d) list capture an even larger number of impairments.

The 2012 list can improve upon the 2008/2010 list by including additional new listings as needed, and in particular those waterways impaired by trash and bacteria. In order to rectify this, the State Water Board must ensure that the 2012 List reflects water quality data and information submitted by Waterkeeper and other groups monitoring local water quality. We bring to the Board's attention just some of the numerous water quality issues in watersheds from the Oregon border to San Diego that have yet to be addressed by the State Board's 303(d) List, and incorporate by reference the related data submissions by local Waterkeepers and the undersigned organizations. This information is by no means comprehensive, but provides the Water Board with examples of additional listings that should be carefully reviewed for inclusion in the 2012 303(d) list.

<u>North Coast</u>

Humboldt Baykeeper's Citizen Monitoring Program has collected water quality data from sites throughout the Humboldt Bay, Mad River, and Little River watersheds since 2005. Numerous waterbodies in the Humboldt Bay, Mad River, and Little River watersheds have quite high levels of fecal coliform (*E. coli*), particularly after major rain events. High fecal coliform levels have resulted in posted closures of several local beaches by the Ocean Monitoring Program of the Humboldt County Division of Environmental Health.[23] These beaches include Moonstone Beach County Park (at the outlet of Little River), and Mad River Mouth North (at the outlet of Widow White Creek and Mad River). The County has sampled ocean waters since 2003, and has documented exceedences of fecal coliform and/or Enterococcus at both Moonstone Beach County Park and Mad River Mouth North.[24] Moonstone Beach County Park is on the 303(d) list for indicator bacteria, but Humboldt Baykeeper's Citizen Monitoring Program is the only source of water quality data upstream from these beaches were water pollution due to indicator bacteria is of concern. This water quality data warrants several additional listings, as described in Humboldt Baykeeper's 303(d) comment letter.

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[23] http://co.humboldt.ca.us/hhs/phb/environmentalhealth/oceanmonitoringprogram/.
[24] http://co.humboldt.ca.us/hhs/phb/environmentalhealth/oceanmonitoringprogram/waterqualitytestresults-archive.asp.

Central Coast

From July 2008 to March 2010 San Francisco Baykeeper conducted *Enterococcus* monitoring near storm drains in San Francisco Bay's Oakland Inner Harbor.[25] The data collected reflected exceedences of Basin Plan water quality standards for *Enterococcus*, [26] and showed that contact recreation in the vicinity of these storm drains poses serious risks.[27] Accordingly, Oakland Inner Harbor should be designated as impaired for Indicator Bacteria. In addition, polybrominated diphenyl ethers (PBDEs) are present in Bay sediments, are accumulating in Bay organisms, and are known to negatively impact aquatic life. For these and other reasons, Baykeeper found that the Regional Board should consider a PBDE listing for San Francisco Bay in this 2012 listing cycle. Please refer to San Francisco Baykeeper's independent letter in response to the State Board's data solicitation for further information regarding Indicator Bacteria concentrations and PBDE toxicity in San Francisco Bay.

Despite Santa Barbara Channelkeeper's (SB Channelkeeper) submission of data and photographic evidence reflecting a serious trash problem in San Pedro Creek, the Creek was not listed for trash on the 2010 303(d) List. SB Channelkeeper's data for 2012, which was collected in compliance with the State Water Board's SWAMP guidance on rapid trash assessments, confirms that trash impairs over half the streams monitored in the Santa Barbara and Goleta Area.[28] The State Water Board should review this carefully, and consider other data submitted on trash listings so that another listing cycle does not go by without action to address this important water quality issue.

Ventura Coastkeeper (VCK) conducted water quality monitoring throughout the Santa Clara River, Ormond Beach, Calleguas Creek, and Nicholas Canyon Creek watersheds from June 2009 to August 2010. VCK found based on this information that trash listings for Nicholas Canyon Creek, San Jon Barranca, the Ormond Beach Lagoon, the Santa Clara River Estuary, and Santa Clara River Reaches 1, 3, 4a, and 5 are warranted. Additionally, VCK found the following exceedences that warrant listing on the 2012 303(d) list: Santa Clara River Estuary for flow, dissolved oxygen, pH, phosphate, and nitrate; Santa Clara River Reach 3 for *E. coli*; Ormond Beach wetlands for pH, nitrate, and *E. coli*; San Jon Barranca for *E. coli*; and Santa Clara River Reaches 1 and 2 for flow.

[25] Under this standard, only two stations satisfied the geometric mean objective during the summer and none satisfied the objective during the winter. In addition, none of the stations achieved compliance with the "no sample greater than 104 MPN/100ml" objective within a given 30-day sampling period during either the summer or winter monitoring seasons.

[26] Pursuant to the San Francisco Bay Basin Plan, the *Enterococcus* objectives include a geometric mean of less than 35 MPN/100 ml and states that no sample should exceed 104 MPN/100 ml.

[27] San Francisco Bay is only subject to bacteriological monitoring at designated beaches, although contact recreation occurs routinely throughout the Bay, including Oakland Inner Harbor.

[28] Atascadero, Bell, Cieneguitas, Maria Ygnacio, Phelps Ditch (El Encanto Creek), San Jose, and San Pedro Creeks. *See* Santa Barbara Channelkeeper's 2012 303(d) Comment Letter responding to the State Water Board's request for data.

South Coast

From July of 2007 through February of 2010 Orange County Coastkeeper (OCCK) conducted water monitoring at a total of seven sites on San Juan, San Mateo and Cristianitios Creeks in Orange and San Diego County. All of these Creeks are under the authority of the San Diego Regional Water board. After analyzing the data from this monitoring in accordance with the current state guidelines for developing 303d listings, OCCK found that there are sufficient exceedences of basin plan objectives for ammonia, nitrate, phosphate, and cadmium to warrant additional impairment listings on the 2012 impaired waters list.

The Inland Empire Waterkeeper sampled 10 sites on a weekly basis from July 2008 through November 2009 under contract with the Santa Ana Regional Water Quality Control Board. The project included four locations on San Timoteo Creek (one site perpetually dry), four locations on Warm (Twin) Creek and two locations on City Creek; all of which drain to Reach 4 of the Santa Ana River.[29] The primary focus was *E. coli* bacteria indicators, but samples were also taken for pH, conductivity, dissolved oxygen, flow rate, temperature, metals, minerals, nutrients, PCBs, organochlorine pesticides, TDS, hardness, and COD. Five sites contained *E. coli* bacteria levels during the warm season or cool season (or both) that exceed the proposed geo-mean basin plan objective. All nine sites had a minimum of two exceedences; ranging from the most natural mountain stream, up to as many as twelve in a highly urban concrete channel.

San Diego Coastkeeper is submitting information about trash collected at beach cleanups to seek the listing of all 21 San Diego County beaches. Volunteer data shows the annual removal of more than 200 pounds of trash from 9 out of 21 beaches from Oceanside to Imperial Beach. Data indicates pervasive and widespread debris impairment along the San Diego shoreline as well as nearby watersheds which drain into coastal waters.[30] San Diego Coastkeeper is also submitting ambient water quality data for nine of the eleven watersheds in San Diego County. San Diego has collected data on conventional constituents (pH, DO, temperature) as well as other key water quality indicators (including, but not limited to, nitrogen, phosphorus, toxicity, *E. coli*, *Enterococcus*) for over three dozen sites across San Diego County each month. Data indicate that exceedences of objectives are widespread and require management action.

III. THE STATE MUST IDENTIFY AND LIST ALL WATER BODIES THREATENED OR IMPAIRED BY ALTERATIONS IN NATURAL FLOW.

U.S. EPA requires waterways with flow-related impairments to be listed on the state's 303(d) list, typically (though not exclusively) in Category 4C ("water segment that is impaired or affected by non-pollutant related cause(s)"). If pollutants are also present, the waterway must be listed in Category 5. As discussed further below, we contend that despite U.S. EPA inclination to assess flow alterations as "pollution" to be listed in Category 4C (which should *at a minimum* be populated with flow listings for California in the 2012 list), there is also support for listing such impairments in Category 5 and preparing TMDLs to address them.

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[29] *See* final report at: http://www.iewaterkeeper.org/iewaterkeeper/work/projects/UpperSARWaterQuality/.
[30] Please refer to San Diego Coastkeeper's 2012 303(d) Letter to the SWRCB on trash impairments.

A. The State Water Board Must Address Impacts to Beneficial Uses of Water Bodies Caused By Alterations in Natural Flows.

The health of rivers, streams, creeks and other waterways is inextricably linked to the volume, frequency, magnitude, timing, and duration of flows.[31] "[W]ater quantity is closely related to water quality; a sufficient lowering of the water quantity in a body of water could destroy all of its designated uses, be it for drinking water, recreation, navigation, or . . . a fishery."[32] As the U.S. Supreme Court has held,

> there is recognition in the Clean Water Act itself that reduced stream flow, *i.e.*, diminishment of water quantity, can constitute water pollution. First, the Act's definition of pollution . . . encompasses the effects of reduced water quantity. *33 U.S.C. 1362(19).* This broad conception of pollution – one which expressly evinces Congress' concern with the physical and biological integrity of water – refutes petitioners' assertion that the Act draws a sharp distinction between the regulation of water 'quantity' and water 'quality.'[33]

The state's ability to ensure healthy waterways hinges in part on its ability to identify waterways impaired or threatened by altered natural flow, and to take targeted action to restore and maintain necessary flow regimes.

Water quality standards encompass both the designated uses of a water body and the water quality criteria established to protect those uses, as well as antidegradation requirements. Altered natural flows (usually reduced flows) may impact a water body's beneficial uses in a number of ways, causing a violation of standards that prompts 303(d) listing. For example, if a river is designated for use as a coldwater fishery, but reduced flows have resulted in increased temperatures and lowered water depths such that the river can no longer support fish, low flows clearly have impacted the water body's designated use.[34] Where low flows in rivers, creeks, and stream have impaired a beneficial use, the water quality standards have been violated, and the water body segment must be listed under Section 303(d).[35]

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[31] MacDonnell, Lawrence J., "Return to the River: Environmental Flow Policy in the United States and Canada. Journal of the American Water Resources Association" 45(5):1087-1099 (2009), DOI: 10.1111 ⁄ j.1752-1688.2009.00361 *citing* Poff, N.L., *et al.*,"The Natural Flow Regime: A Paradigm for River Conservation and Restoration," *BioScience* 47:769-784 (1997); Poff, N.L., "Managing for Variation to Sustain Freshwater Ecosystems," *Journal of Water Resources Planning and Management* 135:1-4 (2009).

[32] *PUD No.1 v. Washington Department of Ecology*, 511 U.S. 700, 719 (May 31, 1994).

[33] *Id. See also* U.S. EPA, **"**Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act" (July 21, 2003) ("2004 Guidance"), available at: http://www.epa.gov/owow/tmdl/tmdl0103/2004rpt_guidance.pdf *(2004 (*"Low flow can be a man-induced condition of a water (i.e., a reduced volume of water) which fits the definition of pollution. Lack of flow sometimes leads to the increase of the concentration of a pollutant (e.g., sediment) in a water.")

[34] For example, adult coho salmon migrate at water temperatures of 45 to 59ºF, a minimum water depth of approximately seven inches, and streamflow velocities less than eight ft/sec. National Marine Fisheries Service, "Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan," p. 4 (July 2007), available at: http://www.swr.noaa.gov/salmon/MSRA_RecoveryPlan_FINAL.pdf. Research has demonstrated that upstream migration of Klamath River Chinook salmon is suppressed at mean daily water temperatures above 23.5°C if temperatures are falling.

[35] Attachment 2 provides photos and other information of waterways in California so impacted, such as the Scott River.

For example, in the Russian River Watershed, excessive water diversions have turned fish-bearing creeks such as Mark West Creek and Macaama Creek into dry stream beds.[36] In the Klamath River Watershed, high diversion rates from agricultural developments limit flow levels in river mainstems and tributaries, which raise water temperatures and lower water quality, making segments of the Scott and Shasta Rivers unsuitable for rearing juvenile coho salmon.[37]

In addition, excessive withdrawals, water diversions and dams can concentrate pollutant loadings, resulting in higher in-stream concentrations and impacts. For example, rivers in the Klamath watershed are impaired by toxic algae, temperature, and nutrient pollution caused by dams, cattle grazing and irrigated agriculture.[38] All of these problems are made significantly worse by reduced natural flows. In 2006, U.S. EPA formally recognized that dam impacts to flow caused the impairment of the Klamath River by toxic blue green algae *Microcystis aeruginosa*, a liver toxin and known tumor promoter.[39]

1. Altered Flows Must Be Identified as *Causes* of Impairment, Not Solely *Sources* of Impairment

The State Water Board has identified altered natural flows in its just-adopted 303(d) list as a potential *source* of impairment of dozens of water body-segment pollutant combinations. However, California generally has avoided its responsibility to recognize reduced natural flows, streamflow alterations, water diversions, or similar flow issues as *independent causes* of impairment that require listing of the waterway for "flow alterations" under Category 4C *at a minimum*, or Category 5 where appropriate.[40] This failure to address flow alterations directly is a serious omission by the State Water Board and must be addressed in the 2012 303(d) List.

The *source* of impairment provides available information tied to the impaired segment that generally describes the type of *activity* that has resulted in the impairment. Typical examples in California's 303(d) list include, but are not limited, to the following: range grazing, silviculture, agriculture, construction/land development, urban runoff/storm sewers, mine tailings, onsite wastewater systems (septic tanks), and marinas and boating. This information is generally used to help sort out which parties will be allocated responsibility for addressing the contamination at issue.

By contrast, altered natural flows can be the *cause* of impairment of a water body – just as altered concentrations of various contaminants (dissolved oxygen, mercury, temperature, etc.)

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[36] *See* Appendix A and A-1 for more information.
[37] NMFS, "Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan Prepared by The National Marine Fisheries Service Southwest Region," p. 32 (July 10, 2007), available at: http://www.swr.noaa.gov/salmon/MSRA_RecoveryPlan_FINAL.pdf.
[38] *See* SWRCB, "2010 California 303(d) List of Water Quality Limited Segments: Category 5," North Coast RWQCB, available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/category5_report.shtml.
[39] http://www.klamathriver.org/media/pressreleases/Press-Release-032008.html.
[40] Exceptions include Regional Water Quality Control Board 4's listing of Ballona Creek Wetlands as impaired by "Hydromodification" and "Reduced Tidal Flushing," and applicable segments of the Ventura River as impaired by "Pumping" and "Water Diversion." *See infra* n. 48.

similarly *cause* impairment. The *sources* of the listings for “altered natural flows” would then be activities such as agriculture, mining, construction, grazing, etc. The parties undertaking these activities would then be contacted to take action to reduce the impacts of their various operations on waterway flow.

This distinction is important if the actual impairment of a water body is to be properly addressed. For example, if natural flows in a creek that has been designated as “cold freshwater habitat” have been diverted to the point that the shallow water becomes too warm to be adequate fish habitat, the water body should be listed as impaired in Category 5 because of *both* low natural flow *and* elevated temperature, rather than improperly listed only for elevated temperature, with flow alteration as a mere “source” of impairment. If the creek is solely listed as impaired because of elevated temperature, the mitigating action could be (for example) solely planting trees along the banks to create shade. If a creek is listed because of both flow and temperature impairments, responsive actions are much more likely to include increased flows as well as increased shade, which would provide for a healthier outcome for the stream and its inhabitants overall.[41]

EPA’s 2006 Guidance specifically describes “lack of adequate flow” as a *cause* for listing an impaired or threatened segment on the 303(d) list,[42] distinguishing it from listings of *sources* contained in separate summary tables.[43] A number of states accordingly include flow alterations as a cause of impairment in their 303(d) lists. Specifically, **U.S. EPA has compiled nationwide data submitted by states showing that 56,981 miles of rivers and streams, 517,857 acres of lakes, reservoirs and ponds, 299 square miles of bays and estuaries, and 33,054 acres of wetlands nationwide have been listed on states’ 303(d) lists as impaired by “Flow Alterations.”**[44] This corresponds to listings for over 100 water bodies nationwide in the District of Columbia, Idaho,[45] Michigan, Wyoming, Ohio and California.[46]

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[41] Of course, the listing should also ideally include the “sources” of both the temperature and low flows impairments, such as agriculture or other activities.

[42] “Examples of circumstances where an impaired segment may be placed in Category 4c include segments impaired solely due to lack of adequate flow or to stream channelization.” 2006 Guidance at 56.

[43] *See* U.S. EPA, “National Causes of Impairment” versus “National Probable Sources Contributing to Impairment,” available at: http://iaspub.epa.gov/waters10/attains_nation_cy.control#causes.

[44] *See* U.S. EPA, “Specific State Causes of Impairment That Make Up the National Flow Alteration(s) Cause of Impairment Group,” available at: http://iaspub.epa.gov/tmdl_waters10/attains_nation_cy.cause_detail?p_cause_group_name=FLOW%20ALTERATION%28S%29. *See also* details of flow impairment listings at U.S. EPA, “Impaired Waters , Cause of Impairment Group: Flow Alteration(s),” available at: http://iaspub.epa.gov/tmdl_waters10/attains_impaired_waters.control?p_cause_group_id=545. For information on the status of data collection by state for these tables, *see* U,S, EPA, “Status of Available Data Used in This Report,” available at: http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T#status_of_data.

[45] Idaho’s 2008 Integrated Report shows more than 100 waterbody-pollutant segment listings for low flow alterations and other flow regime alterations under its “Section 4C Waters Impaired by Non-Pollutants.” Idaho 2008 Integrated Report: “Section 4c Waters Impaired by Non-Pollutants,” http://www.deq.state.*Id*.us/water/data_reports/surface_water/monitoring/integrated_report_2008_final_sec4c.pdf.

[46] *See* U.S. EPA, “Watershed Assessment, Tracking and Environmental Results: Specific State Causes of Impairment That Make Up the National Flow Alteration(s) Cause of Impairment Group,” (last updated August 12, 2010), available at: http://iaspub.epa.gov/tmdl_waters10/attains_nation_cy.cause_detail_303d?p_cause_group_id=545. Conversation with Douglas Norton, U.S. EPA Headquarters (August 9, 2010).

2. Waterways Impaired by Altered Flows Must at a Minimum Be Listed in Category 4C of the 303(d) List, and Also May Be Listed in Category 5

As discussed above, U.S. EPA's and California's Category 4C *must* be populated with all waterways that are impaired or threatened solely due to the presence of non-pollutants. At a minimum, then, *all* flow-related impairments in California *must* be included in the Category 4C portion of the 2012 303(d) list. We would argue as well, however, that many if not all of these impairments could be included in Category 5.[47]

In California, "Pumping" and "Water Diversion" are listed as the sole causes of impairment for the water body segment Ventura River Reach 4.[48] This water body segment is listed specifically in Category 5 and requires a TMDL by 2019, even though Pumping and Water Diversion are the *only* causes of impairment. Water Diversion is specifically identified as a "Pollutant" in the Fact Sheet[49] describing this listing, as is the case with Pumping.[50]

California's choice to list, and most recently uphold the listing of, flow-caused impairments as a "pollutant" under Category 5 is not prohibited by the definition of "pollutant" or by U.S. EPA guidance. First, courts have interpreted the definition of "pollutant" broadly, as noted above, stating that it is "meant to leave out very little."[51] Second, U.S. EPA Guidance, while favoring a position that flow-related impairments are "pollution," does so in a less than

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[47] Idaho, which deferred to EPA's preference that flows be included in Category 4C, tried to provide a rationale for EPA's preference on flows as follows: "A pollutant is a substance, such as bacteria or sediment, that is identifiable and in some way quantifiable. Some unnatural conditions that impair water quality, such as flow alteration, human-caused lack of flow, and habitat alteration, are considered pollution, but are not caused by quantifiable pollutants. Temperature, while not a substance, is considered a pollutant, as changes in water temperature are quantifiable." Idaho DEQ, "Surface Water: Water Quality Improvement Plans (TMDLs), available at: http://www.deq.state.Id.us/water/data_reports/surface_water/tmdls/overview.cfm#Pollution. This loyal though somewhat strained reasoning ignores the fact that flow itself, as well as its impacts, is most certainly quantifiable – as are Pumping and Water Diversion, for which California waters have been listed in Category 5 as discussed below.

[48] SWRCB, "2010 California 303(d) List of Water Quality Limited Segments: Category 5," "Ventura River Reach 4 (Coyote Creek to Camino Cielo Road)," available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml?wbid=CAR4022002119990203090836. Ventura River Reach 3 had an identical listing in 2006, also with a 2019 TMDL, though Indicator Bacteria was added as a cause of impairment in the 2010 list update. SWRCB, "2006 CWA Section 303(D) List of Water Quality Limited Segments Requiring TMDLS," Region 4: "Ventura River Reach 3 (Weldon Canyon to Confl. w/ Coyote Cr)," available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/docs/303dlists2006/epa/r4_06_303d_reqtmdls.pdf.

[49] Supporting Information, 2010 Integrated Report, Ventura River Reach 4: Water Diversion, http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01015.shtml#7310.

[50] Supporting Information, 2010 Integrated Report, Ventura River Reach 4: Pumping, http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/01015.shtml#7308.

[51] *See supra* n. 8. The definition of "pollutant" in Section 502(6) includes: "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water." Several other items are specifically excluded; flow alteration is not one of those items. Arguably, the actions taken by industrial, municipal and agricultural operations (*i.e.* essentially all activities that could impact flow) could be viewed as the discharge of "waste," which is undefined in Section 502 but which could readily be interpreted as the by-product of "operations"*; i.e*. changes in the health of the waterway to its detriment.

definitive manner and without analysis, leaving room for California to make its own determination. For example, the 2004 Guidance states simply that "EPA does not *believe* that flow, or lack of flow, is a pollutant as defined by CWA Section 502(6)."[52] The 2006 Guidance similarly simply asserts without further support or discussion that "[e]xamples of circumstances where an impaired segment may be placed in Category 4c include segments impaired solely due to lack of adequate flow or to stream channelization."[53]

In sum, California can and should protect its waterways as fully as possible, including through the complete identification and listing of waterways impaired by the *cause* of natural flow alterations. Other states have shown leadership in this regard, and California's waters are no less precious or threatened.

Moreover, to ensure full protection and restoration of the waterways' beneficial uses, the identified waters should be placed on the 303(d) list under Category 5 (most certainly if there are additional pollutant impairments), and at a minimum in Category 4C. Section 510 of the Clean Water Act sets a floor but no ceiling for state action to protect and enhance the health of waters of the United States. California should make full use of this provision, and should leverage its prior flow-related listings in Category 5 into a comprehensive effort to address *all* flow-related impairments under the federal Section 303(d) listing and TMDL program, as well as under state law and other programs.

B. The State Must Use and Consider All Readily Available Information Related to Identifying Natural Flow-Related Impairments.

Under federal law[54] and the California Listing Policy, the State and Regional Water Boards must "actively solicit, assemble, and consider all readily available data and information,"[55] including from local, state and federal agencies, for purposes of developing the 303(d) list. This includes but is not limited to: reports of fish kills; dilution calculations; and "predictive models for assessing the physical, chemical, or biological condition of streams, rivers, lakes, reservoirs, estuaries, coastal lagoons, or the ocean."[56]

Accordingly, the State Water Board must examine and consider all readily available information that could inform 303(d) decisions related to alterations in natural flow. This includes but is not limited to the following:

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[52] U.S. EPA, "Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act," p. 8 (July 21, 2003) (emphasis added), available at: http://www.epa.gov/owow/tmdl/tmdl0103/2004rpt_guidance.pdf. It also states, as quoted above, that reduced water volume "fits the definition of pollution" – which could be the case for essentially any water impairment, including more traditional "pollutants."
[53] 2006 Guidance, *supra* n. 1, at 56.
[54] 40 CFR 130.7.(b)(5), see http://law.justia.com/us/cfr/title40/40-21.0.1.1.17.0.16.8.html.
[55] SWRCB, *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List* (Listing Policy) (Sept. 2004), Section 6.1.1" Definition of Readily Available Data and Information (emphasis in original), available at http://www.waterboards.ca.gov/water_issues/programs/tmdl/docs/ffed_303d_listingpolicy093004.pdf.
[56] *Id.* (emphasis added).

- Data collected through the Department of Fish and Game's Instream Flow Program[57]
- Information compiled pursuant to programs and funding by the Ocean Protection Council[58]
- The findings of the recently-adopted State Water Board report on Delta flow criteria requirements (attached)[59]
- All comments, information and associated data sets submitted to the State Water Board during the development of its AB 2121 "Policy for Maintaining Instream Flows in Northern California Coastal Streams"[60]
- Flow data released by the California Department of Water Resources,[61] including data from the Water Data Library[62] generally and the Interagency Ecological Program[63] in particular, as well as and outside compilations of DWR data organized by waterbody segments[64]
- Data in the Klamath Resource Information System (KRIS);[65]
- Information and datasets presented at "My Water Quality" meetings,[66] including data from the Department of Natural Resources presented at the August 11, 2010 meeting
- Data contained in CalFish, the California Cooperative Anadromous Fish and Habitat Data Program,[67] especially the Passage Assessment Database.[68]

Note that Federal agencies, such as the U.S. Fish and Wildlife Service,[69] Federal Energy Regulatory Commission,[70] NOAA (particularly the National Marine Fisheries Service[71] and

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[57] *See* DFG Instream Flow Program, http://www.dfg.ca.gov/water/instream_flow_docs.html. *See also* DFG Water Rights Program, http://www.dfg.ca.gov/water/water_rights_docs.html.

[58] This includes but is not limited to Instream Flow Analysis – Santa Maria River, http://www.opc.ca.gov/2009/05/instream-flow-analysis-santa-maria-river/, Instream Flow Analysis – Big Sur River, http://www.opc.ca.gov/2009/05/instream-flow-analysis-big-sur-river/, and Instream Flow Analysis – Shasta River, http://www.opc.ca.gov/2009/05/instream-flow-analysis-shasta-river/.

[59] SWRCB, "Final Report on Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem" (Aug. 3, 2010) (Delta Flow Report), available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/final_rpt.shtml.

[60] As required by California Water Code § 1259.4 (AB 2121), available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/instream_flows/.

[61] DWR, California Data Exchange Center, http://cdec.water.ca.gov/.

[62] DWR, Water Data Library, http://www.water.ca.gov/waterdatalibrary/.

[63] Interagency Ecological Program, http://www.water.ca.gov/iep/.

[64] "CA DWR CDEC Interface," a compilation of data from DWR's California Data Exchange Center, available at: http://acme.com/jef/flow/cdec.html.

[65] http://www.krisweb.com/index.htm.

[66] http://www.waterboards.ca.gov/mywaterquality/monitoring_council/meetings/index.shtml.

[67] www.calfish.org;

[68] http://www.calfish.org/portals/0/Programs/CalFishPrograms/FishPassageAssessment/tabid/83/Default.aspx. This letter incorporates by reference the comments of Heal the Bay with respect to required 303(d) listings needed for beneficial uses impaired by fish passage barriers. The same legal and policy requirements that call for 303(d) listing of water bodies impaired by altered natural flows also apply to listings for water bodies impaired by fish barriers. The Water Board should review the Passage Assessment Database, which has extensive information on barriers, to ensure that all impaired waterways are properly included on the Section 30(d) list. *See also* CCKA's compilation of fish barriers impacting the RARE beneficial use at: http://www.cacoastkeeper.org/programs/mapping-initiative/fish-barriers.

[69] *See, e.g.*, U.S. FWS, Water and Fishery Resources Program, http://www.fws.gov/cno/fisheries/.

[70] *See* http://elibrary.ferc.gov/idmws/search/fercgensearch.asp to search for details of California hydropower projects, which would provide further information on flows.

[71] California is in the Fisheries Service's Southwest Region; *see* http://swfsc.noaa.gov/ for data and publications.

analyses such as the Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan[72]), USGS[73] and U.S. EPA, must also be "*actively*" solicited for data and information.[74]

This and other flow information can provide invaluable insight into the "physical, chemical, or biological condition" of the state's waterways as required by federal law and state Policy. It should be considered carefully in developing a comprehensive Category 4C list as well as Category 5 listings that appropriately include impairments caused by altered natural flows, and combinations of altered natural flows and pollutants.

C. Specific Listing Proposals for Impairments Caused by Reduced Natural Flows

Numerous beneficial uses are impaired by the altered flows, including but not limited to GWR (groundwater recharge discussed separately below), COLD (cold freshwater habitat), MIGR (fish migration), SPWN (fish spawning) and RARE (preservation of rare and endangered species). In addition to the data described elsewhere in this letter and other readily available data sources, data and information for a number of many flow-impaired waterways can be found through KRIS.[75] This letter also includes and incorporates by reference the flow-related listing proposals provided in the detailed comments submitted by Heal the Bay,[76] the Natural Resources Defense Council (NRDC),[77] and Ventura County Coastkeeper.[78]

Please note that the waterways described below, in addition to the flow-related listing proposals incorporated by reference, are just *some* of the numerous flow-impaired waterways throughout the state. <u>This list is by no means a comprehensive assessment</u>. The final 2012 303(d) list should include *all* of the waterways that "readily available" data indicate are threatened or impaired due to alterations in natural flow.

1. <u>Rivers, Creeks and Streams</u>

Carmel River and San Clemente Creek

As documented in a white paper prepared for the Carmel River Steelhead Association, significantly reduced flows in the Carmel River and its tributaries, particularly San Clemente

[72] National Marine Fisheries Service, "Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan" (July 2007), available at: http://www.swr.noaa.gov/salmon/MSRA_RecoveryPlan_FINAL.pdf.
[73] *See* USGS, "What kinds of water data does the U.S. Geological Survey gather?" available at: http://www.usgs.gov/faq/index.php?action=artikel&cat=102&id=1148&artlang=en.
[74] Listing Policy, Section 6.1.1: Definition of Readily Available Data and Information (emphasis added).
[75] Klamath Resource Information System, http://www.krisweb.com/index.htm.
[76] Letter from W. Susie Santilena, Heal the Bay to Jeffrey Shu, SWRCB, Public Solicitation of Water Quality Data and Information for 2012 Integrated Report (Aug. 20, 2010).
[77] Letter from Doug Obegi, NRDC, to Jeffrey Shu, SWRCB, Public Solicitation of Water Quality Data and Information for 2012 Integrated Report (Aug. 27, 2010).
[78] Letter from Jason Weiner, Ventura County Coastkeeper, to Jeffrey Shu, SWRCB, Public Solicitation of Water Quality Data and Information for 2012 Integrated Report (Aug. 30, 2010) (incorporated herein by reference).

Creek, are placing serious stress on native steelhead populations.[79] This white paper, which includes a comprehensive bibliography of information, should be considered along with DFG data in assessing the Carmel River and San Clemente Creek for listing as impaired by water diversions/flow alterations.

Eel River

A comprehensive assessment of Eel River conditions shows significant impairment as a result of low flows.[80] The report found that:

> low flows . . . often produce temperatures lethal to listed fish species in the Eel River and beneficial to predatory pikeminnow, resulting in a compounding adverse effect on salmonids. Based on available science, increasing flows in the Eel River to 68-265 cfs in the summer will produce corresponding temperature benefits for salmonids that will likely support survival of the species. Bradbury et al (1995) point out that <u>Pacific salmon cannot be recovered without having access to habitat similar to that with which they co-evolved</u>; therefore, to ensure longer term salmonid recovery, access to refugia above the PVP must be provided.[81]

The report recommended that "[i]If summer flow levels were maintained at the 76 to 166 cfs . . . surface water temperatures would drop due to effects described above, increased volume and decreased transit time and steelhead could successfully rear . . . in the mainstem."[82] The flow conditions in the Eel have clearly impaired the health of the river and its associated beneficial uses, and accordingly the waterway must be listed.

Gualala River

The "National Marine Fisheries Service (NMFS, 2001), the California Department of Fish and Game (CDFG, 2002) and Brown et al. (1994) have found that coho salmon are at risk of extinction throughout Mendocino and Sonoma County."[83] With native species facing extinction, healthy water flows should be of paramount importance. However, "CDFG 2001 habitat typing surveys [citation] found that extensive reaches of the Gualala River and its tributaries lacked surface flows."[84] As in the Russian River, water diversions continue despite the serious and

[79] *See* Appendix A.
[80] Patrick Higgins, Consulting Fisheries Biologist, "Evaluation of the Effectiveness of Potter Valley Project National Marine Fisheries Service Reasonable and Prudent Alternative (RPA): Implications for the Survival and Recovery of Eel River Coho Salmon, Chinook Salmon, and Steelhead Trout" (Feb. 2010) (included in Appendix A under "Eel River").
[81] *Id.* at p. 39 (emphasis added).
[82] *Id.*
[83] Letter from Patrick Higgins, Consulting Fisheries Biologist to Allen Robertson, California Department of Forestry and Fire Protection, "Negative Declaration for Sugarloaf Farming Corporation dba Peter Michael Winery" (Dec. 12, 2003)
[84] *Id*. at p. 10.

significant impairments in the Gualala, prompting a recent public trust lawsuit.[85] Significant data and information on the Gualala River is provided in Appendix A.

Mark West Creek

Ten years ago all 28 miles of Mark West Creek had water in the summer. Today, because of increased diversions, only 3½ miles have water. DFG flow records of Mark West Creek dating back to the 1960s show that the lowest summer stream flow has historically been 2 cfs, and Summer 2010 is measuring on average at approximately that level. The Russian Riverkeeper[86] has photo-documented this decline. Data and information on the serious and escalating impairments to this creek are provided in Appendix A-1[87] and on the Friends of the Mark West Watershed website.[88]

Mattole River

A detailed study of the Mattole River Basin found that:

> Lack of adequate late summer and early fall streamflow is recognized as one of the most important limitations on salmonid habitat in the Mattole River basin (NCWAP, 2000). In recent years, juvenile salmonids have become stranded in pools due to excessively low flows, causing mortality and necessitating fish rescue operations.[89]

Additional support for a flow-related listing of the Mattole River is found in Appendix A.

Napa River

Studies referenced in AB 2121 comments illustrate the significantly degraded habitat of the Napa River, which can only be restored with a focus on reversing severely reduced natural flows.[90] Research shows that "even in good years. . . 80% of tributary habitat surveyed was marginally functional or non-functional."[91] The Napa River "was formerly a very important nursery area for older age juvenile steelhead (Anderson 1969) . . . and that habitat is now completely non-functional for rearing. Therefore, all indications are that lack of older age steelhead rearing habitat is limiting the population."[92] Moreover, low water years (which are to

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[85] Center for Biological Diversity, "Lawsuit Imminent over Water Diversions Killing Salmon and Steelhead in Russian and Gualala Rivers," (Nov. 17, 2009), available at: http://www.biologicaldiversity.org/news/press_releases/2009/russian-river-11-17-2009.html.
[86] www.russianriverkeeper.org.
[87] Appended separately from Appendix A due solely to formatting requirements.
[88] http://www.markwestwatershed.org/Cornell_Winery_PrimerDocsDirectory.html.
[89] Randy D. Klein, Hydrologist, "Hydrologic Assessment of Low Flows in the Mattole River Basin 2004-2006," p. 1 (March 2007), *see* Appendix A.
[90] Letter from Patrick Higgins, Consulting Fisheries Biologist to SWRCB, "Comments on *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams"* (April 2, 2008), pp. 13-15 (in Appendix A).
[91] Letter from Patrick Higgins, Consulting Fisheries Biologist to Thomas Lippe, Living Rivers Council (Aug. 17, 2010), p. 5 (included in Appendix A under "Napa River").
[92] *Id.*

be expected and built into water planning) are "depressing smolt production" due to a continued lack of attention to sufficient flows.[93]

Navarro River

As described in more detail in Appendix A, "diversions from the Navarro River and its tributaries, primarily for agricultural purposes, have significantly impaired instream fish and wildlife beneficial uses, to the point where the river was literally pumped dry" on past occasions.[94] Numerous data sets indicate growing impacts from cumulatively increasing water diversions in this already heavily-drained area.

Redwood and Maacama Creeks

As described in detail in Appendix A, in Maacama Creek "[s]tanding crops of fall fish show a major reduction in many years, suggesting that low flow conditions are limiting, and these low flow conditions are likely linked to agricultural water use."[95] "[A]lmost 70% of habitats in Redwood Creek [are] dry (Figure 12) and all other streams showed signs of dewatering related to diversion of surface water and likely contributed to by over-use of groundwater."[96] Additional assessments have found that

> in undisturbed Pacific Northwest streams, pool frequencies range from 37% to greater than 80% (Murphy et al. 1984 and Grette 1985) and CDFG (2004) rates frequencies greater than 40% as functioning for salmon and steelhead. Figure 12 shows that pool frequencies were under 10% on Redwood and Foote Creeks in some reaches and only about 25% of most Maacama Creek reaches. Pool depths are similarly compromised (Figure 13) with none over three feet deep in Foote Creek and the majority on Redwood Creek as well.[97]

This report concludes that "Coho salmon are at very high risk of extinction in the Russian River basin, yet NMFS (2008) considers their gene resources to be of extremely high importance for rebuilding of the entire CCC ESU. Expensive recovery efforts to restore Russian River coho salmon using captive broodstock from Green Valley Creek is failing to re-establish breeding populations in any Russian River tributary (NMFS 2008)."[98] Because "the biggest problem is over-consumption of water,"[99] listing of these waterways as impaired by natural flow alterations/water diversions is an important step in ensuring their return to good health.

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[93] *Id.*
[94] Letter from Patrick Higgins, Consulting Fisheries Biologist to SWRCB, "Comments on *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams*," p. 15 (April 2, 2008).
[95] Letter from Patrick Higgins, Consulting Fisheries Biologist to Traci Tesconi, County of Sonoma, "Pelton House Winery Application #PLP05-0010," (Dec. 29, 2008), p. 12 (included in Appendix A).
[96] *Id.* at p. 13.
[97] *Id*. at pp. 12-13.
[98] *Id*. at p. 19.
[99] *Id*. at p. 20.

Russian River

As illustrated in documents attached as Appendix A[100] and elsewhere, [101] the Russian River is increasingly impaired due to flow alterations. Numerous technical analyses have found that "[l]egal and illegal diversions pose significant risk to the last streams where coho still persist in the Russian River."[102]

Salinas River

As described in more detail in Appendix A, "channel alteration and changes in flow regime have caused a virtual loss of the anadromous life history of three steelhead [distinct population segments] in the Salinas River."[103] More generally, "flows in lower reaches for adult and juvenile steelhead passage are often lacking,"[104] with "[g]roundwater pumping related to agricultural activities . . . caus[ing] the loss of surface flow in winter and spring."[105] This detailed analysis concluded that "unless the Salinas River channel and flow move back towards their more normal range of variability steelhead cannot be restored."[106]

Santa Clara River

As described in more detail in the comments submitted by Ventura Coastkeeper,[107] which are incorporated here by reference, USGS, county and local agency data show that enough water is diverted at the Vern Freeman Diversion Dam for agricultural usage, groundwater recharge, and other uses to deprive migrating steelhead of sufficient flows and juvenile steelhead of healthy estuary rearing grounds. These activities impact the beneficial uses for this river as habitat for fish, necessitating a listing caused by water diversion. Moreover, as discussed in the Ventura Coastkeeper letter, the river is also impaired for fish passage since the United Conservation Water District put in an impassable fish barrier.

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[100] *See* Letter from Patrick Higgins, Consulting Fisheries Biologist to SWRCB, "Comments on *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams"* (April 2, 2008), pp. 16-20 (included in Appendix A under "Navarro River"). *See also* Merenlender, Adina et al, "Decision support tool seeks to aid stream-flow recovery and enhance water security," 62 *California Agriculture* 148 (Oct.-Dec. 2008), *available at*: http://ucanr.org/repository/cao/landingpage.cfm?article=ca.v062n04p148&fulltext=yes.

[101] *See supra* n. 85, "Lawsuit Imminent Over Water Diversions Killing Salmon and Steelhead in Russian and Gualala Rivers" (data associated with filing should be closely examined).

[102] Higgins, *supra* n. 100 at p. 16.

[103] Letter from Patrick Higgins, Consulting Fisheries Biologist to Curtis Weeks, Monterey County Resources Agency, Comments on Salinas River Channel Maintenance Project (CMP) 404 Permit Application and Mitigated Negative Declaration, p. 4 (Aug. 6, 2009).

[104] *Id.* at p. 5; *see also* Letter from Patrick Higgins, Consulting Fisheries Biologist to SWRCB, "Comments on *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams"* (April 2, 2008).

[105] *Id.*

[106] *Id.* at p. 17.

[107] Letter from Jason Weiner, Ventura Coastkeeper to Jeffrey Shu, SWRCB, Public Solicitation of Water Quality Data and Information for 2012 Integrated Report (Aug. 30, 2010).

Scott River and Shasta River

In summer 2009, agricultural irrigation and dewatering caused record low flows in the Scott and Shasta River watersheds, flows that will continue to impair these waterways because they are associated with increased usage for agriculture and other, non-situational sources.[108] Extensive photo documentation of the activities producing this flow impairment and its impact on fish habitat was collected by Klamath Riverkeeper and others.[109] The Pacific Coast Federation of Fishermen's Associations and Environmental Law Foundation have already brought a public trust action[110] against the State Water Board and Siskiyou County regarding flows in the Scott River. Information associated with that lawsuit should be considered in the determination that the river is and will continue to be impaired due to low flows associated with withdrawals. Additional instream flow analyses are being conducted by Humboldt State University under the oversight of the California Ocean Protection Council.[111]

Documentation of the impacts of low flows in these waterways is extensive and included in Appendix A and other readily available data sources. For example, the Scott River Sediment and Temperature TMDL process several years ago produced substantial evidence of impaired beneficial uses resulting from low flows, including reaches that now regularly go dry, placing the Scott River salmon and steelhead stocks at "high risk of extinction"[112] Similarly, the recent Shasta River Watershed Dissolved Oxygen and Temperature process produced information supporting the conclusion that "[t]he need for a baseline minimum flow with most reaches of the Shasta River, and the importance to salmon . . . of maintaining minimum flows even during low water years, cannot be over-stated."[113] Properly listing these water bodies as impaired by flows, in addition to the other listed causes for their impairment, will ensure the appropriate attention is paid to addressing alterations in natural flow that are devastating the rivers' beneficial uses.

2. The Sacramento-San Joaquin Delta

Finally, *all* of the Delta waterways examined in the State Water Board's recently-adopted "Final Report on Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem" should be considered for flow impairments. This Report concluded unequivocally

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[108] See attached documentation in Appendix A.
[109] Klamath Riverkeeper, "Scott and Shasta Rivers 2009 Flow Emergency," available at: http://picasaweb.google.com/klamathriverkeeper/ScottAndShastaRivers2009FlowEmergency#.
[110] "Fishing and Conservation Groups Sue over Poor Water Management on Northern California's Scott River" (June 24, 2010) (press release), available at: http://www.envirolaw.org/documents/ScottRiverPTDSuitPressRelease062410.pdf; *see also* Petition for Writ of Mandamus and Complaint for Declaratory and Injunctive Relief (Sup. Ct. Sacramento, June 23, 2010), at: http://www.envirolaw.org/documents/WRITPETITIONCOMPLAINT.pdf.
[111] CA Ocean Protection Council, "Instream Flow Analysis – Shasta River," available at http://www.opc.ca.gov/2009/05/instream-flow-analysis-shasta-river/.
[112] Letter from PCFFA *et al* to Tam Doduc, SWRCB, "Joint Comments on the Proposed Action Plan for the Scott River Watershed Sediment and Temperature TMDL," Attachment A - Scott TMDL Related Data, Photos and Maps Regarding Flow and Temperature Problems (June 12, 2006) (included in Appendix A).
[113] Letter from Pacific Coast Federation of Fishermen's Associations and the Institute for Fisheries Resources to SWRCB, "Comment Letter - Shasta River Watershed DO and Temperature TMDLs," p. 4 (Oct. 29, 2006) (included in Appendix A).

that **"[r]ecent Delta flows are insufficient to support native Delta fishes for today's habitats."**[114] More specifically, the Report found that:

> In order to preserve the attributes of a natural variable system to which native fish species are adapted, many of the criteria developed by the State Water Board are crafted as percentages of natural or unimpaired flows. These criteria include:
>
> - 75% of unimpaired Delta outflow from January through June;
> - 75% of unimpaired Sacramento River inflow from November through June; and
> - 60% of unimpaired San Joaquin River inflow from February through June.
>
> It is not the State Water Board's intent that these criteria be interpreted as precise flow requirements for fish under current conditions, but rather they reflect the general timing and magnitude of flows under the narrow circumstances analyzed in this report. In comparison, historic flows over the last 18 to 22 years have been:
>
> - approximately 30% in drier years to almost 100% of unimpaired flows in wetter years for Delta outflows;
> - about 50% on average from April through June for Sacramento River inflows; and
> - approximately 20% in drier years to almost 50% in wetter years for San Joaquin River inflows.[115]

In other words: (a) the Delta is always impaired for flow in drier years and potentially impaired seasonally in wetter years, (b) the Sacramento River is regularly flow impaired, and (c) the San Joaquin River is always flow impaired. Note that this comparison is based on averages over the past two decades; flow data from more recent years (available from the citations above and other readily available sources) would likely skew these results towards more, not less, impairment, as noted in the Report quote above.

Accordingly, *all* Delta waterways for which the Report has found flow-related impairments of beneficial uses should be listed in the 2012 303(d) list as impaired by water diversion, flow alteration, and/or other appropriate cause, with the specific sources (agriculture, etc.) clearly delineated.

D. The State Must Specifically Identify and List All Surface Waters That Can No Longer Provide the Beneficial Use of "Groundwater Recharge" Due to Reduced Flows

"Groundwater recharge" is defined as the use of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers. "Groundwater recharge" is listed as a beneficial use for 2,167 hydrologic units/areas in eight out of nine of the Regional Basin Plans for surface waters around the state: North Coast: 109, San Francisco Bay: 23, Central Coast: 396, Los

[114] Delta Flow Report, *supra* n. 59, at p. 5 (emphasis added).
[115] *Id.*

Angeles: 222, Central Valley: 0,[116] Lahontan: 1009, Colorado River: 93, Santa Ana: 98, San Diego: 217.[117] Despite the widespread recognition of "groundwater recharge" as a beneficial use by Regional Water Boards, the protection of this use has been rarely acknowledge or addressed by the 303(d) listing process. This must be rectified in the 2012 list.

The State Water Board's map of high-use groundwater basins and hydrogeological areas depicts vulnerable groundwater recharge basins in every region of California.[118] In many of California's river basins, agricultural and other users divert surface stream flows to the extent their actions impair the groundwater recharge beneficial use. Similarly, in river basins with a hydrologically connected groundwater aquifer that is being pumped, large scale groundwater pumping depletes the connected surface waterway, further diverting percolation from the stream into the aquifer and impairing the "groundwater recharge" beneficial use of impacted surface water.[119] The State can and should incorporate such listings in the 2012 list, *i.e.* where readily available data provides the information needed to identify water bodies for which designated "groundwater recharge" uses are threatened or impaired.

IV. THE STATE WATER BOARD MUST COMPREHENSIVELY ADDRESS GROUNDWATER CONTAMINATION AND WITHDRAWALS THAT IMPAIR OR THREATEN SURFACE WATERS.

The State's 303(d) list must reflect instances where contaminated groundwater discharges to rivers, estuaries and other surface waters is the cause or source of surface water impairment. California's Section 303(d) list must also reflect instances where excessive withdrawals and pumping of groundwater impairs and threatens surface waters, including rivers, creeks, estuaries, and wetlands, such as through reduced flows.[120]

Actions to address groundwater sources of surface water impairment with specificity are feasible and have been undertaken by California and other states during the course of 303(d) listing and TMDL development. California and other states have shown that it is feasible—and often necessary—to identify and address groundwater sources of surface water impairment with high levels of specificity during the development of a TMDL. The State Water Board should require Regional Water Boards to identify the name of groundwater sources of surface water impairment, including the name of groundwater basins, point source discharges from cleanup and dewatering operations, and other relevant sources; assess and measure groundwater loading

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[116] The Central Valley Regional Water Quality Control Board explains that there are surface waters that have the beneficial use of Groundwater Recharge, but that they have not yet been identified: "NOTE: Surface waters with the beneficial uses of Groundwater Recharge (GWR),Freshwater Replenishment (FRSH), and Preservation of Rare and Endangered Species (RARE) have not been identified in this plan. Surface waters of the Sacramento and San Joaquin River Basins falling within these beneficial use categories will be identified in the future as part of the continuous planning process to be conducted by the State Water Resources Control Board." *See* http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/sacsjr.

[117] *See* Chapter 2 of Basin Plans for Regions 1-9 at http://www.waterplan.water.ca.gov/waterquality/basin_plan.cfm.

[118] http://www.waterboards.ca.gov/water_issues/programs/gama/docs/hydro_areas.pdf.

[119] J. Daubert, R. Young, *Managing an Interrelated Stream-Aquifer System, Economics, Institutions, Hydrology,* Colorado Water Resources Research Institute, Technical Report #47, p. 1 (April 1985). Available at: http://www.cde.state.co.us/artemis/ucsu6/UCSU6141347INTERNET.pdf.

[120] A detailed discussion of flow impacts to water quality can be found in Section III.

to surface waters during the development of TMDLs; and assign wasteload allocations to groundwater sources of impairment to surface waters, to the extent possible. Please refer to Appendix B for a synopsis of TMDLs in California and elsewhere that address how to manage groundwater loadings with specificity.

A. The State Water Board Has a Duty to Address Groundwater-Related Sources of Impairment to Surface Waters under Section 303(d) of the Clean Water Act.

1. The hydrological connectivity of surface waters and groundwater triggers the Board's legal mandate under Section 303(d) of the Clean Water Act.

Because of the pervasive hydrological connectivity of surface waters and groundwater, polluted groundwater can substantially impact the quality of surface waters.[121] Streamflow may recharge alluvial aquifers, and groundwater conversely can provide substantial amounts of flows into lakes, streams, and rivers.[122] The hydrological connectivity is widely interpreted—by U.S. EPA, courts, and several states, including California—as triggering a regulatory duty under the Clean Water Act.

For example, U.S. EPA has stated that "in general, collected or channeled pollutants conveyed to surface water via groundwater can constitute a discharge subject to the Clean Water Act."[123] The determination of whether a discharge to ground water can be subject to regulation under the Clean Water Act is a determination that involves an ecological "judgment about the relationship between surface waters and groundwaters."[124]

Courts have also found that hydrologically connected groundwater and surface waters can trigger regulatory duties with respect to contaminated groundwater under the federal Clean Water Act.[125] In 2006, U.S. Supreme Court Justice Kennedy wrote in his concurring and oft-cited *Rapanos* opinion that water bodies will "come within the statutory phrase 'navigable

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[121] United States Geological Survey, Ground Water and Surface Water: A Single Resource, Circular 1139, available at: http://pubs.usgs.gov/circ/circ1139/ ("*USGS: Single Resource*"). *See also* R. Thomas, *Comment: The European Directive on the Protection of Groundwater, A Model for the United States*, 26 Pace Envtl. L. Rev. 259, 264 (Winter 2009) ("*Groundwater Protection Model*") ("… groundwater does not exist in isolation from other bodies of water; it is an integral part of the hydrological cycle and discharges into lakes and streams. Such "tributary" groundwater is vital for maintaining surface water supplies and sustaining surface ecosystems"); William M. Alley, "Tracking U.S. Groundwater: Reserves for the Future," *Environment*, pp. 10, 15 (Apr. 2006); *see also* William M. Alley *et al.*, "Flow and Storage in Groundwater Systems," 296 *Sci*. 1985, 1990 (2002).

[122] *See* Aiken, J. David, The Western Common Law of Tributary Groundwater: Implications for Nebraska. (2004) at p. 545, available at http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1032&context=ageconfacpub. *See also USGS: Single Resource*: USGS finds that groundwater contribution to surface waters has been shown to range from 10% to over 90% across the U.S., with an estimated average of over 40%.

[123] EPA, *National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitations Guidelines and Standards for Concentrated Animal Feeding Operations* 66 Fed. Reg. 2960, 3017 (Jan. 12, 2001).

[124] 66 Fed. Reg. at 3018 (emphasis added.)

[125] *See e.g. Greater Yellowstone Coalition v. Larson,* 641 F. Supp. 2d 1120, 1138 (D. Idaho 2009) ("[t]here is little dispute that if the ground water is hydrologically connected to surface water it can be subject to 401 certification."); *Coldani v. Hamm*, 2007 WL 2345016, at 9 (E.D. Cal. Aug. 16, 2007) ("the court finds that because Coldani has alleged that Lima Ranch polluted groundwater that is hydrologically connected to surface waters that constitute navigable waters, he has sufficiently alleged a claim within the purview of the CWA [citations]")

waters,'" and thereby fall under the Clean Water Act, if they "significantly affect the chemical, physical, and biological integrity of other covered waters more readily understood as 'navigable.'"[126]

The Ninth Circuit Court of Appeals has also repeatedly interpreted the Clean Water Act to include regulation of groundwater hydrologically connected to surface waters.[127] In *Northern Plains Resource Council v. Fidelity Exploration* the Ninth Circuit found that even the discharge of "unaltered" groundwater into a river could be considered a pollutant and subject to water quality standards where the company's discharge altered the river's water quality.[128] The *Northern Plains Resource Council* opinion went on to explain that:

> Were we to conclude otherwise, and hold that the massive pumping of salty, industrial waste water into protected waters does not involve discharge of a "pollutant," even though it would degrade the receiving waters to the detriment of farmers and ranchers, we would improperly "undermine the integrity of [the CWA's] prohibitions."[129]

Section 303(d) of the Clean Water Act, in particular, has been recognized by U.S. EPA and several states as a proper tool for addressing groundwater contaminant loading to surface waters and other groundwater-related sources of impairment. EPA has identified four potential sources of groundwater-related impairment of surface water for states' 303(d) Lists (though others are possible): "Groundwater Loadings," "Groundwater Withdrawals," "Contaminated Groundwater," and "Saltwater Intrusion."[130] EPA records reflect that several states, including California, have adopted 303(d) lists that include groundwater loadings or withdrawals as a source of impairment: **to date, 181 miles of rivers and streams, 158 square miles of bays and estuaries, 3,045 acres of wetlands, and 98,009 acres of lakes, reservoirs and ponds have been listed nationally as impaired in part due to groundwater sources of impairment.**[131]

2. Public policy concerns of efficiency and public health weigh heavily in favor of proactively addressing groundwater contamination of surface waters through the 303(d) process.

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[126] *Rapanos v. United States*, 547 U.S. 715, 779-780 (2006) (Kennedy, J., concurring).
[127] *N. Cal. River Watch v. City of Healdsburg*, 496 F.3d 993, 1000 (9th Cir. 2007) (court found that water that seeped into the river through both the surface wetlands and the underground aquifer and had significant effect on "the chemical, physical, and biological integrity" of the Russian River sufficient to confer jurisdiction under the Act pursuant to Justice Kennedy's substantial nexus test.); *Northern Plains Resource Council v. Fidelity Exploration and Dev. Co*., 325 F.3d 1155, 1162 (9th Cir. 2003).
[128] *Northern Plains Resource Council v. Fidelity Exploration and Dev. Co*., 325 F.3d 1155 (9th Cir. 2003).
[129] *Id.*, citing *APHETI*, 299 F.3d at 1016.
[130] *See* U.S. EPA, "National Summary of State Information: National Probable Sources Contributing to Impairments," available at: http://iaspub.epa.gov/waters10/attains_nation_cy.control#causes, and U.S. EPA, "Specific State Probable Sources That Make Up the National Groundwater Loadings/Withdrawals Probable Source Group," available at: http://iaspub.epa.gov/tmdl_waters10/attains_nation_cy.source_detail?p_source_group_name=GROUNDWATER%20LOADINGS/WITHDRAWALS.
[131] *Id.* California has also recognized groundwater sources of impairment on its 303(d) List. The most recent 2010 303(d) List contains 27 waterbody-segment pollutant combinations that identify groundwater loadings as potential sources of impairment.

There are considerable practical reasons to address groundwater loadings with as much specificity as possible. For example, rapid mixing, dilution, and dispersal of pollutants, which are factors that often mitigate surface water contamination, do not occur with polluted groundwater,[132] resulting in much lengthier persistence of pollutants and their harmful effects. Moreover, the costs, difficulties, and uncertain benefits of remediation weigh strongly in favor of efficient agency action to address groundwater pollution.[133]

Additionally, addressing groundwater contamination of surface waters is necessary to protect public health.[134] Discharges from septic systems and agricultural runoff can cause waterborne diseases and chemicals found in groundwater, including pesticides, gasoline additives such as MTBE, arsenic, and other hazardous wastes, present significant threats.[135]

The state's pending public health crisis fueled by nitrate-polluted groundwater provides a particularly compelling example. Nitrate, the most common groundwater contaminant in California in drinking water can cause "blue baby syndrome," lead to miscarriages and death in infants, and may cause certain types of cancers. A recent California Watch report found that the number of California wells that exceeded the health limit for nitrates jumped from nine in 1980 to 648 in 2007. To date, the State Board has not been able to effectively regulate and ensure the cleanup of nitrates. The 303(d) process was designed to do just that and should be applied to address nitrate and other pervasive groundwater contaminants that impact surface waters. Such efforts will at the same time help establish much-needed improvements in groundwater quality itself.

B. The State Must Use All Readily Available Data to Specifically Identify Surface Waters Impaired by Contaminated Groundwater Loadings.

As discussed above, under federal law[136] and the California Listing Policy, the State and Regional Water Boards must "actively solicit, assemble, and consider all readily available data and information, including drinking water source assessments and existing and readily available water quality data and information reported by local and state agencies."[137] Information regarding groundwater impairments that contaminate surface waters, groundwater hydrological connections with surface waters, and groundwater withdrawals that impact surface waters is essential in the compilation of a complete 303(d) list that correctly identifies pollutants and sources that can then be effectively prioritized.[138] Further, groundwater data can provide valuable clues to uncover the existence of hydrologically-connected, impaired surface water bodies that the state may otherwise have missed.

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[132] 2006 Guidance.
[133] *Id.*
[134] *See* Harter, T. & Rollins, L., *Watersheds, Groundwater and Drinking Water: A Practical Guide,* University of California, Agriculture and Natural Resources, Publication 3497 (2008).
[135] *Supra* n. 121, *Groundwater Protection Model* at 263.
[136] 40 CFR 130.7(b)(5), see http://law.justia.com/us/cfr/title40/40-21.0.1.1.17.0.16.8.html
[137] *See* CA Listing Policy, Section 6.1.1 Definition of Readily Available Data and Information
[138] 40 CFR 130.7(b)(4).

The State's own 2002 305(b) Report contains an extensive catalog of efforts and available data to monitor groundwater quality in California."[139] It is worth noting that the most recent groundwater quality assessment included in the State's 305(b) Report will be a *decade* old in 2012. By contrast, EPA's 2006 Guidance contemplates the completion of such assessments every two years:

> by April 1 of all even numbered years, a description of the water quality of all waters of the state (including, rivers/stream, lakes, estuaries/oceans and wetlands). States may also include in their section 305(b) submittal a description of the nature and extent of ground water pollution and recommendations of state plans or programs needed to maintain or improve ground water quality.[140]

Updated monitoring and assessment of groundwater quality is highly relevant to the state's proper assessment of the overall health of its waterways as called for by the federal Clean Water Act. These and other readily available sources of information and data on groundwater contamination and withdrawals must be integrated into the State Water Board's analysis of impairment sources of surface waters in its biennial Integrated Report (303(d) list and 305(b) report).[141] A brief discussion of data that should be incorporated immediately in the current data scoping for the 2012 303(d) List is provided below.

First, the State Water Board should assess its own data from its Groundwater Ambient Monitoring and Assessment (GAMA) Program and Underground Storage Tank, Land Disposal, and Spills, Leaks, Investigations, and Cleanup Programs in its biennial 303(d) analysis. The GeoTracker GAMA Groundwater Database contains groundwater data searchable by chemical and is readily available, highly relevant and compatible to specify groundwater loadings to listed surface waters. Additionally, the California Water Quality Monitoring Council, which is co-chaired by Cal-EPA and the Natural Resources Agency and managed by the State Water Board, is very close to completing an interactive suite of databases to be released shortly on groundwater quality. This portal of information compiles existing groundwater quality data from USGS and others that similarly should be examined for 303(d) listing implications.

The State Water Board should also closely collaborate with and solicit groundwater quality data held by other state agencies, most notably the Department of Pesticide Regulation (DPR) and California Department of Public Health (DPH). DPR's Ground Water Protection Program[142] maintains a well inventory program that contains information about the collection and analysis of data on wells sampled for pesticides by state and local agencies, as well as DPR's own monitoring of pesticides that have the potential to pollute groundwaters.[143] Under the Safe Drinking Water Act, each state is required to assess drinking water sources, including

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[139] SWRCB, 2002 Integrated Report, Chapter IV: Groundwater Quality Assessment, available at: http://www.swrcb.ca.gov/water_issues/programs/tmdl/305b.shtml.

[140] 2006 Guidance at 9.

[141] *See* 2006 Guidance for details on U.S. EPA requirements for the inclusion of updated groundwater data in the state's biennial Integrated Report (http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2006IRG_index.cfm).

[142] *See* California Department of Pesticide Regulation, Groundwater Protection Programs website at http://www.cdpr.ca.gov/docs/emon/grndwtr/index.htm.

[143] Well Inventory Reports on Ground Water Testing for Pesticides from 1986-2008, and other data and information is available at http://www.cdpr.ca.gov/docs/emon/grndwtr/wellinv/wirmain.htm.

groundwater wells. California DPH is currently implementing these requirements as part of the Drinking Water Source Assessment and Protection Program (DWSAP), which includes an assessment of 14,326 groundwater sources.[144] Several other state agencies implement groundwater-related monitoring and assessment programs, such as the Department of Water Resources (DWR) and Department of Toxic Substances Control (DTSC); these must be solicited for data as well.

Local groundwater management districts and banks also must be solicited for information on the contamination and overuse of groundwater basins and aquifers that are hydrologically connected to impaired surface waters. The Santa Clara Valley Water District, for example, monitors groundwater quality for common inorganic constituents and identifies which contaminants exceed Regional Water Quality Control Board agricultural water quality objectives.[145] There are also nine local groundwater management districts[146] in California that maintain groundwater data, as well as watermasters[147] and other local entities that maintain data and information about groundwater water quality.

Additionally, federal agencies that implement groundwater-related monitoring and assessment programs, such as U.S. EPA and the United States Geological Survey (USGS),[148] must be "actively solicited" for information. In 2007, USGS conducted an analysis of California's well water quality that examined the presence of 11 contaminants in groundwaters including arsenic, atrazine, benzene, nitrate, radon, and uranium.[149] California Coastkeeper Alliance created two interactive maps depicting groundwater polluted by nitrates and arsenic, primarily relying on these USGS data.[150] Other independent researchers have developed excellent maps of nitrate and other incidences of groundwater pollution that may impact surface waters.[151] This and related information should be carefully scanned for related impacts to hydrologically-connected surface water bodies.

Finally, data on groundwater withdrawals and pumping that impairs or threatens surface water beneficial uses similarly must be solicited and considered. The State Water Board's Water Rights division has such data, which could be cross-referenced with streamflow and other data from numerous other sources.[152] The Santa Clara Valley Water District monitors groundwater elevation and maintains a database of elevation data, searchable by location or well number.[153]

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[144] *See* California Department of Health, Drinking Water Source Assessment and Protection Program, January 1999. Available at http://www.cdph.ca.gov/certlic/drinkingwater/Documents/DWSAPGuidance/DWSAP_document.pdf.
[145] Table 3-3a, Santa Clara Valley Water District, 2008 Groundwater Quality Report.
[146] A list of groundwater management district can be found at DWR, Water Facts: Groundwater Management Districts or Agencies in California, available at http://www.dpla2.water.ca.gov/publications/waterfacts/water_facts_4.pdf.
[147] *See* Chino Basin Watermaster Engineering Reports: http://www.cbwm.org/rep_engineering.htm.
[148] *See, e.g.*, USGS Groundwater Information Pages, http://water.usgs.gov/ogw/ and information on what type of data USGS collects at http://www.usgs.gov/faq/index.php?action=artikel&cat=102&id=1148&artlang=en.
[149] Excerpt of California data available at http://www.cacoastkeeper.org/document/ca-domestic-well-water-quality.pdf.
[150] *See* http://www.cacoastkeeper.org/programs/mapping-initiative/nitrates-in-groundwater-maps and http://www.cacoastkeeper.org/programs/mapping-initiative/arsenic-in-groundwater-maps.
[151] *See* California Watch Report, *Nitrate Contamination Spreading in California Communities* (May 13, 2010), available at: http://www.californiawatch.org/nitrate-contamination-spreading-california-communities.
[152] *See* Section III. above for additional sources of flow- and pumping-related data. Future data collected pursuant to SB X7 6 (2009), which establishes collaborations to collect groundwater elevations statewide, will provide

If the State Water Board declines to use such readily available data and information related to groundwater loadings that threaten or impair surface waters, the Board *must* submit a formal "rationale" for the decision in its Assessment Methodology.[154] EPA requires that states' submissions of 303(d) Lists include an Assessment Methodologies section, which includes a "rationale for any decision to not use any existing and readily available data and information."[155] We urge the Water Board, however, to fully exercise its authority and mandate to comprehensively assess and report on the health of all waterways in the state, as required by the 2006 Guidance and Clean Water Act Sections 303(d) and 305(b).

C. The State Water Board Must Ensure that Groundwater Sources of Surface Water Impairment Are Specifically Identified in All Affected Regions of California.

The State Water Board has made progress in identifying groundwater "sources" of surface water impairment in its 303(d) assessment and listing process.[156] Whereas the 2006 303(d) List contained only two references to groundwater as a source of impairment,[157] the 2010 303(d) List contains 27 water body-pollutant segments which identify groundwater as a source of impairment. This type of information is extremely useful in prioritizing waters for action and setting appropriate loads.

Despite the Board's progress, though, groundwater sources of contamination are not identified consistently throughout California's nine regions, nor is there enough information included about groundwater loadings on the List as with other listed sources of impairment. The majority of groundwater-related listings in the 2010 303(d) List are limited to Regions 3 and 4, with only one listing each in Regions 5, 6, and 8. Further, where the Board has identified groundwater contamination as a source of impairment, the groundwater basins and the extent of contaminant loading has not been identified specifically.

The problem of contaminated groundwater loadings to surface waters is not limited to 27 waterbody-pollutant segments, nor is it limited to Regions 3 and 4; it is a pervasive issue that must be proactively addressed throughout the State's 303(d) Listing Process. There are myriad examples spanning the entire state of contaminated groundwater impacts to surface waters. For example, researchers working in San Francisco Bay found that excess levels of certain dissolved

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additional information (DWR is in the process of launching the California Statewide Groundwater Elevation program).

[153] Santa Clara Valley Water District Online Groundwater Elevation Query, available at: https://gis.valleywater.org/GroundwaterElevations/index.asp.

[154] 40 CFR 130.7(b)(6)(iii); U.S. EPA 2006 Guidance, Section C.2, p. 18 ("The assessment methodology should be consistent with the state's WQSs and include a description of the following as part of their section 303(d) list submissions … Rationales for any decision to not use any existing and readily available data and information."). Note that EPA's subsequent Guidance documents for 2008 and 2010 incorporate the 2006 Integrated Reporting Guidance.

[155] 2006 Guidance at 18.

[156] *See* discussion of Source versus Cause in Section III. above.

[157] "Groundwater withdrawal" was listed as a source of impairment of a surface water in only one listing in 2006 (Mendota Pool in Region 5). Lake Tahoe listed "groundwater loadings" as a source of impairment. See www.waterboards.ca.gov/water_issues/programs/tmdl/docs/303dlists2006/epa/state_06_303d_reqtmdls.pdf.

metals in the Bay resulted in large part from groundwater seepage.[158] Similarly, nitrate contamination of groundwaters in California Central Coast valleys, such as Salinas, has become a national example of how fertilizers can impact public health and water quality.[159] For example, the Salinas River is severely impaired by nutrients and nitrates, flows of which often originate from groundwater tainted by irrigation releases.[160] In 2007, the Central Coast Regional Quality Control Board staff investigated reports of heavily nutrient-contaminated discharges from greenhouses near the City of Carpinteria, finding that such discharges of groundwater contribute to existing nutrient impairments in the Carpinteria Salt Marsh and its tributary streams.[161]

Data from the Malibu Watershed,[162] Los Osos,[163] and San Francisco Bay Area[164] demonstrate another pervasive form of surface water pollution caused by groundwater: septic tank releases that reach coastal waters, estuaries and other surface waters. For example, a recent Stanford study found that contaminated groundwater discharging from a small stretch of Stinson Beach was contributing as much nutrient flux to nearshore coastal waters as *all* local creeks and streams in the Bolinas Lagoon drainage.[165]

Southern California surface waters are particularly impacted by contaminated groundwater and excessive withdrawals and pumping. In particular, a number of Orange

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[158] Spinelli, G.A. *et al*., "Groundwater seepage into northern San Francisco Bay: Implications for dissolved metals budgets," *Water Resources Research*, 38(10.1029/2001WR000827) (2002). The researchers sought to quantify groundwater seepage and bioirrigation rates in the area to determine their roles in transporting dissolved metals from benthic sediments to surface waters. After applying their groundwater flow seepage model to northern San Francisco Bay, the researchers found that "benthic fluxes of dissolved metals to the surface waters could account for a relatively large amount (<60%) of the unknown sources of dissolved cobalt and a relatively small amount (<4%) of the unknown sources of dissolved silver, cadmium, copper, nickel, and zinc." *Id.* at 1 (Abstract).

[159] Robert E. Criss "Fertilizers, water quality, and human health," *Environmental Health Perspectives*. FindArticles.com. Aug 23, 2010. http://findarticles.com/p/articles/mi_m0CYP/is_10_112/ai_n15688580/.

[160] *See* USGS, J. Kulongoski, K. Belitz, *Ground-Water Quality Data in the Monterey Bay and Salinas Valley Basins, California, 2005—Results from the California GAMA Programs*, Data Series 258, available at: http://pubs.usgs.gov/ds/2007/258/pdf/DS_258.pdf.

[161] Staff concluded that the discharges were either the result of sump pumping activities conducted by greenhouse operators or groundwater leaching into the storm drain system and then Arroyo Paradon creek. These discharges of groundwater contribute to existing nutrient impairments in the Carpinteria Salt Marsh and its tributary streams. Data and information on file with Santa Barbara Channelkeeper.

[162] Santa Monica Bay Restoration Commission, "Risk assessment of septic systems in lower Malibu Creek watershed" (2001) (Characterizes vulnerability of Malibu Creek and Lagoon and Surfrider Beach to contamination from on-site septic systems in the Malibu Civic Center).

[163] Central Coast Regional Water Quality Control Board, "Los Osos Water Quality Project and Status of Sewer Project" (October 2005), available at: http://www.swrcb.ca.gov/rwqcb3/water_issues/programs/los_osos/docs/master_docs/ 2005_10_los_osos_water_quality_impacts_and_status_of_sewer_project.pdf ("Los Osos septic tanks are causing severe environmental problems in Morro Bay and surrounding areas. This is a surface water (Morro Bay National Estuary) problem in addition to a groundwater problem").

[160] Alexandria B. Boehm, Gregory G. Shellenbarger, Adina Paytan, "Groundwater Discharge: Potential Association with Fecal Indicator Bacteria in the Surf Zone" *Environmental Science & Technology* 38 (13), 3558-3566 (2004) (this work establishes a mechanism for the subterranean delivery of fecal indicator bacteria pollution to the surf zone from the surficial aquifer and presents evidence that supports an association between groundwater discharge and FIB). See http://www.stanford.edu/~aboehm/research.htm for this and additional information.

[165] N. de Sieyes, *et al*., "Submarine Groundwater Discharge to a High-Energy Surf Zone at Stinson Beach, California, Estimated Using Radium Isotopes," *Estuaries and Coasts*, DOI 10.1007/s12237-010-9305-2 (Apr. 2010).

County's coastal creeks and waterways receive significant amounts of groundwater and have been seriously impacted by contamination.[166] The Chino Basin, one of the largest groundwater basins in Southern California,[167] contains a high concentration of dairies that contribute high concentrations of salts and nitrates that degrade the water quality of Orange County's groundwater basin, and ultimately, the Santa Ana River, resulting in significant water treatment costs for residents.[168]

The State Water Board's "Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List" makes clear that for each water body-pollutant combination proposed for the 303(d) list, the Regional Water Quality Control Board must prepare fact sheets. These fact sheets must identify a pollutant's potential source, and "the source category should be identified as specifically as possible."[169] As Regional Water Boards increasingly identify groundwater loadings as a source of surface water impairments, the State Water Board should encourage this progress and work to ensure that the Regional Boards specify the name, location, size, and other identifying data for the groundwater basins at issue as much as possible in the proposed 2012 303(d) list. This information is necessary in order to identify, analyze, and clean up ground water sources of surface water impairment.

This progression in increasing specificity of information is contemplated by U.S. EPA, which recommends in its 2006 Integrated Report Guidance that states use a combination of monitoring and assessment techniques to "increase the percentage and types of waters assessed,"[170] waters that "may include, but are not limited to . . . *ground water*."[171]

As described in Appendix B, there is significant precedent around the country for actively using groundwater data to ensure the proper identification of the extent and sources of surface water impairments, and cleaning up all of those sources (including the groundwater), with the goal of ensuring healthy waterways. The state can and should follow this path to healthy waterways. To do this, the state *must* update its 2002 Groundwater Quality Assessment[172] in the 2012 Integrated Report. Further, the State Water Board, in close collaboration with Regional Water Boards, must go beyond recognizing where groundwater contamination is a possible source of impairment. The State and Regional Water Boards should proactively identify, analyze, and clean up groundwater sources of surface water impairment to ensure the full health of both its groundwater and surface water bodies.

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[166] *See* "Orange County Water District adopts resolution targeted at dairies in Chino Basin" *U.S. Water News Online* (December 1999), available at http://www.uswaternews.com/archives/arcpolicy/9oracou12.html.
[167] The Chino Basin contains approximately 5,000,000 acre-feet of water. *See* Chino Basin Watermaster Overview http://www.cbwm.org/overview.htm.
[168] *Supra* note 166.
[169] 2006 Guidance at p. 19 (Section 6.1.2.2(K)).
[170] *Supra* n. 1, 2006 Guidance, at Appendix: Data Elements for 2006 Integrated Water Quality Monitoring and Assessment Report and Documentation for Defining and Linking Segments to the National Hydrography Dataset, p. A-8, available at: http://www.epa.gov/owow/tmdl/2006IRG/report/2006irg-appendix.pdf.
[171] *Id.*at A-1 (emphasis added).
[172] http://www.swrcb.ca.gov/water_issues/programs/tmdl/305b.shtml.

D. The State Must Specifically Identify Surface Waters Impaired by Excessive Groundwater Withdrawals and Pumping.

As described in detail in Section III. above, Clean Water Act Section 303(d) lists must also reflect instances where excessive withdrawals and pumping of groundwater impair and threaten surface waters, particularly through flow alterations. Large-scale pumping and withdrawals of groundwater for agricultural irrigation threaten entire hydrological systems in many areas of California and reduce surface water flows to the detriment of a waterway's beneficial uses.[173]

For example, Northern California's Scott River is so dependent on groundwater that the Legislature amended the California Water Code to formally declare that "by reason of the geology and hydrology of the Scott River, it is necessary to include interconnected ground waters in any determination of the rights to the water of the Scott River as a foundation for a fair and effective judgment of such rights."[174] The State Water Board's assessment of groundwater withdrawal impacts on surface water quality is equally necessary.

The expansion of groundwater-fed agriculture in the Scott Valley is draining the connected, once-mighty Scott River dry. Decreased base flow during summer months increases water temperature and decreases surface water depth, velocity, connectivity which prevents the necessary pollutant load reductions from being realized.[175] Severely reduced flows in the Scott River from groundwater pumping recently prompted legal action by the Pacific Coast Federation of Fisherman's Association and Environmental Law Foundation.[176] In summer 2009, reduced flows in the Scott Valley caused the salmon population to drop down to 81 adults, down from many tens of thousands decades earlier.[177] The groups filed suit against the State Water Board and Siskiyou County for violating the public trust doctrine by allowing unchecked groundwater use to the detriment of the Scott River and several dependent special status fish and wildlife. In addition to having a public trust duty, the State has a legal duty under Section 303(d) of the Clean Water Act to address all sources of surface water impairment.

The lesson of the Scott River and other affected surface waters is that when excessive groundwater withdrawals outpace water recharge, groundwater overdraft occurs, which can directly impact surface waters by diminishing the amount of groundwater that flows into surface waters.[178] Pumping groundwater without regard to streamflow can "turn gaining streams into

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[173] Macdonnel, *supra* n. 31 at 1090, citing Glennon, R., *infra* n. 179.
[174] Cal. Water Code Section 2500.5(b) (2005).
[175] *See* para. 21-22, Pet. for Writ of Mandamus and Complaint for Declaratory and Injunctive Relief filed on June 23, 2010 by Environmental Law Foundation, Pacific Coast Federation of Fisherman's Association, Institute of Fisheries Resources ("PCFFA Scott River Petition") available at http://www.envirolaw.org/documents/WRITPETITIONCOMPLAINT.pdf.
[176] *Id.*
[177] *See* entire PCFFA Scott River Petition, *supra* n. 110. *See also* text and photo accompanying "A Watery Balancing Act" http://www.sfgate.com/cgi-bin/blogs/lsheehan/detail?entry_id=66993.
[178] *See* Glennon, R., *Water Follies: Groundwater Pumping and the Fate of America's Freshwaters*, p. 32 (Island Press, Washington, D.C 2004) ("Along coastal areas, overdrafting may cause the intrusion of salt water into the aquifer, rendering the water no longer potable. This problem is quite serious in California, Florida, and South Carolina."). *See also* Howard J., Merrifield M., *Mapping Groundwater Dependent Ecosystems in California* (2010)

losing streams, and perennial streams into intermittent streams."[179] This alteration to a water body's natural flow creates a cascade of negative impacts on aquatic life and ecosystems, and can destroy a water body's beneficial uses.

Nationally, by far the largest number of groundwater-related impairments of surface waters occurs as a result of groundwater withdrawals, including 97,546 acres of lakes, reservoirs, and ponds, and 3,456 acres of wetlands.[180] As described in Appendix B, other states are taking action to protect surface waters from harmful groundwater withdrawals. For example, in 2000, the Washington Supreme Court upheld the state Department of Ecology's denial of applications for new groundwater withdrawals that would diminish protected stream flows in *Postema v. Pollution Control Hearings Board*.[181] The Michigan Legislature is currently considering a bill that would codify the applicability of the public trust doctrine to groundwater[182] to protect water supplies and connected surface waters from excessive groundwater withdrawals.[183]

Despite a growing movement nationwide to address groundwater withdrawals that affect the health of surface waters, "Groundwater withdrawal" is listed as a source of impairment of a surface water body in only two listings in the State Water Board's 2010 List (Blosser Channel in Region 3 and Mendota Pool in Region 5).[184] Belying these limited listings, satellite-based findings show that large-scale groundwater withdrawals in California[185] are draining surface waters around the state. California's annual statewide overdraft is estimated by the Department of Water Resources to be approximately 1.4 million acre-feet on average, with the majority of overdraft occurring in the San Joaquin Valley and Central Coast.[186] Since October 2003, the aquifers that supply Central Valley and the Sierra Nevada have lost nearly enough water combined to fill Lake Mead.[187] More than 75 percent of this is due to groundwater pumping in the southern Central Valley, primarily to irrigate crops.[188]

PLoS ONE 5(6): e11249. doi:10.1371/journal.pone.0011249, available at: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0011249.

[179] *Supra* note 122, Aiken at 546.

[180] U.S. EPA, "Specific State Probable Sources that make up the National Groundwater Loadings/Withdrawals Probable Source Group," available at: http://iaspub.epa.gov/tmdl_waters10/attains_nation_cy.source_detail?p_source_group_name=GROUNDWATER%20LOADINGS/WITHDRAWALS.

[181] *Postema v. Pollution Control Hearings Board*, 11 P.3d 726 (Wash. 2000).

[182] Michigan law already recognizes the doctrine's applicability to surface waters. *See e.g.*, Article IX, Sec. 40 of the Michigan Constitution of 1963; MCL 324.30111; 324.32502; 324.32505, etc.). The Great Lakes - St. Lawrence River Basin Water Resources Compact (codified at MCL 324.34201) also explicitly recognizes that "the Waters of the Basin are precious natural resources shared and held in trust by the states."

[183] Proposed House Bill No. 5319, available at http://www.legislature.mi.gov/documents/2009-2010/billintroduced/House/pdf/2009-HIB-5319.pdf.

[184] "Domestic ground water" use is also listed twice; *see* http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/category5_report.shtml.

[185] University of California – Irvine, "California's troubled waters: Satellite-based findings reveal significant groundwater loss in Central Valley," *Science Daily* (Dec. 15, 2009), retrieved August 2, 2010, from http://www.sciencedaily.com/releases/2009/12/091214152022.htm.

[186] California Department of Water Resources, "California's Ground Water," Bulletin 118, Update 2003, Sacramento, CA (2003).

[187] *Id.*

[188] *Id.*

The State Water Board can and must ensure full compliance with Sections 303(d) and 305(b), and the 2006 Guidance, by listing these and other surface waters impaired by low flow caused by excessive groundwater withdrawals and pumping.[189]

V. THE STATE WATER BOARD MUST INCLUDE IN ITS 2012 303(D) LIST ANTHROPOGENIC CLIMATE CHANGE-DRIVEN SOURCES AND IMPAIRMENTS OF CALIFORNIA WATERWAYS.

Global climate change is altering the biological, chemical, and physical properties of California waterways. Projected impacts in California provide an added impetus for the State Water Board to take swift action on flows and groundwater, as described above. For example, California's total water demand is projected to increase by up to 12% or more between 2000 and 2050, and the impacts of climate change will greatly increase the number of areas where water demands will exceed supplies.[190]

Climate change will not only increase the number and severity of existing waterway impairments, it will also drive new sources and causes of impairments. Data and information in the California Climate Change Adaptation Strategy[191] and other analyses generated by the state[192] strongly suggest that climate change will have demonstrable impacts on beneficial uses of California waterways. The most immediate impairments, and those with the strongest causal connection to global climate change, are driven by four principal dynamics: oceanic and estuarine carbon absorption, sea level rise, air and water temperatures increases, and shifting precipitation patterns.

We respectfully request that the State Water Board ensure that the 303(d) list identifies climate change driven-impairments to waterway health, and consider including reference data and information contained herein in your pending "Guidance Document on Climate Change."[193] An initial identification of climate change-driven impairments is provided below as a starting point for the State Water Board's analysis of surface waters that should be included on the 2012 303(d) List as either threatened or impaired:

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[189] Excessive groundwater withdrawals can also cause groundwater levels to decline below sea level, causing seawater to intrude into fresh water aquifers. Saltwater intrusion into groundwater aquifers is likely to become a pressing threat in many watersheds as sea level rises. (*See* AMEC Earth & Environmental (2005) Santa Clara River Enhancement and Management Plan. 260 p. Prepared for the Ventura County Watershed Protection District and Los Angeles Department of Public Works, Santa Barbara, Riverside, San Diego, California.) This threat is described in more detail in the climate change section below.

[190] Natural Resources Defense Council, *Water Facts: Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable*, p. 2 (July 2010) ("NRDC Climate & Water Risk"). Available at http://www.nrdc.org/global-Warming/watersustainability/.

[191] The California Climate Adaptation Strategy, released in December 2009, summarizes the best known science on climate change impacts in California and outlines possible solutions that can be implemented within and across state agencies to promote resiliency. California Natural Resources Agency, "2009 California Climate Adaptation Strategy: A Report to the Governor of the State of California in Response to Executive Order S-13-2006," (CA Climate Adaptation Strategy), available at www.climatechange.ca.gov/adaptation.

[192] *See* documents referenced in Section IV.A.

[193] *See* http://www.waterboards.ca.gov/water_issues/programs/climate/index.shtml#.

Ocean Acidification:

- o decreased pH of oceanic and estuarine waters
- o acidification impacts to nearshore coastal waters, bays and estuaries

Sea level rise:

- o salinity intrusion into groundwaters hydrologically connected to surface waters
- o salinity intrusion into estuaries, bays, and coastal rivers
- o increased contaminant flows in waterways surrounding wastewater treatment plants and sewer outfalls
- o habitat alterations

Air and water temperature increases:

- o rivers, streams, and creeks: climate change-driven temperature listings
- o decrease in dissolved oxygen
- o loss of temperature-dependant beneficial uses (*e.g.* cold freshwater habitat)

Shifting precipitation patterns:

- o decreased reservoir levels and spring-fall flows (increased water temperature, decreased dilution of pollutants)
- o increase in winter flows, flooding, and runoff (increase in sedimentation and pollutant runoff)

These and other climate change-driven impacts are discussed in more detail below.

A. The State Must Use All Readily Available Data to Identify Climate Change-Driven Sources and Causes of Surface Waters Impairment.

As noted above, the State and Regional Water Boards must "actively solicit, assemble, and consider all readily available data and information," including information reported by local, state, and federal agencies.[194] Given the global and quickly-evolving nature of climate change, the State Water Board should also consider information from international bodies, such as the Water Quality Section of the Intergovernmental Panel on Climate Change's Assessment Report, which provides a useful overview of projected and already-occurring impacts to water quality. Additionally, local, state, and federal agencies have amassed a tremendous amount of regionally-scaled studies and analyses regarding climate change impacts to California water quality that have not yet been integrated into the State's biennial 303(d) (or 305(b)) data collection. In particular, there is a significant amount of modeling and data on how climate change will impact the water quality and water supply of the San Francisco-San Joaquin Delta that should be considered.

More specifically, the State Water Board must examine and consider all readily available information that could inform 303(d) decisions related to climate change-driven impacts to California waterways, including but by no means limited to the following:

- o Pertinent reports from the Department of Water Resources' (DWR) Integrated Regional Water Management Climate Change Document Clearinghouse.[195] This Clearinghouse

[194] *See* CA Listing Policy, Section 6.1.1 Definition of Readily Available Data and Information.
[195] A complete list of climate change publications written by DWR is available at http://www.water.ca.gov/climatechange/articles.cfm.

references dozens of pertinent reports that detail projected climate impacts to water quality, flow and species, including several recent DWR reports on how impaired water bodies and water quality will be impacted by climate change, including sea level rise;

- Analysis in the *California Water Plan Update 2009*[196] on how impaired water bodies and water quality will be impacted by climate change;
- Information from DWR's *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*[197] on waterways hydrologically connected to groundwater basins and on waterways vulnerable to sea level rise;
- Data and information in the Public Policy Institute of California's *Adapting Water Management to Climate Change*[198] on sea level rise and temperature impairments, as well as information on changes in the timing and amount of precipitation;
- Information regarding impairments stemming from salinity intrusion, inundation of wastewater treatment plants, and other impairments stemming from sea level rise in the Pacific Institute's *The Impacts of Sea-Level Rise on the California Coast*;[199]
- Ocean carbon data from NOAA's Pacific Marine Environmental Laboratory[200] and the U.S. Department of Energy's Carbon Dioxide Information Analysis Center;[201] and
- Data on changes in precipitation and temperature in the California Climate Tracker,[202] which is maintained by the Western Regional Climate Center, which would be extremely useful to identify related climate change-driven impairments as described below.

Information specific to the San Francisco-San Joaquin Delta includes, but is not limited to:

- Water quality monitoring data in the Central Valley Watershed Monitoring Directory, a joint effort by the San Francisco Estuary Institute (SFEI), the Central Valley Regional Water Quality Control Board Surface Water Ambient Monitoring Program (SWAMP) and the U.S. EPA;[203]
- Water quality and water supply studies from the CALFED Bay-Delta Program;[204] including the Delta Regional Ecosystem Restoration Implementation Plan models;[205]
- Reports and resources from the Water Quality, Supply and Reliability Workgroup of the California Partnership for the San Joaquin Valley;[206]

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[196] California Department of Water Resources (DWR), *California Water Plan Update 2009* (October 2009), available at http://www.waterplan.water.ca.gov/cwpu2009/index.cfm.
[197] DWR, *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water* (October 2008), available at http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf.
[198] Public Policy Institute of California, *Adapting Water Management to Climate Change* (November 2008), available at http://www.ppic.org/content/pubs/report/R_1108JLR.pdf.
[199] California Climate Change Center, The Impacts of Sea-Level Rise on the California Coast ("Impacts of Sea Level Rise on CA"), May 2009, available at www.pacinst.org/reports/sea_level_rise/report.pdf.
[200] *See* Pacific Marine Environmental Laboratory homepage at http://www.pmel.noaa.gov/co2/OA/.
[201] Global Ocean Data Analysis Project, http://cdiac.ornl.gov/oceans/.
[202] *See* California Climate Tracker at http://www.wrcc.dri.edu/monitor/cal-mon/. Abatzoglou, J.T., K.T. Redmond, L.M. Edwards, "Classification of Regional Climate Variability in the State of California," *Journal of Applied Meteorology and Climatology*, 48, 1527-1541 (2009).
[203] Central Valley Watershed Monitoring Directory: http://www.centralvalleymonitoring.org/.
[204] CALFED Bay-Delta Program: http://www.science.calwater.ca.gov/science_index.html.
[205] Delta Regional Ecosystem Restoration Implementation Plan at http://www.science.calwater.ca.gov/drerip/drerip_index.html.
[206] California Partnership for the San Joaquin Valley Water Quality, Supply and Reliability Document Library http://www.sjvpartnership.org/wg_doc_lib.php?wg_id=10.

- The SWRCB's Final Report on Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem and studies supporting the recently-adopted Delta flow criteria;[207] and
- DFG biological opinions on Delta smelt and other endangered species.

The State Water Board should solicit, assemble and consider all readily available data relating to climate change-driven impairments for the 2012 303(d) List, with a particular focus on developing appropriate 303(d) listings for which a large amount of data currently exists, such as for ocean acidification impairments and climate change-driven Delta waterway impairments. The Board should also use and consider data regarding potential sources and causes of impairment cased by climate change-driven sea level rise, warming and shifting precipitation. Finally, the Board should augment its "Climate Change and Water Resources" website with data and information regarding the aforementioned climate change-driven impairments.[208]

B. The State Water Board Must Take Immediate Action to Ensure That the 2012 303(d) List Reflects Data on Climate Change-Driven Impairments Related to Ocean Acidification.

There is a significant amount of data and information currently available with requisite specificity for assessing which waterways are impaired by ocean acidification for the 2012 303(d) List. The State must collect data regarding the pH of bays, estuaries, the ocean, near-coastal areas, and coastal shorelines, and list waterways impaired or threatened by ocean acidification. The State Board must take action to ensure that the 2012 303(d) List contains pertinent data and lists impaired waterways as appropriate. If the State declines to do so, it must submit a "rationale" for not doing so, as required by the Clean Water Act, though we urge the State to implement its responsibilities and authorities fully in ensuring comprehensive listings.

Ocean acidification, a decrease in ocean pH fueled by the ocean's absorption of carbon dioxide, threatens the seawater quality of California's bays and estuaries. The ocean absorbs about half of all anthropogenic carbon dioxide emissions, an estimated 22 million tons of carbon dioxide (CO_2) every day.[209] When CO_2 dissolves in seawater it forms carbonic acid, which decreases ocean pH and causes "ocean acidification."[210] Global average surface pH has already decreased by approximately 0.1 units, and is expected to decrease by another 0.3-0.4 units by the end of the century, depending on future levels of atmospheric carbon dioxide.[211]

The latest science indicates that ocean acidification impacts to the seawater quality of California bays, estuaries and near coastal areas may already be occurring, and are projected to

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[207] http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/
[208] *See* http://www.waterboards.ca.gov/water_issues/programs/climate/index.shtml.
[209] Feely, R. A., C. L. Sabine, K. Lee, W. Berelson, J. Kleypas, V. J. Fabry, and F. J. Millero. "Impact of anthropogenic CO2 on the CaCO3 system in the oceans," *Science* 305:362-366 (2004).
[210] Orr, J.C. *et al*. "Research Priorities for Understanding Ocean Acidification," *Oceanography*, 22(4): 182 (2009).
[211] Hauri, Claudine, Gruber, N, Lachkar, Z., Plattner, G. Abstract. "Accelerated acidification in eastern boundary current systems," Goldschmidt Conference Abstracts (2009); citing Orr, J.C., V.J. Fabry, O. Aumont, L. Bopp, S.C. Doney, R.A. Feely, A. Gnanadesikan, N. Gruber, A. Ishida, F. Joos, et al, "Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms," 437 *Nature* 681-86 (2005), http://www.nature.com/nature/journal/v437/n7059/full/nature04095.html.

accelerate.[212] In 2008, scientists discovered high levels of acidified ocean water within 20 miles of the Pacific Coast.[213] Given that atmospheric levels of carbon dioxide have increased drastically in the last half century, and are likely to increase further, such acidification trends are projected to increase, a trend that should be considered in projecting "threatened" waterways in particular.[214] Natural upwelling in nearshore waters, coupled with oceanic uptake of anthropogenic CO_2, mean that "ocean acidification has already decreased mean surface water pH in the California Current System to a level that was not expected to happen for open-ocean surface waters for several decades."[215] Projections indicate that the Humboldt Current System, another eastern boundary upwelling system that impacts ocean waters off of California, may be subject to the same conditions.[216]

There is precedent both for listing waterways impaired or threatened by atmospheric sources of pollution and for listing waterways impaired for pH. U.S. EPA maintains a list of waterways impaired for pH under the 303(d) program, with more than 3,500 waterbodies so listed as of May 2010.[217] Section 303(d) of the Clean Water Act also has been interpreted by both U.S. EPA and states to cover waterways impaired by atmospheric sources of pollution (such as carbon deposits). Specifically, in March 2007, EPA issued information on listing waters impaired by mercury from atmospheric sources under Section 303(d) of the Clean Water Act.[218] Subsequent to EPA's action, in October 2007, a group of Northeast states established the Northeast Regional Mercury TMDL, a regional cleanup plan to reduce mercury entering the states' watershed from a range of pollution sources, including atmospheric deposition of mercury.[219]

In response to legal action from the Center for Biological Diversity directly on the issue of climate change, the U.S. EPA solicited public comment on how to address listing of waters as threatened or impaired for ocean acidification under the 303(d) program.[220] <u>California need not wait for EPA's issuance of guidance on listing waters impaired by ocean acidification. The State should immediately assemble and consider all readily available evidence regarding waters impaired by ocean acidification and list waters accordingly</u>.

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[212] Byrne, R. H., S. Mecking, R. A. Feely, and X. Liu (2010), "Direct observations of basin-wide acidification of the North Pacific Ocean," 37 *Geophys. Res. Lett.* (2010), L02601, doi:10.1029/2009GL040999, http://www.agu.org/journals/ABS/2010/2009GL040999.shtml.

[213] Feely, R. A., C. L. Sabine, J. M. Hernandez-Ayon, D. Ianson, and B. Hales, "Evidence for upwelling of corrosive "acidified" water onto the continental shelf," *Science* 320:1490-1492 (2008), http://www.sciencemag.org/cgi/content/abstract/sci;320/5882/1490. *See also* Hauri *et al*. at p. 66.

[214] *Id. See also* http://www.sciencedaily.com/releases/2008/05/080522181511.htm.

[215] Hauri *et al*. at p. 69.

[216] *Id.*

[217] *See* Environmental Protection Agency Watershed Assessment, Tracking & Environmental Results webpage, Specific State Causes of Impairment That Make up the National pH/Acidity/Caustic Conditions Cause of Impairment, available at: http://iaspub.epa.gov/tmdl_waters10/attains_nation_cy.cause_detail_303d?p_cause_group_id=1188.

[218] Hooks, Craig, EPA Office of Wetlands, Oceans, and Watersheds, "Memorandum: Listing Waters Impaired by Atmospheric Mercury Under Clean Water Act Section 303(d): Voluntary Subcategory 5m for States with Comprehensive Reduction Programs" (March 8, 2007).

[219] New England Interstate Water Pollution Control Commission, "Northeast Regional Mercury Total Maximum Daily Load," p. 32 (October 24, 2007), available at http://www.neiwpcc.org/mercury/mercurytmdl.asp.

[220] *See* EPA's Federal Register Notice at http://www.epa.gov/owowwtr1/tmdl/oceanfrMarch_2010/.

C. The State Water Board Must Use and Consider Data on Sea Level Rise, Warming, and Precipitation Changes That Cause or Are Potential Sources of Impairments.

Projections of climate change-driven sea level rise, increased temperature, and shifting precipitation patterns will continue to have a major impact on California's water quality. The water quality impacts of climate change-driven sea level rise will be felt throughout California. In particular, a change in sea level will substantially alter San Francisco Bay-Delta conditions, where water surface elevations and associated fluctuations drive Bay-Delta hydrodynamics, which in turn dictate the location and nature of physical habitat and the quantity and quality of water.[221] Even under modest sea level rise and climate warming projections, an increase in the frequency, duration, and magnitude of water level extremes is expected in the Delta, to the detriment of numerous waterway beneficial uses.[222]

As for ocean acidification, we respectfully request that the State Water Board review and assess whether water bodies are impaired or threatened by climate change and also to list climate change as a potential source of impairment, where appropriate, on the 2012 303(d) List.[223] As outlined at the beginning of this section, we bring the following impairments to the Board's attention, although review of climate change impairments should by no means be limited to the impairments described below.

1. Sea Level Rise

Climate change is projected to result in sea level rise in California of 16 inches by 2050 and 55 inches by the end of the century.[224] In the Bay Area, 180,000 acres of shoreline are vulnerable to flooding by 2050, putting 21 wastewater treatment plants at risk of inundation.[225] Sea level rise also will substantially impair California's waterways by causing saltwater intrusion into estuaries and hydrologically connected groundwaters, inundating or eroding habitats, altering species composition, changing freshwater inflow, and impairing water quality.

a. Saltwater intrusion of hydrologically connected groundwaters.

Saltwater intrusion into aquifers is a man-made problem in many places in California, resulting from over-pumping and excessive withdrawals from groundwater aquifers.[226] Pumping coastal aquifers in excess of natural recharge rates draws down the surface of the aquifer, allowing surface water to move inland into a freshwater aquifer and contaminate it with salts.[227] When the ocean has a higher water elevation, it causes the saltwater wedge to intrude further

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[221] CALFED Bay-Delta Program Independent Science Board, Memorandum: *Sea Level Rise and Delta Planning* (September 6, 2007).
[222] *Id*. at 2.
[223] *See* discussion in Section III. above regarding "causes" versus "sources" of impairment.
[224] California Climate Change Center, "Climate Change Scenarios and Sea Level Rise Estimates for the California 2008 Climate Change Scenarios Assessment (Draft Paper)," available at www.energy.ca.gov/2009publications/CEC-500-2009-014/CEC-500-2009-014-D.PDF.
[225] *Id*.
[226] *Impacts of Sea Level Rise on CA* at 80.
[227] *Id*.

inland.[228] Seawater intrusion is already problematic in California's coastal aquifers throughout Central and Southern California, including the Pajaro and Salinas Valleys and aquifers in Orange and Los Angeles Counties. Groundwater supplies in the Santa Clara Subbasin are also vulnerable to salinity intrusion.[229]

Overdraft and saltwater intrusion into groundwater aquifers will be accelerated and made worse by sea level rise. Where these groundwater aquifers are hydrologically connected to surface waters, and thus affect the water quality of those surface waters, the State Water Board should list climate change/sea level rise as a source or cause of impairment so that appropriate remedial action can be taken.

b. Salinity intrusion into estuaries

Sea-level rise and changes in the intensity of storm events will impact low-lying coastal areas and result in the loss or inundation of coastal wetlands and dune habitat, resulting in salt water intrusion and loss of freshwater habitat for fish and wildlife.[230] Changes in salinity from reduced freshwater inflow will affect fish, wildlife and other aquatic organisms in intertidal and subtidal habitats. Increasing rates of saltwater intrusion into groundwater that impacts the beneficial uses of connected surface waters will need to be addressed in water quality management decisions, including the 303(d) List.[231]

c. Increased contamination from inundation of wastewater treatment facilities and sewer outfalls.

A recent Pacific Institute study found that a 1.4 meter sea level rise makes 28 wastewater treatment plants vulnerable to inundation: 21 plants around the San Francisco Bay and 7 other plants on the Pacific coast.[232] The combined capacity of these plants is 530 million gallons per day.[233] Some wastewater treatment plants are preparing for projected inundation,[234] but many more are not taking any action. Inundation from sea level rise, as well as an increased number of extreme weather events, could damage pumps and other treatment plant equipment and interfere with discharges from outfalls sited on coast and bay shorelines.[235] This will lead to an increased

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[228] *Id.*
[229] Santa Clara Valley Water District, "Groundwater Quality Report," p. 19 (2008) ("Saltwater intrusion of the Santa Clara Subbasin shallow aquifer zone adjacent to the southern shore of the San Francisco Bay has been studied and monitored for many years by the District. Although the contamination has been somewhat widespread in the shallow aquifer zone, fortunately, the lower aquifer has not been affected significantly.")
[230] *CA Climate Adaptation Strategy* at 73.
[231] *Id.* at 70.
[232] *Impacts of Sea Level Rise on CA* at 62-63, *see* Figure 24: Wastewater treatment plants on the Pacific coast vulnerable to a 100-year flood with a 1.4m sea-level rise.
[233] *Id.* at 63.
[234] In 2009, the City of Morro Bay commissioned a *Wastewater Treatment Plant Flood Hazard Analysis* and concluded that the existing wastewater treatment plant (WWTP) was subject to inundation from the Morro Creek watershed. The City recommended that the new site for a WWTP be developed with the placement of engineered fill to raise the new site above the 100-year flood elevation. *See* City of Morro Bay and Cayucos Sanitary District Wastewater Treatment Plant Upgrade Project, Facility Master Plan Draft Amendment No. 2, p. 12 (July 2010).
[235] *Id.* at 63.

number of untreated and partially treated sewage discharges and increased contamination and impairment of proximate waterways.

Discharges from sewage treatment plants already impair waterbodies throughout California. Pathogen impairments, which are linked to discharges from wastewater treatment plants among other sources, represent the second highest number of impairments for California waterways.[236] High concentrations of bacteria such as fecal coliform and E. coli raise the risk of waterborne diseases and starve fish of the oxygen they require, destroying several beneficial uses for affected waterbodies.

d. Sea level rise-caused habitat alterations

EPA records show 699 waterbody-segments listed nationwide as impaired due to "habitat alteration." This habitat alteration impairment group captures numerous impacts to waterways, including but not limited to alterations to wetland habitats, habitat barriers, degraded habitat and other forms of habitat alterations. Projected sea level rise similarly could result in a large number of habitat alteration impairments, both directly from sea level rise alteration to coastal wetland and other habitats, and indirectly by prompting construction of hard structures on the coastline such as seawalls and levees.

For example, according to the report *Impacts of Sea Level Rise on the California Coast* rising seas threaten to substantially modify or destroy wetland habitats.[237] More specifically:

> Vast areas of wetlands and other natural ecosystems are vulnerable to sea level rise. An estimated 550 square miles, or 350,000 acres, of wetlands exist along the California coast, but additional work is needed to evaluate the extent to which these wetlands would be destroyed, degraded, or modified over time. A sea level rise of 1.4 m would flood approximately 150 square miles of land immediately adjacent to current wetlands, potentially creating new wetland habitat if those lands are protected from further development."[238]

2. <u>Air and water temperature increases</u>

a. Warming of streams and rivers

New research shows that water temperatures are increasing in many streams and rivers throughout the United States,[239] with less water available for ecosystem flow and temperature needs in spring and summer.[240] In many low- and middle-elevation streams today, summer temperatures often approach the upper tolerance limits for salmon and trout; higher air and water

[236] http://iaspub.epa.gov/waters10/state_rept.control?p_state=CA&p_cycle=.
[237] *Impacts of Sea Level Rise on CA* at 27.
[238] *Id.* at 17.
[239] Kaushal et al., "Rising stream and river temperatures in the United States," *Frontiers in Ecology and the Environment*, 2010; 100323112848094 DOI: 10.1890/090037; University of Maryland Center for Environmental Science, "Rising water temperatures found in US streams and rivers" (April 7, 2010), available at: http://www.sciencedaily.com/releases/2010/04/100406101444.htm.
[240] *CA Climate Adaptation Strategy* at 80.

temperatures will exacerbate this problem.[241] Thus, climate change might require dedication of more water, especially cold water stored behind reservoirs, to simply maintain existing fish habitat.[242] The 303(d) List should reflect instances where scientific evidence suggests that climate change is a cause or source of temperature impairments. Doing so would ensure that appropriate mitigating and prevention measures can be taken.

b. Decrease in dissolved oxygen

An inverse correlation between water temperature and the amount of dissolved oxygen in a waterbody is well-known and understood by water quality managers. Many California waterbodies that are impaired for temperature are also impaired because of low dissolved oxygen. Where waterbodies experience unnaturally high temperatures, the amount of dissolved oxygen can drop to levels that negatively impact water quality and aquatic species. Studies suggest that climate change-driven warming of streams, rivers, and other waterways could similarly decrease dissolved oxygen levels.[243] This is a phenomena the State Water Board must track and address in its 303(d) list, as appropriate.

3. Shifting precipitation patterns

Observational records and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change.[244] The decrease in precipitation and increase in potential evapotranspiration will have a significant affect on California's "available precipitation," which means water falling as rain or snow.[245] Projections suggest that precipitation will decline five inches per year by 2050 in California.[246] The Department of Water Resources projects that the Sierra Nevada snowpack may be reduced from its mid-20th century average by 25 to 40 percent by 2050.[247]

a. Longer low flow conditions

Climate change should be specifically identified as the source of low flow conditions where data so indicate. For example, projected declines in summer stream flows may impair Delta waterways through low-flow conditions and higher stream water temperatures.[248] As freshwater inputs decrease, Delta water quality may also be degraded as saltwater intrudes further upstream from the Pacific Ocean.[249] Salinity intrusion, low-flow conditions and higher

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[241] *Id.*
[242] *Id.*
[243] *See* IPCC Assessment Report, Working Group II: "Impacts, Adaptation and Vulnerability," Section 4.3.10 available at http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=173.; B. A. Cox and P. G. Whitehead, "Impacts of climate change scenarios on dissolved oxygen in the River Thames, UK, Hydrology Research," 40(2-3): 138–152 © IWA Publishing 2009 doi:10.2166/nh.2009.096.
[244] Climate Change and Water: Intergovernmental Panel on Climate Change Technical Report VI – June 2008, available at: http://www.ipcc.ch/publications_and_data/publications_and_data_technical_papers_climate_change_and_water.htm.
[245] *NRDC Climate & Water Risk* at 2.
[246] *Id.*
[247] CA Climate Adaptation Strategy at 82.
[248] *Id.* at 86.
[249] *Id.*

stream water temperatures are all sources and causes of waterway impairment that could and should be addressed under the State Water Board's 2012 303(d) process.

The California Natural Resources Agency made an initial determination that mitigating these impacts requires more freshwater releases from upstream reservoirs.[250] The State Water Board should work with the Central Valley Regional Water Quality Control Board to examine data on climate change-driven impairments of Delta waterways and tributaries so that impaired waterways can be correctly identified and appropriate mitigating actions can be implemented to restore waterway health.

b. Increased contamination from stormwater runoff

Many models project higher contaminant concentrations in waterways as less frequent but more intense rainfall patterns change water quality.[251] An increased number and severity of extreme weather events and storm surges are also predicted. These climate change-driven phenomena will increase runoff and flooding, thus exacerbating levels of storm water pollution and sediment runoff.

* * *

Thank you for the opportunity to provide this information in support of a comprehensive 2012 Section 303(d) list that meets the mandates of the Clean Water Act. California's 303(s) list cannot be limited to "traditional" Category 5 listings. To comply with the Act, and to help lead the state to achieving its goals of clean waters with healthy flows and biodiverse aquatic ecosystem, the 2012 303(d) list must also include waterways impaired or threatened by: altered natural flows in surface waters, groundwater contamination and excessive groundwater withdrawals that impact surface water health, and anthropogenic climate change-caused impacts to surface waters. The data and information contained and referenced in this letter, as well as extensive other databases and peer-reviewed reports that are readily available to the State and Regional Water Boards, should provide more than adequate support for the listing of numerous waterways that are impaired and threatened and that therefore require the state's attention under the Clean Water Act and Porter-Cologne.

If you have any questions, please do not hesitate to contact us.

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[250] *Id.*
[251] *CA Climate Adaptation Strategy* at 82.

Sincerely,

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APPENDIX A

FLOW IMPAIRMENT DATA AND INFORMATION

CONTENTS

Appendix A (cont'd)

Mattole River

- Randy D. Klein, Hydrologist, "Hydrologic Assessment of Low Flows in the Mattole River Basin 2004-2006" (March, 2007)

Napa River

- Letter from Patrick Higgins, Consulting Fisheries Biologist to Thomas Lippe, Living Rivers Council, "Sufficiency of SFBRWQCB Staff *Napa River Sediment TMDL Appendix D: Responses to Comments*" (Aug. 17, 2010)

Navarro River

- Letter from Patrick Higgins, Consulting Fisheries Biologist to SWRCB, "Comments on *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams*," (April 2, 2008)
- KRIS Navarro Project: "Hypothesis #5: Surface flows in the Navarro River basin have been diminished in recent decades, which reduces salmon and steelhead productivity," available at: http://www.krisweb.com/krisnavarro/krisdb/html/krisweb/analysis/hypoth5_nav.htm.

Redwood and Maacama Creeks

- Letter from Patrick Higgins, Consulting Fisheries Biologist to Traci Tesconi, County of Sonoma, "Pelton House Winery Application #PLP05-0010," (Dec. 29, 2008)

Salinas River

- Letter from Patrick Higgins, Consulting Fisheries Biologist to Curtis Weeks, Monterey County Resources Agency, Comments on Salinas River Channel Maintenance Project (CMP) 404 Permit Application and Mitigated Negative Declaration (Aug. 6, 2009)

Scott River

- California Dep't of Fish and Game, "Stream Flow Needs for Anadromous Salmon in the Scott River Basin, Siskiyou County – A Summarized Report" (1974)
- Memorandum from Mark Hampton, CDFG to Mark Pisano, CDFG, "Chinook salmon reconnaissance survey on the Scott River" (Dec. 28, 2009)
- Letter from PCFFA *et al* to Tam Doduc, SWRCB, "Joint Comments on the Proposed Action Plan for the Scott River Watershed Sediment and Temperature TMDL" (June 12, 2006)

Shasta River

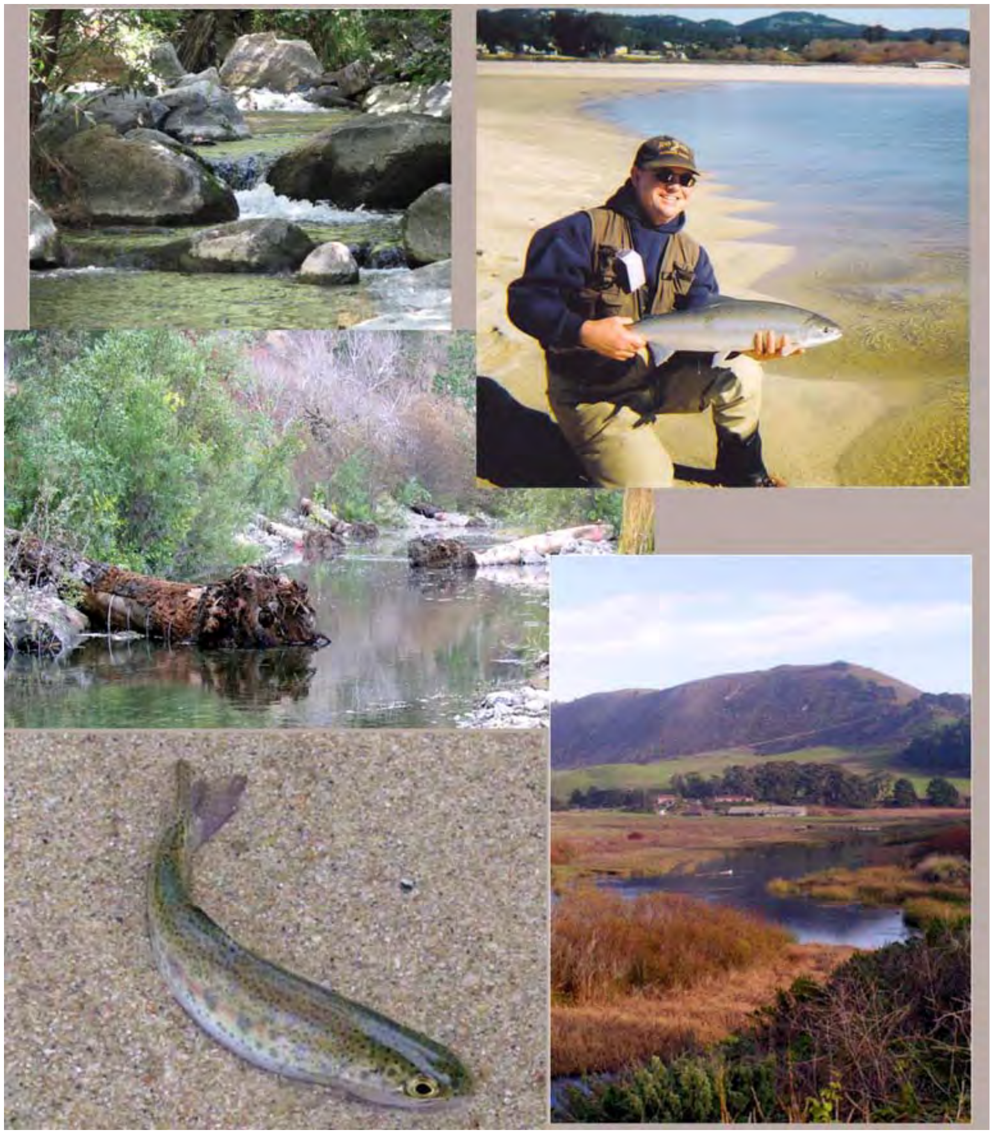
- Letter from Pacific Coast Federation of Fishermen's Associations and the Institute for Fisheries Resources to SWRCB, "Comment Letter - Shasta River Watershed DO and Temperature TMDLs" (Oct. 29, 2006)

The Sacramento-San Joaquin Delta

- SWRCB, "Final Report on Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem" (Aug. 3, 2010)
- SWRCB, **"**Draft Water Quality Control Plan for Salinity" (Oct. 1998)

CARMEL RIVER AND SAN CLEMENTE CREEK FLOWS

Historic and Present Angler Impacts on Carmel River Steelhead Trout Relative to Other Stressors on the Population



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For the

Carmel River Steelhead Association

August 2010

Table of Contents

Cover Image: Collage is from photos acquired from the following sources MPWMD (2002), Daniels et al. (2010), Hamson (2008) and Frank Emerson of the CRSA.

Executive Summary

This white paper was prepared for the Carmel River Steelhead Association to characterize sport angling pressure as a stressor on the river's native steelhead population. Current levels of fishing pressure and fish mortality after the re-opening of the Carmel River to sport fishing since 1998-99 are contrasted with the findings of Dettman (1986), who characterized sport fishing impacts as of 1984. In addition, other factors placing stresses on the Carmel River steelhead population are discussed and their relative impacts are characterized. Incidental hooking mortality of adult steelhead is likely not significant under current regulations and fishing effort, whereas, continuing habitat loss from progressive dewatering is diminishing carrying capacity for juvenile steelhead rearing and population resilience. The CDFG report *Reconnaissance of the Steelhead Resource of the Carmel River Drainage, Monterey County* (Snider 1983) provides invaluable information on stream conditions and spawning habitat capability as of 1984 that are invaluable in interpreting the findings and checking the assumptions of Dettman (1986). Numerous other documents pertaining to the Carmel River were reviewed in preparation of this report, including ones on flow conditions in tributaries. The San Clemente Creek case study demonstrates how continuing reduction in flows is hampering steelhead recovery and evidence is summarized in Appendix A of this report.

Background

The Carmel River was long famous for its steelhead fishing and historic run size may have been on the order of 20,000 adults, according to the California Salmon and Steelhead Advisory Committee (1988). Boughton et al. (2006) analyzed steelhead productivity in the South Central California Coast region and found that the Carmel River had the largest quantity of suitable habitat (Figure 1) based on criteria such as valley width, gradient, air temperature and summer base flow.

Despite a long history of development in the watershed (CRWC 2010), steelhead survived and provided a highly popular sport fishery (Dettman 1986) until the prolonged drought of 1987-1992. From 1987 to 1991 the Carmel River failed to flow to the ocean and anadromous steelhead runs ceased (McKeon and Jackson 1996, CRWC 2010). The Carmel River Steelhead Association (CRSA) worked cooperatively with the California Department of Fish and Game (CDFG) to create a captive broodstock program from smolts captured within the Carmel River Basin. Weather cycles turned wet in 1995 and the river has had a connection to the ocean in all years since. Captive broodstock progeny were planted as river flows improved. Just 15 adult steelhead returned in 1992 but runs quickly rebuilt in succeeding years to a high of 861 fish in 1998 (Figure 2). Although runs from 1993 to 2010 averaged 443 adult steelhead, low flows in 2009 contributed to a return of only 95 fish. The 2010 water year was much wetter, but the adult steelhead return was only 155. These fluctuations to low levels indicate that the Carmel River steelhead population is still not stable or secure.

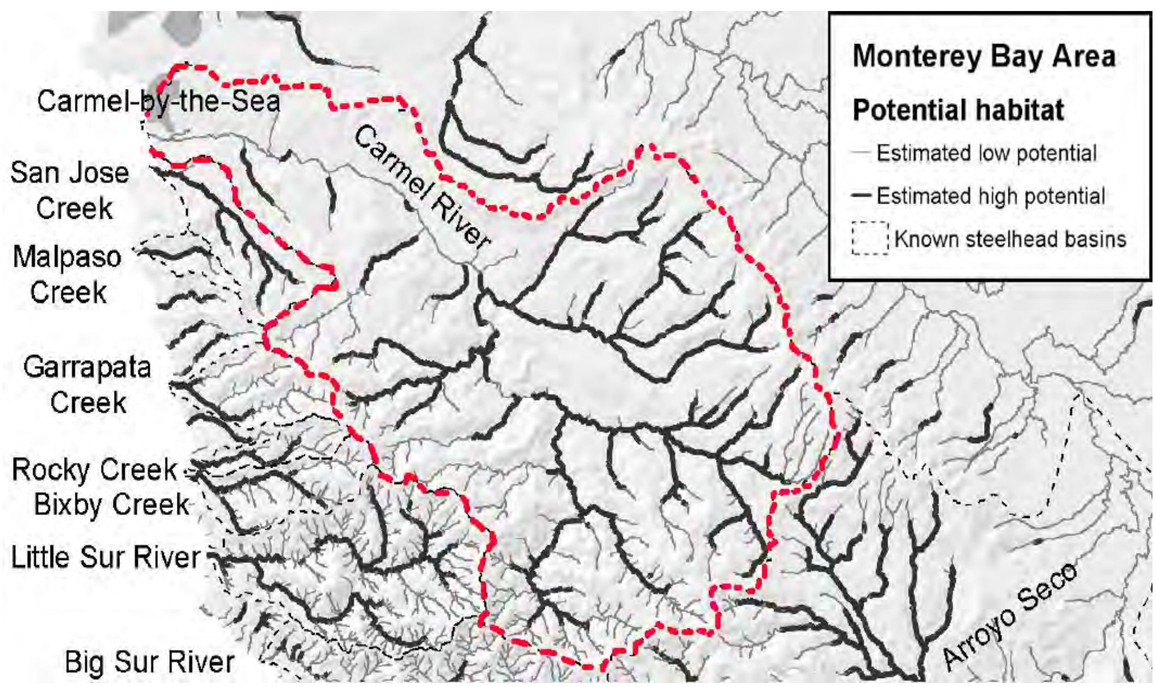


Figure 1. The map above is taken from Boughton et al. (2007) and shows high intrinsic potential steelhead habitat in the Carmel River (red outline) as well as in surrounding watersheds. Assumptions include access and use of streams with gradients up to 12% and low productivity of low gradient alluvial reaches.

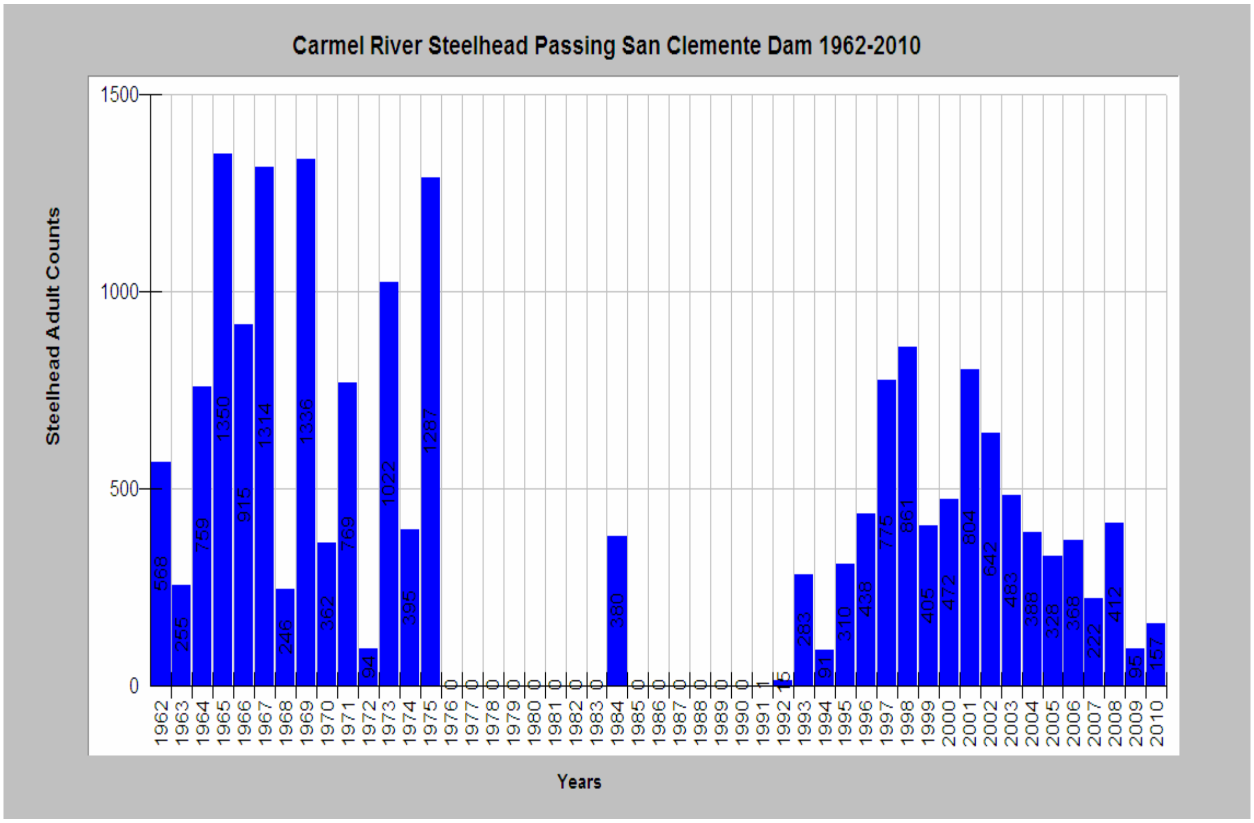


Figure 2. Adult steelhead returns to San Clemente Dam from 1962 to 2010. No steelhead were able to access the basin from 1988-1991, but other zero counts are a result of no surveys being conducted.

Critique of Assumptions, Methods and Findings of Dettman (1986)

The report by D.W. Kelly and Associates to the Monterey Peninsula Water Management District entitled *Relationships Between Steelhead Sport Catch Angling Success and Streamflows in the Carmel River During 1984* (Dettman 1986) characterized angling pressure and its effect on adult steelhead populations and concluded that sport fishing was a major limiting factor. The report has many unfounded assumptions and uses erroneous methods to arrive at its estimated sport angler steelhead catch and ignores potential for successful adult steelhead spawning below San Clemente Dam. It also does not discuss preceding stream channel changes that contribute to angling vulnerability and that have the potential to exert considerable natural selection pressure on spawn timing.

<u>Angler Catch Data Analysis</u>: Dettman (1986) used a combination of angling report cards filled out by Carmel River Steelhead Association (CSRA) members and angler surveys conducted by the CDFG warden to estimate the adult steelhead catch in the 1983-1984 steelhead fishing season. A major unmet assumption when using these data sets in combination was that "catch/angler-day made by CSRA anglers is equal to the efficiency of effort expended by the average angler in 1984." CRSA anglers were some of the most experienced and knowledgeable Carmel River fishermen and, therefore, likely more proficient than "average" anglers. Consequently, straight multiplication of all anglers versus CRSA catch rate yields harvest results that are skewed high.

Ironically, Dettman (1986) eliminated consideration of data from the three most successful CSRA anglers when estimating catch and release fishing because they released all their fish and he considered that completely different from "average" anglers. He also made adjustments to the catch rate without justification, because "CSRA fishermen often hooked fish but did not catch them" without explaining why the same thing would not happen to "average" anglers. Consequently, Dettman (1986) "multiplied the number of fish hooked times the overall fraction (0.61) of fish that CSRA anglers hooked and caught", which is another source of bias that is likely to increase the catch estimate.

The CDFG warden recorded the number of fishermen and the catch of steelhead on 27 of the 30 legal fishing days in the 1983-1984 season and logged 1529 angler visits and 216 adult steelhead caught. Table 4.4 of the Dettman (1986) report captured the number of patrol hours by the warden and he sometimes worked more than 10 hours on days with high angler use. For example, the warden noted 90 anglers harvested 30 fish on February 11 and that 60 anglers caught 15 steelhead the following day. The warden worked 7 hours on February 11 and 12.5 hours on February 12, which indicates that he may have performed a very exhaustive survey of the 14 mile fishable reach of the Carmel River. Dettman (1986) catch estimates for those days were 72 and 60 adult steelhead respectively, without addressing warden survey effort. If the focus of the warden's patrol was only the Carmel River, he likely visited the most productive fishing holes more than one time and it is implausible that 2 to 4 times the number of fish he recorded were landed on those days. Dettman (1986) described fishing conditions: "At many times the pools are ringed with anglers." Crowded conditions with multiple fish hook-ups often times cause adult steelhead to become stressed, which usually decreases angling success.

<u>Adult Counts at San Clemente Dam</u>: Information provided by Dettman (1986) about San Clemente Dam adult steelhead is insufficient to judge the accuracy of counts and raises questions about under-counting. The counting meter at the top of the fish ladder at the dam would register when open more than 2 inches. Dettman (1986) "assumed that all steelhead would bump into the gate once before moving through and that the time between the bump and passage of fish was 1 to 10 seconds." Steelhead also sometimes move in schools and it would have been good to have some means of verification or discussion in the paper about how multiple fish moving through the gate within seconds of each other would be distinguished from the assumed bumping. This could have resulted in substantial under-estimation of the above San Clemente Dam steelhead escapement.

Snider (1983) noted similar problems with steelhead run estimates from 1964 to 1973, when the MPWMD dewatered the fish ladder during the day to count steelhead, when many fish were likely also to have passed up through the ladder at night. Counts in 1984 were also unavailable from the period of February 13 to 21 (Dettman 1986), when a rain event occurred, flows increased to more 172 cfs, and angling success indicated that fish had moved into the river from the ocean. It would be surprising if fish staged near the dam would not ascend over it with the increased flow and it is additional evidence that the adult steelhead escapement to the upper basin is skewed low by Dettman (1986).

Impacts of Angling on Run Timing: Only 28 steelhead moved over San Clemente Dam in January and February 1984 according to Dettman (1986). He assumed steelhead entering the Carmel River in those months that did not pass San Clemente Dam were mostly caught by anglers and did not successfully spawn. He further postulated that this selective harvesting of the early part of the run and was cutting off early spawning higher in the watershed and shifting run timing later when conditions in the upper watershed were less conducive to egg incubation and juvenile rearing.

Dettman (1986) stated that steelhead needed a flow of 200 cfs in the lower Carmel River to stimulate migration upstream and past San Clemente Dam, but also noted that a major migration of adult steelhead passed the dam in March 1984 on flows of 124 cfs. Flows in January 1984 were well over 200 cfs at the beginning of the month and averaged 157 cfs, yet few adult steelhead passed upstream and over San Clemente Dam. The flow of 172 cfs on February 16 noted above should also have stimulated major dam passage. This raises the question of whether environmental factors may have been selecting for later run timing, similar to what Cederholm (1983) described for the Clearwater River in Washington State. Snider (1983) and CRWC (2010) note a large number of flood events spanning from 1950 to 1984 and provide substantial evidence of problems related to excess sediment. The selective advantage is for fish to deposit eggs on the falling hydrograph of the last storm of the season to avoid smothering of eggs or scour of redds.

Dettman (1986) asserts that late spawning (April-May) in the upper watershed above Los Padres Dam in April by steelhead would likely be unsuccessful. There is also the possibility that selection pressure related to upper basin spawning might be for later timing because of potential for bedload movement in the steep rock bound channels of the headwaters. Perennial spring sources of water may maintain cold water flows and topographic shading may help keep them in the range of suitable for salmonids. Dettman (1986) also noted that it took an average of 12 days for steelhead to migrate the several miles between San Clemente Dam and Los Padres Dam, which raises questions as to whether increasing or fluctuating flows in this reach might speed migration.

Lack of Consideration of Spawning Below San Clemente Dam: Dettman's (1986) assumption that steelhead adults that did not migrate upstream to San Clemente Dam in January and February fell prey to fishermen also overlooks potential for spawning below the dam. Boughton et al. (2006) estimated 10-50% of Carmel River steelhead spawning takes place in reaches downstream of San Clemente Dam. Snider (1983) reported results from a Carmel River CDFG spawning habitat assessment (Figure 3) that showed substantial capacity below the dam, although habitat below river mile 10 was of lesser quality. At flows of 50 cfs, Snider (1983) estimated a spawning capacity in the lower mainstem of 400 adult steelhead and that capacity increased to 5000 spawners at flows of 80 cfs. Therefore, it is possible that some of the adult steelhead entering the Carmel River during January and February 1984 that did not migrate past San Clemente Dam may have spawned successfully and contributed to the replenishment of the population. The failure to assess this potential in the field or to address it in the report is significant oversight.

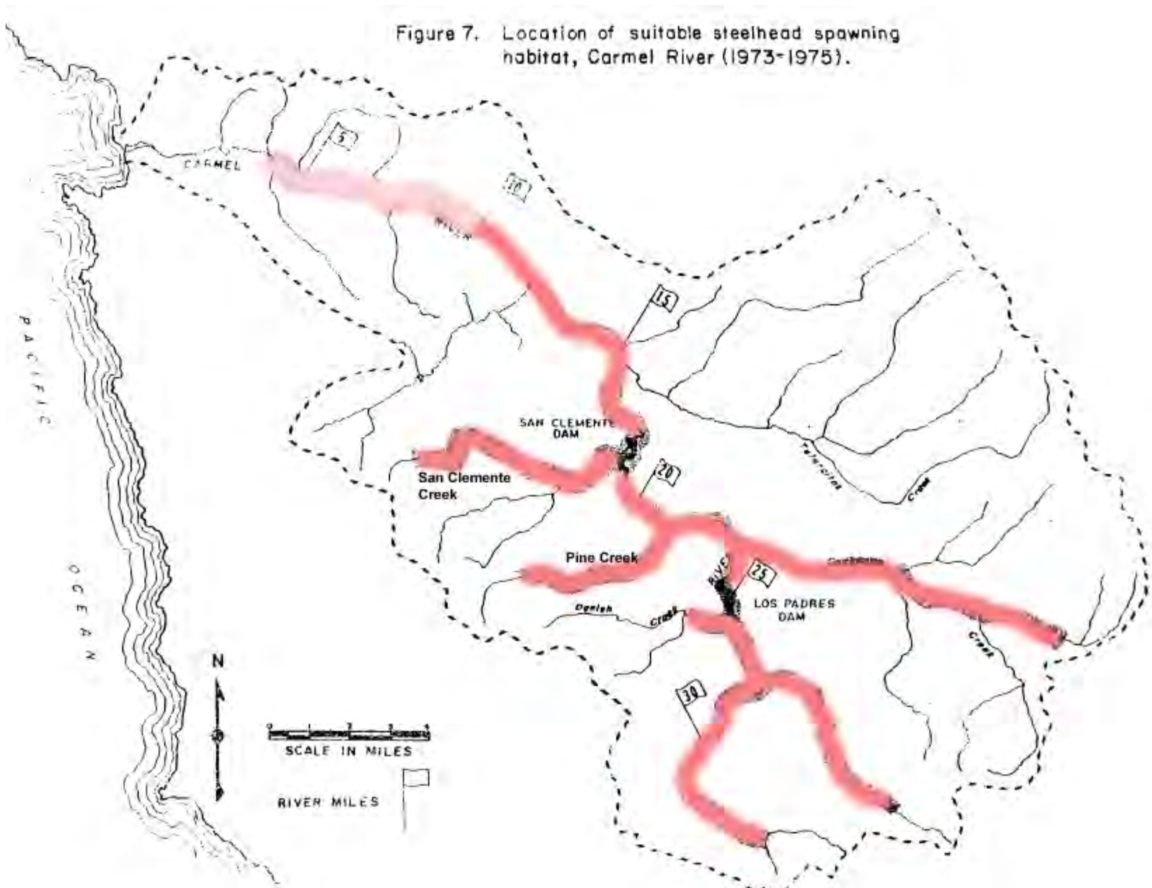


Figure 3. Map of suitable spawning habitat according to CDFG surveys taken from Snider (1983) where it appeared as Figure 7. Red highlights have been added to denote spawning steelhead habitat and the lighter shade of color downstream of river mile 10 indicates lesser quality.

Current Carmel River Angling Pressure and Steelhead Population Impacts

As steelhead runs rebounded in the Carmel River after the 1987-1992 drought, sportfishing was reopened in the 1998-1999 season (CDFG 2007). Fishing is still allowed three days a week from December through February, but only when flows are greater than 80 cubic feet per second (cfs). Good et al. (2005) reviewed the status of West Coast Pacific salmon, including the Carmel River, and found that hook and release mortality of sport caught steelhead was not likely a major limiting factor on South Central California Coast steelhead stocks:

> "A recent draft of the Fishery Evaluation and Management Plan (CDFG 2001) argues that the only mortality expected from a no-harvest fishery is from hooking and handling injury or stress. They estimate this mortality rate to be about 0.25–1.4%. This estimate is based on angler capture rates measured in other river systems throughout California (range of 5–28%), multiplied by an estimated mortality rate of 5% once a fish is hooked."

Although steelhead hooking mortality may rise in warm water (Taylor and Barnhart 1997), Nelson et al. (2005) found rates of 1.4-5.8% in cool water temperatures. Therefore, use of 5% hooking mortality for caught and released steelhead in the Carmel River is conservative.

CDFG's (2007) report to the legislature on its steelhead report card program includes information on Carmel River angling pressure and success that allows rough calculation of incidental mortality for steelhead. An annual average of 70 steelhead fishing days on the Carmel River were estimated for the years 2003 to 2005 with an average catch and release of 15 adult steelhead. When the mortality rate of 5% is applied to this average catch, it yields an angling mortality of 0.75 adult steelhead annually. This amounts to 0.2% of the average run of 400 adult steelhead returning to the Carmel River in this period. The Carmel River has steelhead reporting angler forms in boxes at popular fishing access points, which is an additional reporting mechanism to the steelhead report card (CDFG 2007). Even if there was an under-reporting of 40% by anglers, which is the statewide estimate (CDFG 2007), impacts from incidental hooking mortality would only be 0.3%.

There are additional mitigating factors that are playing into a diminished role for angler mortality as a source of stress in the Carmel River. In severely dry years, such as January and February 2009, there is sometimes little or no angling pressure because flows remain below 80 cfs for most of the season. Snider (1983) described considerable channel widening, bank erosion and loss of habitat complexity. This channel simplification would have lead to very open conditions and higher vulnerability to angling. Lower Carmel River riparian restoration has now been extensive (CRWA 2010), which has resulted in a substantial increase in habitat complexity that provides cover for adult steelhead and reduces angler success in both hooking and landing steelhead.

Notes on Limiting Factors and Potential for Restoration Success

NMFS (2007) gives the South Central Coast steelhead distinct population segment (DPS) only a moderate potential for recovery, but Moyle et al. (2008) note the positive trend on the Carmel River. As shown in Figure 2, run trends have tapered off since 2008, which is source of concern since this represents lack of population replacement and negative trends despite mostly good water years for recruitment. Progress is being made on mainstem restoration, other major problems like restoring flow in accordance with SWRCB (1995) Order WR 95-10 and there are even plans for removal of San Clemente Dam (MPWMD 2010). There are also plans for improving movement of adult steelhead above Los Padres Dam and for increasing flows from that dam downstream to San Clemente Dam, which will substantially assist in increasing successful juvenile rearing. However, in reviewing Carmel River literature for this project, it also became apparent that substantial juvenile steelhead production in tributaries like San Clemente Creek may be compromised as a result of increased water diversion (Castorani and Smith 2008, 2009). What is likely occurring is that groundwater and surface water use for residences and golf courses are depleting flows in an area recognized as significantly contributing to historic juvenile steelhead production. This is a pervasive problem in California, particularly since there is little State oversight of groundwater extraction (Higgins 2008).

Appendix A provides evidence of diminished carrying capacity of San Clemente Creek, which produced a significant proportion of the juvenile steelhead in the Carmel River basin in 1973 and 1974 (Snider 1983).

Moyle et al. (2008) point out the need to "identify and maintain sustainable refugia against severe droughts and heat waves." Smith et al. (2004) note that high rainfall due to topographic relief near the coast leads a disproportionately large amount of flow and water supply coming from Pine, San Clemente and Garzas creeks. While these basins occupy only 15%of the Carmel River watershed, they supply 27% of the basin's flow. Consequently, it is not surprising that these watersheds were formerly high producers of juvenile steelhead. Reeves et al. (1995) point out that to restore Pacific salmon populations that watershed processes with which they co-evolved must be restored. It would seem that while carrying capacity may be increasing as a result of restoration activities by MPWMD, water use by smaller land owners may be increasing and causing a simultaneous habitat decline. Lower mainstem Carmel River flow objectives may be difficult to achieve unless water use by smaller riparian water users and those with pumps that effect surface flow are not also regulated.

Rieman et al. (1993) point out that maintaining diverse sub-populations of salmonids is a good hedge against extinction. Titus et al. (2006) confirm that non-anadromous resident rainbow trout high in southern and south central coastal California watersheds may exhibit an anadromous life history, if washed downstream to the ocean. Similarly, sea run steelhead may gain access to steep headwater streams in years of high flow and replenish "trout" populations. This likely assisted with anadromous steelhead recovery after 1992 (Good et al. 2005, Boughton et al. 2006, Moyle et al. 2008). The upper eastern portion of the Carmel River basin receives much less rainfall (Smith et al. 2004) and streams like Tularcitos and Cachauga creeks have much less carrying capacity for steelhead juveniles as a result. They are also much more likely to lose surface flow during a drought. Consequently, streams like San Clemente Creek that have naturally higher base flows should be protected and restored as a buffer against future droughts and potential loss of steelhead trout in the Carmel River basin.

The rebound of the Carmel River steelhead population after its cessation from 1987-1991 is an encouraging sign, but it should not be a cause for complacency. Nearby drainages such as the Salinas River have virtually lost their anadromous steelhead runs despite maintaining gene resources as resident trout populations in tributaries, such as the upper Salinas and Nacimiento rivers (Higgins 2009). To reduce long term risk of extinction, the anadromous life history form of steelhead also needs to be maintained in the SCCC region. The Carmel River has the best possibility of maintaining and restoring mainstem habitat and anadromous steelhead runs, but long term success will rely on looking at the water supply and water use in the basin holistically.

References

Boughton, D.A., P.B. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelly, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Steelhead of South- Central/Southern California Coast: Population Characterization for Recovery Planning. NOAATM- NMFS-SWFSC-394. National Marine Fisheries Service Southwest Fisheries Science Center. 123 p.

California Department of Fish and Game (CDFG). 2001. Fishery management and evaluation plan, Central California Coast evolutionarily significant unit, draft. (Available from California Department of Fish and Game, 830 S St., Sacramento, CA 95814.)

California Department of Fish and Game. 2007. California Steelhead Fishing Report/Restoration Card - Report to the Legislature. CDFG, Sacramento, CA. 91 p.

California State Water Resources Control Board. 1995. Order on Four Complaints Filed Against The California-American Water Company Carmel River, Monterey County. Order No. WR 95-10 issued July 6, 1995. SWRCB Water Rights Division, Sacramento, CA. 50 p.

Carmel River Watershed Conservancy. 2010. Carmel River History. Carmel River Watershed Council, Carmel, CA. 11 p. www.carmelvalleyassociation.org/assetts/docs/CV_Voices/Carmel_River_History.pdf

Castorani, S. and D. Smith. 2008. 2008 Annual Report: Hydrologic Conditions in Baseflow Reaches Pursuant to Conditions 14 and 15, Santa Lucia Preserve, Monterey County, California. The Watershed Institute, California State Monterey Bay, Publication No. WI-2008-06. 31 p.

Castorani, S. and D. Smith. 2009. Summary of Precipitation and Streamflow for Potrero and San Clemente Creeks in Water-Year 2008 Santa Lucia Preserve Monterey County, California. Performed by the Watershed Institute, California State Monterey Bay. Publication No. WI-2009-01. 30 p.

Cederholm, C.J. 1983. Clearwater River wild steelhead spawning timing. Proceedings of Olympic Wild Fish Conference. Peninsula College, Port Angeles, Washington.

Daniels, M., D. Frank, R. Holloway, B. Kowalski, P. Krone-Davis, S. Quan, E. Stanfield, A. Young, and F. Watson. 2010. Evaluating Good Water Quality Habitat for Steelhead in Carmel Lagoon: Fall 2009. The Watershed Institute, California State Monterey Bay, Publication No. WI-2010-03, 42 pp. http://ccows.csumb.edu/pubs/reports/CSUMB_ENVS660_ClassReport_CarmelLagoon_100618d_fw.pdf

Dettman, D.H. 1986. Relationships between steelhead sport catch angling success and streamflows in the Carmel River during 1984. Prepared for the Monterey Peninsula Water District in cooperation with the Carmel Steelhead Association. D.W. Kelley & Associates, New Castle, CA. 37 p.

Good, T. P., R. S. Waples and P. B. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-66. 598 pp.

Hamson, L. 2008. Carmel River- History, Restoration and Protection, Slide show given to the Carmel Residents Association. By Larry Hamson, Monterey Peninsula Water Management District from Thursday, October 23, 2008. 72 p. http://www.mpwmd.dst.ca.us/Mbay_IRWM/IRWM_library/Presentations/CRApresentation20081023.pdf

Higgins, P.T. 2008. Comments on Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams. Prepared for the Redwood Chapter of the Sierra Club by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 49 p.

Higgins, P.T. 2009. Comments on Salinas River Channel Maintenance Project (CMP) 404 Permit Application and Mitigated Negative Declaration. Performed under contract to the Monterey Coastkeeper, Monterey, CA by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 22 p.

Kier Associates and National Marine Fisheries Service (NMFS). 2007. Guide to Reference Values used in the South-Central/Southern California Coast Steelhead Conservation Action Planning (CAP) Workbooks. National Marine Fisheries Service, Santa Barbara, CA. 41 p.

McEwan, D., and T. A. Jackson. 1996. Steelhead Restoration and Management Plan for California. CDFG, Inland Fisheries Division, Sacramento, CA. 234 p.
Monterey Peninsula Water Management District. 2002. Installation of Large Wood Habitat Structures at the deDampierre Restoration Project. Presentation format.

Monterey Peninsula Water Management District. 2002. Installation of Large Wood Habitat Structures at the deDampierre Restoration Project. Power Point slide show. Monterey Peninsula Water Management District, Monterey, CA.

Monterey Peninsula Water Management District. 2010b. San Clemente Dam Removal Project: Project Description. Monterey Peninsula Water Management District, Monterey, CA. 7 p.

Moyle, P.B., J. A. Israel, and S. E. Purdy. 2008. Salmon, Steelhead, and Trout in California: Status of an Emblematic Fauna. Commissioned by California Trout. 316 pp.

National Marine Fisheries Service (NMFS). 2007. NMFS (2007) 2007 Federal recovery outline for the Distinct Population Segment of Central California Coast Steelhead. National Marine Fisheries Service, Southwest Regional Office, La Jolla, CA.

Nelson, T.C., M.L. Rosenau, and N.T. Johnston. 2005. Behavior and Survival of Wild and Hatchery-Origin Winter Steelhead Spawners Caught and Released in a Recreational Fishery. North American Journal of Fisheries Management 25:931–943, 2005.

Reeves, G.H., L.E. Benda, K.M. Burnett, P.A. Bisson, and J.R. Sedell. 1995. A Disturbance-Based Ecosystem Approach to Maintaining and Restoring Freshwater Habitats of Evolutionarily Significant Units of Anadromous Salmonids in the Pacific Northwest. American Fisheries Society Symposium 17:334-349, 1995.

Rieman, B., D. Lee, J. McIntyre, K. Overton, and R. Thurow 1993. Consideration of Extinction Risks for Salmonids. As FHR Currents # 14. US Forest Service, Region 5. Eureka, CA. 12 pp.

Smith, D.P., Newman, W.B., Watson, F.G.R., and Hameister, J., 2004, Physical and Hydrologic Assessment of the Carmel River Watershed, California. The Watershed Institute, California State University Monterey Bay, Publication No. WI-2004-05/2, 88 pp.

Snider, W.M. 1983. Reconnaissance of the Steelhead Resource of the Carmel River Drainage, Monterey County. California Department of Fish and Game, Environmental Services Branch Administrative Report No. 83-3, Sacramento, CA. 49 p.

Taylor, G. and R.A. Barnhart. 1997. Mortality of Angler Caught and Released Summer Steelhead. Performed for the California Department of Fish and Game Steelhead Trout Catch Report - Restoration Card Program. Contract Number FG 5018 IF. Humboldt State University Cooperative Fishery Research Unit, Arcata, CA. 31 p.

Titus, R. G., D. C. Erman, and W. M. Snider. 2006. History and status of steelhead in California coastal drainages south of San Francisco Bay. In draft for publication as a Department of Fish and Game, Fish Bulletin. 293 p.

Appendix A. Evidence of San Clemente Creek Flow Reduction

Castorani and Smith (2008, 2009) provide rainfall (Figure 4) and flow data (Figure 5) for San Clemente Creek and also a comparison of dry stream reaches from 1990 and 2008 (Figure 6). Figure 4 shows that rainfall in the water year 2008 (10/1/07-9/30/08) was well above the 2001-2007 average in upper San Clemente Creek at the site of the Santa Lucia Preserve golf course. Despite what appears to be significantly above average rainfall, flows in San Clemente Creek dropped to below 0.1 cfs. Furthermore, water use throughout the day seems to be causing a fluctuation in flow that nearly dried up the stream at the stream gauge. This is despite the fact that the gauge is located below a spring. Even more telling is the map provided by Castorani and Smith (2008) that shows that there was a greater extent of dry stream reaches in 2008 than there were in 1990. Since 1990 was the fourth year of a severe drought and 2008 was above average, one can only assume that water use in San Clemente Creek has increased substantially. The flow depletion indicates that steelhead juvenile rearing capacity is likely seriously compromised in what was once a major source area.

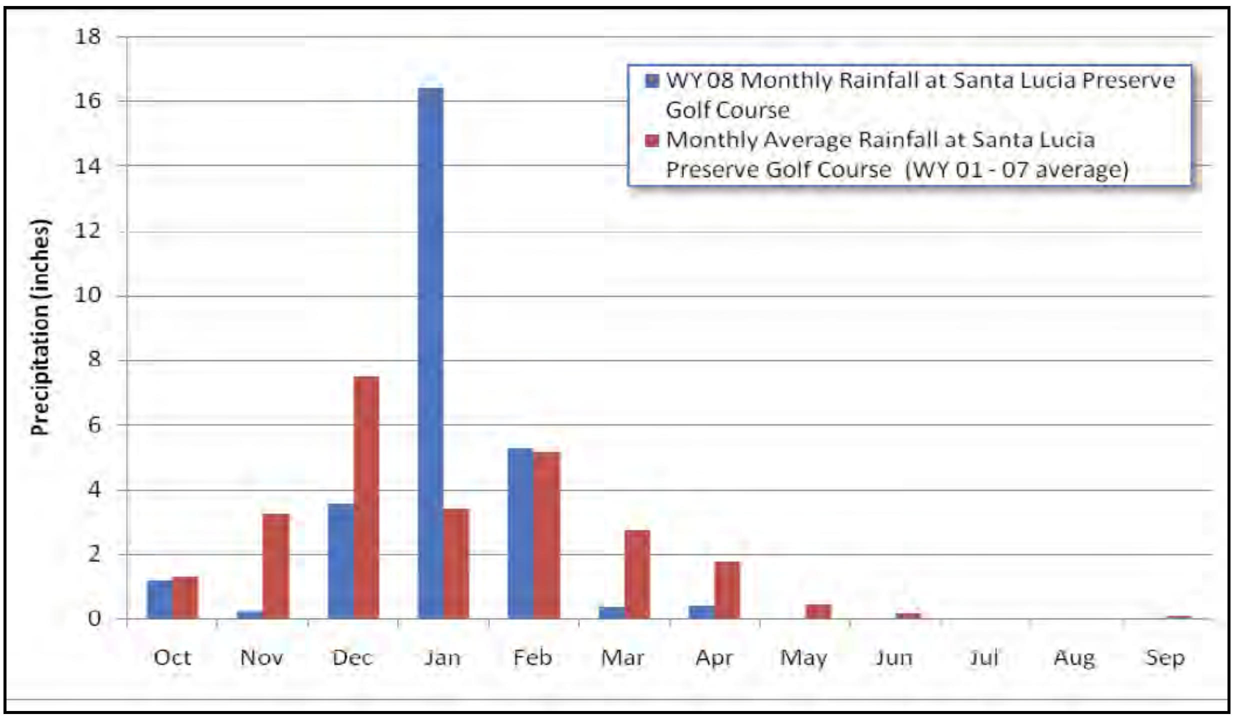


Figure 4. Rainfall in upper San Clemente Creek at the Santa Lucia Preserve golf course for the water year 2008 compared to the average of the previous seven years. From Castorani and Smith 2009.

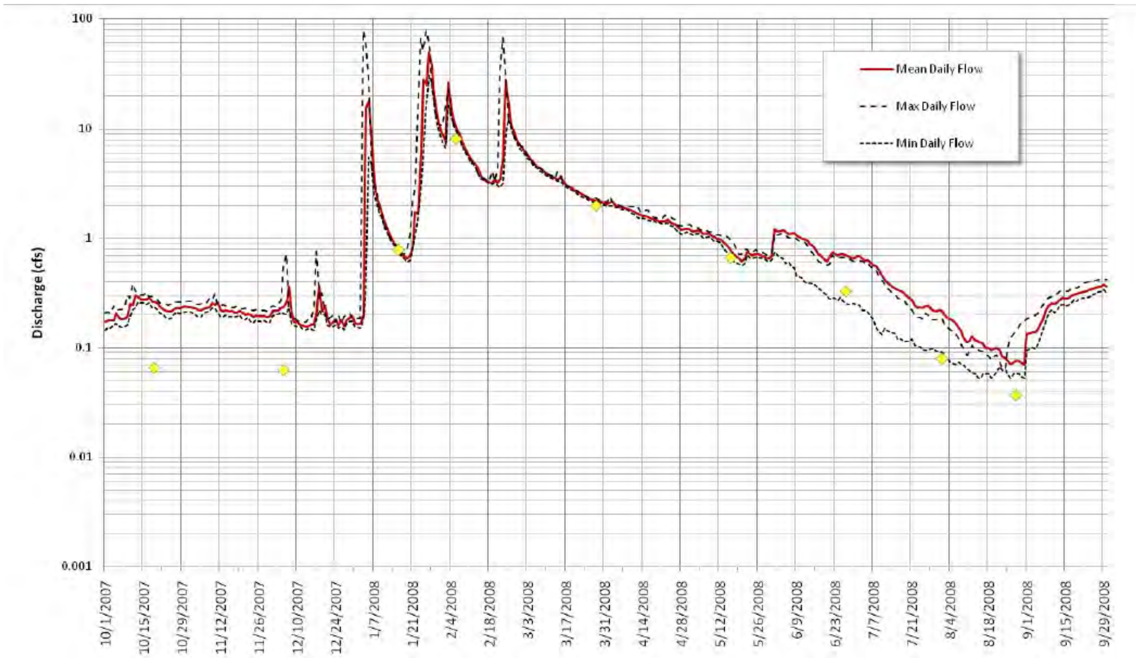


Figure 5. Flow data for upper San Clemente Creek at the lower property boundary of the Santa Lucia Preserve for the water year 2008. Minimum, average and maximum flows are displayed and show that the stream almost dried up at the gauge during some times of the day in late August. From Castorani and Smith 2009.

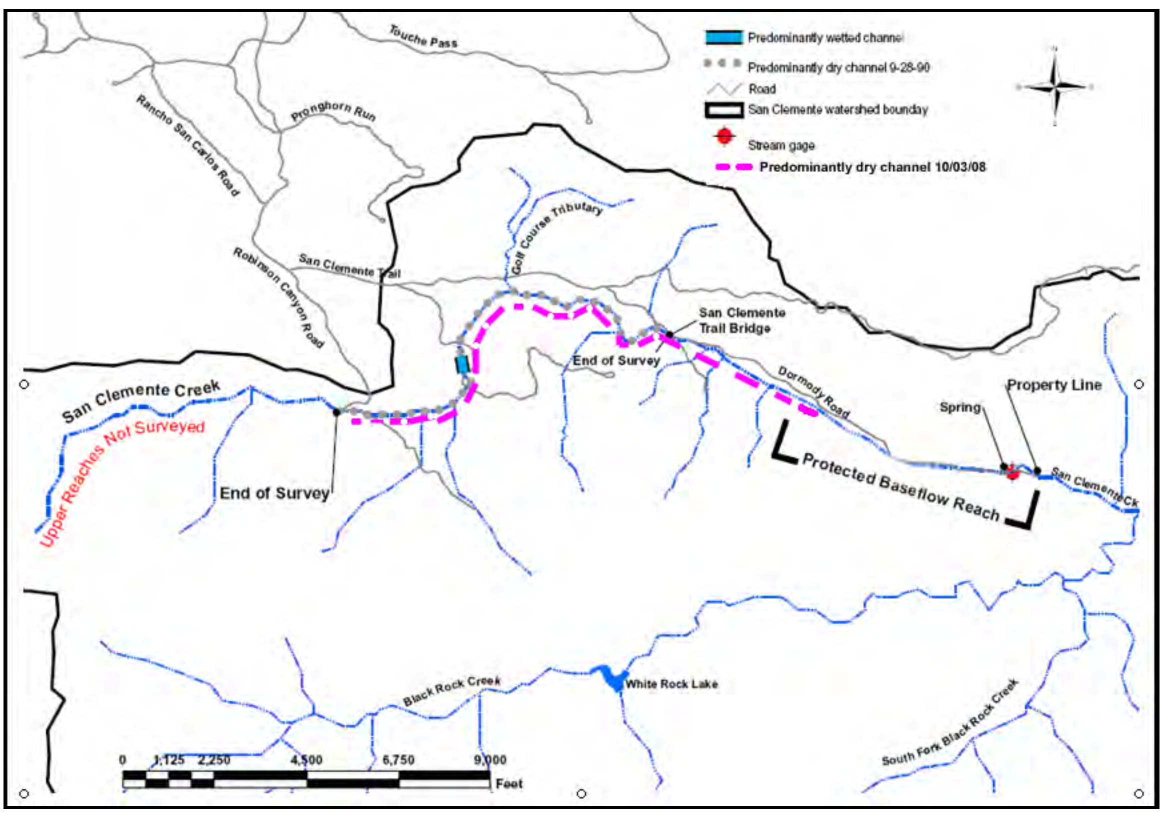
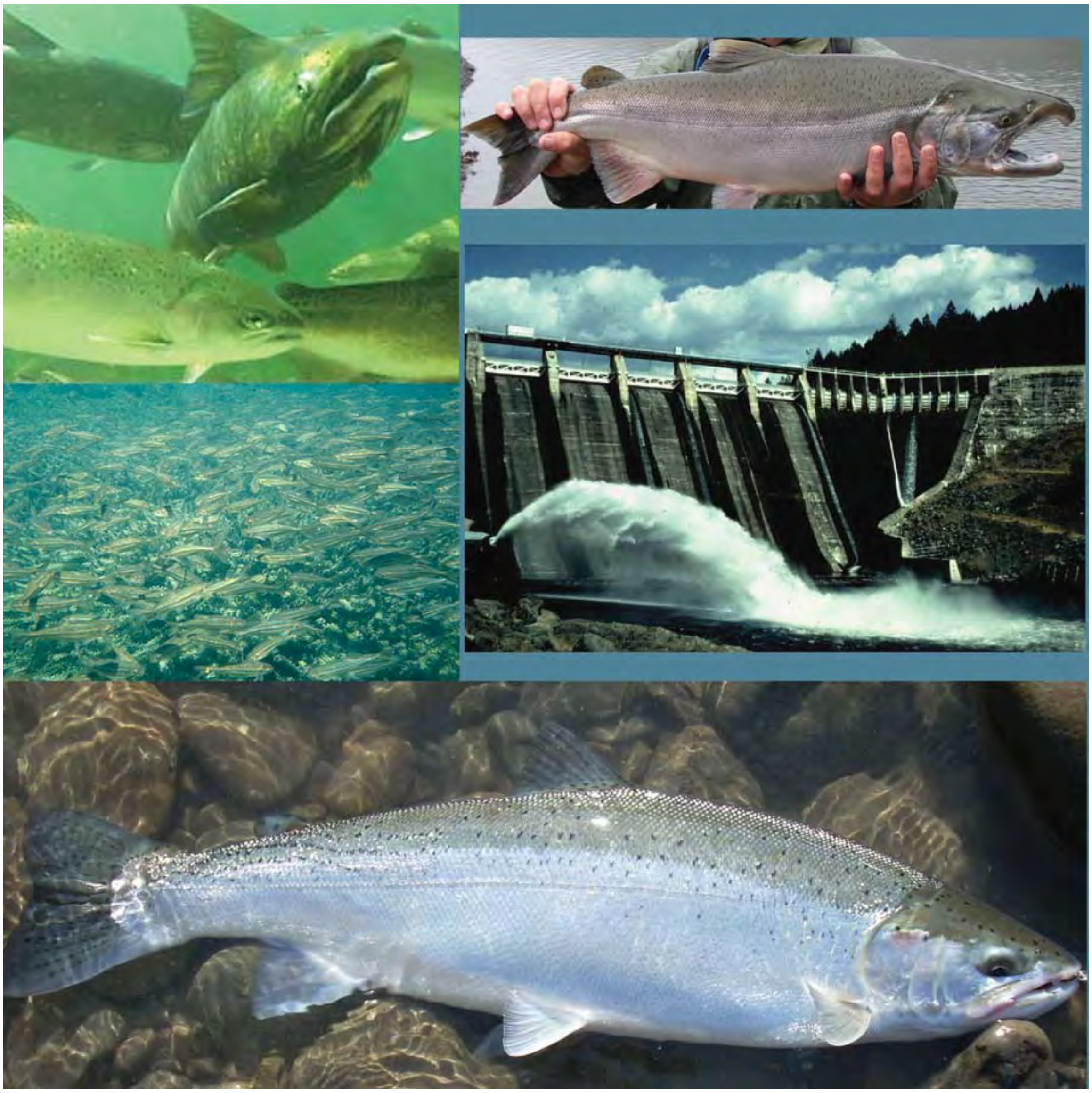


Figure 6. Comparison of dry reaches in San Clemente Creek between 2008 and 1990 showing more extensive dry reaches in 2008 despite much higher rainfall. From Castorani and Smith 2008.

EEL RIVER FLOWS

Evaluation of the Effectiveness of Potter Valley Project National Marine Fisheries Service Reasonable and Prudent Alternative (RPA): Implications for the Survival and Recovery of Eel River Coho Salmon, Chinook Salmon, and Steelhead Trout



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Executive Summary

The migration of salmon and steelhead to the headwaters of the mainstem Eel River has been blocked since the construction of Scott Dam and the creation of Pillsbury Reservoir in 1922. The project impounds and diverts water from the upper Eel River into the East Branch Russian River and is licensed by the Federal Energy Regulatory Commission (FERC) as the Potter Valley Project (PVP). Project components include 1) Scott Dam, 2) Lake Pillsbury, 3) Cape Horn Dam, 4) Van Arsdale Reservoir and 5) the East Fork Russian tunnel and powerhouse. The effects of the PVP are acknowledged to have significant negative impacts on the entire mainstem Eel River downstream of Cape Horn Dam and the Russian River from the East Fork downstream to the ocean and on all native Pacific salmon species. Although power production is small (9.4 megawatts), large volumes of water (averaging 160,000 acre feet per year) have been transferred from the Eel to the Russian River basin and the timing of those transfers in fall and early winter are particularly problematic.

The original license ran from 1922 to 1972, but re-licensing did not occur until 1983 after a study was conducted for Pacific Gas and Electric (PG&E), which acquired the PVP during the initial license period. A ten-year study was required by Article 39 of the FERC license to assess the need for changes of structures and operations to protect and maintain anadromous salmonids in the Eel River. Steiner Environmental Consulting (SEC 1998) collected field data and analyzed effects of PVP on salmonids, but the more significant and useful contribution is from VTN (1982), and their *Potter Valley Project (FERC No. 77) Fisheries Study Final Report, Volume 1* is sited below as authoritative on issues related to flow needs of fall Chinook salmon (Oncorhynchus tshawytscha) and summer and winter steelhead trout (Oncorhynchus mykiss) and PVP operation.

In 1998, PG&E issued its report pursuant to Article 39 and recommended a new flow release schedule, which FERC treated as a license amendment request. With the listing of southern Oregon and northwestern California (SONCC) coho salmon (Oncorhynchus kisutch) in 1996, the National Marine Fisheries Service (NMFS) began consultation with FERC regarding the license amendment to insure compliance with Section 7 of the Endangered Species Act (ESA). Chinook salmon (Central Coast) and steelhead (North and Central Coast) were subsequently listed under ESA and are also affected by the PVP. Although NMFS temporarily signed on to a flow recommendation (PG&E 1999) for project operation, they later completed a Biological Opinion (BO) (NMFS 2002) that concluded that implementation of the proposal would jeopardize ESA-listed salmonids in the Eel River.

The reasonable and prudent alternative (“RPA”) issued by NMFS as part of the BO is to prevent violation of ESA. This white paper explores the question of whether actions required under the RPA are sufficient to: 1) prevent the extinction of Pacific salmon species endemic to the upper Eel River drainage and 2) foster the recovery of those species. The principal components of the NMFS RPA are 1) modification of flows to improve conditions for salmon and steelhead, 2) Pacific salmon population monitoring, 3) Sacramento pikeminnow (Ptychocheilus grandis) suppression and monitoring, and 4) study of summer water temperatures related to flows.

Although the NMFS’ BO (2002) asserts that the RPA will attain salmonid conservation objectives, the evidence is to the contrary. The flows required by the RPA are supposed to mimic unimpaired flows, but comparison with the nearby un-dammed Middle Fork Eel River basin show peaks below the PVP bearing no resemblance to that of the un-dammed basin. The Tomki-Upper Eel fall Chinook salmon population is hovering near critical levels (<500 adults) and is not likely to persist over the next several decades given continuing environmental problems associated with PVP operations. The flow regimes below Van Arsdale Dam constitute an acute stress to upper Eel River salmon and steelhead populations and the intent of the RPA to improve flow for fall Chinook spawning during critical fall periods is not being met nor will it be met by RPA required flows in the future.

Coho likely once thrived in Gravelly Valley, submerged by Pillsbury Reservoir since 1922, and there is a possibility they might recur if Scott Dam was removed. Steelhead are hearty and more tolerant of warm water than coho or Chinook salmon juveniles, but they are not as well adapted to mainstem spawning as Chinook salmon (Groot and Margolis 1991) and their population trends show cause for concern as well. All three at-risk Pacific salmon species would benefit from significant flow increases as recommended below, and their extinction forestalled somewhat. Real population recovery and perpetuation of Pacific salmon endemic to the upper Eel watershed, however, requires expeditious PVP removal.

While the RPA recommended increasing minimum flow requirement for migrating adult fall Chinook after December 1 from PG&E's proposed 35 cubic feet per second (cfs) to 100 cfs in some years, VTN (1982) showed 235 cfs was required for up stream migration above Outlet Creek, substantially higher flows than required under the RPA. Since hundreds of miles of habitat are blocked, the target flows for Chinook trapped within and below the project should be at least 200 cfs from Pillsbury dam, when tributaries are at baseflow levels (VTN 1982). These flow levels have rarely been met under the NMFS RPA. Very dry year minimum flows could be reduced to 35 cfs in December under the RPA, which would have a disastrous impact on fall Chinook migration ability and spawning success. There is also a large discrepancy between PG&E reported flows in some years and those indicated by the California Data Exchange Center (see Adaptive Management).

Annual PG&E (2004-2008) reports show that the non-native Sacramento pikeminnow problem is intractable and the RPA objective of suppression or control is infeasible. Large reservoirs on river systems confer a major competitive advantage to pikeminnow (Moyle et al. 1995) and Pillsbury Reservoir is thus a major source of the problem. Therefore, removal of Pillsbury and Van Arsdale Reservoirs would be an effective measure for controlling Sacramento pikeminnow. Short of PVP removal, higher spring and early summer flows would help downstream migrating Chinook and steelhead juveniles avoid predation. Ultimately, the ecological imbalance limits viability of salmonids because of the inexhaustible supply of competitive pikeminnow from Pillsbury Reservoir and the altered Eel River conditions below the PVP that so favor them.

NMFS (2002) acknowledges that water temperatures would be more suitable for salmonids for a longer period in spring with higher flows. VTN (1982) indicated that optimal flows for juvenile steelhead rearing and optimum thermal benefits are at 68-265 cfs, but this flow level is not required by the RPA and has not been achieved. VTN (1982) also demonstrated that Chinook and steelhead downstream migration could be stimulated by fluctuating flows and temperatures of Pillsbury flow releases from April through June, but this strategy has not been employed under the RPA.

A sounder solution to thermal problems, however, is to allow passage of salmon and steelhead upstream through the removal of Scott Dam and Pillsbury Reservoir. This would allow fish to find thermal refugia (U.S. EPA 2003) that are likely scattered throughout the upper Eel River headwaters. If freshwater habitat improvement, such as removal of the PVP, is not conducted during favorable ocean and wet on-land climatic conditions, then prospects for Pacific salmon recovery will be greatly diminished (Collison et al. 2003). Given our understanding of Pacific Decadal Oscillation (PDO) cycle (Hare et al. 1999), a switch from currently favorable to less favorable ocean and climate conditions is predicted to occur somewhere from 2015 to 2025. If decommissioning is just being considered in 2022 and it takes several years to carry out, there may be few viable Chinook salmon and steelhead gene resources remaining for rebuilding.

Status of Eel River Pacific Salmon Stocks

The PVP affects coho salmon, Chinook salmon and steelhead trout, and project impacts are recognized as extending downstream to the Pacific Ocean (NMFS 2002). NMFS (2008) has recognized that excess flows in the Russian River, which are exacerbated by flows diverted from the Eel River to the Russian River, are detrimental to historical flow regimes and native Pacific salmon species there, but discussion of Russian River stocks and PVP impacts is beyond the scope of this report.

Scott Dam that forms Pillsbury Reservoir has never provided fish passage and has blocked over 100 miles of spawning and rearing habitat since 1922 (Shapovalov 1938). Adult salmon and steelhead counts are available for Cape Horn Dam as a result of FERC license requirements, and Tomki Creek Chinook salmon counts have been added under the recent license amendment implementing the RPA. Annual salmon carcass surveys have been conducted by PG&E and reports are filed as part of the Annual Data Report on Reasonable and Prudent Measures (RPM) (PG&E 2004, 2005, 2006, 2007, 2008).

NMFS (2002, Good et al. 2005) has concerns about the natural variability of flow and its effect on migration and return of salmon and steelhead to the Van Arsdale Fish Station; consequently, they do not use the data to characterize trends under the assumption that fish may be successfully spawning in lower mainstem Eel River reaches. This report interprets data conservatively under the assumption that survival of egg to smolt is very low for mainstem spawners that do not reach Van Arsdale in dry years due to potential bedload movement, thermal problems and Sacramento pikeminnow predation. In summary, the case will be made that available data indicates that the PVP is posing a high risk of extinction to coho salmon and Chinook salmon and steelhead of the upper Eel River.

Coho Salmon

NMFS (1996) listed the Southern Oregon-Northern California Coastal (SONCC) coho salmon populations as threatened under the Endangered Species Act (ESA) and more recently affirmed that level of risk (Good et al., 2005). CDFG (2002) found coho salmon in need of protection under the California ESA and they were subsequently listed as Threatened in northern California in 2004. Brown and Moyle (1991) published an historical estimate of the Eel River coho salmon as 40,000 fish, but estimated runs as of 1991 at less than 1,000 fish. Higgins (2007) chronicled the decline and disappearance of coho salmon in the Van Duzen River basin and lower Eel River due to widespread clear cut logging and road building and resulting flood damage from the January 1997 storm.

Tributaries of the Van Duzen and lower Eel River were recovering from post WW II logging and harbored coho, but changed rapidly in response to sediment yield. For example, the stream bed of Bear Creek in the lower Eel River basin was buried 8-15 feet deep (Pacific Watershed Associates 1998). Ecological impacts to macroinvertebrates and elevation of water temperatures due to stream widening is well documented (Friedrichsen et al. 1998; Higgins 2007). Adult fish counts at the Van Arsdale Fish Station and Cape Horn Dam included 47 adult coho in 1946-47, but there has been no other occurrence before or since. Williams et al. (2006) estimated that there was approximately 54 km of high intrinsic potential (IP) coho salmon habitat above the convergence of Tomki Creek on the upper mainstem Eel River. Scott Dam blocks 99% of this habitat (Figure 1).

Williams et al. (2006) analysis of habitat potential is based on gradient and valley width. Much of the area in the mainstem Eel River that would have been optimal for coho is the river reach now submerged by Pillsbury Reservoir. They estimated that an average of 39 spawning coho per kilometer likely used the habitat, which equates to a spawning population in the upper Eel River without disturbance at 2100 adults annually. Other areas of optimal IP habitat for coho are in Tomki Creek, Outlet Creek, Mill Creek (MF Eel) and the upper South Fork Eel River, including Ten Mile Creek. Historic photos of Gravelly Valley (Figure 2) show a broad meandering stream course, a channel form known to accumulate substantial quantities of large wood (Sedell et al. 1988) and multiple braided channels suitable for spawning and rearing of Pacific salmon species. Williams et al. (2006) also point out that the geology underlying Pillsbury Reservoir is alluvium that would provide excellent spawning gravel substrate in the upper Eel River watershed. Such valley segments of rivers are also known as response reaches (Montgomery and Buffington 1993), and historically these had the highest Pacific salmon species diversity and productivity (Frissell et al. 1992). Shapovalov (1938) stated that Scott Dam "has cut off some of the best spawning grounds in the entire watershed (Gravelly Valley)".

Although coho have not been seen in the vicinity of Cape Horn Dam, they are known to at least sporadically persist in Outlet Creek (CDFG 2004). There is concern otherwise that the coho population in the Eel River above the South Fork is on the verge of extinction. Coho salmon are thought extinct in the Middle Fork and North Fork Eel River (Moyle et al. 2008), and no adult coho salmon have been found in Tomki Creek in recent surveys (PG&E 2004, 2005, 2006, 2007, 2008).

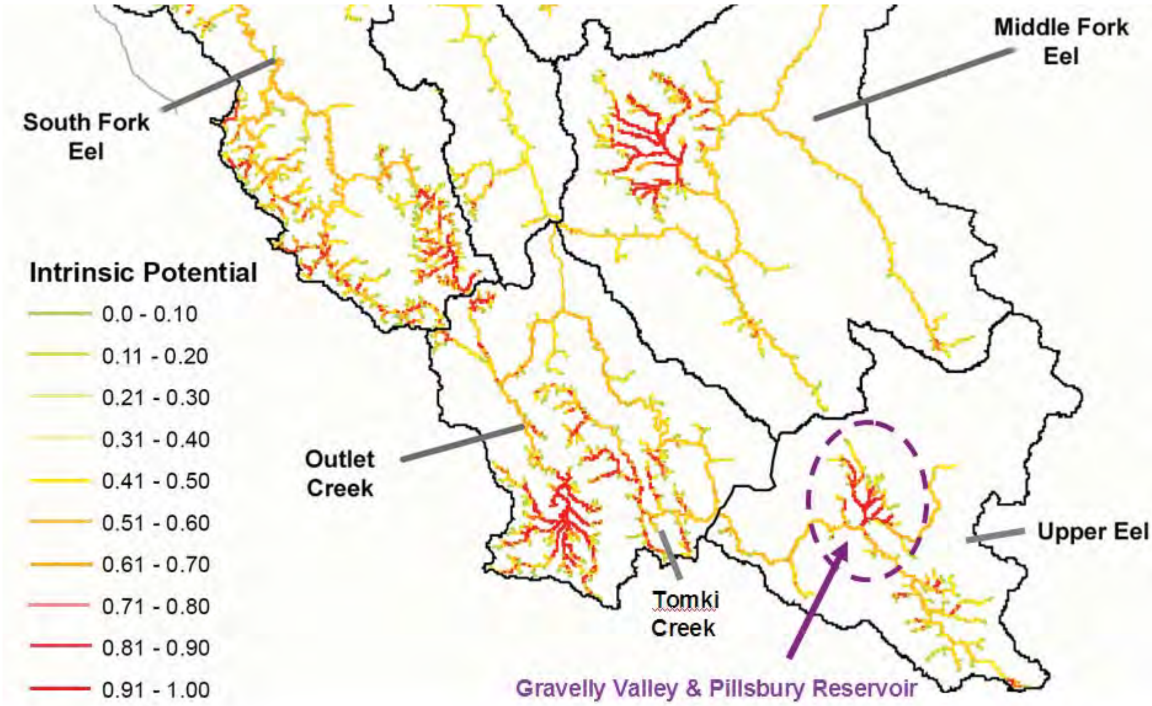

Figure 1. Williams et al. (2006) indicates highest intrinsic potential coho salmon habitat in red with a highlight on location of Gravelly Valley and Pillsbury Reservoir.

Figure 2. Historical photo of Gravelly Valley during the construction of Scott Dam. Trees from the flood plain have been logged in anticipation of reservoir filling. Photo from the Heald-Poage Museum in Ukiah, CA.

California Department of Fish and Game (CDFG 2009) adult salmon live fish and carcass counts point to a very spotty distribution of coho, and there are only a few dozen spawners in the creeks that retain them (Figure 3). Trends from surveys may not be representative of run strength in all years because of turbid conditions during surveys or high flows that make counts infeasible, but recent trends in overall returns (Figure 4) are not positive. Groot and Margolis (1991) note that most coho salmon return to spawn at three years of age, so if returns are very low in one year the pattern tends to recur 3 years later. Such a pattern of "weak year classes" is evident in the CDFG (2009) data and, because of this rigid life history, Eel River coho salmon may have trouble rebuilding weak brood years naturally, which elevates their extinction risk (Rieman et al. 1993). Coho salmon in the Eel River appear to be facing a similar challenge for survival as the Russian River population where NMFS (2008) has declared them to be in an "extinction vortex." This means that numbers are so low that finding mates is problematic and likelihood of extinction due to stochastic events is high.

Key questions for coho survival revolve around access to Outlet Creek and whether timely flows from Cape Horn Dam are sufficient to assist passage upstream for adults in fall and downstream migration of juveniles in spring. Flow levels recommended by VTN (1982) for adult Chinook salmon fall passage and improved downstream migrant survival of juvenile steelhead in spring would also assist coho salmon adults and juveniles. Removal of Scott Dam and Pillsbury Reservoir would open up historically optimal habitat, but the ability of native Eel River coho salmon to rebound and re-colonize is compromised because distribution and productivity of the population may have dropped too low (Rieman et al. 1993). If action to increase flows at crucial times below Cape Horn Dam for Chinook salmon and steelhead is delayed too long, these species may also fall below levels where recovery is possible.

Chinook Salmon

The California Coastal Chinook salmon ESU, which includes the Eel and Van Duzen River, was recognized as threatened under ESA in 1999 (NMFS, 1999) and this status was later confirmed in 2005 (Good et al. 2005). Historic basin-wide returns of Chinook salmon were estimated at 500,000 adults based on cannery pack records from the lower Eel River (Higgins 1991)(Figure 5). In fact it is likely that the Tomki Creek and upper Eel River populations form one metapopulation. The blockage of passage for spawners by man-made structures (Titus et al. 2006) or natural impediments caused by natural events like volcanic eruptions (Dale et al. 2005) can cause populations to disperse to adjacent areas with viable habitat that are still accessible. After Scott Dam was erected, Chinook salmon only had access to downstream mainstem reaches and tributaries such as Tomki Creek. Spring Chinook likely returned to the upper Eel River (Bjorkstedt et al. 2005, Spence et al. 2007) but there were insufficient deep, cold holding pools below Cape Horn Dam; as a result, spring Chinook populations were lost. The following discussion of population trends pertains only to fall Chinook.

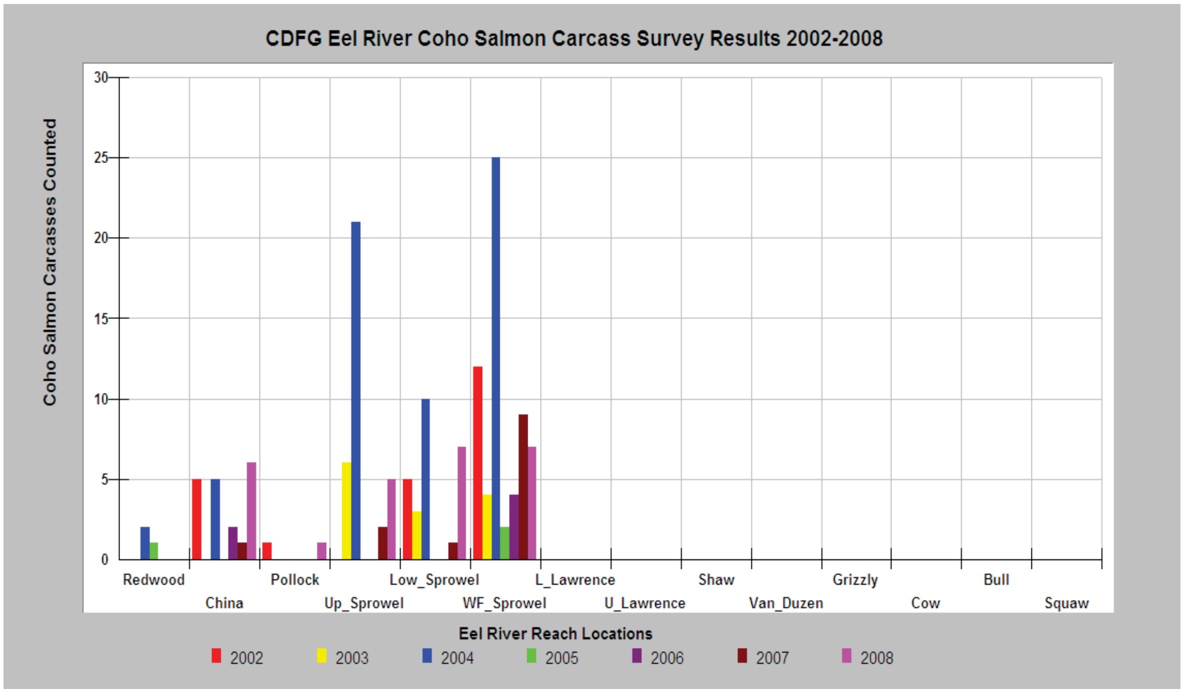

Figure 3. CDFG (2009) carcass survey results by tributary for coho salmon show them absent from more than half the 14 streams surveyed and that only a few dozen fish are counted even in high return years. Years convention reflect fall survey start but counts extend to following year (2002 = 2002-03).

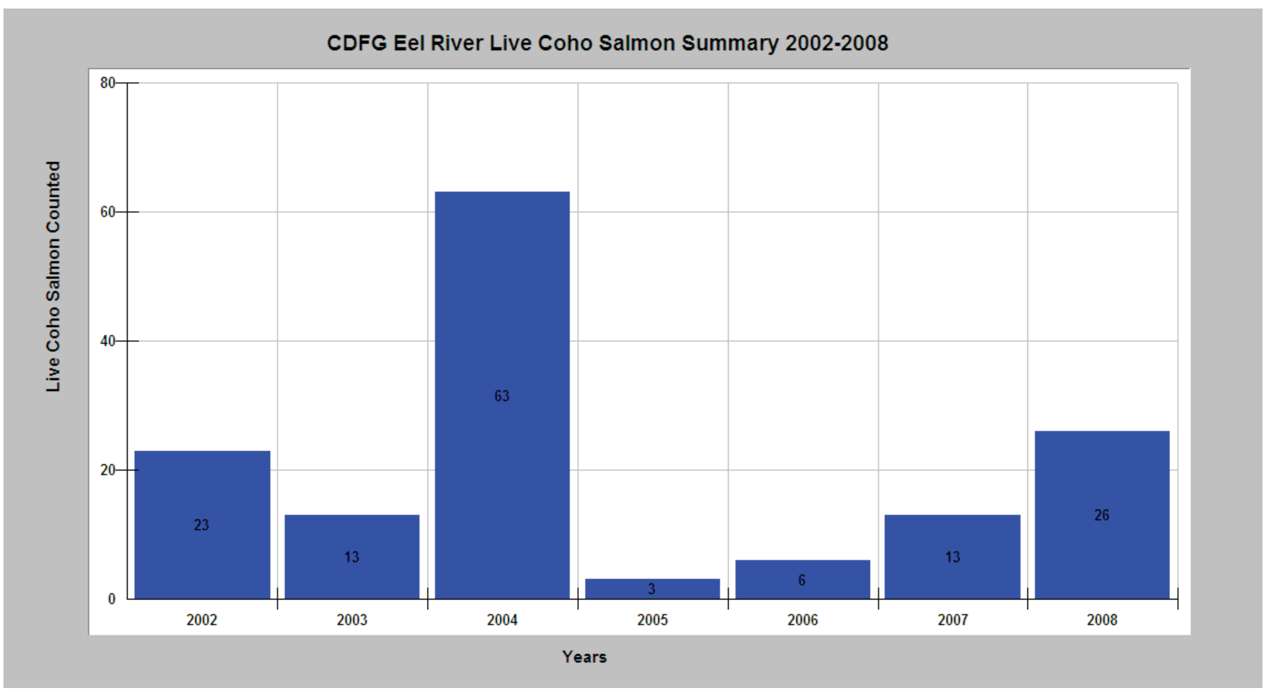

Figure 4. Cumulative live coho salmon counts from CDFG (2009) surveys of 14 creeks from 2002-2008 show very few coho salmon sited in any year. The 2001, 2004 and 2007 returns are recognized as a stronger year class for northern California coho salmon, but 2007 returns do not reflect this. However, flow conditions make survey variability high and there may be more coho in some years of high fall and winter rainfall, but turbidity or flow skews counts low.

Figure 5. Eel River Chinook salmon captured using a horse seine near Scotia in 1892 are indicative of the great abundance in the watershed prior to human alteration of habitat. Photo courtesy of the Humboldt Room Collection, HSU Library.

The U.S. Fish and Wildlife Service (UFWS 1960) counted 25,000 redds in 1958 in the Eel River basin, likely indicating 50,000 to 75,000 adult fall Chinook based on two to three fish per redd. This estimate is similar to the CDFG (1965) estimate of 76,000 Eel River fall Chinook prior to the 1964 flood. USFWS (1960) surveys covered the upper Eel River and Tomki Creek (Figure 6) and they found 3,500 redds, which would indicate 7,000-10,500 spawners. More recent trends noted by Spence et al. (2007) give an indication of the precipitous drop in Eel River sub-populations, including Tomki Creek. They point out that Tomki Creek Chinook salmon returns have varied from 0 to 2,187 since the late 1970s, but the mean is only 244, and over the last 12 years the average number of spawners declined to 144. Although Sprowel Creek is one of the highest producing index streams for fall Chinook salmon in the Eel River basin (Figure 7), it has seen a similar decline to Tomki Creek. In the 4.5 miles of Sprowel Creel surveyed, spawner counts have varied from 3 to 3,666, with a mean of 741, but again the most recent 12 years averaged only 68 spawners (Spence et al. 2007). This order of magnitude drop indicates an Eel River stock collapse. Further, recent live fish and carcass surveys by the California Department of Fish and Game (2009) show very low fall Chinook totals (Figure 8).

Van Arsdale Fisheries Station (VAFS) and Tomki Creek spawner counts (PG&E 2008) are a source of concern. PG&E carcass surveys (2005, 2007, 2008) find so few fall Chinook spawning in the mainstem in the mile reach below Tomki Creek that no population estimate could be generated, indicating that most upper Eel River fall Chinook are passing VAFS and spawning in the reach above. In aggregate the VAFS-Tomki population did not exceed 500 fish (Figure 9), a recognized floor for maintaining long term genetic diversity (Gilpin and Soule 1991), from 1990 through 2000 and in 2002. The total population estimate again in

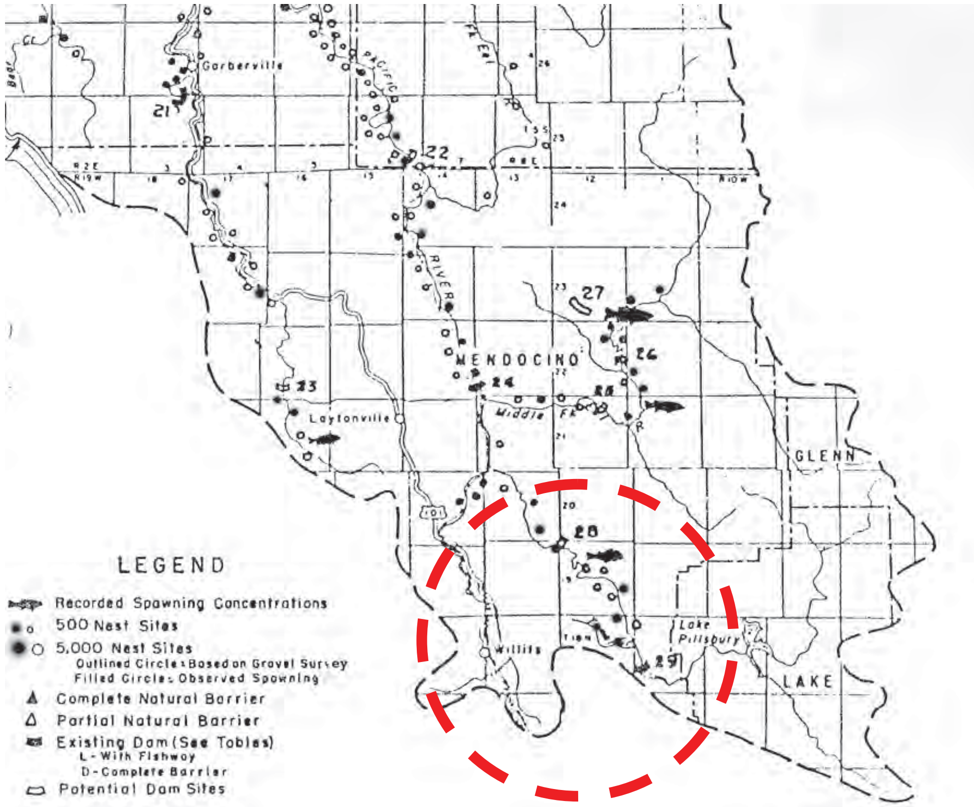

Figure 6. USFWS (1960) Chinook salmon redd map indicates 5,000 redds in the upper Eel River including Tomki and Outlet Creeks, which equates to greater than 10,000 fish in 1958.

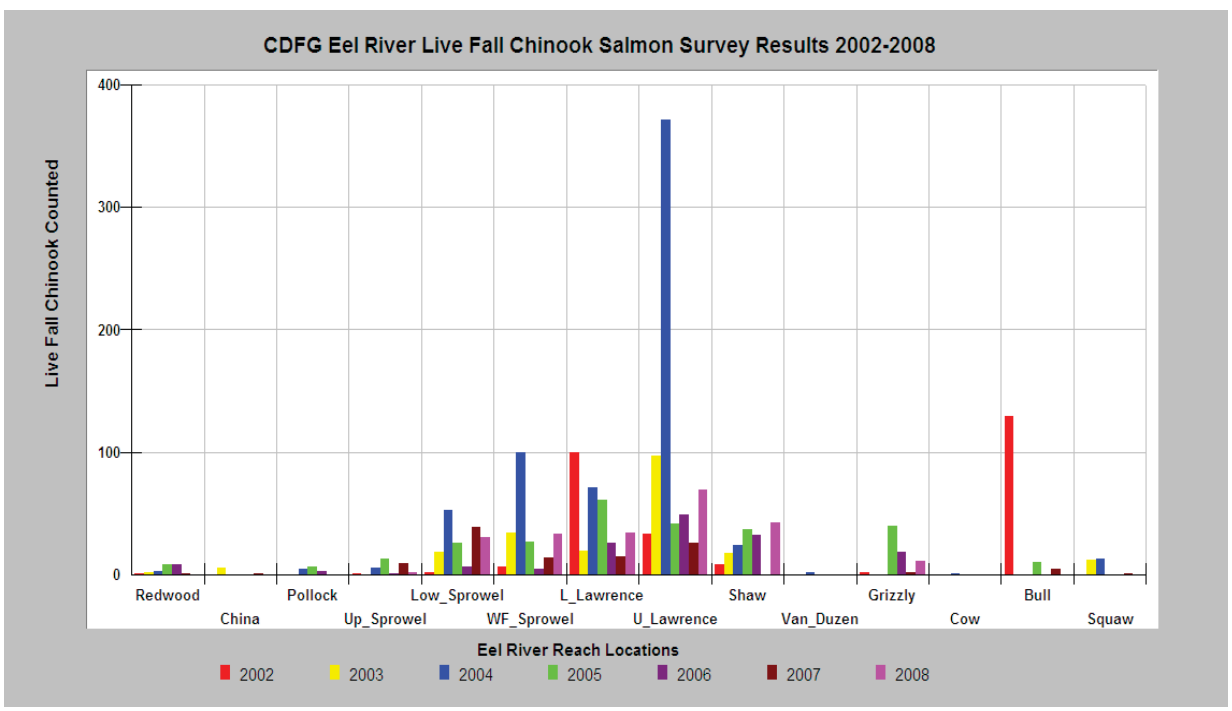

Figure 7. Eel River survey fall Chinook live fish counts by stream from 2002-2008 by CDFG (2009). Results show very low returns in most sub-basins.

2005 and 2007 hovered near this level after RPA measures had been instituted. More troubling is the almost complete failure of natural production in Tomki Creek, which is likely owing to a loss of flow further discussed below. Another concern is that Van Arsdale counts may be inflated by hatchery supplementation (PG&E 2008) that is poorly documented (see below).

> "It is clear that the majority of returns to the upper mainstem Eel River watershed since 1995/96 have been counted at Cape Horn Dam. The preference for returns to Cape Horn Dam may be partially explained by significant numbers of hatchery fish that have been released since December 1995 and have contributed to escapements in most of the following years. These fish have all been imprinted and released from Van Arsdale Fisheries Station, with the exception of limited releases in fall 1995 and fall 1996 from String Creek in the Tomki Creek drainage. However, the persistence of the trend favoring high returns to Van Arsdale in recent years when hatchery supplementation was not conducted suggests other factors may be at work. None of the 478 Chinook recorded at Van Arsdale were of hatchery origin in 2007/08" (PG&E 2008).

Hatchery fish brood handling practices may compromise the genetic integrity and fitness of wild fish (Simon et al. 1986, Simon 1988) and Upper Eel River fall Chinook may be experiencing such negative impacts.

Salmon fishing restrictions brought on by the Pacific Fisheries Management Council (PFMC) circa 1984 caused a large increase in returns to rivers of northern California from 1985-1988 (Kier Associates 1991) and this cessation of fishing is likely linked to the high number of fall Chinook salmon in Tomki Creek at that time (Figure 8). Chinook salmon returns should be showing a similar resurgence now due to complete ocean closures precipitated by the Central Valley fall Chinook stock collapse (Lindley et al. 2008), however, this rebound is not apparent in either the Tomki/Van Arsdale returns or in basin wide live fish and carcass counts by CDFG (2009). Lichatowich and McIntyre (1987) found that depressed stocks returning to poor habitat are vulnerable to accelerated extirpation in mixed stock ocean fisheries and certainly this would apply to Eel River basin fall Chinook stocks, if ocean salmon fisheries are reinitiated.

The upper Eel/Tomki Creek fall Chinook metapopulation is likely limited in its recovery potential by Sacramento pikeminnow, but declining flows and habitat trends in Tomki Creek may also be a factor (Higgins 2003)(see Cumulative Effects). Risk factors described by Rieman et al. 1993 may be impacting fall Chinook, which have not improved under the RPA and instead appear headed for extinction. This trend will likely continue unless flows are increased to levels recommended by VTN (1982) and, ultimately, fish passage upstream of Scott Dam remedied. Moyle et al. (2008) made this categorical statement regarding the upper Eel River Chinook population recovery: "Until water transfers out of the Eel River basin are reduced to provide necessary spring and fall flows for juvenile and adult Chinook, recovery of these multiple populations is unlikely."

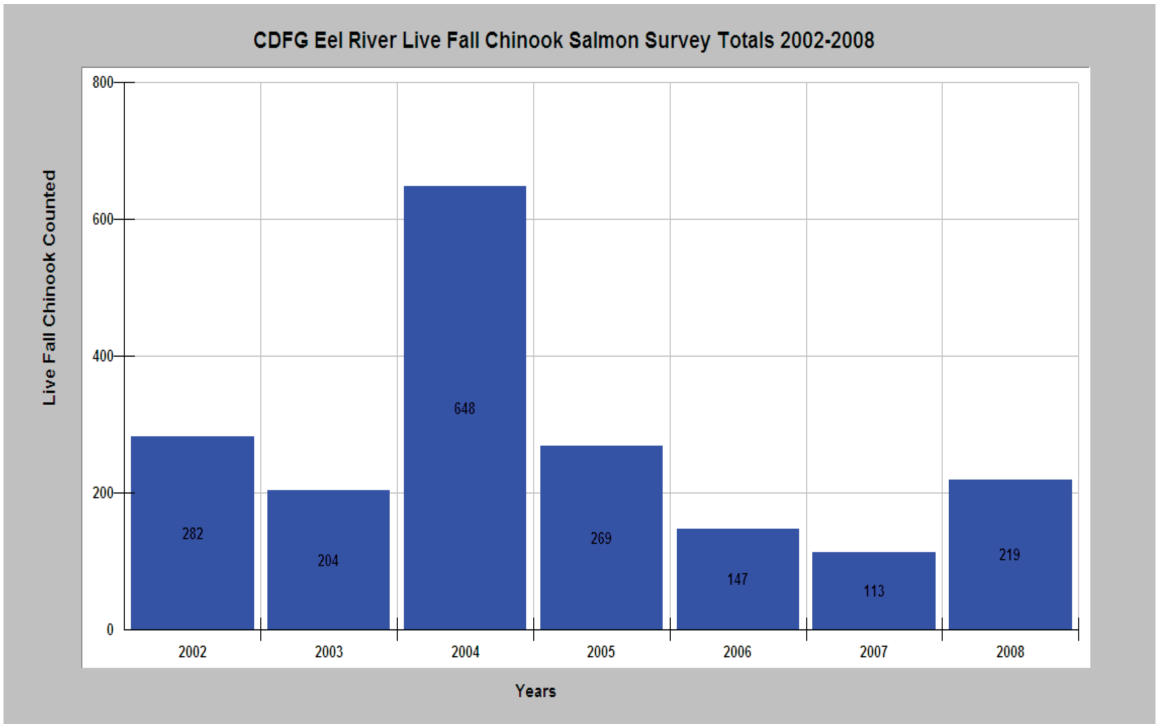

Figure 8. Basinwide index stream fall Chinook live fish count survey totals from CDFG (2009).

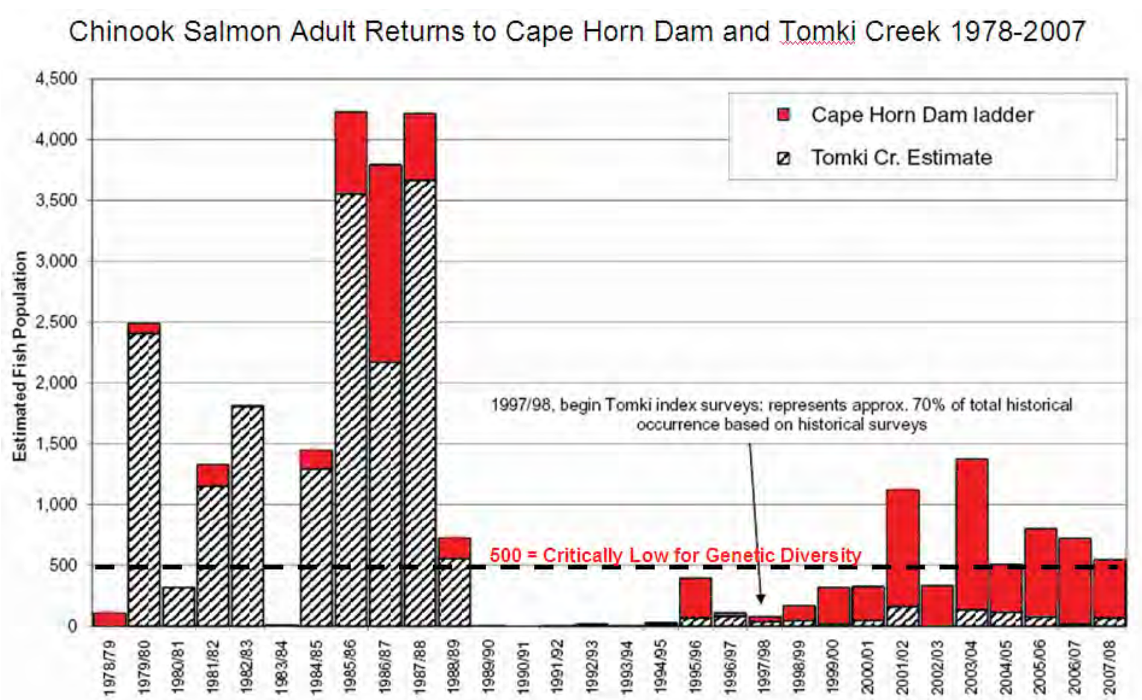

Figure 9. PG&E (2008) Tomki Creek spawner estimates and Cape Horn Dam returns indicate a substantial decline from the 1980s and an almost complete failure of Tomki Creek production.

Steelhead Trout

Steelhead were listed as Threatened in the North Coast California ESU by the National Marine Fisheries Service (2000) and listing was upheld and reconfirmed in 2006 (NMFS, 2006). Most trend data below focus on winter steelhead, but the upper Eel River watershed likely had summer steelhead (Bjorkstedt et al. 2005, VTN 1982) and so a brief discussion of that species is also warranted. Although they are not subject to discussions in the BO and RPA, the upper Eel summer steelhead population is potentially recoverable, if the PVP is decommissioned, due to likely colonization by fish from the adjacent Middle Fork Eel River.

Summer steelhead are recognized as an at-risk species state-wide (Moyle et al. 1995) with the Middle Fork Eel having one of the last three viable populations (Moyle et al. 2008). VTN (1982) reported the occurrence of summer steelhead at Van Arsdale Fisheries Station in 1982: "Three steelhead, one female and two males, arrived at Cape Horn Dam in the first three days of June in 1982. The fish were very bright and firm, indicating a short residence and migration time from the ocean to Cape Horn Dam and appeared to be summer run steelhead (Weldon Jones, CDFG, personal communication)."

Moyle et al. (2008) reported Middle Fork Eel summer steelhead (Figure 10) trends from 1966 to 2005, with overall average of 796 (Figure 11). However, if one examines the trends before and after the introduction and spread of the Sacramento pikeminnow (Brown and Moyle 1997), the average is 900 adults from 1966-1990 but only 561 after 1990 (see Pikeminnow Control). Moyle et al. (2008) noted potential significant impacts to Middle Fork Eel summer steelhead from the PVP: "Increased spring withdrawals from the Upper Eel River at Scott Dam likely reduces the time available for migrating juvenile and adult summer steelhead to move through the mainstem river."

NMFS (2002) provided average returns of winter steelhead to the VAFS by decade for the period of the 1930s to the 1980s demonstrating a substantial long-term decline (Figure 12). A more recent indication of the status of this steelhead population's can be found in the following passage from the 2005 Sacramento pikeminnow report (PG&E 2005):

> "Prior to 1986, summer rearing populations in this 12-mile section were sufficient to maintain wild adult steelhead returns in excess of 1,000 fish in many years, By the 1988/89 season (when juveniles from the 1986 brood year would begin returning as adults), wild steelhead returns to Van Arsdale Fisheries Station had dropped to 138 fish. Since that time, wild steelhead returns have ranged from 19 to 355 fish."

The Upper Eel River TMDL (U.S. EPA 2004) provided a chart of long-term annual winter steelhead population returns to the Van Arsdale Fisheries Station (Figure 13) and it is modified to show a critical minimum reference of 500 fish based on Gilpin and Soule (1991). Low flows and Sacramento pikeminnow predation are likely suppressing wild upper Eel River winter steelhead populations. As with fall Chinook returning to VAFS, it is difficult to discern hatchery effects on winter steelhead population trends because there is a significant undocumented history of supplementation. Figure 14 is taken from PG&E (2008) and indicates that a large percentage of steelhead returning to the VAFS were of hatchery origin. (See Hatchery Supplementation and Potential Genetic Effects).

Figure 10. Middle Fork Eel River summer steelhead in pool above the Eel River Guard Station in July 1988. Photo by Mike Ward.

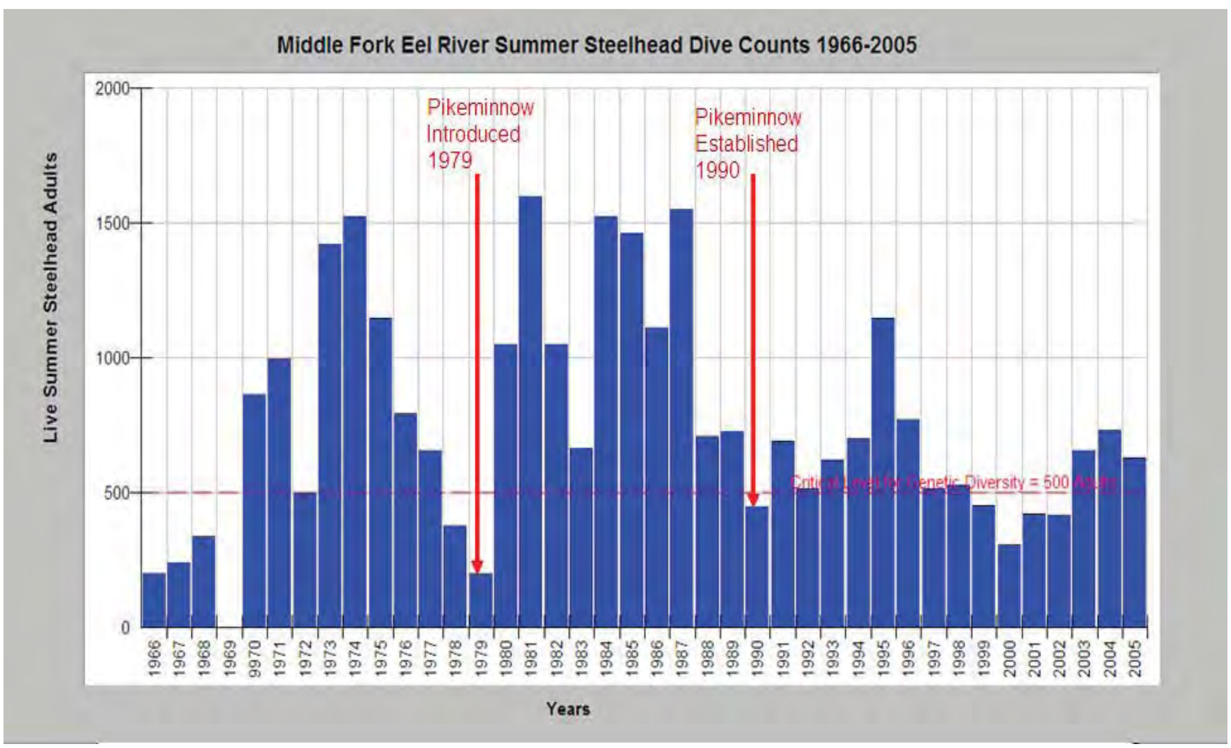

Figure 11. Middle Fork Eel River summer steelhead population from dive counts from 1966 to 2005 with critically low population level of 500 from Gilpin and Soule (1991) indicating that runs often below this critical minimum. Data from Moyle et al. (2008) and pikeminnow highlights from Brown and Moyle (1997).

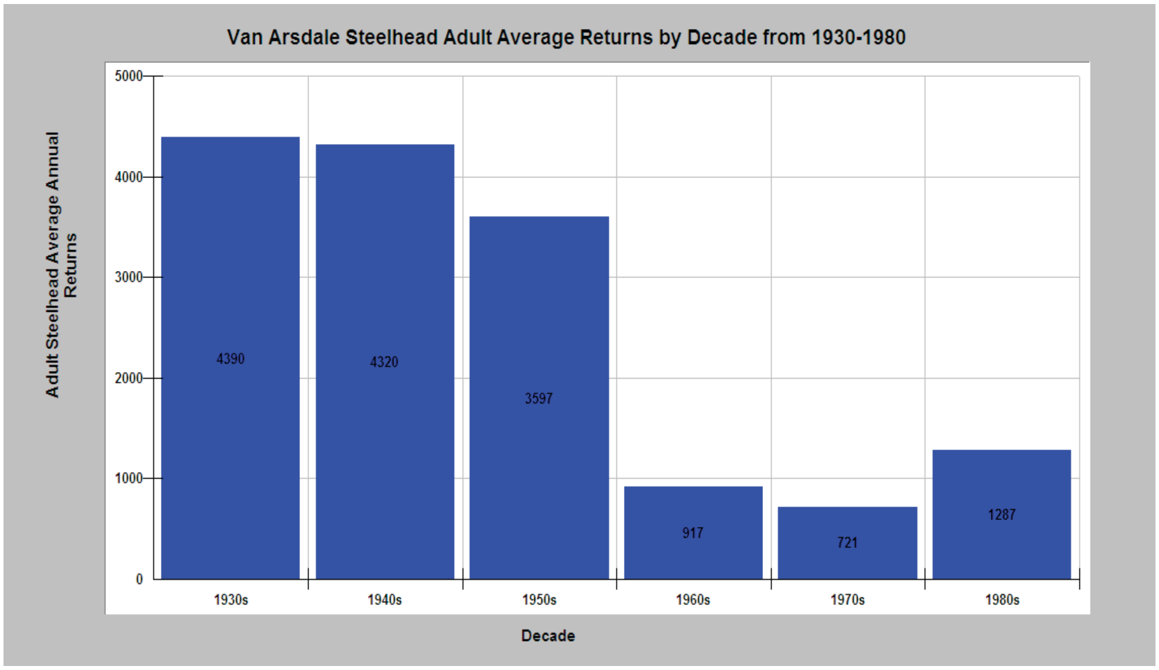

Figure 12. Decadal average of annual steelhead returns to the Van Arsdale Fisheries Station from NMFS (2002).

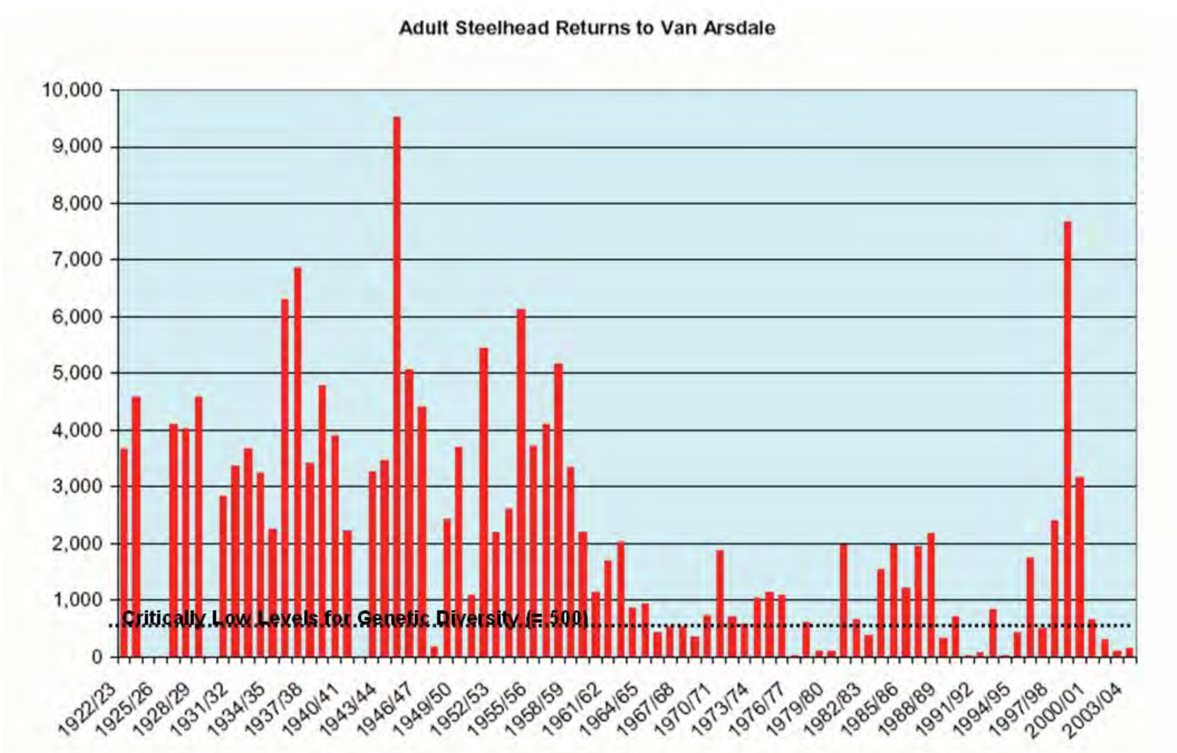

Figure 13. Annual steelhead returns to the Van Arsdale Fisheries Station from 1922 to 2004 from U.S. EPA (2004).

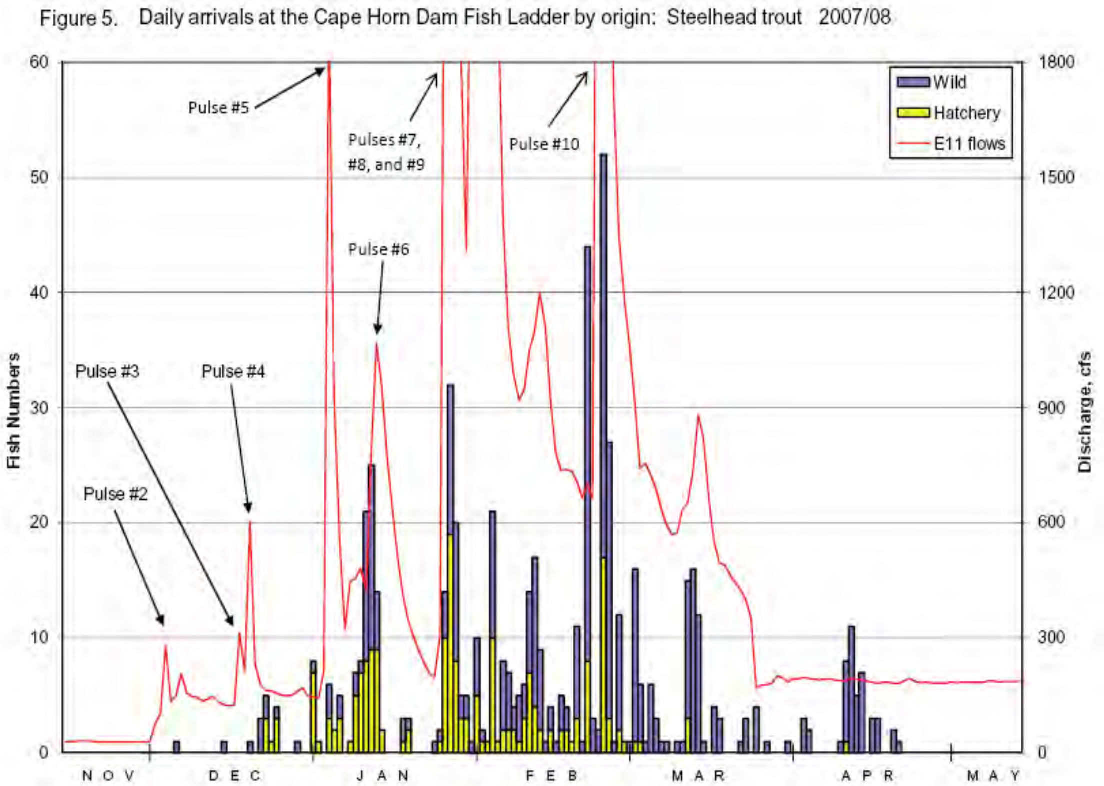

Figure 14. PG&E (2008) published this chart which is copied here to show that a significant number of hatchery fish comprised the 2007 Van Arsdale Fisheries Station adult steelhead returns.

Populations like the summer steelhead in the adjacent Middle Fork are at high risk because of their isolation (Moyle et al. 2008) and potential for stochastic events (Rieman et al. 1993). Winter steelhead returns to VAFS are mostly low and highly unstable and with approximately 500 adults or less in 17 of 30 years between 1977 and 2007, which is below critical genetic minimums (Gilpin and Soule 1991). This pattern indicates winter steelhead are also at high risk of loss (Rieman et al. 1993), even with ongoing artificial culture to maintain population levels. In addition to pikeminnow problems and flows as noted above, steelhead are not as well adapted to mainstem spawning as Chinook salmon due to substrate size (Groot and Margolis 1991) so loss of viability for Pacific salmon in Tomki Creek may have an even greater impact on steelhead locally than on Chinook salmon. Although winter steelhead might respond positively to flow levels as recommended by VTN (1982), Dam removal is what is really needed so that summer and winter steelhead could re-expand into the headwaters of the upper Eel, where excellent habitat exists today (MNF 1995). This would greatly lessen the probability of losing summer steelhead because the Upper Eel would join the Middle Fork as a population center, with less risk of loss due to stochastic events (flood or drought conditions). Rieman et al. 1993 document the dynamics effecting risk of extinction that support this hypothesis.

Analysis of PVP Flows and Pacific Salmon Recovery Prospects

VTN (1982) defined fall flow needs for fall Chinook salmon migration and spawning and also spring and early summer flows needed for successful rearing and downstream migration of salmon and steelhead juveniles. Their report is based on a combination of locally collected field data and results generated by widely accepted models. Their recommendations have the soundest scientific footing of any available regarding PVP operation and salmonids of the upper Eel River. Their findings include the following:

> "Peak flows above Outlet Creek of at least 235 cfs occurred before Chinook arrived at Cape Horn Dam with 60% arriving after peak flows of 900 cfs or more above Outlet Creek. These data suggest releases at Cape Horn Dam that result in flows of at least 235 cfs above Outlet Creek to stimulate migration. Peak releases of at least 135 cfs below Cape Horn Dam should be adequate for Chinook migration during periods of normal storm activity when tributary inflow is 100cfs or greater. In the absence of natural storm activity, artificial peak releases of 205 cfs below Cape Horn Dam would be necessary assuming tributary inflow of at least 30 cfs.
>
> The timing of peak flows also appears more critical to Chinook salmon than steelhead because of the shorter duration of Chinook runs; Chinook counts at Cape Horn Dam are smaller in years where peak flows did not occur until December.
>
> A flow release of 175 to 250 cfs is the optimum range (>90% of peak total) for Chinook salmon spawning considering total available habitat area (AHA) in the Eel River from Cape Horn to Outlet Creek. …..A flow release of 175-300 cfs is the optimum range for Reach Type I (Emandal and Big Bend sub-reaches), where the majority of AHA occurs….Considering both reaches, an optimum flow release appears to be in the range of 175 to 200 cfs.
>
> An evaluation of summer rearing habitat for steelhead trout, modified for existing temperature suitability, indicates the most important rearing area exists between Scott and Cape Horn Dams. Summer rearing habitat in this section (>80% of optimum) at flows releases from 68-265 cfs…..Releases ranging from 76 to 166 cfs would be required to achieve suitable temperature conditions between Tomki Creek and Outlet Creek.
>
> It appears that manipulation of water releases from Scott Dam can affect the timing of emigration of Chinook salmon from the Eel River above Cape Horn Dam, and is an effective tool for improving timely emigration of salmon from the study area."

VTN (1982) found flow releases below Cape Horn Dam were insufficient in the majority of years to allow Chinook salmon passage upstream and that shallow flows over the riffle just above Outlet Creek stopped migration in many years.

NMFS (2002) recognized flow releases from the PVP as still insufficient and set forward the following objectives for flow under the RPA:

> "The RPA should provide Eel River salmonids with a quasi-natural hydrograph with sufficient flows for fall and winter migrations, spring emigrations, and in some years will provide improved summer rearing habitat in the mainstem below Cape Horn Dam. Project flows under the RPA will support salmonid recovery efforts by providing improved salmonid habitat conditions that will benefit multiple salmonid life stages. All three listed salmonids would be expected to benefit from better habitat conditions, especially Chinook salmon and steelhead."

Average daily flow releases at Cape Horn Dam and Pillsbury Reservoir elevation data were obtained from the California Data Exchange Center and are used to assess whether flows meet the foregoing criteria. Only 2007-2009 data were available for download; consequently, those years are the subject of discussion. Fall flows have been far below those needed for upstream passage of Chinook and to maintain coverage of redds (VTN 1982) and spring hydrographs remain non-normative and, therefore, not conducive to increasing steelhead populations. Major discrepancies between Cape Horn Flow data and pulse peak flows and durations reported by PG&E (2008) are discussed later in this white paper.

NMFS RPA Flow Criteria is Flawed

NMFS (2002) B.O. criteria for flow are in conflict with the VTN (1982) study values that were based on field measurements and well reasoned science. For example:

> "The RPA introduces a fixed minimum flow floor which is generally equal to 100 cfs from December 1 through May 15, with some exceptions. The 100 cfs floor corresponds to ensuring availability of about 80% of the maximum potential physical habitat conditions for spawning and incubation of steelhead and Chinook salmon."
>
> "Increasing the floor from 35 cfs to 100 cfs in December through May 15 will increase flows for Chinook salmon and steelhead migration in all but critically dry years and will provide out-migrating salmonids additional flow to migrate farther downstream in spring."

These recommended flow values are far below those cited from VTN (1982). VTN (1982) noted that Chinook salmon and steelhead trout arrived at Cape Horn Dam "from mid-November to early December, after one or two peak flows have occurred. It appears that peak flows are a necessary trigger to stimulate upstream movement." It is well established that Eel River fall Chinook historically entered the lower river beginning in August (Higgins 2007), but even today heavy runs can begin in October. Therefore, minimum flows requirements are needed starting at least on November 1. Waiting for December 1 to increase flows, therefore, leaves fall Chinook salmon stranded downstream in many years, lessening their survival and opportunities for successful reproduction. The 100 cfs flow is also inconsistent with BO (NMFS 2002) emphasis on the need to assist upper Eel River fall Chinook that have early run timing:

> "Early access to spawning areas is important to Chinook salmon productivity. Broods from fish that spawn earlier are more likely to hatch and emigrate before the onset of thermally adverse conditions."

VTN (1982) also estimated that optimal mainstem Eel River spawning for Chinook salmon was at flows from 175 to 200 cfs, but maximizing spawning in the most productive reaches (Type I) would require flows as high as 300 cfs. The NMFS (2002) BO notes that maintaining flows after redds are established is important to prevent desiccation of eggs. If maintaining and rebuilding Chinook populations within and below PVP were the main goal, minimum flows of 200 cfs after November 15 would be required, with a ramp up beginning by November 1. The 200 cfs flow for passage would then be maintained to February 15 in order to accommodate maximum spawning success and egg incubation. A major problem with defining flow release requirements for the PVP is the lack of gauges for inflow into Pillsbury Reservoir. Instead of requiring such gauges as a term of the RPA, NMFS (2002) put their request in voluntary "Conservation Recommendations":

> "DOI and NMFS have concluded that additional gages above Lake Pillsbury would be beneficial in developing an indexing equation for unimpaired flow calculation. This may be especially important for implementation of more natural pulse flows as part of the flow schedule."

It is the lack of this flow gauge data that necessitates the comparison of the upper Eel to the nearby Middle Fork to answer the question of whether flows are simulating natural ones that foster salmon and steelhead conservation and recovery.

Cape Horn Dam 2007-2009 Fall Releases, Reservoir Storage and Chinook Salmon Migration and Spawning

Flow releases at Cape Horn Dam show a pattern of neither meeting objectives for improved Chinook salmon passage nor for optimal spawning. Although flows may be meeting the letter of the RPA requirements, they clearly do not meet the intent of simulating natural flows with which upper Eel River fall Chinook salmon co-evolved. Furthermore, PVP flow patterns impede migration, increase adult stress, decrease fecundity and cause conditions that reduce egg and larvae (alevin) survival. U.S. Geologic Survey (USGS) Middle Fork Eel River flow records are used to represent a natural un-dammed hydrograph as opposed to the regulated flow below the PVP. When the mainstem Cape Horn Dam flows are compared to the Middle Fork Eel River hydrograph for the fall periods of recent years, the peaks evident in the Middle Fork are wholly lacking in the upper mainstem Eel below the PVP.

The upper Eel River watershed above Scott Dam is 288 square miles which equates to about 38% of the area of the Middle Fork Eel River (753 sq. mi.). Although flows in the upper Eel may not be linearly related to the Middle Fork basin because of differences in area at higher elevations, a comparison on an area basin is useful (Table 1). For example in the fall and early winter of 2007-2008 base flows were below the PVP were at or around 35 cfs (Figure 15), which is well below passable for Chinook salmon (VTN 1982) throughout October and November with only a two day fluctuation around the seasons first rain on October 19. The October 20 flow of 1600 cfs on the Middle Fork (Figure 16) indicates that substantially greater releases were warranted below and within the PVP.

Table 1. Flow comparison between Cape Horn Dam Eel River gauge below PVP in fall 2007 and 2008 and Middle Fork Eel River gauge for same dates plus a column showing 38% of MF flows as a rough approximation of natural flow scaled by area.

Date	Middle Fork Flow	Cape Horn Flow	Scaled Flow Estimate (38%)
10/20/07	1300 cfs	75 cfs	494 cfs
12/4/07	2950 cfs	324 cfs	1121 cfs
12/14/07	3070 cfs	614 cfs	1166 cfs
01/02/08	1090 cfs	143 cfs	414 cfs
11/04/08	1220 cfs	161 cfs	463 cfs

The subsequent peak on November 28 of 104 cfs shows no corollary peak on the Middle Fork hydrograph and may have been a pulse flow, but it is still less than half of the VTN (1982) recognized 235 cfs needed for Chinook salmon distribution. Flows on December 4, 2007 of 324 cfs below Cape Horn represented only 11% of the Middle Fork peak of 2950 cfs, and December 14: were 614 cfs vs. 3070. The flow in the first few days of December were ramped down to approximately 50 cfs, which failed to meet the NMFS (2002) RPA flow level of 100 cfs, in prime Chinook salmon emigration and spawning time. Fall Chinook salmon returns to the Van Arsdale Fisheries Station (PG&E 2008) on November 16 despite baseflows of 35 cfs.

The small fluctuation in flow (104 cfs) on November 28 brought up four adults, but the bulk of the run came with the storm peaks of early December, when flows exceeded the VTN (1982) recommended passage levels of 235 cfs twice.

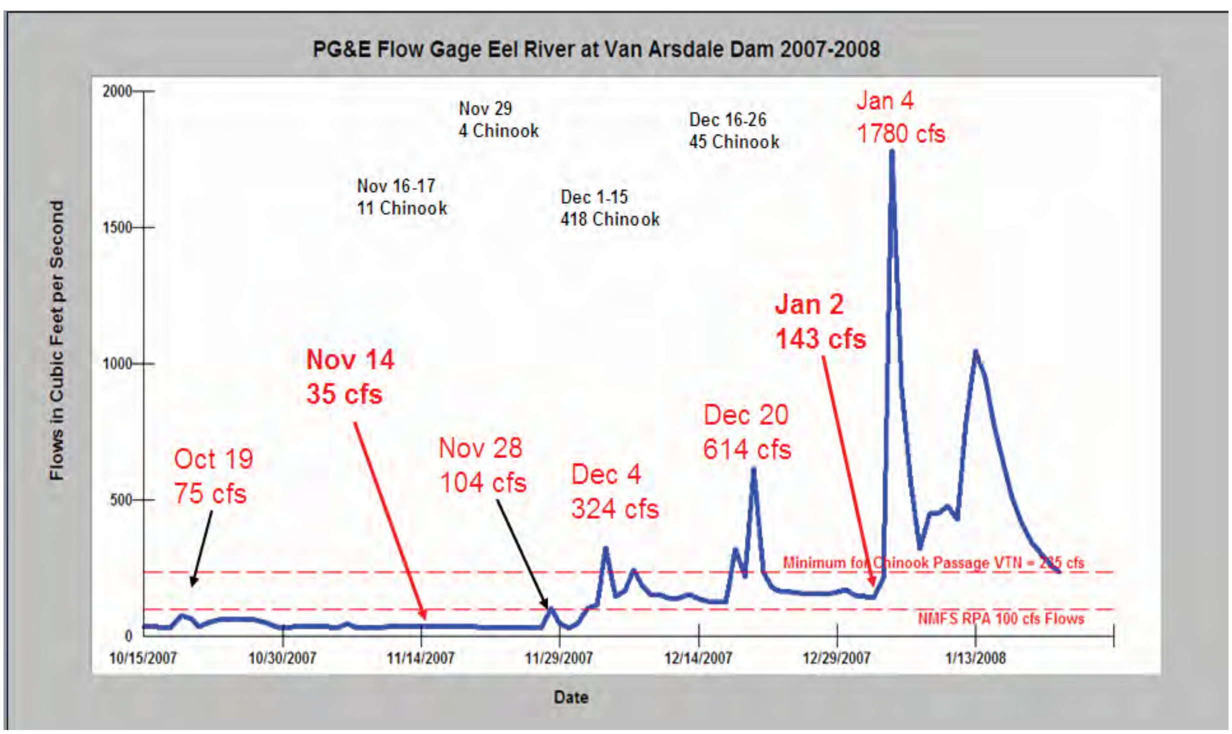

Figure 15. Flow at Cape Horn Dam for the period from October 15, 2007 to the end of January 2008 with flow peaks and levels labeled with bold indicating particularly damaging to fall Chinook migration and spawning. Data from CDEC and PG&E via the Internet.

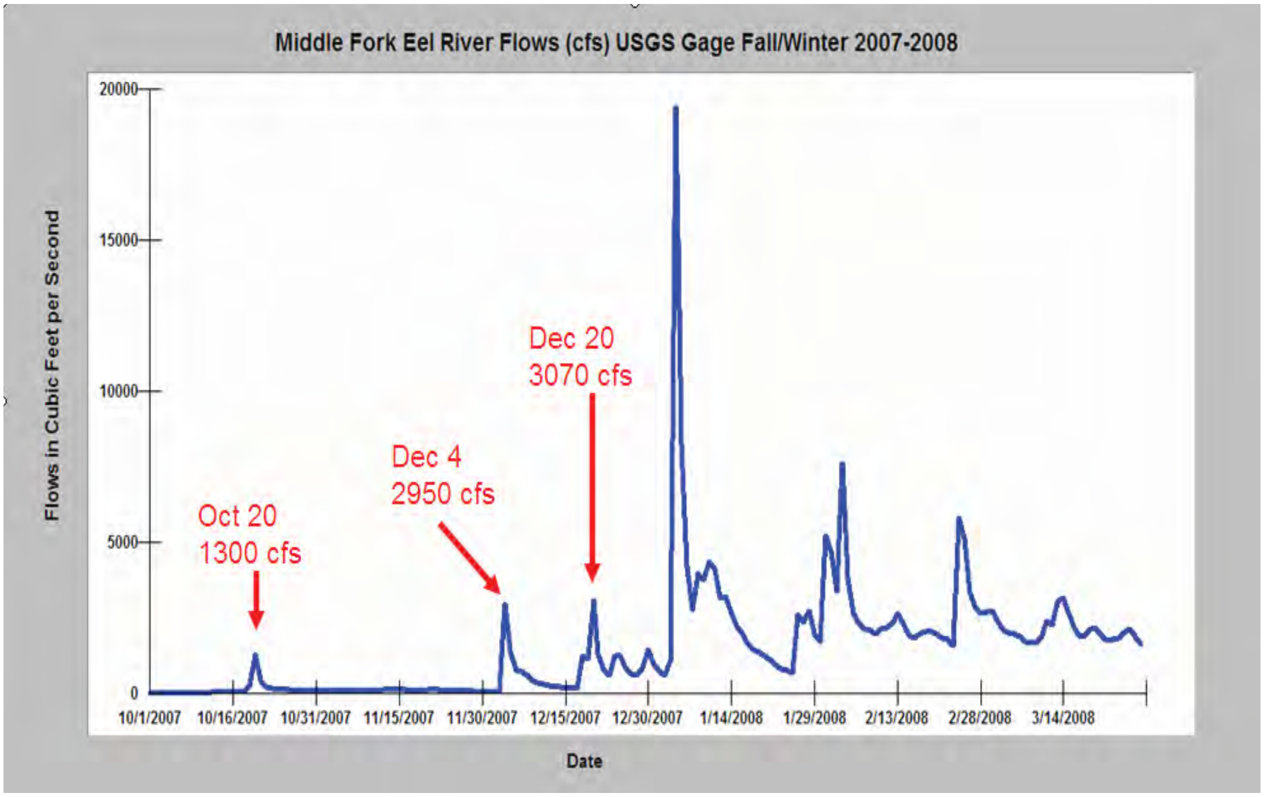

Figure 16. of the Middle Fork Eel River for the period from October 1, 2007 to the end of March 2008 with flow peaks labeled. Data from U.S. Geologic Survey via the Internet.

Unfortunately, flows after the peak spawning in late December and early January were reduced to 150 cfs or less after the flows had been up high enough for Chinook salmon to spawn in stream margins. If the PVP were being operated for maximizing Chinook salmon survival, flow reduction would not have dropped below the recommended optimum spawning flow level recognized by VTN (1982) of 175 to 200 cfs. This drop in flow may have dewatered redds. Reservoir levels of Pillsbury Lake during fall and winter of 2007-2008 shows that filling was occurring during critical times for Chinook salmon spawning when flow releases were needed for the fish (Figure 17).

Fall Chinook tuned to early spawning, which NMFS (2002) recognizes as in need of protection, are forced to spawn in the deepest part of the river channel or thalweg, as opposed to edges when flows of less than 100 cfs are released in November and early December. This makes the nest or redd more vulnerable to scour on subsequent high flows that often occur before the gestation period for eggs and larvae is complete and fry have emerged. Incubation in the upper mainstem Eel River below Scott and Cape Horn Dams would likely require 90 to 120 days before hatching, alevin gestation and emergence of fry, due to low water temperatures water temperatures (6-8°C) (PG&E 2009). Therefore, the 200 cfs for optimum spawning habitat should be maintained through at least the end of February. Also, salmon spawning areas would be very limited at flows such as the 35 cfs of experienced in November and December 2007 and super-imposition of redds may occur. This is where eggs laid prior are scoured from the gravel when later waves of fish spawn in the same area.

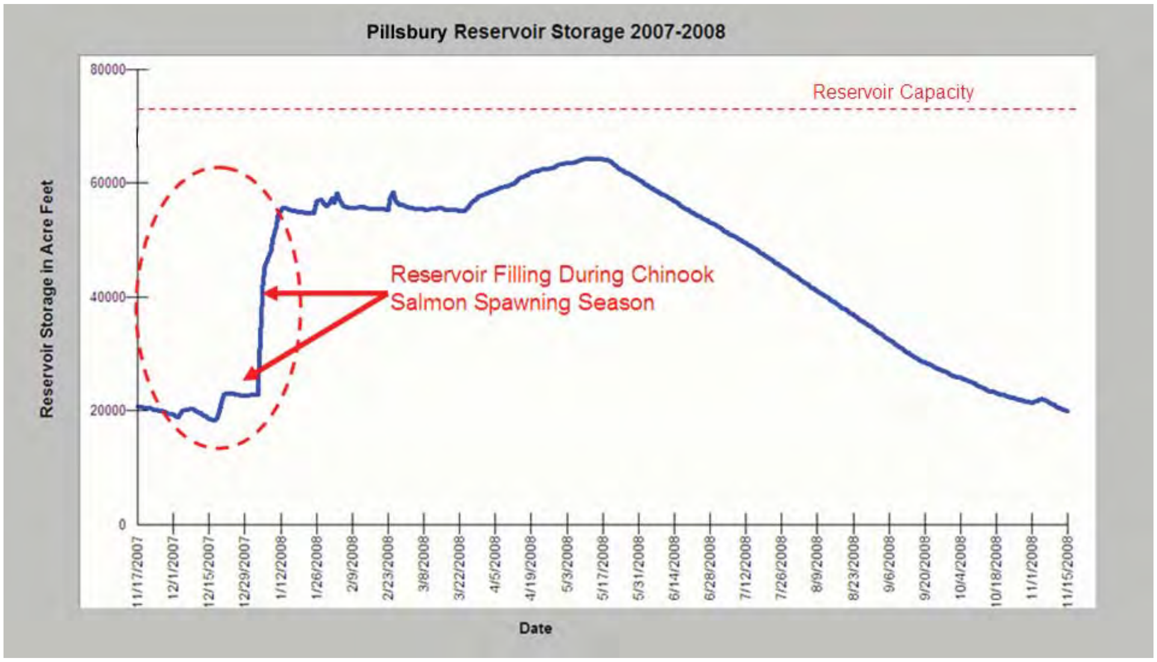

Figure 17. Pillsbury Reservoir levels for the period from November 1, 2007 to November 15, 2008. The level increased during the time of migration and spawning of fall Chinook salmon indicating that peak flows in tributaries went into storage. Data from CDEC and PG&E via the Internet.

Optimal passage and spawning flow for Chinook salmon of 175 or 200 cfs are more in the range of norm that should be released based on Middle Fork flow scaling and would allow Chinook to select habitats more in the margin of the stream and reduce risk of scour and likelihood of redd super imposition.

PG&E (2008) provided a chart of pulse flows at Cape Horn Dam with Chinook salmon returns (Figure 18) and it shows that attracting flows of 200 cfs caused a major migration upstream to Cape Horn Dam. Lower and upper optimal Chinook salmon spawning flows determined by VTN (1982) are overlaid on the chart and show that 175 cfs was only reached a few times until Pillsbury Reservoir was filled. Analysis of the 2008-2009 fall and early winter period shows even less favorable conditions for fall Chinook salmon as a result of non-normative flow releases at Cape Horn Dam (Figure 19). Flows in the Middle Fork Eel River (Figure 20) provide a comparison to a natural hydrograph from similar watershed and the difference with below PVP is clear. The slight increase in flow on October 16 to 48 cfs was not significant in terms of its ability to stimulate salmon migration, but the storm of November 4 had the potential to do so. Instead the flow from upper tributaries was captured in Pillsbury Reservoir (Figure 21).

PG&E (2008) published a chart of the rate of Pillsbury Reservoir filling contrasted to the NMFS (2002) BO model curve and there is a distinct departure from the curve at a time critical to Chinook salmon spawning and egg and alevin development (Figure 22). This difference is highlighted in orange and shows non-compliance with the intent of the RPA. If PG&E had opted to defer storage as suggested by language of the RPA, optimal flows for all reaches could have been attained, greatly increasing Chinook salmon production. Earlier flow releases would provide additional storage space in Pillsbury Reservoir possibly allowing diminished later peaks that otherwise cause red scour.

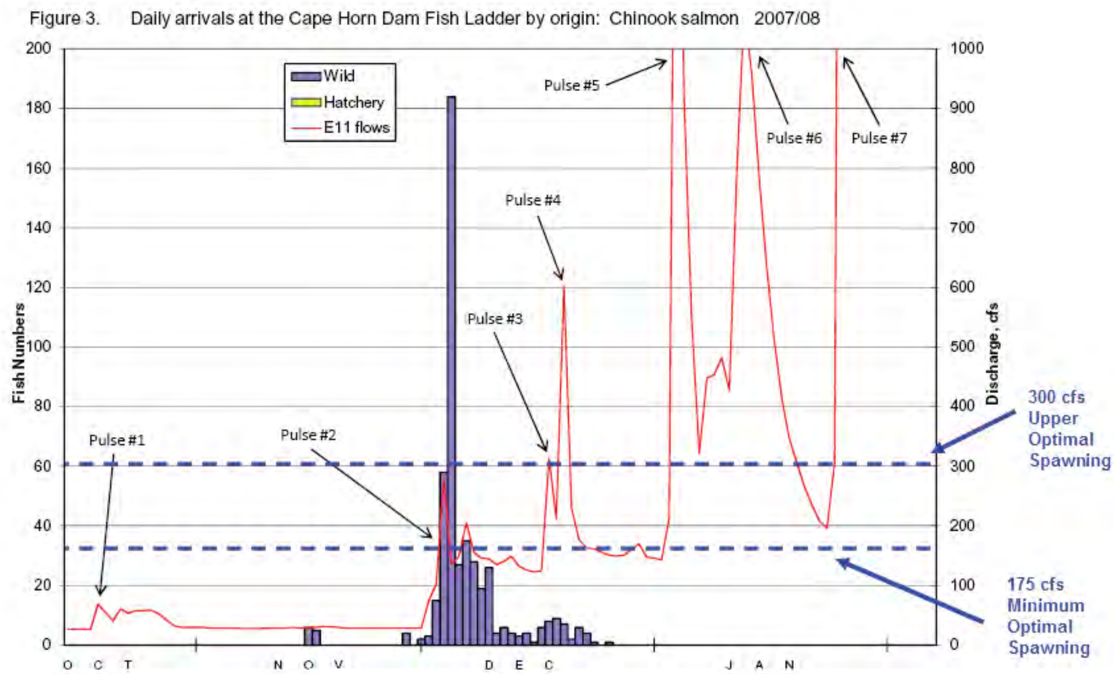

Figure 18. Flows at Cape Horn Dam with fall Chinook salmon returns to the Van Arsdale Fisheries Station from PG&E (2008). Note that VTN (1982) lower optimal (175 cfs) and upper optimal (300 cfs) are infrequently attained during peak migration and spawning season.

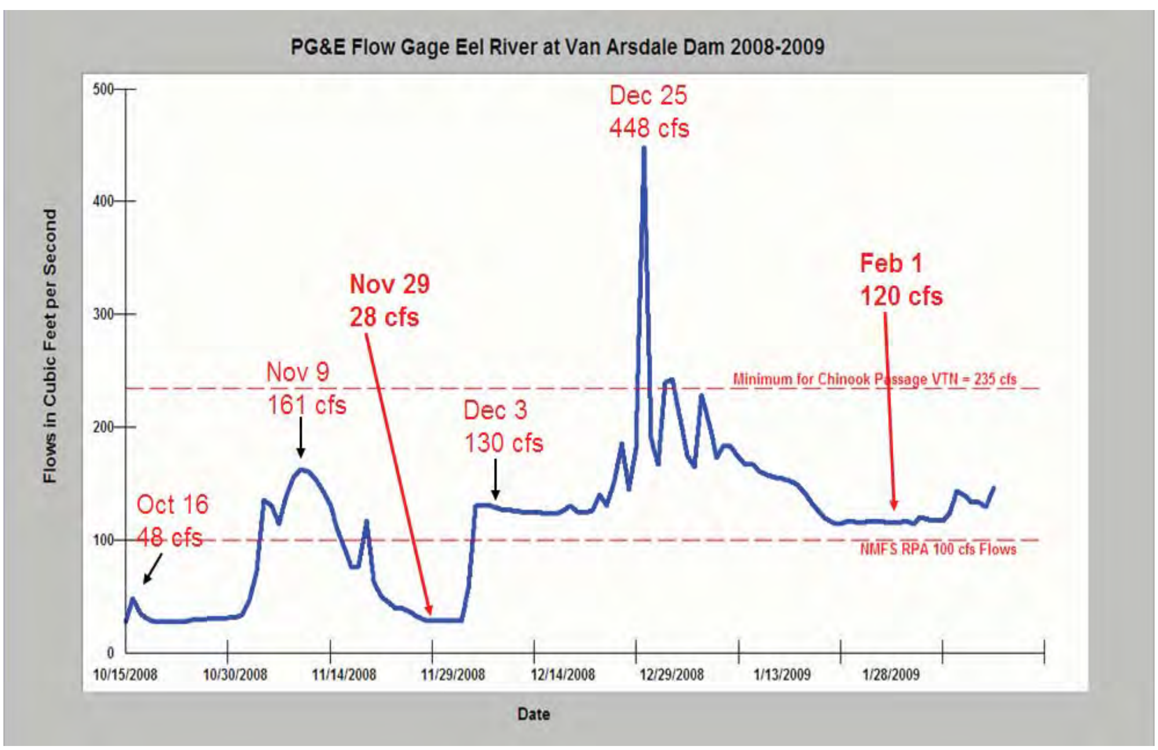

Figure 19. Flow at Cape Horn Dam for the period from October 15, 2008 to the end of January 2009 with flow peaks and levels labeled with bold indicating particularly damaging to fall Chinook migration and spawning. Data from CDEC and PG&E via the Internet.

The same problems with releases were manifest in fall and early winter 2008. Flows were ramped down to 28 cfs prior to being raised to 130 cfs on December 2, 2008. The pulse flow of early November would have triggered upstream movement of Chinook salmon and spawning in the several days of increased flow during that period. The subsequent decrease to 28 cfs would decrease the wetted width and very adversely affect any existing redds in stream margins. This action of de-watering a section of the streambed critical for salmon spawning success might also result in stranding of adult Chinook salmon that would be trying to spawn. Similarly, the drop in flow in February 2009 to 120 cfs had a potential to de-water redds. All flow peaks once again show major reductions in mainstem Eel River flows and differences in the shape of the hydrograph when compared with Middle Fork Eel River (Figure 20). The increases Pillsbury Reservoir levels (Figure 21) show how much water is stored during peak runoff times that is not being released for salmon.

The flow releases in 2009 at Cape Horn Dam are provisional data, but results with peak and baseflow levels labeled (Figure 22) show meager releases. Releases at Cape Horn Dam are less than 10 cfs for many days, which causes major thermal problems downstream. Once again flows during Chinook salmon migration and spawning periods were run well below VTN (1982) guidelines recognized as necessary for passage and spawning. However, this does not violate NMFS (2002) RPA flows because they don't apply until December 1. No data for reservoir inflow or Middle Fork Eel were available for the Chinook salmon run timing in fall 2009, but there was a large run in the lower Eel River as a result of ocean closures and the lack of flows did not help maximize survival and spawning success. All three years examined show that flows under NMFS RPA are not working to maximize production of fall Chinook salmon and have been incompatible with recovery.

Cape Horn Spring Flows 2007-2009 and Chinook and Steelhead Juvenile Survival

Once again, availability of flow release data for Cape Horn Dam is limited to the period from March 2007 to November 2009 and so only that period can be examined to determine whether spring flows under the NMFS RPA are benefiting juvenile Chinook salmon and steelhead and fostering their recovery. To understand spring flow patterns in a watershed like the upper Eel that has high elevation and significant snowfall, comparison with flows in the adjacent Middle Fork Eel River watershed is instructive. USGS flow data for the 1995 water year was chosen because it clearly shows snow melt peaks that are expected in watersheds like the Middle Fork and Upper Eel River that have significant area over 5,000 feet in elevation (Figure 23). These show up as peak flow events in April, May and June after rainfall events have subsided. These wide fluctuations in flow are followed by long descending hydrographs that often take over a month to reach baseflows (June 28, 200 cfs), a pattern with which Chinook salmon and steelhead co-evolved. Water from snowmelt would also have major benefit for salmonids because of its cooling influence. When examining flow releases in the Eel River at Cape Horn Dam from 2007-2009, however, very few similarities are evident.

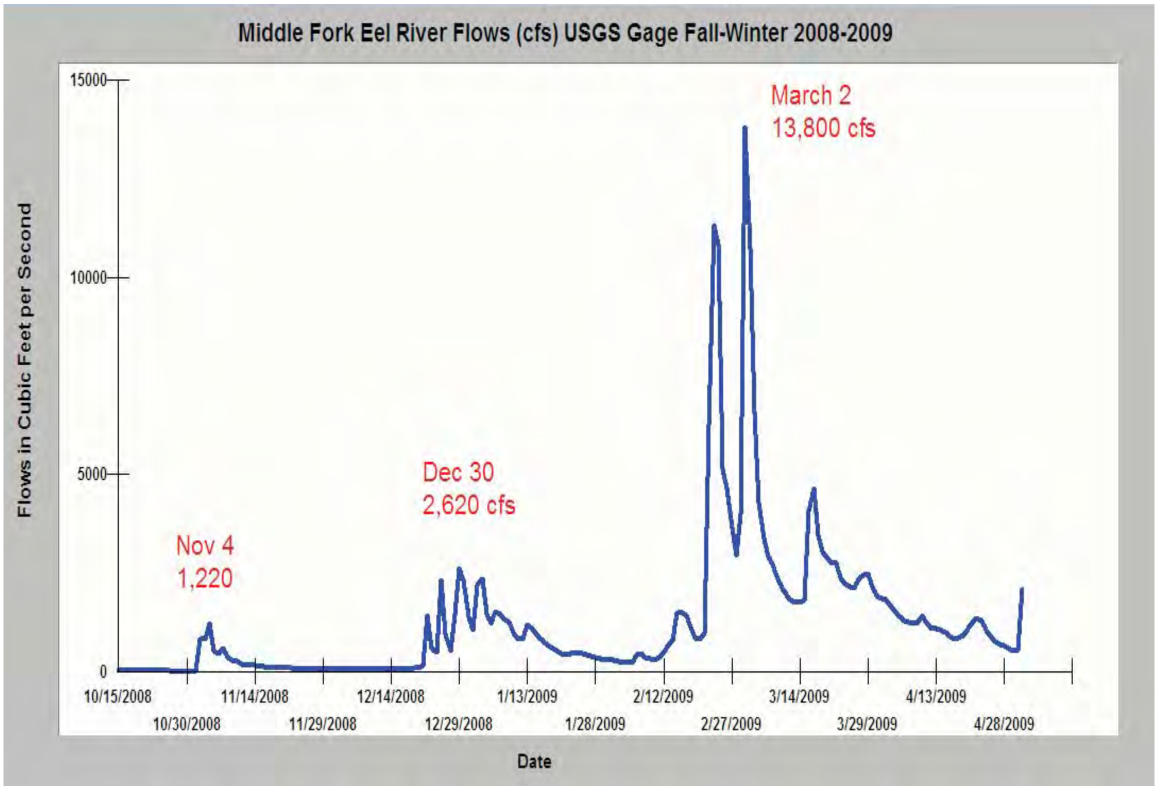

Figure 20. Flows of the Middle Fork Eel River for the period from October 15, 2008 to the end of April 28, 2009 with flow peaks labeled. Data from U.S. Geologic Survey via the Internet.

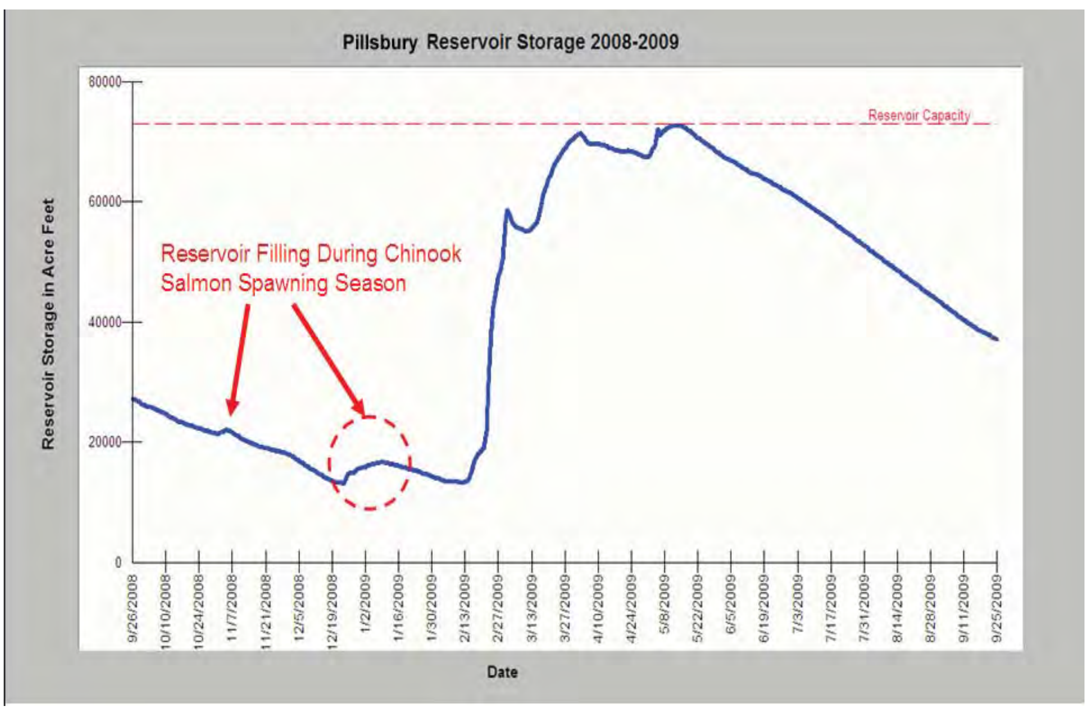

Figure 21. Pillsbury Reservoir levels for the period from September 26, 2008 to September 25, 2009. The level increased during the time of migration and spawning of fall Chinook salmon indicating that peak flows in tributaries went into storage. Data from CDEC and PG&E via the Internet.

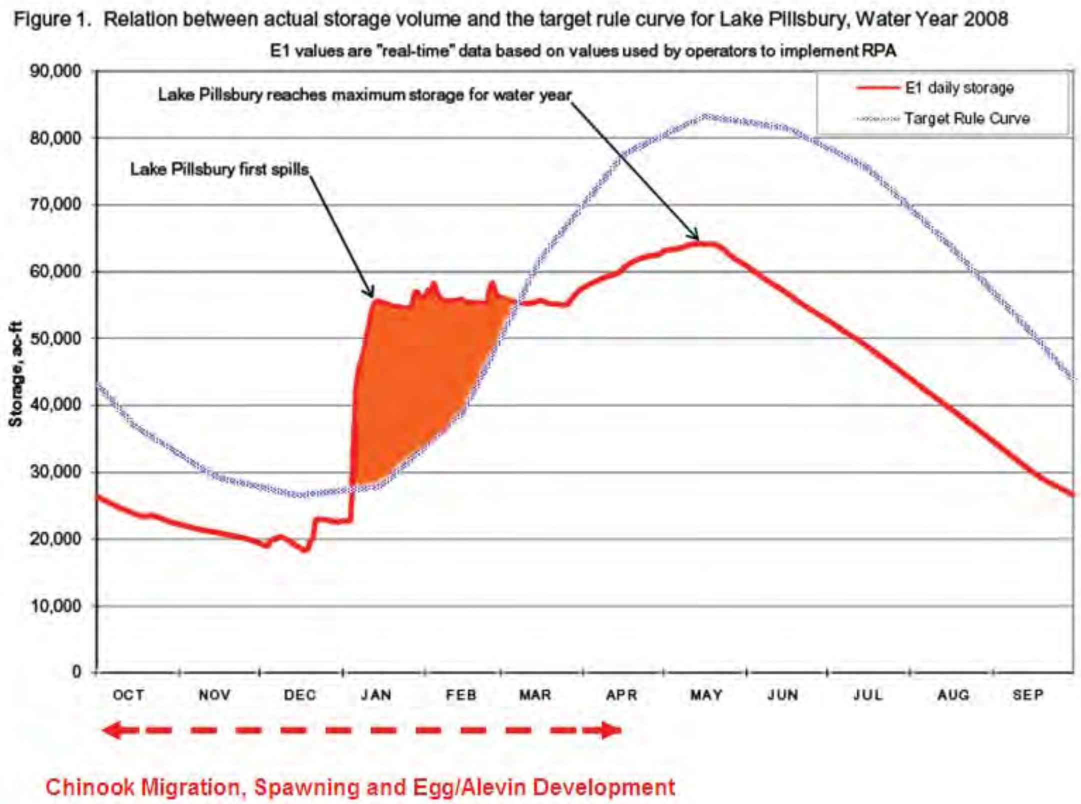

Figure 22. Pillsbury Reservoir storage in 2008-09 with departure from RPA curve (orange) during the most important time for Chinook salmon spawning and egg incubation. From PG&E (2008).

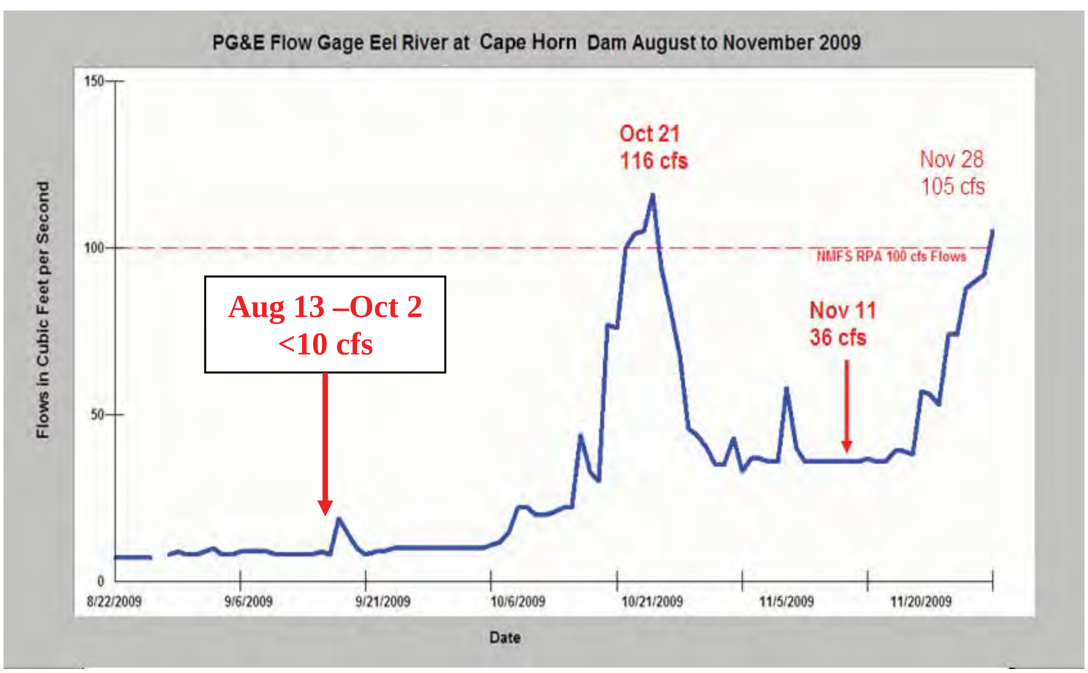

Figure 23. Eel River flows at Cape Horn Dam are far less than the 230 cfs needed for passage and minimum of 175 cfs needed for optimal spawning (VTN 1982). NMFS 100cfs guideline not required until December 1. Data from CDEC and PG&E via the Internet.

Eel River flow releases at Cape Horn Dam in spring of 2007 (Figure 25) can be contrasted with Middle Fork Eel River flows in the same year (Figure 26). The Middle Fork peak flow of 2130 cfs on April 22 and descending hydrograph of more than a week reflect characteristics of releases from melting snow fields. This is completely unlike the sharp spike in flow of 328 and fall to less than 200 cfs in less than 72 hours at Cape Horn Dam. Using the 38% scaling to reflect watershed size, the flow at Cape Horn Dam should have been nearer 814 cfs with releases only representing 17% of those of the Middle Fork due to reservoir storage. The extremely sharp rise is also not normal (non-normative) and may strand juveniles and trigger inappropriate behaviors with associated low survival of juvenile salmonids (VTN 1982). An upper Eel flow peak at Cape Horn Dam coupling with Middle Fork flows would help adult summer steelhead upstream passage and trigger migration of Chinook and steelhead juveniles at a time when Sacramento pikeminnow predation would be low.

The spring flow releases in 2008 from Cape Horn Dam (Figure 27) show an even greater departure from the Middle Fork Eel River flow patterns (Figure 28). The constant release of 200 cfs from April 1 to June 1 may have kept steelhead redds submerged but its lack of fluctuation makes it completely ineffective in triggering downstream migration of salmonid juveniles. VTN (1982) noted that flow fluctuation and varying the temperature by changing the depth of release from Scott Dam could be used as an effective tool to trigger downstream migration, but the 2008 patterns are the opposite of their recommendations and also not in concert with what is known about maximizing juvenile salmonid survival.

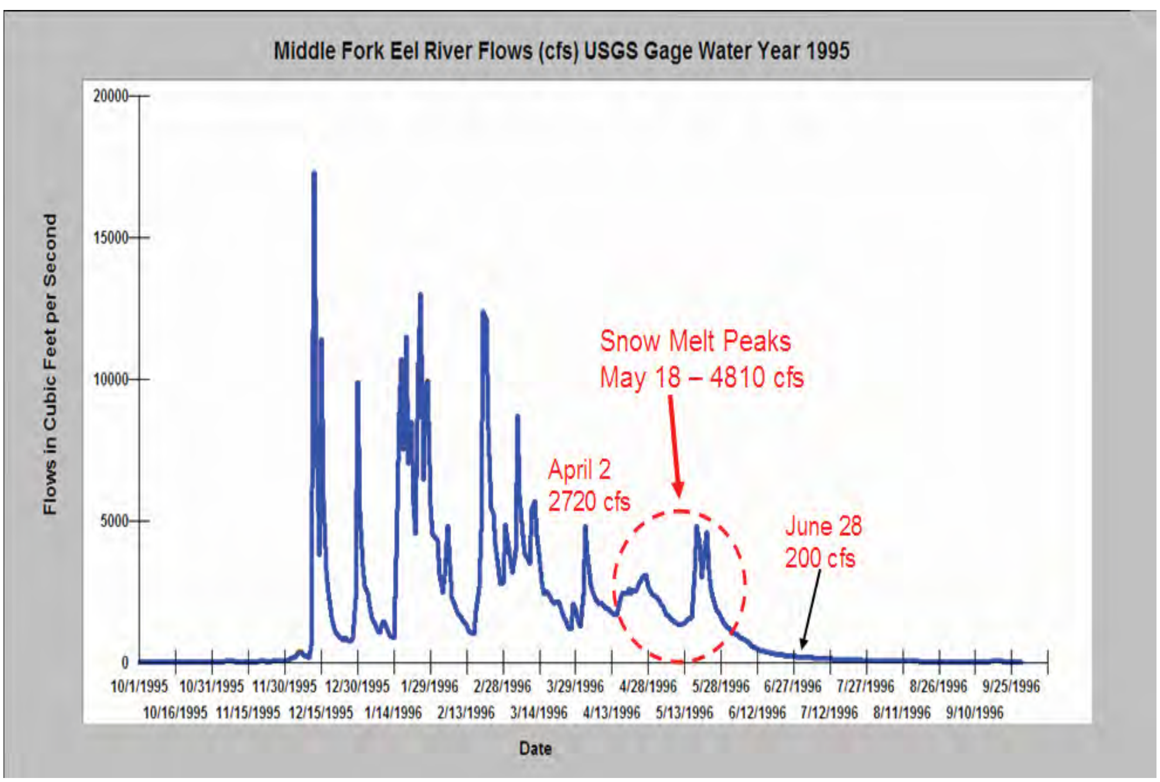

Figure 24. Middle Fork Eel River flows for the 1995 water year show several apparent snowmelt peak flows in late April and late May that are highlighted. Data from USGS.

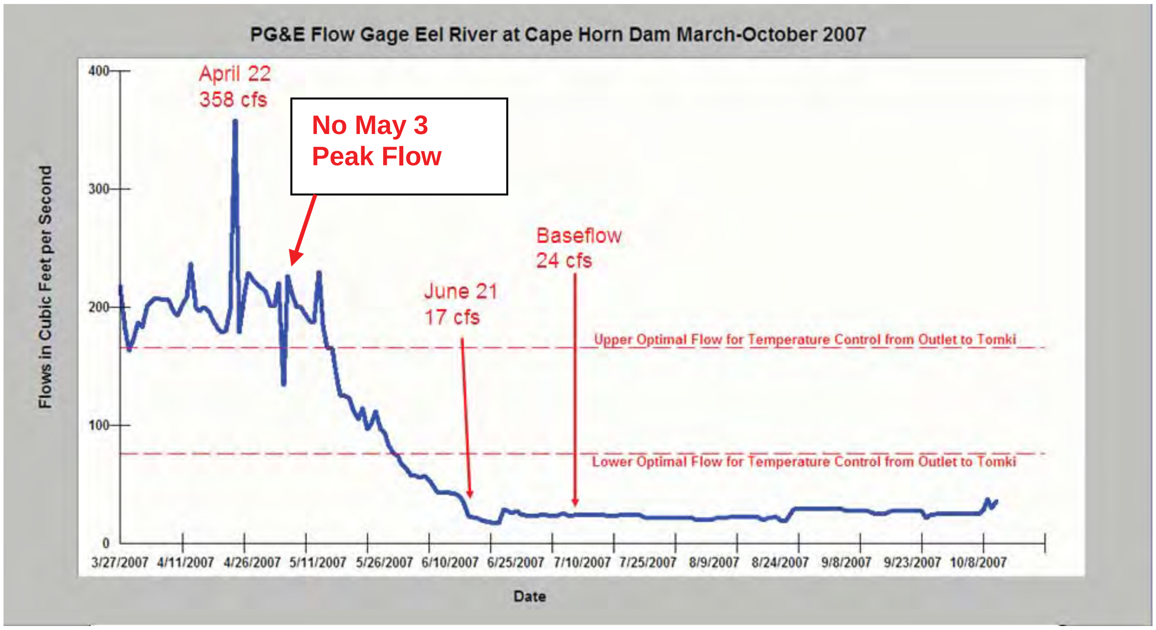

Figure 25. Mainstem Eel River flows from March through October 2007 at Cape Horn Dam show considerable departure from normal spring flow patterns in that the early May peak flow in the Middle Fork Eel is not evident. Also, summer base flows are less than those recommended for temperature control between Tomki and Outlet Creeks (VTN 1982).

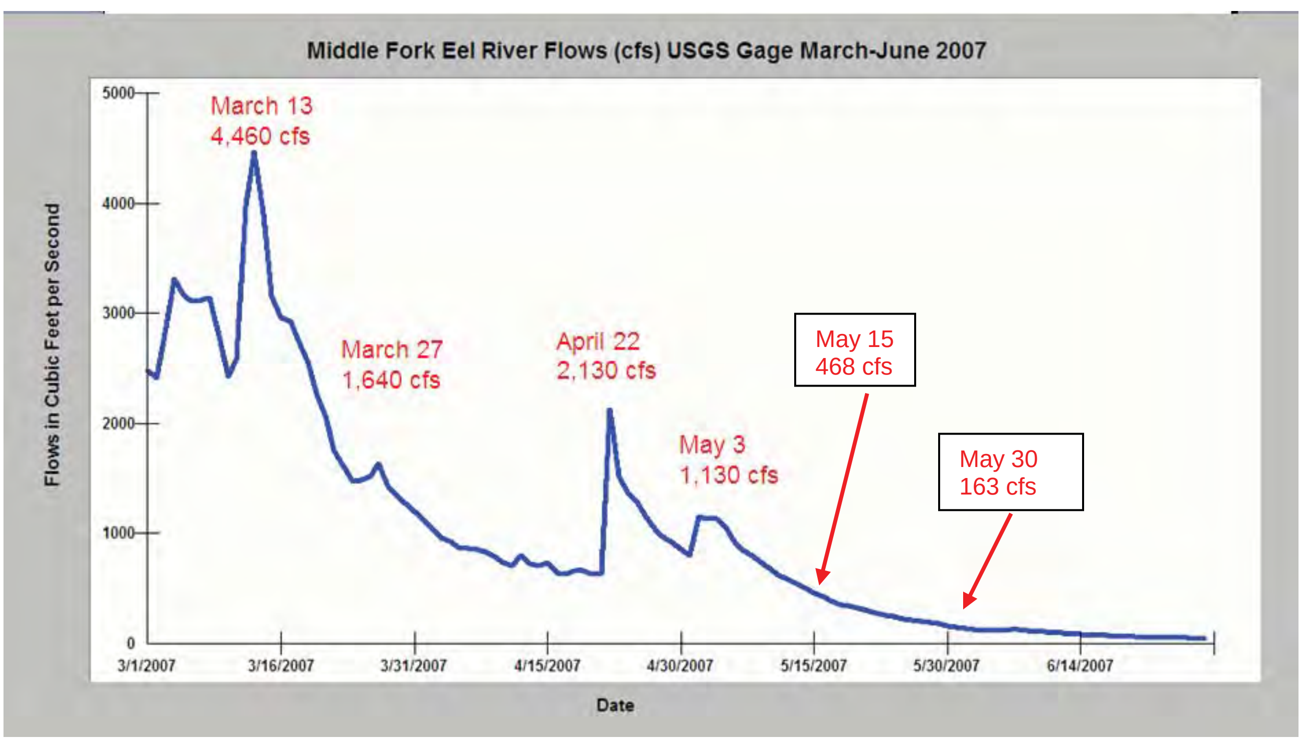

Figure 26. Middle Fork Eel River flows March 1 to June 2007 show several apparent snow melt peak flows (April 22 and May 3) that are highlighted. Data from USGS.

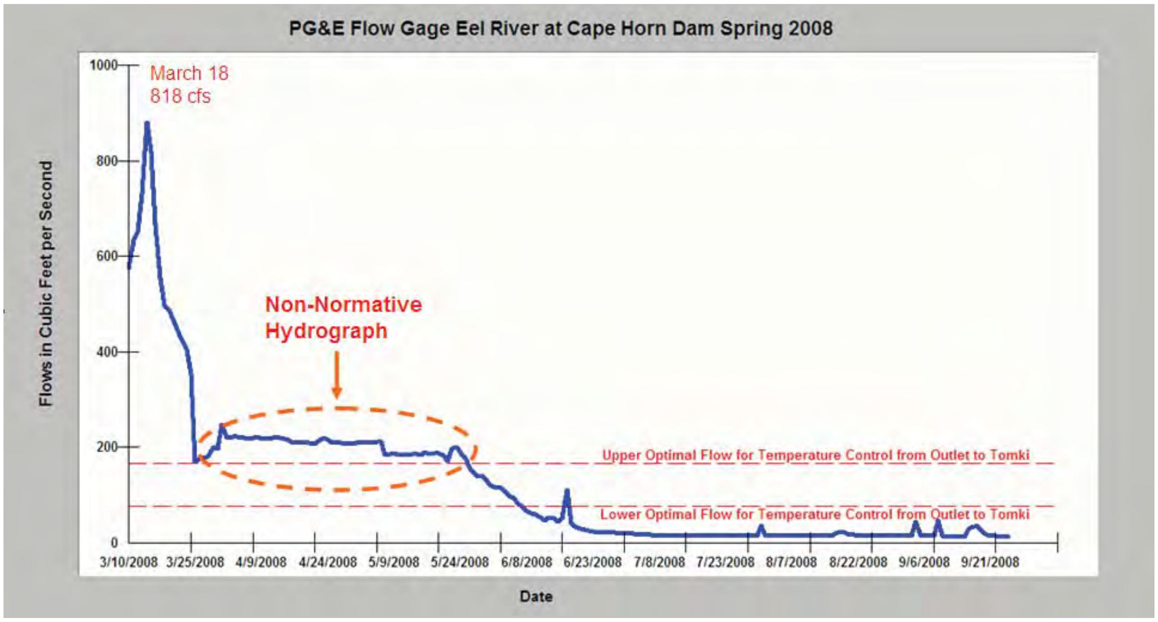

Figure 27. Mainstem Eel River flows from February 10 through October 2008 at Cape Horn Dam show considerable departure from normal spring flow patterns in that flow releases were a constant flow of 200 cfs from April 1 to June 1. Also, summer base flows are less than those recommended for temperature control between Tomki and Outlet Creeks (VTN 1982). Data from CDEC and PG&E via the Internet.

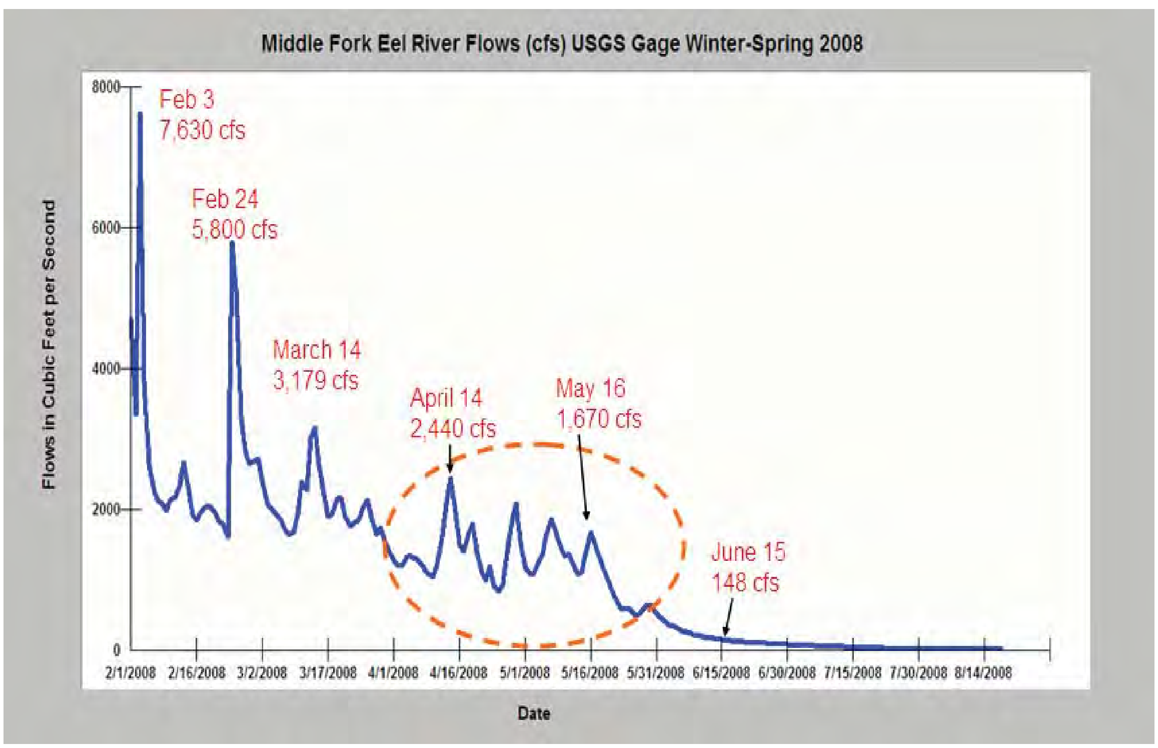

Figure 28. Middle Fork Eel River flows February 1 to August 2008 show several apparent snow melt peak flows (April 14 to late May) that are highlighted. Data from USGS.

There was a major release to the Eel River below Cape Horn Dam in 2009 reflecting a snow-melt peak (Figure 29), but again the ramping down was much more rapid in comparison with the Middle Fork Eel River for the same period (Figure 29). The mainstem Eel at Cape Horn Dam was reduced from 2,448 cfs on May 5 to 248 cfs a week later on May 13, but the descent of the Middle Fork Eel hydrograph took a month. Also notable for the period is the lack of a flow peak similar to the Middle Fork (4,660 cfs) on March 17 when only 319 cfs was released at Cape Horn Dam. Baseflows below 10 cfs from August to October were noted above in discussion of fall flows. None of the summer release patterns were anywhere near the VTN (1982) maximum flow for steelhead habitat between Scott and Cape Horn Dams (68-265 cfs) or for thermal benefits in the reach between Tomki and Outlet Creeks (76-166 cfs). Low spring and summer flows are contributing to continued low survival of both upper Eel River fall Chinook and winter steelhead when both are at already low and perilous population levels despite the RPA.

Pikeminnow Control

Moyle et al. (2008) give the following summary of the problems caused by the introduction of the predatory Sacramento pikeminnow into the Eel River for Chinook salmon:

> "In the Eel River, Sacramento pikeminnow were introduced illegally in 1979 and they quickly spread throughout much of the watershed (Brown and Moyle 1997). They are now one of the most abundant fish in the river and it is highly likely that they are suppressing Chinook salmon populations through predation on emigrating juveniles. This effect on Chinook juveniles is likely compounded by stress associated with other factors discussed above (i.e. water temperatures)."

Brown and Moyle (1991, 1991a, 1997) also noted that the pikeminnow predated on juvenile steelhead and caused a shift in habitat preference from pools to riffles when pools were inhabited by the pikeminnow, which is a particular problem for steelhead in the reach between Scott Dam and Van Arsdale reservoir.

A memo from CDFG Inland Fisheries Supervisor L.B. Boydstun (1991) to Emile Ekman of the Mendocino National Forest documented the population explosion of Sacramento pikeminnow in Pillsbury Reservoir a little over a decade after their introduction. His account from April 1991 refers to the pikeminnow as squawfish, which was their formerly accepted common name:

> "We did, however, catch lots of squawfish (20?) up to 7 pounds….They were particularly abundant up the Rice Fork arm, where I took about five casts and hooked a similar number of squawfish."

Clancy (1993) reported on dive counts conducted in 140 miles of the lower Eel River and Van Duzen River that documented the presence of 180,000 Sacramento pikeminnow and extensive river reaches where they were the predominant species. Pikeminnow flourish in

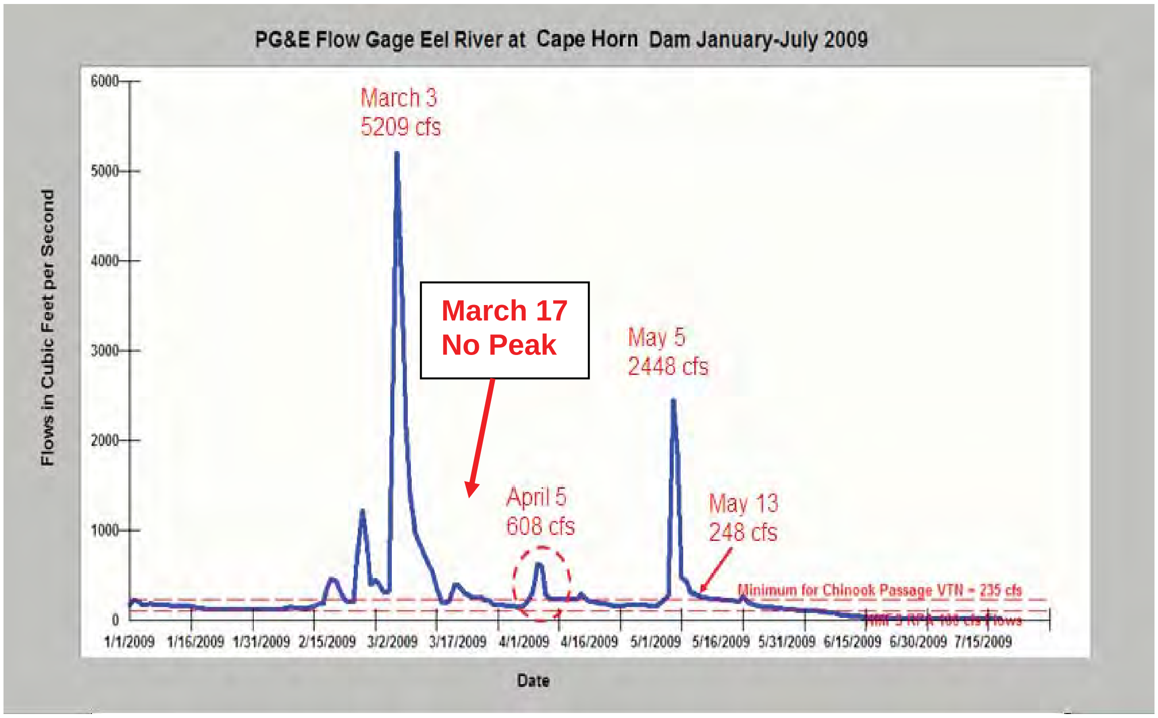

Figure 29. Mainstem Eel River flows from January 1 through July 2009 at Cape Horn Dam with peaks highlighted. Again there is considerable departure from normal spring flow patterns with sharp drops after peaks. Data from CDEC and PG&E via the Internet.

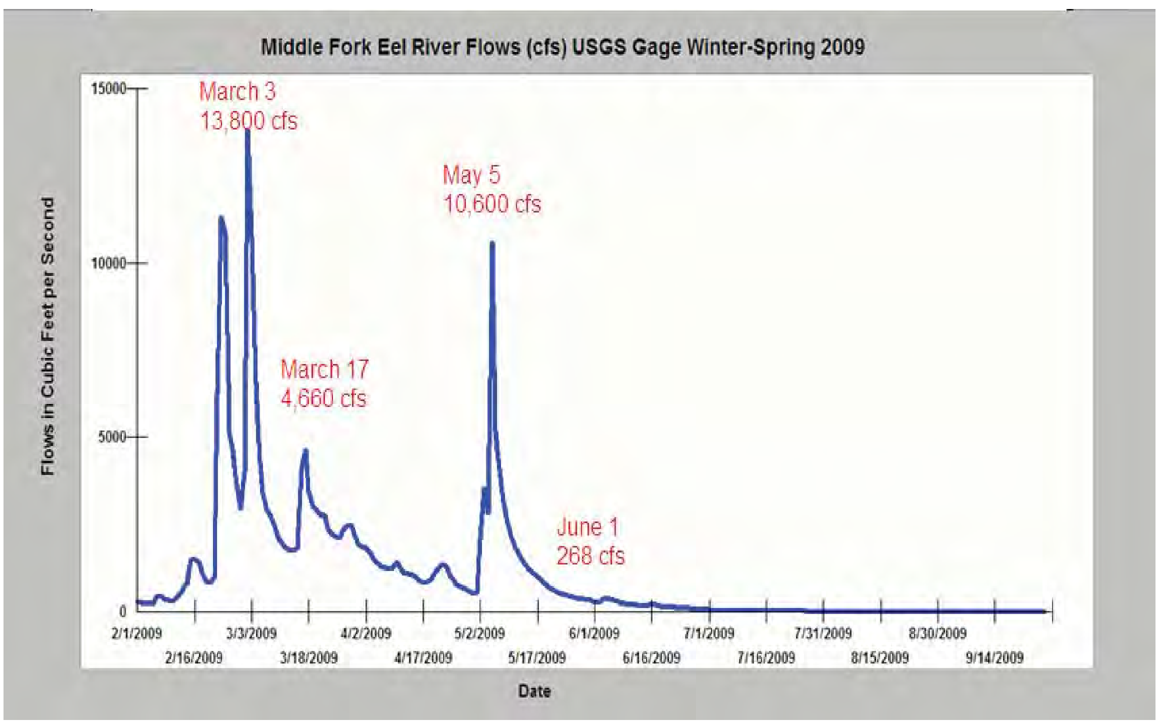

Figure 30. Middle Fork Eel River flows February 1 to September 2009 shows one major apparent snow melt peak on May 5 and earlier rain or rain-on-snow peaks that are highlighted. Data from USGS.

reservoirs (Moyle 2002, NWPPC 2004) and Pillsbury Reservoir is a constant source population that confounds suppression of pikeminnow through removal of individuals.

The effect of the PVP in elevating water temperatures provides another competitive advantage to Sacramento pikeminnow over salmonids. The following is information on temperature tolerance of Sacramento pikeminnow (SEC 2007):

> "Pikeminnow are found in summer water temperatures of 18°C to 28°C (Brown and Moyle 1993, Baltz et al. 1987, Dettman 1976) and often seek warmer temperatures if other habitat features are appropriate (Baltz et al. 1987, Dettman 1976). Knight (1985) determined Sacramento pikeminnow had a preference for average water temperatures ranging from 13.2°C to 27.8°C at acclimation temperatures of 10°C and 30°C, respectively (Dettman 1976). The final preferred temperature for pikeminnow was 26.0°C. The CTM for pikeminnow increased with acclimation temperature, beginning at 28.3°C for an acclimation temperature of 10 and peaking at 38.0°C at an acclimation temperature of 30°C. Temperatures above 38°C are lethal (Knight 1985).

This summary indicates that the pikeminnow optimal temperature of 26° C is over that recognized as lethal for all Pacific salmon species (Bartholow 1999, Sullivan et al. 2000), which is 25° C.

Although pikeminnow suppression is a stated objective of the NMFS (2002) BO, there has been no success of measures stipulated as part of the RPA. Review of Pikeminnow Adaptive Management and Suppression Operations Plans (PG&E 2005, 2006, 2007, 2008) indicate that activities have been completely ineffective. In 2005 seven gill net samples captured only 56 Sacramento pikeminnow. Table 1 shows 2006 gillnet capture results as part of the Sacramento pikeminnow suppression efforts but only 62 of the target species was captured and 13 juvenile steelhead mortalities occurred due to by-catch. Gillnet capture for three stations below Trout Creek, above Bucknell Creek and above Benmore Creek in 2006 are displayed as Figure 31 with a breakdown of fish species.

In a letter to PG&E (2007) in May 2007, NMFS requested that gillnet sampling be discontinued. Consequently, suppression efforts went forward in the summer of 2007 using electrofishing, but incidental steelhead trout mortality still occurred (Figure 32). Results were similar for 2008 electrofishing sampling and a summary of catch can be reviewed as Figure 33.

Table 1. Catch totals for gillnet suppression in 2006 in the Eel River at four sites within and below the PVP (PG&E 2007).

Species	**Number Captured**
Sacramento pikeminnow	61
Sacramento sucker	46
Steelhead trout	13

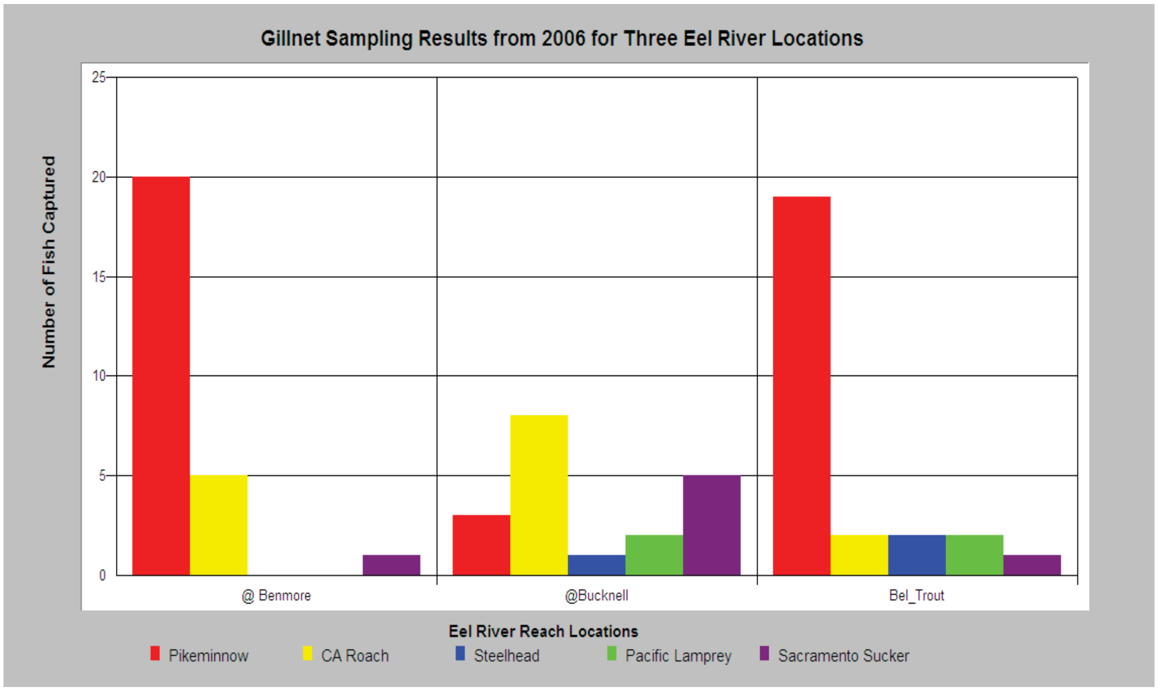

Figure 31. Gillnet samples in the Upper Eel in 2006 by species. While Sacramento pikeminnow were predominant in the catch above Benmore Creek and below Trout Creek, California roach and suckers were more numerous above Bucknell Creek. Data from PG&E 2008.

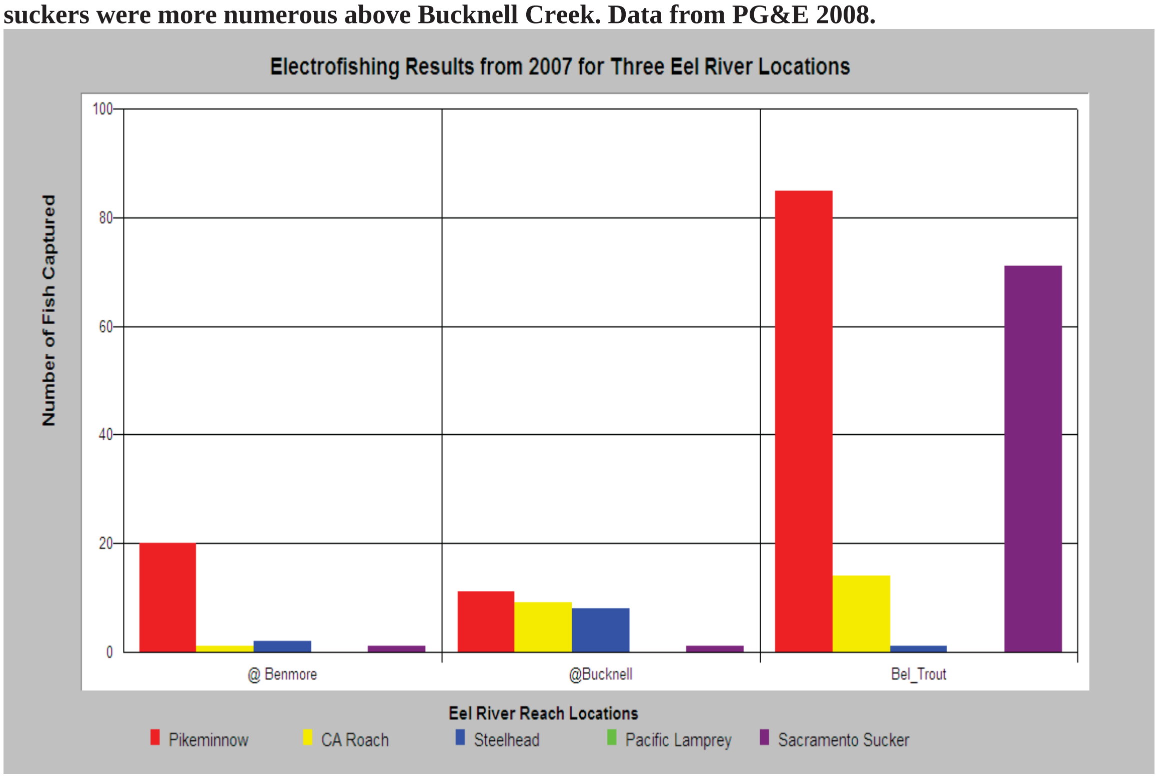

Figure 32. Electrofishing samples in 2007 at three Eel River monitoring sites yielded similar results to gill netting in 2006 except that Sacramento pikeminnow were most numerous at all locations. (@Benmore = above Benmore Cr., @Bucknell = above Bucknell Cr. and Bel_Trout = below Trout Cr.). Data from PG&E 2008.

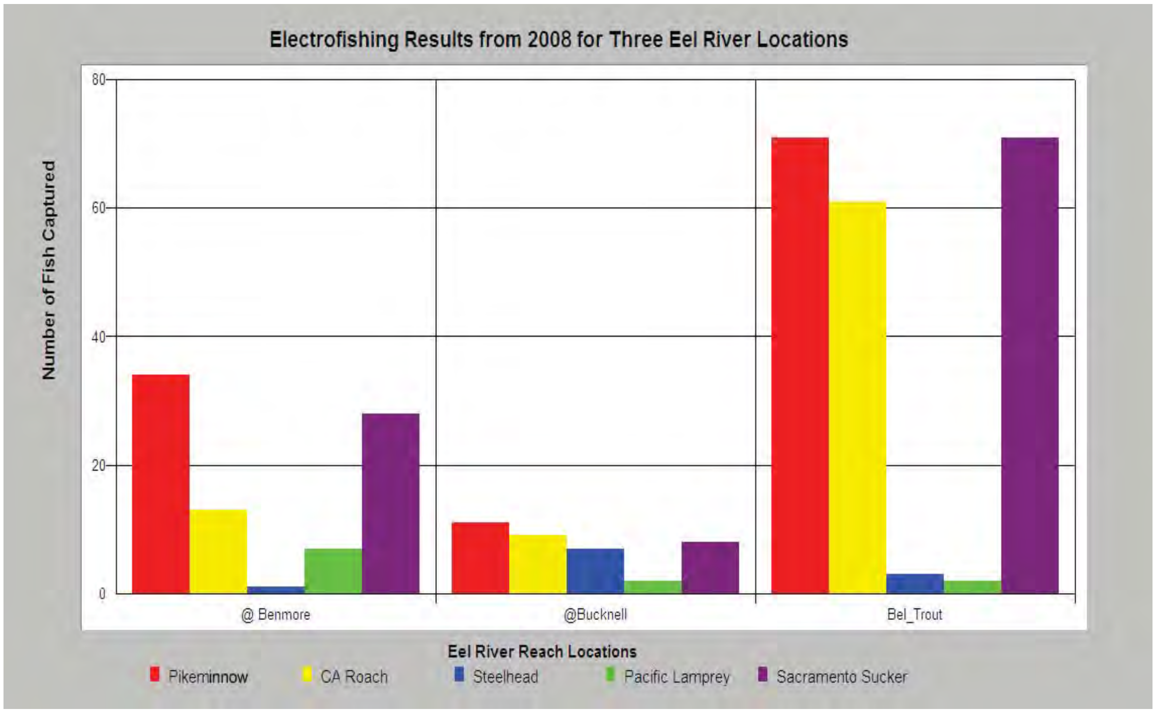

Figure 33. Electrofishing samples in 2008 at three Eel River monitoring sites had a similar community as in previous sampling years. (@Benmore = above Benmore Cr., @Bucknell = above Bucknell Cr. and Bel_Trout = below Trout Cr.). Data from PG&E 2008.

Suppression efforts in the reach between Scott and Cape Horn Dams, which was formerly a steelhead juvenile refugia (Moyle and Brown 1997), are not feasible. Rapid flows and a confined channel proved so challenging that the electrofishing boat almost capsized in that reach (PG&E 2006). The sampling indicates that there is a diverse age structure of Sacramento pikeminnow and suckers and that steelhead trout make up part of the fish community, along with the warm water adapted California roach that was also introduced to the Eel River. As discussed above, flows have not approached or attained the 68-265 cfs that VTN (1982) calculated would expand steelhead habitat maximally, moderate temperatures and provide competitive advantages for both Chinook and steelhead juveniles in helping them avoid pikeminnow predation.

Discussions of temperature follow, and flows have not been sufficient to moderate water temperatures to the benefit of juvenile salmonids. Although the RPA claims that flows could benefit salmonids in some water years, recent water year classification has left spring and summer baseflows at extremely low levels. In 2009 CDEC flow data indicated flows dropped as low as 7 cfs for several days in August 2009, which would set up ideal conditions for pikeminnow. This is despite the following in the NMFS (2002) BO:

> "Sacramento pikeminnow have enjoyed a competitive advantage over Eel River salmonids since their introduction as a result of Project operations. Low flows below the Project in recent years have limited salmonids, and at the same time have provided ideal conditions for the Sacramento pikeminnow. It is NMFS biological opinion that improved flows, particularly in summer months, in

> conjunction with a pikeminnow suppression program, are absolutely necessary to decrease the decline of Eel River salmonids."
>
> "Flows that mimic unimpaired flows, especially spring and summer flows may also aid in the suppression of Pikeminnow by providing less conducive habitat conditions for pikeminnow especially in wet years."

Summer base flows have continued to favor Sacramento pikeminnow and the spring flows under the RPA at least since 2007 have not been operated to couple with natural peaks. This clearly deviates from any reasonable or cogent program to limit this invasive, non-native fish species that is a major threat to Chinook salmon and steelhead recovery. There is no suppression strategy that will work and Sacramento pikeminnow are likely in the Eel River to stay. The question needs to be shifted to how we can decrease the pikeminnow's competitive advantage over salmonids. In the short term, that is letting more water out of Scott Dam and Cape Horn Dam when salmonid juveniles need it. In the longer term, Pillsbury Reservoir must be removed.

Water Temperatures and Water Flows

While water temperature data and reports are required of PG&E (2005, 2006, 2007, 2008) under the RPA, older reports have illegible temperature graphics, printed tables of flows and temperatures are difficult to use, raw data are not available, temperature data for above the PVP is sparse and PG&E probes continually turn up missing in the upper watershed. The datasets in legible charts provided for 2008 are a step in the right direction, but temperature records are cutoff in terms of covering dates when flows are high and temperature buffering benefits likely occurring (Figure 34). Flow levels in summer are not those envisioned as benefiting salmonids and moderating temperatures and instead summer base flows have ranged from 7-24 cfs. The relationship between lower flows and higher water temperatures is well established (Bartholow 1999, NAS 2004) with less water volume moving at a slower speed more subject to warming. In the upper Eel River this creates an advantage for pikeminnow (Figure 35).

Figure 35 clearly shows that flows in 2008 were insufficient to prevent the maximum floating weekly average temperature (MWAT) of below Thomas Creek from rising to 25.7 ^{o} C, which is above the lethal temperature of 25 ^{o} C for juvenile steelhead (Sullivan et al. 2000). This indicates ideal conditions for Sacramento pikeminnow that have a thermal optimum of 26^{o} C. Flow conditions in 2007 were slightly better at 24 cfs, but temperature information in PG&E reports does not show significant improvement. No temperature data are available for 2009, but flows of 10 cfs from August through October likely created even more adverse conditions below Cape Horn Dam for salmonids and even better ones for pikeminnow. Alteration of flow and temperature at Cape Horn Dam propagate downstream and create adverse conditions for summer steelhead adult migrations and juvenile immigration of wild Chinook and steelhead juveniles well downstream earlier in the season than if the PVP was not in operation.

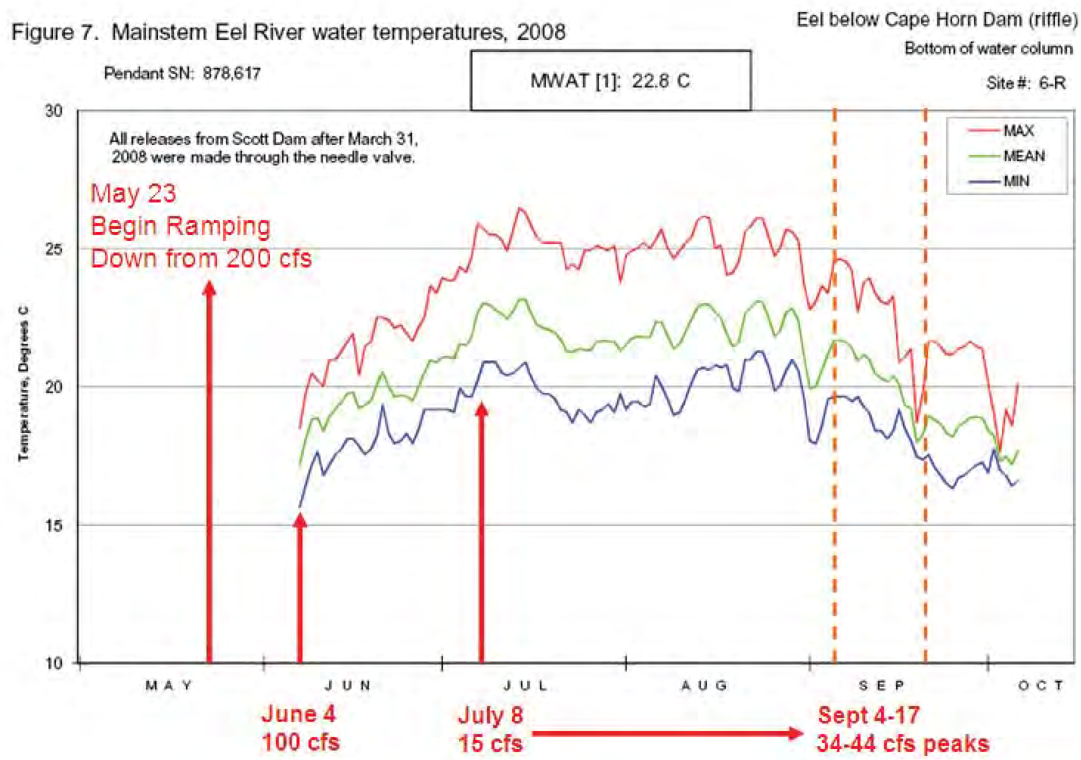

Figure 34. Water temperature chart of mainstem Eel River below Cape Horn Dam from PG&E (2008) with annotation showing missing records during periods of high flow and timing and level of flow releases.

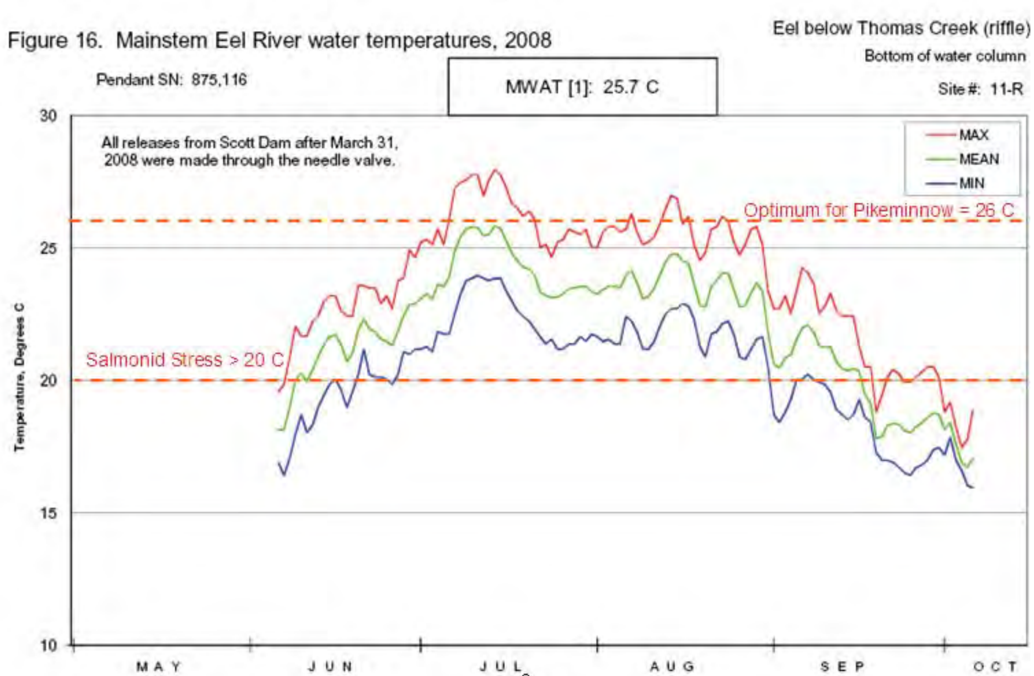

Figure 35. PG&E (2008) minimum, average and maximum water temperature chart from a riffle below Thomas Creek shows optimal conditions for Sacramento pikeminnow and lethal ones for salmonids.

Friedrichsen (2003) provided comprehensive electronic water temperature data for the Eel River basin and the summary of results for the upper Eel River basin is displayed as Figure 36. The maximum floating weekly average water temperatures (MWATs) from 1999-2003 show a pervasive pattern where conditions are lethal to salmonids and optimal for pikeminnow at sites below Cape Horn Dam, such as above Outlet Creek and at Emandal. Sites above Pillsbury Reservoir have more moderate temperatures where night time lows likely allow salmonid survival (U.S. EPA 2003). The paucity of data from PG&E (2008) for sites upstream of the PVP likely overlook a great deal of temperature suitable habitat for salmon and steelhead, if passage were open. The U.S. EPA (2003) points out the importance of access to refugia when mainstem river temperature conditions are elevated.

Tributaries like Tomki Creek were highly suitable for salmonids throughout the year prior to the 1964 flood, but channel changes caused warming throughout the Eel River basin (Kubicek 1977). Many additional factors now also contributed to temperature pollution, including flow depletion in tributaries (U.S. EPA 2004). For example, lower Tomki Creek from 1999 to 2003 ranged from 19.3 ^{o} C to 25.2 ^{o} C (Friedrichsen 2003) with the majority of years favoring pikeminnow over salmonids (Harvey and Nakamoto 1999, Harvey et al. 2002). This deterioration of tributary habitat leaves little suitable rearing habitat in the region and makes it necessary to allow access to thermal refugia in the upper Eel River, if Pacific salmon species are to survive into the future.

A map taken from Friedrichsen (2003) of MWATs (Figure 37) shows mainstem temperatures below the PVP to be lethal for salmonids in most years (23.2 ^{o} -28 ^{o} C), while sites like Bloody Rock above are within the range of suitable for steelhead juveniles (MWAT range of 18.9 ^{o} to 21.3 ^{o} C). The PG&E (2008) probe data (Figure 38) indicate a somewhat higher MWAT of 22.4 C, but the night time minimum temperatures fall below 20 ^{o} C and provide a period of recovery from thermal stress for juvenile steelhead. These areas would be optimal for attainment of two years of age for summer steelhead juveniles that would colonize this area after PVP removal. Moyle et al. (2008) point out that summer steelhead need to rear for two years before ocean entry and two year old downstream migrants would have a high likelihood of avoiding pikeminnow predation.

Geology of the upper Eel watershed includes volcanic terrain in the high country along its eastern rim (Figure 39) that likely manifests in cold groundwater storage in the upper watershed not described by PG&E data.

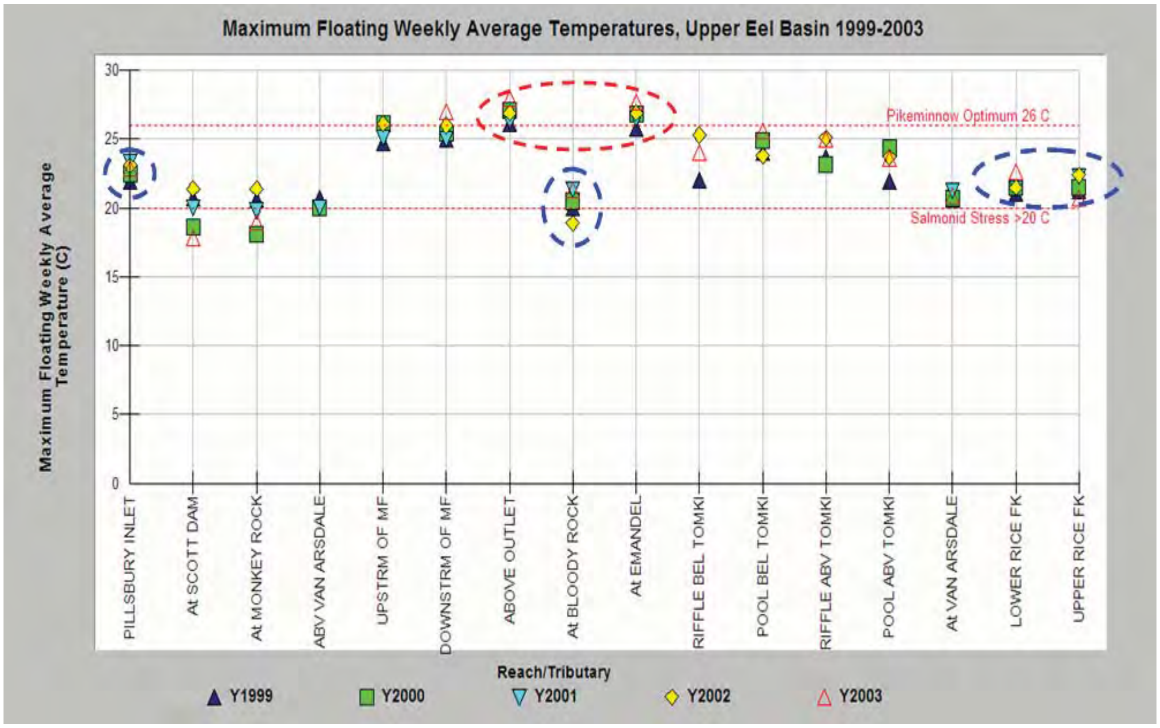

Figure 36. Humboldt County RCD (Friedrichsen 2003) maximum floating weekly average water temperature (MWAT) scatter plot for 1999-2003 shows below project sites lethal for salmonids (red), Tomki Creek supportive in only some years (pink) and locations above PVP as suitable or optimal for salmonids (blue).

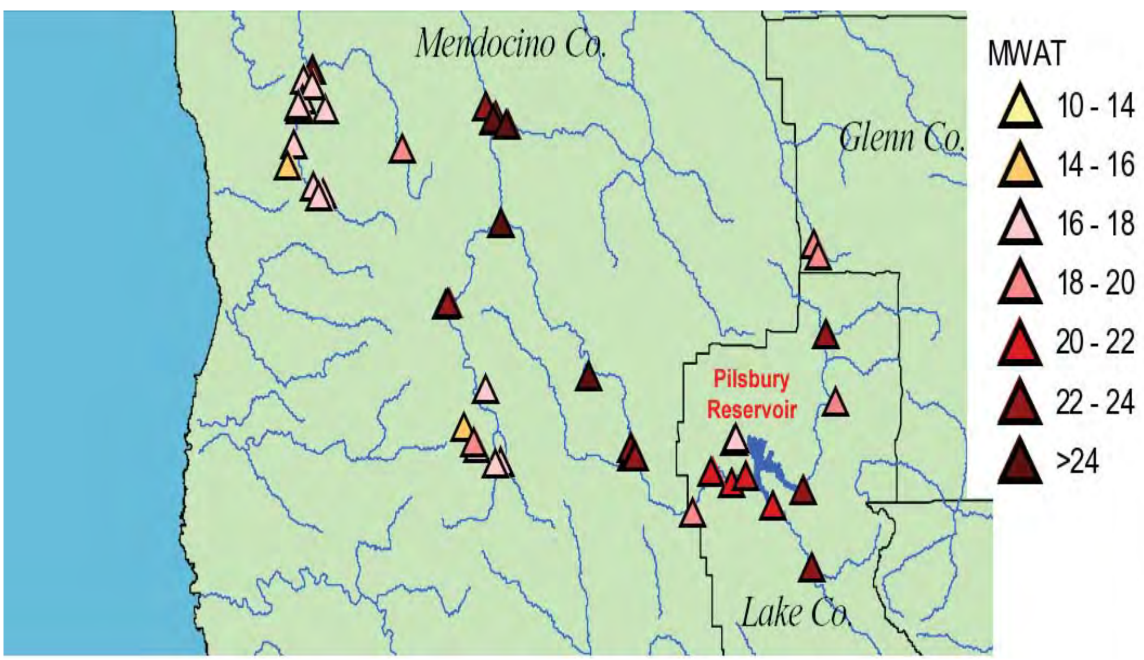

Figure 37. Upper Eel River map of MWATs from Friedrichsen (2003) show ranges suitable for salmonids at several locations above Pillsbury Reservoir.

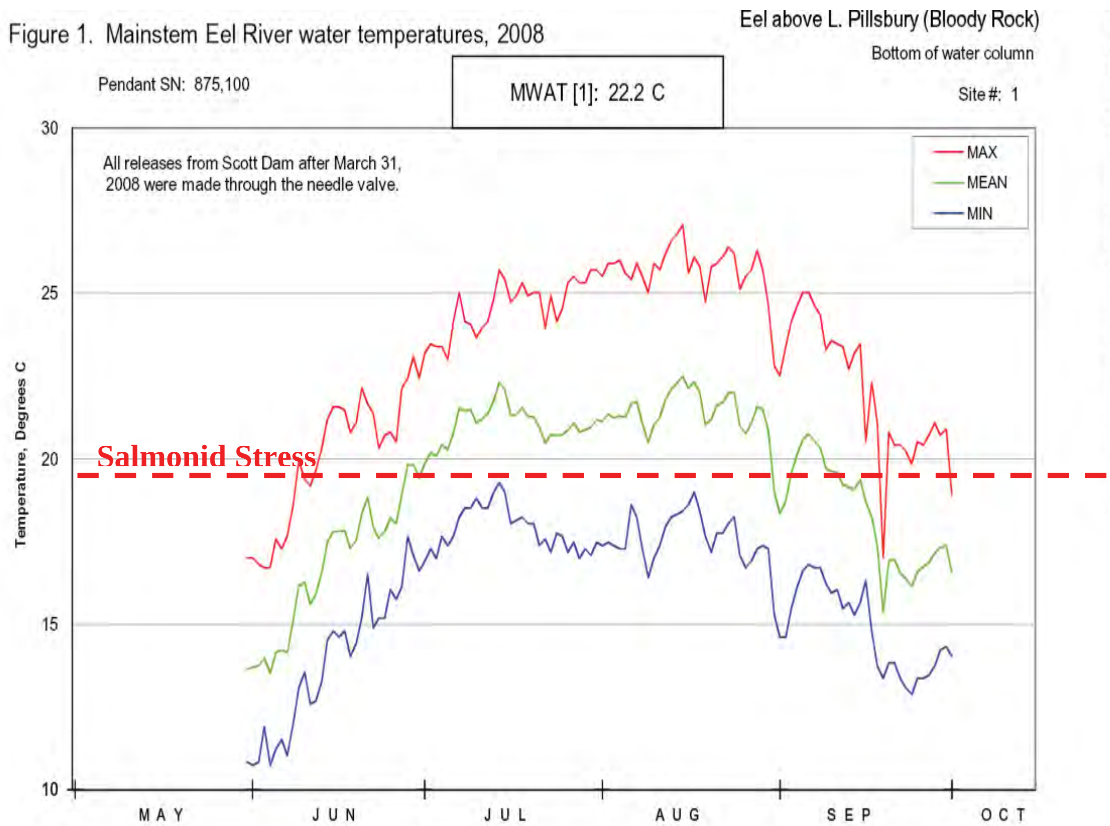

Figure 38. The Upper Eel at Bloody Rock minimum, average and maximum water temperatures show an MWAT of 22.4 ^{o} C, but the night time minimum temperatures fall below 20 ^{o} C and provide a period of recovery from thermal stress for juvenile steelhead at this location above Pillsbury Reservoir. Data from PG&E (2008)

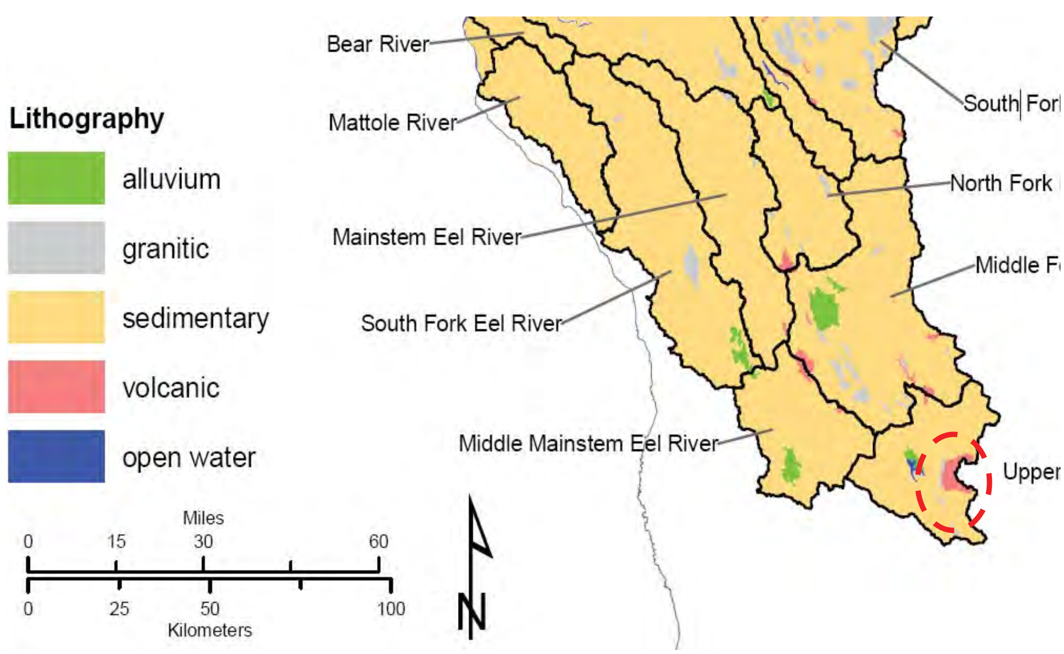

Figure 39. Lithology map from the *Upper Eel River TMDL* (U.S. EPA 2004) shows volcanic terrain (red circle) on the eastern watershed boundary that likely gives rise to high groundwater storage and spring areas down-slope in tributaries above the PVP.

Higher flow releases from Cape Horn Dam might create more pressure in subsurface gravels through downwelling that also forces cold water back to the surface downstream (ODEQ 2008). U.S. EPA (2003) notes that such connections can create critical refugia for salmonids. VTN (1982) noted potential for such hyporheic zone connection, but flows have been insufficient in recent years to trigger such effects. Furthermore, it would be impossible to determine any such relationship on the limited data available. If summer flow levels were maintained at the 76 to 166 cfs recognized by VTN (1982), surface water temperatures would drop due to effects described above, increased volume and decreased transit time and steelhead could successfully rear between Tomki and Outlet Creeks in the mainstem. These flows would also delay onset of lethal mainstem temperatures below the Middle Fork benefiting summer steelhead adults and juvenile downstream migrants.

Low summer flows are allowed under the RPA based on agreement with PG&E about water year classification. These discussions reflect only the needs of salmonids and do not delve into the specifics of the flaws in formulas and questions related to water years, which could be better answered by a hydrologist.

One additional note is warranted regarding the blending of surface and deeper water at Scott Dam. PG&E (2008) shows that blending of surface and deeper waters took place in March, likely to warm stream flow, but not later in spring. VTN (1982) noted that using reservoir surface waters in April and May to cause warming pulses triggered earlier salmonid juvenile downstream migration and this option is open to PG&E and NMFS but is not specified in the RPA.

In sum, the low flows required by the RPA, especially in the summer, often produce temperatures lethal to listed fish species in the Eel River and beneficial to predatory pikeminnow, resulting in a compounding adverse effect on salmonids. Based on available science, increasing flows in the Eel River to 68-265 cfs in the summer will produce corresponding temperature benefits for salmonids that will likely support survival of the species. Bradbury et al (1995) point out that Pacific salmon cannot be recovered without having access to habitat similar to that with which they co-evolved; therefore, to ensure longer term salmonid recovery, access to refugia above the PVP must be provided

Immediate Action to Increase Flows and Remove PVP Due to Current Eel River Cumulative Watershed Effects and Potential Salmonid Loss

The Eel River has experienced an aquatic habitat collapse with regard to its ability to produce Pacific salmon (Higgins et al. 1992, Brown and Moyle 1997, Moyle et al. 2008) during the time that the PVP has been in place. The press disturbance (Reeves et al. 1995) related to widespread logging on private land (Higgins 2007, 2009), urbanization (Friedrichsen 1998) and rural residential development has caused a massive decline in all Pacific salmon species. Mainstem environments in the South Fork and Van Duzen are so aggraded and flow depleted that they are optimal temperatures for Sacramento pikeminnow (Figure 40). Warm Eel River tributaries were found by Harvey et al. (2002) to produce numerous juvenile pikeminnow, while cool streams instead produced steelhead juveniles.

Friedrichsen (1998) noted that there was a general lack of recovery of suitable water temperatures for salmonids in the Eel River when comparing data with the findings of Kubicek (1977) collected in the year 1972.

Figure 40. Underwater view of juvenile Sacramento pikeminnow in a back water pool below Dora Creek on the South Fork Eel River. Photo by Pat Higgins, June 1994.

The Eel River estuary lies in the fog belt and once provided vast habitat area for juvenile salmonid rearing, but it has been diminished due to sedimentation and warming (Puckett 1977, Higgins 1991).

When Scott Dam blocked upper Eel River migrations, it is likely that fish spawned in high concentrations downstream in the mainstem and strayed into Tomki Creek in very large numbers. This is confirmed by historic accounts from Michael Morford (1982) and Robert Keiffer (1983) who interviewed Mendocino life-long residents Herman Sagehorn and Donald and Roland Graf, respectively. The following descriptions are of those accounts and are excerpted from Higgins (2003), a report that evaluated habitat restoration efforts on String Creek, a tributary of Tomki Creek.

> "Herman Sagehorn (Morford 1982) described Tomki Creek as ideal salmonid habitat, with abundant deep pools, good spawning gravel, low fine sediment and tree-lined banks. Several Chinook runs were described with an early run of highly colored fish, described by the locals as 'black salmon'. A run of brighter fish came with high flows in December, when coho salmon also ran. Steelhead runs began in January and fish of up to 25 pounds were occasionally caught in Tomki and String creeks.
>
> The degree to which these fish used tributaries, such as String Creek, varied depending on flows. Chinook for example might use riffles in the main Eel River

near Hearst, if low flow conditions persisted, but might also use Tomki and tributaries like String Creek if high flows prevailed. Holes in Tomki Creek were up to fifteen feet deep and salmonid juveniles ("trout") thrived in them even when summer low flows caused loss of connection between pools because of connections to cold groundwater. Pools below the convergence of String Creek in Tomki Creek were ten to twelve feet deep. String Creek was perennial and had adult winter steelhead sometimes holding through summer in pools (Keiffer 1983). Conservative estimates of the old-timers were that there were at least 200 spawning pairs of Chinook per mile. One hole on the main Eel at Hearst was measured by the Graf brothers and found to be greater than 70 feet deep (Keiffer 1983)."

In 2002, Higgins (2003) conducted a habitat survey in spring and fall of String Creek for the Mendocino County Resource Conservation District (RCD) to determine whether a bioengineering restoration project was effective in restoring fish habitat. Although the use of living plant materials like willow in combination with large rock had caused the scour of 6 feet deep holes and narrowed the stream course, there was no surface flow in String Creek in late summer. Higgins (2003) provided the following discussion:

> "String Creek is completely dewatered in summer, although it was noted to have perennial surface flows prior to the 1964 flood. Streams that have an over-burden of gravel often regain surface flows when the stream down cuts to its original bed. There are two potential hypotheses as to why String Creek still runs dry after it has reached its original grade: 1) a profound change in hydrology due to cumulative effects of past land use, and 2) increased diversion related to increased rural sub-divisions in the headwaters. Altered hydrology could cause an increase in peak flows but reduction in base flows."

Regardless of the causal mechanism, flows in String Creek are greatly decreased from historic and the ripple impacts of such decreased flows are reflected in Tomki Creek downstream. The high water temperature in Tomki Creek noted above is in part as a result of this reduced flow as well as changes in width to depth ratio caused by sediment from logging. In short, Tomki Creek served as a refugia for upper Eel River Chinook salmon, coho salmon and steelhead prior to 1964 and productivity has been so diminished that coho went extinct and fall Chinook are down in the dozens. This change in habitat argues strongly for the removal of Pillsbury Dam because some of the best habitat for salmon in steelhead in the entire Eel River watershed lies above the PVP.

This long term change in temperature regime is doubly damaging because of the introduction and spread of the predacious and warm adapted Sacramento pikeminnow. The latter species is now likely permanently established in the Eel River basin and the continual infestation from Pillsbury Reservoir must be curtailed if a new equilibrium is to be established between salmonids and the pikeminnow.

Climatic Cycles and Climate Change

Collison et al. (2003) point out that northern California Pacific salmon respond to climatic and oceanic variations known as the Pacific decadal oscillation (PDO) cycle (Hare, 1998, Hare et al., 1999). Positive ocean cycles coincide with wet on-land conditions in northwestern California for a period of about 25 years, then alternate with ocean conditions prone to warm El Nino events and periods of lesser rainfall. Positive PDO conditions prevailed from 1950-1975 and negative ocean and dry on-land conditions extended from 1975-1995 (Collison et al. 2003). We are currently in a productive ocean and wet climatic phase that provides an opportunity to recovery coho and Chinook salmon and steelhead. However, if freshwater habitat is not recovered by the time the next switch in the PDO occurs sometime between 2015-2025, then additional Pacific salmon stocks will likely go extinction.

NMFS (2002) and PG&E (2008) do not seem aware of emerging science on climate change that have bearing the sustainability of Pacific salmon populations. Snowy Mountain at the upper Eel River headwaters is the southern extent of the Klamath Mountain Geologic Province and Van Kirk and Naman (2008) studied snow fall patterns in this range about 150 miles north. They concluded that the snow level had risen approximately 1,000 feet over the last 50 years as a result of climate change resulting in diminished snow pack and likelihood of diminished cold water flows for salmonids. NMFS (2002) BO is designed around water and flow years that may be becoming less frequent as a result of climate change. This results in much less flow than expected over the remaining years of the license and higher likelihood of extinct.

Hatchery Supplementation and Chinook and Steelhead Recovery

The RPA does not deal directly with hatchery supplementation yet (PG&E 2005, 2007, 2008) reports give indications that both Chinook salmon and steelhead have continued to be cultured despite misgivings regarding genetic effects in other NMFS (Good et al. 2005) reports. If the broodstock of contributing parents is low (<50 adults), salmon or steelhead may suffer from inbreeding that can cause extremely poorly adapted fish (Simon 1988) that experience high incidence of rare diseases and other defects. A common problem from inbreeding of hatchery fish is "inbreeding depression" in which fertility of hatchery broodstock may drop dramatically (Simon et al. 1986). Inbreeding is extremely undesirable, because even if fish are of local origin, they may become unfit to survive in the wild. If inbred fish spawn with wild fish, they can also decrease the success of natural reproduction.

Although Chinook salmon hatchery culture at VAFS may have ceased, steelhead hatchery fish returns continued through 2007. Given the potential for genetic consequences of hatchery practices, it is surprising that NMFS has not required or conducted genetic testing to see if previous practices have compromised stocks. The sporadic and unreported use of hatchery supplementation can mask habitat decline and poor wild fish productivity. Artificial culture at VAFS should not be conducted unless the facility is operated as a conservation hatchery with appropriate budget and brood handling measures (Riggs 1990, Kier Associates 1991, 1999).

Adaptive Management: No Change in Action Despite Negative Results

The RPA invokes adaptive management (Walters 1997, Walters and Hilborn 1978, Walters and Holling 1990) with regard to the Sacramento pikeminnow suppression and the rebound of Chinook and steelhead, but there is no indication that appropriate action implied by use of the term is contemplated or forthcoming. The National Research Council (2004), in recommending that adaptive management be used to recover the endangered fishes of the Klamath basin, described it as follows:

> "Adaptive management is a formal, systematic, and rigorous program of learning from the outcomes of management actions, accommodating change, and improving management (Holling 1978). Its primary purpose is to establish a continuous, iterative process for increasing the probability that a plan for environmental restoration will be successful. In practice, adaptive management uses conceptual and numerical models and the scientific method to develop and test management options."

Walters (1997) points out that a common failure in the application of adaptive management is that change is insufficient to discern changes in conditions associated with the project from those that reflect natural variability. As noted above, flows have been so low that no temperature benefits or suppressing effects on pikeminnow were discernable from 2007-2009. It seems that NMFS may be using the term adaptive management to imply flexibility in action, but is actually using it to defer management decisions. NRC (2004) characterized such an approach as follows:

> "In the deferred-action approach, management methods are not changed until ecosystems are fully understood (Walters and Hilborn 1978, Walters and Holling 1990). This approach is cautious but has two notable drawbacks: deferral of management changes may magnify losses, and knowledge acquired by deferred action may reveal little about the response of ecosystems to changes in management. Stakeholder groups or agencies that are opposed to changes in management often are strong proponents of deferred action."

Given the strong evidence that Chinook salmon and steelhead are not rebounding, that flows under the RPA are not improving and that habitat has collapsed in Tomki Creek, alternative courses for perpetuating salmon and steelhead of the upper Eel River need to be explored. At present the delay offers PG& E continuing opportunities for revenue, but the natural capital of upper Eel Pacific salmon populations is nearly exhausted and may be irretrievably and irreversibly lost in the near future due to lack of prompt action.

A requirement of successful application of adaptive management is also complete sharing of data, including raw data. NMFS (2002) requested that PG&E post a website for sharing PVP information with agencies, tribes and the public and yet only a minimal amount of flow data (3 years) and no temperature or fish data are posted. As noted above, data are shared in paper not electronic and datasets that are shared in electronic are not easily useable because of formatting (spreadsheets versus large databases). Flow data related to Pillsbury Reservoir inflows and temperatures above the PVP are critical data gaps that PG&E seems to have no desire to fill.

Data reported by PG&E (2008) on flows have major discrepancies versus those reported on the CDEC website (Table 2) and it calls data reliability into question.

Table 2. Start dates and end dates, duration (Days) and maximum flows (PGE Max) are from PG&E (2008) and these dates and values are contrasted with CDEC gage data for Cape Horn Dam downloaded from the Internet.

Start Date	End Date	Real Peak	Days	PGE Max	CDEC_Max
10/19/2007	10/21/2007	10/19/2007	2	164	75
12/2/2007	12/5/2007	12/7/2007	3	592	243
12/18/2007	12/19/2007	12/18/2007	1	526	320
12/20/2007	12/22/2007	12/20/2007	2	1011	614
1/4/2008	1/7/2008	1/4/2008	3	3732	1780
1/13/2008	1/16/2008	1/13/2008	3	3439	1046
1/26/2008	1/27/2008	1/26/2008	1	5380	2433
1/28/2008	1/30/2008	1/28/2008	2	5970	2532
2/3/2008	2/5/2008	2/3/2008	2	10380	4704
2/24/2008	3/2/2008	2/25/2007	7	6483	4532

This photo shows the East Fork Russian River above Lake Mendocino with swimmers and sun bathers enjoying flows that are actually a result of Eel River diversion. Picture taken by Patrick Higgins. July 13, 2003.

This photo shows the mainstem Eel River being joined by Outlet Creek at left. Picture by Patrick Higgins, October 1996.

References

Baltz, D.M., B.Vondracek, L.R. Brown, and P.B. Moyle. 1987. Influence of temperature on microhabitat choice by fishes in a California stream. Transactions of the American Fisheries Society 116:12-20.

Bjornn, T.C. and N. Homer. 1980. Biological criteria for classification of Pacific salmon and steelhead as threatened or endangered under the Endangered Species Act. Report to National Marine Fisheries Service, Seattle, WA.

Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D. L. Bottom, W.E. Weaver and R. L. Beschta. 1995 Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Pacific Salmon. Published by Pacific Rivers Council, Eugene, OR. 56 p. Available online at: www.krisweb.com/biblio/gen_xxxx_bradburyetal_1995.pdf

Brown, L.R. and P.B. Moyle. 1991. Eel River Survey: Final Report. Department of Fish and Wildlife, University of California, Davis. Contract F-46-R-2 for the California Department of Fish and Game. U.C. Davis Dept. of Fisheries and Wildlife, Davis, CA. 74 p.

Brown, L.R., and P.B. Moyle. 1991a. Changes in Habitat and Microhabitat Partitioning within an Assemblage of Stream Fishes in Response to Predation by Sacramento Squawfish (Ptychocheilus grandis). Can. J. Fish. Aquat. Sci. 48,. 849-856.

Brown, L.R. and P.B. Moyle. 1991. Status of Coho Salmon in California. Report to the National Marine Fisheries Service. Department of Wildlife and Fisheries Biology University of California Davis, CA. 89 p.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management 14(2):237-261.

Brown, L.R., and P.B. Moyle. 1997. Invading species in the Eel River, California: successes, failures, and relationships with resident species. Environmental Biology of Fishes 49. 21pp

California Department of Fish and Game (CDFG). 2002. Status Review of California Coho Salmon North of San Francisco . Report to the California Fish and Game Commission. California Department of Fish and Game, Sacramento , CA. 336pp.

California Department of Fish and Game. 2004. Recovery strategy for California coho salmon. Report to the California Fish and Game Commission. 594 pp. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Sacramento, CA. 594 p.

California Department of Fish and Game (CDFG). 2009. Eel River adult Chinook salmon and coho salmon spawning survey data 2002-2008. California Department of Fish and Game, Fortuna, CA. Excel spreadsheet shared with FOER.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

Dale, V.H., F.J. Swanson and C.M. Crisafulli (eds). 2005. Ecological Responses to the 1980 Eruption of Mount Saint Helens. Springer Press. 291 p.

Dettman, D.H. 1976. Distribution, abundance, and microhabitat segregation of rainbow trout and Sacramento squawfish in Deer Creek, California. M.S. thesis, University of California, Davis.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.

Friedrichsen, G. 1998. Eel River water quality monitoring project. Final report. Submitted to State Water Quality Control Board, for 205(J) Contract #5-029-250-2. Humboldt County Resources Conservation District. Eureka, CA. 76 pp.

Friedrichsen, G. 1999. Eel River water quality monitoring project: 1999 Interim Report. Submitted to the California Association of Resource Conservation Districts. Humboldt County Resources Conservation District. Eureka, CA. 15 pp.

Friedrichsen, G. 2001. Eel River water quality monitoring project: Final Report 1999-2001. Submitted to the California Association of Resource Conservation Districts. Humboldt County Resources Conservation District. Eureka, CA. 33 pp.

Friedrichsen, G. 2003. Eel River Baseline Temperature Final Report. Performed for the California Department of Fish and Game under Agreement No. P0110546. Humboldt County Resources Conservation District. Eureka, CA. 32 pp.

Gilpin, M.E. and M.E. Soule. 1990. Minimum Viable Population: Processes of Extinction. In M. Soule (ed.), Conservation Biology: The Science of Scarcity and Diversity, Univ. of Michigan Press, p. 13-36.

Good, T. P., R. S. Waples and P. B. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-66. 598 pp.

Grass. A. 1993. Annual Report Van Arsdale Fisheries Station, 1991-92. California Department of Fish and Game, Administrative Report 93-6. Region 3, Yountville, CA. 10 p.

Grass. A. 1995. Annual Report Van Arsdale Fisheries Station, 1993-94. California Department of Fish and Game, Administrative Report 95-5. Region 3, Yountville, CA. 12 p.

Groot, C. and L. Margolis. 1991. Pacific Salmon Life histories. University of British Columbia Press, Vancouver, BC. 564 p.

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

Harvey, B.C. and R.J. Nakamoto. 1999. Diel and seasonal movements by adult Sacramento pikeminnow (Ptychocheilus grandis) in the Eel River, northwestern California. Ecology of Freshwater Fish 1999: 8: 209-215.

Harvey, Bret C., Jason L. White, and Rodney J. Nakamoto. 2002. Habitat relationships and larval drift of native and nonindigenous fishes in neighboring tributaries of a coastal California river. Transactions of the American Fisheries Society 131: 159-170.

Higgins, P.T., S. Dobush, and D. Fuller. 1992. Factors in Northern California Threatening Stocks with Extinction. Humboldt Chapter of American Fisheries Society. Arcata, CA. 25 p.

Higgins, P.T. 1991. Habitat Types of the Eel River Estuary and Their Associated Fishes and Invertebrates. In: C. Roberts (ed.) Report on Fish and Wildlife Species of the Eel Delta. Funded by Eel River RCD, USDA Soil Conservation Service, Eureka, CA.

Higgins, P.T. 2003. Fisheries Element of Streeter and String Creek Restoration Assessment. Prepared for the Mendocino Co. RCD with funding from the CARCD. Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 19 p.

Higgins, P.T. 2007. Comments on Van Duzen River and Yager Creek Sediment TMDL with Recommendations for Implementation Action and Monitoring. Performed for Van Duzen Watershed Project & Friends of Eel River with funding from California State Water Resources Control Board. By Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 55p.

Higgins, P.T. 2009. Comments on Proposed Threatened and Impaired Watershed Rules. Prepared for the Center for Biodiversity, San Francisco, CA, by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 35 p.

Holling, C.S., ed. 1978. Adaptive Environmental Assessment and Management. Wiley & Sons, New York, New York.

Keiffer, R. 1983. Tomki Watershed History: An Interview with Donald and Ronald Graf, life long Mendocino County resident. Recorded February 14, 1983. 7 p.

Kier Associates. 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program. Klamath River Basin Fisheries Task Force. Yreka, CA.

Kier Associates. 1999. Mid-term evaluation of the Klamath River Basin Fisheries Restoration Program. Sausalito, CA . Prepared for the Klamath River Basin Fisheries Task Force. 303 pp.

Kier Associates and National Marine Fisheries Service (NMFS). 2008. Updated Guide to Reference Values used in the Southern Oregon / Northern California Coho Salmon Recovery Conservation Action Planning (CAP) Workbook. Kier Associates, Blue Lake, CA and National Marine Fisheries Service, Arcata, CA. 31 pp.

Kubicek, P.F. 1977. Summer water temperature conditions in the Eel River system with reference to trout and salmon. Masters thesis, Humboldt State University, Arcata, Ca.

Lichatowich, J.A. and J.D. McIntyre. 1987. Use of hatcheries in the management of Pacific anadromous salmonids. American Fisheries Society Symposium, Volume 1: 131-136.

Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, L.W. Botsford, , D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells, T. H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council, Portland, OR. 57 p.

McCullough, D. 1999. A Review and Synthesis of Effects of Alterations to the Water Temperature Regime on Freshwater Life Stages of Salmonids, with Special Reference to Chinook Salmon. Columbia Intertribal Fisheries Commission, Portland, OR. Prepared for the U.S. Environmental Protection Agency Region 10. Published as EPA 910-R-99-010.

Mendocino National Forest (MNF). 1995. Mendocino National Forest Land Management Plan. MNF, Willows, CA.

Montgomery, D. R. and J.M. Buffington, 1993. Channel classification, prediction of channel response, and assessment of channel condition. TFW-SH10-93-002. Prepared for the SHAMW committee of the Washington State Timber/Fish/Wildlife Agreement. Seattle, WA. 110 pp.

Morford, M. 1982. Tomki Creek History: Interview with Mr. Herman Sagehorn, life long Tomki Creek resident. Recorded March 29, 1982. 8 p.

Moyle, P.B., J. A. Israel, and S. E. Purdy. 2008. Salmon, Steelhead, and Trout in California: Status of an Embelmatic Fauna. Commissioned by California Trout. 316 pp.

Moyle, P.B. 2002. Inland fishes of California. University of California Press, Berkeley, California.

Moyle, P.B., R.M. Yoshiyama, J.E. Williams and E.D. Wikramanayake. 1995. Fish Species of Special Concern. Second edition. Performed under contract to California Department of Fish and Game. Department of Wildlife and Fisheries Biology, U.C. Davis, CA. 277 p.

Murphy, G.I. and J.W. Dewitt. 1951. Notes on the fishes and fisheries of the lower Eel River, Humboldt County, California. Calif. Dept. Fish and Game, Admin. Rept. 51-9. 28 pp.

National Academy of Science (NAS). 2004. Endangered and threatened fishes in the Klamath River basin: causes of decline and strategies for recovery. Committee on endangered and threatened fishes in the Klamath River Basin, Board of Environmental Toxicology, Division on Earth and Life Studies, Washington D.C. 424 pp.

National Marine Fisheries Service. 2001. Status Review Update for Coho Salmon (Oncorhynchus kisutch) from the Central California Coast and the California portion of the Southern Oregon/Northern California Coasts Evolutionarily Significant Units. Southwest Fisheries Science Center, Santa Cruz, CA. 43 p.

National Marine Fisheries Service. 2002. Endangered Species Sct Section 7 Consultation Biological Opinion for the Proposed License Amendment for the Potter Valley Project (FERC Project #77-110). Issued for Federal Energy Regulatory Commission on 11/26/02 by NOAA NMFS Southwest Region, Long Beach, CA. 140 p.

National Marine Fisheries Service. 2008a. Biological Opinion for ESA Section 7 Consultation on Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed. NMFS, Santa Rosa, CA. 386 p.

Nehlsen, W., J.E. Williams, J.A.Lichatowich. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

Northwest Power Planning Council (NWPPC). 2004. Pikeminnow. Volume III, Chapter 5 in Lower Columbia Basin Plan, Technical Foundation section. NWPPC, Portland, OR. 23 p.

Pacific Gas and Electric (PG&E). 1998. Article 39 Joint Recommendation, developed by PG&E, California Department of Fish and Game, U.S. Fish and Wildlife Service, National Marine Fisheries Service. March 30, 1998. PD&E, San Ramone, CA.

Pacific Gas and Electric (PG&E). 2001. Modification to the Potter Valley Irrigation District (PVID) and PG&E Potter Valley Proposal (PVP), FERC Permit No. 77-110. June 2001. PG&E, San Francisco, CA.

Pacific Gas and Electric (PG&E). 2005. Potter Valley Project (FERC No. 77) Annual Data Report on Reasonable and Prudent Measures (RPM) 1,2,8 & License Article 52(b), 53, 57. Provided to Magalie R. Salas, FERC, Washington DC on 6/29/06 by PG&E, San Francisco, CA. 299 p.

Pacific Gas and Electric (PG&E). 2006. Potter Valley Project (FERC No. 77-181) Annual Performance Monitoring Report License Article 52. Provided to Magalie R. Salas, FERC, Washington DC on 8/27/07 by PG&E, San Francisco, CA. 55 p.

Pacific Gas and Electric (PG&E). 2007. Potter Valley Project (FERC No. 77-181) Annual Performance Monitoring Report License Article 52. Provided to Magalie R. Salas, FERC, Washington DC on 8/18/08 by PG&E, San Francisco, CA. 56 p.

Pacific Gas and Electric (PG&E). 2008. Potter Valley Project (FERC No. 77-181) Annual Performance Monitoring Report License Article 52. Provided to Magalie R. Salas, FERC, Washington DC on 8/25/09 by PG&E, San Francisco, CA. 55 p.

Poole, G.C., and C.H. Berman. 2000. Pathways of Human Influence on Water Temperature Dynamics in Stream Channels. U.S. Environmental Protection Agency, Region 10. Seattle, WA. 20 p.

Puckett, L.E. 1975. The status of spring-run steelhead (Salmo gairderi) of the Eel River system. Calif. Dept. Fish and Game Memo. Rep. 22 pp.

Puckett, L.K. 1976. Observations on the downstream migrations of anadromous fishes within the Eel River system. Calif. Dept. Fish and Game Memorandum Report. 34 pp.

Puckett, L.K. 1977. The Eel River estuary – observations on morphometry, fishes, water quality and invertebrates. Calif. Dept. Fish and Game and Dept. of Water Resources Report. 26 pp

Quesenberry, S.V. 2001. Comments on the PVID/PG&E Modified Proposal on FERC Project 77-110, PG&E Potter Valley Project. August 6, 2001 memo to Davvid P. Boergers, Sec. of FERC. CA Indian Legal Services, Oakland, CA. 7 p.

Reeves, G.H., L.E.Benda, K.M.Burnett, P.A.Bisson, and J.R. Sedell. 1995. A Disturbance-Based Ecosystem Approach to Maintaining and Restoring Freshwater Habitats of

Evolutionarily Significant Units of Anadromous Salmonids in the Pacific Northwest. American Fisheries Society Symposium 17:334-349, 1995.

Rieman, B., D. Lee, J. McIntyre, K. Overton, and R. Thurow 1993. Consideration of Extinction Risks for Salmonids. As FHR Currents # 14. US Forest Service, Region 5. Eureka, CA. 12 pp.

Riggs, L. 1990. Principles for genetic conservation and production quality. Northwest Power Planning Council contract no. C90- 005. Portland, OR

Sedell, J. R., P. A. Bisson, E J. Swanson, and S. V. Gregory. 1988. What we know about large trees that fall into streams and rivers. Pages 47-81 in C. Maser, R. F. Tarrant, J. M. Trappe, and J. E Franklin, From the forest to the sea: a story of fallen trees. U.S. Forest Service General Technical Report PNW-GTR-229.

Simon, R. C., J. D. McIntyre, H. Hemminigson. 1986. Family size and effective population size in a hatchery coho salmon population. Canadian Journal of Fisheries and Aquatic Sciences 43: 2434- 2442.

Simon, R. C. 1988. Seven Avenues for Redress of Fish Hatchery Problems Involving Restricted Genetic Variability. Proceedings of the American Fisheries Society Bioenhancement Seminar. Portland, Ore. 102 p.

Southern California Edison (SCE). 2007. Amended Preliminary Draft Environmental Assessment (APDEA) for FERC Project Nos. 2085, 2175, 67 and 120 (Big Creek/SF San Joaquin). 5.2.4 Aquatic Resources. SEC, Rosemead, CA. 18 p. http://www.sce.com/NR/rdonlyres/C86C78B0-F954-47A2-8B42-3AC786FE4F64/0/APDEA_AttachmentH.pdf

Spence , B., E. Bjorkstedt , J.C. Garza , D. Hankin, J. Smith, D. Fuller, W. Jones, R. Macedo, T.H. Williams and E. Mora. 2007. A Framework for Assessing the Viability of Threatened and Endangered Salmon and Steelhead in North-Central California Coast Recovery Domain. Public Review Draft, June 14, 2007. National Marine Fisheries Service SW Science Center, Santa Cruz, CA. 170 p.

SEC (Steiner Environmental Consulting). 1998. Potter Valley Project monitoring program (FERC no. 77, Article 39): Effects of operations on upper Eel River Anadromous Salmonids, March 1998 Final Report. Prepared for Pacific Gas and Electric Company, San Ramon, CA.

Sullivan, K., D. J. Martin, R. D. Cardwell, J. E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute. Portland, OR. 192 pp.

Titus, R. G., D. C. Erman, and W. M. Snider. 2006. History and status of steelhead in California coastal drainages south of San Francisco Bay. In draft for publication as a Department of Fish and Game, Fish Bulletin. 293 p.

U.S. Environmental Protection Agency. 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA Project # 910-B-03-002. Region 10 U.S. EPA, Seattle WA. 57 p.

U.S. Environmental Protection Agency. 2004. Upper Main Eel River and Tributaries (including Tomki Creek, Outlet Creek and Lake Pillsbury) Total Maximum Daily Loads For Temperature and Sediment. U.S. EPA, Region IX, San Francisco, CA. 70 p.

U.S. Forest Service and U.S. Bureau of Land Management. 1995. Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl. Interagency SEIS Team, Portland, OR. 557 p. http://www.fs.fed.us/r6/nwfp.htm

Van Kirk, R. and S. Naiman. 2008. Relative effects of Climate and Water Use on Base-flow Trends in the Lower Klamath Basin. Journal of American Water Resources Association. August 2008. V 44, No. 4, 1034-1052.

VTN Oregon, Inc. 1982. Potter Valley Project (FERC No. 77) Fisheries Study Final Report, Volume 1. Performed under contract to PG&E by VTN Oregon, Inc., Wilsonville, OR. 326 p.

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology [online] 1(2):1. Available from the Internet. URL: http://www.consecol.org/vol1/iss2/art1/

Walters, C.J., and R. Hilborn. 1978. Ecological optimization and adaptive management. Ann. Rev. Ecol. Syst. 8:157-188.

Walters, C.J., and C.S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology 71(6):2060-2068.

Williams, T.H., E.P. Bjorkstedt, W.G. Duffy, D. Hillemeier, G. Kautsky, T.E. Lisle, M. McCain, M. Rode, R.G. Szerlong, R.S. Schick, M.N. Goslin and A. Agrawal. 2006. Historical population structure of coho salmon in the southern Oregon/northern California evolutionarily significant unit. NOAA-TM-NMFS-SWFSC-390. NMFS, Southwest Fisheries Science Center, Santa Cruz, CA. 85 p.

Williams, T.H., B. C. Spence, W. Duffy, D. Hillemeier, G. Kautsky, T. Lisle, M. McCain, T. Nickelson, G. Garman, E. Mora, and T. Pearson. 2008. Framework for assessing viability of threatened coho salmon in the Southern Oregon /Northern California Coast Evolutionarily Significant Unit. NMFS SW Science Center, Santa Cruz, CA. 97 p.

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GUALALA RIVER FLOWS

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Sacramento, CA 94244-2460

Re: Negative Declaration for Sugarloaf Farming Corporation dba Peter Michael Winery, Timberland Conversion No. 524; THP 1-01-223 SON

Dear Mr. Robertson,

I am writing in regards to Timberland Conversion Application 524 and Timber Harvest Plan (THP) 1-01-223 SON in the upper South Fork Gualala River basin at the request of, and on retainer to local citizens, who are concerned about the deterioration of the Gualala River watershed. These comments bear substantial similarity to those which I filed on May 20, 2003 with your office on Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1—01-171 SON, which was nearer Annapolis on Patchet Creek, a tributary to the Wheatfield Fork Gualala (Higgins, 2003). Please review my last correspondence for my qualifications to comment in this regard.

These plans have the same patent flaws as the Annapolis proposal and issuance of a Negative Declaration with regard to environmental effects is again unjustified. As stated in my last comments, there is potential for irreversible and irretrievable loss of cold water habitat in the Gualala basin, including in this case the South Fork Gualala River. The analysis of impacts is fundamentally flawed because it does not focus on the scale of the South Fork Gualala and the Gualala watershed as a whole, which the North Coast Watershed Assessment Program (CRA, 2002) identified has having major cumulative effects problems. The South Fork was until recently one of the more productive Gualala basin salmonid habitats, but has deteriorated in recent years until it is a very impaired aquatic ecosystem even losing surface flows according to the California Department of Forestry's (CDF) own reports. A project with such acknowledged risk to fish, water quality and wildlife (NCRWQCB, 2002; CDFG, 2002) should necessitate a full Environmental Impact Statement under the California Environmental Quality Act.

Fisheries

The environmental review documents submitted by the consultants for this project ignore the regional and in-basin status of coho salmon (Oncorhynchus kisutch) and steelhead trout (Oncorhynchus mykiss). National Marine Fisheries Service (NMFS, 2001), the California Department of Fish and Game (CDFG, 2002) and Brown et al. (1994) have found that coho salmon are at risk of extinction throughout Mendocino and Sonoma County. Coho salmon were known to occur in the South Fork Gualala, according to the California Department of Fish and Game (Cox, 1994; Park and Poole, 1964), yet there are no data or information in the plan as to whether they still persist in this sub-basin. CDFG (CA RA, 2002) surveyed over 100 miles of stream in the Gualala basin and collected fish samples using electroshocking and found no coho salmon anywhere. CDFG (2002) noted that coho salmon were "extirpated or nearly extirpated" in the Gualala. Conditions on the South Fork are already adverse for this species (see Sediment, Temperature) and further impacts related will diminish chances for recovery. The fact that coho salmon are on the verge of extinction should make any additional contributions of sediment from this project unacceptable.

Steelhead trout have also diminished substantially in distribution and abundance in the Gualala River watershed, with tributaries like the lower South Fork Gualala now supporting predominantly the California Roach (Levenia parvipinnis) and stickleback (Gasterosteus aculeatus) instead of juvenile steelhead in some seasons (Figure 1).

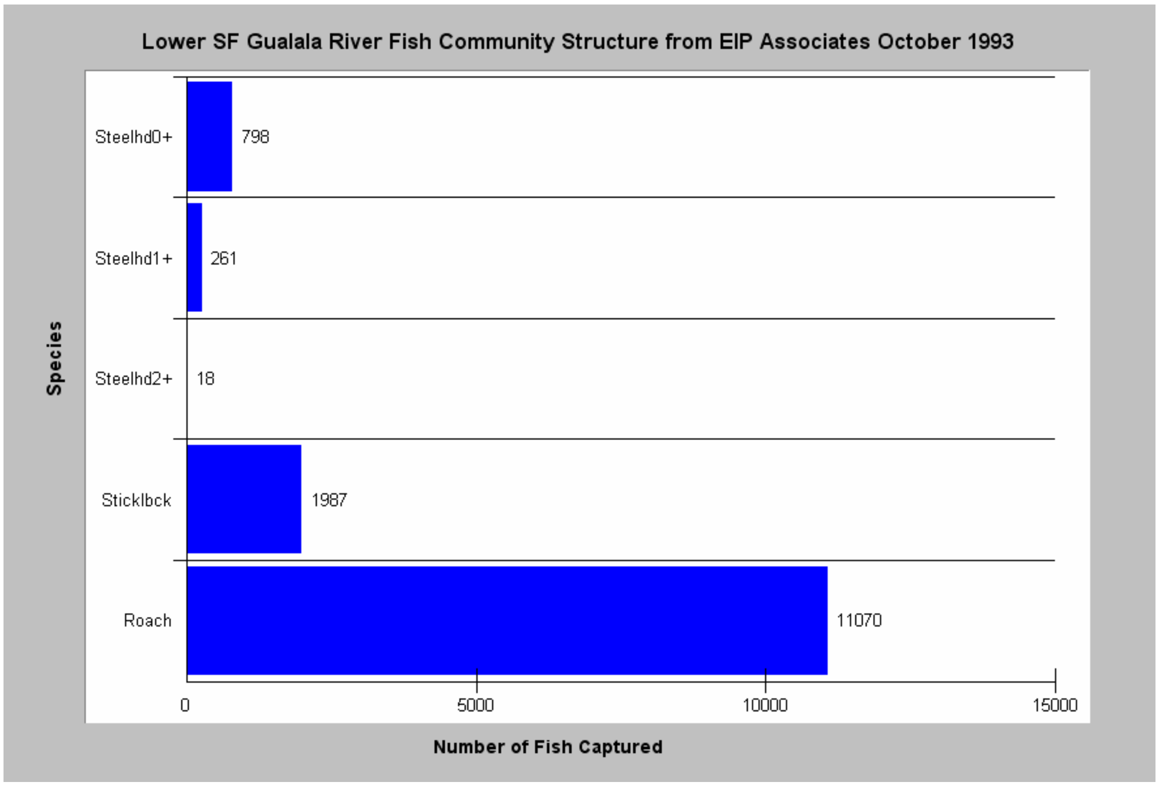

Figure 1. This chart shows results of dive surveys of the Lower South Fork Gualala River below the Wheatfield Fork in October 1993 by EIP Associates. The fish community was dominated by Gualala roach and stickleback with steelhead of several age classes present, but sub-dominant. Data from Gualala Aggregates gravel operation Environmental Impact Statement (EIS).

The fish community found by EIP Associates (1994) strongly suggests that the South Fork Gualala is compromised by elevated water temperatures. The lower South Fork has continued to deteriorate since that time and the South Fork at its convergence with the Wheatfield Fork now loses surface flows for much of the summer (CDF, 2002); therefore, periodically has no ability to support fish life of any kind (see Flow Issues).

The acute aggradation of the Gualala River mainstem reaches has shifted the ecology of the river substantially. CDFG (CA RA, 2003) electrofishing samples from the 100 miles surveyed in 2001 did not include the Sacramento sucker (Catostomus occidentalis). The absence of suckers in the Gualala River in all recent surveys is likely indicative of a major decline in their population, if not their wholesale disappearance. This fish is somewhat tolerant of sediment and very tolerant of warm water. Consequently, the Gualala River is well outside its normal range of variability with regards to its ability to support its native aquatic community. If corrective actions are not taken with regard to sediment abatement and flow preservation, more of the Gualala River channel can be expected to go dry causing further impacts to the already imperiled fish community. This project will exacerbate both problems.

No fish data on the reaches potentially impacted was supplied with the plans, which makes them inadequate under CEQA.

Temperature

The lower mainstem and South Fork Gualala River have acutely stressful temperatures for salmonids in most mainstem habitats (Figure 2). Suitable habitat for coho salmon with regard to temperature is found only in small tributaries like Big (bpw) and Little (lpw) Pepperwood Creek, the upper reach of McKenzie Creek (mck) and two second order tributaries of the South Fork (gh250, gh277). Floating weekly average water temperatures of less than 16.8^0 Celsius (C) are needed to support rearing coho salmon juveniles, according to Welsh et al. (2001). They refer to the maximum annual floating weekly average water temperature as MWAT. Mainstem stations on the South Fork (sf) and lower mainstem Gualala are not only too warm for coho salmon but indicate that limits for steelhead are being reached. The floating weekly average temperature masks transient peaks and an MWAT of over 22^0 C is likely reaching day time highs of over 25^0 C, which is recognized as incipient lethal for Pacific salmon species (Sullivan et al., 2000).

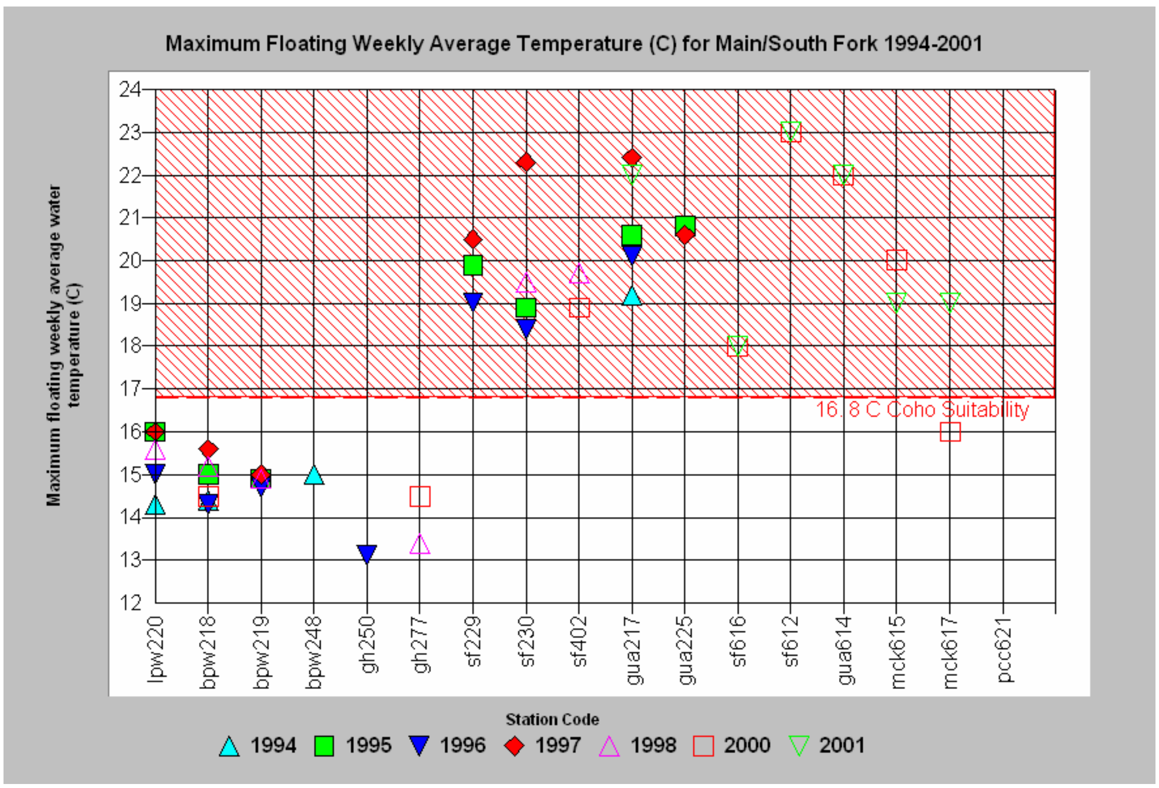

Figure 2. This chart shows the maximum floating weekly average water temperature (MWAT) for all automated temperature probes placed in the lower mainstem and South Fork Gualala River sub-basins from 1994 to 2001. Station location codes are pw = Big Pepperwood Creek, sf = South Fork Gualala River, gua = mainstem Gualala, mck = McKenzie Creek, and gh = lower mainstem tribs. Data provided by Gualala Redwoods, Inc. and the Gualala River Watershed Council.

Of particular interest in Figure 2 is mainstem Gualala River station (gua 217). This station shows a continuing pattern of increasing water temperature between 1994 and 2001. These years also coincide with very high rainfall following a prolonged drought (1986-1994). The pattern would be consistent with major aggradation at this location with the change in the width to depth ratio of the stream here driving increased heat exchange with the atmosphere (Poole and Berman, 2001). The South Fork itself is sufficiently cool at its headwaters above the proposed project to support coho and steelhead trout

(Figure 3), but is too warm for coho and stressful for steelhead in the South Fork further downstream, it's tributary McKenzie Creek and in the lower mainstem Gualala River.

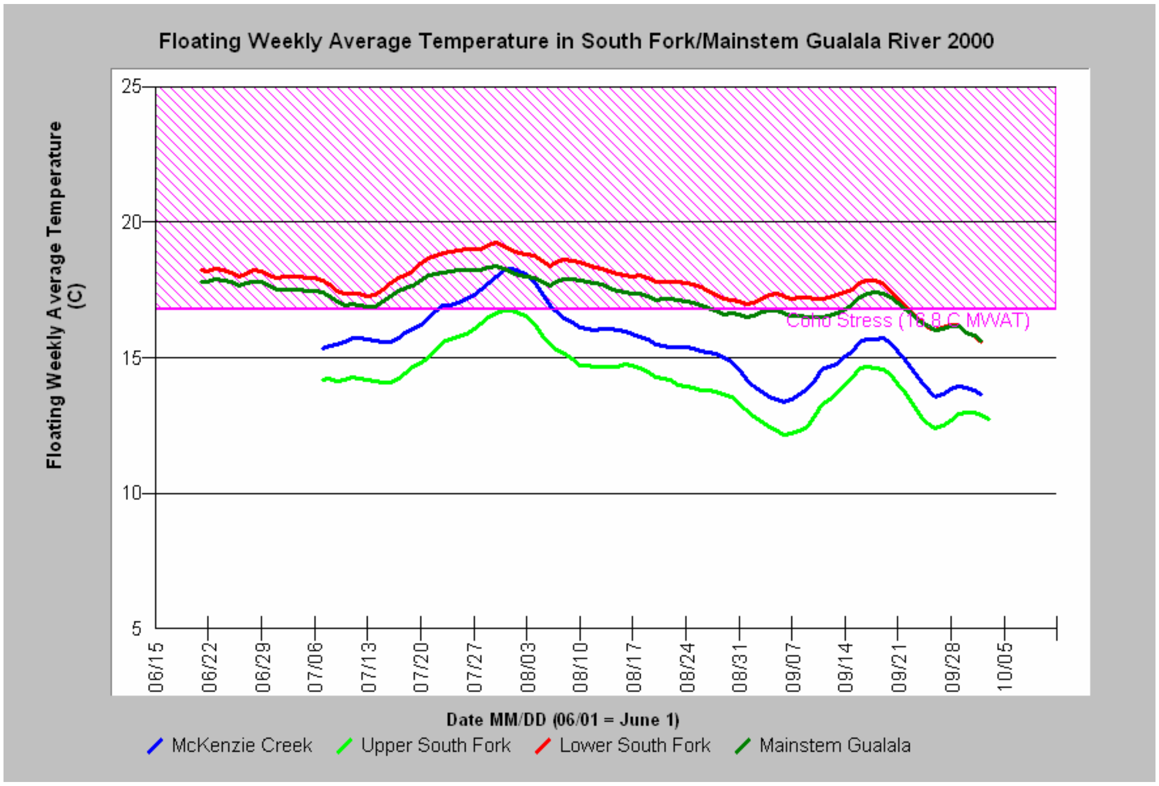

Figure 3. This chart shows the floating weekly average temperature at four sites on the South Fork, its tributary MacKenzie Creek and the lower mainstem Gualala River taken in 2000. Data were provided by the Gualala River Watershed Council.

The proposed project will likely exacerbate water temperature problems in two ways: 1) additional sediment contributions that fill pools and increase the width to depth ratio (see Sediment), and 2) reduced cool water base flows in summer because of how the project will block groundwater recharge (see Flows).

Sediment

The Gualala River watershed is listed as impaired for sediment under section 303(d) of the Federal Clean Water Act, which precipitated the *Technical Support Document for the Gualala River Watershed Water Quality Attainment Action Plan for Sediment* (CWQCB, 2001). This study found that human caused sediment delivery rates are approximately 200% above the natural background rates in the SF Gualala basin (Figure 4), with 190 tons per square mile per year (tons/mi^2/yr) the background value. Documents associated with the plans note that Northwest Hydraulics Consultants established two suspended sediment monitoring sites in streams within the project area in winter 2000 and estimated that between February 24, 2000 and March 1, 2000, when a total of 5.82 inches of rain was recorded nearby, 470 tons per square mile (tons/mi2) were unleashed. This indicates that sediment measured by this one event produced greater sediment yield than expected for the entire year by the Gualala TMDL (CWRCB, 2001).

The geologic setting of the South Fork Gualala River is problematic for the project because it is located nearly on the San Andreas Fault. The bedrock underlying the THP area is marine sediment consisting mostly of sandstone and mélange shale of the Franciscan Complex. Huffman and

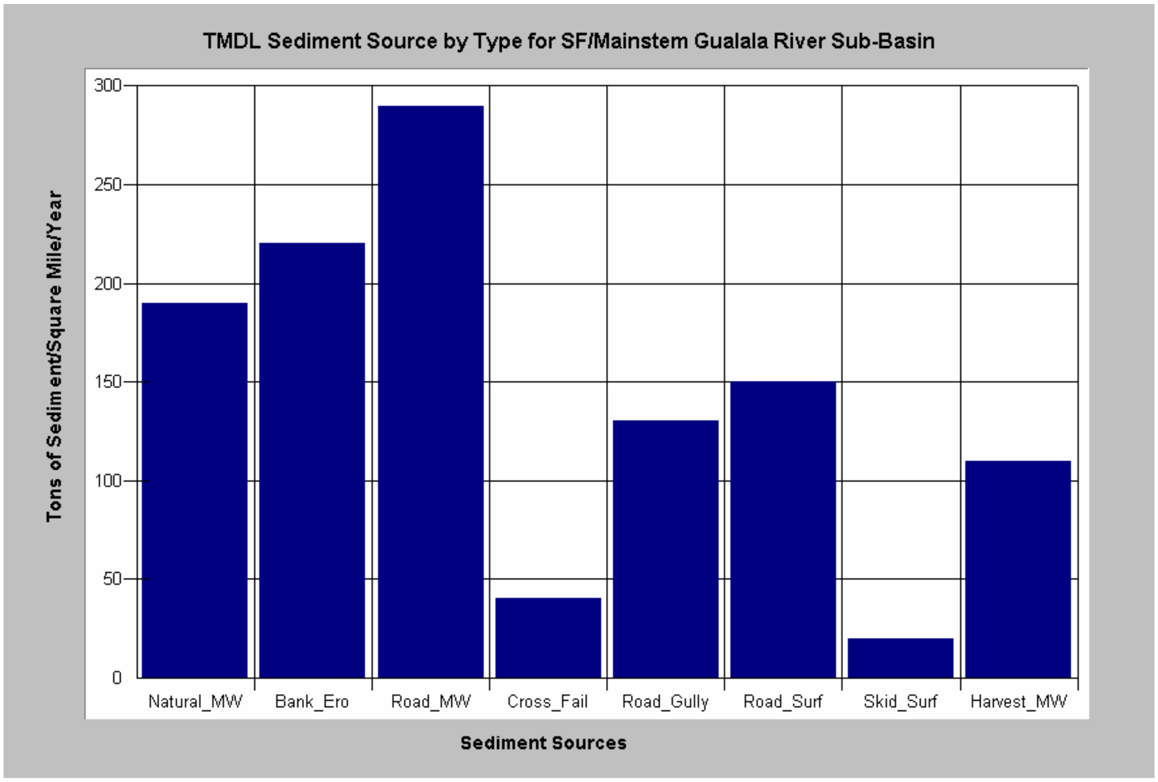

Figure 4. The South Fork Gualala basin sources of sediment estimated by the CWRCB (2001). Road sources had the highest sediment yield in combination. Estimated sediment yield is shown as tons of sediment yielded per square mile per year.

Armstrong (1980) classified the area as "relatively unstable rock and soil units, on slopes grater than 15%, containing abundant landslides" and the proposed project crosses slopes steeper than this. Additionally, several relatively recently active small-scale landslides were mapped in the THP area, many related to poor site drainage and poor road and skid trail construction from past site entries (CDMG, 2002).

Ground movement of up to twelve feet was measured in association with the 1906 earthquake in the South Fork Gualala basin (Huffman, 1972). Nouakchott (1980) noted other effects of the event: "East of Stewart's Point the bridge over the South Fork Gualala River was damaged by slumping of the river terrace on which its south end rests. On both sides of the sharp bend of the river east of the bridges are extensive landslides, making a clean sweep down the mountainside…..The slopes east of the river (near Casey's Ranch) were similarly effected and fallen timber produced a tangle not unlike that of extensive windfalls. In at least two places the (South Fork Gualala) river was temporarily dammed up by slides from both slopes meeting in the stream-bed." The pond associated with this project poses an unacceptable risk of failure in the event of a large earthquake with likely catastrophic sediment yield to the South Fork Gualala River.

Roads are the most significant contributor of sediment in the South Fork and basin-wide (CWQCB, 2001) and road densities in the Gualala River watershed over-all are high, including the lower mainstem and South Fork sub-basins (Figure 5). Road densities in the Upper South Fork Gualala as of 2000 were 3.9 miles per square mile (mi/mi^2) and exceed the threshold of 3 mi/mi^2 established by NMFS (1996) for a properly functioning watershed condition. Cedarholm, et. al. (1981) found that road densities greater than 1.5 mi/mi^2 yielded sediment levels that compromised the success of salmonid spawning. The current conversion and THP proposes to increase the road density in the Upper South Fork Gualala basin by connecting and reconstructing old roads, providing approximately 8,000 linear feet of new actively used road. The new road will increase sediment delivery by

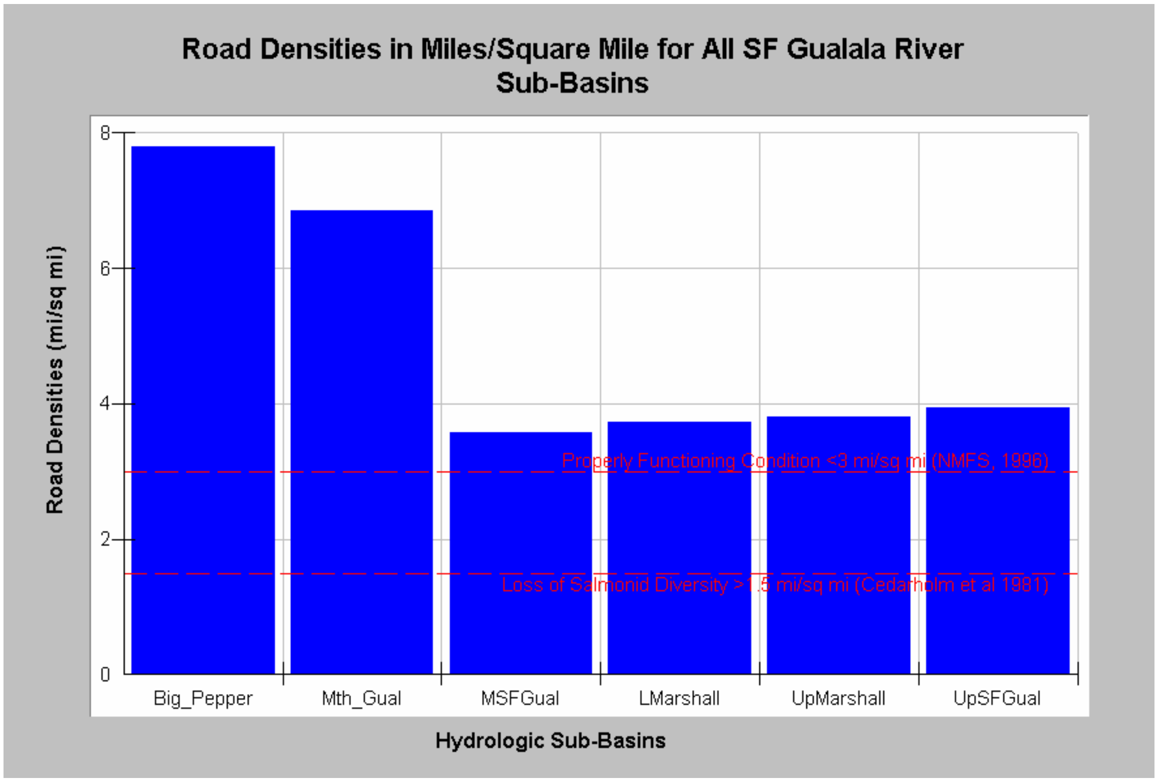

Figure 5. The Chart above shows the density of roads in miles per square mile for South Fork Gualala Calwater Planning Watershed with references based on NMFS (1996) and Cedarholm, et. al. (1981). Data from UC Davis ICE and North Coast Regional Water Quality Control Board.

channeling flow and bank cut, road fill, and surface erosion (RWQCB, 2002). The road density data under-represent actual problems with compaction of soils. They do not include landings, temporary roads and skid trails. The proposed alignment crosses steep and unstable slopes, active slides and 17 watercourses (Class II and III), many that flow through unstable areas (CDMG, 2002). These roads will yield sediment regardless of mitigation and additional sediment contributions to the South Fork Gualala and lower mainstem should not be allowed at this time because of major problems with aggradation.

The most obvious manifestation of sediment over-supply, however, is the fact that South Fork Gualala River is so aggraded that it loses surface flow for much of the summer at its mouth and in upstream reaches. Figure 6 shows the highly aggraded South Fork at its convergence with the Wheatfield Fork Gualala River in early April 2002. The photo shows a very narrow wetted channel and a wide and open and gravel bar. CDF (2002) noted that the mainstem South Fork was underground in summer in comments on a proposed riparian timber harvest (see Flow Issues).

The aggraded gravel beds of the mainstem Gualala and its larger tributaries have very small median particle size (D50) distribution. Small D50 indicate recent contributions of sediment from upslope areas (Dietrich et al., 1989) and samples from the lower mainstem and South Fork Gualala show many sites with similarly small D50 (Figure 7). Knopp (1993) studied 60 north coast California watersheds and found that watersheds with high timber harvest management had a D50 of less than 37 mm, but that recovered or control watersheds had a D50 between 50-88 mm. Nawa et al. (1991) noted that small average particle size distribution in salmonid spawning streams lead to bed load mobility and very low spawning survival rates. The small D50 indicates very degraded spawning habitat conditions for salmonids at most locations.

Figure 6. South Fork Gualala as it joins the Wheatfield Fork Gualala River with a very large sediment plug visible at left. The stream lost surface flow here several months later. Photo by Pat Higgins, April 10, 2002.

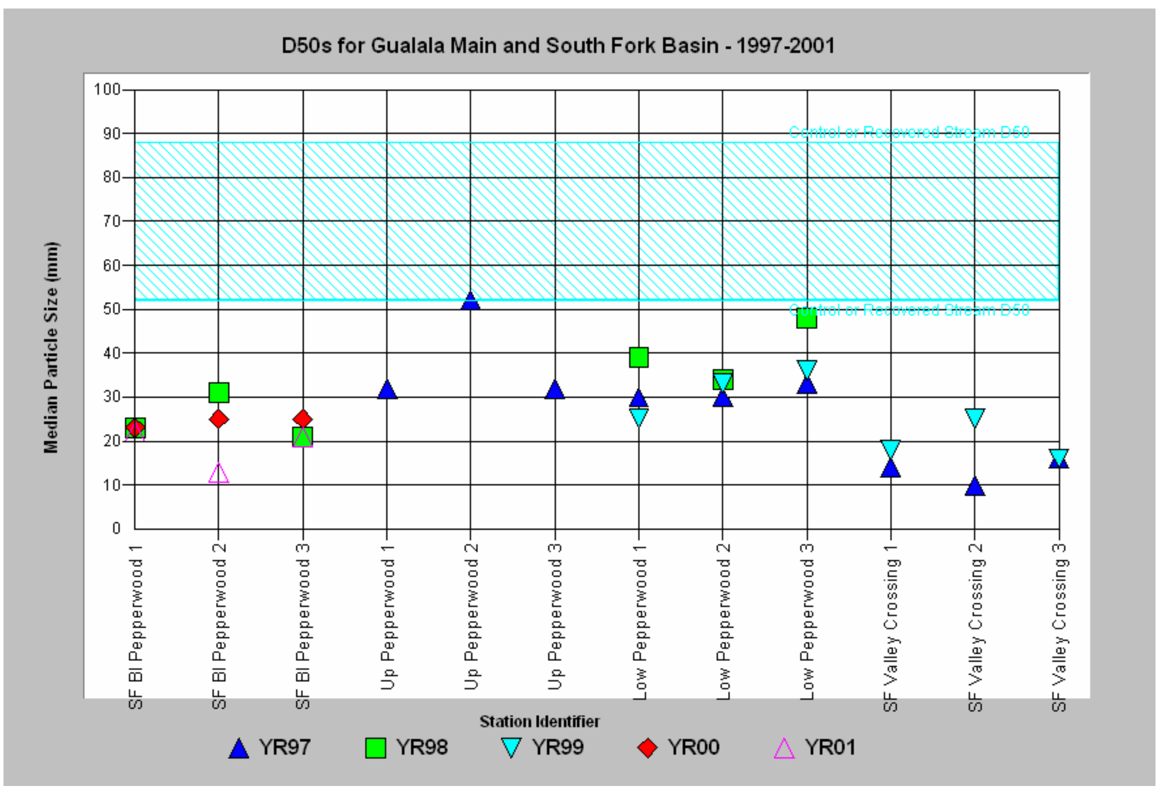

Figure 7. The median particle size distribution of the streambed on the lower SF Gualala River and Big and Little Pepperwood Creek are displayed above with a reference line representative of control or recovered watersheds (40 years rest) from Knopp (1993). Data provided by Gualala Redwoods Inc.

The condition of the South Fork Gualala near the project site is also not fully revealed in project planning documents. Figure 8 shows the South Fork Gualala River at Niestrath Road from a picture taken by NCRWQCB staff. Note the fine sediment on the terraces which indicate that soil loss is already occurring in other upland areas of the South Fork Gualala. Sediment in this size class is highly mobile and would be flushed downstream and replaced by gravels if there was not a high supply from current sources.

Figure 8. The South Fork Gualala River at Niestrath Road on February 13, 2001. Picture provided by Brian McFadden, North Coast Regional Water Quality Control Board.

There are fundamental flaws in the way that planning documents for this conversion and timber harvest calculate sediment yield. Northwest Hydraulics Consultants (2000) and Jones and Stokes (2003) derived theoretical pre- and post-project sediment yields that the proposed vineyard development would actually reduce sediment inputs to South Fork Gualala. Estimates used a number of generalized empirical methods including the Revised Universal Soil Loss Equation (RUSLE), Modified Universal Soil Loss Equation (MUSLE), and the Pacific Southwest Inter-Agency Method (PSIAC). None of the above methods were designed to be applicable to Pacific Northwest Coastal mountain areas (USDA, 1997). For example, the USLE methods were both developed for computing soil loss on gentle slopes in the Mid-western United. These equations contain a large factor of error for steep and irregular slopes. The PSIAC method was developed in the arid Southwest Mountain regions that contain thin erodible soils and alluvial fan topography (PSIAC, 1968). The sediment yield is actually likely to be much higher than estimated, possibly orders of magnitude given the other local site conditions described above.

Timber Harvest and Cumulative Watershed Effects

Timber harvest rates in Gualala River Calwater Planning Watersheds between 1991 and 2001 show that some sub-basins have been harvested at rates as high as 78% (Figure 9). Reeves et al. (1993) aquatic habitat diversity and loss of diversity of Pacific salmon species. CDFG (CA RA, 2001) habitat typing data showed that pool frequency by length was low in recently harvested basins, a result similar to that described by Reeves et al. (1993). High harvest rates in basins like lower Rockpile and Big Pepperwood Creek have caused sediment evulsions that are combining with sediment from other sub-basins. The over-supply below Pepperwood Creek in recent years has caused a loss of surface flow (see below). The plans for this timber harvest and conversion also do not discuss cumulative effects of extensive, recent, riparian timber harvests along the lower South Fork Gualala (Figure 10). Kauffman et al. (1999) point out that riparian areas and watersheds can only recover when anthropogenic stressors are ameliorated. This conversion and timber harvest is particularly ill-timed because of the already widespread nature of watershed disturbance from timber harvest and roads at this time.

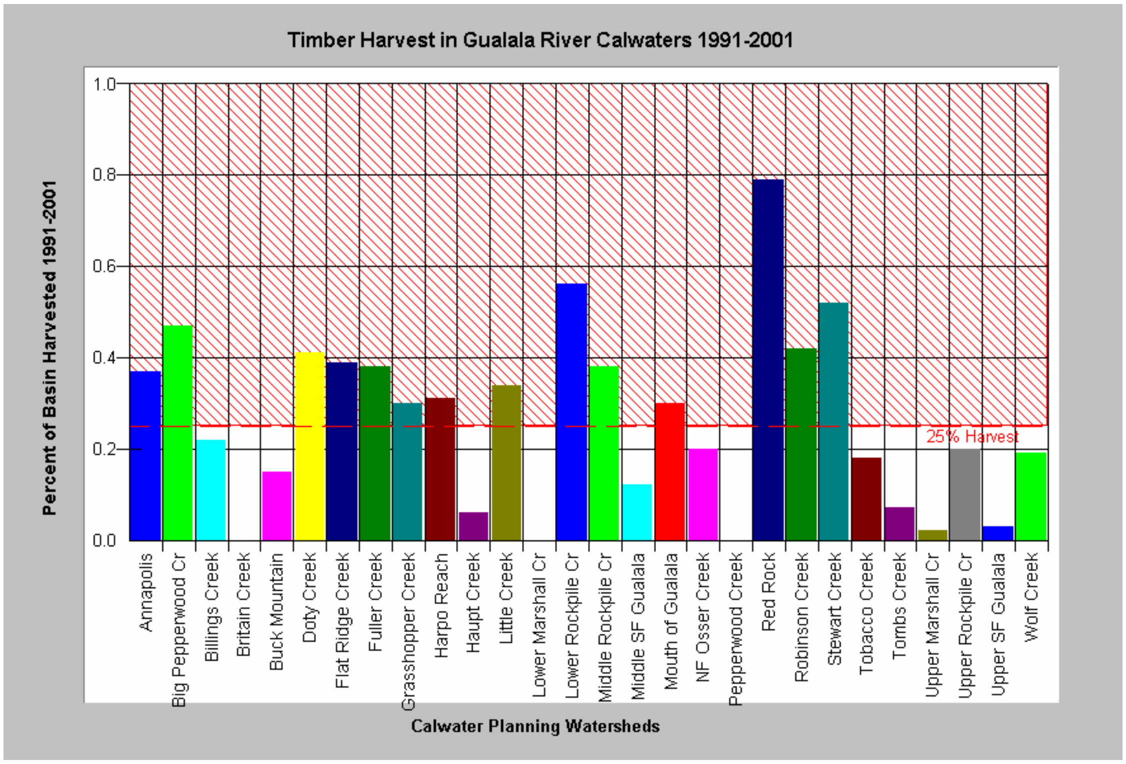

Figure 9. The timber harvest in all Gualala River Calwater Planning Watersheds is shown above as percentage of watershed area. Half of the basins are more than 25% cut in just over ten years. Data from CDF, Santa Rosa.

Conversion Plan 524 and THP 1-01-223 SON and background documents provided do not adequately discuss cumulative effects from previous logging and their effects on landscape stability (NCRWQCB, 2002). Past timber harvest and roads have initiated landslides that may be activated by re-entry. Huffman (1972) in studies of the Gualala basin noted that landslides, once initiated, “influence surrounding terrain by removing support as they move downslope”. These antecedent conditions make it highly unlikely that erosion control measures will succeed and instead substantial contributions of sediment are likely to occur.

Flow Issues

The hydrologic review of this project is not credible when it states winter flows will not increase and summer flows will not decrease when this plan is implemented. Many natural seeps and wet areas within the conversion will be rocked, piped and covered with soil. Kamman Hydrology and Engineering (2003) studied a similar setting in the Gualala basin where a conversion was planned and asserted that similar activities to those proposed in this project would block infiltration into ground water in headwater swales. Cool water base flows in summer are important for maintaining steelhead and recovering coho salmon in the South Fork Gualala River and it is likely that this activity will reduce those flows at a time when the lower mainstem Gualala, South Fork and other major tributaries are severely flow limited.

The California Department of Water Resources (CA RA, 2002) indicated that aggradation had decreased water supply in the Gualala River basin, particularly the lower Gualala River and estuary. CDFG 2001 habitat typing surveys (CA RA, 2001) found that extensive reaches of the Gualala River and its tributaries lacked surface flows, including the mainstem South Fork Gualala below Big Pepperwood Creek (Figure 11). CDFG found flows of 12.5 cfs in this reach in 1977, during an extreme drought (Barrocco and Boccione, 1977). The Wheatfield and upper South Fork contributed three cfs, the North Fork 4.3 cfs, and five cfs came from Buckeye, Rockpile and Big Pepperwood creeks. In 2001, the Wheatfield Fork, upper South Fork and Rockpile were subsurface at, or near, their mouths. Fort Ross rainfall records indicate that only 16.01 inches of rain fell in 1977 while 24.56 fell in 2001. Even if the loss of flow is in part due to increased flow diversion, the mainstem environments of the Gualala are severely impaired. Any additional flow diversions or reductions, such as those likely to occur under Timberland Conversion No. 524; THP 1-01-223 SON, should require a full scale EIS under CEQA due to extremely low flow conditions that currently prevail. While the reduction in flow will likely have negative impacts on salmonids, further flow depletion is also likely to further impact other beneficial uses as well, such as swimming and/or boating.

Leopold and McBain (1995) also pointed out that wide spread compaction related to timber harvest in the Garcia River basin elevated winter runoff as well (Leopold and McBain, 1995). The overall extent of compaction in the watershed and changes in flow basin wide should be considered along with changes in hydrology at the specific site of this conversion and timber harvest.

Figure 10. The South Fork Gualala River winds around a Gualala Redwoods Inc. clear-cut. This is one of many patch clear-cuts that add to problems elevated water temperature and high sediment yield.

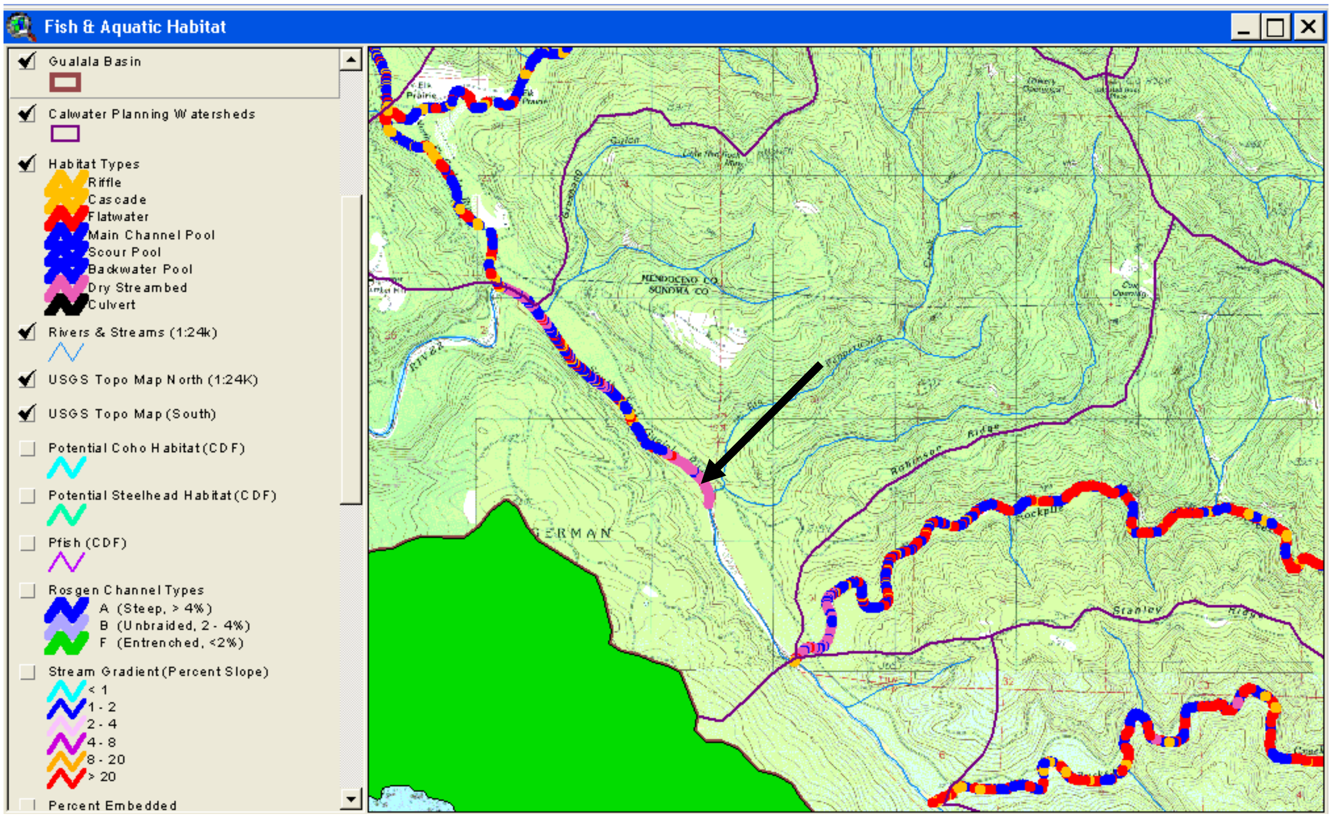

Figure 11. This habitat typing map of CDFG 2001 results (CA RA, 2001) show that the mainstem of the lower South Fork went dry below Big Pepperwood Creek in September 2001, as indicated by the hot pink designation where the arrow is pointing. Rockpile Creek and Buckeye Creek show below and the North Fork Gualala above.

Conclusion

The extremely poor health of the Gualala River watershed and South Fork Gualala sub-basin are ignored by the environmental review documents filed with regard to Timberland Conversion No. 524; THP 1-01-223 SON. The South Fork Gualala River is losing its ability to support coho salmon and steelhead trout. Only the upper reaches of the South Fork near the project are cool enough to be optimal rearing habitat, but the river below the project reaches stressful or lethal levels for these fish. Sediment over-supply is evident in the mainstem South Fork in the vicinity of the plans from photos provided by the NCRWQCB and the South Fork is so aggraded in its lower reaches that it is losing surface flow.

Rieman et al. (1993) characterize a salmonid population as at moderate risk of extinction when:

> "*Fine sediments, stream temperatures, or the availability of suitable habitats have been altered and will not recover to pre-disturbance conditions within one generation (5 years). Survival or growth rates have been reduced from those in undisturbed habitats. The population is reduced in size but no long-term trend in abundance exists.*"

The conditions described above fairly characterize the Gualala River and its steelhead population, while the coho population would merit a high risk classification (CDFG, 2002). This level of risk is nowhere acknowledged in the Plan and discussions do not even include data from the upper South Fork Gualala and the effected tributaries, which may be a key cold water refuge for steelhead and/or coho salmon juveniles.

This project is likely to decrease ground water recharge and thus reduce base flows in summer needed by salmonids. The reduced cold water flow will also increase problems with elevated water temperature. Increased sediment from the site will also contribute to stream warming as it reduces the width to depth ratio of the stream and increases opportunities for heat exchange with the atmosphere. Impacts from these projects coupled with existing high levels of disturbance and existing problems with aquatic health are likely to have dire consequences for the prospect of salmonid recovery in the Gualala River basin.

Additional timber harvests in the Gualala River basin, and especially vineyard conversions, should not go forward until water temperature and sediment transport have returned to unimpaired levels and salmonid productivity has been restored. Road densities in the upper South Fork Gualala River watershed should meet “properly functioning condition” for salmonids of less than 2.5 miles of road per square mile (including landings) and have few or no streamside roads (NMFS, 1996) before additional, large scale disturbance is allowed.

This timber harvest and conversion, in combination with others already permitted, are highly likely to negatively impact coho salmon and steelhead in the basin and will help continue the trend toward increased sediment, increased water temperatures and decreased surface flows. Ultimately the entire aquatic community of the Gualala is at risk from such activities, including non-listed species like the Sacramento sucker, as more of the river will lose surface flow. At that point, other beneficial uses under the Clean Water Act such as boating and swimming may also be diminished or lost.

Sincerely,

Patrick Higgins

References

Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D. L. Bottom, W.E. Weaver and R. L. Beschta. 1995 Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Pacific Salmon. Published by Pacific Rivers Council, Eugene, OR. 56 p.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management. 14(2):237-261.

California Department of Fish and Game. 2002a. Pre-Harvest Inspection Report for the Seaview Timber Harvest Plan and Conversion, Number 1-01-223 SON South Fork Gualala, Sonoma County. CDFG, Central Coast Region, Yountville, CA.

CA Department of Fish and Game. 2002b. Status Review of California Coho Salmon North of San Francisco . Report to the California Fish and Game Commission. California Department of Fish and Game, Sacramento , CA. 336pp.

California State Water Resources Control Board. 2001. Technical Support Document for the Gualala River Watershed Water Quality Attainment Action Plan for Sediment. CRWQCB, Region 1. Santa Rosa, CA. 147 pp.

Cederholm, C.J., L.M. Reid,and E.O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington. p.3874. In: Proceedings from the conference Salmon-Spawning Gravel: A Renewable Resource in the Pacific Northwest? Rep. 39. State of Washington Water Research Center, Pullman, WA.

Crop Care Associates, 1998. Baseline Soil Analysis for Vineyard Development Peter Michael Winery – Camp Meeting Ridge Property Project #8841.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.

Higgins, P.T. 1997. Gualala River Watershed Literature Search and Assimilation. Funded by the Coastal Conservancy under contract to Redwood Coast Land Conservancy. Gualala, CA. 59 pp.

Higgins, P.T. 2003. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1—01-171 SON. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p.

Huffman and Armstrong 1980. Geology for planning in Sonoma County. California Division of Mines and Geology, Special Report 120, 6 plates, scale 1:62,500.

Jones and Stokes. 2003. Post Project Sediment Yield Assessment Seaview Property, Peter Michael Winery. Jones and Stokes, Sacramento, CA.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An Ecological Perspective of Riparian and Stream Restoration in the Western United States. Fisheries 22(5):12-24.

Knopp, C. 1993. Testing Indices of Cold Water Fish Habitat. Final Report for Development of Techniques for Measuring Beneficial Use Protection and Inclusion into the North Coast Region's Basin Plan by Amendment of the.....Activities, September 18, 1990. North Coast Regional Water Quality Control Board in cooperation with California Department of Forestry. 57 pp.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat. Prepared for the Resources Agency of California and the National Marine Fisheries Service; Sacramento, CA.

Leopold, L. and S. McBain. 1995. Sediment processes in the Garcia River estuary related to enhancement feasibility. Final report. Performed under contract with Moffett and Nichol Engineers. Funded by the Mendocino Resources Conservation District. 29 pp.

National Marine Fisheries Service. 1996. Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast. US Dept. Commerce, NOAA. 4 pp.

National Marine Fisheries Service. 2001. Status Review Update for Coho Salmon (Oncorhynchus kisutch) from the Central California Coast and the California portion of the Southern Oregon/Northern California Coasts Evolutionarily Significant Units. Southwest Fisheries Science Center, Santa Cruz, CA. 43 p.

North Coast Regional Water Quality Control Board (NCRWQCB). 2002. Memo regarding Pre-Harvest Inspection Report for THP 1-01-223 SON. Christine Wright-Schacklet. NCRWQCB, Santa Rosa, CA.

Northwest Hydraulics Consultants. 2000. Field Monitoring Program Results Sediment Yield Monitoring Seaview Property – Peter Michael Winery. Performed under sub-contract to Jones and Stokes, Sacramento, CA.

Northwest Hydraulics Consultants. 2000. Sediment Yield Analysis Seaview Property – Peter Michael Winery. Performed under sub-contract to Jones and Stokes, Sacramento, CA.

PSIAC. 1968. Factor Affecting Sediment Yield and Measures for Reduction of Erosion and Sediment Yield.

Reeves, G.H., F.H. Everest, and J.R. Sedell. 1993. Diversity of Juvenile Anadromous Salmonid Assemblages in Coastal Oregon Basins with Different Levels of Timber Harvest. Transactions of the American Fisheries Society. 122(3): 309-317.

Rieman, B. 1993. Consideration of Extinction Risks for Salmonids. As FHR Currents # 14. US Forest Service, Region 5. Eureka, CA. 12 pp.

Sullivan, K., D. J. Martin, R. D. Cardwell, J. E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute . Portland, OR. 192 pp.

Twiss, R., D. Tarboton, R. Marston, F. Everest, A. Collison, W. Emmingham, and W. Haneberg. 2002. Final Report on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Under the Auspices of the North Coast Regional Water Quality Control Board, Santa Rosa, CA.

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April 14, 2004

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Re: Negative Declaration for THP 1-04-030SON, Hanson/Whistler Timberland Conversion Permit (TCP) #530

Dear Mr. Robertson,

I am writing in regards to Timberland Conversion Permit #530 (Hanson/Whistler) and Timber harvest Plan (THP) 1-04-030SON at the request of, and on retainer to local citizens, who are concerned about the deterioration of the Gualala River watershed. This conversion and harvest are in the Little Creek watershed, a lower tributary to Buckeye Creek. These comments bear substantial similarity to those which I filed on May 20, 2003 with your office on Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1—01-171 SON, which was also near Annapolis on Patchet Creek, a tributary to the Wheatfield Fork Gualala (Higgins, 2003a) and in December 2003 on Timberland Conversion Application 524 and Timber Harvest Plan (THP) 1-01-223 SON (Higgins, 2003b) in the upper South Fork Gualala River basin. Please review the first of those correspondences for my qualifications to comment in this regard.

The California Department of Forestry continues to blatantly disregard any prudent, risk based management of cumulative watershed effects as recommended by Ligon et al. (1999) and Dunne et al, 2001). It also ignores a preponderance of evidence that the Gualala River is an extremely degraded water body (CSWRCB, 2001) and fails to recognize the recent National Marine Fisheries Service (2001) and California Department of Fish and Game (2002) coho status reviews. The latter points out that coho are "extirpated or nearly so" in the Gualala River basin. There are numerous false statements in THP 1-04-030SON/ TCP #530 regarding watershed condition and cumulative effects. A major problem with analysis of potential cumulative effects of this project, and ones adjacent, is that the vegetation of the area has been dramatically altered, yet there are no recorded timber harvest permit applications (see below). Once again, the analysis of impacts is fundamentally flawed because it does not focus on the scale of Buckeye Creek and the Gualala watershed as a whole. Consequently, a Negative Declaration is wholly inappropriate for THP 1-04-030SON/TCP #530 and complex unanswered questions, such as its potential impact to flows, water temperatures and fisheries, should necessitate a full Environmental Impact Statement under the California Environmental Quality Act.

Fisheries

The environmental review documents submitted by the consultants for this project ignore the regional and in-basin status of coho salmon (Oncorhynchus kisutch) and steelhead trout (Oncorhynchus mykiss). National Marine Fisheries Service (NMFS, 2001), the California Department of Fish and Game (CDFG, 2002) and Brown et al. (1994) have found that coho salmon are at risk of extinction throughout Mendocino and Sonoma County. Coho were once known to be abundant in the Gualala

River (Taylor, 1972) yet CDFG (CA RA, 2002) surveyed over 100 miles of stream in the Gualala basin and collected fish samples using electroshocking and found no coho salmon anywhere. As indicated in my previous correspondence steelhead in the Gualala River are also greatly diminished.

The acute aggradation of the Gualala River mainstem reaches has shifted the ecology of the river substantially. THP 1-04-030SON/TCP #530 mis-characterizes Buckeye Creek as having healthy conditions for salmonids and as being in recovery from past forest harvest effects. In fact conditions for fisheries are extremely poor in Buckeye Creek and advanced cumulative effects are recognized in tributary channels adjacent to or near Little Creek, such as Franchini Creek and Grasshopper Creek. If corrective actions are not taken with regard to sediment abatement and flow preservation, more of the Gualala River channel can be expected to go dry causing further impacts to the already imperiled fish community. This project will exacerbate both problems.

Temperature

Buckeye Creek is characterized in the report as suitable habitat for salmonids with few lingering cumulative watershed effects (CWE). In fact Buckeye Creeks water temperatures remain substantially over those recognized as suitable for coho salmon (Welsh et al., 2001) and in fact are in the range known to be highly stressful for steelhead (Sullivan et al., 2000). Figure 1 shows the maximum water temperature of Buckeye Creek for several years between 1994 and 2001 and values are all in the range of stressful for steelhead trout and completely unsuitable for coho salmon. Coho should be recognized as the most critical “beneficial use” associated with cold water fish under the Clean Water Act in the Gualala River and long term goals should be to return the western tributaries to coho suitability. Continuing timber harvests and conversions will have the opposite effect. Figure 2 shows that water temperatures are above suitable for coho salmon not just in Buckeye Creek but in all larger tributaries.

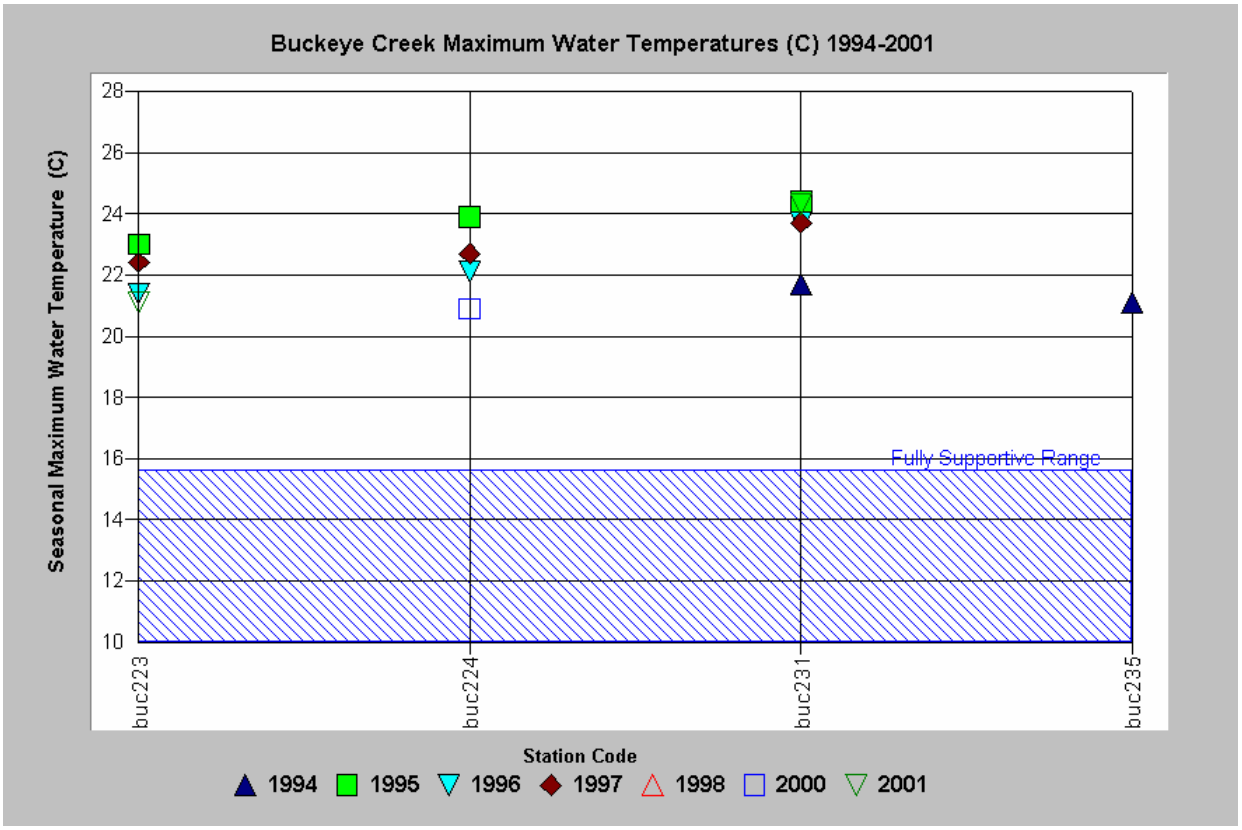

Figure 1. This chart shows the maximum water temperature for all automated temperature probes placed in the Buckeye Creek from 1994 to 2001. Data provided by Gualala Redwoods, Inc. and the Gualala River Watershed Council.

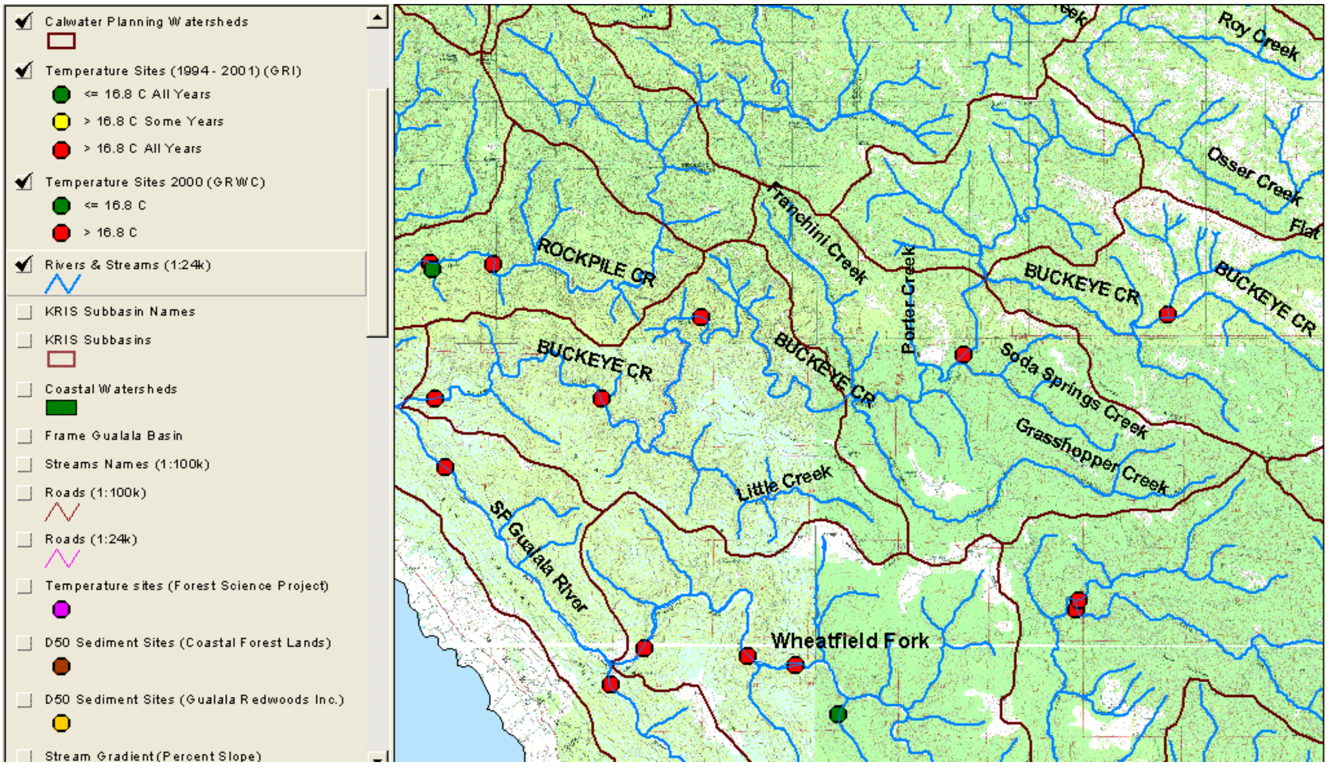

Figure 2. This map shows that water temperatures are unsuitable for coho salmon at most locations in the western Gualala River basin. Data provided by Gualala Redwoods, Inc. and the Gualala River Watershed Council.

Only small tributaries of the Gualala River have water cold enough to be optimal for salmonids and particularly coho salmon. As shown in Figure 2, minor tributaries of Rockpile Creek and the Wheatfield Fork alone have are optimal. Little Creek water temperatures may be cool and provide important salmonid refugia, but no temperature data are supplied. THP 1-04-030SON/TCP #530 must deal with the question of the importance of Little Creek to ecosystem function of Buckeye Creek and its ability to support salmonids and more genuinely with the potential impacts to water temperature of the project. The plan acknowledges that water temperatures may be increased if base flows decrease, but then fails to deal with potential effects of the project on base flows and temperatures (see below).

Sediment

Documents associated with THP 1-04-030SON/TCP #530 portray Buckeye Creek and its tributaries as being in advanced recovery from past timber harvest with regard to sediment impacts, but there is substantial information available to refute that assertion. The Gualala River watershed is listed as impaired for sediment under section 303(d) of the Federal Clean Water Act, which precipitated the *Technical Support Document for the Gualala River Watershed Water Quality Attainment Action Plan for Sediment* (CWQCB, 2001). This study found that human caused sediment delivery rates are approximately 200% above the natural background rates in the Buckeye Creek basin (Figure 3). Two tributaries of Buckeye Creek upstream of Little Creek, Franchini and Grasshopper creeks have recognized problems with sediment.

North Coast Regional Water Quality Control Board staff observed a significant amount of sediment in transport in Franchini Creek (Figure 4). The small particle size distribution and concave nature of the stream indicate very recent contributions of sediment (Dietrich et al., 1989), not advanced recovery.

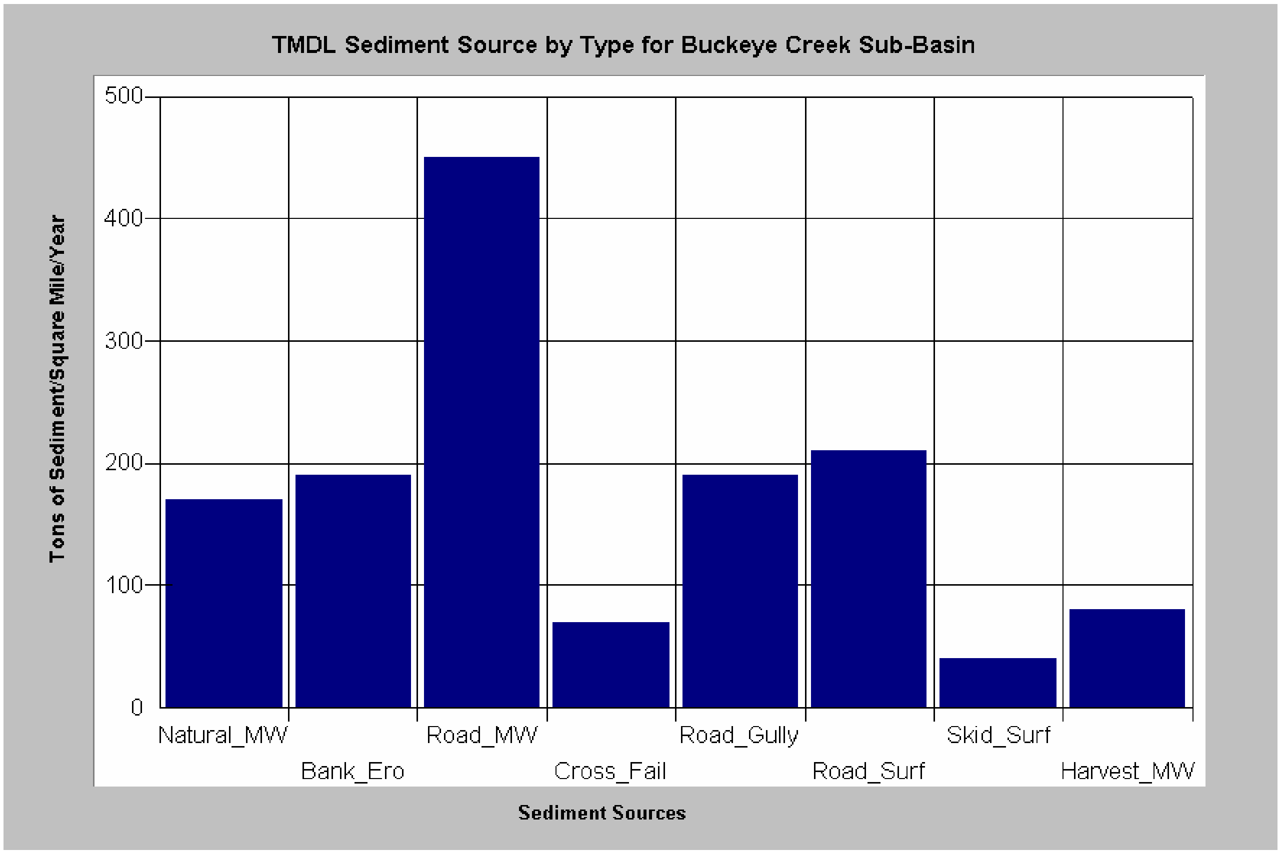

Figure 3. The Buckeye Creek basin sources of sediment estimated by the CWRCB (2001). Road sources had the highest sediment yield in combination. Estimated sediment yield is shown as tons of sediment yielded per square mile per year. From CWRCB (2001).

Figure 4. Franchini Creek and NCRWQCB staff during 2001 survey indicating major sediment problems and recent active contributions.

Knopp (1993) studied 60 north coast California watersheds and found that watersheds with high timber harvest management had compromised pool volumes as measured using the V-star method (Hilton and Lisle, 1992). Values measured in Grasshopper Creek indicated that had a V-star score of 0.59, while TMDL targets indicate that a healthy stream would have a value of less than 0.21 (CSWRB, 2001). The values in Grasshopper Creek actually ranged as high as 0.739, indicating that some pools were almost three quarters filled with sediment.

The lack of pools in the mainstem of Buckeye Creek and the infrequency of pools deeper than three feet are indicative of major cumulative watershed effects. The lack of pool depth is likely to be a major limiting factor for juvenile steelhead (Reeves, 1988) and coho salmon (Brown et al., 1994). Habitat typing data from CDFG (2001) are displayed in Figure 6 and show that pools deeper than three feet are uncommon in lower Buckeye Creek, although it is a relatively large fourth order stream. The sediment cycling from tributaries such as Franchini Creek and Grasshopper Creek are likely contributing to the compromised pool frequency and depth. The lack of proper characterization of existing sediment problems in Buckeye Creek and its tributaries make THP 1-04-030SON/TCP #530 insufficient in terms of proper CWE analysis. Figure 6 also shows the acute problems with sediment and CWE as reflected by lack of deep pools in adjacent Rockpile Creek and in the South Fork and Wheatfield Fork of the Gualala River.

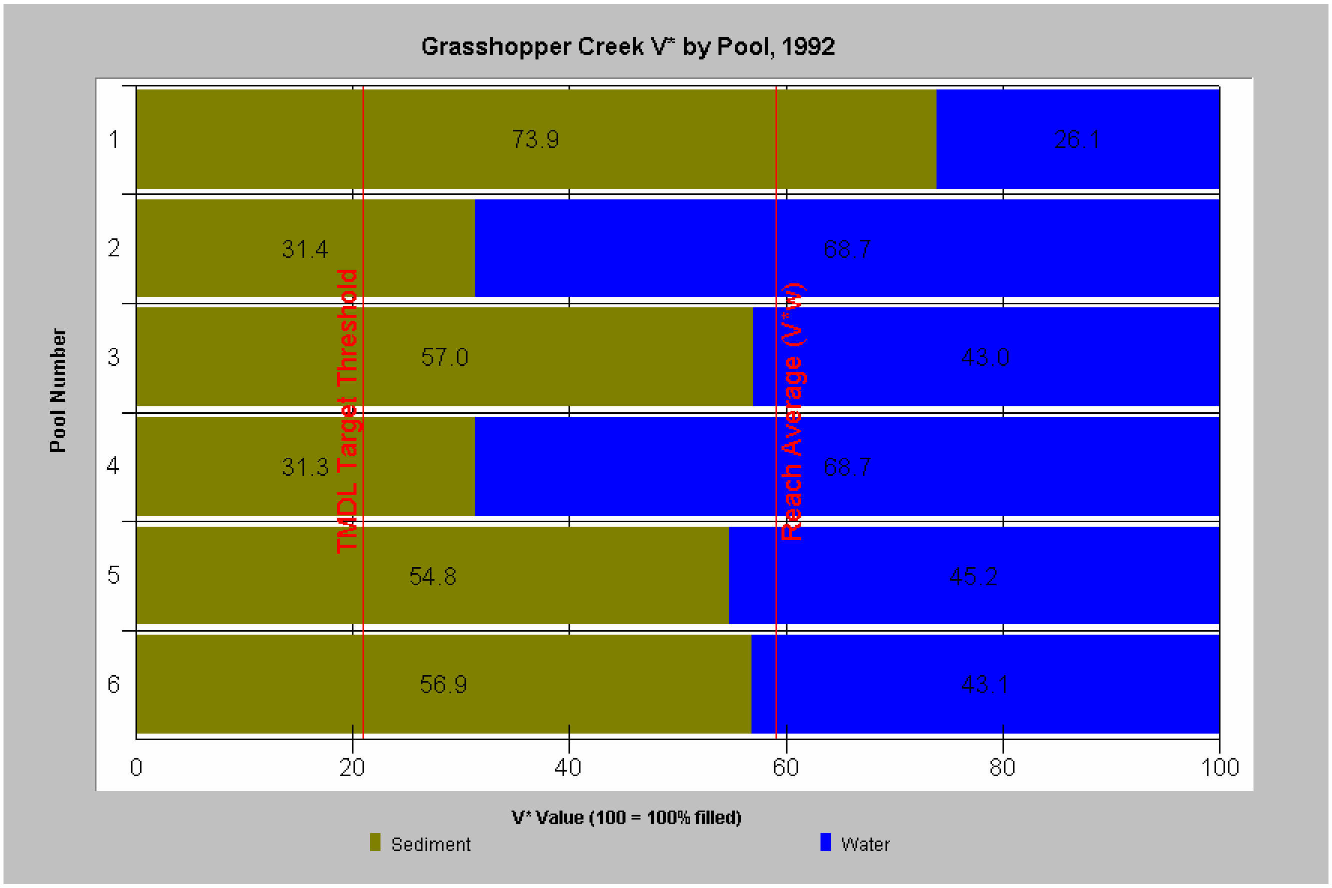

Figure 5. V-star values in Grasshopper Creek as collected by Knopp (1992) indicating major sediment problems related to recent past management in this Buckeye Creek tributary.

Roads are the most significant contributor of sediment in Buckeye Creek and basin-wide (CWQCB, 2001) and road densities in the Gualala River watershed over-all are high, including the Buckeye watershed (Figure 7). Road densities in the Little Creek Calwater Planning Watershed, which encompasses lower Buckeye Creek and all of Little Creek has some of the highest road densities in the

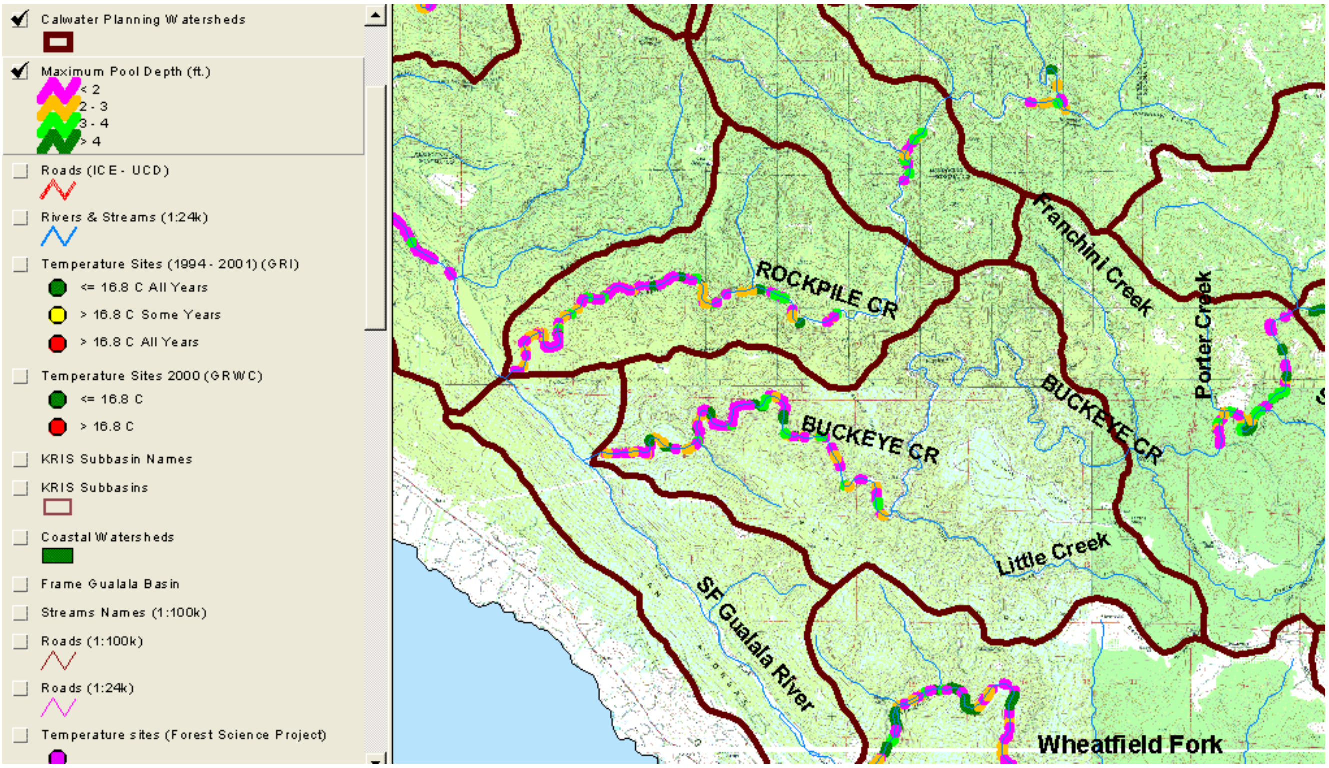

Figure 6. This map image shows pool depth in lower Buckeye Creek, lower Rockpile Creek and pert of the lower Wheatfield and SF Gualala River according to CDFG (2001) data.

Gualala River basin at over 8 miles per square mile (mi/mi^2). This exceeds by a large margin the threshold of 2.5 mi/mi^2 established by NMFS (1996) for a properly functioning watershed condition. Cedarholm et. al. (1981) found that road densities greater than 1.5 mi/mi^2 yielded sediment levels that compromised the success of salmonid spawning. Jones and Grant (1996) noted that interception of sub-surface flows by road cuts as a major factor in increasing peak flows during storm events. The current conversion and THP fails to acknowledge this significant CWE with regard to roads, which the effects of THP 1-04-030SON/TCP #530 must be judged.

Timber Harvest and Cumulative Watershed Effects

Timber harvest rates in Gualala River Calwater Planning Watersheds between 1991 and 2001 show that some sub-basins have been harvested at rates as high as 78% (Figure 8). Reeves et al. (1993) pointed out that logging in over 25 % of a watershed's area in less than 30 years compromised aquatic habitat diversity and cause loss of diversity of Pacific salmon species. CDFG (CA RA, 2001) habitat typing data showed that pool frequency by length was low in recently harvested basins, a result similar to that described by Reeves et al. (1993). All Buckeye Creek Calwater Planning Watersheds are over this prudent level of disturbance of 25% timber harvest in just ten years of records provided by CDF. Another troubling aspect of the THP 1-04-030SON/TCP #530 application is its failure to acknowledge major removal of timber that does not appear as part of CDF records (Figure 9). Kauffman et al. (1999) point out that riparian areas and watersheds can only recover when anthropogenic stressors are ameliorated. This conversion and timber harvest is particularly ill-timed because of the already widespread nature of watershed disturbance from timber harvest and roads at this time.

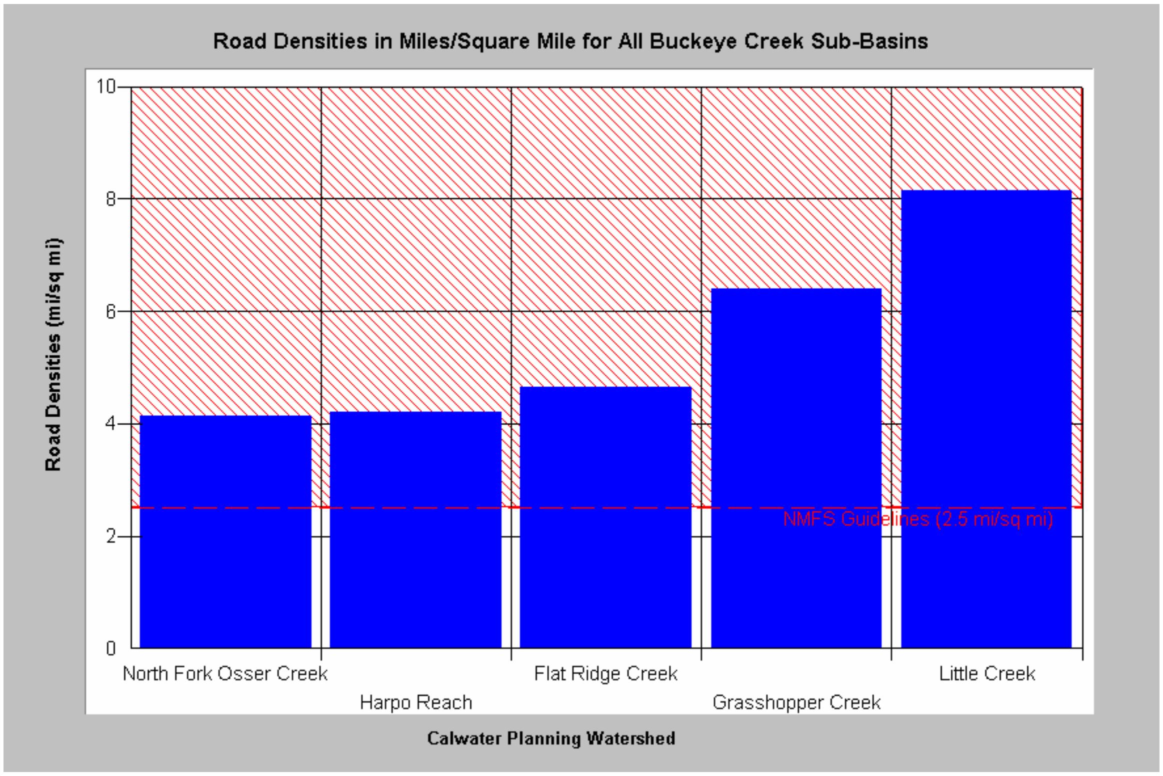

Figure 7. This chart shows the density of roads in miles per square mile for Buckeye Creek watershed with references based on NMFS (1996). Data from UC Davis ICE and North Coast Regional Water Quality Control Board.

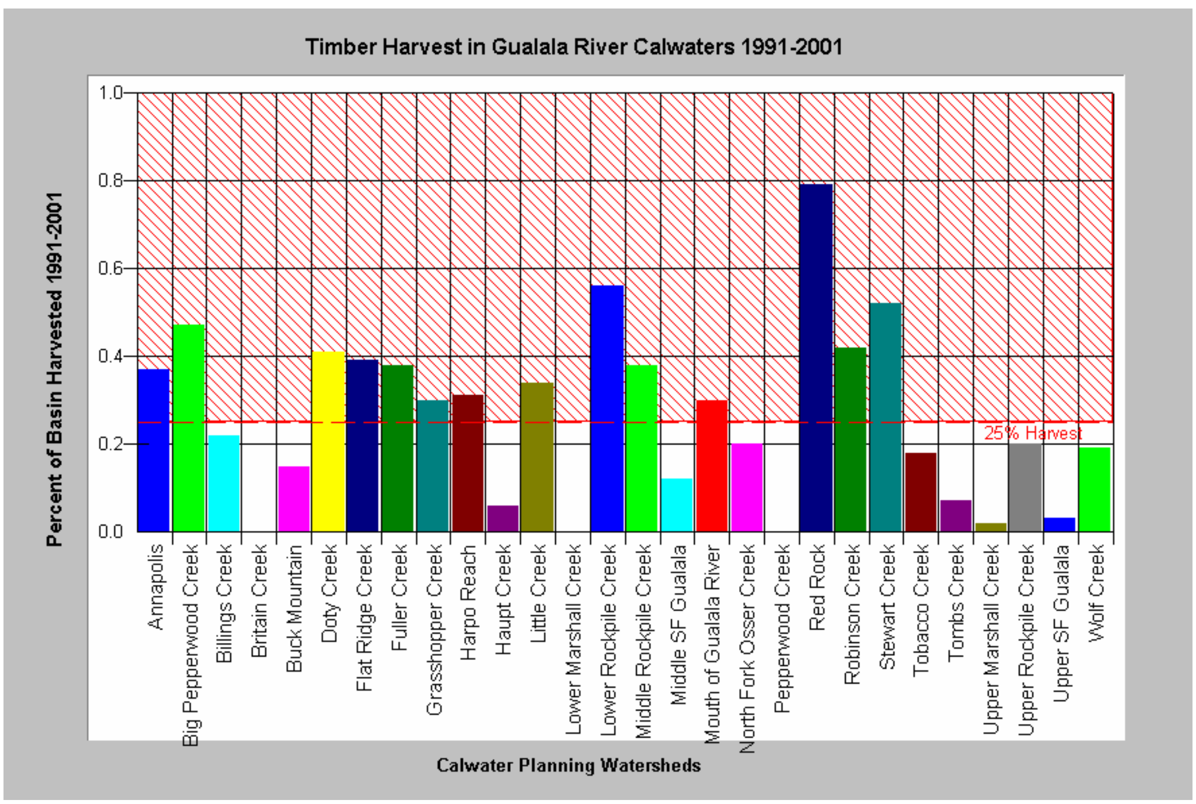

Figure 8. The timber harvest in all Gualala River Calwater Planning Watersheds is shown above as percentage of watershed area. Half of the basins are more than 25% cut in just over ten years, including all Buckeye Creek Calwaters (Little, Grasshopper, Harpo and Flat Ridge) except NF Osser Creek. Data from CDF, Santa Rosa.

Figure 9a. Area of THP 1-04-030SON/TCP #530 in 1990 showing almost complete cover, but high road and skid trail densities.

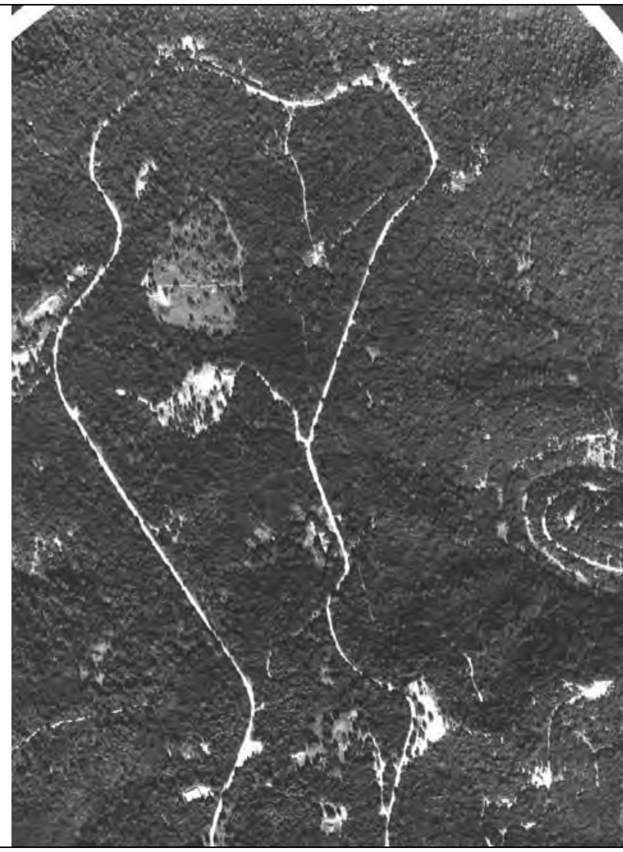

Figure 9b. This photo shows the same area as Figure 9a in 1996 with major changes in vegetation, but no THPs filed.

Figure 9c (At left): The 2002 aerial photo shows major new openings and substantial thinning of forests, again with no record from CDF for timber harvests on file. This type of large scale vegetation removal is a clear cut equivalent in places and likely already contributing to changes in runoff patterns (Jones and Grant, 1996), even without further conversion to vineyards.

THP 1-04-030SON/TCP #530 makes a number of gratuitous statements with regard to cumulative watershed effects:

- The impacts of the harvesting plans listed have been mitigated to a level of insignificance. The possible impacts of the proposed plan have been mitigated to the level of insignificance.

- Overall impacts from past timber management appear to have been beneficial.

- Recent projects are all subject to intensive pre and post project multi-agency review and follow-up. Concerns have been addressed and mitigated.

Dunne et al. (2001) point out that in fact widespread disturbance in the Gualala River, Buckeye Creek and Little Creek watersheds, as documented above, have major impacts which the plan and CDF do not acknowledge:

> "Generally speaking, the larger the proportion of the land surface that is disturbed at any time, and the larger the proportion of the land that is sensitive to severe disturbance, the larger is the downstream impact. These land-surface and channel changes can: increase runoff, degrade water quality, and alter channel and riparian conditions to make them less favorable for a large number of species that are valued by society. The impacts are typically most severe along channels immediately downstream of land surface disturbances and at the junctions of tributaries, where the effects of disturbances on many upstream sites can interact."

It has been pointed out that THP 1-04-030SON/TCP #530 does not deal sufficiently with endangered and threatened salmonid species and Dunne et al. (2001) point out that at risk populations can be lost, if cumulative effects are ignored and anthropogenic stressors continued:

> "Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time. They may occur at a site through repetition of a change caused by successive operations, or through two or more results of an operation, or they may occur at a site remote from the original land transformation and with some time lag. The concern about cumulative effects arises because it is increasingly acknowledged that, when reviewed on one parcel of terrain at a time, land use may appear to have little impact on plant and animal resources. But a multitude of independently reviewed land transformations may have a combined effect, which stresses and eventually destroys a biological population in the long run."

Dunne et al. (2001) also point out that CWE must be managed by minimizing risk: "Inevitably, the institutional aspects involve decisions about how much environmental and other risks are acceptable in a project. Before the institutional evaluation can be made, however, the risks of CWEs need to be identified in some transparent manner." The lack of provision of sufficient information on which to judge impacts of THP 1-04-030SON/TCP #530 fails the test of transparency. CDF should be rejecting this project because the high existing impacts and additional threats posed by previously permitted or completed projects, not proposing a Negative Declaration.

Flow Issues

The hydrologic review of THP 1-04-030SON/TCP #530 is not complete or credible. It states categorically that "Once the vineyard is established, the conversion will likely result in a net increase in water availability" without providing any substantive discussion or noting current flow levels in Little Creek or their importance in supporting fish life. The project will use tile drains that are likely to block ground water percolation, establishes a pond and will also employ deep water wells. Kamman Hydrology and Engineering (2003) studied a similar setting in the Gualala basin where a conversion was planned and asserted that similar activities to those proposed in this project would block infiltration into ground water in headwater swales. Cool water base flows in summer are important for maintaining steelhead and recovering coho salmon in Buckeye Creek and it is likely that this activity will reduce those flows at a time when they are already severely flow limited. CDF does not have the experience or expertise in this area to properly evaluate changes in flow related to vineyard development. Changes in hydrology and flow diversions or reductions, such as those likely to occur under THP 1-04-030SON/TCP #530, should require a full scale EIS under CEQA.

Leopold and McBain (1995) also pointed out that wide spread compaction related to timber harvest in the Garcia River basin elevated winter runoff. This finding is similar to Jones and Grant (1996) who estimated that when 25% of the area of a basin were impacted by timber harvest and roads that flow increases of 50% resulted. They note that increased peak flows can scour riparian areas, potentially elevating water temperatures.

Conclusion

The extremely poor health of the Gualala River watershed and Buckeye Creek sub-basin are ignored by the environmental review documents filed with regard to THP 1-04-030SON/TCP #530. The Gualala River is losing its ability to support coho salmon and steelhead trout. Sediment over-supply is evident in the mainstem Buckeye Creek and its tributaries in the vicinity of the plan.

Rieman et al. (1993) characterize a salmonid population as at moderate risk of extinction when:

> "*Fine sediments, stream temperatures, or the availability of suitable habitats have been altered and will not recover to pre-disturbance conditions within one generation (5 years). Survival or growth rates have been reduced from those in undisturbed habitats. The population is reduced in size but no long-term trend in abundance exists.*"

The conditions described above fairly characterize the Gualala River and its steelhead population, while the coho population would merit a high risk classification (CDFG, 2002). This level of risk is nowhere acknowledged in the Plan and discussions do not even include data from the effected tributary Little Creek, which may be a key cold water refuge for steelhead juveniles.

This project is likely to decrease ground water recharge and thus reduce base flows in summer needed by salmonids. The reduced cold water flow will also increase problems with elevated water temperature. Increased sediment from the site will also contribute to stream warming as it reduces the width to depth ratio of the stream and increases opportunities for heat exchange with the atmosphere. Impacts from these projects coupled with existing high levels of disturbance and existing problems with aquatic health are likely to have dire consequences for the prospect of salmonid recovery in the Gualala River basin.

Additional timber harvests in the Gualala River basin, and especially vineyard conversions, should not go forward until water temperature and sediment transport have returned to unimpaired levels and salmonid productivity has been restored. Road densities in the Little Creek Calwater Planning Watershed and those adjacent should meet "properly functioning condition" for salmonids of less than 2.5 miles of road per square mile (including landings) and have few or no streamside roads (NMFS, 1996) before additional, large scale disturbance is allowed.

This timber harvest and conversion, in combination with others already permitted, are highly likely to negatively impact coho salmon and steelhead in the basin and will help continue the trend toward increased sediment, increased water temperatures and decreased surface flows. Ultimately the entire aquatic community of the Gualala is at risk from such activities, including non-listed species like the Sacramento sucker (Higgins, 2003b), as more of the river will lose surface flow. The Negative Declaration should be withdrawn and a full EIS required.

Sincerely,

Patrick Higgins

References

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management. 14(2):237-261.

CA Department of Fish and Game. 2002. Status Review of California Coho Salmon North of San Francisco . Report to the California Fish and Game Commission. California Department of Fish and Game, Sacramento , CA. 336pp.

California Resources Agency. 2002. Gualala River Watershed Synthesis. CA Dept. of Fish and Game, State Water Res. Control Bd., CA Dept. of Water Resources, CA Div. on Mines and Geology and CA Dept. of Forestry. Sacramento, CA.

California State Water Resources Control Board. 2001. Technical Support Document for the Gualala River Watershed Water Quality Attainment Action Plan for Sediment. CRWQCB, Region 1. Santa Rosa, CA. 147 pp.

Cedarholm, C.J., L.M. Reid, and E.O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington. p.3874. In: Proceedings from the conference Salmon-Spawning Gravel: A Renewable Resource in the Pacific Northwest? Rep. 39. State of Washington Water Research Center, Pullman, WA.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.

Higgins, P.T. 1997. Gualala River Watershed Literature Search and Assimilation. Funded by the Coastal Conservancy under contract to Redwood Coast Land Conservancy. Gualala, CA. 59 pp.

Higgins, P.T. 2003a. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1—01-171 SON. May 20, 2003. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p.

Higgins, P.T. 2003b. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Negative Declaration for Sugarloaf Farming Corporation dba Peter Michael Winery, Timberland Conversion No. 524; THP 1-01-223 SON. December 12, 2003. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p

Hilton, S. and T. E. Lisle. 1993. Measuring the fraction of pool volume filled with fine sediment. Res. Note PSW-RN-414. US Forest Service, Pacific Southwest Research Station. Albany, CA . 11 pp.

Kamman, G. 2003. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1—01-171 SON. Kamman Hydrology and Engineering.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An Ecological Perspective of Riparian and Stream Restoration in the Western United States. Fisheries 22(5):12-24.

Knopp, C. 1993. Testing Indices of Cold Water Fish Habitat. Final Report for Development of Techniques for Measuring Beneficial Use Protection and Inclusion into the North Coast Region's Basin Plan by Amendment of the.....Activities, September 18, 1990. North Coast Regional Water Quality Control Board in cooperation with California Department of Forestry. 57 pp.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat. Prepared for the Resources Agency of California and the National Marine Fisheries Service; Sacramento, CA.

Leopold, L. and S. McBain. 1995. Sediment processes in the Garcia River estuary related to enhancement feasibility. Final report. Performed under contract with Moffett and Nichol Engineers. Funded by the Mendocino Resources Conservation District. 29 pp.

National Marine Fisheries Service. 1996. Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast. US Dept. Commerce, NOAA. 4 pp.

National Marine Fisheries Service. 2001. Status Review Update for Coho Salmon (Oncorhynchus kisutch) from the Central California Coast and the California portion of the Southern Oregon/Northern California Coasts Evolutionarily Significant Units. Southwest Fisheries Science Center, Santa Cruz, CA. 43 p.

Reeves, G.H.1988. Distribution patterns of fish in the Elk River basin. COPE Report l(3): 4-6.

Reeves, G.H., F.H. Everest, and J.R. Sedell. 1993. Diversity of Juvenile Anadromous Salmonid Assemblages in Coastal Oregon Basins with Different Levels of Timber Harvest. Transactions of the American Fisheries Society. 122(3): 309-317.

Rieman, B. 1993. Consideration of Extinction Risks for Salmonids. As FHR Currents # 14. US Forest Service, Region 5. Eureka, CA. 12 pp.

Sullivan, K., D. J. Martin, R. D. Cardwell, J. E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute . Portland, OR. 192 pp.

Taylor, S.N. 1978. The status of salmon populations in California coastal rivers. California Department of Fish and Game. Salmon/Steelhead Program, Anadromous Fisheries Branch. 14 pp.

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July 17, 2004

Allen Robertson, Deputy Chief
California Department of Forestry and Fire Protection
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Sacramento, CA 94244-2460

Re: Negative Declaration for Timber Harvest Plan (THP 1-04-059)/ Martin Timberland Conversion Permit (TCP 04-531)

Dear Mr. Robertson,

I am writing in regards to Timber Harvest Plan (THP) 1-04-059/ Martin Timberland Conversion Permit (TCP) 04-531 at the request of, and on retainer to local citizens, who are concerned about the deterioration of the Gualala River watershed. I have read THP 1-04-059/TCP 04-531 and the Negative Declaration from the California Department of Forestry (CDF), as well as related information (Baye, 2004; Erman, 2004; Poehlman and Levine; Plum, 2004, Barbour, 2004). I would like to incorporate by reference my comments recently filed on other THP/TCP projects in the Gualala River basin also given Negative Declarations by CDF:

- May 20, 2003 on the Artesia Timberland Conversion Permit 02-506 and Timber Harvest Plan (THP) 1—01-171 SON, which was also near Annapolis on Patchet Creek, a tributary to the Wheatfield Fork Gualala (Higgins, 2003a),
- In December 2003 on the Seaview Timberland Conversion Permit 524 and Timber Harvest Plan (THP) 1-01-223 SON (Higgins, 2003b) in the upper South Fork Gualala River basin, and
- April 14, 2004 on THP 1-04-030SON, Hanson/Whistler Timberland Conversion Permit (TCP) #530 (Higgins, 2004).

The CDF Negative Declaration fails to recognize the advancements in knowledge of cumulative watershed effects (CWE) in northwestern California as embodied by works such those of Ligon et al. (1999), Dunne et al (2001) and Collison et al. (2003). These studies recognize that CDF's fragmented approach to analysis is not preventing CWE and related loss of biodiversity, such as Pacific salmon species. Recent regional studies of Pacific salmon status and trends are not acknowledged or their relevance discussed (NMFS, 2001; CDFG, 2003). The THP/TCP does not credibly characterize existing impacts within the Little Creek Calwater Planning Watershed, let alone the Gualala River basin as a whole. The THP/TCP only mentions the Gualala River Total Maximum Daily Load (CSWRCB, 2001) study in passing without acknowledging its findings of major existing sediment problems. The THP/TCP claims that there will be no sediment and flow impacts from this land use activity, which is not possible. The Registered Professional Forester (Jacobszoon, 2004) and the CDF Negative Declaration fail to provide data or credible science-based discussions of potential changes in flow associated with conversion of intact forest land to vineyard. The above omissions and problems should have caused you to decline Negative Declaration on status on THP 1-04-059/TCP 04-531 in accordance with the California Environmental Quality Act (CEQA).

My Qualifications

I have been a consulting fisheries biologist for the last 15 years with an office in Arcata, California. My academic training includes both completion of a B.S. in Biology from Humboldt State University awarded in 1975 and graduate work in fisheries at the same institution from 1985-1989. In 1992, I served as lead author of *Factors Threatening Stocks with Extinction in Northwestern California* (Higgins et al., 1992), a peer reviewed position paper for the American Fisheries Society on regional Pacific salmon. I also have expertise in Pacific salmon restoration and have written elements of restoration plans for river basins in California including the: Klamath River (Kier Assoc., 1991), South Fork Trinity River (Pacific Watershed Associates, 1994), Garcia River (Monschke and Caldon, 1991) and San Mateo Creek and the Santa Margarita River (Higgins, 1992). In 1997, I conducted an assessment of the Gualala River based on existing literature (Higgins, 1997) for the Redwood Coast Land Conservancy. Since 1992, I have been working on comprehensive watershed databases for numerous Northern California basins. That project began in the Klamath, after which the project was named (Klamath Resource Information System or KRIS). A number of KRIS projects have been sponsored by CDF, including ones for the Noyo, Big, Ten Mile, Mattole and Gualala rivers. The KRIS Gualala project provides data that is in part the basis of these comments, including fisheries, water quality, timber harvest, vegetation types, roads and riparian conditions.

Fisheries

The environmental review documents submitted by the Registered Professional Forester (RPF) for this project (Jacobszoon, 2004) state that its watershed area of analysis (WAA) is the Little Creek Calwater Planning Watershed (5,869 Acres), yet they give only the barest fisheries information regarding Buckeye Creek, the lower reaches of which are within it, or Little Creek itself. The National Marine Fisheries Service (NMFS, 2001), the California Department of Fish and Game (CDFG, 2002) and Brown et al. (1994) have found that coho salmon (Oncorhynchus kisutch) are at risk of extinction throughout Mendocino and Sonoma County. The THP/TCP notes that coho are absent in the WAA and refers to its Federally Threatened only through an abbreviation. It completely skips discussions of the implications of habitat changes related to the proposed activities and prospects for recovery of at risk salmonid species in the Gualala basin and regionally. Coho were once known to be abundant in the Gualala River (Taylor, 1972) yet CDFG (CA RA, 2002) surveyed over 100 miles of stream in the Gualala basin and collected fish samples using electroshocking and found no coho salmon anywhere. CDFG (2002) acknowledges that coho in the Gualala basin are “extirpated or nearly so.” The status of the steelhead trout (Oncorhynchus mykiss) is again referred to in the THP/TCP only through abbreviation. There are no discussions of substance as to reason for listing as Threatened under the Endangered Species Act (Busby et al., 1996; NMFS, 1996), their prospects for recovery in the Gualala, and the proposed actions effects on those prospects.

The THP/TCP does not mention that coho salmon were likely to have inhabited lower Little Creek and lower Buckeye Creek, have been extirpated and are not likely to be restored unless streams are allowed to recover. Groot and Margolis (1991) note that coho salmon prefer streams in the range of 1-2% gradient or less for spawning and rearing and data from the KRIS Gualala project show that Buckeye Creek and lower Little Creek fall within this range (Figure 1). Steelhead can actually leap 15 feet vertically and are known to inhabit reaches with higher gradient. The THP/TCP says they exist only in the lowest reach of Little Creek, but provides not supporting data. This activity is likely to further decrease suitability for coho salmon and steelhead by increasing sediment, decreasing base flows and increasing peak flows, and elevating water temperatures directly or indirectly (see discussions below).

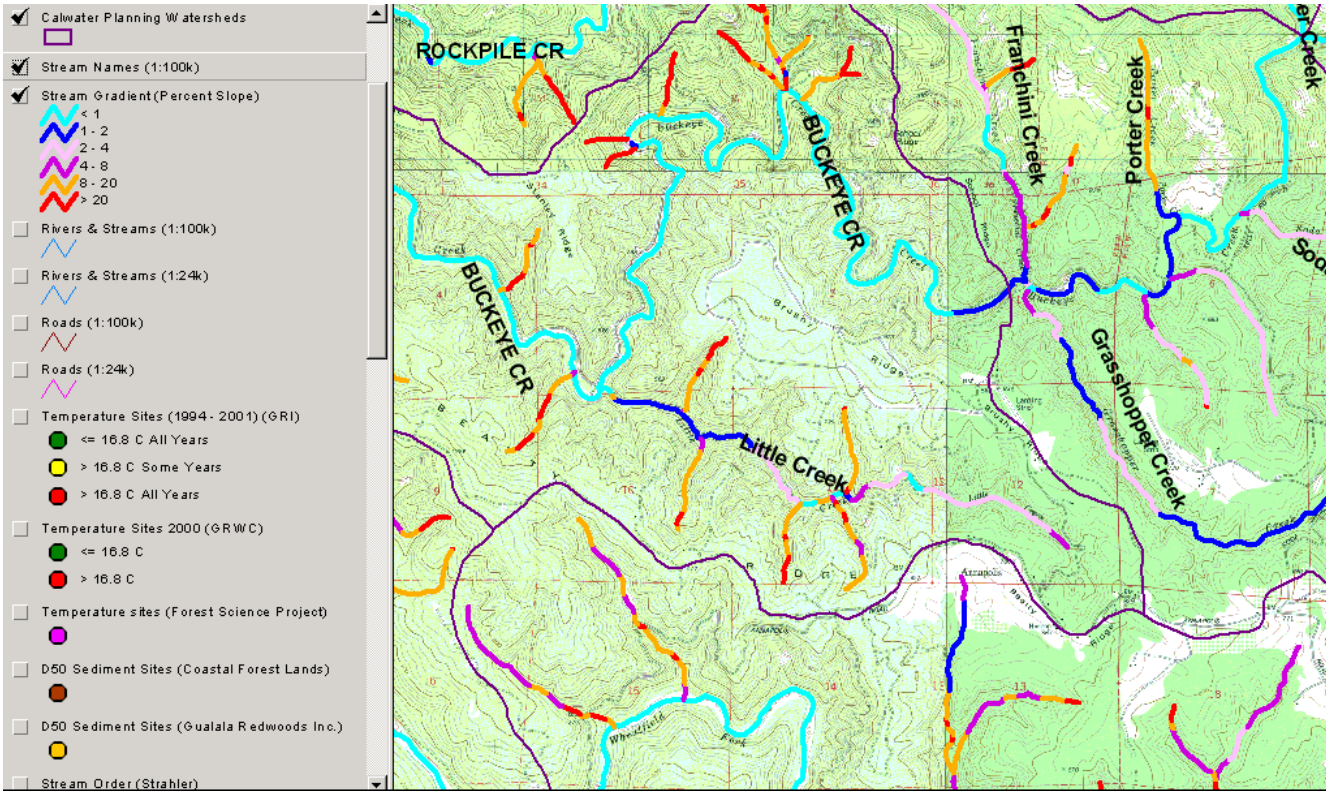

Figure 1. Gradient of Buckeye Creek and Little Creek as depicted by maps generated from CDF elevation data in KRIS Gualala. These data show that both streams would be suitable for coho salmon in their lower reaches.

The KRIS Gualala project (IFR, 2002) advanced an hypothesis that the distribution and abundance of coho salmon and steelhead have decreased in the Gualala River basin, citing evidence of stream segments that were buried or so impaired as to lack depth, substrate conditions or appropriate water temperature to support these sensitive species. This and other hypotheses advanced by IFR (2003) were peer reviewed with oversight from the University of California (Standiford, 2003) and reviewers said that the arguments offered were supported by the available literature and data. CDFG (CA RA, 2002) electrofishing samples included few older age steelhead trout juveniles, with smaller Gualala River tributaries being too shallow to support summer rearing of larger fish, and larger streams too warm (IFR, 2003). Barnhart (1986) noted that northern California steelhead most often spend two years in freshwater before going to the ocean. If fish do not attain a large size before ocean entry, their likelihood of survival in the ocean is quite low.

Despite steelhead trout being noted as present in Little Creek, the THP/TCP presents no fish sampling data to indicate the level of present use or standing crops. Given the depressed status of this species regionally and in the Gualala River basin, the THP/TCP should acknowledge if this stream has higher carrying capacity than Buckeye Creek itself and what role it serves in potential protection and recovery of steelhead at both scales. The THP/TCP notes that “the small number of deep pools” makes the local streams “marginal” for coho salmon juvenile rearing, but there are no quantitative data with which to judge present fish habitat quality in Little Creek such as pool frequency and depth, substrate conditions, large wood availability and riparian canopy conditions. Without these data one cannot judge potential impacts on coho salmon and steelhead populations of this and other land use activities. Lack of baseline data also prevents future monitoring to judge aquatic response to land use over time.

Water Temperature of Buckeye Creek and Gualala River and Suitability for Salmonids

As discussed in my previous comments on other Gualala River THP/TCP projects (Higgins, 2003a; 2003b; 2004), smaller tributaries in the Gualala Basin like Little Creek are likely to suffer less temperature impairment than larger order streams like Buckeye Creek (Figure 2). If Little Creek is summer periods when water temperatures in larger Gualala River tributaries often exceed stressful or lethal levels (Sullivan et al., 2001). Optimum temperatures for steelhead are between 10-15 degrees Celsius (C) and data from KRIS Gualala (Figure 3) show that mainstem Buckeye Creek water temperatures are well over stressful for steelhead (McCullough, 1999) and well beyond the range needed for coho salmon rearing (Welsh et al., 2001).

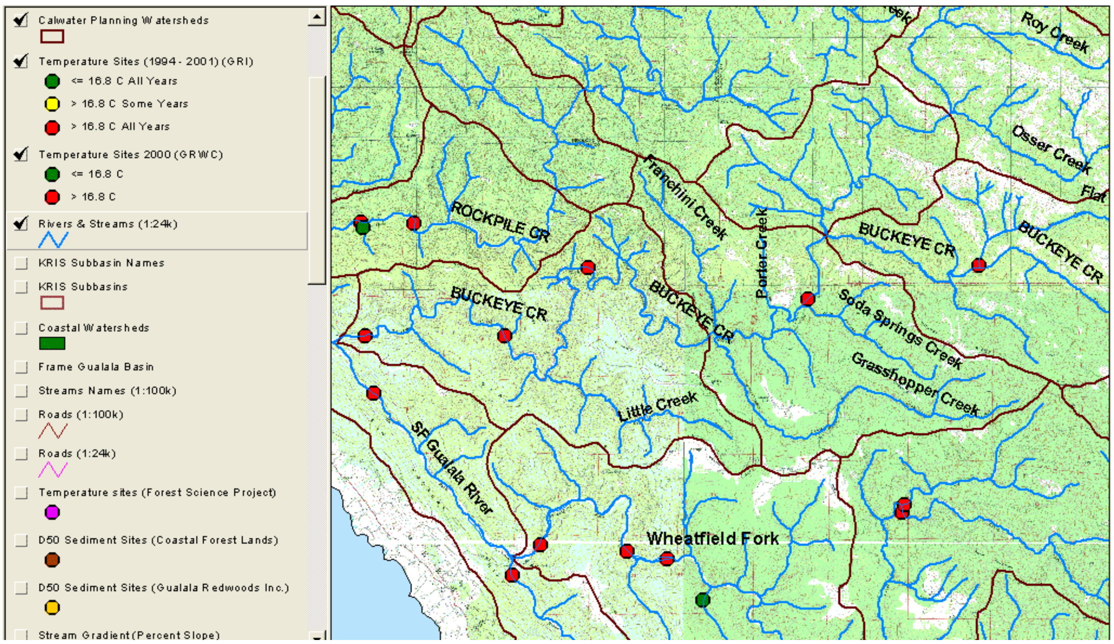

Figure 2. Water temperature suitability for coho salmon is displayed above from the KRIS Gualala project showing that the mainstem of Gualala River and its larger tributaries, including Buckeye Creek, are too warm in all years (red). Only two small tributaries of lower Rockpile Creek and the Wheatfield Fork were found to be suitable in all years measured (green), although these streams are likely too small and steep to support the species.

Poole and Berman (2000) note anthropogenic mechanisms that change water temperature regimes and at least two apply to the current project. The proposed project will likely exacerbate water temperature problems by: 1) additional sediment contributions that fill pools and increase the width to depth ratio facilitating heat exchange with the atmosphere (see Sediment), and 2) reducing cool water base flows in summer because of how the project will alter flow regimes (see Flows).

If Little Creek is less impacted by sediment and has cooler water temperature regimes than other nearby streams, its alteration could be extremely deleterious for near term prospects of steelhead recovery and longer term prospects for coho recovery in this portion of the Gualala River basin. Coho should be recognized as the most critical "beneficial use" associated with cold water fish under the Clean Water Act in the Gualala River and long term goals should be to return the western tributaries to coho suitability (<16.8 C MWAT). Continuing timber harvests and conversions will have the opposite effect.

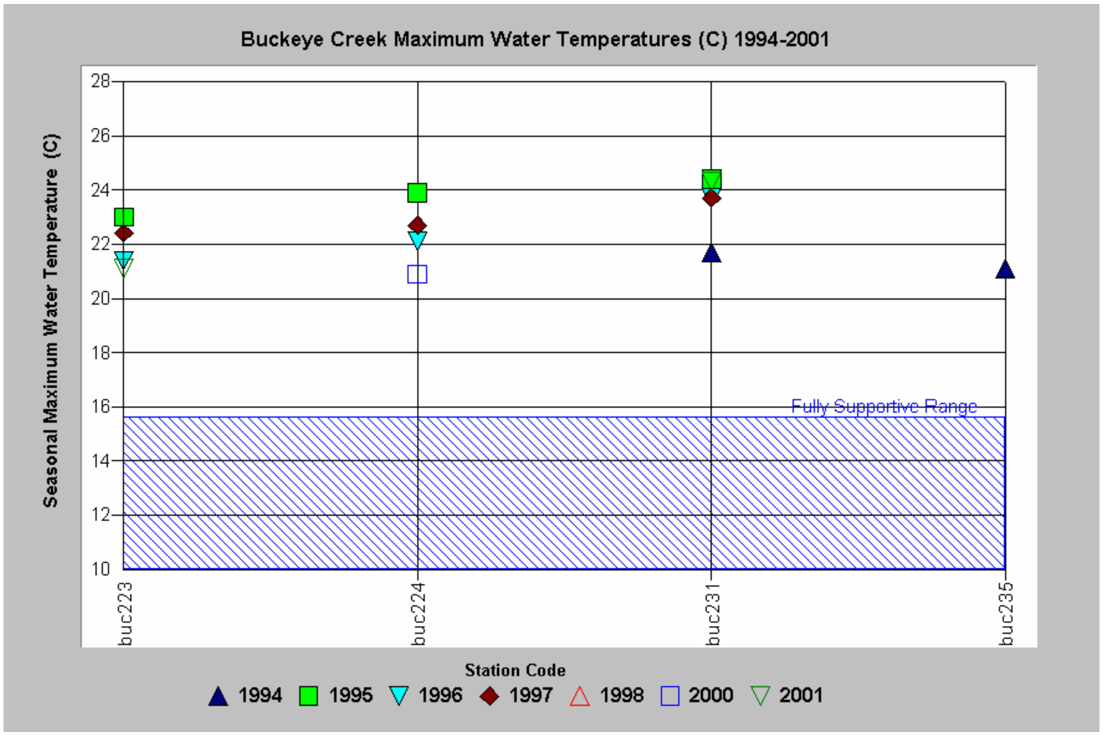

Figure 3. This chart from KRIS Gualala shows the maximum water temperature for all automated temperature probes placed in the Buckeye Creek from 1994 to 2001 with temperatures well outside the optimal range for salmonid rearing and rather in the range of highly stressful or lethal. Data provided by Gualala Redwoods, Inc. and the Gualala River Watershed Council.

Sediment Levels and Sources Not Acknowledged in THP/TCP

THP 1-04-059/TCP 04-531 (Jacobszoon, 2004) states that most sediment impacts in the Gualala River basin are from long-past logging carried out before the passage of the California Forest Practice Rules in 1972. The Gualala River watershed is listed as impaired for sediment under section 303(d) of the Federal Clean Water Act (NCRWQCB, 2003). The *Technical Support Document for the Gualala River Watershed Water Quality Attainment Action Plan for Sediment* (CWQCB, 2001) found that human caused sediment delivery rates are approximately 200% above the natural background level in the Buckeye Creek basin (Figure 4).

Roads are the most significant contributor of sediment in Buckeye Creek and basin-wide (CWQCB, 2001) and road densities in the Gualala River watershed over-all are high, including the Buckeye watershed (Figure 5). Road densities in the Little Creek Calwater Planning Watershed, which encompasses lower Buckeye Creek and all of Little Creek has some of the highest road densities in the Gualala River basin at over 8 miles per square mile (mi/mi^2). Road density data are conservative because temporary roads, skid trails and landings may not be mapped. All Buckeye sub-basins exceed by a large margin the threshold of 2.0 mi/mi^2, with no streamside roads, defined by NMFS (1996) as properly functioning watershed conditions for Pacific salmon. The USGS topographic map of Little Creek itself shows logging roads paralleling the entire stream, sometimes on both sides of the stream. Cedarholm et. al. (1981) found that road densities greater 4.2 mi/mi^2 yielded sediment levels 260% to 430% higher than background levels. Jones and Grant (1996) noted that interception of sub-surface flows by road cuts as a major factor in increasing peak flows during storm events. THP 1-04-059/TCP 04-531 does not give specific road lengths in miles, but states that between 2.5 and 3 acres of roads will be constructed. This would be expected to increase both sediment yield and peak flows in the Little Creek basin.

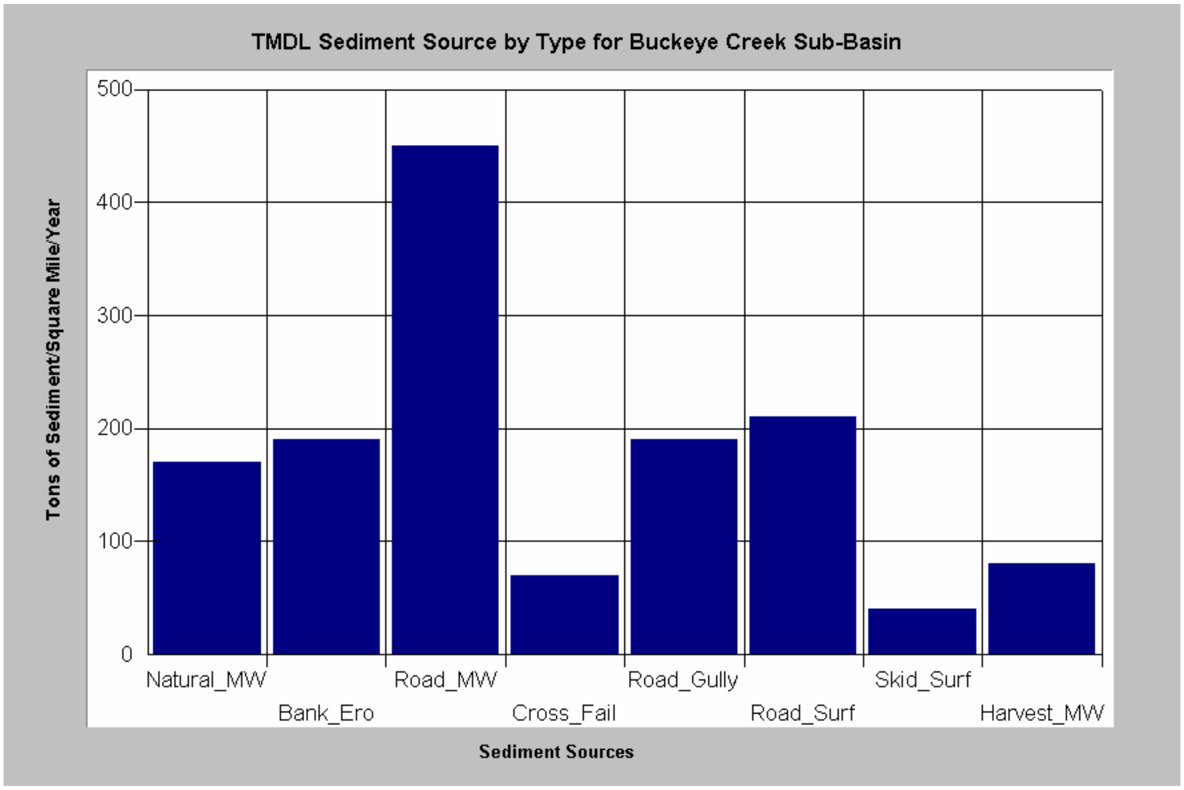

Figure 4. The Buckeye Creek basin sources of sediment estimated by the CSWRCB (2001). Road sources had the highest sediment yield in combination. Estimated sediment yield is shown as tons of sediment yielded per square mile per year. Chart from KRIS Gualala.

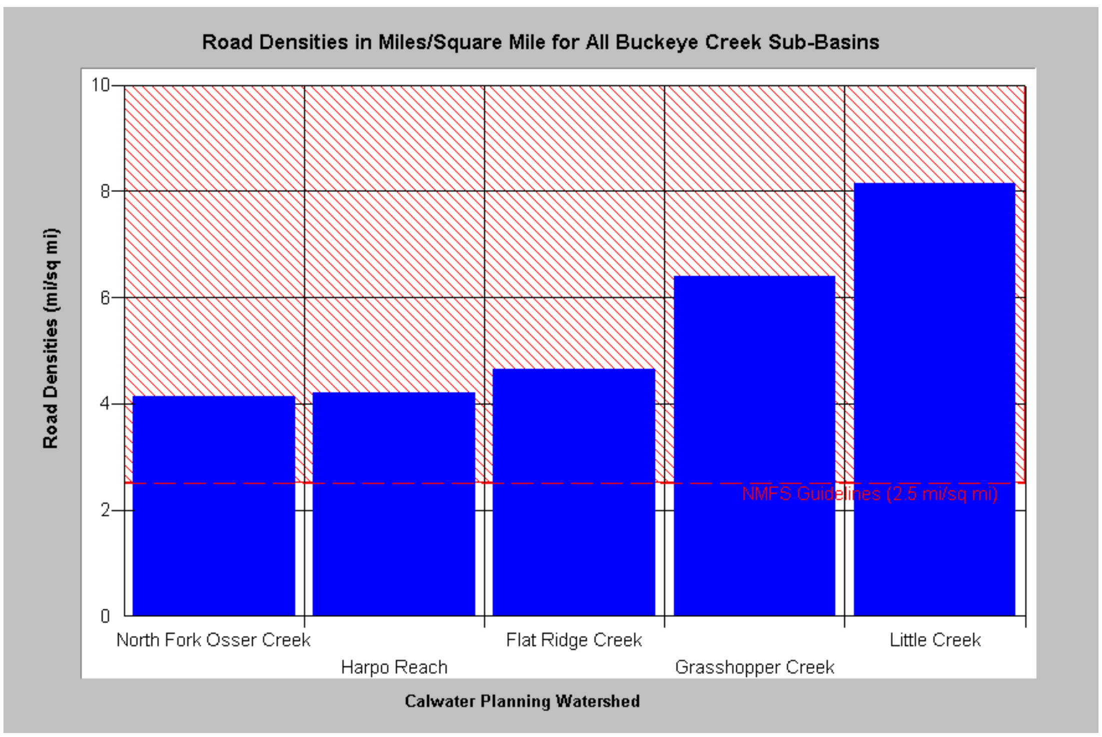

Figure 5. This chart from KRIS Gualala shows the density of roads in miles per square mile for Buckeye Creek watershed with a reference line of 2.5 mi/sq. mi which is slightly above NMFS (1996) properly functioning watershed condition level for Pacific salmon. Little Creek has one of the highest road densities in the Gualala River basin. Data from UC Davis ICE and North Coast Regional Water Quality Control Board.

With regard to the THP/TCP's inference that all sediment sources are old, IFR (2002) advanced the following hypothesis in KRIS Gualala: "Continuing sediment contributions to the Gualala River and its tributaries from recent land use (1985-2001) are preventing recovery of coho salmon and steelhead habitat." This hypothesis was supported by several lines of evidence: small median particle size distribution (Dietrich et al., 1989; Knopp, 1993), increasing fine sediment in size classes with potential to prevent successful salmonid spawning (McHenry et al., 1994) and decreased pool volume, frequency and depth (Knopp, 1993; Entrex, 1994; CDFG, 2001). It was also evaluated and validated by the U.C. Berkeley appointed peer review panel funded by CDF's Fire and Resource Assessment Program (FRAP) in Sacramento (Standiford, 2003).

Sediment Impacts on Aquatic Ecosystems Evident in Buckeye Creek and Gualala River Basin

There has been a substantial amount of data collected in the Gualala River basin that can be used to judge the health of streams (CA RA, 2001; Knopp, 1993), much of which has been captured in KRIS Gualala. Results of various surveys and their significance are described below.

<u>Mean Particle Size (D50)</u>: The median size of stream bed gravels (D50) can be used to characterize stream health (Knopp, 1993). Small median particle size may lead to bed load instability, which may cause mortality salmon or steelhead eggs when bed load transport occurs during their gestation (Nawa and Frissell, 1990). Dietrich et al. (1989) point out that small particles on stream beds are extremely mobile and, if the median particle size distribution of substrate is small, then it is likely that active erosion in the watershed recently contributed sediment. Knopp (1993) studied 60 streams in northwestern California and found that watersheds with a history of high intensity timber harvest management had a D50 of below 37 mm in diameter. Data from KRIS Gualala show that most sites measured in the western Gualala River basin were below the 37 mm threshold indicating high impairment likely related to recent, active timber harvest and road building (Figure 6). The reference lines shown on Figure 6 show undisturbed or recovered values for D50 from Knopp (1993), which range from 52 mm to 88 mm.

<u>Fine Sediment in Spawning Gravels</u>: Small sediment particles less than 0.85 mm are known to infiltrate salmon and steelhead nests, which are excavated in the stream bed gravels, and greatly decreasing survival due to smothering of the eggs (McNeil and Ahnell, 1964). Gualala Redwoods Inc. collected fine sediment data in the North Fork Gualala from 1992 to 1997. The North Fork Gualala River watershed was undergoing rapid timber harvest and a substantial increase in its road network (see CWE discussions below). Gravel grab samples showed a sharp increase in fine sediment less than 0.85 mm (Figure 7), from 10-12% of the stream bed to as high as 28%. McHenry et al. (1994) found that, when fine sediment (<0.85 mm) comprised 13% or greater of the substrate inside redds, it caused the mortality of steelhead and coho salmon eggs. The Gualala River TMDL (CSWRCB, 2001) set 14% as a target for fine sediment in accordance with this knowledge of potential harm to salmonid spawning. Extensive logging, road building and conversions have taken place in the lower Buckeye Creek basin (see CWE discussions below), but no fine sediment data have been collected. Photos from the NCRWQCB staff (Figure 8), however, show that some adjacent tributaries like Franchini Creek are choked with fine sediment. This not only shows that sediment is of recent origin, but also illustrates CWE in this nearby basin not acknowledged by Jacobszoon (2004).

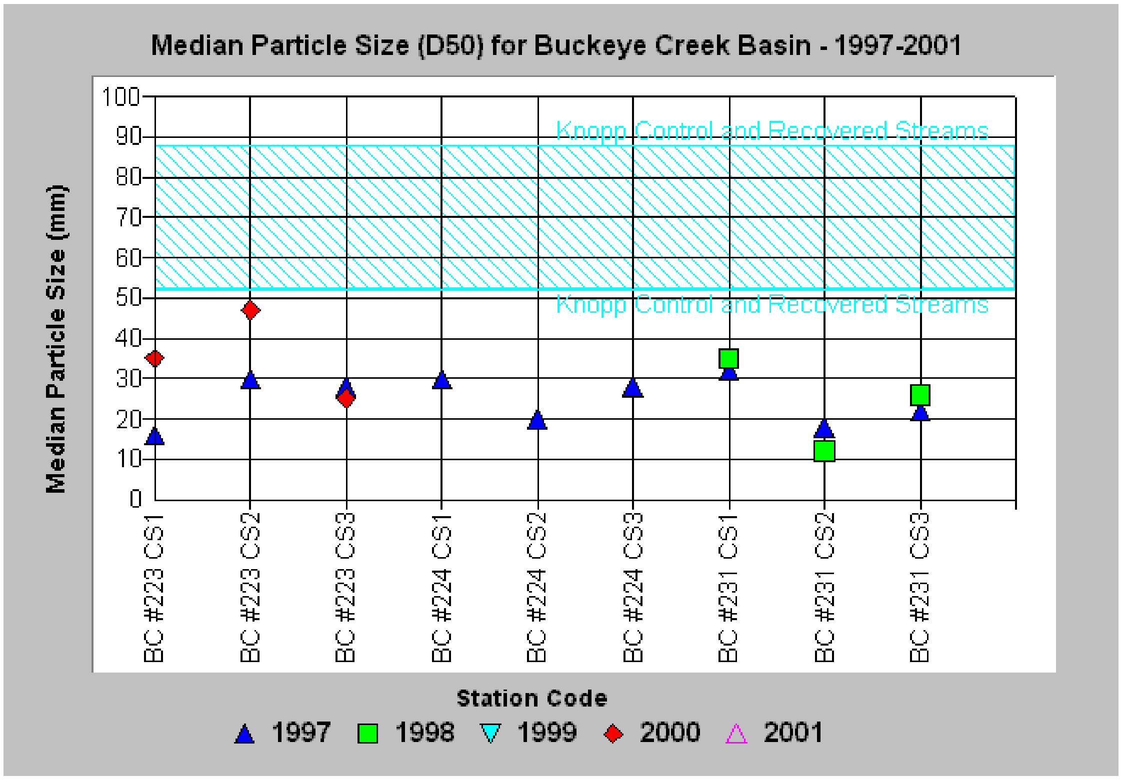

Figure 6. Median particle size distribution of stream gravels from KRIS Gualala show that almost all sites measured within the Buckeye Creek watershed were at levels indicating sediment impairment (Knopp, 1993). Data from Gualala Redwoods, Inc.

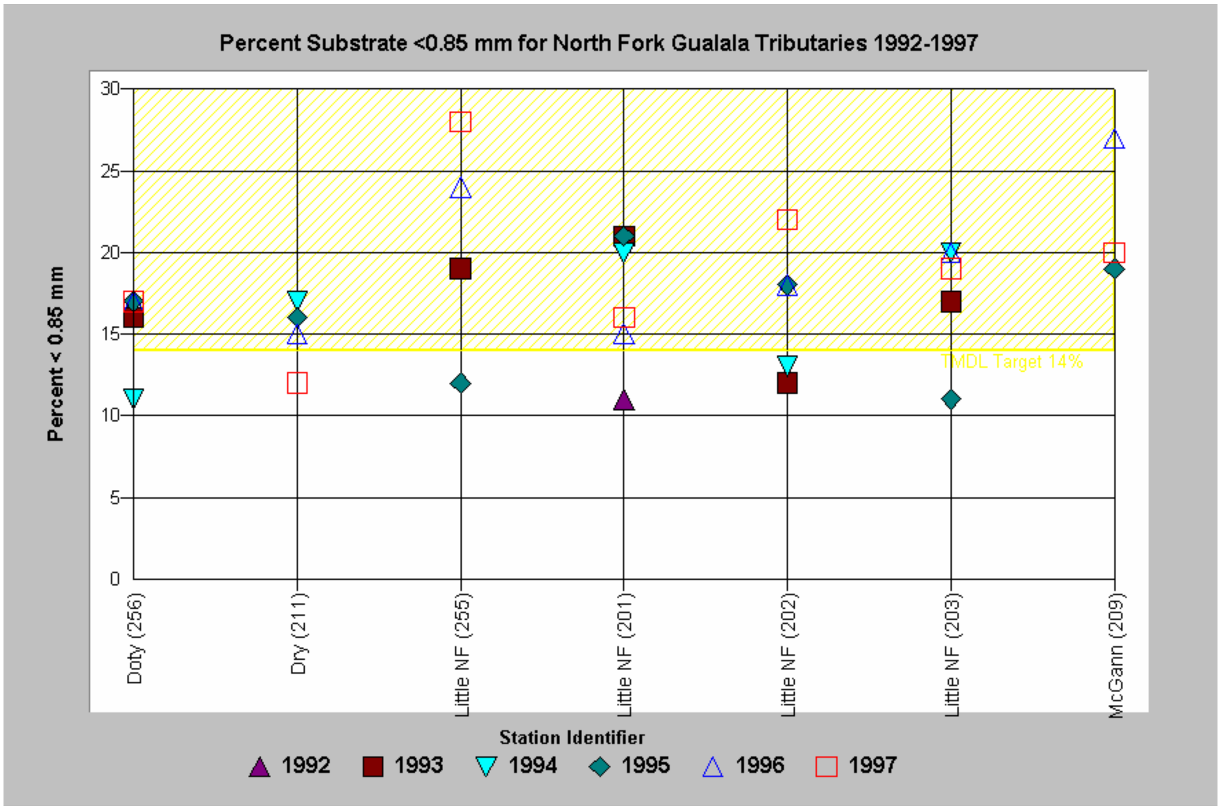

Figure 7. Fine sediment less than 0.85 mm exceeded levels recognized to be harmful to salmonid egg survival and the TMDL recognized threshold of 14% in Doty and Dry creeks, McGann Gulch and the Little North Fork Gualala River, with mostly increasing trends during the period of record. Data from Gualala Redwoods Inc.

Figure 8. Franchini Creek, tributary to lower Buckeye Creek and NCRWQCB staff during 2001 survey indicating major sediment problems and recent, active contributions. This is not viable salmonid spawning or rearing habitat. Photo by Brian McFadin.

Volume of Sediment in Pools (V-Star): Knopp (1993) found that northern California streams draining watersheds with high timber harvest management had higher levels of sediment in pools. He used a method of measuring pool volume relative to sediment known as the V-star method (Hilton and Lisle, 1992). Values measured are roughly equivalent to the percent of the pool volume filled by sediment. Figure 9 shows V-star values for six pools measured in Grasshopper Creek, the tributary to the east of Little Creek that had a V-star score of 0.59. This indicates a high degree of impairment from sediment and is far above the TMDL target set for the Gualala River basin of less than 0.21 (CSWRB, 2001). Again Jacobszoon (2004) failed to note sediment impairment and to meet the standard for use of best available science under CEQA.

Pool Frequency and Depth: The California Department of Fish and Game (1998) describes a method of stream habitat inventory known as habitat typing. Pool frequency by length and depth from these surveys can be used as an index of habitat suitability for salmonids. Optimal quality salmonid streams have 50% or more of their length in pool habitat (CDFG, 1998). Survey results from the Gualala River basin collected by CDFG in 2001 (CA RA, 2002) indicate many tributaries of the Gualala River have less than 20% pool frequency by length (Figure 10), which indicates major problems with sediment filling pools (Reeves et al., 1993). The high amount of dry channel is indicative of severe aggradation where surface flows are lost because the stream bed is buried so deeply. THP 1-04-059/TCP 04-531 acknowledges that “coho salmon habitat within the assessment area is marginal due to the small number of deep pools,” but fails to link this to any proposed action or long term plan for the recovery of habitat for this species and steelhead.

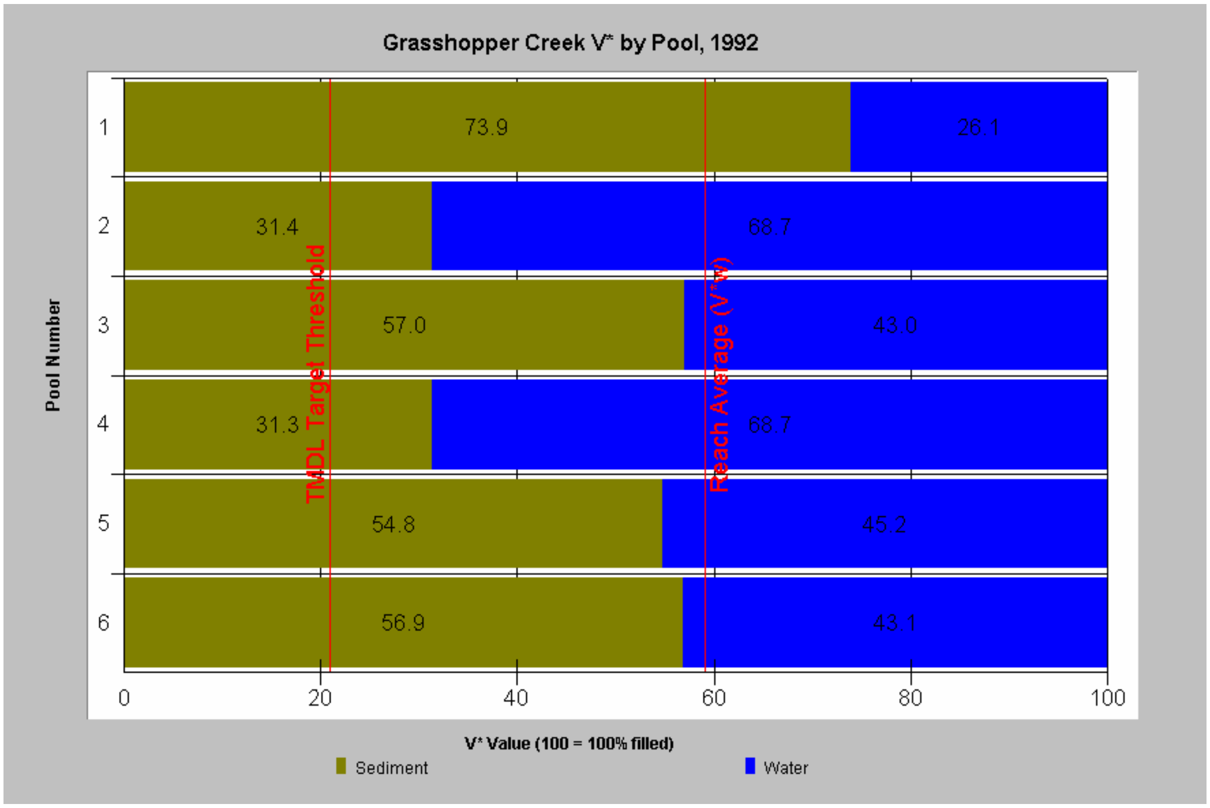

Figure 9. V-star values in Grasshopper Creek as collected by Knopp (1993) indicating major sediment problems likely related to logging in this Buckeye Creek tributary adjacent to Little Creek. Reference of 0.21 V* is from CSWRCB (2001). Chart from KRIS Gualala.

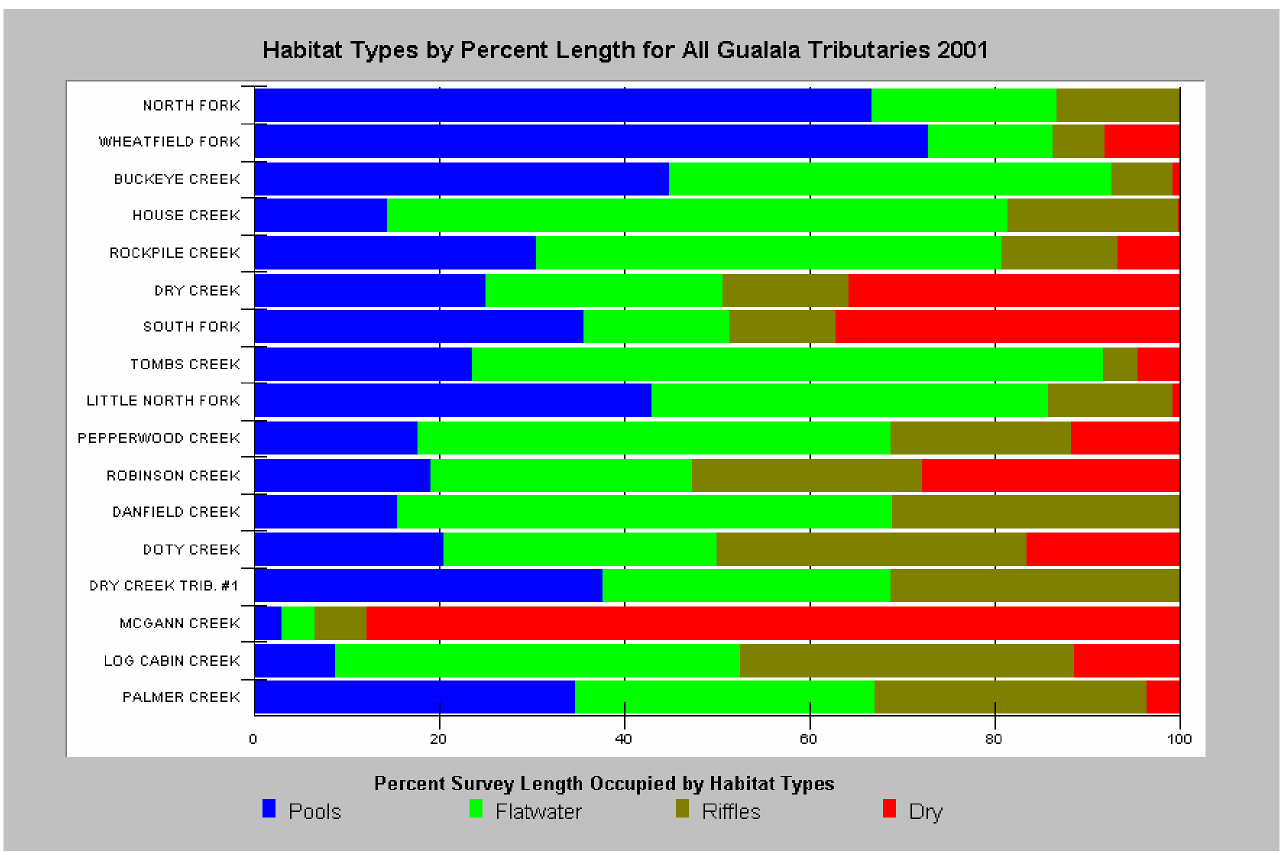

Figure 10. This chart from KRIS Gualala shows habitat frequency by length from 2001 CDFG habitat typing surveys of over 100 miles of Gualala River reaches or tributaries.

Although the pool frequency of for Buckeye appears as if the stream might be in moderate health, pool depth is lacking. Brown et al. (1994) recognize pools greater than three feet in depth as optimal rearing habitat for coho salmon. Larger, older age steelhead also prefer deeper pools (Reeves, 1988), which provide better cover from predators. Gualala River tributaries measured by CDFG (CA RA, 2002) show that more than 80% of pools in Buckeye Creek are less than 3 feet deep (Figure 12). This finding is very surprising because the stream is a fourth order stream (Strahler, 1957) and has a large watershed and discharge. It is likely that Buckeye Creek would scour deep pools if there were not an over-supply of sediment from tributaries, such as Grasshopper and Franchini creeks. The survey on Buckeye Creek by CDFG in 2001 is the reach beginning at Little Creek and extending down to the lower South Fork Gualala River (Figure 11). This is within the Little Creek Calwater Planning Watershed yet Jacobszoon (2004) fails to make reference to either these data or their significance. Buckeye Creek cannot take more sediment at this time and remain viable steelhead habitat and sediment should be reduced to ultimately allow recovery of coho salmon.

The lack of proper characterization of existing sediment problems in Buckeye Creek and its tributaries make THP 1-04-059/TCP 04-531 insufficient in terms of proper CWE analysis. Figure 11 also shows the acute problems with sediment and CWE as reflected by lack of deep pools in adjacent Rockpile Creek and in the South Fork and Wheatfield Fork of the Gualala River. The lack of pools is clear evidence major problems with sedimentation of streams and no further land use contributing sediment should be allowed in the Gualala River basin until pool frequency and depth have recovered to those suitable for salmonids.

Timber Harvest and Cumulative Watershed Effects

Timber harvest rates in Gualala River Calwater Planning Watersheds between 1991 and 2001 show that some sub-basins have been harvested at rates as high as 78% (Figure 12). Reeves et al. (1993) pointed out that logging in over 25 % of a watershed's area in less than 30 years compromised aquatic habitat diversity and cause loss of diversity of Pacific salmon species. CDFG (CA RA, 2001) habitat typing data showed that pool frequency by length was low in recently harvested basins, a result similar to that described by Reeves et al. (1993). All Buckeye Creek Calwater Planning Watersheds are over this prudent level of disturbance of 25% timber harvest in just ten years of records provided by CDF and harvest was active in the 1980's. Therefore, cumulative watershed effects from this land use were underestimated by CA RA (2001). The location of permitted timber harvests are displayed in Figure 13, which also shows the number of road-stream crossings. Armantrout et al. (2001) note that road stream crossings should be limited to one per mile to reduce risk of sediment yield. There appear to be five crossings in approximately three miles of stream on Little Creek, which indicates it is over this CWE threshold as well.

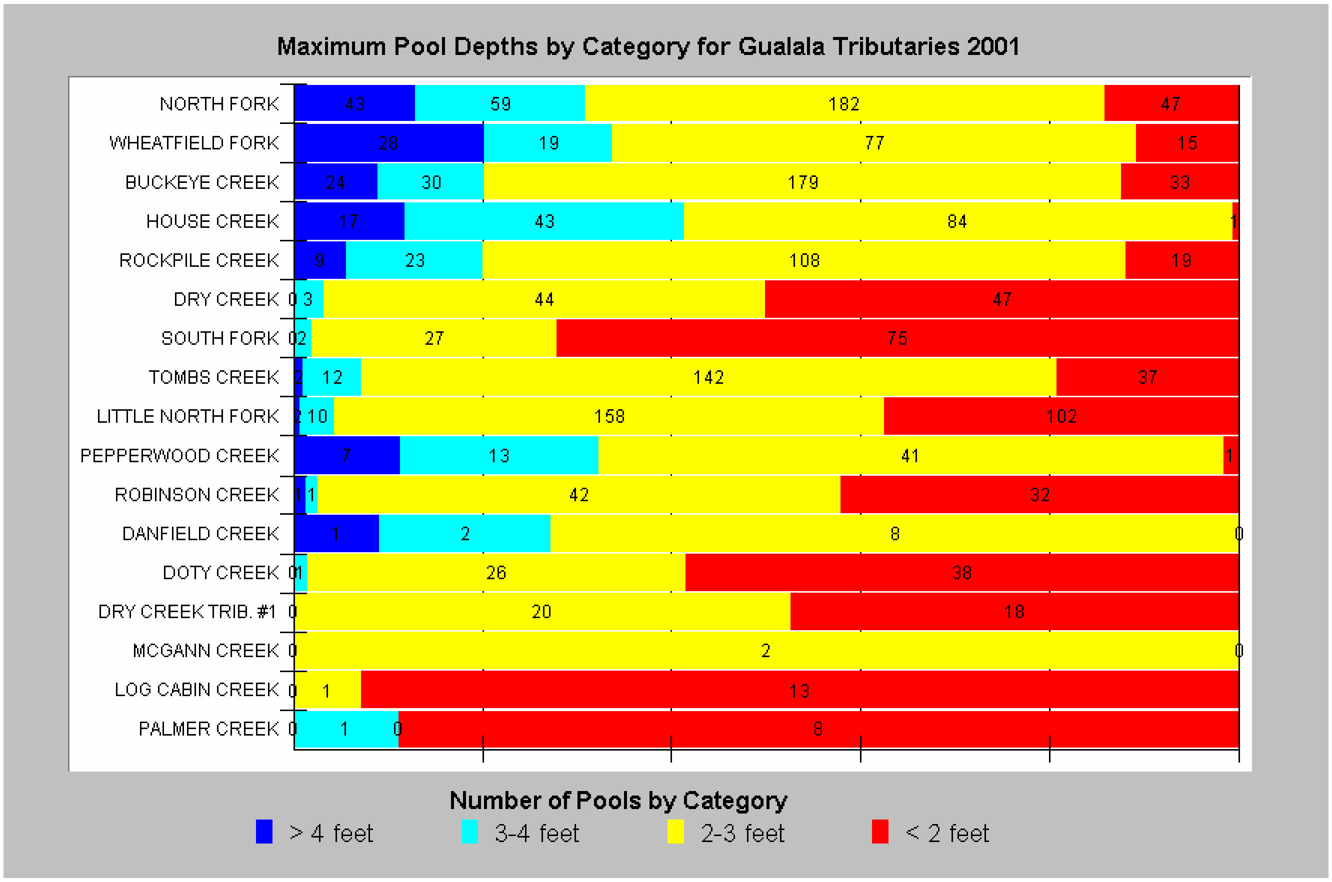

Figure 10. The habitat typing results from over 100 miles of CDFG surveys in 2001 show that pools deeper than three feet are rare on smaller tributaries and even on some mainstem Gualala River reaches like the South Fork. Chart from KRIS Gualala.

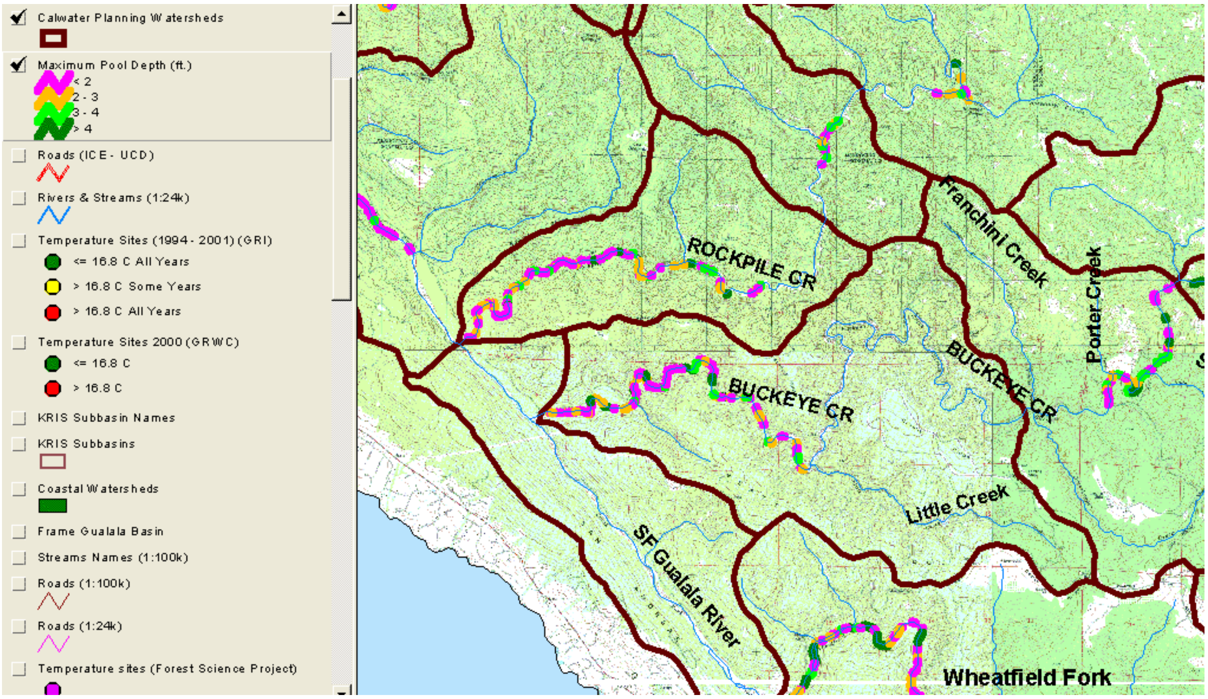

Figure 11. This map image shows pool depth in lower Buckeye Creek, lower Rockpile Creek and part of the lower Wheatfield and SF Gualala River according to CDFG (2001) data. Note that the majority of pools in Buckeye Creek are 2 feet deep or less.

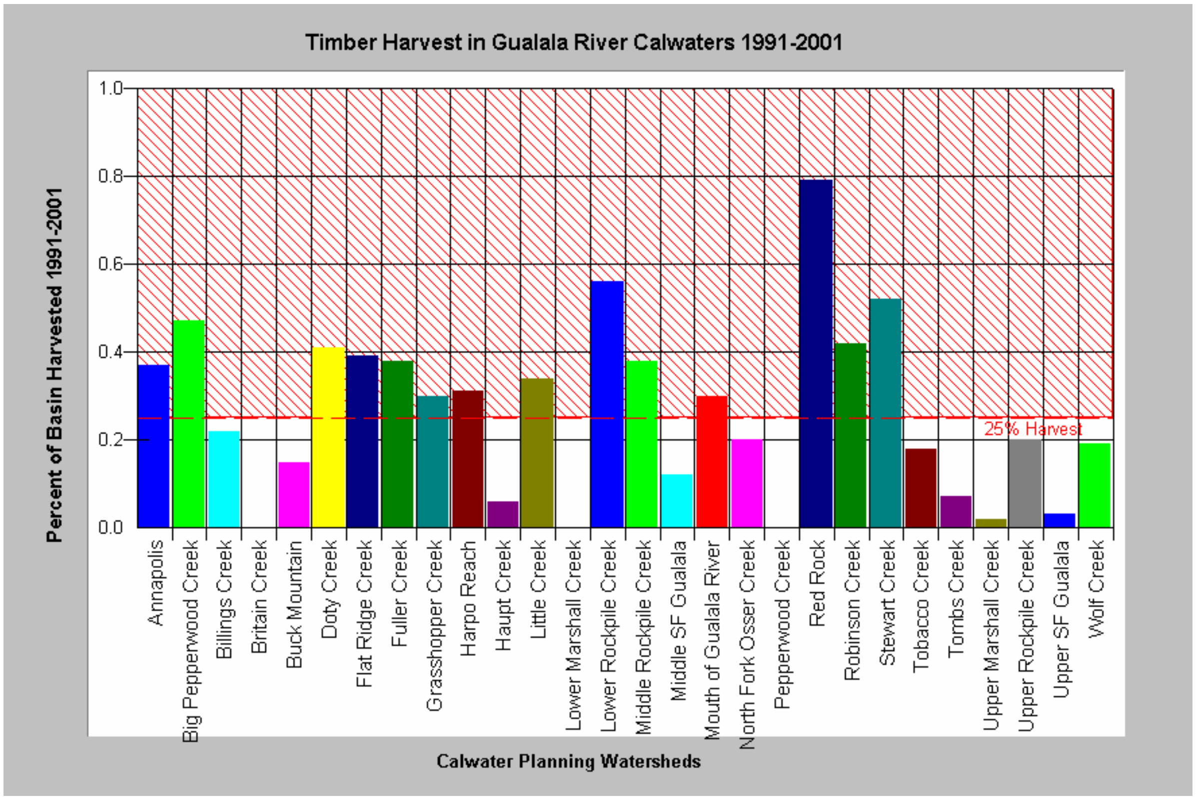

Figure 12. The timber harvest in all Gualala River Calwater Planning Watersheds from 1991-2001 is shown above as percentage of watershed area. Half of the basins are more than 25% cut in just over ten years, including all Buckeye Creek Calwaters (Little, Grasshopper, Harpo and Flat Ridge) except NF Osser Creek. Data from CDF, Santa Rosa.

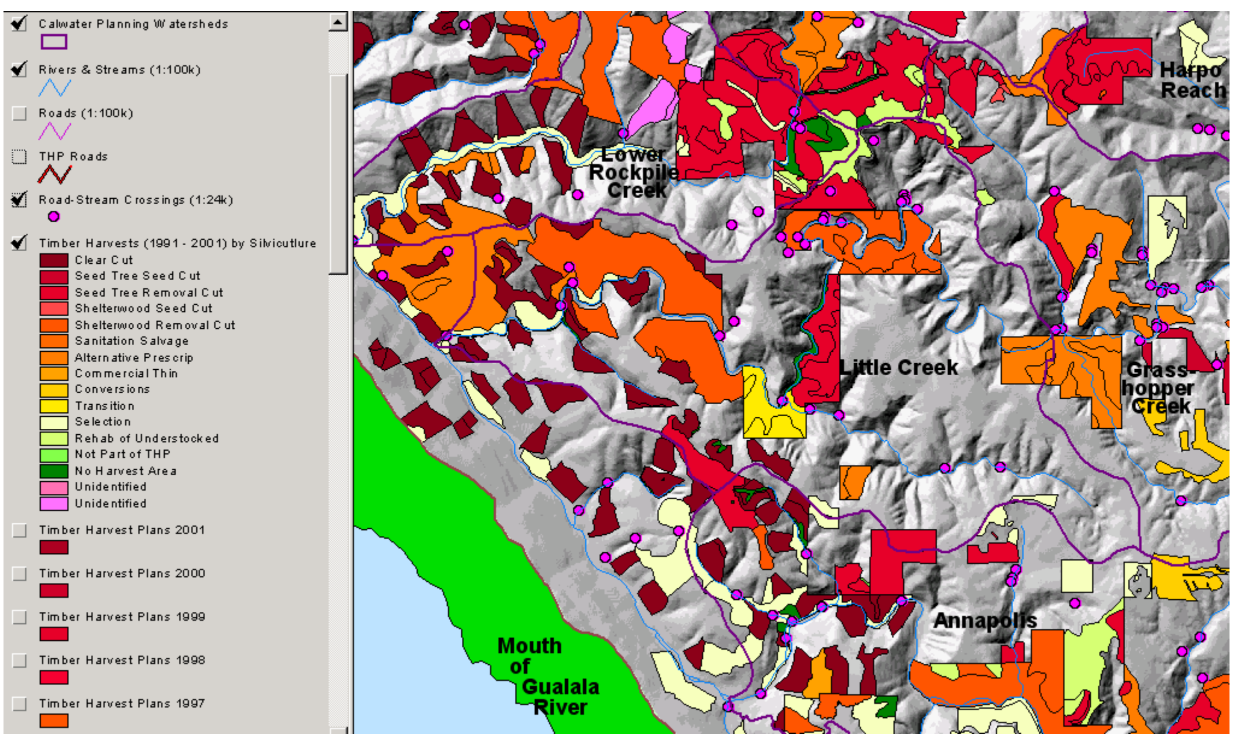

Figure 13. This map image comes from the KRIS Gualala ArcView project and shows THP's approved by CDF from 1991-2001, including harvest type. Road-stream crossings are shown as pink dots with five shown on Little Creek in a reach less than three miles long.

Another troubling aspect of the THP 1-04-059/TCP 04-531 application is its failure to acknowledge major removal of timber in the Little Creek watershed proper that does not appear as part of CDF THP records (Figure 14). Gualala River residents concerned about land use activities in the Little Creek watershed and the Annapolis vicinity provided aerial photo documentation of un-permitted harvests in the area affected by the THP 1-04-030SON, Hanson/Whistler Timberland Conversion Permit (TCP) #530. These impacts are not noted by Jacobszoon (2004) nor by the CDF Negative Declaration, yet they appear large enough to contribute significantly to problems similar to those that would be generated by THP 1-04-059/TCP 04-531. Kauffman et al. (1999) point out that riparian areas and watersheds can only recover when anthropogenic stressors are ameliorated. This conversion and timber harvest is particularly ill-timed because of the already widespread nature of watershed disturbance from timber harvest and roads at this time.

THP 1-04-059/TCP 04-531 states that "Adherence to plan elements should result in similar erosion potential for both pre and post-construction conditions." Collison et al. (2003) note that all timber harvest and road building have significant sediment impacts even under current California FPR's. Dunne et al. (2001) point out that in fact widespread disturbance, as documented here for the Buckeye Creek, Little Creek and Gualala River watersheds, have major impacts that this THP/TCP and CDF's Negative Declaration do not acknowledge:

> "Generally speaking, the larger the proportion of the land surface that is disturbed at any time, and the larger the proportion of the land that is sensitive to severe disturbance, the larger is the downstream impact. These land-surface and channel changes can: increase runoff, degrade water quality, and alter channel and riparian conditions to make them less favorable for a large number of species that are valued by society. The impacts are typically most severe along channels immediately downstream of land surface disturbances and at the junctions of tributaries, where the effects of disturbances on many upstream sites can interact."

In the Fisheries section above, it was pointed out that 1-04-059/TCP 04-531 does not deal sufficiently with endangered and threatened Pacific salmon and Dunne et al. (2001) point out that at risk populations can be lost, if cumulative effects are ignored and anthropogenic stressors continued:

> "Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time. They may occur at a site through repetition of a change caused by successive operations, or through two or more results of an operation, or they may occur at a site remote from the original land transformation and with some time lag. The concern about cumulative effects arises because it is increasingly acknowledged that, when reviewed on one parcel of terrain at a time, land use may appear to have little impact on plant and animal resources. But a multitude of independently reviewed land transformations may have a combined effect, which stresses and eventually destroys a biological population in the long run."

Dunne et al. (2001) also point out that CWE must be managed by minimizing risk: "Inevitably, the institutional aspects involve decisions about how much environmental and other risks are acceptable in a project. Before the institutional evaluation can be made, however, the risks of CWEs need to be identified in some transparent manner." The lack of provision of sufficient information on which to judge impacts of 1-04-059/TCP 04-531 fails the test of transparency. CDF should be rejecting this project because the high existing impacts and additional threats posed by previously permitted or completed projects, or at least calling for a full Environmental Impact Statement (EIS).

Figure 14a. Area of THP 1-04-030SON/TCP #530 in 1990 showing almost complete cover, but high road and skid trail densities.

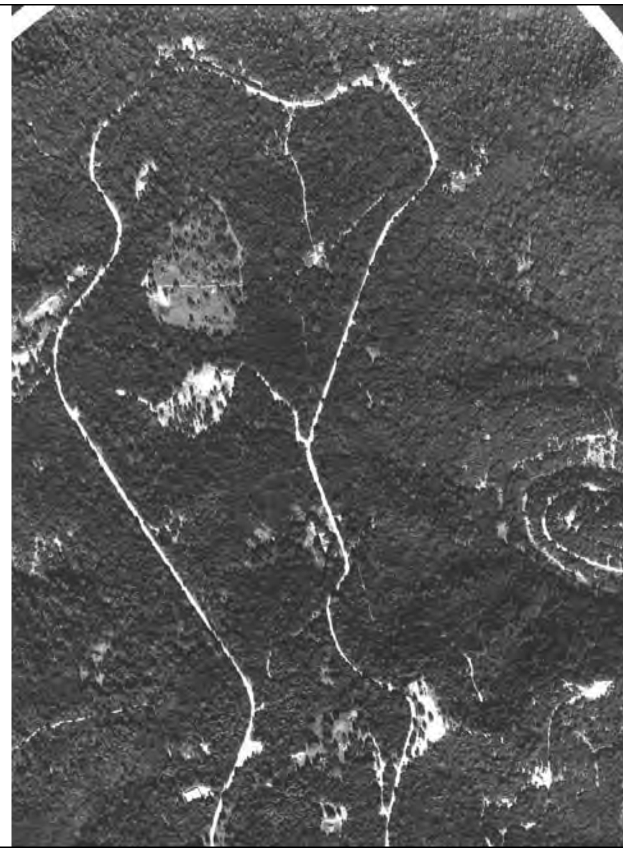

Figure 14b. This photo shows the same area as Figure 14a in 1996 with major changes in vegetation, but no THPs filed.

Figure 14c (At left): The 2002 aerial photo shows major new openings and substantial thinning of forests, again with no record from CDF for timber harvests on file. This type of large scale vegetation removal is a clear cut equivalent in places and likely already contributing to changes in runoff patterns (Jones and Grant, 1996), even without further conversion to vineyards.

Flow Issues

The hydrologic review of THP 1-04-059/TCP 04-531 is not complete or credible. It makes a number of unfounded assertions and provides no flow measurement data from Little Creek for assessing impacts of the project or judging their importance in supporting fish life. The THP/TCP notes that coho salmon are absent in the project WAA, that habitat for them is judged as marginal due to "inconsistent flow levels", yet makes no attempt to relate that information back to the plans. Jacobszoon (2004) makes many misstatements related to flows:

- "Surface flow will occur during winter months and is unavailable during low flow summer conditions with or without project implementation."
- "There is no scientifically valid way to directly correlate well water levels or yield in any area with local rainfall patterns or with surface runoff patterns."
- "The hydraulic impacts of any well are limited to a cylindrical zone of tens to a few hundred feet in proximity to the bore hole…"

A report by Kamman Hydrology and Engineering (2003), which was written in response to a similar Gualala River THP/TCP, reflects a more scientific approach to the question of the affect on flow of vineyard development in headwater swales. Jacobszoon's (2004) characterization of ground water infiltration as being unimportant in groundwater recharge has no scientific support (CDWR, 2003). Associations between rainfall, runoff and infiltration can be calculated, but such studies have not been carried out in the Gualala River basin. Again the assertion by Jacobszoon (2004) that the potential zone of influence for the wells proposed being limited to tens or hundreds of feet has no support (CDWR, 2003). Jacobszoon (2004) states erroneously that watershed size dictates base flow and implies that water withdrawal from a well could not decrease the surface flows because of lack of a groundwater connection, yet provides no data to support this contention.

Kamman Hydrology and Engineering (2003) note the importance of infiltration in wild land hydrology and ground water recharge. Head water springs may be an important source of water during low flows of summer. Jacobszoon (2004) notes that "a backhoe/excavator shall be used to construct a diversion from a spring to an adjacent Class III watercourse." Activities around headwater springs with heavy equipment are likely to disrupt groundwater recharge and natural connections between spring areas and streams below. Cold water base flows in summer are critical to the maintenance of steelhead trout and their further disruption will make the eventual recovery of coho salmon less likely. CDF does not have the experience or expertise in this area to properly evaluate changes in flow related to vineyard development. Changes in hydrology and flow diversions or reductions, such as those likely to occur under THP 1-04-059/TCP 04-531, should require a full scale EIS under CEQA.

Leopold and McBain (1995) also pointed out that wide spread compaction related to timber harvest in the Garcia River basin elevated winter runoff. This finding is similar to Jones and Grant (1996) who estimated that, when 25% of the area of a basin were impacted by timber harvest and roads, flow increases of 50% resulted. They note that increased peak flows can scour riparian areas, potentially elevating water temperatures. The increase in peak flows likely associated with road construction are noted above. IFR (2002) advanced a hypothesis that coho salmon and steelhead recovery are limited by summer low flows in the Gualala River basin. Both Jacobszoon (2004) and CDF in their Negatively Declaration fail to note that extensive reaches of the Gualala River currently lack surface flow because of severe aggradation, yet many of these reaches once supported standing crops of older age steelhead. No further diversions in the Gualala River basin should be allowed until sediment has been flushed from the system and surface flows restored in formerly productive reaches and tributaries.

Conclusion

Despite CDF having spent hundreds of thousands of dollars in public money to build tools for watershed analysis in the Gualala River basin (IFR, 2003), these data seem to be ignored by CDF regional staff when reviewing land use plans, such as Timber Harvest Plan 1-04-059 SON and the Martin Timberland Conversion Permit 04-531. I am enclosing a copy of the KRIS Gualala database and companion ArcView electronic map project, although much of this information is also available over the Internet at www.krisweb.com. CEQA calls for use of the best available scientific information in planning processes and the CDF Negative Declaration for these plans certainly does not meet that criteria because it ignores a great deal that exists.

The extremely poor health of the Gualala River watershed and Buckeye Creek sub-basin are ignored by Jacobszoon (2004) and CDF. The Gualala River is losing its ability to support coho salmon and steelhead trout. Sediment over-supply is evident in the mainstem of Buckeye Creek and its tributaries in the vicinity of the plan. No data are supplied for Little Creek itself with regard to its current condition.

Rieman et al. (1993) characterize a salmonid population as at moderate risk of extinction when:

> "*Fine sediments, stream temperatures, or the availability of suitable habitats have been altered and will not recover to pre-disturbance conditions within one generation (5 years). Survival or growth rates have been reduced from those in undisturbed habitats. The population is reduced in size but no long-term trend in abundance exists."*

The conditions described above fairly characterize the Gualala River and its steelhead population, while the coho population would merit a high risk classification (CDFG, 2002). This level of risk is nowhere acknowledged in the THP/TCP and discussions do not even include data from the effected tributary Little Creek, which may be a key cold water refuge for steelhead juveniles.

This project is likely to decrease ground water recharge and thus reduce base flows in summer needed by salmonids. The reduced cold water flow will also increase problems with elevated water temperature. Increased sediment from the site will also contribute to stream warming as it reduces the width to depth ratio of Little Creek and Buckeye Creek below and increases opportunities for heat exchange with the atmosphere. Impacts from these projects, coupled with existing high levels of disturbance and existing problems with aquatic health, are likely to have dire consequences for the prospect of salmonid recovery in the Gualala River basin.

Additional timber harvests in the Gualala River basin, and especially vineyard conversions, should not go forward until water temperature and sediment transport have returned to unimpaired levels and salmonid productivity has been restored. This timber harvest and conversion, in combination with others already permitted, are highly likely to negatively impact recovery prospects for coho salmon and steelhead in the basin and will help continue the trend toward increased sediment, increased water temperatures and decreased surface flows. Ultimately the entire aquatic community of the Gualala is at risk from such activities, including non-listed species like the Sacramento sucker (Higgins, 2003b), as more of the river will lose surface flow. The Negative Declaration should be withdrawn and a full EIS required.

Sincerely,

Patrick Higgins

References

Barbour, J. 2004. Letter to Wayne Burgstahler regarding water needs of vineyards near Annapolis, CA. Barbour Vineyards Management and Development, St. Helena, CA. 1 p.

Barnhart, R. A. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--steelhead. U.S. Fish Wildlife Service Biological Report. 82(11.60), 21 p.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management. 14(2):237-261.

Busby, P.J., T.C.Wainwright, and G.J.Bryant. 1996. Status Review of West Coast Steelhead from Washington, Oregon and California. NOAA Technical Memorandum NMFS-NWFSC-27. National Marine Fisheries Service. Seattle WA.

California Department of Fish and Game. 2002. Status Review of California Coho Salmon North of San Francisco . Report to the California Fish and Game Commission. California Department of Fish and Game, Sacramento , CA. 336pp.

California Department of Water Resources. 2003. Annapolis Ohlson Ranch Formation Highlands Groundwater Basin. CA Groundwater Bulletin #118. CDWR, Red Bluff, CA. 3 p.

California Resources Agency. 2002. Gualala River Watershed Synthesis. CA Dept. of Fish and Game, State Water Res. Control Bd., CA Dept. of Water Resources, CA Div. on Mines and Geology and CA Dept. of Forestry. Sacramento, CA.

California State Water Resources Control Board. 2001. Technical Support Document for the Gualala River Watershed Water Quality Attainment Action Plan for Sediment. CRWQCB, Region 1. Santa Rosa, CA. 147 pp.

California State Water Resources Control Board. 2001. California 303-D List and TMDL Priority Schedule. CSWRCB, Sacramento, CA. 128 pp.

Cedarholm, C.J., L.M. Reid, and E.O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington. p.3874. In: Proceedings from the conference Salmon-Spawning Gravel: A Renewable Resource in the Pacific Northwest? Rep. 39. State of Washington Water Research Center, Pullman, WA.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.

Erman, D. 2004. Comments to California Department of Forestry Northern Region on timber harvest and timber conversion to vineyards in the watershed of the Gualala River (THP 1-04-030 SON {TCP 04-530}; THP 1-04-055 SON {TCP 04-533}; THP 1-04-059 SON {TCP 04-531}. Don Erman, University of California Professor Emeritus (retired), Davis, CA. 3 p.

Groot, C. and L. Margolis (eds). 1991. Pacific salmon life histories. Univ. Of British Columbia Press, Vancouver, B. C.

Higgins, P.T. 1997. Gualala River Watershed Literature Search and Assimilation. Funded by the Coastal Conservancy under contract to Redwood Coast Land Conservancy. Gualala, CA. 59 pp.

Higgins, P.T. 2003a. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1—01-171 SON. May 20, 2003. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p.

Higgins, P.T. 2003b. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Negative Declaration for Sugarloaf Farming Corporation dba Peter Michael Winery, Timberland Conversion No. 524; THP 1-01-223 SON. December 12, 2003. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p

Higgins, P.T. 2004. Letter to Allen Robertson regarding Negative Declaration THP 1-04-030SON, Hanson/Whistler Timberland Conversion Permit (TCP) #530. April 14, 2004. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p

Hilton, S. and T. E. Lisle. 1993. Measuring the fraction of pool volume filled with fine sediment. Res. Note PSW-RN-414. US Forest Service, Pacific Southwest Research Station. Albany, CA . 11 pp.

Institute for Fisheries Resources. 2003. KRIS Gualala Database and Map Project Two CD Set. Funded by the California Department of Forestry FRAP, Sacramento, CA. (Also on the Internet at www.krisweb.com).

Jacobszoon, R. 2004. Timber Harvest Plan 1-04-059 SON and Timberland Conversion Permit 04-531. Filed on behalf of Robert and Emily Martin with the California Department of Forestry, Santa Rosa, CA.

Kamman, G. 2003. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1—01-171 SON. Kamman Hydrology and Engineering.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An Ecological Perspective of Riparian and Stream Restoration in the Western United States. Fisheries 22(5):12-24.

Knopp, C. 1993. Testing Indices of Cold Water Fish Habitat. Final Report for Development of Techniques for Measuring Beneficial Use Protection and Inclusion into the North Coast Region's Basin Plan by Amendment of the.....Activities, September 18, 1990. North Coast Regional Water Quality Control Board in cooperation with California Department of Forestry. 57 pp.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat. Prepared for the Resources Agency of California and the National Marine Fisheries Service; Sacramento, CA.

Leopold, L. and S. McBain. 1995. Sediment processes in the Garcia River estuary related to enhancement feasibility. Final report. Performed under contract with Moffett and Nichol Engineers. Funded by the Mendocino Resources Conservation District. 29 pp.

National Marine Fisheries Service (NMFS). 1996a. Factors for Decline: A supplement to the Notice of Determination for West Coast Steelhead under the Endangered Species Act. NMFS Protected Species Branch (Portland, OR) and NMFS Protected Species Management Division (Long Beach, CA). 82 pp.

National Marine Fisheries Service. 1996b. Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast. US Dept. Commerce, NOAA. 4 pp.

National Marine Fisheries Service. 2001. Status Review Update for Coho Salmon (Oncorhynchus kisutch) from the Central California Coast and the California portion of the Southern Oregon/Northern California Coasts Evolutionarily Significant Units. Southwest Fisheries Science Center, Santa Cruz, CA. 43 p.

Poole, G.C., and C.H. Berman. 2000. Pathways of Human Influence on Water Temperature Dynamics in Stream Channels. U.S. Environmental Protection Agency, Region 10. Seattle, WA. 20 p.

Plum, R. 2004. Assessment of water needs and supply for proposed Hanson-Whistler vineyard in Annapolis, CA. Burnham and Plum Well Drilling Co. Healdsburg, CA 1p.

Reeves, G.H.1988. Distribution patterns of fish in the Elk River basin. COPE Report l(3): 4-6.

Reeves, G.H., F.H. Everest, and J.R. Sedell. 1993. Diversity of Juvenile Anadromous Salmonid Assemblages in Coastal Oregon Basins with Different Levels of Timber Harvest. Transactions of the American Fisheries Society. 122(3): 309-317.

Rieman, B. 1993. Consideration of Extinction Risks for Salmonids. As FHR Currents # 14. US Forest Service, Region 5. Eureka, CA. 12 pp.

Standiford, R. 2003. Letter to Russ Henley, CA Dept. of Forestry and Fire Protection Fire and Resource Assessment Program re: Review of Institute for Fisheries Resources KRIS Gualala project. University of California, Center for Forestry, Department of Natural Resources, Berkeley, CA. 2 p.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. American Geophysical Union Transactions. 38: 913-920.

Sullivan, K., D. J. Martin, R. D. Cardwell, J. E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute . Portland, OR. 192 pp.

Taylor, S.N. 1978. The status of salmon populations in California coastal rivers. California Department of Fish and Game. Salmon/Steelhead Program, Anadromous Fisheries Branch. 14 pp.

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December 19, 2004

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California Department of Forestry and Fire Protection
135 Ridgeway Avenue
Santa Rosa, CA 95401

Re: Response to Comments on Timber Harvest Permit THP 1-04-030 SON, Hansen/Whistler and Timberland Conversion Permit (TCP) #530

Dear Ms. Markham,

I have just completed review of the response to comments for the Hansen/Whistler Timber Harvest Permit THP 1-04-030 SON, including responses to comments I filed on April 14, 2004. I am once again doing this review for local watershed residents who are concerned about the health of the Gualala River. They also feel that the California Department of Forestry (CDF) is not preventing damage to the river as required under the Federal Clean Water Act (CWA) and the California Environmental Quality Act (CEQA). This conversion and harvest are in the Little Creek watershed, a lower tributary to Buckeye Creek, which is showing advanced signs of cumulative watershed effects (CWE) as established in my previous comments, and new evidence presented by CDF indicates that Little Creek itself has a similar level of impacts.

After acknowledging that the stream is barely showing surface flow due to aggradation, CDF has approved the TCP and is now moving to approve the THP. This is a direct violation of CEQA because sediment impacts will occur and other recent and foreseeable activities in the watershed have also contributed to this recognized problem. The repeated statement that all effects from the plan can be fully mitigated and that there will be no impact to Little Creek is not credible (Dunne et al., 2001; Collison et al., 2003).

My Qualifications

To remind you, my expertise in the Gualala River watershed is a result of my having studied the watershed since 1997. I have recapped (and recaptured) the literature on fisheries and watershed processes for the Gualala River for the Redwood Coast Land Conservancy (Higgins, 1997). I then worked closely with the Gualala River Watershed Council and the California Resources Agency to provide technical assistance for the *Gualala River Watershed Assessment* (CARA, 2002) as part of the North Coast Watershed Assessment Program (NCWAP). In addition to providing analytical support to the agency staff, I helped assemble all available data, bibliographic resources, photos and electronic maps into the KRIS Gualala database (IFR, 2002), which is part of your record. Despite the fact that the KRIS Gualala project was funded by CDF to provide a tool for cumulative watershed effects analysis, your staff does not appear to be using it, even at this late date.

Cumulative Watershed Effects

Once again the project proponents and CDF have failed to deal with risk of cumulative watershed effects quantitatively or credibly. For the purpose of these comments, these impacts will be termed cumulative watershed effects and be abbreviated CWE. The definition of CWE from Dunne et al. (2001) was provided in former comments, but it is similar to those described in CEQA:

- “Cumulative impacts’ are defined as ‘two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts.
- Individual effects may be changes resulting from a single project or a number of separate projects.
- The cumulative impacts from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time."

As I pointed out in my April 14, 2004 memo to your regarding this THP/TCP, until risk is quantified scientifically, CDF and other agencies cannot gauge effects or prevent further damage to the Gualala River and its tributaries as required by CEQA. Response to my comments, and those of others who oppose the project, show that parties preparing these responses are unwilling or unable to understand arguments advanced related to CWE and confirm that they, like CDF staff, do not have capacity to meet CEQA requirements in this regard. The Dunne et al. (2001) report is from the foremost authorities on watershed processes from the University of California system and they point out systematic problems in timber harvest review and problems with dealing with CWE that are exemplified in this THP/TCP. The fact that this project involves a Timberland Conversion raises hydrologic impact questions even further beyond those normally considered for THPs.

The statement in responses to comments that CWE from the pending vineyard conversion “have been mitigated to less than significant” is not credible. Since the response, like the original THP/TCP, fails to reflect the findings of Dunne et al. (2001), I will provide the following quotes from the document which are applicable to attempts at CWE analysis. It is obvious that methods of analysis have not changed since 2001, despite the advice of the U.C. systems foremost watershed science authorities.

Dunne et al. (2001) describe how mitigation such as that offered on this THP/TCP will likely be imperfect and lead to impacts, but because of the lack of effectiveness monitoring that CWE will be untraceable, but none-the-less extant:

> “However, widespread experience in most types of terrain and land uses (forestry, agriculture, urbanization, mining, etc.) has proven that mitigation by on-site BMPs is usually imperfect, and much of the induced perturbation (say of runoff or sediment) “escapes” or “leaks” from the impoundment device or from the surface protection, and accumulates downstream, though at a reduced level. It is because of the limited effectiveness of on-site mitigation that CWEs have been identified widely by environmental scientists.”

Once again, the responders and CDF remains use an artificially defined boundary for CWE analysis for this project and ignore substantial evidence of previous disturbance and aquatic stress at the scale of Little Creek, the Little Creek Calwater Planning Watershed, Buckeye Creek and the Gualala River. Dunne et al. (2001) characterized this approach to CWE assessment:

> “The resulting ‘postage-stamp’, or ‘parcel-by-parcel’, approach, in which only the immediate project area of a single, small timber harvest is ever reviewed. —- as all other reviewers have said --- does not capture the cumulative influence of multiple harvests over a long period of time in a large, complex watershed.”

Dunne et al. (2001) noted a significant impediment to proper characterization of CWE in the THP review process is CDF’s “unquestioning and unverified reliance on mitigation.”

> “While there are clear benefits of, say, removing unstable, eroding roads, the notion that such practices coupled with new land-use activities will avoid CWE is unsubstantiated. There has also been a reliance on untested mitigation measures rather than an effort to documenting CWE processes. The resulting belief that BMPs mitigate or prevent potential problems accounts for the proclivity among many THP applicants to assert that no cumulative effects will occur because they will be mitigated out of existence.”

This is exactly the approach taken with THP 1-04-030 SON and response to comments and it lacks scientific credibility or a basis in data collected at the appropriate scales. This includes a complete lack of quantitative aquatic data from Little Creek, the water body most likely impacted by this project.

The responders say that the THP will cause the loss of some forest and have some watershed impacts, but such impacts are insignificant because they affect only 2.5% of the Little Creek Calwater Planning Watershed (CPW) and “approximately 95% of the planning watershed remains forested.” This statement does not reflect that tree size in the basin indicates very early seral conditions, as shown by CDF and U.S. Forest Service (Warbingtron et al., 1999). Figure 1 shows the size of trees in the Little River CPW as of

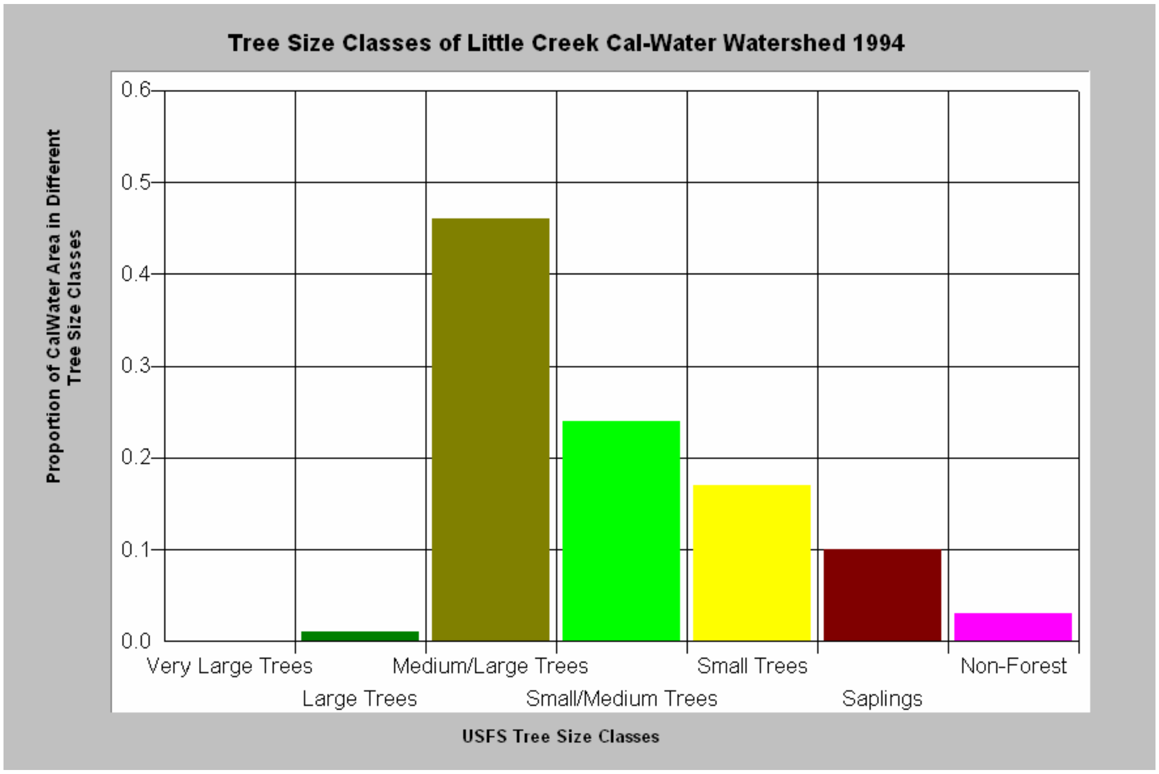

Figure 1. Tree size and vegetation types of the Little Creek Calwater Planning Watershed derived from a 1994 Landsat image shows that the forest is in early seral stages. Data from the USFS Spatial Analysis Lab and CDF Fire and Resources Assessment Program (FRAP).

1994 according to Landsat data. Because site potential in old growth redwood forests on the Gualala can be in excess of ten feet (IFR, 2002), the fact that there are almost no trees greater than 3 feet in diameter at breast height (dbh) shows that the entire area is in early seral conditions. The fact that 30% of the watershed is in trees smaller than 12 inches shows that there has been disturbance at that level in the 15 years prior to 1994. Recent timber harvests are likely to continue to cause erosion problems for at least 15 years after logging. Effects from roads related to projects may have a much more long lasting hydrologic impact (Quigley and Arbelbide 1997).

Reeves et al. (1993) point out that timber harvest in greater than 25% of Oregon coastal watersheds in less than 30 years caused a loss of Pacific salmon species diversity. That pattern of disturbance and response is extant in the Gualala River watershed as established in KRIS Gualala (IFR, 2002), where coho salmon have disappeared and attempts to re-establish them as recently as 1995-1998 through direct planting have failed as a result of CWE in the North Fork Gualala River and its tributaries.

While CDF quantifies agricultural conversions in Sonoma County as part of CWE analysis, their database queries for CWE analysis do not even include timber harvests, presumably because they think they have been fully mitigated. The timber harvest map

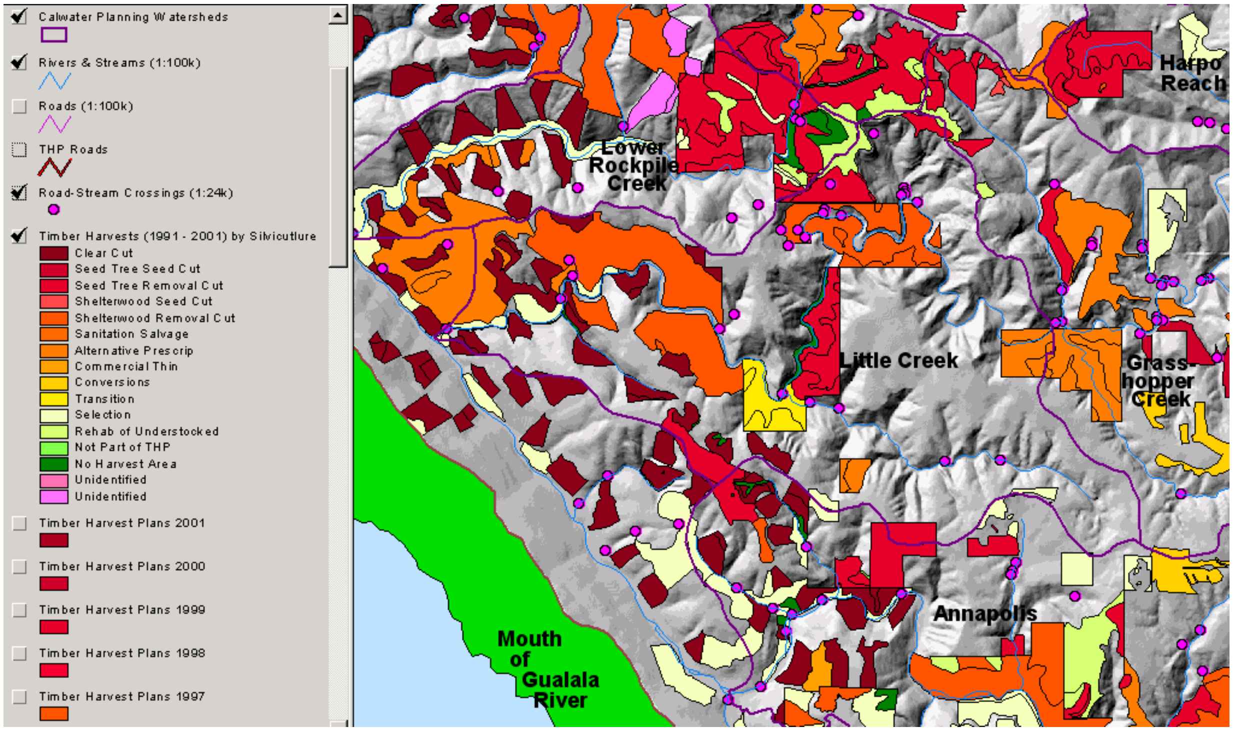

Figure 2. Timber harvests permitted in the Little Creek CPW by CDF between 1991 and 2001. Data from CDF Santa Rosa.

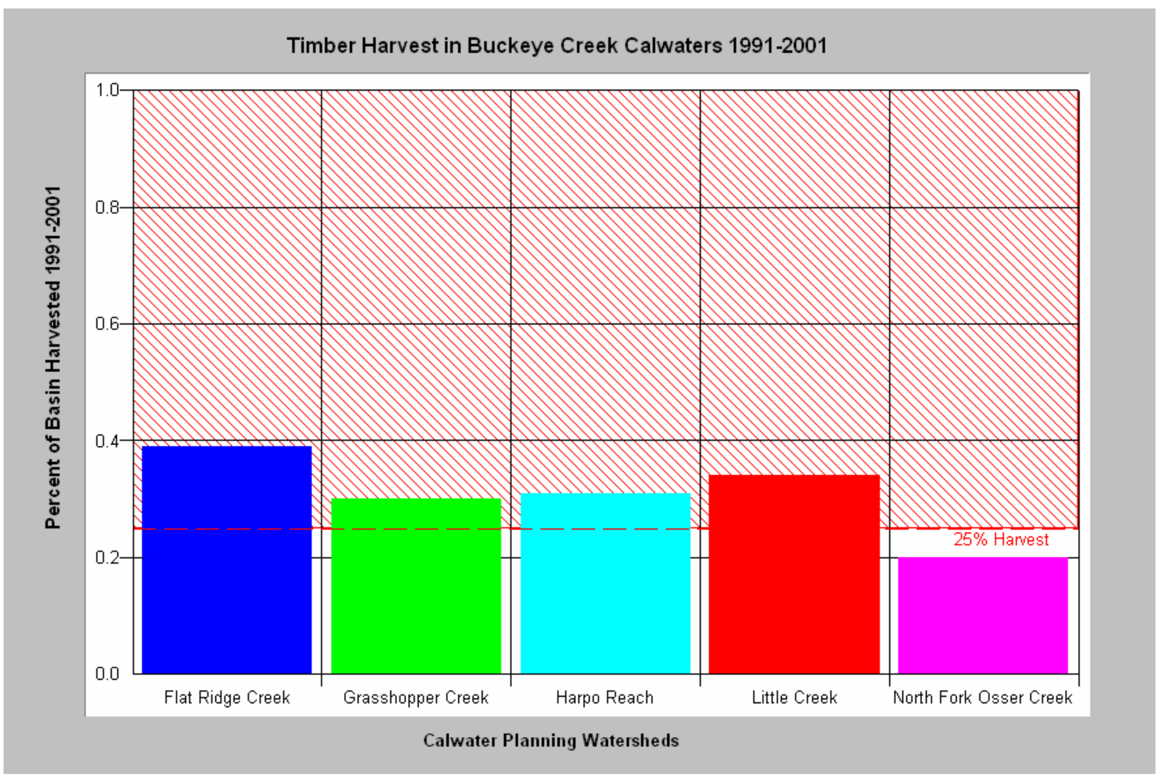

Figure 3. Summary chart of timber harvest levels by CPW in the Buckeye Creek sub-basin showing most have harvests over the recognized 25% harvest level CWE threshold demonstrated by Reeves et al. (1993). Chart from KRIS Gualala and data from CDF.

what was inferred above from tree diameters, that 34% of the CWP has been logged in a ten year period. The addition of the 4.5% of the area of the Little Creek CPW developed in vineyards must be considered in conjunction with this level of pre-existing disturbance, which is well over recognized CWE thresholds (Reeves et al., 1993). As indicated in my previous comments, there is photographic evidence of additional, unpermitted timber harvest and conversion in this CPW and CDF and responders are failing to quantify or fully recognize this as well.

CDF did respond to questions I raised about unpermitted land use activities in the Little Creek CPW with useful information. In fact CDF acknowledges illegal, unpermitted timber harvests and unpermitted vineyard conversions had taken place as well as legal conversions of parcels less than 3 acres that did not require permits. The response states that one illegal timber harvester paid a “substantial fine.” Payment of fines to the State does not abate environmental problems caused by the illegal activities. It is likely that less care was taken by illegal operators than by those working with State agencies and CDF and that sediment contributions from their activities has been considerable.

Although CDF and those providing comments say they are responding to my CWE concerns with regard to fisheries and aquatic habitat, indeed the additional information they have supplied prove problems already exist. The CDF or private consultant habitat “survey” as part of Response to Comments really only represents a quick reconnaissance, but confirms my assertions of advanced CWE:

- “Pools in Little Creek tend to be shallow and silted in….
- Pools in Little Creek are intermittent due to siltation….
- Pools observed on the subject property are acting as sediment traps for fines and gravel.”

The same report documents a “load of silt not yet flushed through the system.” CDF states that it acknowledges Buckeye Creek impairment but cites NCWAP (CARA, 2002) as indicating “apparent recovery in watershed conditions.” The *Gualala River WA* (CARA, 2002) found compromised habitat conditions in Buckeye Creek in 2001 and, without more recently collected channel data to confirm this “apparent recovery”, such claims lack credibility.

For Little Creek to classify as an unimpaired water body, it would have to meet the following criteria:

- Pools frequency of 40% by length with pools greater than three feet deep in abundance,
- Water temperatures at its convergence with Buckeye Creek of less than 16.8 C MWAT, and
- Coho salmon juveniles present and steelhead juveniles of several age classes abundant, including some two year old fish.

This would indicate that Little Creek were a healthy freshwater ecosystem within its former range of variability and not suffering from CWE.

Fisheries Issues: Coho Salmon, Steelhead Trout and ESA Requirements

Fish discussions in the THP/TCP and Response to Comments are generic, in that coho life history information is not specific to the Gualala River basin and no discussions of the status of Gualala River coho are to be found. CDF avoids fundamental requirements to protect coho salmon since they are listed as Threatened in the Gualala River basin under both the Federal and California Endangered Species Acts. Similarly, steelhead are listed as Threatened in the Gualala River basin under Federal law, but no discussions of population status in the Gualala Basin or regionally is offered. The response to comments and CDF are still not citing the *Status Review of California Coho Salmon North of San Francisco* (CDFG, 2002) after my repeated requests that the document be recognized, and that credible discussions regarding both coho and steelhead be included in your reviews.

The field memo from Little Creek provided with the Response to Comments indicates that "coho salmon habitat in the assessment area is marginal due to the small number of deep pools and inconsistent flow levels" and that coho were not found. No methods, such as electrofishing or direct observation (Adams et al., 1999), were discussed in the memo and or the extent of the reach surveyed. In order to ascertain that coho do not occur in some years, surveys would have to be conducted for three years because coho are even age spawners and develop strong and weak years classes as a result.

There is no indication that there are older age steelhead in Little Creek, and compromised pool depth would likely limit carrying capacity for yearlings and two year old fish. This means that Little Creek has similar CWE to most Gualala River basin tributaries, which lack older age steelhead juveniles (CARA, 2002). Electrofishing at dozens of sites in the Gualala River Basin in 2001 caught very few large steelhead juveniles. This is important because steelhead must spend one or two years in freshwater before entering the ocean in order to survive as adults (Barnhart, 1986).

As I have pointed out in past comments, Buckeye Creek and Little Creek are both of sufficiently low gradients that coho salmon would have been at least a co-dominant salmonid species in both streams. The lack of attention to population viability under ESA also shows negligence in terms of CWA requirements. No land use activities should be allowed to further degrade either Little Creek or Buckeye Creek until they are supporting a cold water fishery, including both coho salmon and steelhead juveniles, CWA "beneficial uses."

Roads and Cumulative Watershed Effects and THP 1-04-030 SON

Road discussions again show the incapacity of responders to grasp yet another critical CWE issue. The road densities in the Little Creek CPW are 8 miles per square mile of watershed area (Figure 4), which is very high with regard to CWE risk as defined by the National Marine Fisheries Service (1996). They recommended that densities be limited to less than 2.5 mi./sq.mi. with no streamside roads.

Cederholm et al. (1981) showed that major damage was done to watersheds when road densities exceeded 4.7 mi./sq.mi. and that sediment yield to streams was on the order of 2.6 to 4.2 times the natural rate of sedimentation. CDF does not provide a quantitative assessment of sediment from roads anywhere in the THP/TCP nor does the Response to Comments. This ignores well founded science provided as part of the *Gualala River Technical TMDL* (CA SWRCB, 2001) indicating elevated, man-caused erosion from roads. Those responding to comments should recognize these pre-existing impacts and CDF should consequently deny further development requests until results from monitoring of stream channels indicate recovery.

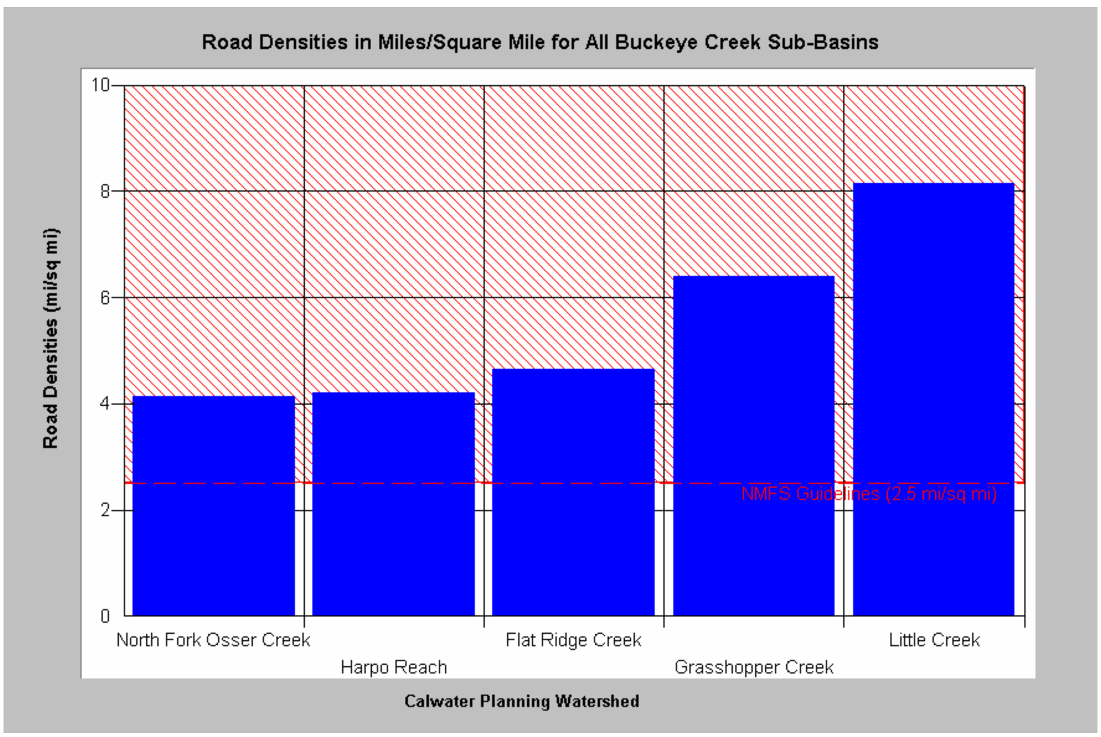

Figure 4. This chart shows the density of roads in miles per square mile for Buckeye Creek watershed with a reference line of 2.5 mi./sq. mi., which is slightly above NMFS (1996) properly functioning watershed condition level for Pacific salmon. Little Creek has one of the highest road densities in the Gualala River basin. Data from U.C. Davis ICE and North Coast Regional Water Quality Control Board.

The U.S. Forest Service (USFS, 1996) considered road densities greater than 4.7 mi./sq. mi. "Extremely High" in terms of potential aquatic impacts in the Interior Columbia

River Basin (Figure 5). Their reference was derived by comparing data for bull trout and other salmonid species with road densities over 3,000 watersheds. They concluded that "the higher the road density, the lower the proportion of sub-watersheds that support strong populations of key salmonids" and that bull trout were absent from watersheds with more than 1.7 mi./sq. mi. of watershed area. They also found a relationship between fine sediment in streams and road density. Quigley and Arbelbide (1997), also in the Interior Columbia Basin, found "increasing road densities (combined with the activities associated with roads) and their attendant effects are associated with declines in the status of four non-anadromous salmonid species." Jones and Grant (1996) noted that road cuts disrupted subsurface flows and routed them to streams, which increases flood frequency.

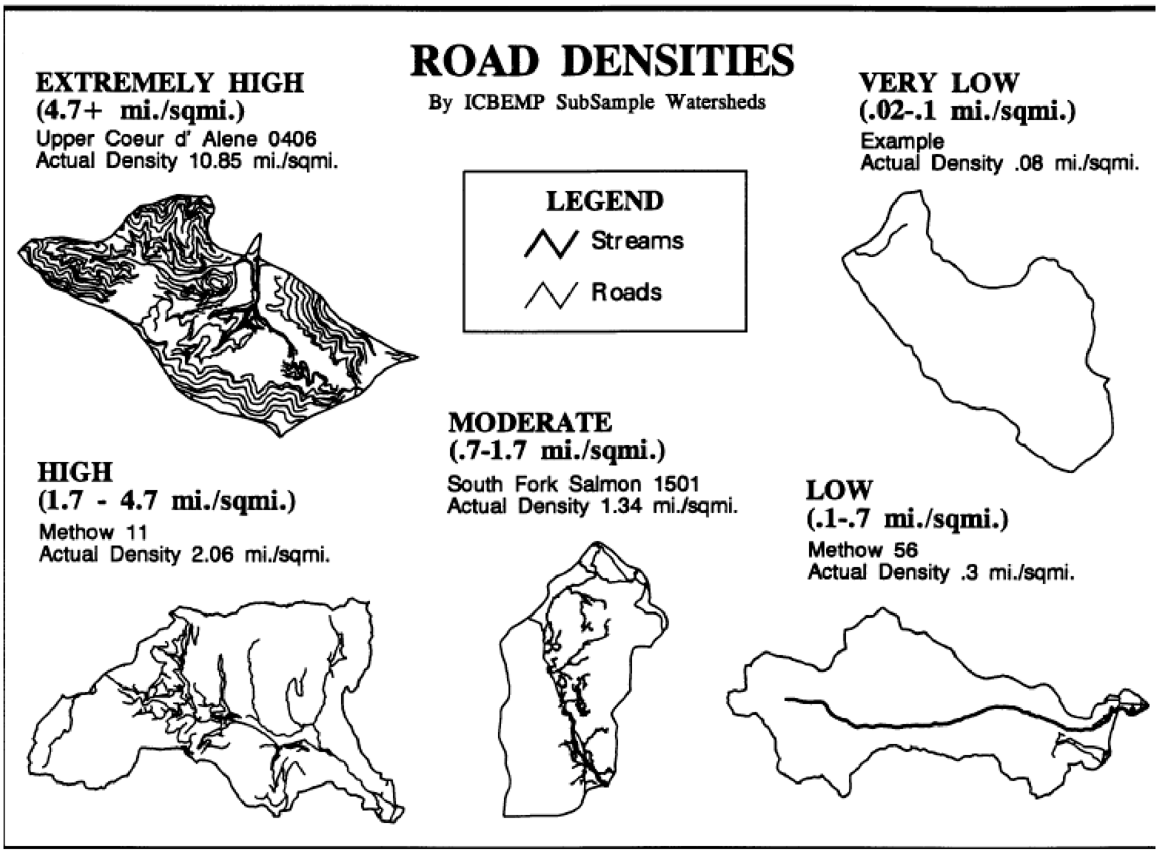

Figure 5. Road density classifications, in miles of road per square mile (mi./sq. mi.), are from USFS (1996) Figure 9 and represent risk to sensitive aquatic species. Note also that they categorize as Extremely High road densities of 4.7 mi./sq. mi. and greater and that the Little Creek CPW has nearly double that.

In response to my comment that the THP and TCP had failed to deal effectively with CWE related to roads, responders acknowledged that there were significant problems with the Little Creek-Flournoy Road, but they were being fixed. This shows a patent misunderstanding that similar problems exist on virtually all roads and there are dozens of miles of roads in just the Little Creek CPW alone. As I pointed out before, the road densities are conservative estimators of disturbance with potential for surface erosion because they do not reflect temporary roads, skid trails or landings.

At other places in the THP/TCP and in Response to Comments it is noted that the road that parallels Little Creek has been abandoned because of stream side landslides. CDF and those responding to comments seem to think that just walking away from such a road prism means that sediment will no longer be contributed to streams. It is likely, however, that this old road bed will continue to erode unless it is recontoured and planted with trees. It also represents a major pre-existing sediment source only recognized by CDF late in the review process. There is discussion of getting grant money for fixing the Little Creek-Flournoy Road and this is taken as mitigating road problems off site. It is inappropriate to be using public money to fix a private land road and then count it as mitigation that allows further development.

Water Temperature

Those responding to comments, like CDF before them, continue to miss the connection between sediment and water temperature. As Dunne et al. (2001) point out, there is almost always "leakage" from mitigation measures, so sediment from the THP/TCP area is likely to reach Little Creek. CDF has established that Little Creek is suffering from advanced CWE, with silt-filled, shallow pools and loss of surface flows due to massive aggradation. Filling of streams with sediment changes the width to depth ratio and increases heat exchange, which results in stream warming (Poole and Berman, 2000). The continued reiteration by CDF and the responders that streams do not cross the property, that there is no riparian removal associated with this project and, therefore, the THP/TCP cannot warm the stream is incorrect.

The responders and CDF are also missing a second well recognized mechanism for stream warming. Brosofske et al. (1997) found that soils warmed in response to vegetation removal and that ground water temperatures also warmed. Changes in ground water temperatures in turn warmed spring flows and adjacent stream reaches. These mechanisms are also likely to cause additional warming to Little Creek for which no actual temperature data are available.

Flows Issues

While substantial quantities of information have been filed by the proponents of THP 1-04-030 SON and TCP-530, there are still fundamental flaws in arguments regarding likely effects on surface flows from this project. I am not a hydrologist so I will restrict my remarks to the mechanism that I know will operate to reduce surface flow.

I have described in previous comments how the Gualala River and its tributaries have lost surface flow because aggradation of the stream bed is so severe that flows now percolate through the gravel bars in late summer and fall. The Response to Comments notes that Little Creek loses surface flow, which is consistent with substantial, pre-existing sediment pollution. Additional sediment from this THP/TCP will continue the pattern of sediment yield over background, and thus further degrade Little Creek and cause it to lose surface flow earlier in the season and ultimately to lose all function as fish habitat. This is a text book case for CWE and, as an issue on its own, should cause CDF to turn down this project and ones similar until Little Creek has recovered.

Agency Incapacity

In my previous comments, I have supplied a scientific basis for CWE assessment, including water temperatures required by coho salmon (Welsh et al., 2001), for fine sediment in spawning gravels (McHenry et al., 1994) and for pool frequencies (CDFG, 1998). In my response here I have acquainted CDF staff with new literature from the Columbia Basin on CWE thresholds and roads (USFS, 1996; Quigley and Arbelbide, 1997) and how sediment affects temperature (Poole and Berman, 2000). I have provided data to show the compromised quality of Buckeye Creek and CDF or project proponents have now demonstrated advanced CWE in Little Creek. Unfortunately, as Dunne et al. (2001) pointed out, CDF, other agencies overseeing and those responding to comments on this THP/TCP lack the professional capacity to deal with the issues I have raised.

CDF and the plan proponents have failed to supply data that show functional aquatic habitat conditions in Buckeye Creek or Little Cree or support of beneficial uses, to prove that CWE are not extant. Dunne et al. (2001) point out that regionally recognized CWE standards should be acknowledged and applied:

> "If there are specific scientific limits (such as a lethal stream temperature for fish or a threshold fine-sediment concentration for spawning beds), RPFs are expected to know this and to apply it in the context of the rules and in protecting beneficial uses of water. If the RPF doesn't know or apply existing knowledge, reviewing agencies have the duty to require additional mitigation."

The appropriate mitigation in the case of the THP 1-04-030 SON, especially in light of the widespread adjacent illegal activity in the plan area, is that the permit should be denied until the Little Creek and Buckeye Creek watersheds have been allowed to recover their watershed health and they are meeting CWA requirements, such as supporting coho salmon and steelhead juveniles of multiple age classes.

Dunne et al. (2001) argue for assessment of CWE risk to be removed from the hands of CDF staff. The lack of capacity of CDF staff, despite having data tools such as the preceding NCWAP report (CARA, 2002) and the KRIS Gualala database, demonstrates that CDF and other agencies may need to acquire additional staff with advanced degrees in watershed science and conversant in the us of cutting edge analysis tools as recommended by Dunne et al. (2001).

Unfortunately, CDF staff and those responding to comments do not appear to be reading literature cited in my comments and those of others and, thus, refusing to recognize advancements in understanding of CWE regionally. Contrary to the following statement by Dunne et al. (2001), CDF is not faced with decisions where scientific literature is not available to support decisions:

> "CWE analysis, like all other human endeavors, will have to be conducted rationally in the face of these uncertainties. Some people will be skillful at this, and will remain well informed as the technology evolves; others will remain confused and be unable to proceed because the scientific literature does not contain the answer to their specific question."

CDF staff could study recent scientific literature on cold water fisheries and forestry interactions and make more informed decisions on this THP/TCP. Their failure to do so and, therefore, to properly assess risk of CWE is insufficient to meet the standards of CEQA..

Conclusion

CDF is now largely defending positions espoused by consultants for project proponents, even though experts with credentials far exceeding those of these consultants, such as Dr. Don Erman and Dr. Michael Johnson, are pointing out major flaws in logic and science. CDF and CDFG have not collected or presented data on the fisheries or water quality of Little Creek to show that it is in a non-degraded condition, not suffering from cumulative watershed effects problems, and, therefore, able to sustain additional impacts.

In fact, additional information provided late in the process of review of THP 1-04-030 SON and TCP-530 establish that Little Creek is similar to other Gualala River tributaries and showing advanced signs of CWE, such as loss of surface flow. This is exactly the response that would be expected given the high degree of legal and illegal development and land alteration that has taken place in the watershed.

Four years after the publication of the Dunne et al. (2001) report, where the best University of California watershed scientists pointed out deficiencies in CDF's approach to cumulative watershed effects analysis, the agency and process are still showing the same flaws. I believe that CDF and the other agencies involved in review are wasting a huge amount of money in defending projects that benefit private parties, but threaten to drive fish stocks in the Gualala River to extinction, and that patently violate CEQA and the Clean Water Act. It may be time to contract with the University of California for field studies in this basin to define CWE thresholds, existing levels of impacts, and recommendations for limits to disturbance, instead of just continuing to fund agencies that lack the capacity to deal with the issues at hand.

Sincerely,

Patrick Higgins

CC: Allen Robertson, Deputy Chief
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References

Adams, P.B. , M.J. Bowers, H.E. Fish, T.E. Laidig, and K.R. Silberberg. Historical and Current Presence-Absence of Coho Salmon (Oncorhynchus kisutch) in the Central California Coast Evolutionarily Significant Unit. Southwest Fisheries Science Center National Marine Fisheries Service, Santa Cruz, CA. 28 p.

Barnhart, R. A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--steelhead. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.60). U.S. Army Corps of Engineers, TR EL-82-4. 26 pp.

Brosofske, K. B., J. Chen, R. J. Naiman, and J. F. Franklin. 1997. Harvesting effects on microclimatic gradients from small streams to uplands in western Washington. Ecological Applications 7(4):1188-1200.

Ca. Department of Fish and Game. 1998. California Salmonid Stream Habitat Restoration Manual. Third Edition. Inland Fisheries Division. California Department of Fish and Game. Sacramento, CA. 495 pp.

California Department of Fish and Game. 2002. Status Review of California Coho Salmon North of San Francisco . Report to the California Fish and Game Commission. California Department of Fish and Game, Sacramento , CA. 336pp.

California Resources Agency. 2002. Gualala River Watershed Synthesis. CA Dept. of Fish and Game, State Water Res. Control Bd., CA Dept. of Water Resources, CA Div. on Mines and Geology and CA Dept. of Forestry. Sacramento, CA.

California State Water Resources Control Board. 2001. Technical Support Document for the Gualala River Watershed Water Quality Attainment Action Plan for Sediment. CRWQCB, Region 1. Santa Rosa, CA. 147 pp.

Cederholm, C.J., L.M. Reid and E.O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations of the Clearwater River , Jefferson County, Washington. Pages 38-74 in Proceedings of Conference on Salmon Spawning Gravel: A Renewable Resource in the Pacific Northwest? Report 19. Wash. State University, Water Research Center, Pullman,WA.

Institute for Fisheries Resources. 2003. KRIS Gualala Database and Map Project Two CD Set. Funded by the California Department of Forestry FRAP, Sacramento, CA. (Also on the Internet at www.krisweb.com).

Jones, J.A. and G.E. Grant. 1996. Peak flow response to clear-cutting and roads in small and large basins, Western Cascades, Oregon. Water Resources Research, April 1996. Vol. 32, No. 4, Pages 959-974.

McHenry, M.L., D.C. Morrill and E. Currence. 1994 . Spawning Gravel Quality, Watershed Characteristics and Early Life History Survival of Coho Salmon and Steelhead in Five North Olympic Peninsula Watersheds. Lower Elwha S'Klallam Tribe, Port Angeles, WA. and Makah Tribe, Neah Bay, WA. Funded by Washington State Dept. of Ecology (205J grant).

Poole, G.C., and C.H. Berman. 2000. Pathways of Human Influence on Water Temperature Dynamics in Stream Channels. U.S. Environmental Protection Agency, Region 10. Seattle, WA. 20 p.

Quigley, T.M. and S.J. Arbelbide (Eds). 1997. An Assessment of Ecosystem Components in the Interior Columbia Basin And Portions of the Klamath and Great Basins: Volume I. U.S. Forest Service and U.S. Bureau of Land Management with assistance from the Pacific Northwest Forest Experiment Station. PNW-GTR-405. Pages 1-351.

Reeves, G.H., F.H. Everest and J.R. Sedell. 1993 . Diversity of Juvenile Anadromous Salmonid Assemblages in Coastal Oregon Basins with Different Levels of Timber Harvest. Transactions of the American Fisheries Society. Vol 122, No. 3. May 1993.

Warbington, R., B. Schwind, C. Curlis and S. Daniel. 1998. Creating a Consistent and Standardized Vegetation Database for Northwest Forest Plan Monitoring in California. USDA Forest Service. Pacific Southwest Region Remote Sensing Lab. Sacramento, CA.

Welsh, H.H., G.R. Hodgson, M.F. Roche, B.C. Harvey. (2001). Distribution of Juvenile Coho Salmon (Oncorhynchus kisutch) in Relation to Water Temperature in Tributaries of a Northern California Watershed Determining Management Thresholds for an Impaired Cold-water Adapted Fauna. In review for publication in the North American Journal of Fisheries Management. 21:464-470, 2001.

U.S. Forest Service. 1996. Status of the interior Columbia basin: summary of scientific findings. Gen. Tech. Rep. PNW-GTR-385. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; U.S. Department of the Interior, Bureau of Land Management. 144 p.

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July 28, 2009

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Re: Comments on Artesa Vineyard Conversion Draft Environmental Impact Report (SCH# 2004082094)

Dear Mr. Robertson,

I provide the comments below on the Artesa Vineyard Conversion Draft Environmental Impact Report (DEIR)(Monk and Assoc. 2009) at the request of the Friends of the Gualala River. The emphasis of my comments will be on cumulative watershed effects from the project activities and likely impacts to coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*), although I also touch on impacts to other native fish species, the western pond turtle (*Clemmys marmorata*) and the yellow-legged frog (*Rana boylii*).

Summary

While the DEIR for the proposed Artesa Vineyard is quite lengthy, there are major flaws in its scientific assumptions and the discussion of fisheries, water quality, hydrology and cumulative effects lack scientific credibility. Ecological problems and watershed and water quality conditions are more aptly characterized than in earlier drafts (Higgins 2003), but the DEIR falsely states that all problems from the project itself will be eliminated through use of best management practices (BMPs) or implementation of mitigation measures:

> "The DEIR found significant impacts related to air quality, biological resources, cultural resources, geology, hydrology and water quality, hazards, transportation and circulation, and noise. All of these impacts were reduced to a less-than-significant level through the implementation of mitigation measures."

Numerous studies of northern California logging impacts over the last decade (Ligon et al. 1999, Dunne et al. 2001, Collison et al. 2003) point out that on-site mitigation cannot prevent downstream damage when too great a watershed area is disturbed in too short a period, which is the case with the Gualala River and Patchett Creek watershed in which the project is taking place. While the DEIR presents alarming statistics on land use that indicate extremely rapid and extensive disturbance and development (i.e. 28% timber harvest in 10 years, > 6 miles of road/square mile), the cumulative effects significance is never discussed and instead old logging activities are blamed for the current aquatic conditions. Evidence presented regarding Patchett Creek indicates advanced cumulative effects that the project will most certainly exacerbate.

In some cases the actual effects of the project are misrepresented, such as the claim that installation of tile drains and storage of runoff in a 73 acre foot reservoir will not alter groundwater recharge or base flow in Patchett Creek. Similarly, the likelihood that invasive and voracious bullfrogs will colonize their pond and likely extirpate native yellow-legged frogs is also overlooked. The DEIR admits that steelhead use lower Patchett Creek in reaches that have perennial flow, but then stakes out the absurd position that because they cannot access upper reaches due to natural barriers that there will be no impact from the project on the species. Despite five years since the first draft TCP, critical data gaps remain regarding use of Patchett Creek by steelhead, flow levels in the creek, groundwater levels at the project site, connection of groundwater and surface water and whether previous development and vineyard conversions have already depleted flows.

My Qualifications

I have been a consulting fisheries biologist with an office in Arcata, California since 1989 and my specialty is salmon and steelhead restoration. I authored fisheries elements for several large northern California fisheries and watershed restoration plans (Kier Associates, 1991; Pacific Watershed Associates, 1994; Mendocino Resource Conservation District, 1992) and co-authored the northwestern California status review of Pacific salmon species on behalf of the American Fisheries Society (Higgins et al., 1992).

Over the past 20 years I have reviewed over 50 timber harvest plans and written comments on several Total Maximum Daily Load reports (NCRWQCB 2001, U.S. EPA 1998, 1999), that examine timber harvest as a pollution source. My recent comments on the proposed Threatened and Impaired Watershed Rules (Higgins 2009) summarize my findings from all those studies and characterize the current status of coho salmon in the northwestern California, including the Gualala River watershed. I am attaching these comments as an Appendix with several other relevant documents for the record.

My other previous work in the Gualala River basin includes the *Gualala River Watershed Literature Search and Assimilation* (Higgins, 1997), which I compiled for the Redwood Coast Land Conservancy. THP and TCP comments for previous clients include the following that I wish to incorporate into the record by reference. Please let me know if you would like me to retransmit copies of these for your files.

- Artesa Timberland Conversion Permit (TCP) 02-506 and Timber Harvest Plan (THP) 1-01-171 SON (Higgins, 2003a),
- Seaview TCP 02-524 and THP1-01-223 SON (upper South Fork Gualala River) (Higgins, 2003b),
- Hanson/Whistler Timberland Conversion Permit TCP 04-530 and THP 1-04-030 SON (Little Creek) (Higgins, 2004a),
- Negative Declaration for Martin TCP 04-531 and THP 1-04-059) (Little Creek) (Higgins 2004b), and
- THP 1-04-260 MEN (Dry Creek, North Fork Gualala River)(Higgins 2007).

Since 1994 I have also been working on a regional fisheries, water quality and watershed information database system, known as the Klamath Resource Information System or KRIS (www.krisweb.com). This custom program was originally devised to track restoration success in the Klamath and Trinity River basins, but has been applied to another dozen watersheds in northwestern California. The California Department of Forestry (CDF) funded KRIS projects in six northern California watersheds as part of the North Coast Watershed Assessment Planning effort, including the Gualala River (IFR, 2003). Several charts and maps within this report come from KRIS Gualala and the source data and raw data that support my assumptions can be checked on-line (www.krisweb.com/krisgualala/krisdb/html/krisweb/index.htm), including complete metadata that provides contacts for data sources.

Between September 2008 and the present I have been assisting the National Marine Fisheries Service (NMFS) with coho salmon recovery planning in southwest Oregon and have become intimately familiar with scientific literature on Pacific salmon restoration (Reeves et al., 1995, Doppelt et al. 1993, Bradbury et al. 1995). I am also attaching my comments on the *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams* (SWRCB 2008) prepared for the Redwood Chapter of the Sierra Club because they cover the Gualala River watershed and cumulative effects problems of flow depletion are manifest throughout the region.

Effects of Proposed Artesa Vineyard on Fisheries

Instead of collecting and presenting data on fisheries, such as whether steelhead are using lower Patchett Creek, the DEIR cites the California Natural Diversity Database indicating that they aren't present within ten miles. In fact the NCRWQCB staff has confirmed their presence in the perennial lower reaches of the creek and it must be assumed for discussion that they are present and dependent on continuing summer baseflows. The DEIR cites the same source for location of the Gualala roach (3.3 miles west), but instead should have used North Coast Watershed Assessment Program (NCWAP 2003) data that are readily available in KRIS Gualala (Figure 1).

California Department of Fish and Game (CDFG) pooled September 2001 electrofishing data indicate that the lower Wheatfield Fork Gualala River had steelhead young of the year (0+) and yearlings (1+), but Gualala roach, stickleback and sculpin were more predominant in the sample. This fish community is indicative of a highly perturbed ecosystem with very warm water temperatures, but cold water seeps and springs or small tributaries are likely allowing for steelhead survival. In the middle reach of the Wheatfield Fork, CDFG found no steelhead and instead only the species more adapted to warm water (Figure 2). The Artesa Vineyard project will further deplete flows to Patchett Creek, which is likely also contributing either surface flows or sub-surface groundwater to the lower Wheatfield Fork. The type of exploration the DEIR should have engaged in was to determine whether the NCWAP team found steelhead juveniles at or below Patchett Creek. The patches of cold water in which steelhead are residing are known as refugia and the U.S. Environmental Protection Agency (2003) counsels that all such cold water sources protected as a priority, especially in large river basins with major water temperature problems. Bradbury et al. (1995) also point out that protection of these features is a priority, if Pacific salmon species are to be successfully restored. Although there are no water temperature data for lower Patchett Creek, it must be assumed that it has very cold water temperatures due to the nearness of groundwater and the incised shady canyon through which its lower reaches flow. Also, NCWAP (2003) water temperature data include a small unnamed tributary of the Wheatfield Fork Gualala (Figure 3) that has temperatures that are fully suitable for Pacific salmon and Patchett Creek would have a naturally similar regime.

CDFG habitat typing data show that the Wheatfield Fork lost surface flow during the summer of 2001 in many of its lower reaches (Figure 4). Flow depletion in Patchett Creek from the Artesa

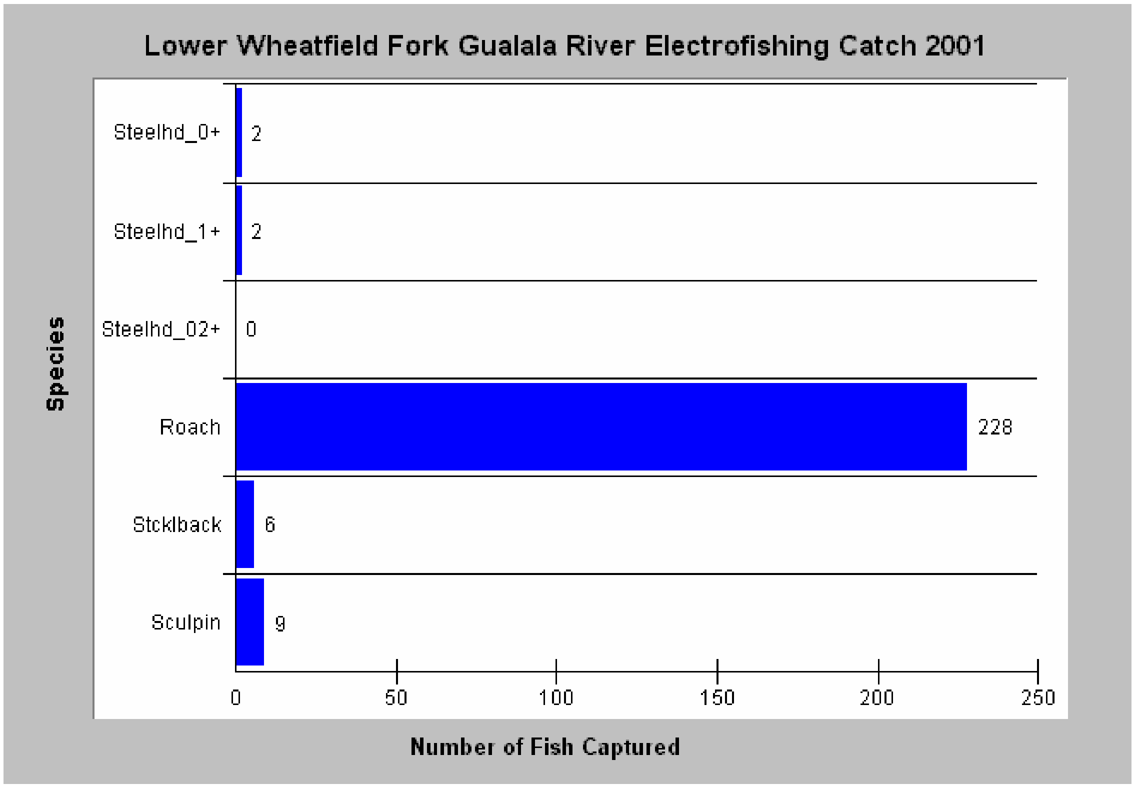


Figure 1. California Department of Fish and Game pooled electrofishing survey data from September 2001 showed that the lower Wheatfield Fork had steelhead but was dominated by warm-adapted fish. Data from CDFG and KRIS Gualala.

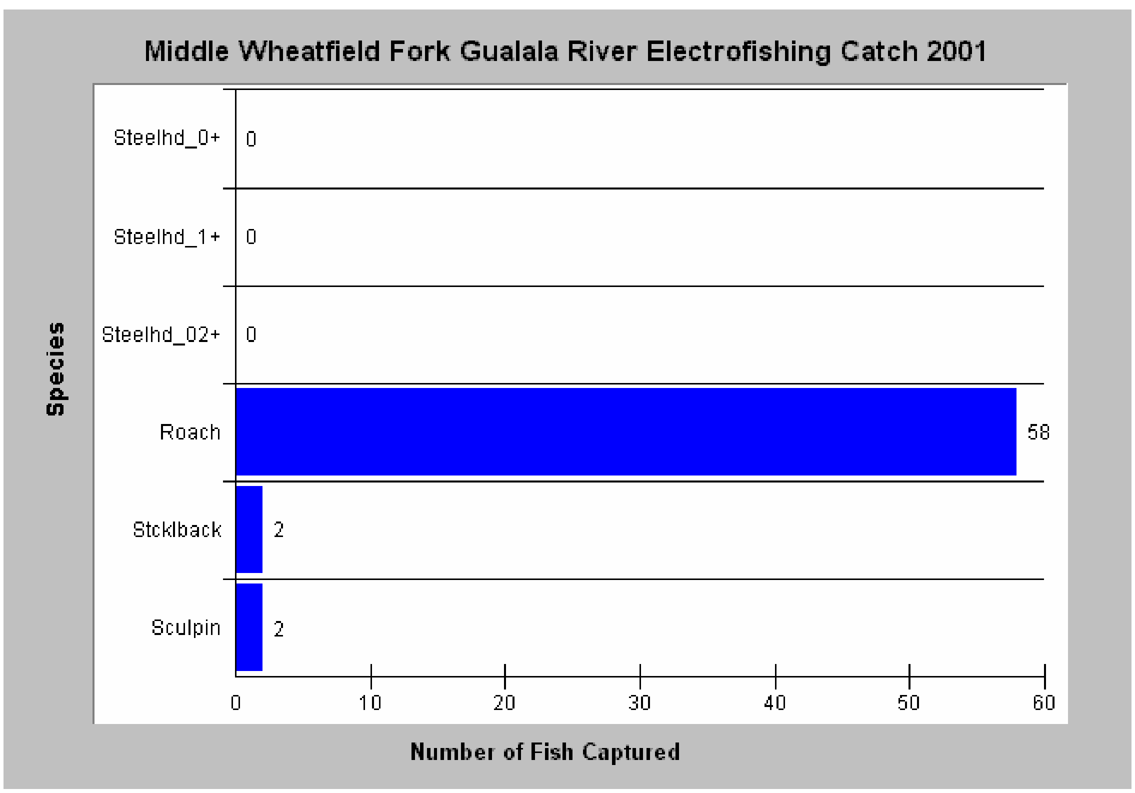


Figure 2. California Department of Fish and Game pooled electrofishing survey data from September 2001 showed that the middle reaches of the Wheatfield Fork Gualala had no steelhead and instead only warm-adapted fish species, particularly the Gualala roach. Data from CDFG and KRIS Gualala.

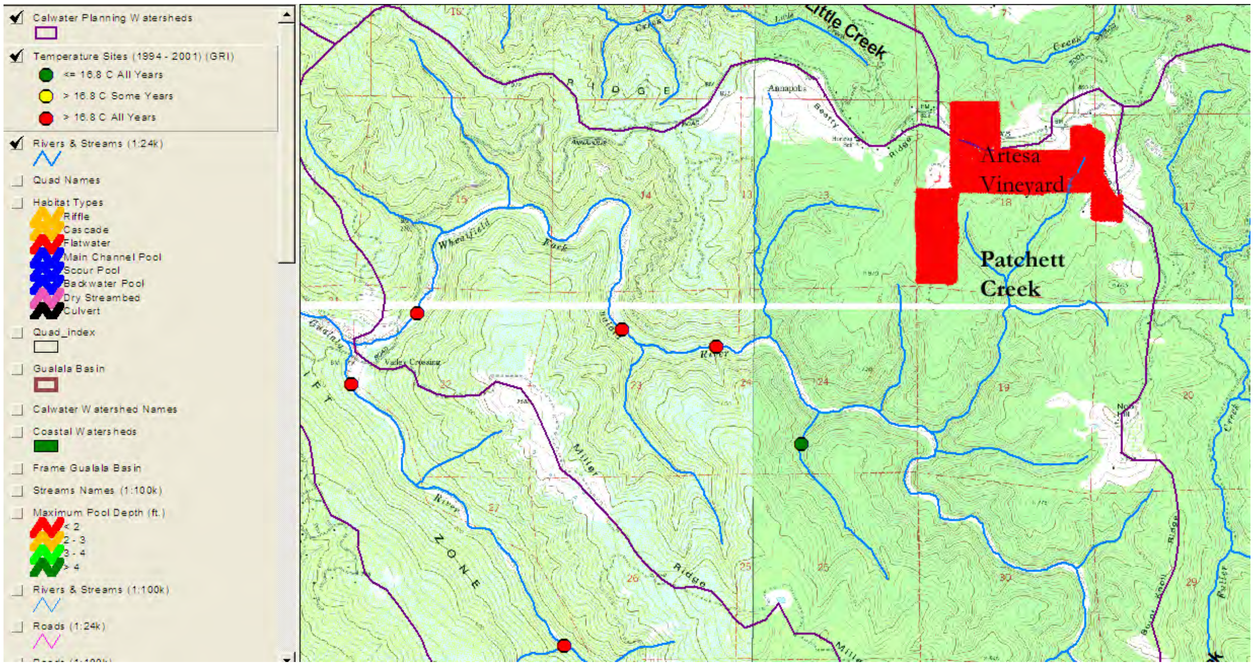


Figure 3. NCWAP (2003) water temperature data indicate the lower Wheatfield Fork Gualala is much too warm for coho salmon or steelhead but the unnamed tributary downstream of Patchett Creek was fully suitable. Data from NCWAP (2003) and KRIS Gualala.

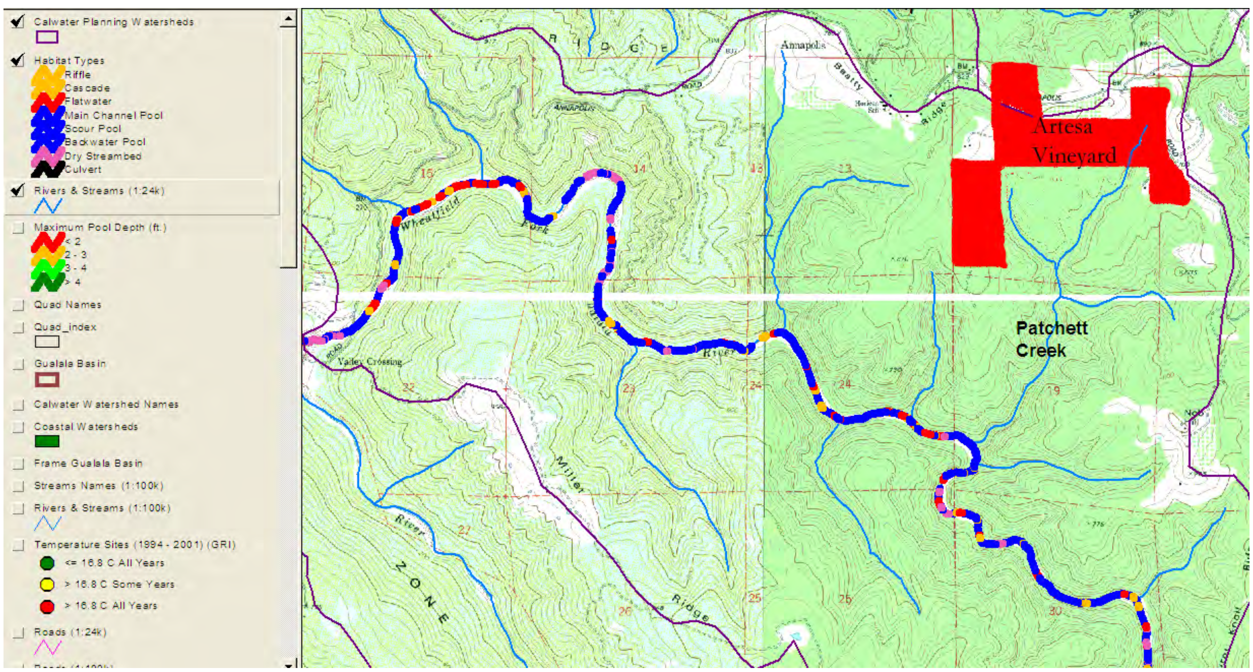


Figure 4. California Department of Fish and Game habitat typing data indicate that numerous reaches of the lower Wheatfield Fork Gualala lacked surface flow. This is indicative of cumulative effects related to aggradation, flow depletion and changes in watershed hydrology. CDFG data from KRIS Gualala.

Vineyard development with its tile drains and 73 acre foot storage reservoir will likely further deplete flows and cause additional reaches of the lower Wheatfield Fork to dry up. As surface flow is lost, even the hardy Gualala roach will decline.

The DEIR does not mention the absence of Sacramento suckers in the Gualala River in all recent surveys, which is likely indicative of a major decline in their population, if not their wholesale disappearance. This fish is somewhat tolerant of sediment and very tolerant of warm water and its disappearance demonstrates the extent to which the Gualala River ecosystem has unraveled. As pointed out in my previous reports and comments (Higgins 1997, 2003, 2007), suckers formerly thrived in the mainstem Gualala after the 1964 flood but flow depletion has now greatly reduced viable summer mainstem habitat. The Gualala River watershed is almost homogeneously disturbed, resulting in a lack of clear water tributaries in winter leaving suckers exposed to high sediment transport levels. Suckers also deposit eggs on the surface of stream gravels and shifting bedload or fine sediment deposits likely limit hatching success.

Coho salmon are “extirpated in the Gualala River or nearly so” according to CDFG (2002), but no further degradation or additive cumulative effects stressors should be allowed if they are ever to be recovered (Kaufmann et al. 1999). DeHaven (In Press) has conducted steelhead spawner and redd counts on the mainstem Wheatfield Fork Gualala River since 2002 and has now compiled trend data for the adult population. His finding is that returns in 2009 were the lowest since surveys began and that it was down by an order of magnitude from the prior year (Figure 5). The estimated return 369 individuals is under the estimate of 500 recognized by Gilpin and Soule (1991) as a critical floor for populations to maintain genetic diversity, although there is likely genetic exchange with populations from other Gualala River sub-basins.

One of the major factors allowing steelhead to survive and for returns to sometimes be in the thousands is the critical role played by the estuary for juvenile steelhead rearing (Higgins 1997). Additional watershed disturbance, including the Artesa Vineyard project that cumulatively deplete flows and contribute sediment will ultimately lead to diminished estuarine volume and carrying capacity for steelhead, if development remains unchecked.

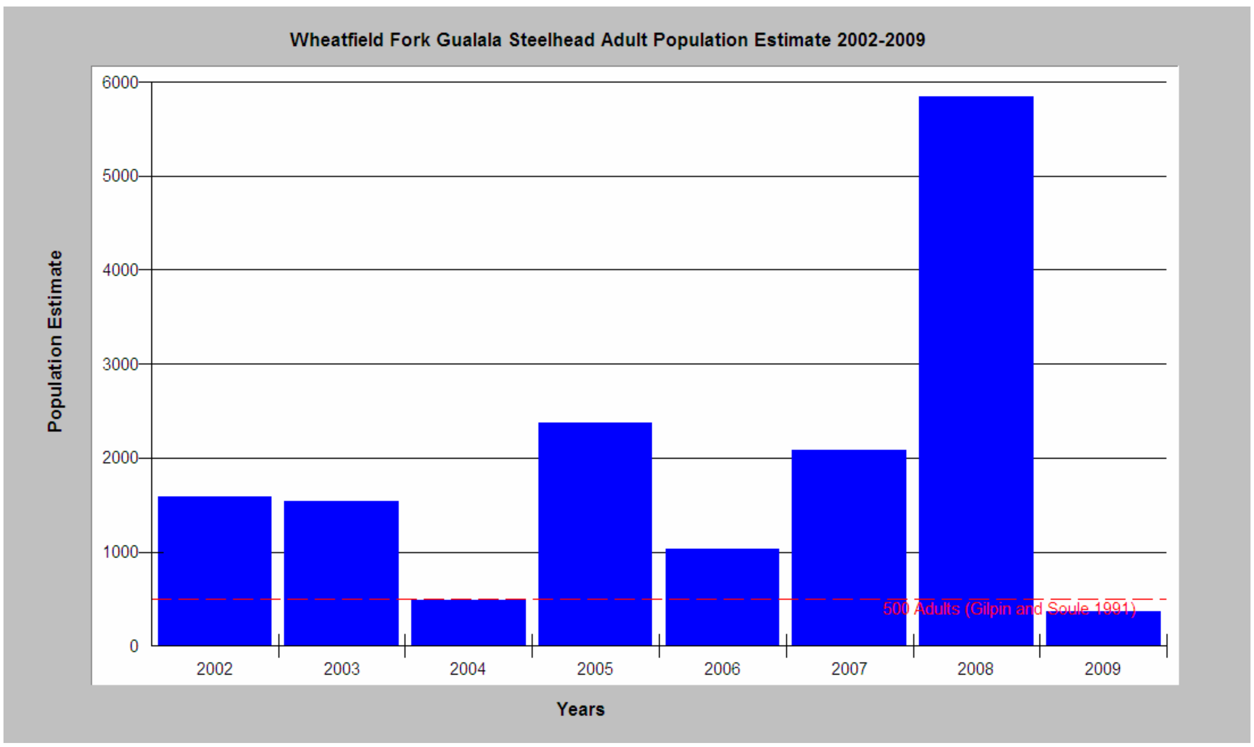


Figure 5. Adult steelhead surveys and redd counts of the Wheatfield Fork Gualala have been conducted by DeHaven (In Press) from 2002 to 2009. Trends indicate substantial fluctuation in returns.

Despite noting that lower Patchett Creek below the proposed Artesa Vineyard has steelhead and agreeing with my assertion that it is likely naturally cold, the DEIR makes the following statement in the Biological Assessment (page 68):

> "The project site does not provide habitat for any fish species, listed or non-listed, since Patchett Creek and the tributaries onsite do not provide suitable flows or water depths for fish. Also, Patchett Creek dries almost completely in the summer months only retaining a few relatively small and shallow pools in the south central reach of Patchett Creek on the project site. While endangered fish species are known to occur in the Gualala River many miles downstream of the project site, the proposed project will not impact these species."

This contrasts with another passage later in the Biological Assessment of the DEIR (p 143):

> "The Fisheries Assessment notes that, according to the North Coast Regional Water Quality Control Board (NCRWQCB), steelhead are found in the lower (Class I) reaches of Patchett Creek commencing about 4,800 feet downstream of the project area. Steelhead are not able to migrate above this point, as there is an impassable area to further upstream reaches."

Steelhead in lower Patchett Creek are not "many miles" downstream of the site, since the stream is only about two miles long. Patchett Creek is already suffering from extensive water extraction and development that the Artesa Project will add to and very clearly diminish if not eliminate carrying capacity for steelhead.

Finally, the DEIR fails to mention another important, endemic anadromous fish that might be impacted by the Project, the Pacific lamprey. Lamprey use a sucking disc to hold fast to rocks and then loosen their grip and wriggle up rock waterfalls. A second order stream such as Patchett Creek would be expected to have smaller median particle size distribution suitable for lamprey spawning. Lower flows in lower Patchett Creek might also disrupt juvenile lamprey or ammocetes that remain in freshwater for up to four years. It is likely that high bedload mobility is also limiting the success of Pacific lamprey spawning and rearing in the Gualala and its tributaries, similar to problems affecting salmonids and the Artesa Vineyard will likely further degrade conditions for this species

Deficiencies of DEIR Discussion of Cumulative Effects

The Cumulative Effects section of the DEIR is riddle with scientific problems and in fact conveys the notion that somehow the Artesa Vineyards mitigation measures are so state-of-the-art that CEQA concerns do not apply:

> The possibility exists that the "cumulative impact" of multiple projects will be significant, but that the incremental contribution to that impact from a particular project (e.g., Fairfax Conversion Project) may not itself be "cumulatively considerable." Thus, CEQA Guidelines section 15064, subdivision (h)(4), states that "[t]he mere existence of significant cumulative impacts caused by other projects alone shall not constitute substantial evidence that the proposed project's incremental effects are cumulatively considerable." Therefore, it is not necessarily true that, even where cumulative impacts are significant, any level of incremental contribution must be deemed cumulatively considerable.

The DEIR claims to be addressing cumulative impacts to fisheries at the Gualala River watershed scale, but in fact there is no candid discussion of the cause and effect relationship of land use and degraded aquatic environments at the scale of Patchett Creek or the Annapolis Calwater Planning Watershed scale let alone basinwide. The framework of the DEIS does not discuss pre-disturbance habitat conditions in Patchett Creek or the Gualala River with which Pacific salmon species like steelhead co-evolved. The historical background offered in the DEIR is telling in this regard: "The project area has historically been a rural/forested environment characterized by small farms and timber operations associated with the logging of the extensive redwood and fir forests." In fact the Gualala River watershed and this site would have historically been within the old growth redwood forest ecosystem where trees were often over ten feet in diameter (Figure 6) and stream systems profoundly different than their present condition in terms of depth, width, temperature, and habitat complexity. The changes in aquatic habitats in response to upland anthropogenic sources of stress, such as timber harvest and roads, are now well recognized by the scientific community (Reeves et al. 1993, Jones and Grant 1996, FEMAT 1993, Spence et al. 1996, NMFS 1996) and they will be discussed in sections below.

The DEIR admits that coho salmon and steelhead are in decline in the Gualala River basin but then makes repeated unsupported claims that all problems in the Gualala River watershed with regard to changes to the hydrologic regime and increased sediment yield that affect them are from past land use:

> "However, the direct factors that continue to limit the distribution and abundance of steelhead trout in the Gualala watershed, including reduced flow and increased sediment inputs and water temperature, result predominantly from the legacy of historic, improperly conducted land use practices. Present-day timber harvesting and road construction activities are subject to the water quality protection measures incorporated into the California Forest Practice Rules, while vineyards within Sonoma County are required to comply with the County Vineyard Sediment and Erosion Control Act (VESCO). It should further be noted that any future projects in the Gualala watershed and elsewhere in Sonoma County would be subject to CEQA environmental review, in which project-specific and cumulative impacts would be evaluated as part of the planning process."

Treating "modern" timber harvest practices and vineyard conversions as fully mitigated and not contributing to cumulative effects is a fantasy that has been debunked by numerous, recent northwestern California studies (Ligon et al. 1999, Dunne et al. 2001, Collison et al. 2003). Dunne et al. (2001) noted the California Department of Forestry's continuing "unquestioning and unverified reliance on mitigation" as a major impediment to recognition and prevention of cumulative effects. The following Dunne et al. (2001) quote argues against the DEIR's notion that reducing gully erosion will improve sediment conditions in Patchett Creek or that implementation of BMPs can be relied upon to prevent damage to downstream reaches:

> "While there are clear benefits of, say, removing unstable, eroding roads, the notion that such practices coupled with new land-use activities will avoid CWE is unsubstantiated. There has also been a reliance on untested mitigation measures rather than an effort to document CWE processes. The resulting belief that BMPs mitigate or prevent potential problems accounts for the proclivity among many THP applicants to assert that no cumulative effects will occur because they will be mitigated out of existence."

Figure 6. Gualala supply wagon passing through old growth forest circa 1900 showing large diameter coastal redwoods typical of the pre-disturbance watershed conditions with which salmon and steelhead co-evolved. Fiscus family photo collection from KRIS Gualala.

This pattern exactly describes the DEIR with regard to the cumulative effects issue. Therefore, the DEIR is completely lacking with regard to CEQA compliance in this regard.

Hydrologic Cumulative Effects

The DEIR arguments that hydrologic cumulative effects of the Artesa Vineyard will be beneficial to steelhead is not supported scientifically. Groundwater issues are dismissed cavalierly, but the evidence of likely depletion is also presented that indicates major problems for steelhead and yellow-legged frogs downstream. The hydrologic impact of the 73 acre foot reservoir planned for the site is completely misstated and the ecological impacts are ignored (see Yellow-legged Frog Impacts). The DEIR has little discussion of obtaining an Appropriative Water right from the State Water Resources Control Board (SWRCB) Water Rights Division (WRD) for the project or whether neighboring ponds are permitted. This constitutes a major cumulative effects omission of the DEIR with regard to illegal use of surface water in the region as documented in the *Draft North Coast Instream Flow Study* (SWRCB WRD 2008).

The Artesa Vineyard will construct a system of tile drains that is designed to prevent saturation of the soil and will also disrupt normal processes of percolation into the water table. Approximately 299 feet of upper reaches of ephemeral Patchett Creek tributaries will be filled yet the DEEIR claims that "downstream reaches will remain unaffected" and that "No proposed work in any tributary will impair, impede or obstruct flows in tributaries on the project site." Flows from the tile drain system are shunted into the agricultural storage reservoir. Based on data from Caspar Creek timber harvest and flow data, O'Connor makes the following claim in the DEIR:

> “Reduced evapotranspiration and canopy interception is the likely cause of increases in both total annual runoff and summer stream flow. Any increase in dry-season base flows would help maintain cooler water and enhance habitat that is critical to steelhead trout survival.”

This argument is also hinged on the assumption that watering vineyards during the summer from the storage reservoirs will recharge groundwater throughout the summer:

> “All water captured by this system will be recycled directly onto the vineyards on the project site. Thus, rainfall retention time on the land above the groundwater table will effectively be increased and consequently groundwater recharge will likely be increased from the proposed project.”

In fact both these assumptions are not met. Grapes will be watered sparingly to conserve water and the tile drain system under them would prevent groundwater recharge. Runoff captured from the tile drain system in winter would otherwise feed the groundwater aquifer at the headwaters of Patchett Creek that sustains baseflows during late summer and fall. The DEIR acknowledges that “Any substantial change in flow in Patchett Creek would be a significant impact” but such impacts from the Project cannot be prevented.

Band (2008) and McMahon (2008), in comments on the *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams* (SWRCB WRD 2008), noted that the synergy between diversion impoundments in multiple tributaries causes unintended consequences on flows, fish passage and alteration of substrate quality in downstream reaches. The DEIR does not discuss cumulative effects related to operation of all reservoirs in the Gualala River basin. It notes, however, that the “first flush” of fall or early winter rains will be caught in stilling ponds or the agricultural impoundment. Band (2008) points out that this type of activity in many vineyard impoundments simultaneously may shave off the early peak of the Gualala River hydrograph that typically allowed coho salmon and early steelhead adults passage to spawning beds. McMahon (2008) shared this concern: “Dams on ephemeral streams have the potential to greatly dampen the early fall/winter freshets important for access to the upper reaches of small spawning tributaries by their capture of the entire flow within the stream until the reservoir is filled, potentially resulting in significant dewatering downstream.” This is exactly the risk development of the agricultural impoundment for the Artesa Vineyard poses.

The DEIR cites a number of different statutes from the Sonoma County General Plan but never proves sufficiency in terms of the project meeting the stated objectives. Examples are:

- Insure that land uses in rural areas be consistent with the availability of groundwater resources.
- Grading, filling and construction should not substantially reduce or divert any stream flow that would affect groundwater recharge.
- Deny discretionary applications unless a geologic report establishes that groundwater supplies are adequate and will not be adversely impacted by the cumulative amount of additional development.
- Revise procedures for proving adequate groundwater for discretionary projects by adding criteria for study boundaries, review procedures, and required findings that the area’s groundwater supplies and surface water flows will not be adversely impacted by the project and the cumulative amount of

development allowed in the area and will not cause or exacerbate groundwater overdraft.

The DEIR simply says that the use of groundwater for farm workers is so miniscule that groundwater is simply not an issue:

> "A well will be dug to provide potable water for the farm workers. Well water would not be used to irrigate vineyards. Groundwater supplies are adequate for this minor water use and thus cumulative impacts are expected to be insignificant."

In lieu of groundwater data from the site, the DEIR provides the following description of groundwater resources in the vicinity of the Project site based on data more than 30 years old:

> "DWR data indicates that wells in the Annapolis area tapping the Ohlson Ranch Formation have reported yields of two to 36 gallons per minute (gpm) with drawdowns ranging from 30 to 125 feet (DWR 1975). Long-term hydrographs or other groundwater trend data are unavailable for the area (DWR 2004)."

In fact the map provided by O'Connor Environmental of well locations and well owners in the DEIR (Figure 7) suggest strongly that groundwater resources are already likely over-demanded. Furthermore, the DEIR disclosed the following:

> "Almost all of the project area is underlain by this sloping shallow aquifer. Groundwater flows are generally from west- northwest to east-southeast, toward Patchett Creek. The geometry of the aquifer and the location of the contact between the Franciscan and the Ohlson Ranch Formations to the west are uncertain. Even if the geologic contact west of the project site dips to the west, the geometry of the rock formations under the project site is relatively well-defined, and groundwater from the project site would still be expected to flow to the east-southeast."

Therefore, it is possible that some wells west of the Project may already be impacting flows in Patchett Creek. The County of Sonoma should require a full groundwater study prior to development of this project because of the substantial questions related to groundwater use and supply near the Project. CDF should also not allow the DEIR to be approved as final until the Project has a permit for an Appropriative Water Right to develop its reservoir.

Sediment and Water Quality Related Artesa Vineyard Cumulative Effects

The DEIS points out that there are two predominant soil types, including the Hugo and Goldridge Series (Figure 8), and provides the following description regarding the proposed Artesa Vineyard area:

> "The runoff potential for this soil type varies from medium to very rapid and the hazard of erosion ranges from moderate at low slope to high at elevated slopes. The Goldridge Series soils are defined as "highly erodible soils" in the Sonoma County Vineyard Erosion and Sediment Control Ordinance."

Other portions of the DEIR provide slope maps for Project site and there is a substantial overlap between steeper slopes and the unstable Goldridge Series in the western lobe of the Project development area that poses a high erosion risk that is not duly noted in the DEIR.

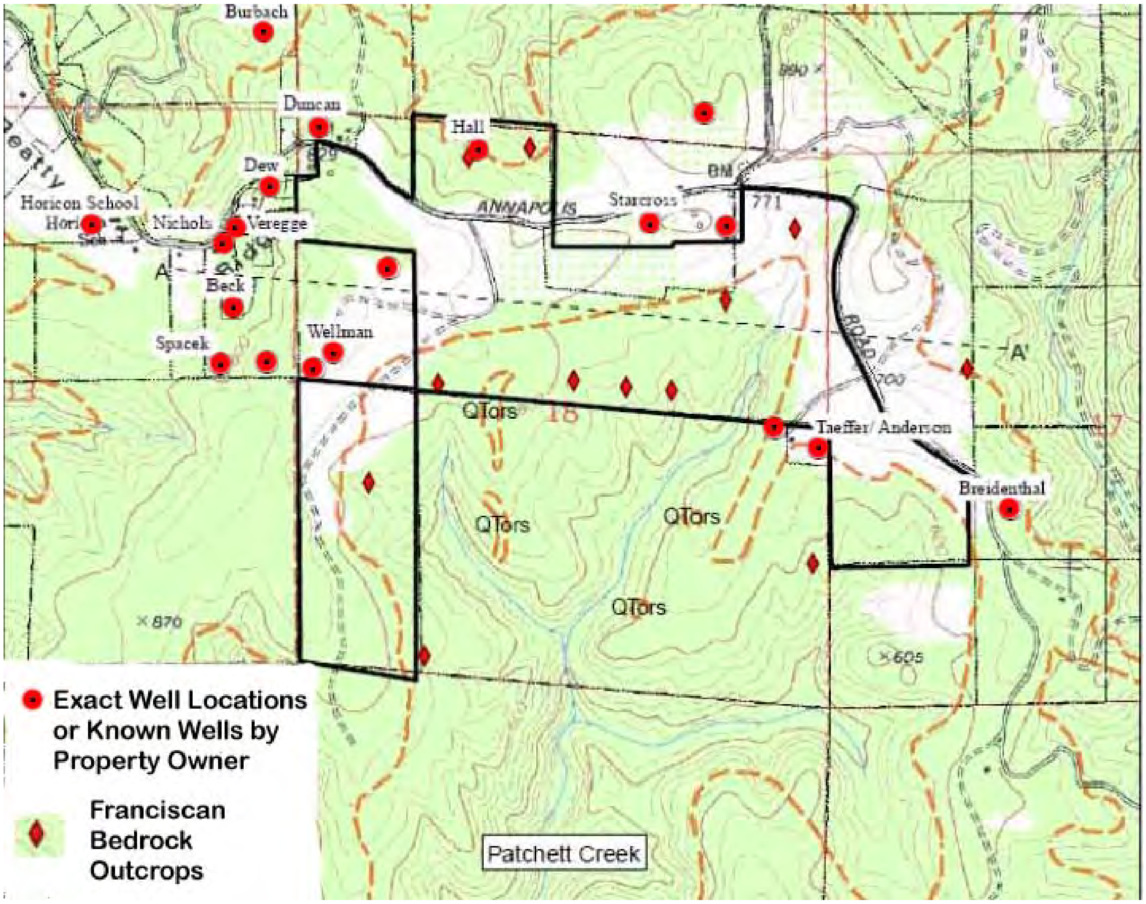


Figure 7. Map of well locations and owners from DEIR with highlights in red so that locations are more visible. Some wells to the west of the Project may be in the zone of influence of Patchett Creek headwaters due to sloping sub-surface bedrock formations.

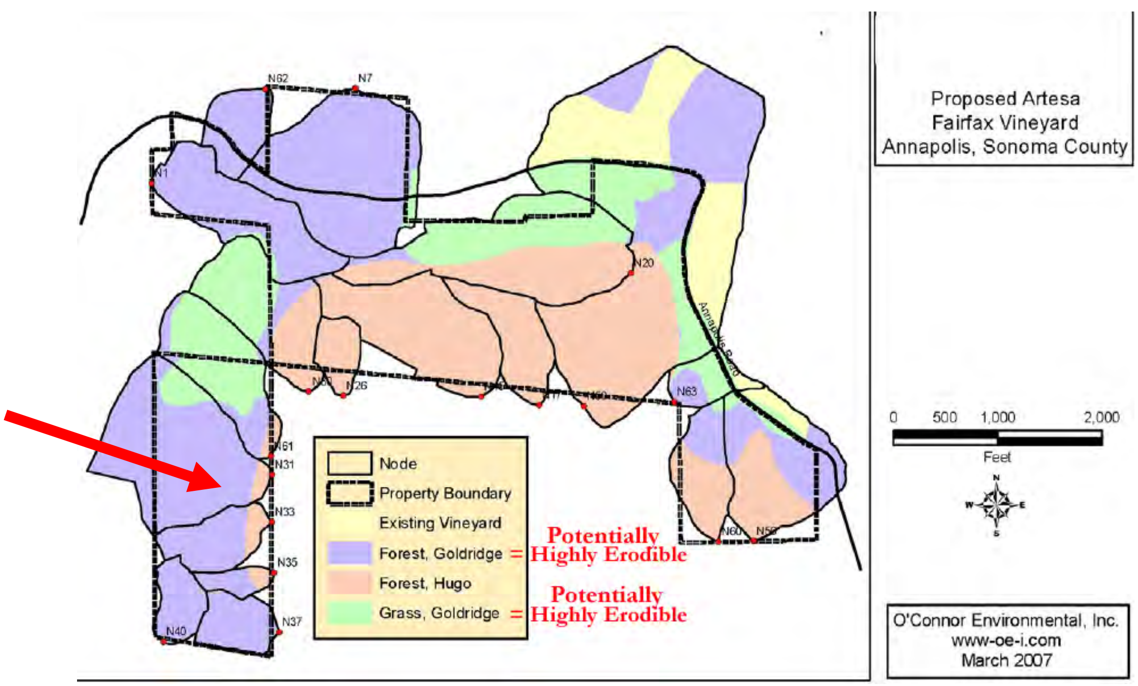


Figure 8. Soil map from DEIR shows that Goldridge Series underlies more than half the Project site with annotation in red added to indicate potential for high erosion. Red arrow highlights steep area.

As with hydrologic effects, cumulative effects related to sediment are treated as fully mitigated. One Freudian slip can be found in the DEIR: “These measures will ensure that siltation of onsite and downstream tributaries are minimized to an imperceptible degree.” I have to agree that the mitigation measures will likely not make a perceptible difference in decreasing sediment that comes from the site after development despite claims in the DEIS:

> “The project also includes post-vineyard construction BMPs including desilting catch basins at the lower ends of all drainage points discharging stormwater from the project site. First flushes from the project site will be captured in these basins and ‘treated.’ These basins will ensure that any silt leaving the project in stormwater flows will undergo ‘stilling’ and desilting prior to flowing off the site.”

In fact when high intensity rainfall persists for a substantial duration basins will over-top and sediment from the project will be released downstream and offsite to the detriment of lower Patchett Creek, the Wheatfield Fork and the lower mainstem Gualala River. The claim in the DEIR that all sediment effecting the Gualala River is from post WW II land use is strongly refuted by data collected in the Gualala River basin by Knopp (1993) and by observation of channel conditions (Figure 9). Knopp (1993) found that aquatic habitat data such as median particle size distribution (D50) of stream beds and the amount of sediment in pools (V*) were strongly related to land use history. His findings with regard to Gualala River V* (Hilton and Lisle 1993)(Figure 10) serve as an example to refute the “old land use” argument.

Grasshopper Creek and Fuller Creek fell within Knopp’s (1993) universe of samples with the former having roughly 59% (V* = 0.59) filled with fine sediment and the latter having a V* score of 37% or a little over one third filled with sediment. The NCRWQCB (2004) and the U.S. EPA (1998) recognize V* values of greater than 0.21 as impaired and Knopp (1993) found that values like those exhibited by Gualala River tributaries represented disturbed and highly disturbed watershed conditions. Northwestern California tributaries that were logged during earlier periods have shown substantial recovery, such as Brandon Gulch (0.18) in Jackson Demonstration State Forest. The latter stream was heavily logged after WW II and yet its channel is no longer sediment rich because it has had watershed rest (Kaufmann et al. 1997. What is actually occurring is that continuing waves of logging and land use such as the Artesa Vineyard are causing channels to remain perturbed. Reeves et al. (1995) and Frissell (1992) point out that it takes about 20-30 years for most stream channels to recover from logging sufficiently to support diverse communities of salmonids and that short rotation logging does not allow such a recovery. Most aquatic habitat data indicate that conditions are far outside the range for suitability of salmonids whether the criteria is pool frequency, pool depth, fine sediment in gravels, water temperature and several other metrics. I am attaching with my comments criteria developed for coho salmon recovery planning (Kier Associates and NMFS 2008) that has useful reference values that CDF should consider adopting for use in the THP/TCP process.

One DEIR illustration (Figure 11) uses a recent aerial photo backdrop indicating substantially elevated risk of sediment yield due to recent and extensive soil disturbance that is not properly addressed in the document. Discussion of impacts of the recent, adjacent vineyard development are avoided because they are considered fully mitigated, but extensive bare soil and subsequent vineyard development likely have yielded and continue to yield excess sediment. The same photo also shows evidence of recent timber harvest and yet increased erosion related to skid trails and landings is unaddressed as are any associated hydrologic perturbations. This land use may also impact water temperature, as discussed below.

Figure 9. Wheatfield Fork Gualala River looking upstream just above convergence with SF Gualala. Note deposits of fine sediment (arrow) that were deposited on the last descending leg of the hydrograph indicating high current supply. Only willows can survive on the mainstem river bars because of constant shifting bedload due to sediment over-supply.

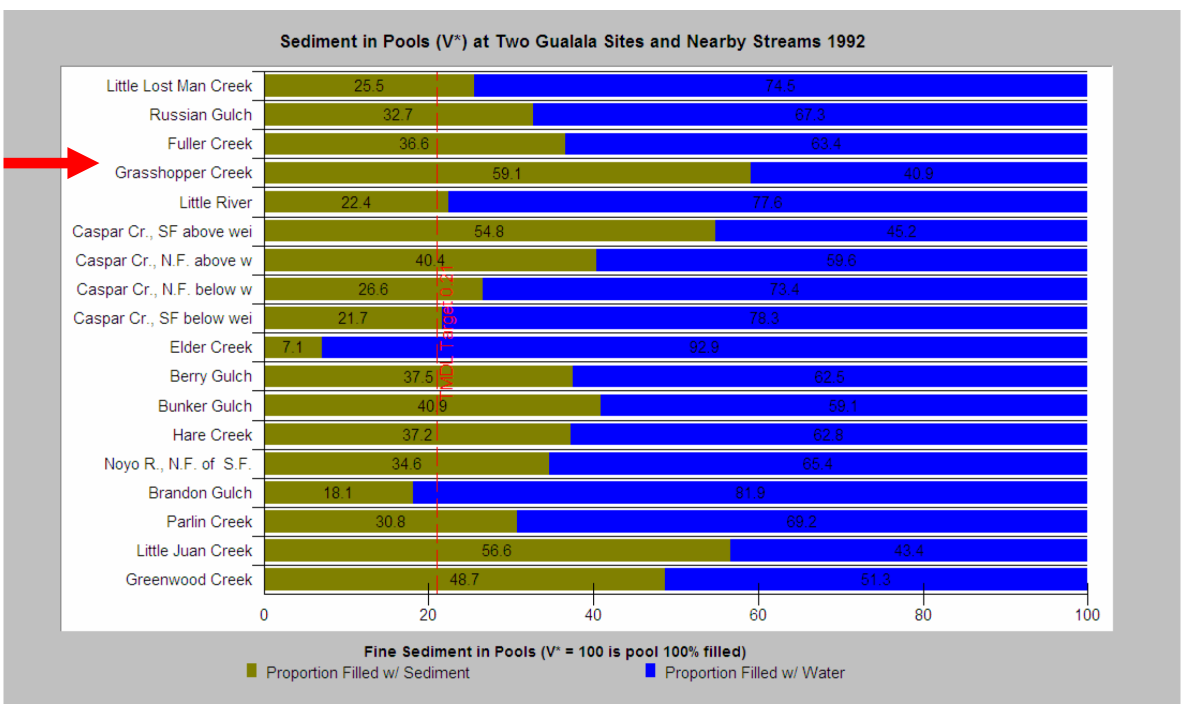


Figure 10. The amount of sediment in pools in Grasshopper and Fuller Creeks measured by Knopp (1993) indicate that Fuller is somewhat recovered from past logging but that Grasshopper Creek has major problems with erosion related to recent land use. Chart from KRIS Gualala. Units are V* X 100.

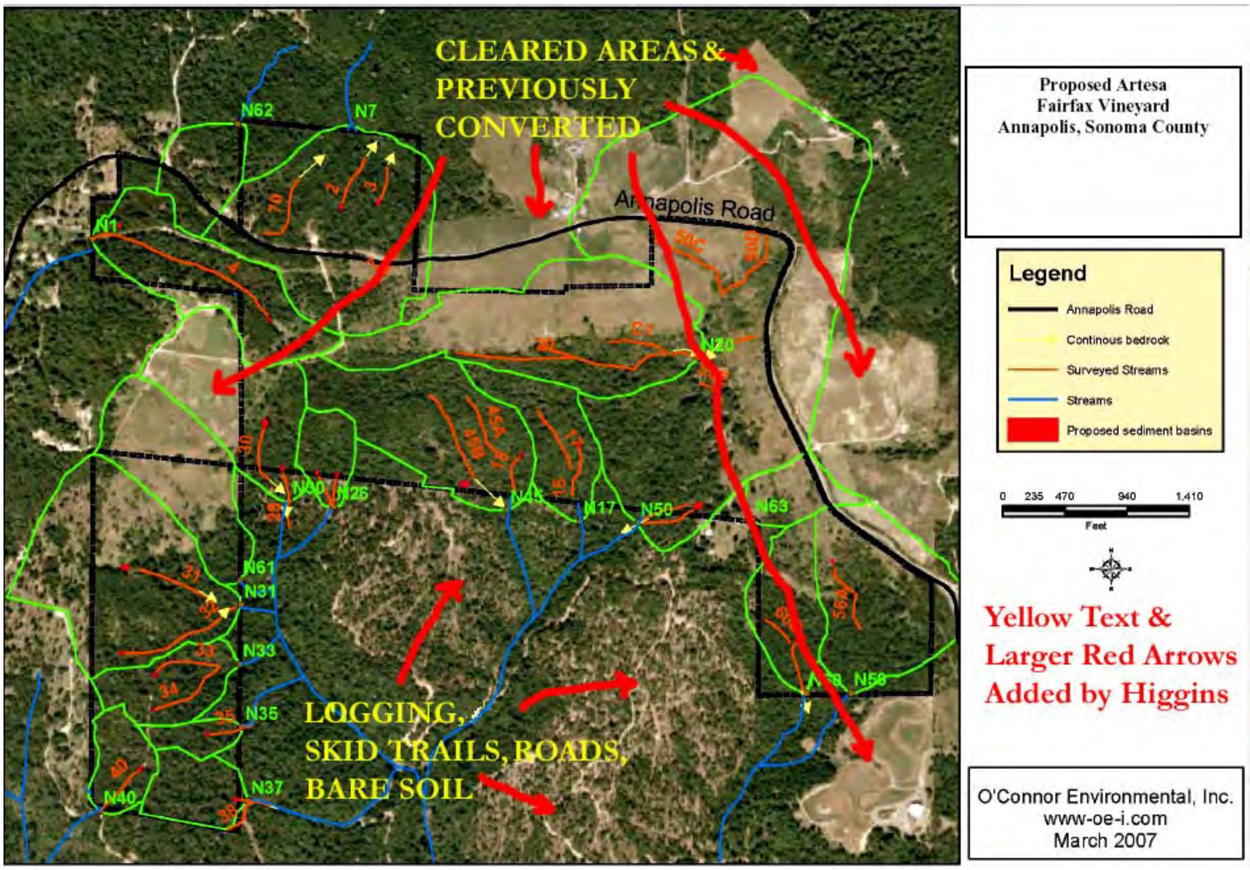


Figure 11. Illustration from DEIR shows intensive land use and yet has no companion discussion regarding issues such as increased sediment from areas cleared for or subsequently converted to vineyards and skid trails, landings and areas of bare soil due to recent logging.

Brosofske et al. (1998) found that logging reducing ground cover in headwater areas warmed stream flows, regardless of whether shade was maintained. The logging activity show in Figure 11 could be having such an effect on Patchett Creek, but the DEIR provides no stream temperature data for evaluation. Claims in the DEIR that water temperature problems in Patchett Creek and in the Wheatfield Fork Gualala are not supported by the argument presented.

The case has been made above that conversion of the Artesa Vineyard site, installation of tile drains and construction of a reservoir will decrease base flows to Patchett Creek. There is a clearly established relationship of water flow volume to flow transit time and the tendency of a stream to warm (NRC 2004). Therefore, reduction of baseflows as a result of the Project will elevate water temperatures with unknown effects to potential refugia in the lower mainstem Wheatfield Fork Gualala River (see Fisheries).

Land Use Discussions Ignore Cumulative Effects Implications

The DEIR provides statistics on timber harvest and road density, but the significance of impact levels is never discussed. Kier Associates and NMFS (2008) provide land use threshold values to gauge likelihood of “stress” being exerted on coho salmon habitat with varying scales of activity and CDF and other reviewers of these comments may go there for more background discussion.

Timber Harvest: The DEIR states that timber harvest has been light compared to the early 1990s then states that “Timber Harvest Plans filed in the Annapolis, Little Creek, and Grasshopper Creek watersheds…..total of 5,535 acres amounts to approximately 28.8 percent of the 19,202 acres that compose the three watersheds in which the project is located. Reeves et al. (1993) found that watersheds on the Oregon coast harvested more than 25%of their watershed area in 30 years had substantial negative cumulative effects that were manifest in 10-47% loss of pools, substantial reduction of large wood and diminished Pacific salmon diversity.

Timber harvest data from CDF from 1991 to 2001 for the Annapolis, Little and Grasshopper Creek Calwater is available from KRIS Gualala (Figures 12 & 13), and in combination with DEIR provided data, can extend the window for THP related cumulative effects to almost 20 years. Total harvest in the three Calwaters was 37%, 34% and 30%, respectively between 1991-2001. An additional 2882 acres in the three Calwaters have received permits for logging or conversion between 2002 and 2008, or approximately 15% of their combined area. Analysis over the period of 1991 to 2008 indicates that the rate of disturbance for all three Calwaters combined is over 50% or more than twice the threshold recognized by Reeves et al. (1995).

This rate of logging is equivalent to 4% of inventory per year, which is recognized by Klein (2003) as linked to substantial sediment yield to streams. Turbidity levels meet beneficial use levels when harvest rates are 1% POI or less, but over 2% POI (50% harvested in 25 years) levels would limit juvenile salmonid growth. Sigler et al. (1984) found that 25 NTU is the threshold over which steelhead juvenile growth is restricted due to limited capability to see prey items. The streams listed on Klein's chart range from 1% POI or less to more than 4% and have substantial variability of time over critical thresholds for salmonids. Control watersheds and those lightly disturbed (1% POI or less) had only 100-400 hours over 25 NTU, highly disturbed watersheds (>4% POI) exceeded this level for over 1100-1200 hours. Maximum turbidities in the highly disturbed watersheds also exceeded 500 NTU, which may directly injure salmonids and other fish exposed (Newcomb and McDonald 2001).

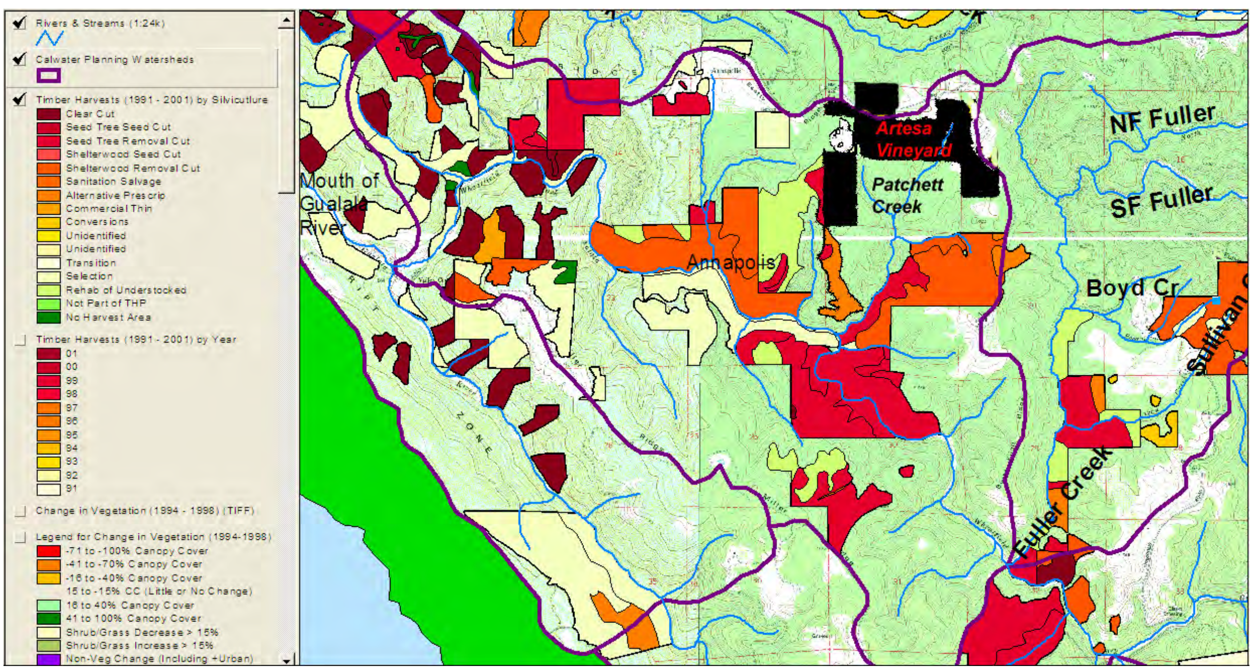


Figure 12. THPs between 1991 and 2001 by year according to CDF data show the 37% timber harvest in the Annapolis Calwater, which is well over prudent risk levels of disturbance known to cause cumulative effects and to degrade channel conditions for salmonids (Reeves et al. 1993). Black area indicating Artesa Vineyard development added for this project otherwise map is from KRIS Gualala.

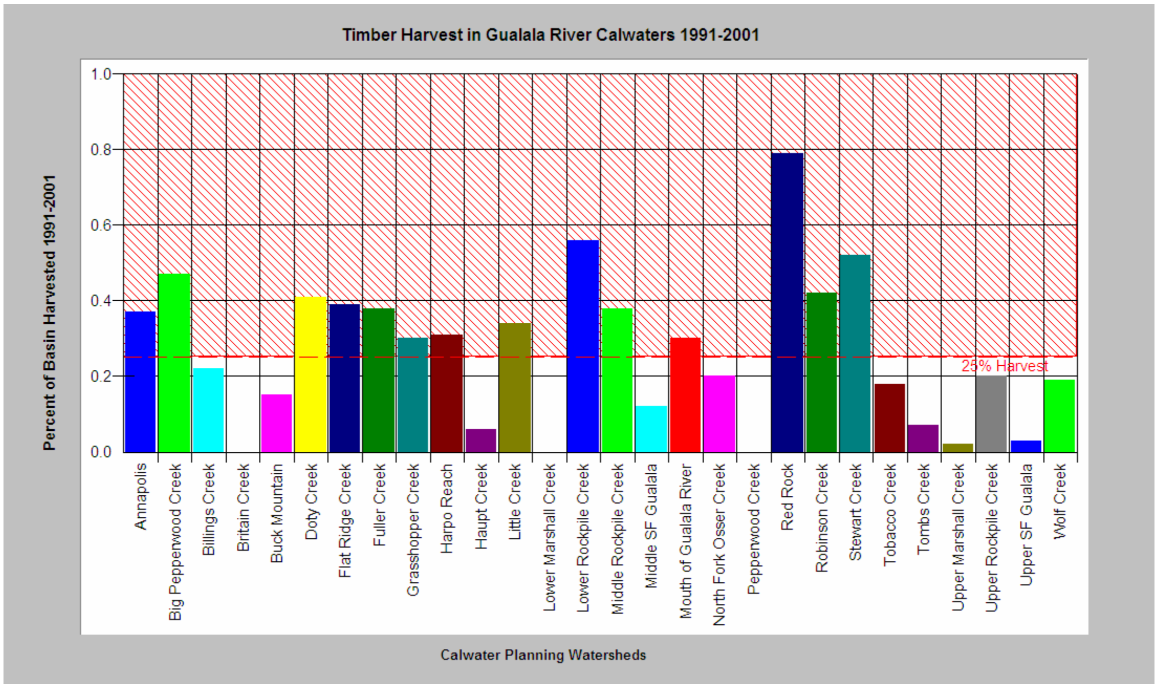


Figure 13. Timber harvest between 1991 and 2001 in the Gualala River watershed is displayed in the chart above and results show that many basins are being harvest at very high rates (>4% POI). Data from KRIS Gualala.

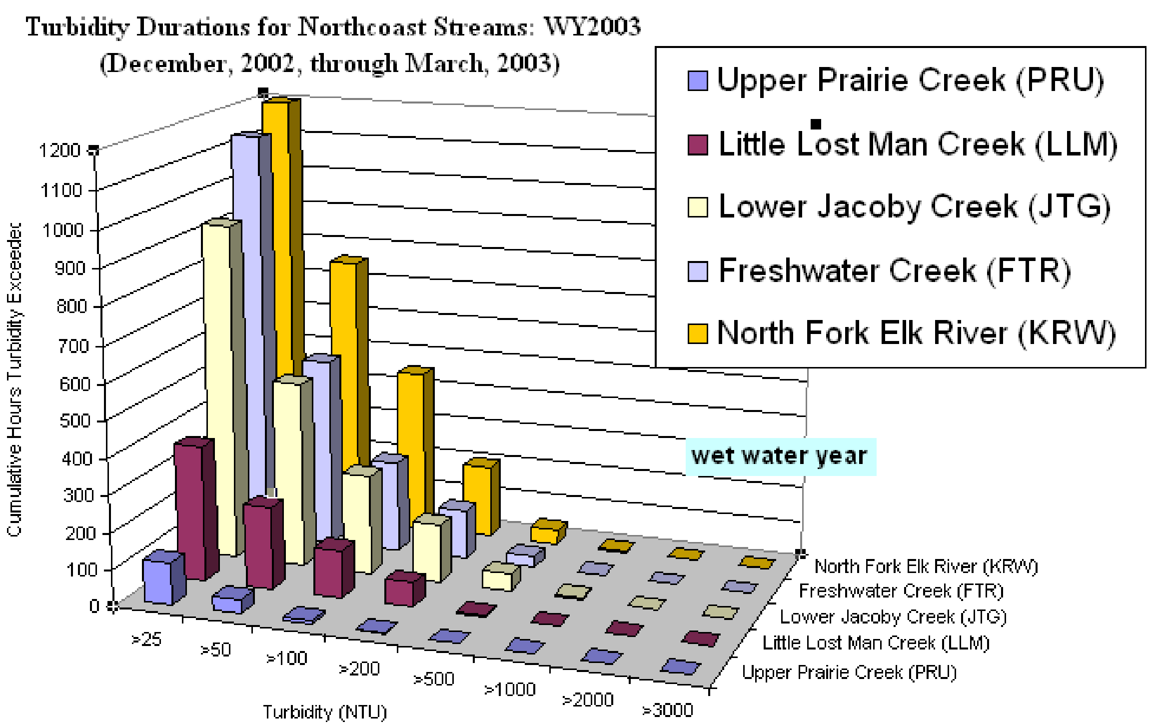


Figure 14. This chart from Klein (2003) shows the total hours over varying turbidity values with 25 NTU the threshold over which steelhead juvenile feeding is impaired (Sigler et al. 1984). Timber harvest rates for basins are as follows: PRU = Control (<1% POI), LLM = Lightly disturbed (1% POI), JTG = Disturbed (2-3% POI), FTR and KRW = Very highly disturbed (4% POI).

Roads Density: The DEIR cites the Gualala River TMDL (NCRWQCB 2003) with regard to roads and erosion: “Road-related erosion is the major portion of the human-caused erosion, and that higher road density in a given area results in greater sediment loading from roads.” It also reports that the Annapolis, Little Creek and Grasshopper Creek Calwaters all have road densities greater than 6 miles per square mile of watershed area (6.1, 6.6 and 6.4 mi/mi^2 respectively), but fails to note the significance of this statistic.

U.S. Forest Service (Quigley et al. 1996) studies in the interior Columbia River basin found that bull trout were not found in basins with road densities greater than 1.7 mi/mi^2 and they rate road density of greater than 4.7 mi/mi^2 as extremely high (Figure 16). National Marine Fisheries Service (1996) guidelines for salmon habitat characterize watersheds with road densities greater than 3 mi/mi^2 as “not properly functioning” while “properly functioning condition” was defined as less than or equal to 2 mi/mi^2 with no or few stream aide roads. NMFS (1995) set the target for road density in the Columbia River Basin as 2.5 mi./mi.^{2} to attain properly functioning watershed condition for sensitive fish species. Just as with timber harvest on the north coast, Klein (2003) found a strong correlation of road density with turbidity levels that would limit juvenile salmonid growth (Figure 17).

The extremely high levels of roads in these three watersheds indicates that CDF and other management authorities should be decommissioning roads and reducing road densities, not allowing new construction. The Artesa Vineyard project will add to sediment loads, as described above, in addition to sediment yield likely coming from roads.

Vineyards and Sediment: The DEIR once again cites the NCRWQCB (2003) with regard to vineyards and erosion: “Viticulture and the associated clearing of vegetation are likely to increase surface erosion through exposure of bare earth to rainfall and runoff. Observations made by Regional Water Board staff in conjunction with the TSD development show that conservation practices used in viticulture (cover cropping, buffer strips, terracing, etc.) have variable effects on erosion prevention.” The DEIR falls back on BMPs and mitigations in claiming that highly erodible Goldridge Series soils will not yield additional sediment when converted to vineyards, including on some areas with steeper slopes.

DEIR Attempts to Narrow Agency Authority and Need for Review

The DEIR tries to argue that Regional Water Control Board staff only have “jurisdiction over 3.610 acres of waters of the State on the project site.” The DEIR makes this calculation as follows:

> “In summary, impacts to RWQCB regulated areas from grading for vineyard installation total 0.414-acre enumerated as follows: impacts to approximately 0.011-acre of other waters; impacts to 0.106-acre of isolated wetland; and impacts to 0.269-acre of seasonal wetlands (Figure 3.4-7). In addition, there would be impacts to 0.001-acre of other waters and 0.027-acre of seasonal wetland from construction of infrastructural elements of the project.”

In fact Pronsolino v. Nastri (F.3d. 7901, U.S. 9th Circuit Court, 2002) makes it clear that authority of the NCRWQCB staff extends to uplands and implementation of measures that prevent sediment and erosion outside wetlands and the stream channel.

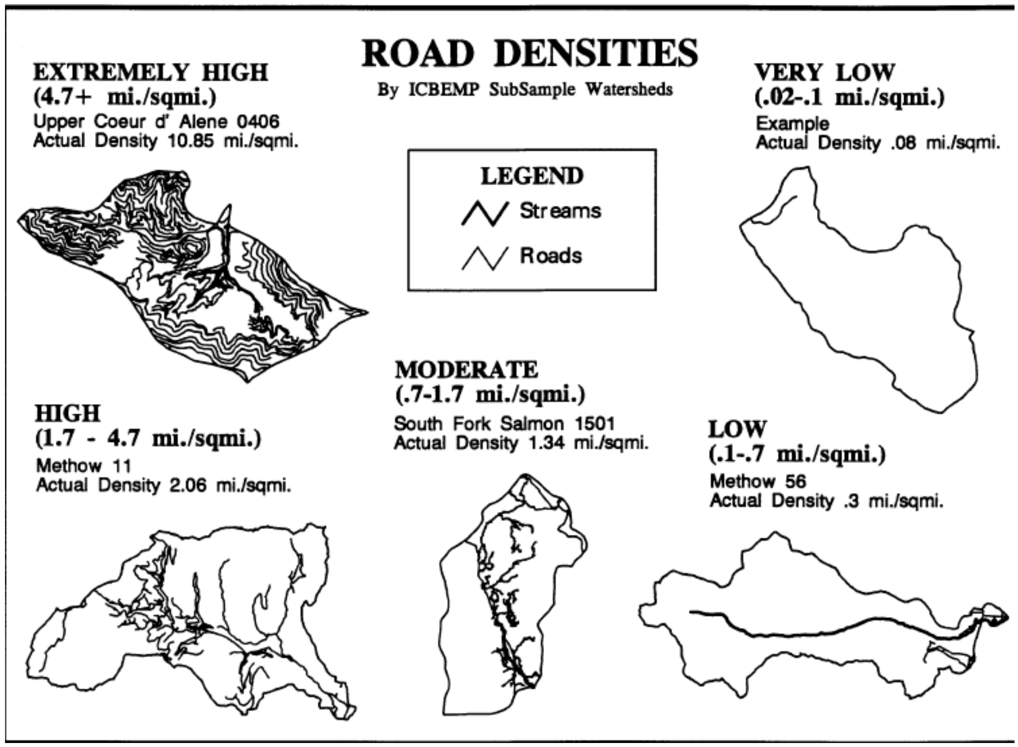


Figure 17. Road density categories from the USFS (Quigley et al. 1996) rating cumulative effects risk.

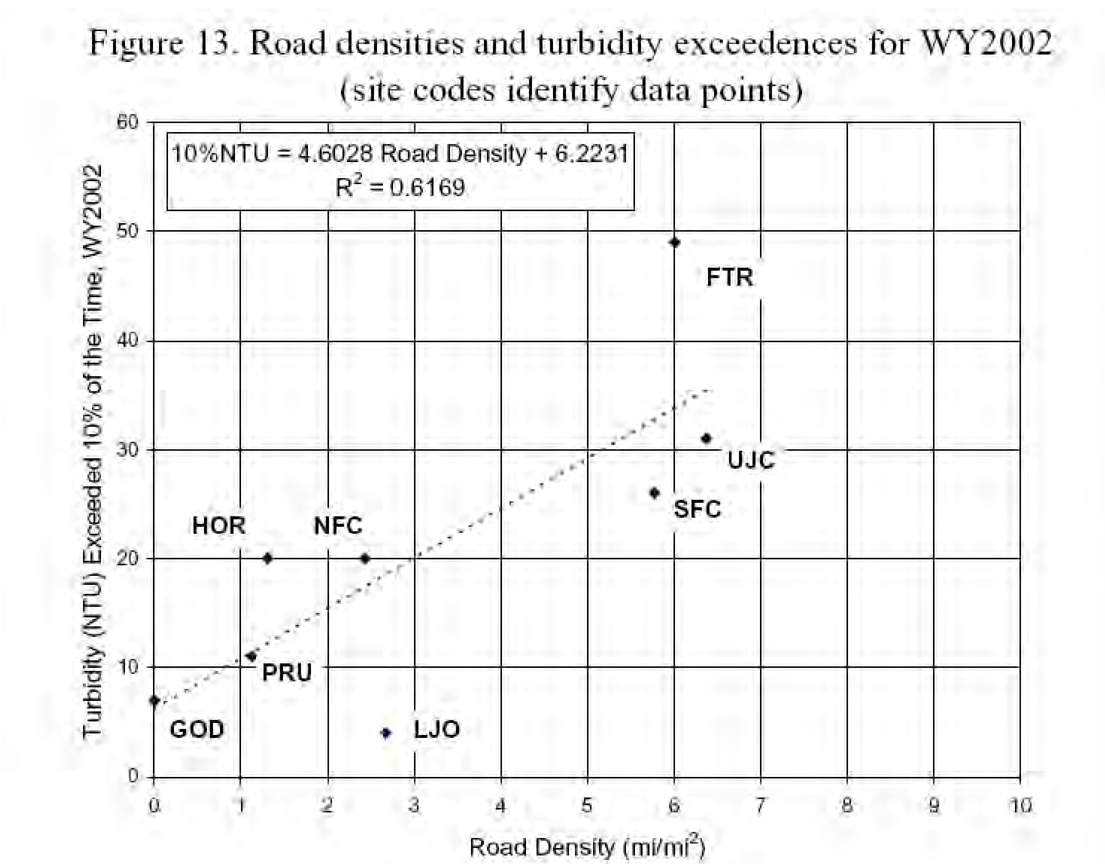


Figure 18. Regression showing string correlation of turbidity and road densities in northwestern California. Turbidities in watersheds with low road densities rarely exceeded 25 NTU while those with higher densities (>5 mi/mi2) did. Taken form Klein (2003).

The DEIR also tries to make the case that no concurrence from NMFS is required because listed steelhead are not on the property, but as explained at length above, the Project will ve3ry likely decrease flows, increase water temperatures and negatively impact steelhead in lower Patchett Creek and possibly the lower mainstem Wheatfield Fork Gualala. Because the potential effect to Patchett Creek is so significant from the Artesa Vineyard, and the functional habitat in the lower Wheatfield Fork Gualala is already so compromised, this Project may rise to the level of a take of that sub-population. The very poor adult return in 2009 (DeHaven In Press) and low juvenile abundance and patchy distribution found in 2001 CDFG NCWAP surveys are also causes for concern. If steelhead do use lower Patchett Creek, their loss from the lower Wheatfield Fork may lead to a loss of connectivity (Williams et al. 2008), and concerns raised above about loss of its function as refugia also have bearing on maintaining salmonids (U.S. EPA 2003).

Potential Project Effects on Yellow-legged Frog and Western Pond Turtle

Although the DEIR admits there are foothill yellow-legged frogs in the Project site, they deny likely impacts from the Project. The decreased baseflows caused by tile drains and reservoirs that I provide evidence for above will decrease yellow-legged frog habitat downstream in Patchett Creek, but the biggest problem is the likely colonization of the Artesa Vineyard reservoir by the invasive and insatiable bull frog (Bury and Whelan 1984). Bury and Whelan (1984) found that man-made impoundments are perfect habitats for the species and recognized the expansion of the bullfrog in the West as having disastrous impacts on native herpetofauna. Bullfrogs can be anticipated to predate upon and out-compete native yellow-legged frogs and could have an equally devastating effect on western pond turtles due to predation on hatchlings. See also Global Invasive Species Database: http://www.issg.org/database/species/ecology.asp?si=80.

Artesa Vineyard Project: Opposite of Needed Actions for Salmon and Steelhead Restoration

Bradbury et al. (1995) point out that preservation can take place without restoration but that restoration of Pacific salmon species cannot take place without habitat protection. CDF's inability to protect aquatic resources by saying no to projects like the Artesa Vineyard is contributing substantially to the decline of Pacific salmon species in northwestern California (Higgins 2009). Reeves et al. (1995) explain that Pacific salmon populations evolved in ecosystems with varying disturbance regimes, but catastrophic habitat changes only occurred in patches or sub-basins, not entire watersheds. Once disturbed, stream channels recovered over decades or sometimes a century to productive salmonid habitat. This "patch disturbance" regime is much different than the extremely high rates of disturbance that take place across much of the landscape and scientists distinguish this as a "press disturbance" regime that is incompatible with salmonid recovery (Collison et al. 2003).

The watershed and hydrologic conditions that salmon and steelhead are now profoundly different than those of the old growth redwood forest. Instead of redwood trees up to 20 feet in diameter, 1994 Landsat data (Warbington et al. 1998) indicate that only 50% are over 24 inches in diameter at breast height (dbh)(Figure 19). This diameter represents mid-seral conditions indicating logging likely after WWI while the other half of the landscape is in smaller trees, brush, grasslands or bare soil. To guide the Gualala River watershed back towards a more normal range of variability and more suitable channel conditions for salmonids, more of the landscape needs to be restored to large trees and a multi-tiered forest canopy. Converting forests and wildland watershed to vineyard will likely eliminate steelhead from lower Patchett Creek instead of helping sustain and restore the species.

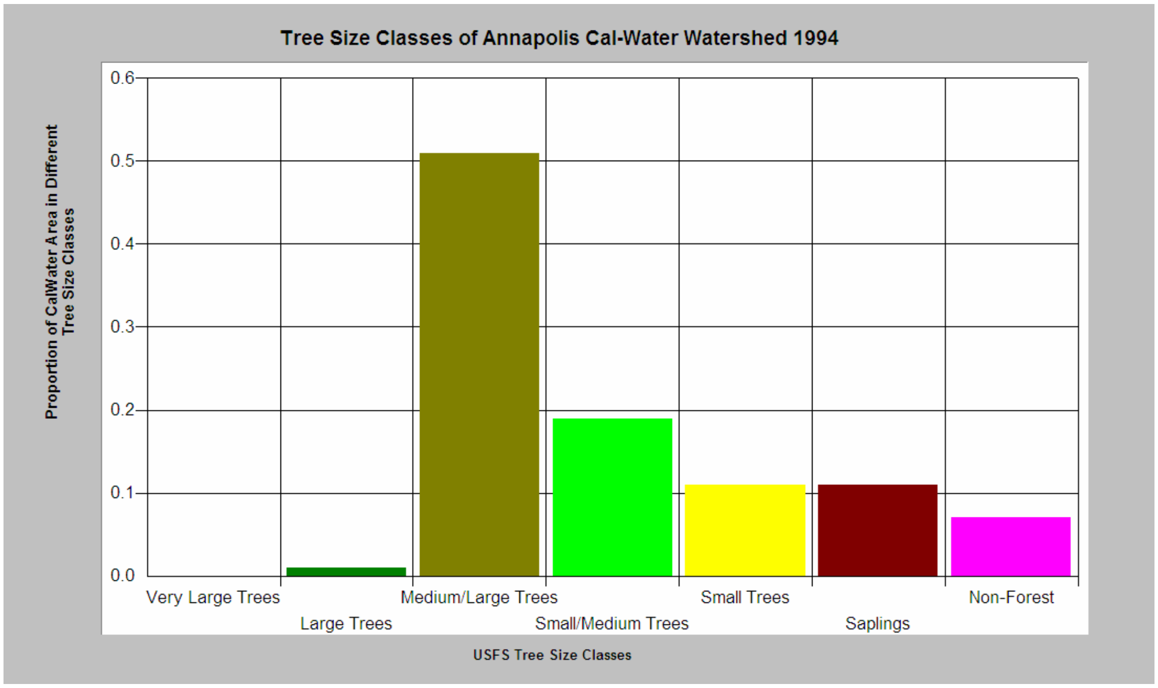
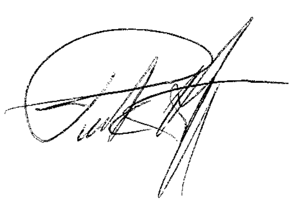


Figure 19. Landsat data analyzed by CDF and the USFS (Warbington et al. 1998) showed that over half of the vegetation in the Annapolis Calwater is less than 20 inches in diameter, indicating harvest in the last 30 years. Vegetation classifications are: Very Large Trees = >40" dbh, Large Trees = Trees 30-39.9" dbh, Medium/Large Trees = 20-29.9" dbh, Small/Medium Trees = 12-19.9" dbh, Small Trees = 5-11.9" dbh, Saplings = Trees < 5"dbh, Non-Forest = No trees, shrubs, grass, bare soil.

Conclusion

The Artesa Vineyard DEIR contradicts itself, adheres to scientifically flawed assumptions and denies impacts by claiming effectiveness of BMPs and mitigation measures. The document clearly fails CEQA tests for use of best available science and for clear analysis of cumulative effects. CDF should reject the DEIR until groundwater issues are resolved and an Appropriative Water Right is obtained by the Project proposers.

Sincerely,



Patrick Higgins

References

Band, L. 2008. Review of the Scientific Basis for the Proposed "North Coast In-Stream Flow Policy." Performed for the SWRCB WRD. Department of Geography, University of North Carolina, Chapel Hill, North Carolina. 12 p.

Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D. L. Bottom, W.E. Weaver and R. L. Beschta. 1995. Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Pacific Salmon. Published by Pacific Rivers Council, Eugene, OR. 56 p.

Brosofske, K. B., J. Chen, R. J. Naiman, and J. F. Franklin. 1997. Harvesting effects on microclimatic gradients from small streams to uplands in western Washington. Ecological Applications 7(4):1188-1200.

Bury, R.B. and J.A. Whelan. 1984. Ecology and management of the bullfrog. US Fish and Wildlife Resource Publication 155:1-23.

California State Water Resources Control Board, Water Rights Division. 2007. Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams. SWRCB WRD, Sacramento, CA.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

DeHaven, R. W. In Press. Draft Steelhead spawning surveys, Wheatfield Fork Gualala River, California 2002-2009. Prepared by the author, September, 2002. http://www.dcn.davis.ca.us/vme/gualala-river/

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.

FEMAT [Forest Ecosystem Management Assessment Team]. 1993. Forest Ecosystem Management: an ecological, economic and social assessment. Report of the Forest Ecosystem Management Assessment Team. 1993-793-071. U.S. Govt. Printing Office.

Gilpin, M.E. and M.E. Soule. 1990. Minimum Viable Populations: Processes of Species Extinction. In: M. Soule (ed) Conservation Biology: The Science of Scarcity and Diversity University of Michigan Press. pp 19-36.

Higgins, P.T. 1997. Gualala River Watershed Literature Search and Assimilation. Funded by the Coastal Conservancy under contract to Redwood Coast Land Conservancy. Gualala, CA. 59 pp.

Higgins, P.T. 2003a. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1-01-171 SON. May 20, 2003. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p.

Higgins, P.T. 2003b. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Negative Declaration for Sugarloaf Farming Corporation dba Peter Michael Winery, Timberland Conversion No. 524; THP 1-01-223 SON. December 12, 2003. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p

Higgins, P.T. 2004a. Comments on Negative Declaration for THP 1-04-030SON, Hanson/Whistler Timberland Conversion Permit (TCP) #530. Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 13 p. 4/14/04

Higgins, P.T. 2004b. Comments on Negative Declaration for Timber Harvest Plan (THP 1-04-055 SON) / Zapar-Roessler Timberland Conversion Permit (TCP 04-533). Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 4 p. 8/16/04.

Higgins, P.T. 2006a. Comments on the Napa River Sediment TMDL and San Francisco Bay Regional Water Quality Control Board Basin Plan Amendment. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA. 21 p. 8/14/06.

Higgins, P.T. 2006b. Comments on the Proposed Mitigated Negative Declaration for Napa Canyon LLC Vineyard Project in American Canyon Creek Watershed. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA. 13 p. 10/7/06.

Higgins, P.T. 2007. Comments on THP 1-04-260 MEN - Robinson Creek Calwater Planning Watershed, Dry Creek, North Fork Gualala River. Performed under contract to the Friends of the Gualala River by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 32 p.

Higgins, P.T. 2008a. Re: Final Napa River Watershed Sediment TMDL and Habitat Enhancement Plan Negotiations. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 3 p. 7/21/08

Higgins, P.T. 2008b. Comments on Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams. Prepared for the Redwood Chapter of the Sierra Club by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 49 p.

Higgins, P.T. 2009. Comments on Proposed Threatened and Impaired Watershed Rules. Prepared for the Center for Biological Diversity by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 17 p. www.biologicaldiversity.org/species/fish/coho_salmon/pdfs/CBD_Combined_T_I_Comments.pdf

Hilton, S. and T.E Lisle. 1993. Measuring the Fraction of Pool Volume Filled with Fine Sediment. Res. Note PSW-RN-414. US Forest Service, Pacific Southwest Research Station. Albany, CA . 11 p.

Institute for Fisheries Resources. 2003. KRIS Gualala database. Performed under contract to CDF as part of NCWAP. IFR, San Francisco, CA. (www.krisweb.com).

Jones, J.A. And G.E. Grant. 1996. Peak flow response to clear-cutting and roads in small and large basins, Western Cascades, Oregon. Water Resources Research, April 1996. Vol. 32, No. 4, Pages 959-974.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An Ecological Perspective of Riparian and Stream Restoration in the Western United States. Fisheries 22(5):12-24.

Kier Associates and National Marine Fisheries Service (NMFS). 2008. Updated Guide to Reference Values used in the Southern Oregon / Northern California Coho Salmon Recovery Conservation Action Planning (CAP) Workbook. Kier Associates, Blue Lake, CA and National Marine Fisheries Service, Arcata, CA. 31 pp.

Klein, R. 2003. Duration of Turbidity and Suspended Sediment Transport in Salmonid-Bearing Streams, North Coast California. Prepared under Interagency Agreement # DW-1495553501-0 between U.S. EPA Region IX, San Francisco, CA and Redwood National and State Parks, Arcata, CA. 45 p.

Klein, R., W. Trush and M. Buffleben. 2008. Watershed Condition, Turbidity and Implications for Anadromous Salmonids in North Coastal Watersheds. Report for the North Coast Regional Water Quality Control Board, Santa Rosa, CA. 106 p.

Knopp, C. 1993. Testing Indices of Cold Water Fish Habitat. Final Report for Development of Techniques for Measuring Beneficial Use Protection and Inclusion into the North Coast Region's Basin Plan by Amendment. September 18, 1990. North Coast Regional Water Quality Control Board in cooperation with California Department of Forestry. 57 pp. http://www.krisweb.com/biblio/ncc_ncrwqcb_knopp_1993_sediment.pdf.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and salmonid habitat. Prepared for the Resources Agency of California and the National Marine Fisheries Service. Sacramento, CA. 181 pp. http://www.krisweb.com/biblio/cal_nmfs_ligonetal_1999_srprept.pdf

McMahon, T. 2008. Review of “Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams.” Performed under contract to the SWRCB WRD. Thomas E. McMahon, Professor of Fisheries, Montana State University. 11 p.

Monk and Associates. 2009. Artesa Vineyard Conversion Draft Environmental Impact Report (SCH# 2004082094). Prepared for Cordineau Winery by Monk and Associates, walnut Creek, CA.

Montgomery, D. R. and J.M. Buffington, 1993. Channel classification, prediction of channel response, and assessment of channel condition. TFW-SH10-93-002. Prepared for the SHAMW committee of the Washington State Timber/Fish/Wildlife Agreement. Seattle, WA. 110 pp.

National Marine Fisheries Service. 1995. Endangered Species Act Section 7 Biological Opinion on the Land and Resource Management Plans for the Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. NMFS Northwest Region, Seattle, WA. 138 p.

National Marine Fisheries Service (NMFS). 1996. Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast. 5 pp.

National Research Council (NRC). 2004. Endangered and threatened fishes in the Klamath River basin: causes of decline and strategies for recovery. Committee on endangered and threatened fishes in the Klamath River Basin, Board of Environmental Toxicology, Division on Earth and Life Studies, Washington D.C. 424 pp.

North Coast Regional Water Quality Control Board. 2001. Gualala River Watershed Technical Support Document for Sediment TMDL. California Regional Water Quality Control Board, Region 1, Santa Rosa, CA. 147 p.

Northcoast Watershed Assessment Program. 2003. Gualala River Watershed Assessment Synthesis Report. Complied by CDF, CDFG, NCRWQCB, and CGS. http://coastalwatersheds.ca.gov/Watersheds/NorthCoast/Gualala/GualalaBasin/tabid/98/Default.aspx

Quigley, T. M. and H. Bigler Cole, 1997. Highlighted scientific findings of the Interior Columbia Basin Ecosystem Management Project. Gen. Tech. Rep PNW-GTR-404. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; U.S. Department of the Interior, Bureau of Land Management. Portland, OR. 47 p.

Reeves, G. H., F. H. Everest, and J. R. Sedell. 1993. Diversity of juvenile anadromous salmonid assemblages in coastal Oregon basins with different levels of timber harvest. Transactions of the American Fisheries Society. 122(3): 309-317.

Reeves, G.H., L.E.Benda, K.M.Burnett, P.A.Bisson, and J.R. Sedell. 1995. A Disturbance-Based Ecosystem Approach to Maintaining and Restoring Freshwater Habitats of Evolutionarily Significant Units of Anadromous Salmonids in the Pacific Northwest. American Fisheries Society Symposium 17:334-349, 1995.

Rieman, B., D. Lee, J. McIntyre, K. Overton, and R. Thurow. 1993. Consideration of extinction risks for salmonids. As FHR Currents # 14. U.S. Department of Agriculture, Forest Service, Region 5 . Eureka, CA. 12 pp.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society. 113:142-150.

Spence, B.C., G.A. Lomnicky, R.M. Hughes and R. P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation. Funded jointly by the U.S. EPA, U.S. Fish and Wildlife Service and

National Marine Fisheries Service. TR-4501-96-6057. Man Tech Environmental Research Services Corp., Corvallis, OR.

Stetson Engineers Inc. 2007. Potential Indirect Environmental Impacts of Modification or Removal of Existing Unauthorized Dams. Appendix to Policy for Maintaining Instream Flows in Northern California Coastal Streams Performed under contract to SWRCB WRD, December 2007. 71 p.

US Environmental Protection Agency (USEPA). 1998. (Final) Garcia River Sediment Total Maximum Daily Load. Dated 16 March 1998. USEPA, Region IX. San Francisco, CA. 51 p.

US Environmental Protection Agency (USEPA). 1999. (Final) Noyo River Total Maximum Daily Load for Sediment. USEPA, Region IX. San Francisco, CA. 87 p.

U.S. Environmental Protection Agency. 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA Project # 910-B-03-002. Region 10 U.S. EPA, Seattle WA. 57 p.

U.S. Ninth Circuit Federal Court of Appeals. 2002. Prosilino et al. vs. Nastri et al. No. 00-16026, D.C. No. CV-99-01828-WHA OPINION.

Warbington, R., B. Schwind, C. Curlis and S. Daniel. 1998. Creating a Consistent and Standardized Vegetation Database for Northwest Forest Plan Monitoring in California. USDA Forest Service. Pacific Southwest Region Remote Sensing Lab. Sacramento, CA.

Williams, T.H., B. C. Spence1, W. Duffy, D. Hillemeier, G. Kautsky, T. Lisle, M. McCain, T. Nickelson, G. Garman, E. Mora, and T. Pearson. 2008. Framework for assessing viability of threatened coho salmon in the Southern Oregon /Northern California Coast Evolutionarily Significant Unit. NMFS SW Science Center, Santa Cruz, CA. 97 p

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April 13, 2007

Mr. William Snyder
Northern Region Headquarters
California Department of Forestry and Fire Protection
135 Ridgeway Avenue
Santa Rosa, CA 95401

Re: Comments on THP 1-04-260 MEN - Robinson Creek Calwater Planning Watershed, Dry Creek, North Fork Gualala River.

Dear Mr. Snyder,

I have reviewed Timber Harvest Plan 1-04-260 MEN and related documents on behalf of the Friends of the Gualala River and provide comments below on cumulative watershed effects and potential impacts to coho salmon (Oncorhynchus kisutch) and steelhead trout (Oncorhynchus mykiss). In addition to the THP, I have read relevant sections of the Coastal Ridges, LLC (2006) *Option A Sustained Yield Plan*, California Department of Fish and Game comments on the THP (CDFG, 2006), and California Department of Forestry (CDF, 1995) *Review Guidelines for Option A Timber Harvest Plans.*

I have been a consulting fisheries biologist with an office in Arcata, California since 1989. My other previous work in the Gualala River basin includes the *Gualala River Watershed Literature Search and Assimilation* (Higgins, 1997), which I compiled for the Redwood Coast Land Conservancy, and the KRIS Gualala database project (IFR, 2003) that was funded by CDF as part of the North Coast Watershed Assessment Program (NCWAP). Charts and maps presented below come from these products which have been made available in electronic form to CDF staff with my previous comments. I wish to incorporate these by reference into the record similar, previous comments on other Gualala River watershed timber harvests and vineyard conversions. Please let me know if you would like me to retransmit copies for your files.

- Artesia Timberland Conversion Permit (TCP) 02-506 and Timber Harvest Plan (THP) 1-01-171 SON near Annapolis on Patchet Creek, a tributary to the Wheatfield Fork Gualala (Higgins, 2003a),
- Seaview TCP 02-524 and THP1-01-223 SON in the upper South Fork Gualala River basin (Higgins, 2003b),
- Hanson/Whistler Timberland Conversion Permit TCP 04-530 and THP 1-04-030 SON in the Little Creek watershed, a lower tributary to Buckeye Creek (Higgins, 2004), and
- Negative Declaration for Martin TCP 04-531 and THP 1-04-059), which is also in the Little Creek watershed.

THP 1-04-260 MEN uses data selectively and tries to present a case that there are no cumulative effects, but it actually documents conditions within the THP boundaries, the adjacent watershed area and in the stream channel of Dry Creek that show the opposite. The plan claims it will fully mitigate all potential effects, but Dunne et al. (2001) point out that such mitigations cannot prevent downstream damage when too great a watershed area is disturbed in too short a period.

The Coastal Ridges, LLC (2006) *Option 10 Plan* does not deal credibly with potential restraints on timber harvest from other forest values as required by Section 913.11(a)(1) of the California Forest Practices Act (CFPA) and does not meet the requirement of the California Environmental Quality Act (CEQA) for use of "best available scientific data." THP 1-04-260 MEN will add to impairment of water quality, cause further loss of fish habitat and be counter-productive for recovery of coho salmon and steelhead trout; therefore, it should be denied at this time and allowed at a later date when "cold water" beneficial uses of Dry Creek and the North Fork Gualala River have been restored.

Cumulative Watershed Effects

THP 1-04-260 makes a rhetorical case that there is no advanced cumulative effects in the Robinson Creek Calwater, but then describes conditions that in fact reflect substantial impairment of hydrologic function and aquatic habitat. Timber harvest and road building within Dry Creek and the Robinson Creek Calwater Planning Watershed have been intensive historically and recently. Lower Dry Creek and the North Fork Gualala and its other tributaries are extremely aggraded as a result of the wave of sediment as a result of recent land management. The mainstem North Fork is shallow and warm and tributaries lose surface flow in late summer because their beds as a result of significant sediment over-supply. My prior comments also present evidence that similar problems with cumulative watershed effects related to timber harvest and stream channel aggradation occur in Buckeye Creek, Rockpile Creek, Wheatfield Fork and the South Fork Gualala River watersheds. THP 1-04-260 MEN and *CR Option 10 Plan* also fail to consider impacts from this harvest to recovery of water quality in the Gualala River basin as a whole.

Dry Creek Sub-Basin Affected by THP 1-04-260

THP 1-04-260 MEN does not adequately define the Dry Creek tributary where the harvest is to take place, which makes it difficult to understand potential cumulative watershed effects in stream channels. In fact the timber harvest encompasses an entire third order tributary of upper Dry Creek (Figure 1). The timber harvest plan map in Figure 1 is based on the original filing in 1998 by Pioneer Resources and THP data are those used by NCWAP (CA RA, 2003). Although this THP did not go forward as scheduled, CDF change scene detection data (Fischer, 2003), based on Landsat imagery from 1994 and 1998, show substantial reduction in canopy cover in adjacent basins where no THP's were filed between 1991-2001 (see Watershed Conditions discussion below).

The Dry Creek tributary where the harvest is to take place is third order stream, according to the Strahler (1957) method (Figure 2). The steepness of the watershed is reflected in the stream gradient (Figure 3), which shows that stream channels are mostly source and transport reaches, while low gradient response reaches suitable for coho salmon are downstream (Lunetta et al., 1997). Any sediment yield from THP 1-04-260 MEN can be expected to be flushed rapidly from the steep channels within this watershed and delivered to already heavily impacted reaches of lower Dry Creek. The adjacent un-named third order tributary to Dry Creek to the east has similar channel gradient and has had significant timber harvest on potential land slide zones and over an extensive area of the watershed. The THP documents a major inner gorge landslide where upper Dry Creek becomes fourth order below the convergence of the tributary slated for harvest and the adjacent previously impacted tributary. Damage at this location is consistent with rapid delivery of sediment during and increased peak discharge during the January 1997 storm event (Dunne et al., 2001). Stream channel condition and water quality impairment in lower Dry Creek demonstrated below are likely a result of these previous land use activities. THP 1-04-260 MEN and Coastal Ridges (2006) *Option 10 Plan* need to provide better maps and descriptions of the hydrology and stream channel conditions.

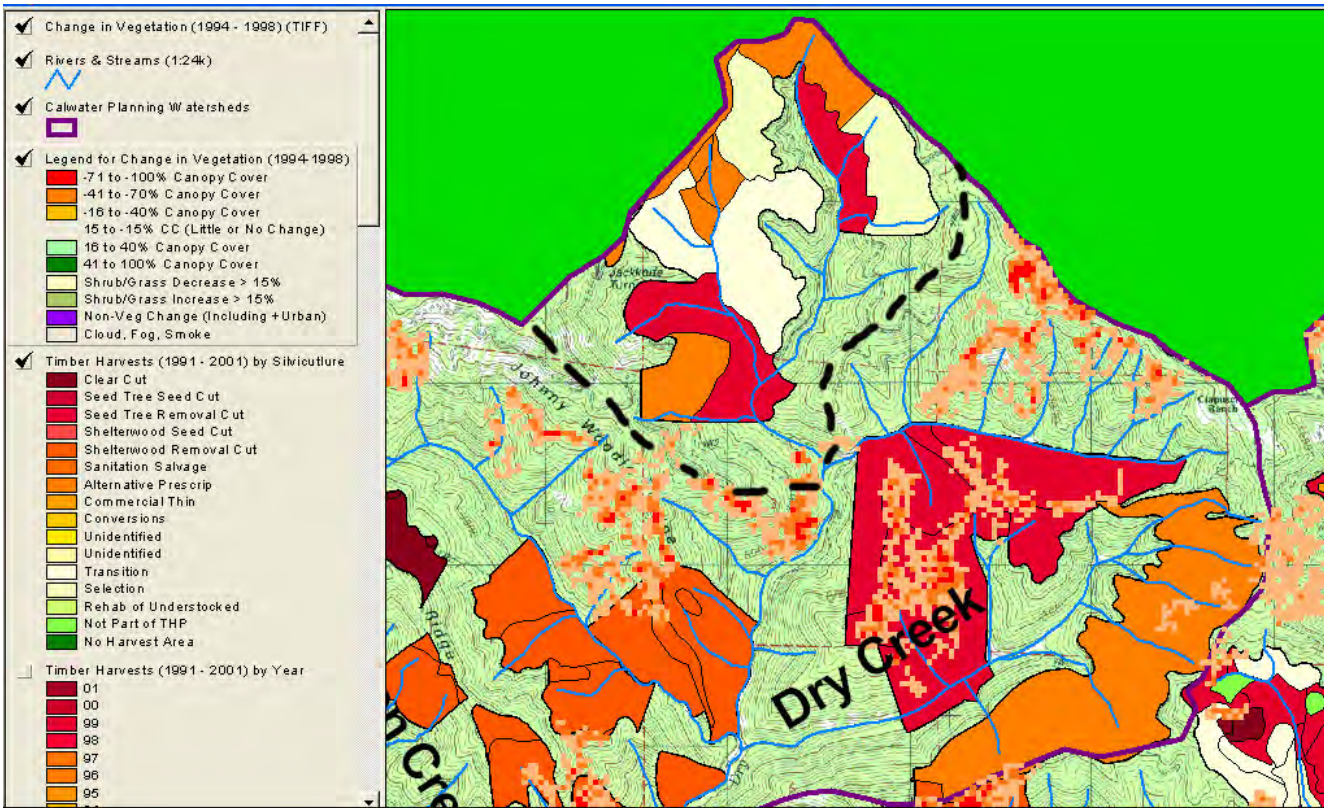

Figure 1. The headwater third order tributary of Dry Creek affected by THP 1-04-260 MEN is outlined above with a black-dashed line. THP and Landsat 1994-1998 change scene data from CDF. Map image from KRIS Gualala Map project.

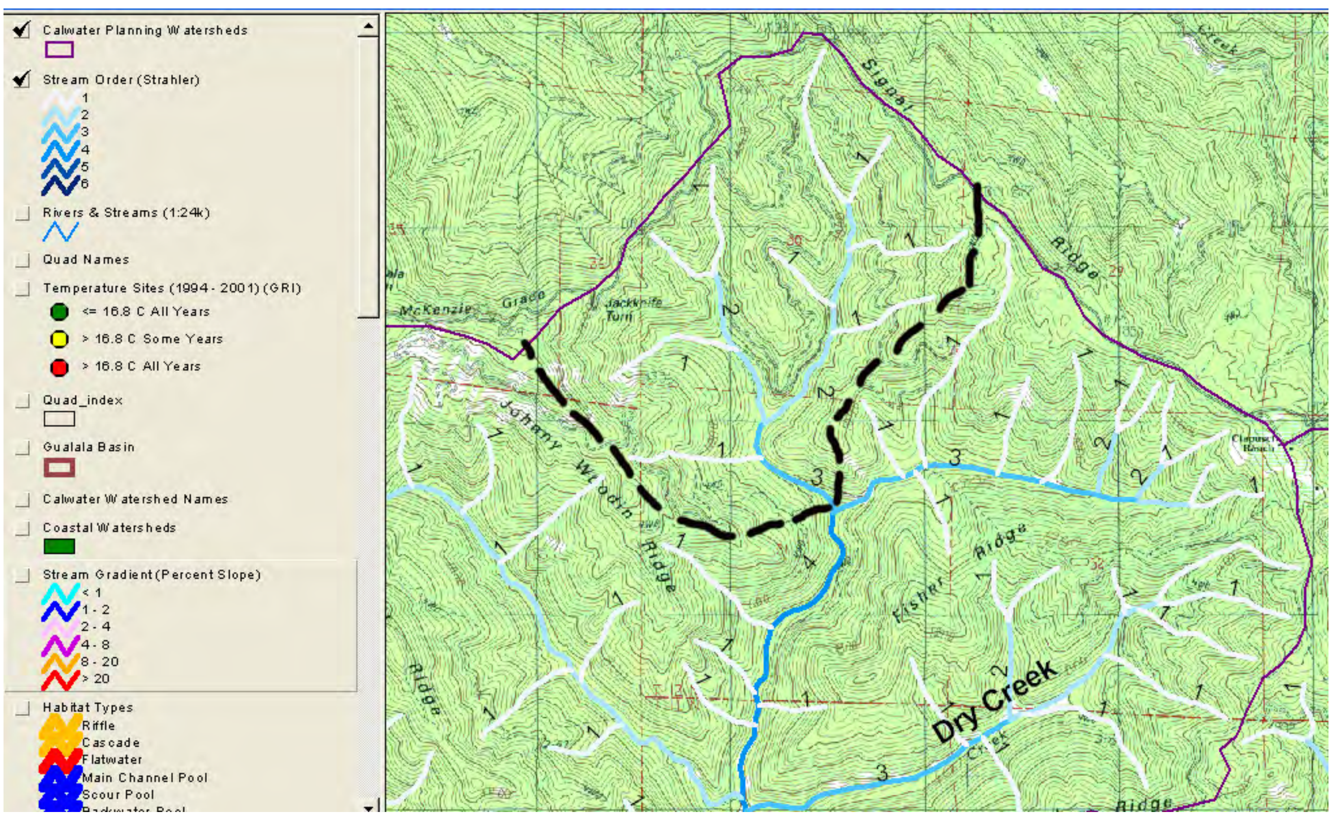

Figure 2. Strahler (1957) stream orders are displayed as numbers next to streams in the headwaters of North Fork Dry Creek, showing the third order status of the effected tributary (outlined in black) and the adjacent tributary. From KRIS Gualala Map project.

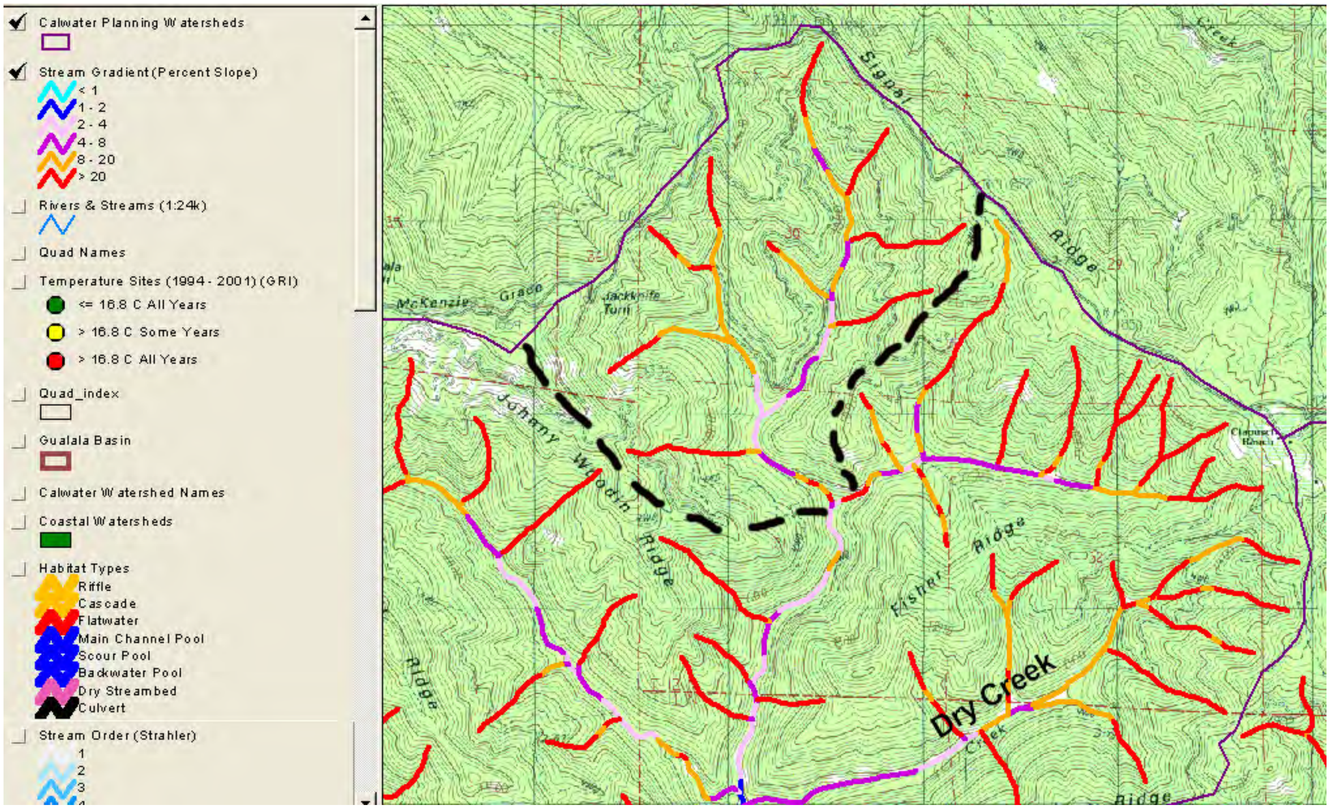

Figure 3. The majority of the stream channels in the third order Dry Creek tributary affected by THP 1-04-260 MEN are high energy. Headwaters have a gradient of greater than 20% (source reaches) and below them are 4-20% gradient channels that are transport reaches. There are only two response reaches of less than 4% gradient, where sediment storage might occur. Note that the adjacent third order Dry Creek tributary to the east has even more supply reaches. From KRIS Gualala Map project.

Stream Channel Conditions of Dry Creek, North Fork Gualala River and Other NF Tributaries

Data from CDFG 2001 habitat typing surveys and other data collected as part of the NCWAP watershed assessment (CA RA, 2003) show major problems with sediment and temperature pollution of Dry Creek, the North Fork Gualala River, and its other tributaries. The NCWAP report did not use standard scientific references for characterizing aquatic habitat conditions (IFR, 2003) and; therefore, failed to reach appropriate conclusions regarding fish habitat and water quality impairment and linkage to recent upland management.

<u>Pool Frequency</u>: Coho salmon juveniles prefer pool habitat formed by large wood (Reeves et al., 1988), and yearling and older age steelhead juveniles also reside in pools (Barnhart, 1986). Murphy et al. (1984) found that natural pool frequencies in unmanaged streams ranged between 39-67%. Peterson et al. (1992) used 50% pool frequency by length as a reference for good salmonid habitat and recognized streams with less than 38% as impaired. CDFG habitat typing surveys of the North Fork Gualala River basin (Figure 4) show Dry Creek to have a pool frequency of 25% and McGann Creek, also within the Robinson Creek Calwater, to have less than 10% pools.

Increased sediment supply can cause loss of pool frequency and depth (Montgomery and Buffington, 1993), particularly in low gradient response reaches, such as the mainstem North Fork Gualala River and flat reaches within lower Dry Creek. Reeves et al. (1993) found that pools diminished in Oregon coastal streams as the extent of timber harvest increased; basins with less than 25% of their watershed area harvested over 30 years had 10-47% more pools per 100 m than did streams in high harvest basins (>25%).

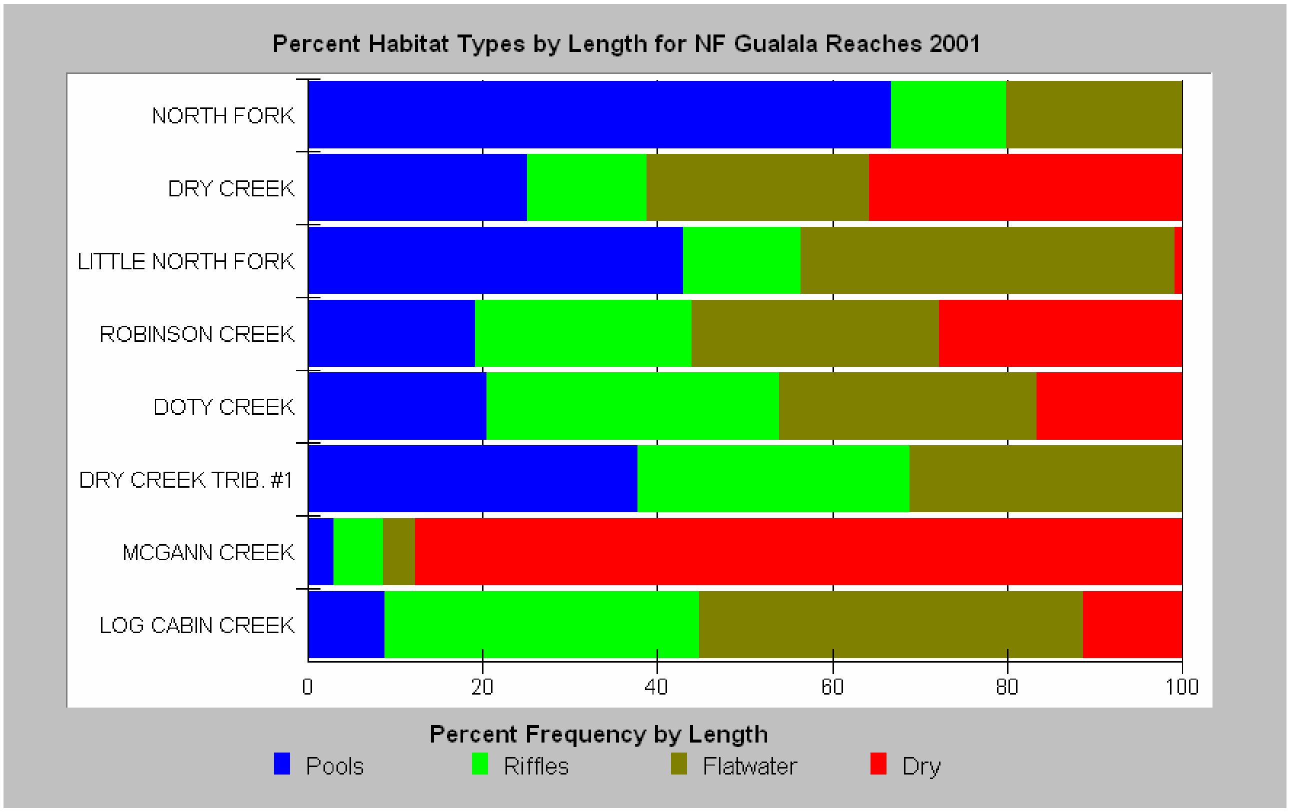

Figure 4. Habitat surveys of the NF Gualala River and its tributaries show low pool frequencies and a high percentage of dry reaches. Data from CDFG (CA RA, 2003) and chart from KRIS Gualala.

Pool Depth: Greater pool depth provides more cover and rearing space for juvenile salmonids and better shelter for migrating or spawning adults (Spence et al., 1996). Pool depths of three feet or one meter are commonly used as a reference for fully functional salmonid habitat (Overton et al., 1993; USFS, 1998; Bauer and Ralph, 1999; Brown et al., 1994). Pools within Dry Creek and NF Gualala River tributaries are almost all less than three feet (Figure 5) as a result of aggradation and are, consequently, very poor salmonid rearing habitat. The section below on Fish Status/Trends documents loss pools, pool depth and carrying capacity for salmonids in the Little North Gualala River watershed, which is adjacent to Robinson Creek Calwater to the west. The NCWAP watershed assessment (CA RA, 2003) noted that "pool depth and shelter are the most limiting factors" for the North Fork Gualala River watershed. THP 1-04-260 MEN also notes that the mainstem Dry Creek has few deep pools.

Dry Reaches: When streams are massively aggraded, they lose surface flow in late summer and early fall. This not only represents a substantial direct loss of habitat for salmonid juvenile rearing, but also prevents juvenile and adult migration. Habitat typing results from the North Fork Gualala River and its tributaries (CA RA, 2003) show that extensive reaches of Robinson Creek, Dry Creek and McGann Gulch lacked surface flow at the time of the survey (Figure 6). All three of these tributaries are within the Robinson Creek Calwater Planning Watershed and the dry reaches conform to low gradient channels that would have formerly been those preferred by coho salmon for spawning and rearing. Figure 7 shows the stream gradient of the North Fork Gualala River, lower Dry and Robinson Creeks and McGann Gulch. Reaches colored in light blue and dark blue indicate a gradient of 1-2%, and would have been optimal for coho (Groot and Margolis, 1991). Coastal Ridges, LLC (2006) and reviewing agencies fail to note that extensive reaches of North Gualala River tributaries, including Dry Creek, currently lack surface flow in late summer and fall because of severe aggradation, yet many of these reaches once supported standing crops of coho and steelhead. No further hydrologic alteration of the Gualala River basin should be allowed until sediment has been flushed from the system and surface flows restored in formerly productive reaches and tributaries.

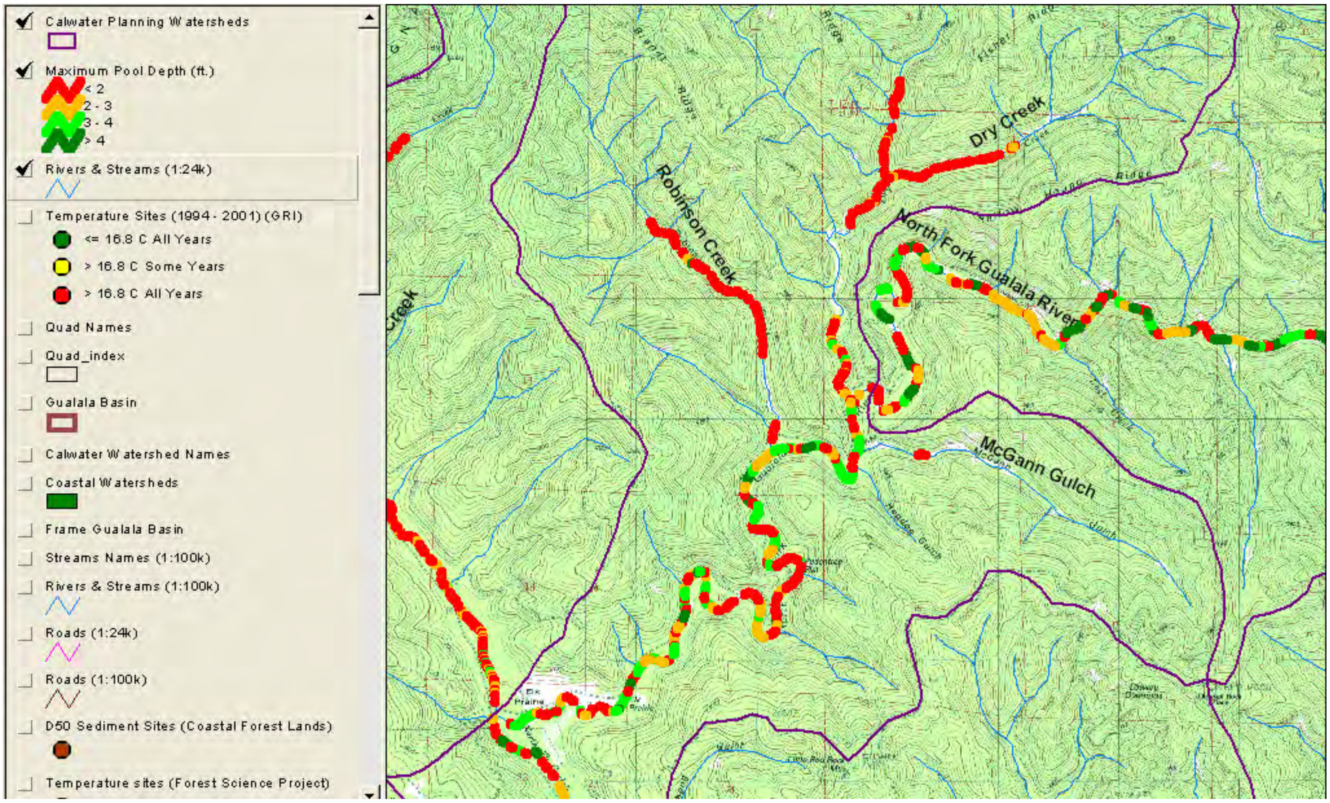

Figure 5. Pool depth in tributaries of the North Fork Gualala within the Robinson Creek Calwater Planning watershed are mostly less than three feet, including lower Dry Creek, providing little suitable habitat for coho juveniles. Data from CDFG 2001 surveys. Map from KRIS Gualala.

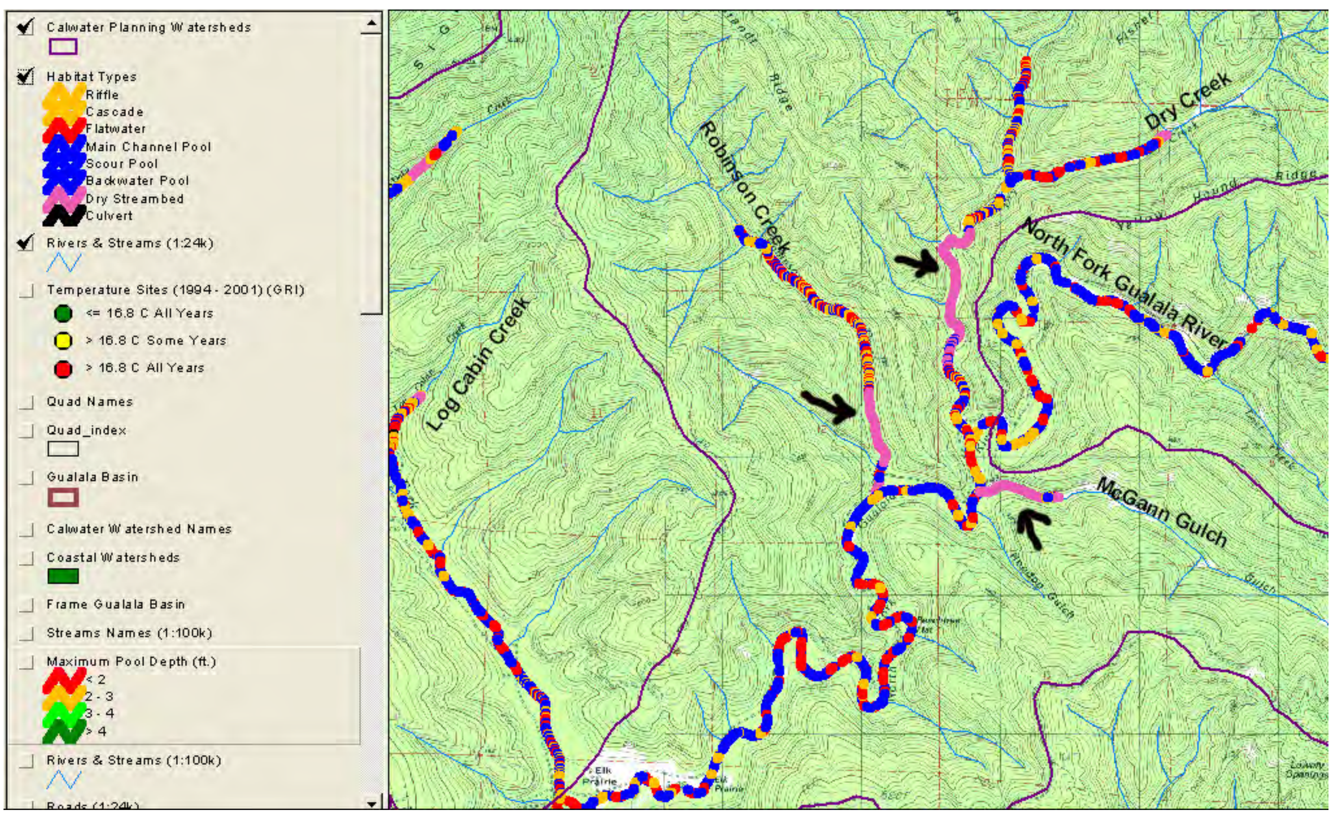

Figure 6. Black arrows point out that lower reaches of Robinson Creek, Dry Creek and McGann Gulch within the Robinson Creek Calwater are all so aggraded that they lacked surface flow at the time they were surveyed by CDFG in 2001. Map image from KRIS Gualala Map Project.

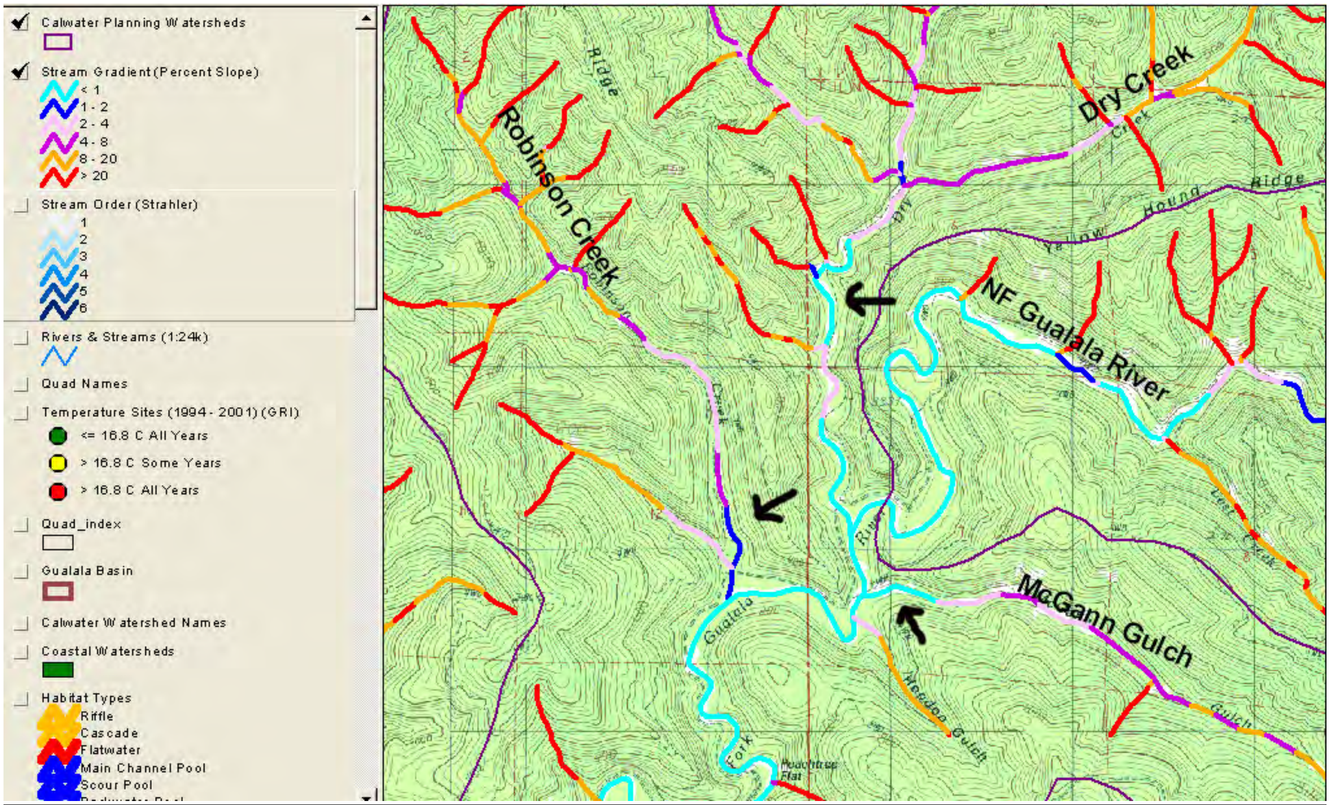

Figure 7. This map image of the North Fork Gualala River and its tributaries show that the mainstem has less than a 1% gradient and is almost all optimal for coho salmon, while reaches of suitable gradient in tributaries are near their convergence with the mainstem. Black arrows show reaches with coho-suitable gradient that were dry during CDFG habitat surveys in 2001. Map from KRIS Gualala.

<u>Median Particle Size (D50)</u>: Knopp (1993) studied 60 northwestern California streams and found a relationship between the median particle size (D50) of a stream bed and watershed conditions. Control watersheds, or those that had recovered from disturbance, had a D50 of 52-88 mm. Values of less than 38 mm were correlated with recent, intensive watershed management. Reduced median particle size often indicates increased fine sediment contributions (Montgomery and Buffington, 1993) and increases likelihood of bedload mobility that can cause egg and alevin mortality (Nawa et al., 1990).

Gualala Redwoods, Inc collected D50 data in the North Fork Gualala watershed (Figure 8) and provided it for use in the NCWAP watershed assessment (CA RA, 2003). The radical change in median particle size at location #211 near the mouth of Dry Creek is indicative of waves of sediment moving down the creek, likely as a result of debris torrents on highly erodible upland areas or as a result of high peak flows. The D50 went from 30 mm at this location in 1997, indicative of very high and recent sediment supply, to 86 mm in 1999 and then back to 45 mm in 2001. The D50 for two of three cross sections at the upstream location provided by GRI (Dry #212) is higher than optimal for salmonid spawning (110 mm and 96 mm). Larger particle size distribution can be indicative of increased shear stress associated with increased peak discharge (Montgomery and Buffington, 1993). Other locations measured by GRI in the mainstem North Fork, Robinson Creek and the Little North Fork Gualala River all had very small D50 sizes in the range recognized by Knopp (1993) as associated with intensive watershed management. This is indicative of major problems for salmonid spawning and egg and alevin survival.

THP 1-04-260 MEN provides charts of cross sections for Dry Creek based on data from Gualala Redwoods, Inc for the same locations where the D50 was measured (P. 127). The charts show major channel migration with the deepest portion of the channel (thalweg) migrating laterally from year to

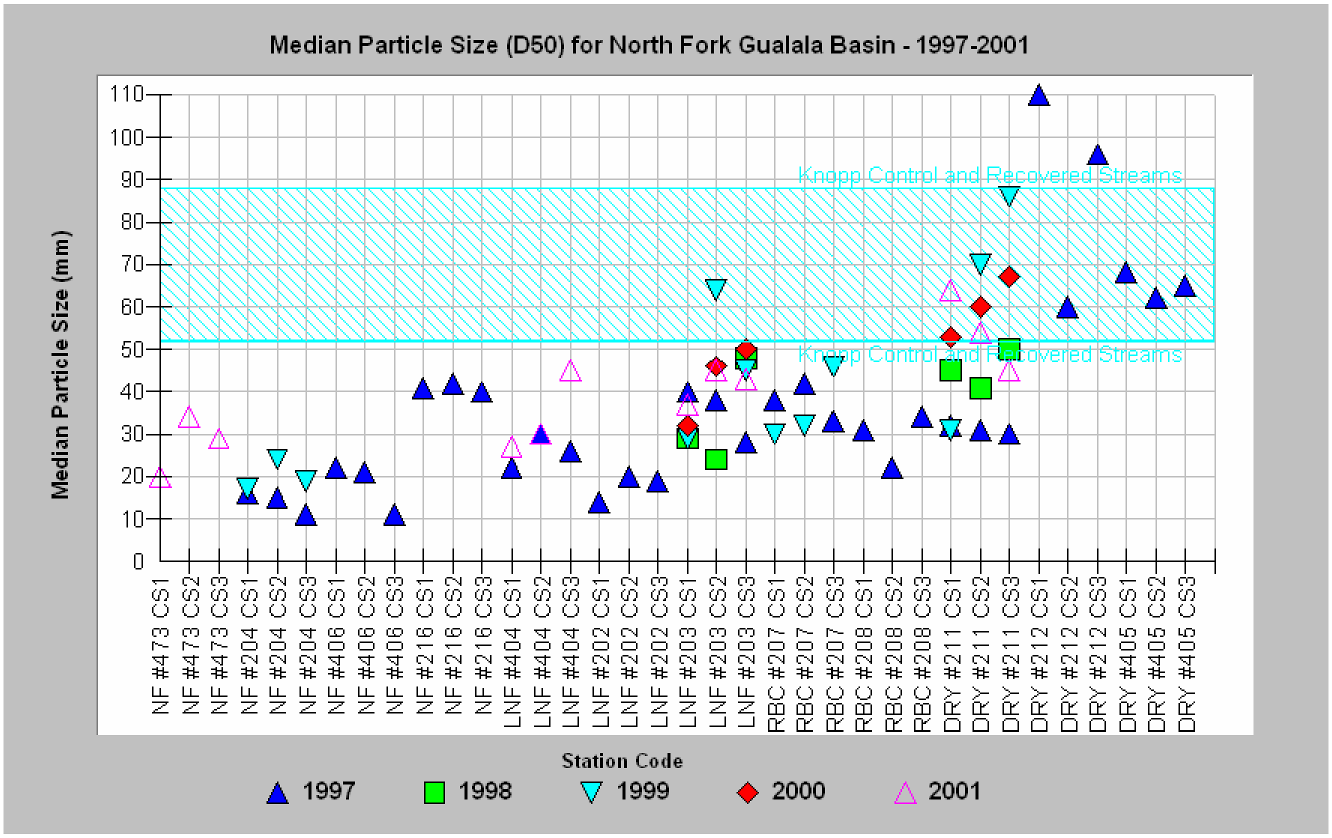

Figure 8. Measurements of median particle size at Dry Creek (DRY) cross sections (CS) from 1997 to 2001 show highly variable D50 at CS 211 near the mouth of the stream, which is indicative of recent waves of sediment pulsing through this reach. D50 at two of three cross sections in upper Dry Creek (CS 212) are higher than optimal for salmonid use, which could be as a result of elevated peak discharge.

year. Units on these charts are not supplied and there is no associated narrative, but assuming the Y-axis is in feet not meters, bed elevation is changing between four and six feet. Since coho salmon and steelhead redds are generally less than two feet deep (Groot and Margolis, 1991), the cross section data indicates that eggs and alevin in lower Dry Creek would be scoured with the bed and washed downstream or buried so deeply that they would not likely emerge.

Fine Sediment in Spawning Gravels: Small sediment particles less than 0.85 mm are known to infiltrate salmon and steelhead nests, which are excavated in the stream bed gravels, greatly decreasing survival due to smothering of the eggs (McNeil and Ahnell, 1964). McHenry et al. (1994) found that, when fine sediment (<0.85 mm) comprised 13% or greater of the substrate inside redds, it caused the mortality of steelhead and coho salmon eggs. The Gualala River TMDL (CSWRCB, 2001) set 14% as a target for fine sediment in accordance with this knowledge of potential harm to salmonid spawning. Gualala Redwoods Inc. collected fine sediment data in North Fork Gualala River tributaries from 1992 to 1997 at a time when the watershed was undergoing rapid timber harvest and a substantial increase in its road network (see CWE discussions below). Gravel grab samples showed a sharp increase in fine sediment less than 0.85 mm (Figure 9), from 10-12% of the stream bed to as high as 28% in the Little North Fork. McGann Gulch had levels of fine sediment indicative of impairment ranging from 19-26%, indicating waves of fine sediment in transport. Data is only supplied for one reach within Dry Creek (CS #211) and values show moderate impairment (15-17%) in all years except 1997, when fine sediment decreased to 12%. Although sorting after the January 1997 storm created conditions with low fine sediment in Dry Creek at CS 211, GRI quit providing this data so longer term trends are unknown.

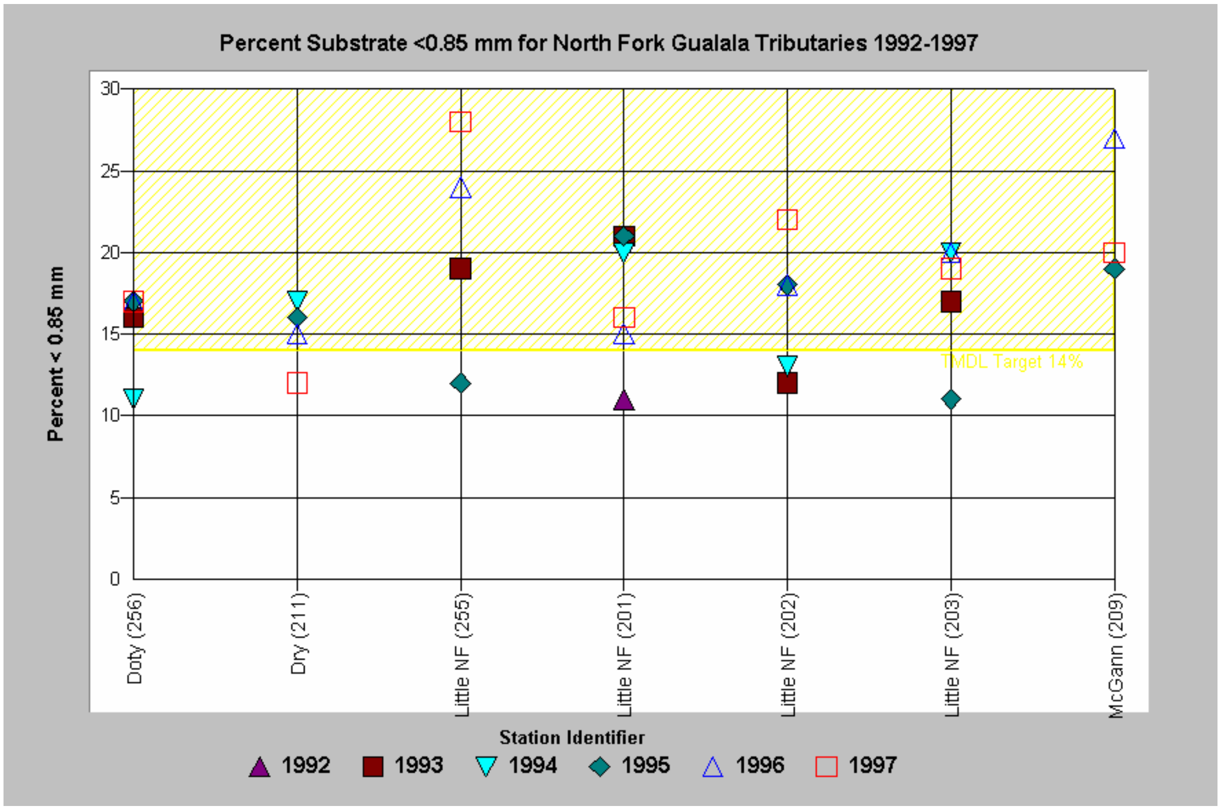

Figure 9. Fine sediment less than 0.85 mm exceeded levels recognized to be harmful to salmonid egg survival and the TMDL recognized threshold of 14% in Doty and Dry creeks, McGann Gulch and the Little North Fork Gualala River, with mostly increasing trends during the period of record. Data from Gualala Redwoods, Inc and chart from KRIS Gualala.

Water Temperature and Riparian Conditions The North Fork Gualala River is recognized as sediment impaired (NCRWQCB, 2005), but it is also temperature impaired with regard to its ability to support coho salmon juvenile rearing. Stream channel aggradation in the North Fork Gualala and its tributaries has increased width and decreased depth, which leads to increased heat exchange with the atmosphere and contributes to temperature pollution (Poole and Berman, 2000). Logging of riparian zones also has contributed to lack of stream shade and stream warming in the North Fork Gualala River basin. Extremely high bedload movement or increased flood flows related to watershed disturbance may cause scour of stream channels and loss of riparian vegetation (Montgomery and Dietrich, 1993), which contributes to stream warming. Studies are needed to assess the degree to which channel scour contributes to thermal pollution in the Dry Creek watershed.

<u>Temperature</u>: Coho juveniles are only found in northwestern California streams where the maximum floating weekly average water temperature is less than 16.8 Celsius (C) (Welsh et al., 2001; Hines and Ambrose, 1998). Optimal growth for steelhead also occurs in this range (Sullivan et al., 2001). The mainstem North Fork Gualala River harbored coho salmon (Park and Pool, 1964) and; therefore, once met this criterion. Temperature data collected as part of the NCWAP Gualala River watershed assessment (CA RA, 2003) and by GRI for the North Fork Gualala and tributaries (Figure 10) shows conditions too warm to support coho salmon in the mainstem and lower Dry Creek. Although the *Option 10 Plan* (CR LLC, 2006) and THP 1-04-260 MEN recognize appropriate values for optimal temperatures for coho salmon, they fail to properly characterize available water temperature data. Robinson Creek, McGann Gulch and the Little North Fork in the adjacent Calwater are cool enough to support coho, but too aggraded to provide habitat.

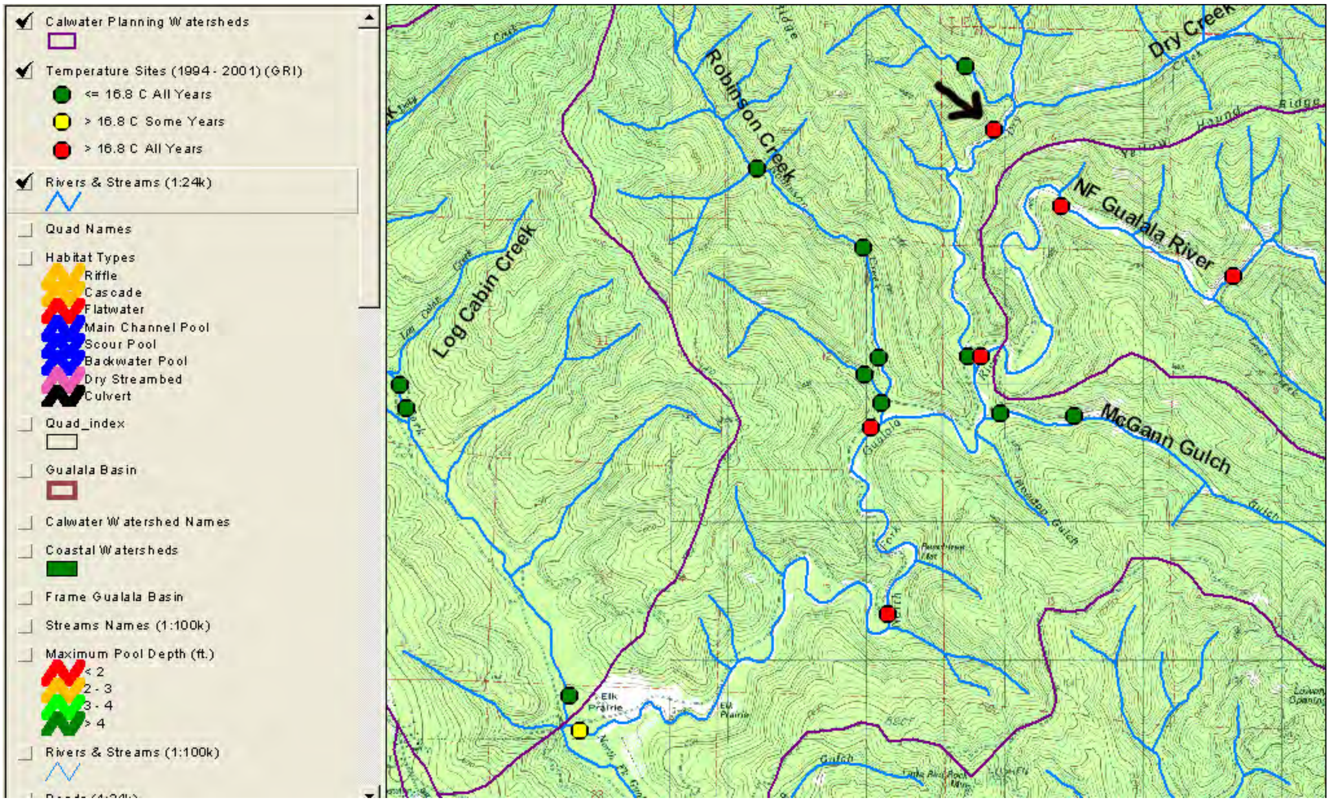

Figure 10. Water temperatures within North Fork Gualala River tributaries are generally cool enough to support coho salmon juveniles, but the mainstem is too warm for them. An exception is the middle reach of Dry Creek (black arrow), where temperatures exceeded habitable for coho. Data from CARA (2003) and map from KRIS Gualala Map Project.

The U.S. EPA (2003) points out that well distributed cool water sources must be maintained when larger rivers to which they are tributary are out of the normal range of variability with regard to temperature and likely to remain so for at least a decade. Land use with the potential to elevate tributary water temperatures should not be allowed until the North Fork Gualala River temperatures regimes are once again capable of supporting coho salmon. Brosofske et al. (1999) note that timber harvest in the riparian zones of headwater streams can affect ground water temperature, which in turn affects the temperature of surface flows.

Riparian Conditions: CDFG (2004) recognizes 80% shade canopy as optimal for preventing direct exposure of streams to sunlight and maintaining cool water temperatures for salmonids. A functional riparian zone, however, extends further from the stream and has several other important functions, such as large wood supply and as a buffer to sediment input from inner gorge landslides. Spence et al. (1996) recognized the distance equal to the potential height of riparian trees (one site potential tree height) as a minimum buffer for Pacific salmon streams. FEMAT (1993) extended that zone of influence to two site potential tree heights or to the top of any inner gorge areas on federal forest lands. Riparian conditions in these comments are also assessed using Landsat-based vegetation type and tree size within 90 meters of streams (Warbington et al., 1998) and change scene detection (Fischer, 2003) that uses 1994 and 1998 Landsat images to discern where riparian logging may have occurred.

NCWAP habitat typing (CA RA, 2003) measured stream canopy of North Fork Gualala River tributaries and Dry Creek reaches had only 60-70% canopy closure (Figure 11). Prior to disturbance the Dry Creek watershed would have had a canopy of almost all giant redwoods, but currently only about 30-35% of shade is provided by conifers. This exemplifies profound riparian alteration as a result of stream side logging and possibly episodes of stream channel scour.

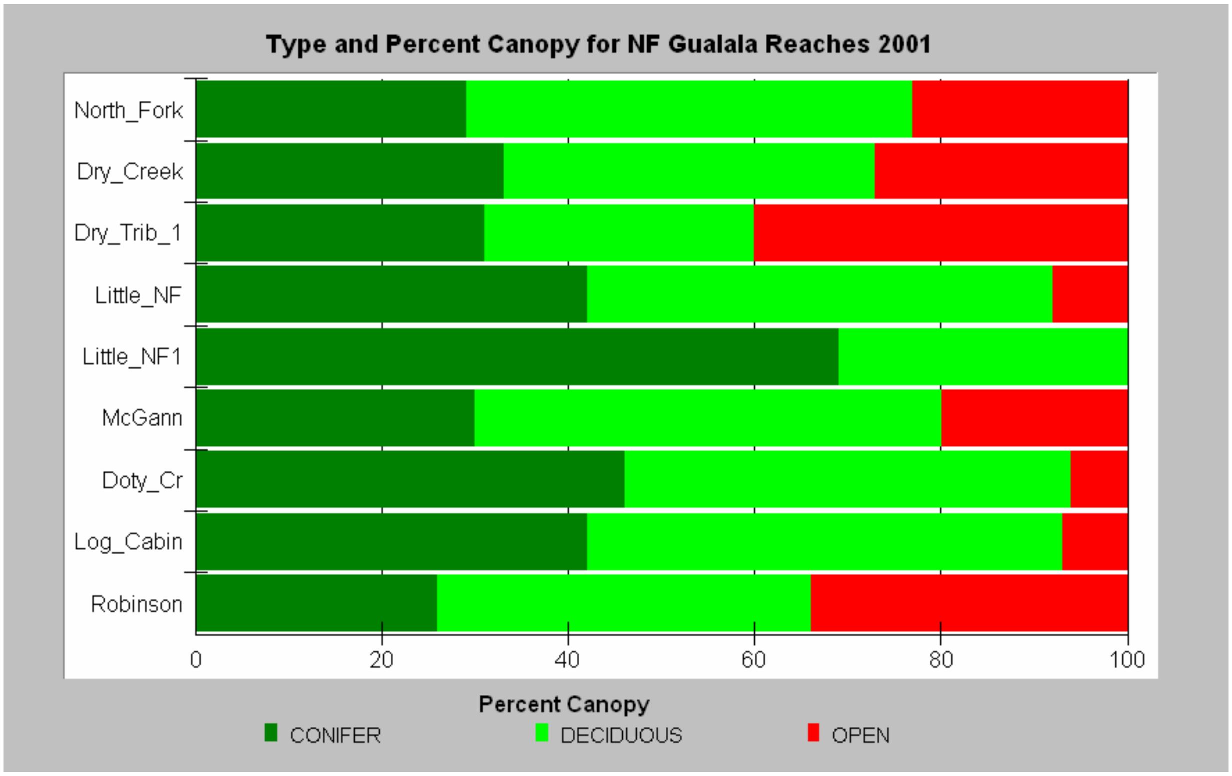

Figure 11. Canopy conditions for the North Fork Gualala shows that Dry Creek's canopy is in early seral conditions with 25-40% of the channel length lacking shade and only 25-35% comprised of coniferous trees. Data from CA RA (2003). Chart from KRIS Gualala.

Vegetation type and tree diameter data based on 1994 Landsat imagery (Warbington et al., 1998) was used to analyze the seral stage of forests within 90 meters of either side of North Fork Gualala River tributaries. The 90 meter (292.5 ft.) distance is a conservative approximation of two site potential tree heights in this redwood ecosystem where individual trees may have approached 300 ft. The one hectare resolution of Landsat imagery may miss individual large trees, but these data provide a good reconnaissance tool for understanding the seral stage of the upper North Fork Dry Creek riparian zone.

Results from the Robinson Creek Calwater Planning watershed show that there are almost no trees over 40" in diameter at breast height (dbh), approximately 1% of trees are 30-40" dbh and that more than 51% of trees are less than 20" in diameter (Figure 12). The largest component of riparian trees are between 20-30", which is still early seral conditions given the original site potential of several feet in diameter in the coastal redwood belt. These same data are displayed in map form as Figure 9 and show that the upper North Fork tributary within THP 1-04-260 MEN is similar to those in the Robinson Creek Calwater. Larger trees seem to predominate on the south side of streams, likely reflecting a bias for their protection during THP reviews to maintain stream shade. This pattern of harvest, however, has allowed long-term depletion of the near stream large wood supply.

CDF (Fischer, 2003) also supplies data that use 1994 and 1998 Landsat images to compare landscape conditions. Figure 13 shows the headwaters of the upper North Fork Dry Creek and surrounding streams within the upper Robinson Creek Calwater. Substantial riparian canopy decrease between 1994-1998 is evident in lower Dry Creek and tributaries adjacent to the proposed THP.

Small diameter trees may also be associated with alder dominated riparian zones (Figure 14). "Dry Creek, Robinson Creek, the central and higher reaches of the NF Gualala, the lower reaches of Bear and Stewart Creeks are high priorities for riparian restoration" (CA RA, 2003).

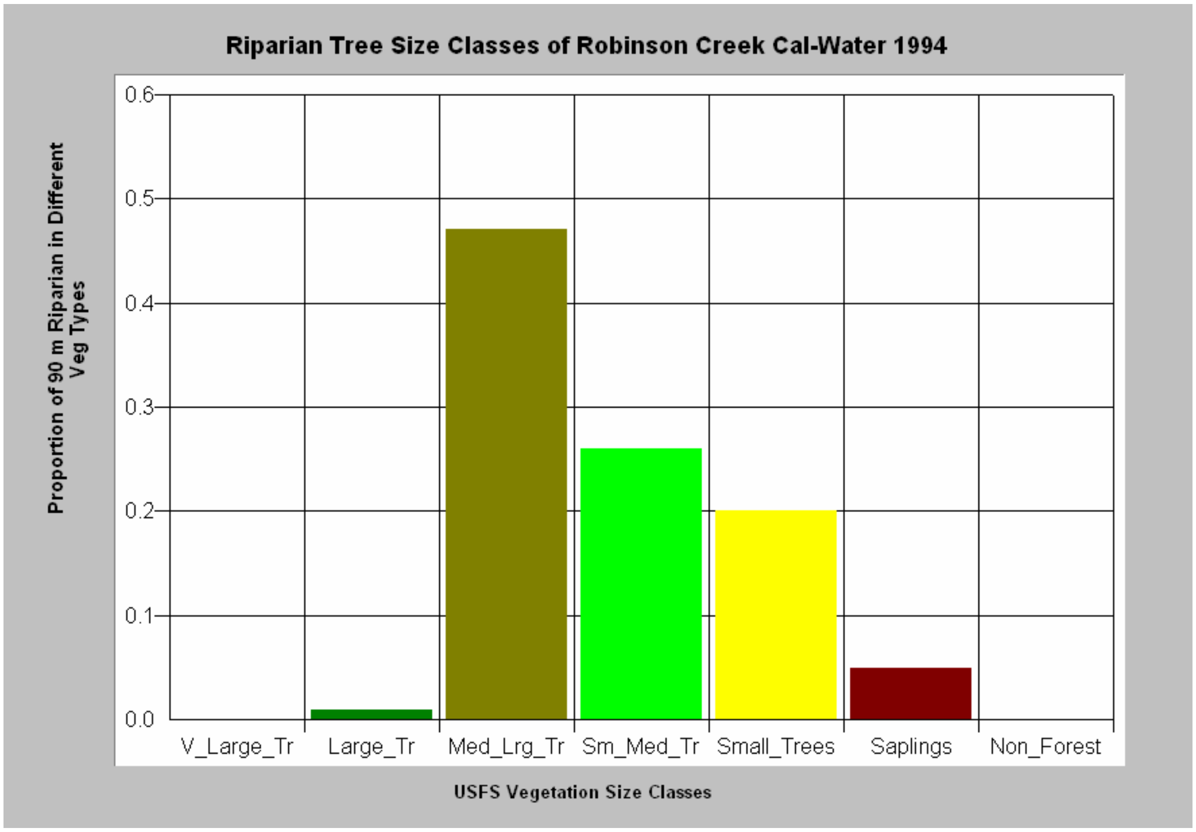

Figure 12. This bar chart shows vegetation and timber types of the riparian zone of the Robinson Creek Calwater planning watershed with no large or very large trees and 51% below 20" dbh. Data from CDF and chart from KRIS Gualala.

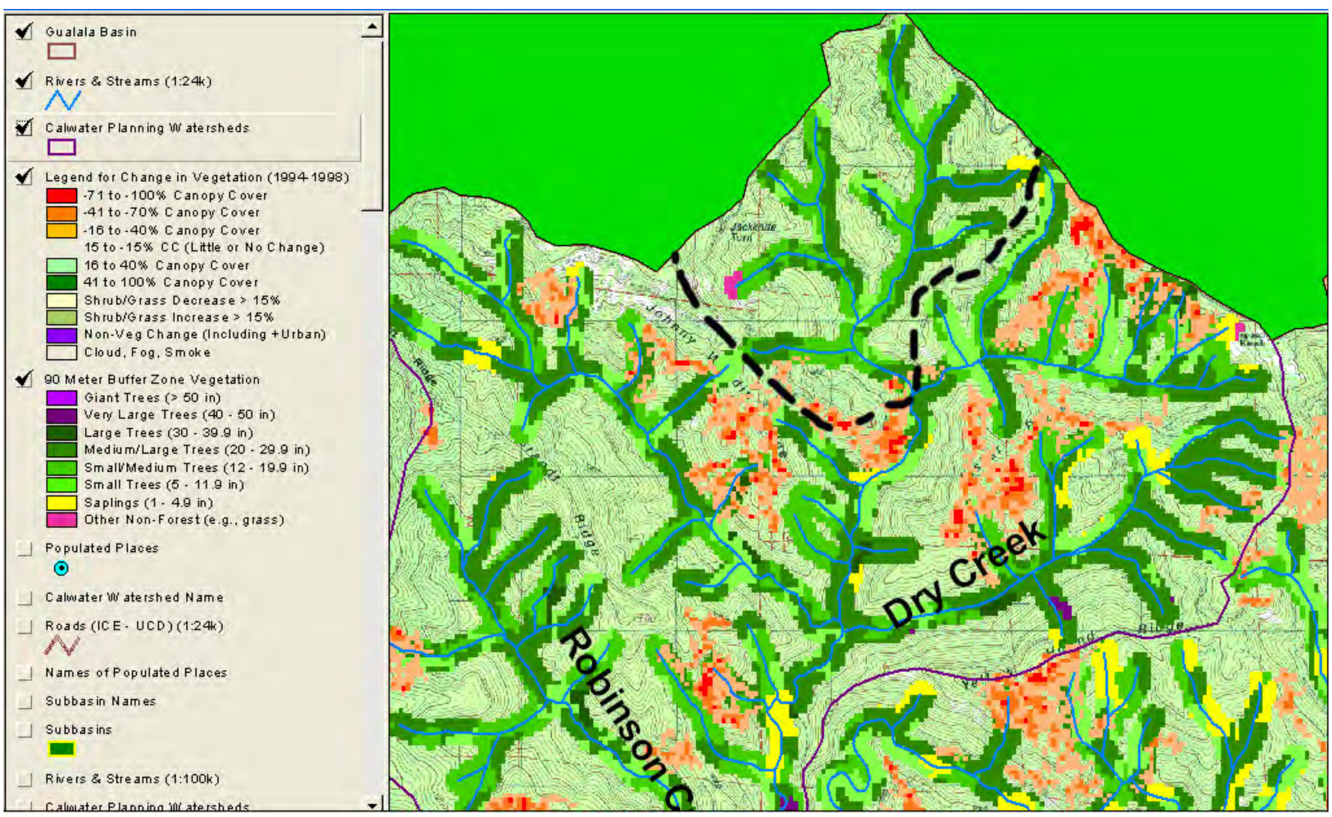

Figure 13. The riparian zone within 90 meters of Dry Creek shows very few mature conifers (>40" dbh) and only about half the trees of greater than 20" dbh. Change scene detection indicates that extensive logging took place within 90 m of streams and in adjacent areas between 1994-1998.

Figure 14. The photo at left shows the channel of the North Fork Gualala River just upstream of its convergence with the Little North Fork. The stream channel shows major signs of excess bedload with no pools in sight and smaller median particle size characteristic of aggraded streams. The riparian zone provides good cover for the stream, but is comprised of mostly alders, which do not provide long lasting habitat forming elements when contributed to streams. Photo by Dave Hope, NCRWQCB from KRIS Gualala (www.krisweb.com).

Large Wood in Streams and Potential for Recruitment

Large trees which fall into coastal streams play a dominant role in forming pools, metering sediment, trapping spawning gravels and creating a more complex stream environment. Redwoods are particularly valuable because a large tree may not decay for several hundred years (Kelly et al., 1995). Fir and spruce trees last for several decades while alder and hardwood species rot within a few years of being recruited into the stream (Cedarholm et al., 1997). The NCWAP watershed assessment (CA RA, 2003) did an inventory of large woody debris (LWD) and concluded that large wood in streams is deficient in most areas of the North Fork Gualala River basin. THP 1-04-260 MEN made the following observation regarding large wood in Dry Creek and potential recruitment:

> "Overall, LWD is lacking within the sections of Dry Creek this THP encompasses. Large events wash what little is in the creek downstream, and, little LWD enters the system, as there are not a lot of large trees along the streamside."

Elsewhere in THP 1-04-260 MEN the lower mainstem of Dry Creek is described with observations on LWD availability:

> "It appears that much of the large woody debris was removed or washed out following the original logging. Because there is a lot of rock that is not easily mobilized and a lack of large woody debris to help form plunge pools, it will take a long time for Dry Creek to develop much structure in the way of large or even medium sized pools."

Map images presented above show considerable evidence of riparian harvest in the North Fork Gualala River basin as recently as 1998 that would substantially reduce large wood recruitment potential. Pacific Watershed Associates (1998) found that timber harvest on steep, unstable areas of Bear Creek in Humboldt County increased landsliding, but slides contained little large wood. Sediment from debris torrents, instead of being caught up behind numerous large wood jams, had a runout distance that extended all the way to the conjunction of Bear Creek and the Eel River.

California Department of Fish and Game (2006) comments on THP 1-04-260 MEN stress the importance of headwater tributaries as sources of sediment and large wood:

> "Steep, intermittent streams store sediment and wood and are sources of these materials to permanently flowing streams (Benda et al., 2005). Therefore, protection of intermittent streams and their origins such as bedrock hollows and swales is important for providing habitat for

> species unique to small stream riparian areas, and maintaining the landslide- and flood-derived supplies of large woody material throughout the landscape."

The depauperate condition of riparian zones in the North Fork Gualala River due to recent logging has caused a gap in large wood availability that will take 50-100 years to recover (Bisson et al., 1987). No activity that decreases large wood recruitment should be allowed at this time. Coastal Ridges *Option 10 Plan* needs to address the issue of large wood supply in Dry Creek and in the North Fork Gualala River basin.

Upland Conditions: Risk of Degradation of Aquatic Habitat

The Coastal Ridges (2006) *Option 10 Plan* does not acknowledge the major problems in the Gualala River sediment supply as described in the Gualala River TMDL (CSWRCB, 2001) nor potential contributions of THP 1-04-260 MEN to existing problems:

> "Natural sediment yield accounts for approximately 1/3 of the total sediment delivery in the Gualala watershed while human-caused sediment delivery accounts for 2/3 of the sediment delivery in the watershed, or 200% of the natural load. The analysis shows that road-related processes are the dominant source of sediment delivery in the watershed."

THP 1-04-260 MEN tries to ascribe most sediment contributions to "natural" events and post WW II logging. In fact the relationship of land use activity and the corollary tributary impairment are similar to patterns in other scientific study results in northwestern California and throughout the Pacific Northwest.

<u>Timber Harvest:</u> Ligon et al. (1999) and Dunne et al. (2001) recognized that a critical shortcoming of the California Forest Practice Rules (CFPR) was the lack of prudent limit or threshold for timber harvest to avoid cumulative watershed effects. Reeves et al. (1992) studied eight Oregon Coastal basins that were less than 25% timber harvested and compared them to adjacent watersheds with greater harvest levels. They found that streams draining watersheds cut in over 25% of their area within a 30 year period were usually dominated by one Pacific salmon species, while basins with less disturbance maintained several species. Reeves et al. (1992) traced the root cause to channel simplification associated with pool filling and large wood depletion.

The NCWAP watershed assessment (CA RA, 2001) used timber harvest data from 1991-2001 provided by CDF. Figure 15 shows the percent area of Gualala Basin Calwater Planning Watersheds permitted for timber harvests and the extent of cumulative effects can be gauged using the reference line based on Reeves et al. (1993). Basins with very high timber harvest permitting are Red Rock Creek (79%), Lower Rockpile (56%), Stewart Creek (52%), Big Pepperwood (47%), Robinson Creek (42%) and Doty Creek (41%). Values are sums without subtraction for overlapping THPs. As in the case of THP 1-04-260 THP, not all those listed have been harvested. However, Figure 1 shows that some areas not scheduled for harvest according to CDF THP data had substantial reduction in canopy between 1994 and 1998, when examined using CDF (Fischer, 2003) interpreted Landsat imagery. The combined THP and change scene data (Figure 16) make it appear that approximately 50% of the Dry Creek basin proper has been harvest since 1991, well over the prudent risk threshold for cumulative effects described by Reeves et al. (1993).

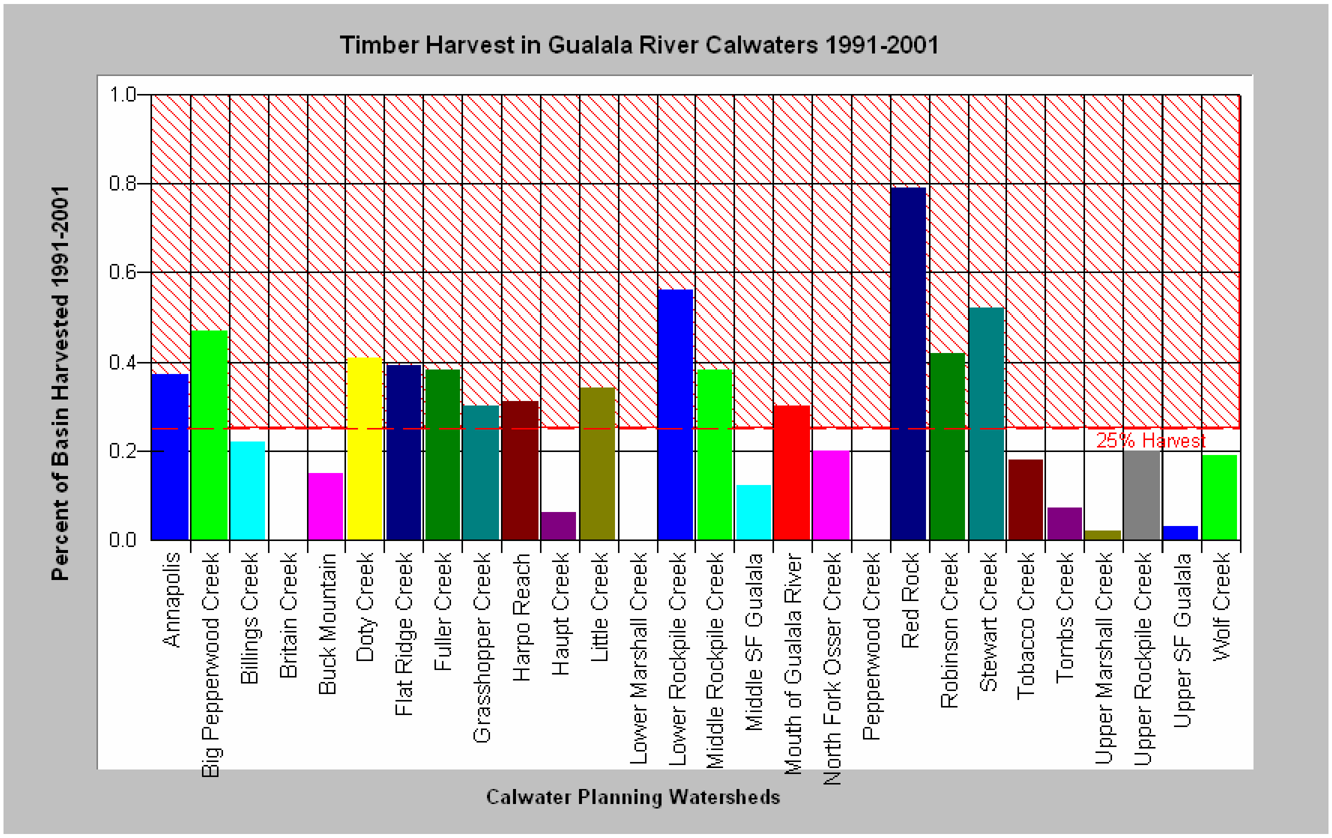

Figure 15. Timber harvests in Gualala River sub-basins according to CDF data. Reference standard of 25% harvest is based on Reeves et al. (1993). Chart from KRIS Gualala.

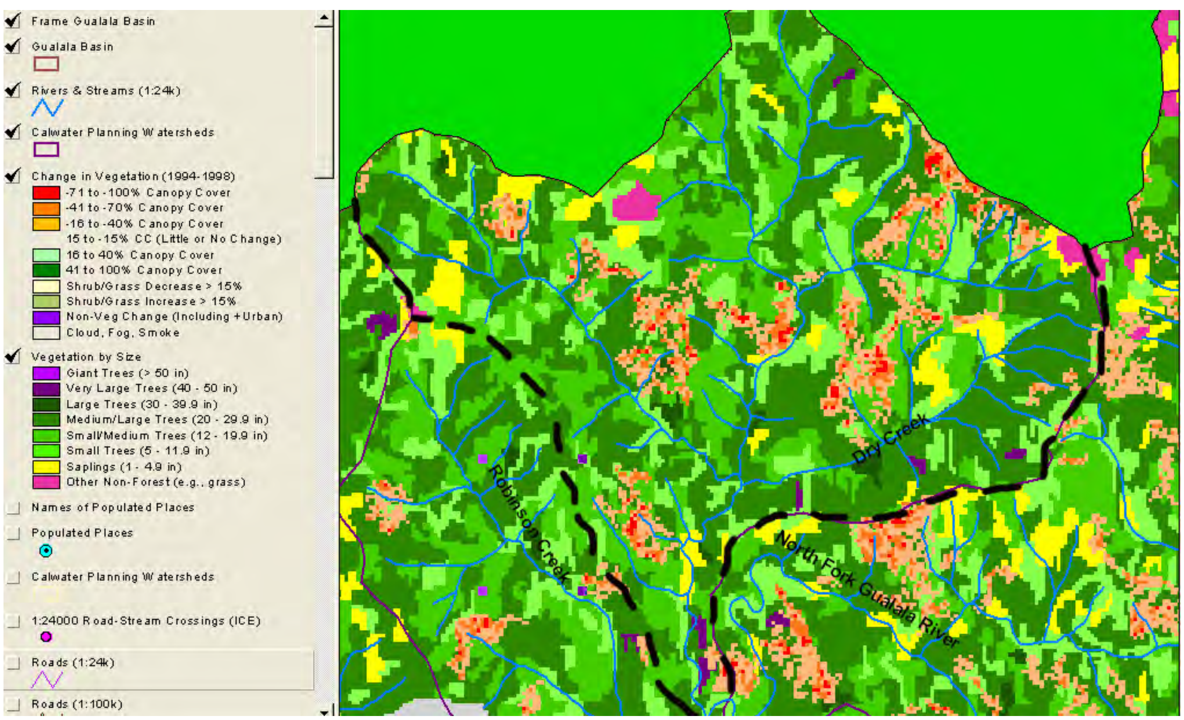

Figure 16. This map image shows Landsat-derived vegetation type and tree size displayed with 1994-1998 change scene detection, also based on Landsat images. These show that the Dry Creek watershed overall (black outline) is 30-40% small trees characteristic of early seral conditions due to logging within the 30 years prior or recently disturbed according to Landsat change scene data. Data from the USFS Spatial Analysis Lab, Sacramento, CA and CDF. From KRIS Gualala Map Project.

Changes in Peak Flow: Leopold and McBain (1995) noted that wide spread compaction related to timber harvest in the Garcia River basin elevated winter runoff. Spence et al. (1996) cited studies by McCammon (1993) and Satterland and Adams (1992) showing increased peak flows resulting from alteration of 15-30% of a watershed's vegetation and concluded "that no more than 15-20% of a watershed should be in a hydrologically immature state at any given time." USFS Landsat derived vegetation data in combination with change scene detection for the whole Dry Creek watershed (Figure 16) shows a predominance of trees less than 20" dbh and extensive areas of decreased canopy from 1994-1998. Early seral stage trees and decreased canopy are indicative of recent timber harvests and represent a level of disturbance of at least 30-40% over approximately the last 30 years. The Dry Creek watershed is, therefore, at very high risk of increased peak flows and THP 1-04-260 MEN would add to this risk.

Kamman (2003) noted the importance of infiltration in wild land hydrology and ground water recharge. Head water springs may be an important source of water during low flows of summer. THP 1-04-260 MEN mentions many locations where roads intercept spring sources. Activities around headwater springs with heavy equipment are likely to disrupt groundwater recharge and natural connections between spring areas and streams below. Cold water base flows in summer are critical to the maintenance of steelhead trout and their further disruption will make the eventual recovery of coho salmon less likely.

Road Densities, Near-Stream Roads and Road Stream Crossings: The NCWAP watershed assessment (CA RA, 2003) noted that the North Fork Gualala River watershed had the highest road density in the Gualala River Basin. The Gualala River TMDL (CSWRCB, 2001) found that sediment contribution from roads in the North Fork Gualala were the highest in the Gualala watershed (Figure 17). Roads can contribute sediment through chronic surface erosion, but mass wasting triggered by roads is a much greater source. Hagans et al. (1986) estimated that 50 to 80% of the sediment that enters northwestern California streams stems from road-related erosion. THP 1-04-260 MEN and Coastal Ridges (2006) *Option 10 Plan* do not deal credibly with road related cumulative effects potential, with no mention of prudent risk limits on road density to maintain hydrologic integrity.

Cedarholm et. al. (1981) found that road densities greater 4.2 miles of road per square mile (mi^2) of watershed yielded sediment levels 260% to 430% higher and increased fine sediment in salmon spawning gravels by 2.6 - 4.3 times over background levels. U.S. Forest Service (1996) studies in the interior Columbia River basin found that bull trout were not found in basins with road densities greater than 1.7 mi/mi^2. They ranked risk road density of greater than 4.7 mi/mi^2 as extremely high (Figure 18). National Marine Fisheries Service (1996) guidelines for salmon habitat characterize watersheds with road densities greater than 3 mi/mi^2 as "not properly functioning" while "properly functioning condition" was defined as less than or equal to 2 mi/mi^2 with no or few stream aide roads.

Road density in the Robinson Creek Calwater is 6.45 mi/mi^2 (Figure 19) and adjacent sub-basins have even greater cumulative effects risk with 7.08 and 7.7 mi/mi^2 in the Stewart Creek and Doty Creek Calwaters, respectively. The road densities estimates are conservative because electronic road maps on which they are based do not include temporary roads, abandoned roads, skid roads or landings.

Jones and Grant (1996) point out that watershed hydrology can recovery rather quickly from timber effects, but that hydrologic perturbations from road networks can persist for decades. They point out that interception of ground water flows by roads causes increased peak discharge and lower groundwater recharge. When 25% of the area of a watersheds under study was impacted by timber harvest and roads, flow increases of 50% resulted (Jones and Grant, 1996).

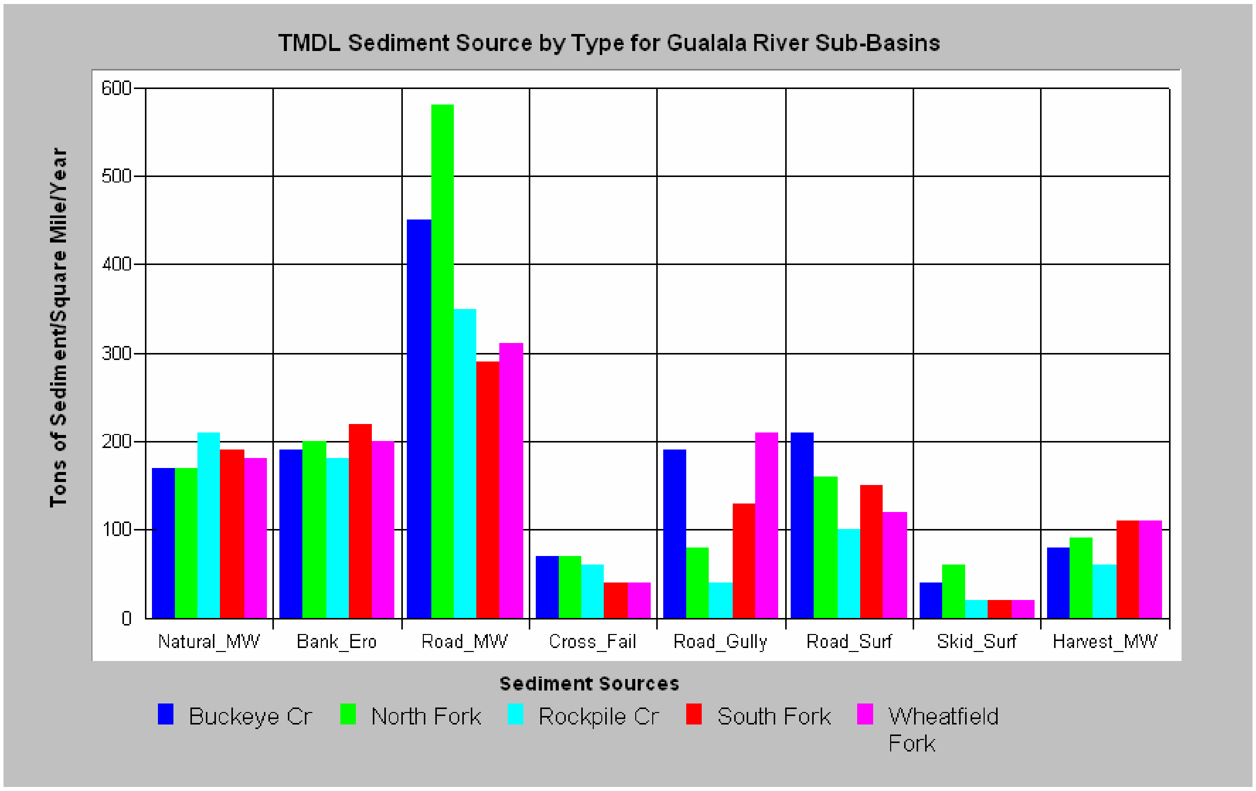

Figure 17. Gualala River TMDL estimates of sediment yield by source and sub-basin show that the North Fork Gualala has very high contributions related to roads. Data from CSWRCB (2001). Chart from KRIS Gualala.

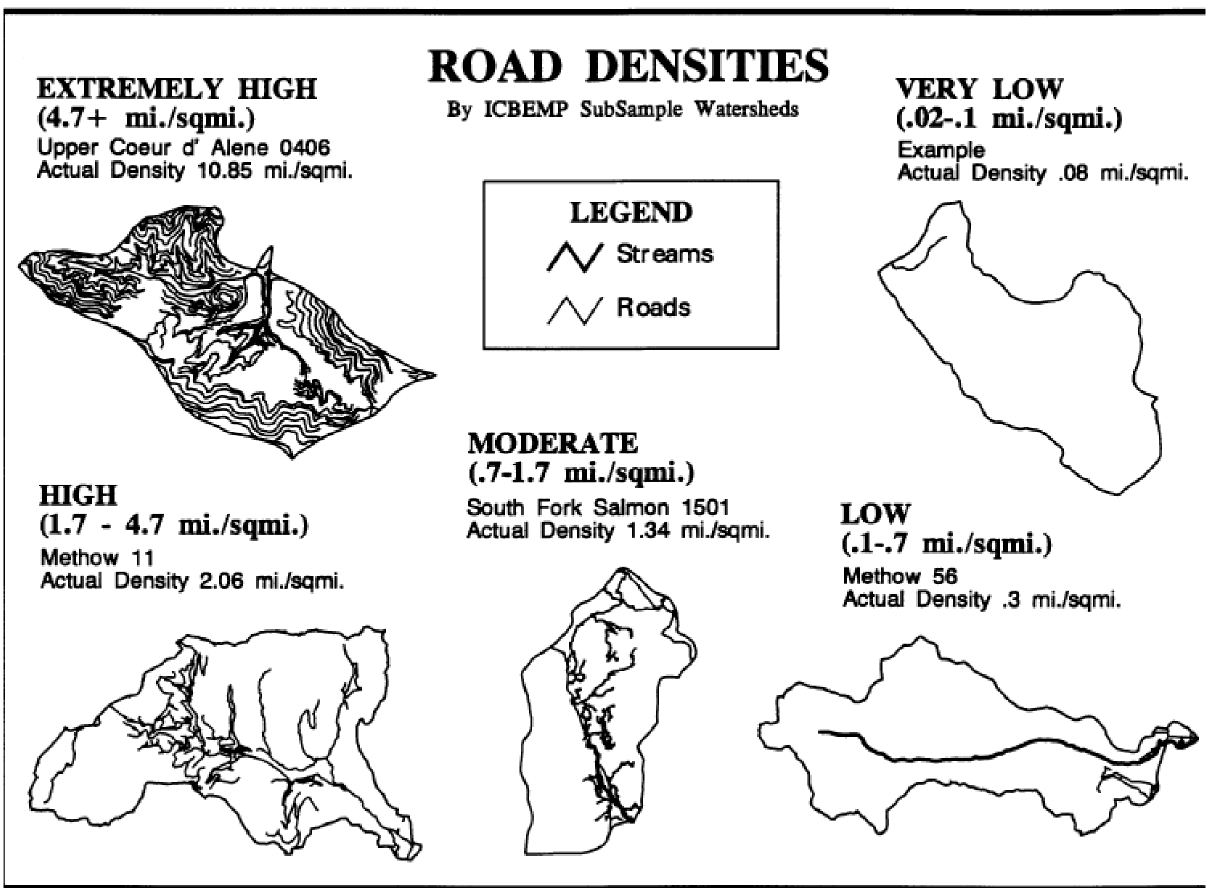

Figure 18. Road density categories from the USFS (1996) rating cumulative effects risk.

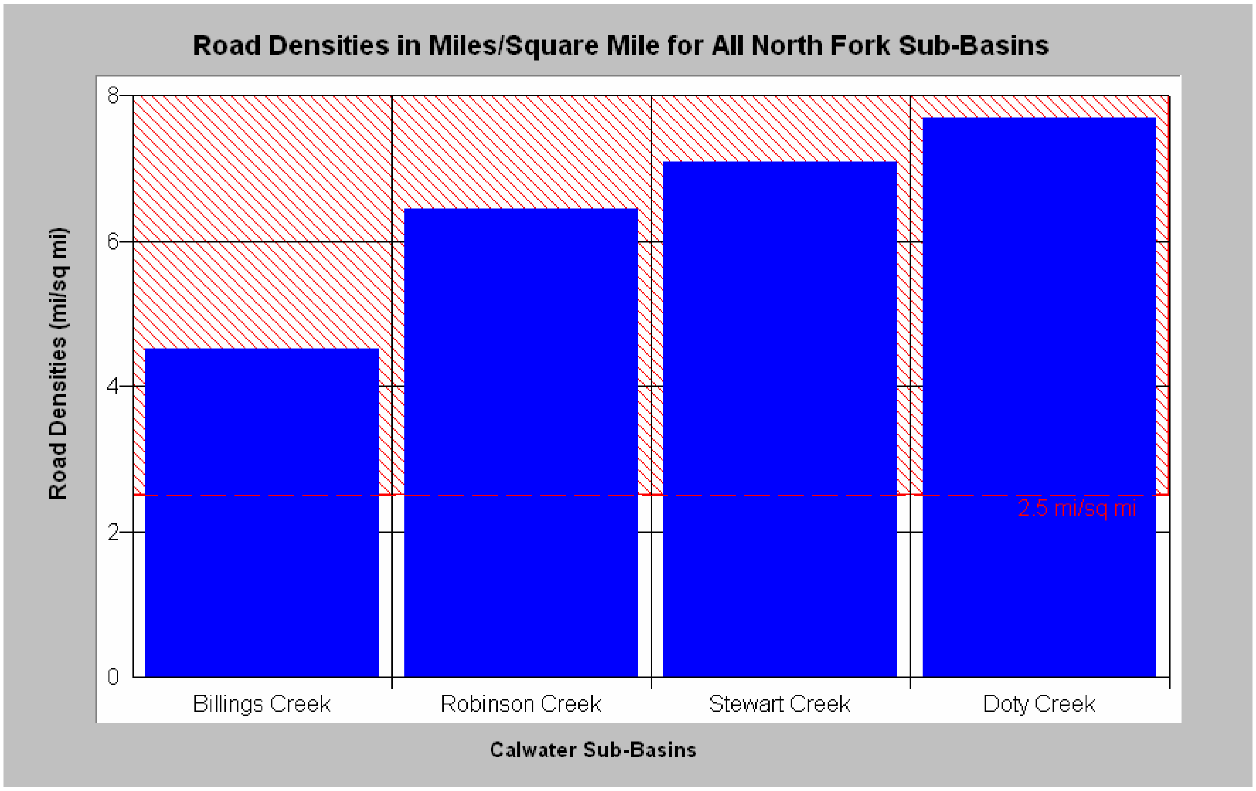

Figure 19. Road density on miles of road per square mile of watershed for the North Fork Gualala River basin showing that the Robinson Creek Calwater has over 6 mi/mi^2 of roads. Reference from NMFS (1996), data from CDF, and chart from KRIS Gualala.

Roads constructed near streams or that cross streams pose the greatest risk of sediment yield and Armentrout et al. (1999) recommended less than 2 stream crossings per mile to limit cumulative effects risk from multiple crossing failures. Both U.S. Geologic Survey 1:24000 hydrology and roads based on data from CDF are under-representative; therefore, road stream crossings estimates are very conservative. Figure 20 shows road-stream crossings and roads within the upper Dry Creek watershed proposed for harvest in THP 1-04-260 MEN. A shallow landslide stability model (Dietrich et al., 1998) map was created by IFR (2003) to assist in the NCWAP watershed assessment and landscape stability is discussed further below. Depressions in the landscape as shown as high risk zones sometimes have streams on USGS 1:24000 topo maps, but it is likely that Class II streams are unmapped but present in these locations. This is an indication of under-representation of stream crossings as well.

The description of mitigations needed at over 30 crossings in THP 1-04-260 MEN includes comments indicative of significant erosion and hydrologic disruption from the existing road system:

- The outlet has back cut some.
- The outside of the road has developed a nick point.
- Existing seasonal road crosses bank seep…..From the end of the down spout where the water hits below, there is a drop of six feet.
- The pipe was poorly installed and is a shotgun pipe with a downspout hanging off the end of the pipe. Replace with 60 feet of 30 inch pipe and install at channel grade.
- Dig a waterhole on the inside edge of the road that is 15 to 20 feet wide and 50-60 feet long. This may fill up with water because it appears there is a high water table in this area because of bank seepage and aquatic vegetation.

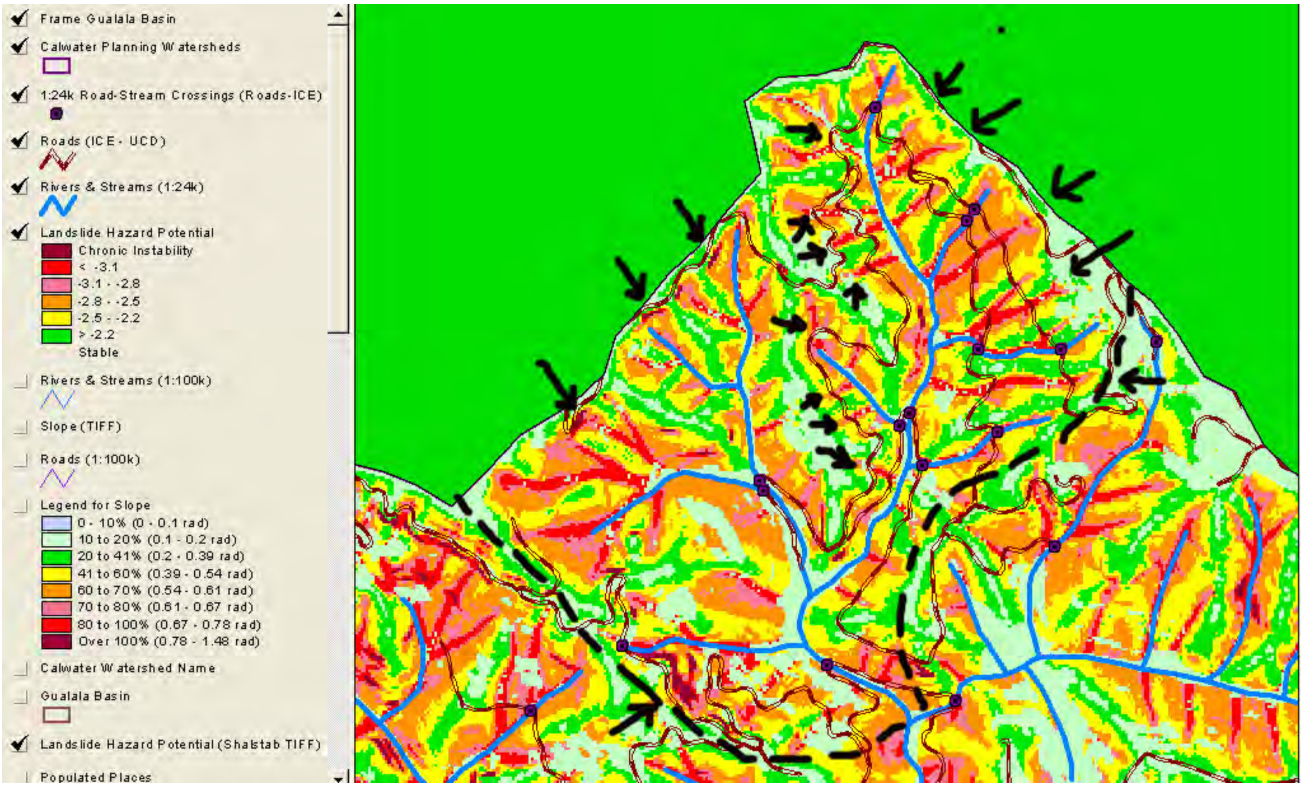

Figure 20. This map shows risk of shallow landslides, roads, and road-stream crossings in upper Dry Creek. Arrows indicate where roads cross high risk landslide zones. High risk zones are depressions often have mapped streams on 1:24000 USGS hydrology, but others do not. This suggests that streams are likely under-represented on USGS topos. Road data from CDF and SHALSTAB and crossing data by IFR. From KRIS Gualala Map Project.

- The gully cut by the diversion (through the landing) is an average of 15 feet deep and varies in width from 10 to 30 feet. It is approximately 100 feet long.
- New road cut off old road so a portion of the new road needs to be constructed leading into and out of a Class II watercourse.
- Water has flowed over the outside edge of the road and caused some fill to wash out."

The gully erosion and downcutting described above demonstrates considerable sediment yield from the existing road system. The roads are located at mid-slope and are significantly disrupting hydrology. In THP 1-04-260 MEN it states that "perennial springs protected per 916.3(d) which are identified and mapped will have a 25' Equipment Limitation Zone (ELZ) with 50% total canopy retention within the 50 feet." In fact the bullet points above demonstrate that roads have been constructed at major spring sources. The 60' long pipe described above is being used because spring flow was being captured by the road and diverted down the road bed. The suggested "waterhole" sounds like it could pose a high risk of a major torrent because its placement above the road could cause the prism to fail. Mid-slope roads in this watershed should be recontoured and abandoned, not re-activated as suggested in THP 1-04-260 MEN. All logging in this basin should be done from ridge top roads with full suspension cable operations.

Activities on Potentially Unstable Areas

The North Fork Gualala River watershed, including Robinson Creek Calwater and Dry Creek, has a major amount of steep, unstable terrain (CA RA, 2003; CSWRCB, 2001). The amount of sediment yield from timber harvest and road building can vary greatly depending on the geology and slope of the watershed area where activities take place (Dunne et al., 2001). USGS orthophotos can be used to do reconnaissance of watershed conditions in the third order tributary of upper Dry Creek to the east of the one affected by THP 1-04-260 MEN (Figure 21). The landscape is extremely steep (Figure 22) and, although road networks are not extensive, cable skid trails associated with mostly clear cut inner gorge slopes and headwalls are apparent. The SHALSTAB model (Dietrich et al., 1998) was used by the Institute for Fisheries Resources (2003) based on 10 meter digital electronic elevation data provided by CDF FRAP. SHALSTAB combines flow accumulation with slope steepness in a map that shows areas at high risk of slope failure as those with negative log rhythm values. Values from -2.8 to -3.1 represent high and very high risk and values less than -3.1 are areas of chronic instability. Although SHALSTAB cannot be used alone for regulation of timber harvest, it is a good screen for understanding cumulative effects risk. Figure 22 shows the same area as Figure 21 and patterns of disturbance associated with logging overlap substantially with SHALSTAB high risk zones.

The January 1997 storm caused 437 miles of stream channel scour on the Klamath National Forest (KNF) (de la Fuente and Elder, 1998) with many debris torrents triggered by road failure. Kier Associates (2005) found a high relationship between SHALSTAB high risk zones and subsequent slope failures in the lower Scott River watershed within the KNF: "A computer analysis showed that 80% (231 of 290) of active landslides intersect with 7% of the part of the landscape marked as very high in risk (log(qt)<-3.1)." The high degree of disturbance in the third order Dry Creek watershed adjacent to THP 1-04-260 MEN in the early 1990's is consistent with elevated sediment and water yield during December 1996 and January 1997. Unfortunately, the NCWAP watershed assessment (CA RA, 2003) failed to study relationships between disturbance of unstable areas, subsequent landsliding and effects on downstream channels so it provides no information on this hypothesis.

Figure 20 shows numerous associations of roads and high risk landslide areas within the THP 1-04-260 MEN. California Geologic Service (CGS) landslide risk maps made for the NCWAP watershed assessment (CA RA, 2003) show very high erosion potential for the area covered by the THP and operations are planned on slopes of 50-80%. THP 1-04-260 MEN mentions that timber harvest buffers above landslides may be as low as 20 feet and that logging on active slides will take place, if approved by a geologist. CGS (2006) did not address all the potential landslide risk areas shown in Figure 20 in its comments. The Coastal Ridges (2006) *Option 10 Plan* needs to discuss cumulative risk and damage of disturbance of steep slopes in the adjacent tributary of Dry Creek by previous THPs to meet requirements of CEQA.

<u>Existing Evidence of Advanced Cumulative Effects</u>: Dunne et al. (2001) describe cumulative effects potential as follows:

> "Generally speaking, the larger the proportion of the land surface that is disturbed at any time, and the larger the proportion of the land that is sensitive to severe disturbance, the larger is the downstream impact. These land-surface and channel changes can: increase runoff, degrade water quality, and alter channel and riparian conditions to make them less favorable for a large number of species that are valued by society. The impacts are typically most severe along channels immediately downstream of land surface disturbances and at the junctions of tributaries, where the effects of disturbances on many upstream sites can interact."

THP 1-04-260 MEN has a description of a major landslide just downstream of the convergence of the third order tributary where logging will take place and the one adjacent to the east:

> "There is a large somewhat active slide downstream near the center of Section 31 on the west side of the large tributary locally referred to as the North Fork Dry Creek. This slide is on an inner gorge slope with a fairly steep stream gradient below. The author first noticed the slide

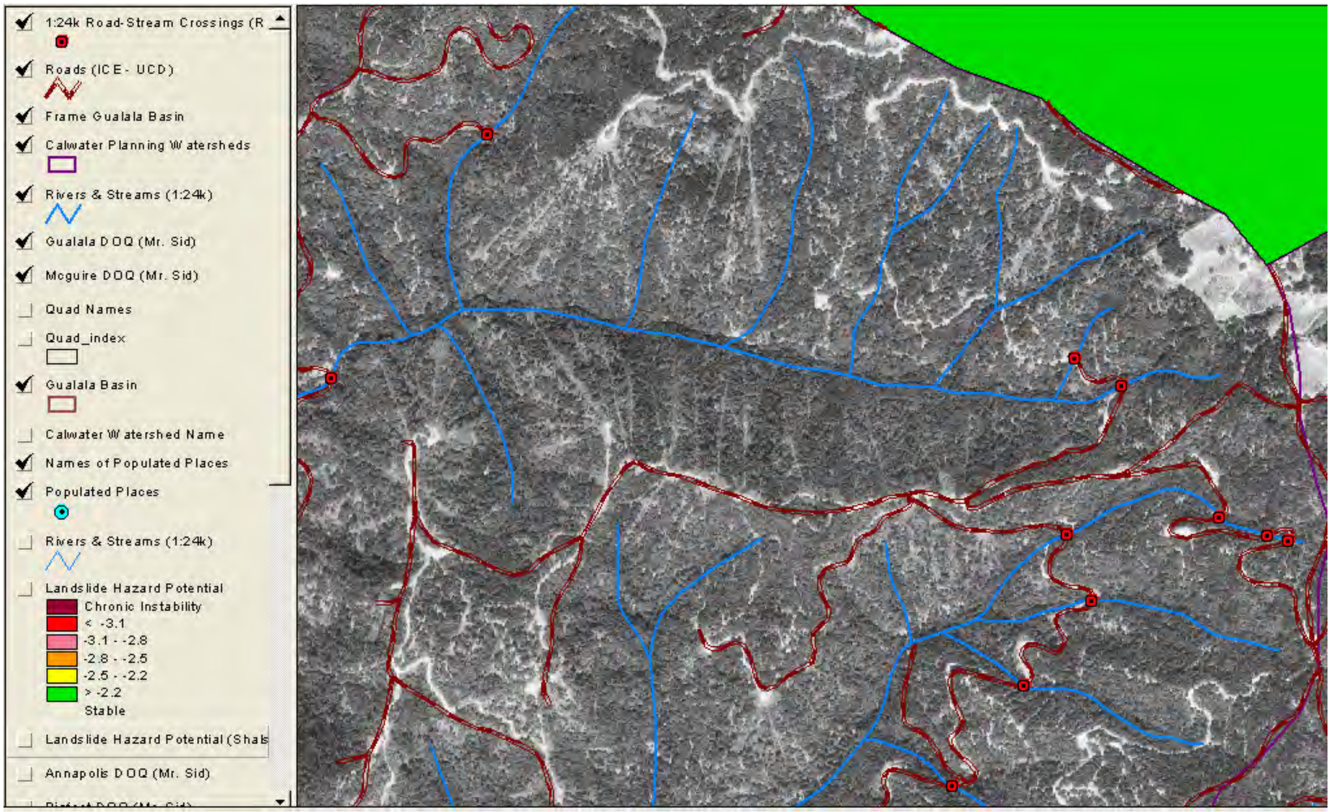

Figure 21. USGS 1996 orthophoto shows watershed conditions in the third order basin east of the one affected by THP 1-04-260 MEN, including roads, road-stream crossings and USGS 1:24000 streams. Note that many roads and skid trails are not included in electronic CDF road data.

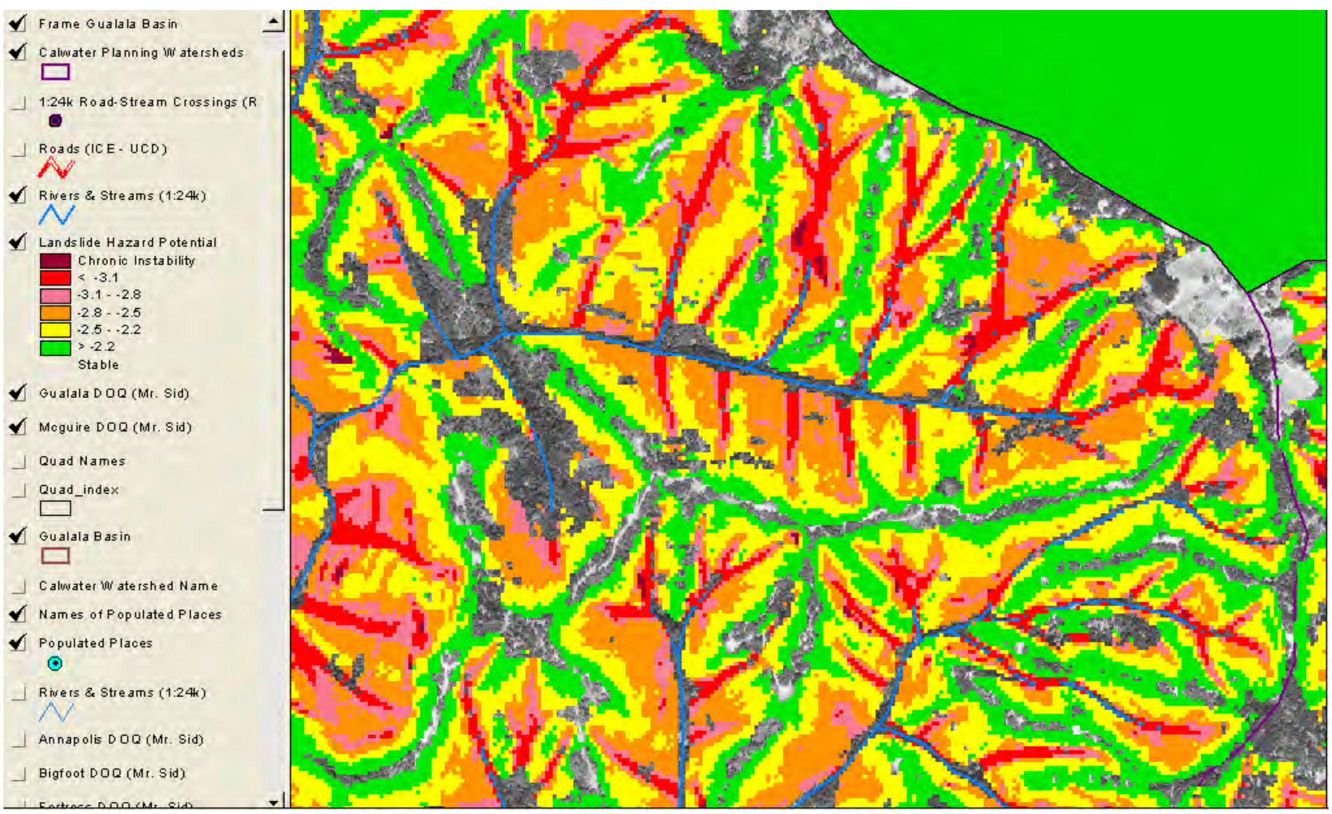

Figure 22. The SHALSTAB model run for the same geographic location as Figure 21 shows that many areas disturbed by logging and skid trails are high risk zones for shallow debris torrents. SHALSTAB by IFR based on 10m DEM from CDF. KRIS Gualala Map project.

> after heavy rains in 1996. The majority of the fines that entered the watercourse from this slide appear to have washed downstream. Short term sediment input is still expected from the slide."

The slide location is just below the tributary junction where Dunne et al. (2001) predict cumulative effects would occur. THP 1-04-260 MEN does not mention any other land use adjacent to or on the area of the landslide, but change scene detection indicates recent timber harvesting on inner gorge slopes near the center of Section 31 (Figure 23). Similarly, the SHALSTAB model for this location shows high risk in the area of timber harvest and also shows a road leading across the top of the high-risk zones in the inner gorge of Dry Creek (Figure 24). THP 1-04-260 MEN claims that landslides are due to natural geologic processes, but a more thorough analysis is needed in the Coastal Ridges (2006) *Option 10 Plan* to meet CEQA requirements on this issue.

Fish Status/Trends and THP1-04-260 MEN

THP 1-04-260 MEN states that "there are 75 miles of silver salmon habitat and 178 miles of steelhead habitat" in the Gualala River watershed and specifically recognizes that coho salmon were present in the North Fork Gualala River in the 1960's according to CDFG surveys (Parker and Pool, 1964). THP 1-04-260 MEN states that the North Fork Gualala River, Robinson Creek, Dry Creek, McGann Gulch, and Hoodoo Gulch in the vicinity of the THP "are low gradient storage reaches that provide spawning habitat for salmonids. Upslope they are fed by high gradient Class II and III water courses that provide the majority of sediment in the system." In fact habitat data from CDFG (CA RA, 2003) shows that low gradient reaches of tributaries of the North Fork Gualala River are unsuitable for coho spawning and rearing because the stream bed is highly unstable and surface flow is lost during summer and early fall.

The true status and habitat requirements of coho salmon and steelhead in the Gualala River are ignored by THP 1-04-260 MEN and Coastal Ridges' *Option 10 Plan*, with neither mentioning recent coho status reviews from the California Department of Fish and Game (2002) and the National Marine Fisheries Service (2001). CDFG (2002) acknowledges that coho in the Gualala basin are "extirpated or nearly so." THP 1-04-260 MEN relies on old Gualala Redwoods THP fisheries sections that make their status within the North Fork Gualala River watershed unclear.

Rieman et al. (1993) characterize a salmonid population as at moderate risk of extinction when:

> "Fine sediments, stream temperatures, or the availability of suitable habitats have been altered and will not recover to pre-disturbance conditions within one generation (5 years). Survival or growth rates have been reduced from those in undisturbed habitats. The population is reduced in size but no long-term trend in abundance exists."

The conditions described above fairly characterize the Gualala River and its steelhead population, while the coho population would merit a high risk classification according to Rieman et al. (1993) criteria:

> "Frequent flood or drought producing highly variable and unpredictable flows, scour events, debris torrents, or high probability of catastrophic fire through a major part of the watershed. Channel simplified providing little hydraulic complexity. Population survival and recruitment respond sharply to annual environmental events. Year class failures common."

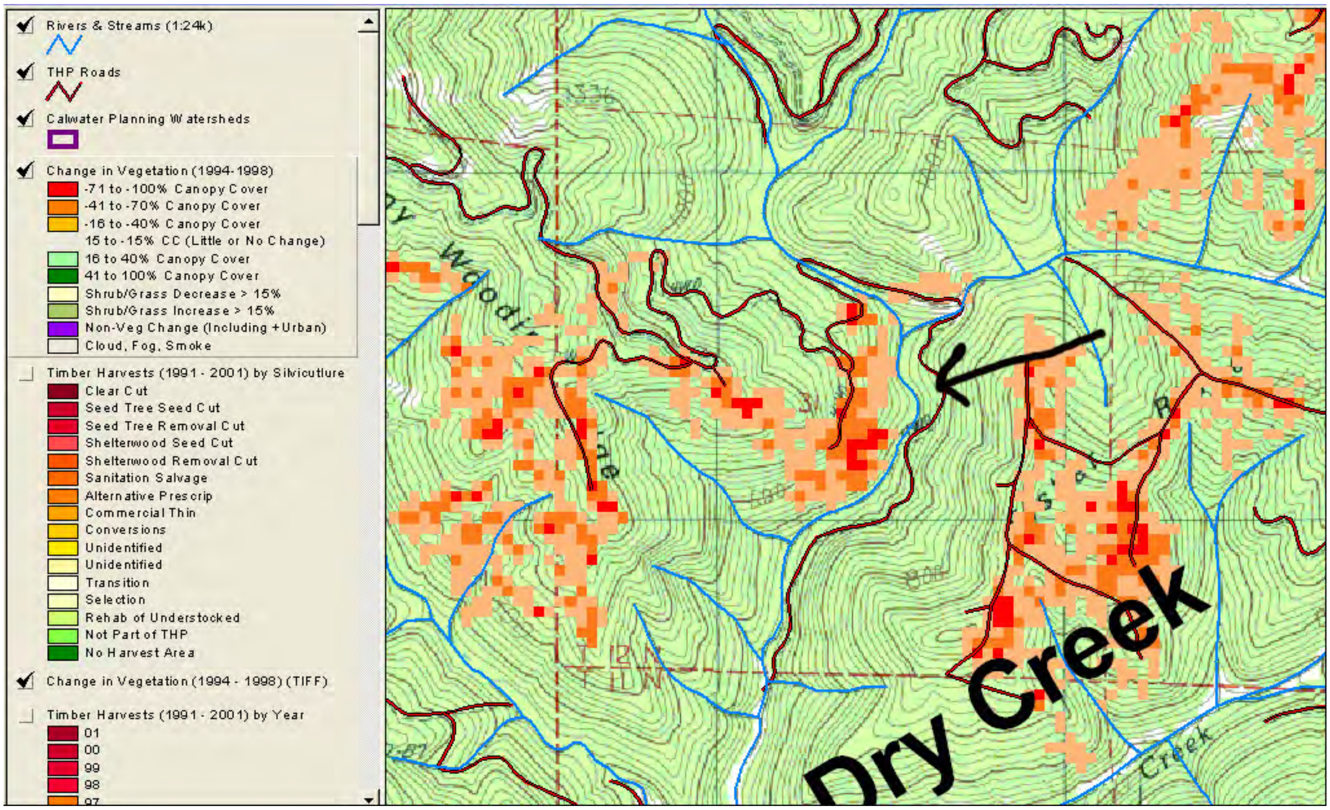

Figure 23. The black arrow points out the Dry Creek reach at the center of Section 31 where THP 1-04-260 describes a large landslide as occurring. CDF change scene detection using 1994 and 1998 Landsat imagery shows substantial canopy reduction (Fischer, 2003). KRIS Gualala Map Project.

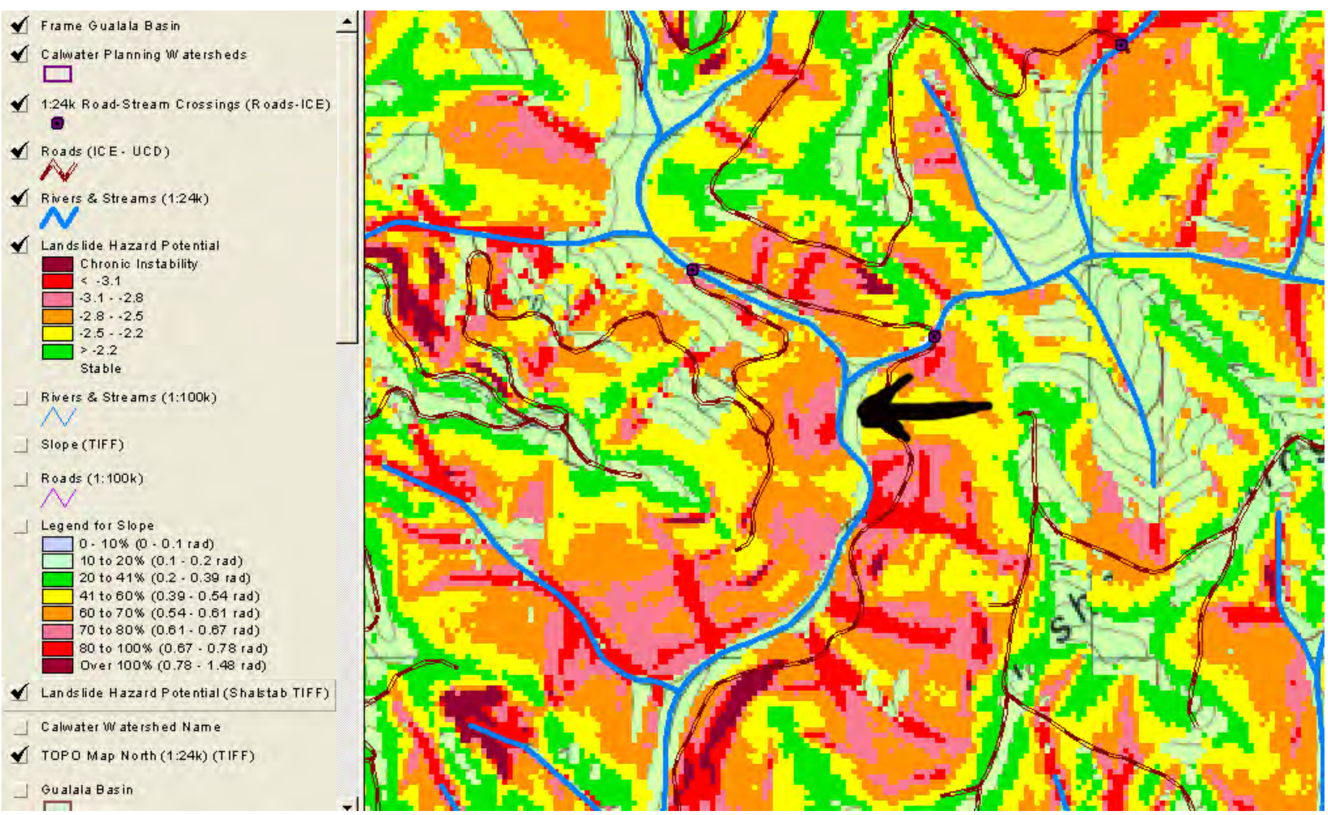

Figure 24. SHALSTAB model run for the area of the convergence of third order Dry Creek headwaters show high risk areas along the inner gorge in the vicinity of the landslide described in the THP (black arrow). Note the road location above the unstable area just downstream of the convergence.

THP 1-04-260 MEN reports planting of the Little North Fork Gualala and other tributaries North Fork tributaries with coho salmon juveniles from 1995-1998. Although the THP notes that no coho juveniles were found in dive surveys in subsequent years in the Little North Fork, it fails to draw appropriate conclusions. In fact 6,000 yearling coho were planted from 1995-1998 and at a weight of six to the pound, which is a large size that usually relates to a high return rate. With the expected survival of smolt to adult of 5% (Groot and Margolis, 1991), means that approximately 300 adult coho salmon should have returned. The occurrence of coho juveniles in 2002 noted in THP 1-04-260 MEN does not establish that coho populations are stable or healthy:

> "In September 2002, coho salmon young-of-the-year were observed in Dry Creek, a tributary to the North Fork during a snorkel survey, and at two sites on the Little North Fork and Doty Creek during electrofishing. Coho young-of-the-year were also present in McGann Gulch."

In fact, absence of coho in most years is indicative of year class failures and confirms the high risk of extinction this species in the Gualala River as noted by CDFG (2002). Ocean conditions have been favorable since 1995 as a result of a switch in the Pacific decadal oscillation cycle (Collison et al., 2003), which should have made ocean survival of smolts released from 1995-1998 high; therefore, freshwater habitat conditions are implicated. While THP 1-04-260 and the Option 10 Plan (CR LLC, 2006) both list appropriate temperature requirements for coho salmon, they do not point out that they are not being met in lower Dry Creek, below where THP 1-04-260 MEN is to take place, and downstream in the lower North Fork Gualala. The high fine sediment levels, small particle size distribution and related bed load mobility, lack of pools and warm water temperatures combined to prevent the survival of juvenile coho and re-establishment of coho salmon in the North Fork Gualala River basin.

There are little data available for tracking adult or juvenile salmonid populations in Dry Creek, but there are electrofishing data from the Little North Fork Gualala River, which is in the Doty Creek Calwater immediately to the west of the Robinson Creek Calwater. The Little North Fork watershed has been extensively clear cut since 1988 and road networks have been expanded. Long-term electrofishing data collected by CDFG in the lower Little North Fork (Figure 24) show samples dominated by steelhead young of the year but with yearling and two year old fish present. Coho salmon young of the year were sampled only in 1988. The standing crop of steelhead juveniles has decreased in number and density, particularly since 1992. This is not consistent with flow and water years, as 1992 was at the end of a five year drought and years since 1995 have been wet. Wet years should have increased available habitat and standing crops.

IFR (2003) obtained habitat typing data for the North Fork Gualala and Little North Fork collected in 1994 by Entrix, Inc.(1995) that was used for comparison with similar CDFG data collected in 2001 (CA RA, 2003) (Figure 26). The number of pools deeper than three feet deep decreased in both the Little North Fork and North Fork Gualala. The North Fork shows the most significant change in terms of loss of fish habitat, with the disappearance of 22 fewer pools deeper than four feet and six fewer pools between 3-4 feet in depth. The loss of pools in the Little North Fork Gualala River is consistent with high sediment delivery between 1994 and 2001 and reduced standing crop of salmonid juveniles. Although channel processes within Dry Creek are different than those of the Little North Fork because of differences in channel gradient and confinement, high sediment yield, peak flows and resulting channel changes have likely similarly decreased salmonid carrying capacity in Dry Creek. The widespread problems with high rates of timber harvest and extensive road networks throughout the Gualala River watershed have lead to a press disturbance (Collison et al., 2003) resulting in no coho being found in over 100 miles of stream surveys by CDFG in 2001 (CA RA, 2003).

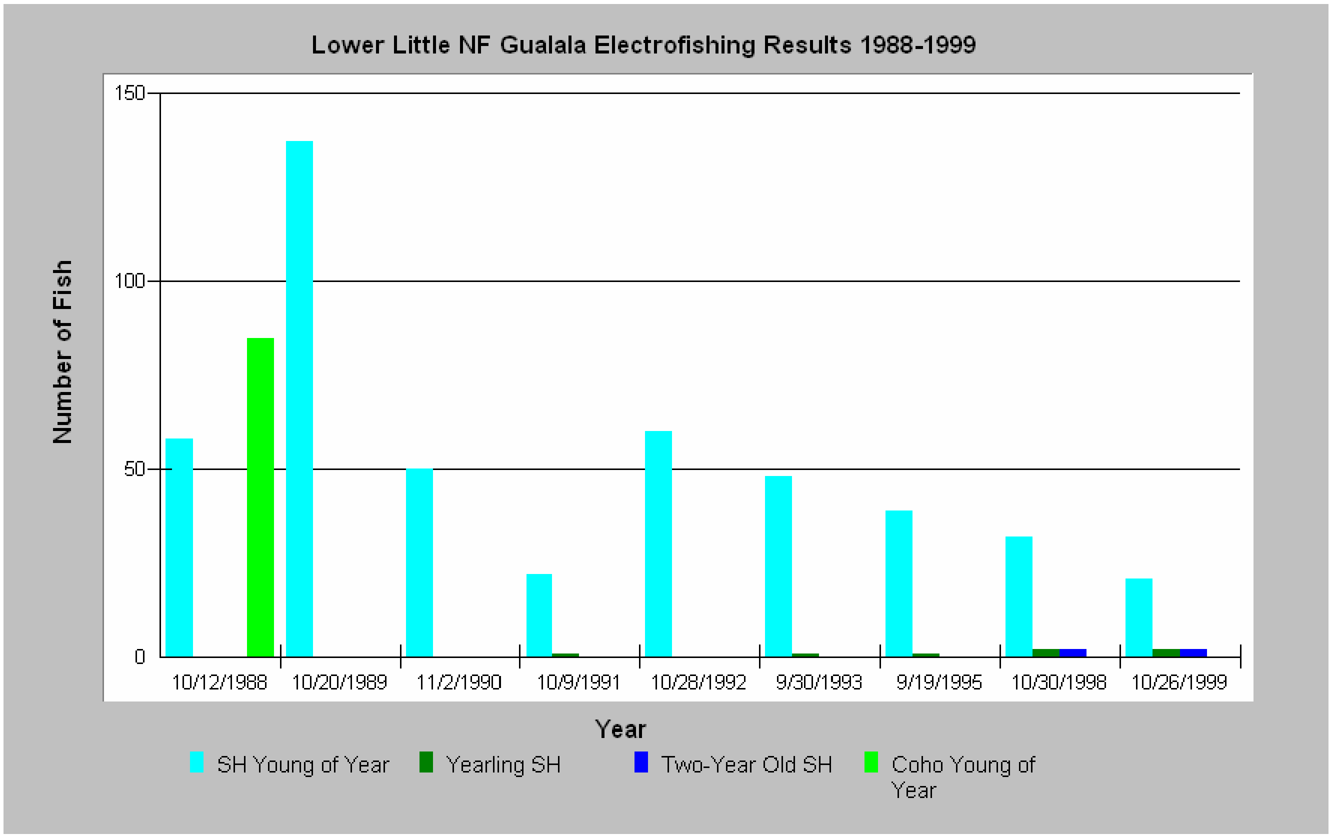

Figure 25. CDFG electrofishing results showing coho juveniles absent except in 1988 and a diminishing standing crop of steelhead from 1988 to 1999. Data from CDFG chart from KRIS Gualala.

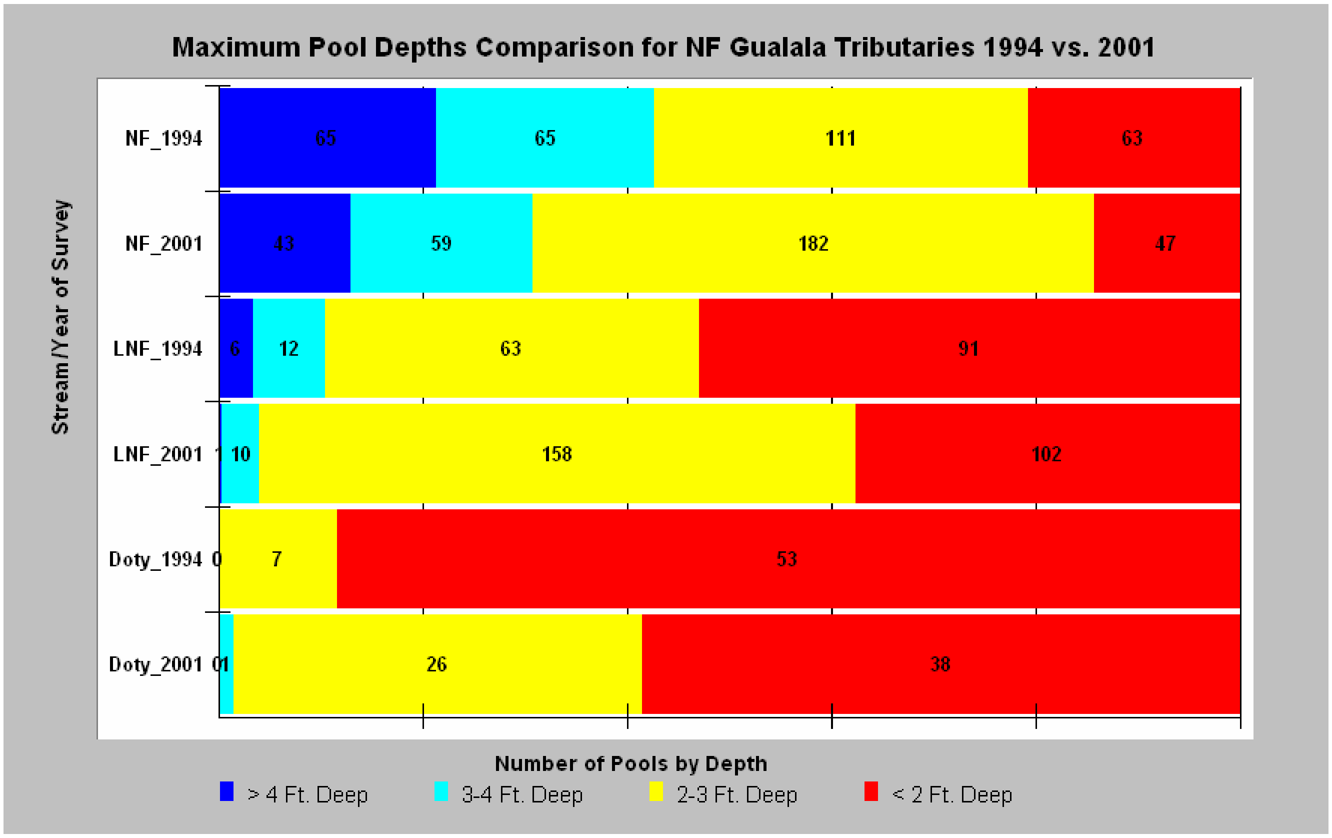

Figure 26. Pool depth data from habitat typing surveys by Entrix (1995) and CDFG (CA RA, 2003) show a loss of deeper pools favored by salmonids between 1994 and 2001. Chart from KRIS Gualala.

Coastal Ridges (2006) Option 10 Plan must more realistically characterize the threat of loss of coho salmon from the Gualala River basin and the potential THP 1-04-260 MEN adds to that risk or decreases chances for successful restoration of coho salmon.

Conclusion

The *Review Guidelines for Option A Timber Harvest Plans* (CDF, 1995) states that "in order to meet the requirements of sections 913.11(a) (1) and (2) it is necessary to establish a link between the analyses of other forest values and the analysis of timber growth." In fact THP 1-04-260 MEN and the *Option 10 Plan* (CR LLC, 2006) both lack any clear description of the degree of impairment of watershed function and water quality related to early seral conditions in surrounding watersheds (CDFG, 2006). Dunne et al. (2001) point out that CWE must be managed by minimizing risk:

> "Inevitably, the institutional aspects involve decisions about how much environmental and other risks are acceptable in a project. Before the institutional evaluation can be made, however, the risks of CWEs need to be identified in some transparent manner."

The lack of provision of sufficient information on which to judge impacts of THP 1-04-260 MEN fails this test of transparency and the *Option 10 Plan* (CR, LLC, 2006); therefore fails to meet requirements of CEQA for cumulative watershed effects.

The evidence presented above shows conclusively that there are advanced cumulative effects problems in the North Fork Gualala River and its tributaries, including Dry Creek where this timber harvest is to take place.

- Stream bed gravel is small and likely too mobile for successful salmonid spawning.
- Fine sediment in stream gravels is high enough at many locations to cause total mortality of coho and steelhead eggs and alevin.
- Low gradient reaches of Dry Creek, Robinson Creek and McGann Gulch suitable for coho salmon spawning and rearing are so aggraded that they lose surface flow in summer and fall.
- Pool frequency is low and pool depth too shallow to support coho salmon in all North Fork Gualala River tributaries.
- Although mainstem North Fork Gualala River pools are deep enough for juvenile coho salmon, water temperatures are too warm to support them.

The loss of year coho salmon classes, evidenced by their absence in North Fork Gualala fish samples in most years, indicates that the species is on the verge of extinction. Habitat and fisheries data from the Little North Fork provides evidence that habitat loss due to high sediment yield is also impacting steelhead.

Any sediment caused by THP 1-04-260 MEN in the steep third order tributary of upper Dry Creek will transported rapidly downstream to lower Dry Creek and the North Fork Gualala River, further degrading water quality and preventing salmon and steelhead recovery. The THP and the NCWAP watershed assessment (CA RA, 2003) both acknowledge that there is a shortage of big wood to force pool scour in the North Fork and its tributaries. Despite the call in the NCWAP report (CA RA, 2003) for riparian protection, this THP plans to harvest large trees in Class II and III riparian zones and on or adjacent to active landslides that are important areas for large wood recruitment.

Dunne et al. (2001) recommended use of GIS tools, including SHALSTAB (Dietrich et al., 1998), to analyze potential impacts from timber harvest and to help prevent cumulative watershed effects. The watershed, aquatic, fisheries and GIS data in the KRIS Gualala project (IFR, 2003) provide such tools, but CDF staff and other agencies reviewing THP's still do not seem to have the capability to use them. The THP and review team instead continue to rely on statements and recommendations supplied in the NCWAP watershed assessment (CA RA, 2003) that are not supported by data (i.e. riparian conditions appear to be improving).

Although I have little expertise in modeling forest growth, the fact that Coastal Ridges, LLC (2006) is using a proprietary model and not providing auditable raw data means that it does not meet standards of scientific transparency (Collison et al., 2003). CDF should be requiring that the Coastal Ridges' model and raw data be provided to reviewing agencies.

Watershed disturbance levels in the North Fork Gualala River watershed, Robinson Creek Calwater and Dry Creek watershed are well above disturbance rates known to cause cumulative watershed effects (Cedarholm et al., 1981; Reeves et al., 1993; Spence et al., 1996). Coho salmon evolved in the redwood forests of the Gualala River basin where cold water temperatures were maintained by giant old growth trees, deep pools formed around fallen trees, and spawning gravels had low fine sediment levels as a result of the hydrologic function of an intact watershed. Kauffman et al. (1997) point out that riparian areas, watersheds, streams and fish populations cannot be recovered unless anthropogenic sources of stress are reduced. Coho salmon in the Gualala River basin cannot be restored unless the vegetative and hydrologic characteristics more closely approach their historic range of variability, which currently requires watershed rest.

Because of impaired water quality and the extreme risk of coho salmon extinction in the North Fork Gualala River basin, no timber harvest activities such as proposed in THP 1-04-260 MEN should be allowed until aquatic habitat conditions and the coho population have shown recovery trends.

Sincerely,

Patrick Higgins

References

Armentrout, S., H. Brown, S. Chappell, M. Everett-Brown, J. Fites, J. Forbes, M. McFarland, J. Riley, K. Roby, A. Villalovos, R. Walden, D. Watts, and M.R. Williams. 1998. Watershed Analysis for Mill, Deer, and Antelope Creeks. U.S. Department of Agriculture. Lassen National Forest. Almanor Ranger District. Chester, CA. 299 pp.

Barnhart, R. A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--steelhead. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.60). U.S. Army Corps of Engineers, TR EL-82-4. 26 pp.

Benda, L.; Hassan, M.A.; Church, M.; and May, C.L. 2005. Geomorphology of steepland headwaters: The transition from hillslopes to channels. Journal of the American Water Resources Association 41(4):835-851.

Bisson, P. A., R. E. Bilby, M. D. Bryant, C. A. Dolloff, G. B. Grette, R. A. House, M. L. Murphy, K. V. Koski, and J. R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present and future. Pages 143-190 in E.O. Salo and T.W. Cundy, editors. Streamside Management Forestry and Fishery Interactions. Univ. of Wash., Institute for Forest Resources, Contribution 57, Seattle, WA.

Brosofske, K. B., J. Chen, R. J. Naiman, and J. F. Franklin. 1997. Harvesting effects on microclimatic gradients from small streams to uplands in western Washington. Ecological Applications 7(4):1188-1200.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management. 14(2):237-261.

California Department of Fish and Game. 2006. Comment on Option A portion of Timber Harvesting Plan (1-04-260 MEN). Memo from Central Coast Region Director Robert W. Floerke to CDF Regional Manager Ken McLean. CDFG, Yountville, CA. 18 p.

California Department of Fish and Game (CDFG). 2005. California Salmonid Stream Habitat Restoration Manual. Fourth Edition. Inland Fisheries Division. California Department of Fish and Game. Sacramento, CA.

California Department of Fish and Game (CDFG). 2002. Status Review of California Coho Salmon North of San Francisco . Report to the California Fish and Game Commission. California Department of Fish and Game, Sacramento , CA. 336pp.

California Department of Forestry (CDF). 1995. Review Guidelines for Option A Timber Harvest Plans. 10/23/95. CDF, Sacramento, CA. 9 p.

California Regional Water Quality Control Board (CRWQCB). 2001. Technical Support Document for the Gualala River Watershed Water Quality Attainment Action Plan. CRWQCB, Region 1. Santa Rosa, CA. 147 pp.

California Resources Agency. In Review. Gualala River Watershed Synthesis. CA Dept. of Fish and Game, State Water Res. Control Bd., CA Dept. of Water Resources, CA Div. on Mines and Geology and CA Dept. of Forestry. Sacramento, CA.

Cederholm, C.J., L.M. Reid, and E.O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington. p.3874. In: Proceedings from the conference Salmon-Spawning Gravel: A Renewable Resource in the Pacific Northwest? Rep. 39. State of Washington Water Research Center, Pullman, WA.

Coastal Ridges, LLC. 2006. A Plan for Meeting MSP Under Option A. Coastal Ridges, LLC, Willits, CA. 70 p plus attachments.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

Dietrich, W.E., R.R de Asua, J. Coyle, B. Orr, and M. Trso. 1998. A validation study of the shallow slope stability model, SHALSTAB, in forested lands of Northern California. Stillwater Ecosystem, Watershed & Riverine Sciences. Berkeley, CA. 59 pp.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.

Entrix, Inc. 1995. Stream Inventory Report North Fork Gualala River. Performed under contract to Gualala Redwoods, Inc. Entrix, Inc., Walnut Creek, CA. 43 p.

FEMAT [Forest Ecosystem Management Assessment Team]. 1993. Forest Ecosystem Management: an ecological, economic and social assessment. Report of the Forest Ecosystem Management Assessment Team. 1993-793-071. U.S. Govt. Printing Office.

Fischer, C. 2003. Monitoring Land Cover Changes in California, North Coast Project Area (1994-1998). California Department of Forestry FRAP and USFS Spatial Analysis Lab, Sacramento, CA.

Groot, C. and L. Margolis (eds). 1991. Pacific salmon life histories. Univ. Of British Columbia Press, Vancouver, B. C.

Higgins, P.T. 1997. Gualala River Watershed Literature Search and Assimilation. Funded by the Coastal Conservancy under contract to Redwood Coast Land Conservancy. Gualala, CA. 59 pp.

Higgins, P.T. 2003a. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1—01-171 SON. May 20, 2003. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p.

Higgins, P.T. 2003b. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Negative Declaration for Sugarloaf Farming Corporation dba Peter Michael Winery, Timberland Conversion No. 524; THP 1-01-223 SON. December 12, 2003. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p

Higgins, P.T. 2004. Letter to Allen Robertson regarding Negative Declaration THP 1-04-030SON, Hanson/Whistler Timberland Conversion Permit (TCP) #530. April 14, 2004. Patrick Higgins, Fisheries Consultant, Arcata, CA. 10 p

Hines, D.H. and J.M. Ambrose. 1998. Evaluation of Stream Temperature Thresholds Based on Coho Salmon (Oncorhynchus kisutch) Presence and Absence in Managed Forest Lands in Coastal Mendocino County, California. Georgia Pacific Corporation, Ft. Bragg, CA. 14 p plus Appendices.

Institute for Fisheries Resources. 2003. KRIS Gualala Database and Map Project Two CD Set. Funded by the California Department of Forestry FRAP, Sacramento, CA. (www.krisweb.com).

Jones, J.A. And G.E. Grant. 1996. Peak flow response to clear-cutting and roads in small and large basins, Western Cascades, Oregon. Water Resources Research, April 1996. Vol. 32, No. 4, Pages 959-974.

Kamman, G. 2003. Letter to Allen Robertson, Deputy Chief, California Department of Forestry and Fire Protection regarding Timberland Conversion Application 02-506 and Timber Harvest Plan (THP) 1—01-171 SON. Kamman Hydrology and Engineering.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An Ecological Perspective of Riparian and Stream Restoration in the Western United States. Fisheries 22(5):12-24.

Kier Associates. 2005. Lower West Side Scott Shallow Landslide Hazard Maps. Performed under contract to the Quartz Valley Indian Reservation by Dr. Jan Derksen of Kier Associates on behalf of the Klamath Basin Water Quality Work Group. September 18, 2005. Kier Assoc., Sausalito, CA. 11 p.

Knopp, C. 1993. Testing Indices of Cold Water Fish Habitat. Final Report for Development of Techniques for Measuring Beneficial Use Protection and Inclusion into the North Coast Region's Basin Plan by Amendment of the.....Activities, September 18, 1990. North Coast Regional Water Quality Control Board in cooperation with California Department of Forestry. 57 pp.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and salmonid habitat. Prepared for the Resources Agency of California and the National Marine Fisheries Service. Sacramento, CA. 181 pp.

Leopold, L. and S. McBain. 1995. Sediment processes in the Garcia River estuary related to enhancement feasibility. Final report. Performed under contract with Moffett and Nichol Engineers. Funded by the Mendocino Resources Conservation District. 29 pp.

McCammon, B. 1993. Determining the risk of cumulative watershed effects from multiple activities. Section 7 ESA consultation between USDA Forest Service and NMFS. Portland, OR.

Montgomery, D. R. and J.M. Buffington, 1993. Channel classification, prediction of channel response, and assessment of channel condition. TFW-SH10-93-002. Prepared for the SHAMW committee of the Washington State Timber/Fish/Wildlife Agreement. Seattle, WA. 110 pp.

Montgomery, D.R. and W.E. Dietrich. 1994. A physically based model for the topographic control on shallow landsliding. Water Resources Research, Vol.30, No.4. April 1994. Pages 1153-1171.

Murphy, M.L., J.F. Thedinga, K.V. Koski and G.B. Grette. 1984. A stream ecosystem in an old growth forest in southeast Alaska: Part V. Seasonal changes in habitat utilization by juvenile salmonids. In Proceedings of Symposium on Fish and Wildlife in Relationships in Old Growth Forests. Eds. W.R. Meehan, T.R. Merrill and T.A. Hanley. American Institute of Fishery Research Biologists, Asheville, North Carolina.

National Marine Fisheries Service. 1996. Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast. US Dept. Commerce, NOAA. 4p.

National Marine Fisheries Service. 2001. Status Review Update for Coho Salmon (Oncorhynchus kisutch) from the Central California Coast and the California portion of the Southern Oregon/Northern California Coasts Evolutionarily Significant Units. Southwest Fisheries Science Center, Santa Cruz, CA. 43 p.

Nawa, RK, C.A. Frissell, and W.J. Liss. 1990. Life history and persistence of anadromous salmonid stocks in relation to stream habitats and watershed classification. Oak Creek Labs, Oregon State University. Corvalis, OR Performed under contract for Oregon Department of Fii and Wildlife.

Overton, C.K., M.A. Radko, and R.L. Nelson. 1993. Fish habitat conditions: using the Northern/Intermountain Region's inventory procedures for detecting differences on two differently managed watersheds. Gen. Tech. Rep. INT-300. US Department of Agriculture, Forest Service, Intermountain Research Station. Ogden, UT. 14 pp.

Pacific Watershed Associates (PWA). 1998. Sediment Source Investigation and Sediment Reduction Plan for the Bear Creek Watershed, Humboldt County, California. Prepared for The Pacific Lumber Company Scotia, California. Arcata, California. 57 pp.

Parker, C. and R.L. Pool. 1964. North Fork Gualala River Stream Survey, North Fork Gualala River surveyed by foot and automobile from the mouth to the headwaters, a total of 15 miles. September 17-18, 1964. California Department of Fish and Game, Region 3, Yountville, CA. 2 p.

Poole, G.C., and C.H. Berman. 2000. Pathways of Human Influence on Water Temperature Dynamics in Stream Channels. U.S. Environmental Protection Agency, Region 10. Seattle, WA. 20 p.

Reeves, G.H., F.H. Everest, and T.E. Nickelson. 1988. Identification of physical habitat limiting the production of coho salmon in western Oregon and Washington. USDA Forest Service, Pacific Northwest Research Station, Portland, Ore. PNW-GTR-245.

Reeves, G.H., F.H. Everest, and J.R. Sedell. 1993. Diversity of Juvenile Anadromous Salmonid Assemblages in Coastal Oregon Basins with Different Levels of Timber Harvest. Transactions of the American Fisheries Society. 122(3): 309-317.

Rieman, B., D. Lee, J. McIntyre, K. Ovetton, and R. Thurow 1993. Consideration of Extinction Risks for Salmonids. As FHR Currents # 14. US Forest Service, Region 5. Eureka, CA. 12 pp.

Satterlund, D.R. and P.W. Adams. 1992. Wildland watershed management. 2nd Edition. Wiley and Sons, NY, NY.

Spence, B.C., G.A. Lomnicky, R.M. Hughes and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. Funded jointly by the U.S. EPA, U.S. Fish and Wildlife Service and National Marine Fisheries Service. TR-4501 96-6057. Man Tech Environmental Research Services Corp., Corvallis, OR. 356 p.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. American Geophysical Union Transactions. 38: 913-920.

Sullivan, K., D. J. Martin, R. D. Cardwell, J. E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute . Portland, OR. 192 pp.

U.S. Environmental Protection Agency. 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA Project # 910-B-03-002. Region 10 U.S. EPA, Seattle WA. 57 p.

Warbington, R., B. Schwind, C. Curlis and S. Daniel. 1998. Creating a Consistent and Standardized Vegetation Database for Northwest Forest Plan Monitoring in California. USDA Forest Service. Pacific Southwest Region Remote Sensing Lab. Sacramento, CA.

Welsh, H.H., G.R. Hodgson, M.F. Roche, B.C. Harvey. 2000. Distribution of Juvenile Coho Salmon (Oncorhynchus kisutch) in Relation to Water temperature in Tributaries of a Northern California Watershed: Determining Management Thresholds for an Impaired Cold-water Adapted Fauna. August 2000 North American Journal of Fisheries Management. U.S.D.A. Forest Service, Redwood Sciences.

MARK WEST CREEK FLOWS
(data attached separately as Appendix A-1)

MATTOLE RIVER FLOWS

HYDROLOGIC ASSESSMENT OF LOW FLOWS IN THE MATTOLE RIVER BASIN 2004-2006

Prepared for:

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March, 2007

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INTRODUCTION

Lack of adequate late summer and early fall streamflow is recognized as one of the most important limitations on salmonid habitat in the Mattole River basin (NCWAP, 2000). In recent years, juvenile salmonids have become stranded in pools due to excessively low flows, causing mortality and necessitating fish rescue operations. With the exception of 2005, late summer and early fall discharges were quite low for the recent six-year the period of 2001-2006, with the summer of 2002 being the driest in the 55-year record of flows on the Mattole River near Petrolia.

A variety of factors influence low flows, such as, climate (rainfall, temperature, relative humidity, wind speed), vegetation species and maturity, ground disturbance, streambed sedimentation, and water use for domestic and agricultural purposes. Of these, only vegetation, ground disturbance and water use are subject to human influences and therefore might be modified to minimize effects on low flows. But the relationships between low flows and influential factors are complex, especially in a basin as large and diverse as the Mattole River. Reducing human water use is often a difficult and expensive undertaking, requiring technological adaptations, financial investments, and conservation practices. To optimize water management and conservation efforts in the Mattole River basin, implementation must be based on a quantitative, site-specific understanding of hydrologic processes and the effects of human water use.

This report presents an analysis of low flows in the Upper Mattole River basin with the following objectives: 1) to analyze recent hydrologic data to compare and contrast summer discharges as they vary in time and space; and 2) to contribute to a technical basis supporting efforts designed to improve low flows in the Upper Mattole River for salmonids. This report builds on an earlier analysis by Klein (2004).

HUMAN-EFFECTS ON LOW FLOWS

Although climate exerts the dominant control on stream discharge, three categories of the effects of human activities on low flow impairment are listed and discussed below.

1) Water withdrawals for:
    a) domestic use,
    b) irrigation of pastures and stock watering,
    c) irrigation of gardens, orchards, and truck farms,
    d) fire suppression,
    e) dust control and perhaps others.

2) Changes in runoff properties of hillslopes:
    a) reduced interception losses from timber harvest,
    b) reduced evapotranspiration from timber harvest,
    c) reduced infiltration capacity from soil compaction due to tractor yarding and road construction.

3) Changes in streambed hydraulic properties due to aggradation:
    a) lower proportion of surface to subsurface flow,
    b) changing a stream segment from a ‘gaining’ reach to ‘losing’ reach.
    c) Higher width to depth ratios increasing vulnerability to warming and evaporation.

Water withdrawals

Obviously, withdrawal of surface water directly from a flowing stream will reduce streamflow at the point of withdrawal and for some distance downstream. The significance of direct withdrawals depends on the rate of streamflow compared with the rate of withdrawal. A single, relatively large withdrawal, or several smaller withdrawals, within a small stream can have a large effect locally. Effects are most acute when streamflows are lowest, as these are times when supply is low and demand (for most uses) is high. However, not all withdrawals are alike. Withdrawal from groundwater wells will have a delayed effect, if any, on streamflow, depending on the proximity to the stream, the source(s) of groundwater recharge, the pumping rate, and the permeability of the supply aquifer. A well located high up in the watershed, even if near a small stream, will have a much delayed and attenuated effect on the mainstem.

Not all water withdrawn from the natural hydrologic system is lost to the surface flow network. For example, a portion of the water used to irrigate a terrace pasture located in the valley adjacent to the stream may flow subsurface back towards the river and reappear as streamflow, a term called 'irrigation return flow'. Similarly, a portion of the water from a leaking or overflowing water storage tank may, in some instances, find its way back to the creek via surface or subsurface pathways, although evaporation may claim a significant portion.

Effects of water withdrawals are complex, particularly in a hydrologically-complex area such as the northcoast. However, a good inventory of withdrawals, including location, rates and timing of withdrawals, will provide a basis, along with other information, for examining the significance of water withdrawals on streamflow and prioritizing actions to reduce harmful effects on the stream ecosystem.

Changes in runoff properties of hillslopes

Human activities can have profound effects on rainfall-runoff relationships, and this has been the subject of much hydrologic research. Urbanization creates impervious or less pervious ground (e.g., roofs, parking lots, streets) than vegetated surfaces, and nearly all the rain falling on such surfaces immediately runs off as stormflow, rather than infiltrating and recharging aquifers. While paving is not an issue in the Mattole River, other, less dramatic effects of land use have undoubtedly played a role in altering the hydrology of the basin.

Research has shown that timber harvesting can increase minimum summer and fall low flows in north coastal streams. For example, Keppeler (1998) showed that low flows increased by as much as 148% in the North Fork Caspar Creek research watershed following clearcutting 50% of the watershed. The increases were attributed to reduced interception (rainfall caught in the tree canopy and evaporating before falling to the ground) and reduced evapotranspiration losses following canopy removal. While minimum low flows were enhanced by experimental logging in Caspar Creek, this case is somewhat different than logging styles in the Mattole. Specifically, tractor yarding, which compacts the soil and removes the protective duff layer, thereby reducing rainfall infiltration, was kept to a minimum in Caspar Creek. In contrast, tractor yarding in the Mattole was widespread, and continues today, although at a much reduced rate compared to the logging boom of the 1950s through 1970s. Compaction and duff removal would tend to negate some portion of the low flow enhancement derived from canopy removal by reducing infiltration. Further, increases in summer low flow that might have been derived from earlier logging have likely waned due to vegetation recovery, although the effects of soil compaction and duff removal are likely to take longer because of the legacy of haul roads (estimated at over 3,000 miles) and skid trails that remain on vast areas within the Mattole River basin.

Changes in streambed hydraulic properties due to aggradation

It is well-established that massive erosion in the Mattole River basin, caused by both natural and human factors, resulted in massive aggradation of lower-gradient streambeds, some of which remain buried under feet or tens of feet of gravel. Madej and Ozaki (1996) have shown that aggraded sediment can take decades or longer to be flushed from a river reach, depending on the magnitude of storms and continued upstream sediment supply and channel transport efficiency.

Stream discharge commonly consists of both surface and subsurface flow, which mix vertically and laterally in the hyporheic zone (the subsurface areas beneath and adjacent to the channel where substantial mixing of surface and subsurface flow occurs), except in bedrock-bounded streams where virtually all flow is at the surface. Where streambed sedimentation is severe, a greater proportion of the water supplied from the watershed upstream flows subsurface through the relatively permeable streambed, leaving less at the surface to provide habitat for many aquatic species. This can be readily seen where a log jam elevates the streambed through localized aggradation. It is not uncommon for all flow to go subsurface just upstream of a log jam under low flow conditions and re-emerge in a less-aggraded reach downstream.

The same phenomenon occurs, although to lesser degrees, in reaches without logjams where channels have become aggraded simply due to excessive coarse sediment loads. Severe aggradation can cause a stream reach to change from being a 'gaining' reach (subsurface water seeps towards the channel and thus augments surface flow) to being a 'losing' reach (subsurface water seeps out of the channel and thus reduces surface flow), sometimes causing an otherwise perennial stream to become intermittent.

Another possible effect of aggradation stems from channels becoming wider and shallower, which enhances warming due to direct sunlight and contact with warm air. The combined effects of reduced surface flow rates and greater width-to-depth ratios are likely to contribute substantially to stream warming in some stream reaches of the Mattole watershed.

EXISTING DATA AND PREVIOUS STUDIES

Climatic and Hydrologic Data

The reader is referred to the Northcoast Watershed Assessment Program's (NCWAP) Mattole River report (NCWAP, 2001) for a compilation of climatic and hydrologic data sources for the Mattole River. Appendix C of the NCWAP report, prepared by the California Department of Water Resources (DWR) lists all known official (government sponsored) data collection efforts in the Mattole and has assembled relevant data and performed some basic analyses, primarily of rainfall and streamflow. In addition to official data collection, numerous basin residents keep records of such basic information as temperature and rainfall.

Sanctuary Forest staff has been collecting streamflow data since summer, 2004, and their data form the basis for most analyses contained herein. In addition, streamflow data collected by the US Geological Survey (USGS) at Petrolia and near Ettersburg, along with rainfall data collected by C. Thompson in the Thompson Creek watershed were used.

Water Use

Because water use was not a component of the present analysis, the reader is referred to the NCWAP (2001) study, which provides a listing of appropriative water rights granted within the Mattole River basin along with estimates of water use. Klein (2004) also summarized water use based on locally-derived estimates provided by Sanctuary Forest staff.

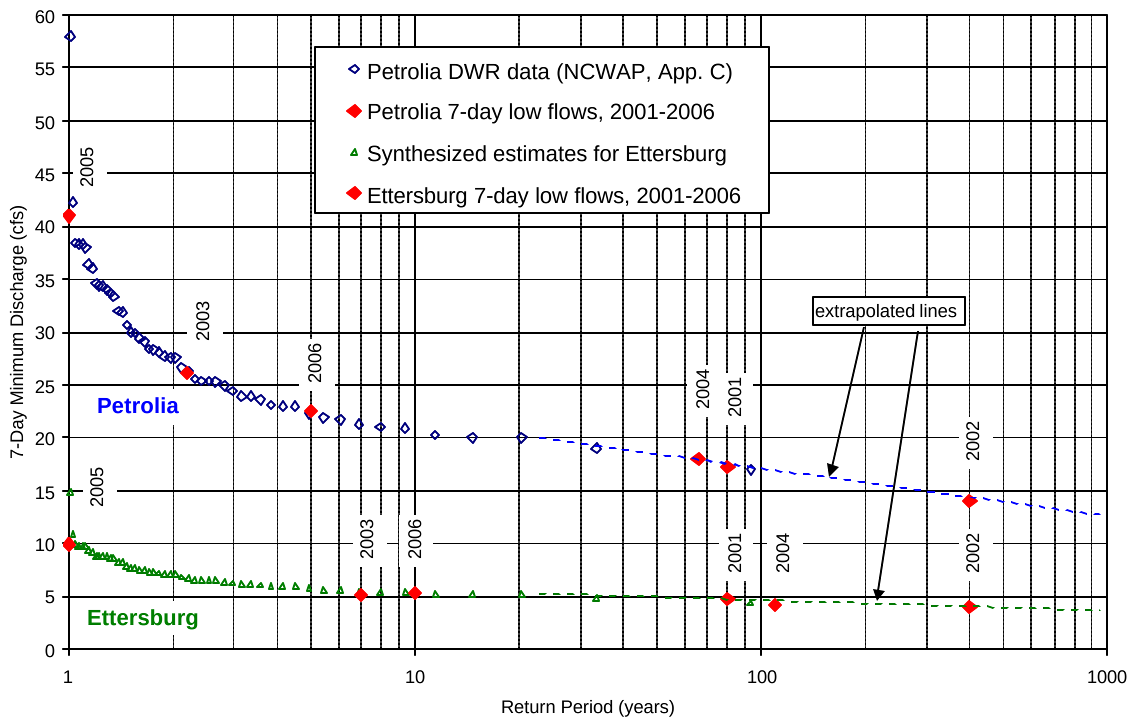
RAINFALL AND LOW FLOW HYDROLOGIC ANALYSES

A Long-term Perspective on Low Flows

The NCWAP (2000) report evaluates rainfall in the Mattole based on two long-term rain gages; one in Petrolia near the basin mouth, and the other in what is called the upper Mattole (according to Figure II-1 on page 4 of the NCWAP report, this gage is actually located in the lower part of the basin at an elevation of 255 feet). Based on analyses of historical rainfall, the NCWAP report concludes there are no discernable long-term trends in annual precipitation. The NCWAP (2000) report also presents and analyzes streamflow records in the Mattole River near Petrolia (USGS Gaging Station No. 1111469000, drainage area 245 mi^2). Floods, low flows, and annual yields were analyzed for long term trends. They reported that there was 'a slight decline with time in annual yields during the 50-year period and a much higher degree of variation during the last 25 years.' They also report that the 7-day low flow running average ranged from a high of 42.3 cfs (1963) to a low of 17.0 cfs (1977). A 'slight overall decline in low flow since…1951.' was noted and tentatively attributed to increased water use. They conclude by reporting that 'streamflow data within the region do not show any distinct long-term increase or decrease in annual runoff.'

Since the NCWAP analyses were done, six additional years of data have been collected at the USGS gages. While the low-flow frequency analysis was not re-done with these newer data, Figure 1 plots the 2001-2006 7-day low flows for both the Petrolia and Ettersburg gages on the NCWAP frequency estimates (reproduced from the NCWAP 2000 report). Although the Ettersburg gaging station lacks sufficient record length to perform low flow frequency analyses, frequency estimates were derived by synthesizing 7-day low flow discharge estimates from the Petrolia gage data using drainage area ratio and applying the frequency estimates from the NCWAP (2000) analysis. The 7-day low flow frequency curves are shown in Figure 1 along with data for both gages for 2000-06.

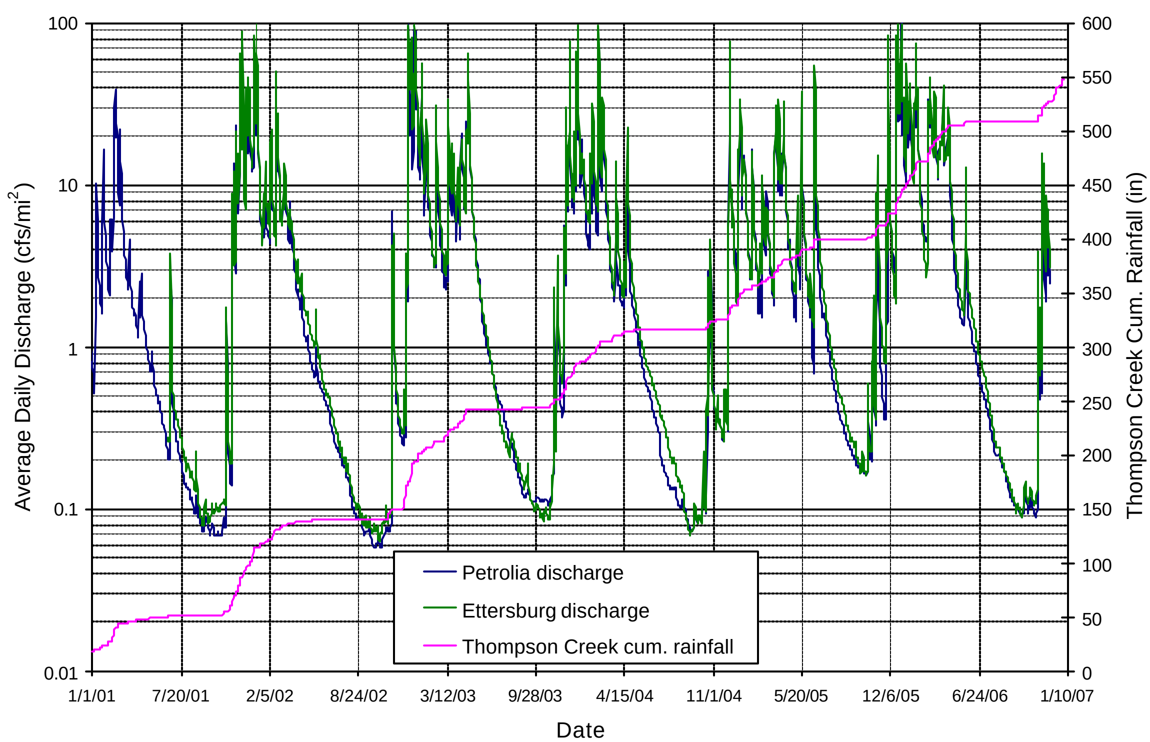
Figure 1. Mattole River near Petrolia (No. 11469000; DA = 245 mi^2) and near Ettersburg (No. 11468900; DA = 58.1 mi^2) 7-day minimum low flow frequency



As shown in Figure 1, the 2002 7-day low flow was the lowest on record for the 56-year period of record at Petrolia, so low that the NCWAP (2000) curve had to be extrapolated downward. Consequently, the return period of about 400-years for the 2002 data is likely an over-estimate, but indicative of the extremity of drought conditions that prevailed then. The 2003-06 low flows were substantially higher than those of 2002, although 2004 can be considered extremely dry as well. While the true frequencies of the 2001-2006 data cannot be precisely evaluated using the 1951-2000 analysis, their positions on Figure 1 are indicative of their relative magnitude within the long term record.

Figure 2 shows discharge as recorded at the USGS gages at Petrolia and near Ettersburg, expressed in cubic feet per second (cfs) per square mile of watershed area (cfs/mi^2) to facilitate comparison. Rainfall in the Upper Mattole, Thompson Creek, is also plotted (note that a logarithmic vertical axis is used to better examine low flows). As is typical of north coastal California, Figure 2 illustrates the degree to which streamflow varies dramatically by season. The trend in low flows can be seen as the degree to which flows dip each summer, with 2002 standing out as the driest year and 2005 the wettest year among those plotted.

Figure 2. Discharge and rainfall in the Mattole River, 2001-06



2004-2006 Low Flows

To characterize recent low flows and rainfall-runoff relationships in greater detail, Sanctuary Forest discharge data were analyzed, using complementary USGS gage data and Thompson Creek rainfall data in some instances. Figures 3-5 depict Upper Mattole rainfall and Ettersburg discharge for the low flow seasons of 2004-06, respectively (note: to show the full range of flows from spring through early winter, a logarithmic scale is used on the discharge y-axis).

In 2004 (Fig. 3), very little rainfall fell in the spring (May), and streamflows recede continuously through the dry season, which ended in early October. The minimum flow (0.069 cfs/mi^2) occurred in early September, leveling off from reduced evapotranspiration as the days shortened and vegetation vigor waned with the approach of fall. The minimum seasonal flow was attained September 10, 2004.

As shown in Figure 4, spring rains in 2005 (early May through mid-June) were unusually heavy, delaying streamflow recession and resulting in the highest minimum flow (0.172 cfs/mi^2) of the 2004-06 period. The minimum flow occurred three weeks later than in 2004, on October 1, 2005. Finally, as shown in Figure 5, the minimum low flow was attained on September 27, 2006, at about the same time as in 2005, but was substantially lower at 0.09 cfs/mi^2, likely owing to the lower amount of rainfall in May, 2006.

Figures 3-6 also indicate that slight amounts of rainfall in the low flow season cause rises in streamflow that, while relatively small, may be biologically significant during critical times of the year. Specifically, on Sept. 19, 2004, a mere 0.39 inches of rainfall caused a 36% rise in streamflow, and the rise in flow lasted over a week. Other years also showed flow increases in response to small rainfall events such that flow might have been restored, at least temporarily, to previously isolated pools. Figure 6 shows discharge for all three dry seasons (2004-06), illustrating the differences among the years in terms of low flow timing and magnitude. Fall rains of enough depth to raise baseflows, effectively ending the dry season, occurred on Oct. 16, Oct. 25, and Nov. 1 in 2004-06, respectively.

Figure 3. Thompson Creek rainfall and discharge at Ettersburg, Mattole River, 2004

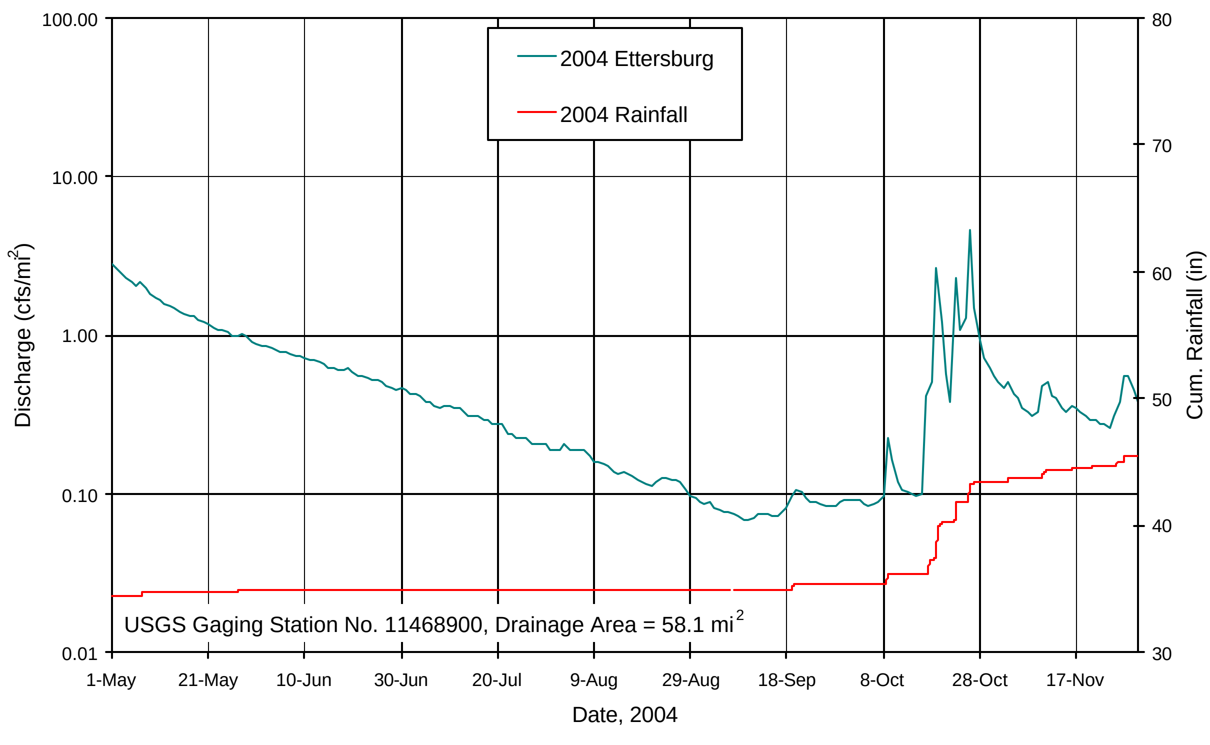


Figure 4. Thompson Creek rain fall and discharge at Ettersburg, Mattole River, 2005

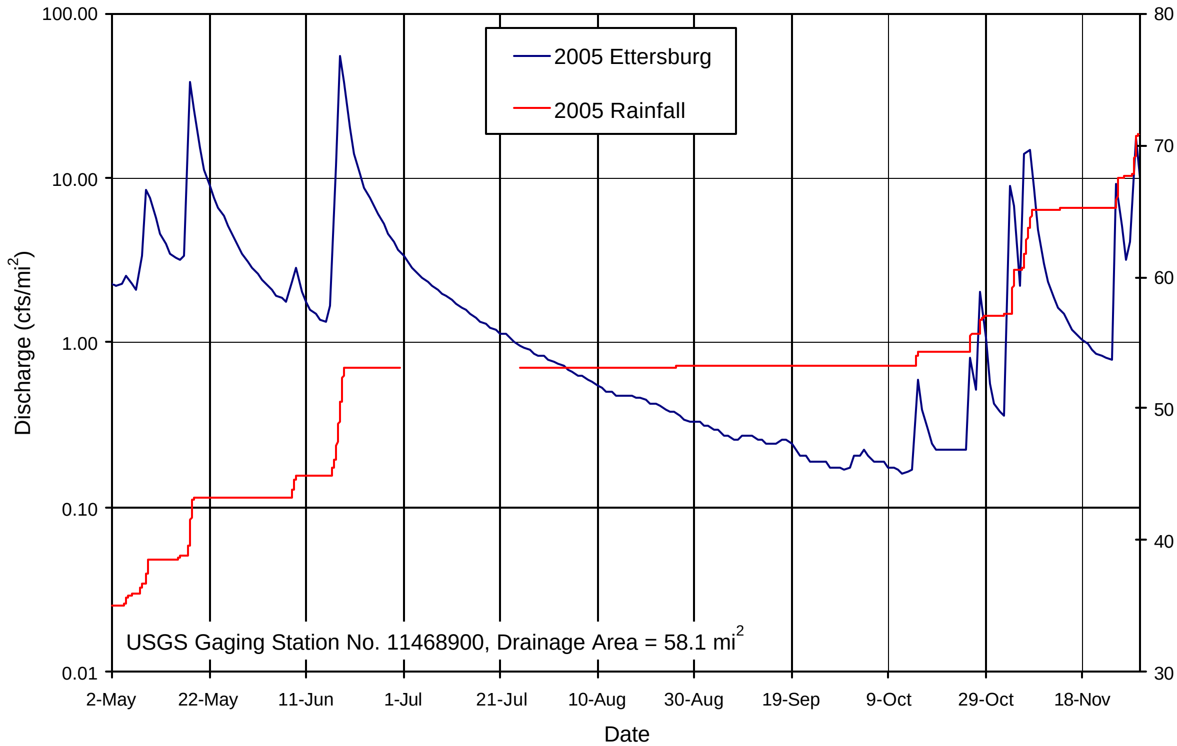
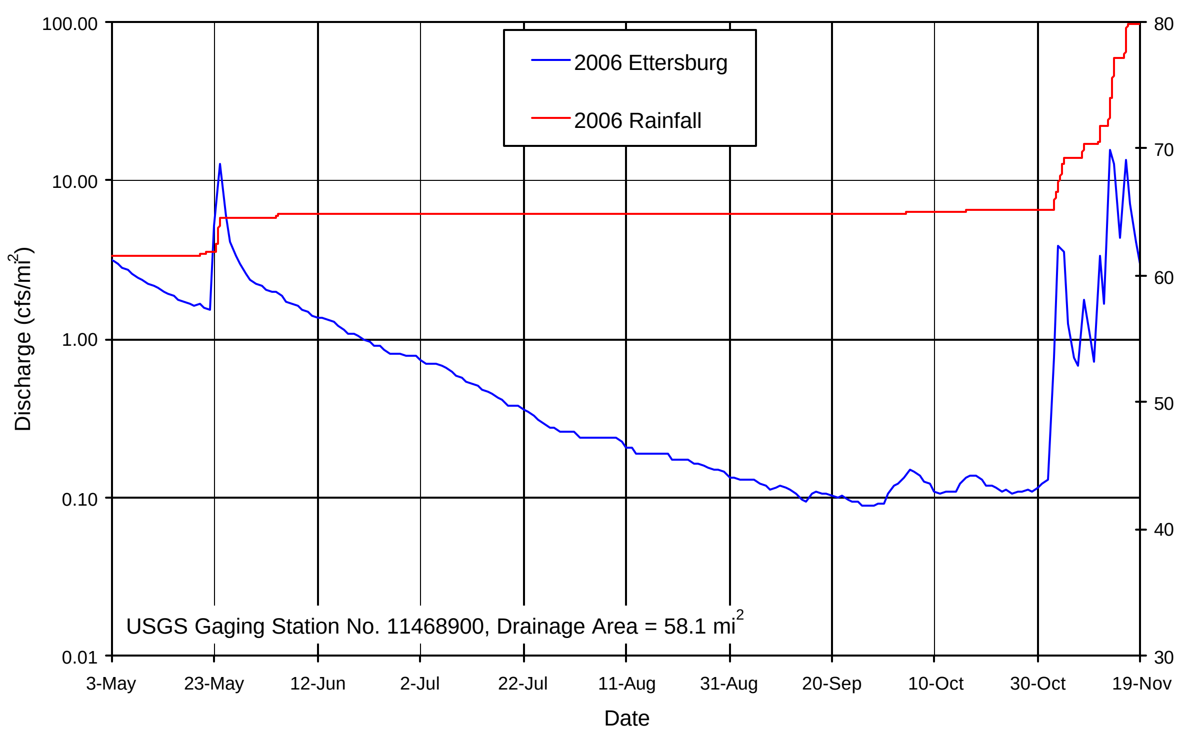
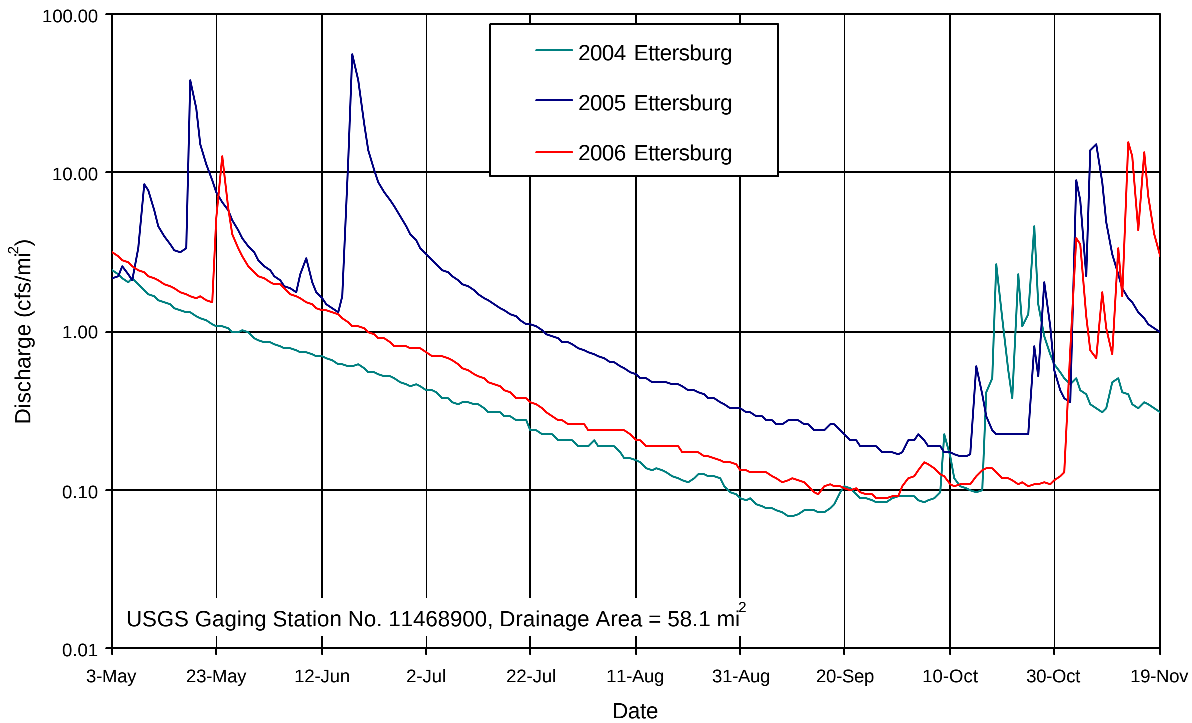


Figure 5. Thompson Creek rainfall and discharge at Ettersburg, Mattole River, 2006



Figures

Figure 6. Discharge at Ettersburg, Mainstem Mattole River, 2004-06



Beginning in August, 2004, flows were measured by SFI staff at selected sites in the Upper Mattole River basin (data in Appendix A). Site descriptions are listed below in Table 1, which includes the USGS sites as well.

Table 1. Sanctuary Forest stream discharge monitoring sites, 2004-06. Note that continuous water levels were monitored at sites MS1 and MS2 using electronic stage recorders in 2006.

Mainstem Sites	***River Mile (RM)***	***Drainage Area (DA, mi^2)***	***Description***
MS1	59.3	3.3	downstream of Big Alder Creek
MS2	58.9	4.0	upstream of Lost River
MS3 (MS1 in 2004)	58.7	6.0	downstream of Shadowbrook bridge
MS4 (MS2 in 2004)	57.2	12.3	upstream of Stanley Creek (at bedrock falls)
MS5	53.2	23.1	upstream of McKee Creek
MS6 (MS4 in 2004)	52.2	25.6	upstream of Bridge Creek
Ettersburg	42.0	58.1	near Ettersburg
Petrolia	5.0	245.0	at Petrolia
Tributaries			
McNasty/Ancestor	60.8	1.0	near confluence with mainstem
Lost River	58.8	1.4	near confluence with mainstem
Helen Barnum	58.7	0.6	near confluence with mainstem
Thompson	58.4	3.8	near confluence with mainstem
Baker	57.6	1.6	near confluence with mainstem
Stanley	57.1	0.8	near confluence with mainstem
Gibson	56.8	0.7	near confluence with mainstem
Harris	56.5	0.9	near confluence with mainstem
(Upper) Mill	56.2	2.3	near confluence with mainstem
Ravishoni/E. Anderson	55.8	0.7	near confluence with mainstem
Anderson	55.6	0.7	near confluence with mainstem
Vanauken	53.8	2.2	near confluence with mainstem
McKee	52.8	2.1	near confluence with mainstem
Bridge	52.1	4.3	near confluence with mainstem
Sinkyone/Buck	52.0	0.8	near confluence with mainstem

These data provide for a more detailed assessment of Upper Mattole low flows than is possible solely using USGS gage data. Measurements were made by collecting the flow at a confined section of the channel in a 5-gallon bucket and timing how long it took to fill the bucket, with a rotating propeller-style current meter (Swoffer), or with an electromagnetic current meter (Marsh-McBirney), depending on prevailing flow conditions. Occasionally, temporary wing-walls were set up in the channel to concentrate the flow area for increased measurement accuracy. Accuracy was judged to be good overall, with repeat measurements taken at times and with crew members frequently checking each others work. However, at extremely low flows, accuracy probably decreased. Accuracy could be increased by ‘smoothing’ out channel sections by clearing a trapezoidal section of coarse gravel, boulders and cobbles, or by installing temporary flumes or some similar apparatus in wide, shallow gravel sections.

Figures 7-9 show the spot measurements of discharge taken in 2004-06 along with mainstem flows from Ettersburg and Petrolia. In the driest year (2004) unit discharges (cfs/mi^2) at the SFI sites were much lower than at the downstream USGS sites, whereas in the wettest year (2005) flows were much more consistent throughout the basin. Further, it appears that in drier years, the seasonal minimum flows occur later at the SFI (upstream) sites while the downstream (USGS) sites cease declining prior to that time. The continued decline, to zero flow in some cases, exhibited by the sites higher in the watershed may be explained in part by the greater presence of exposed bedrock in channels in the upper area: where bedrock is near or at the surface, this implies a more limited aquifer for sustaining surface flow further into the dry season.

Figure 7. Unit discharge in Mainstem Mattole River, 2004

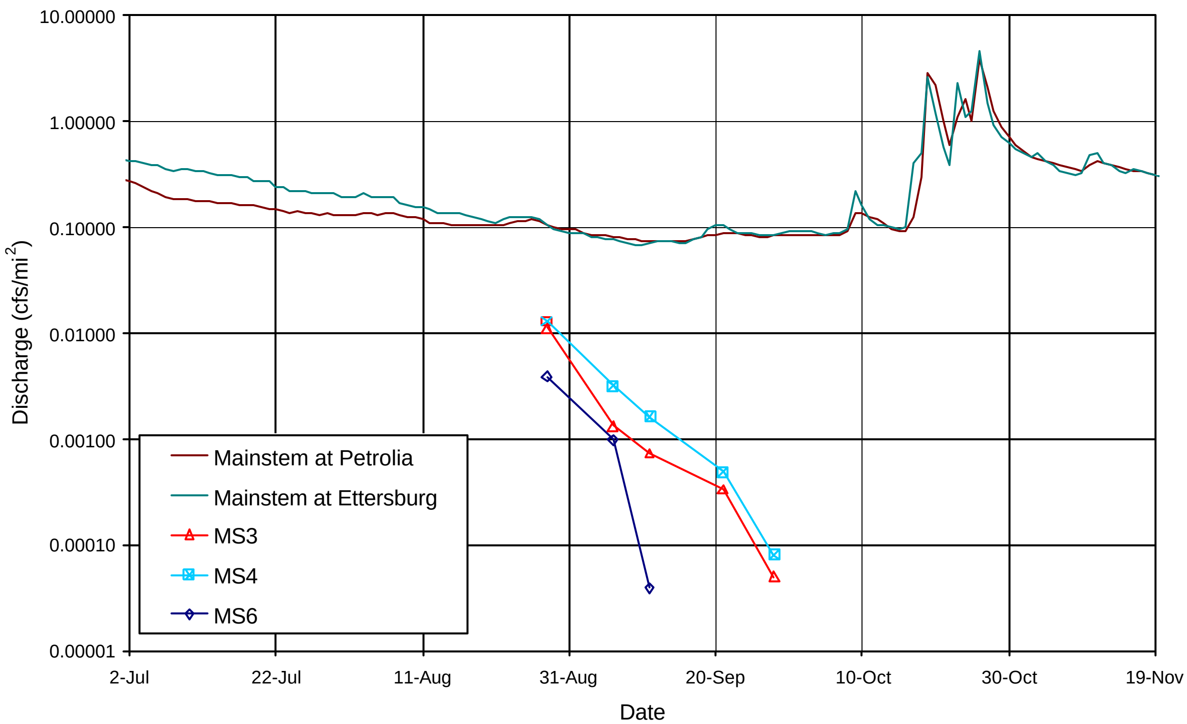


Figure 8. Unit discharge in Mainstem Mattole River, 2005

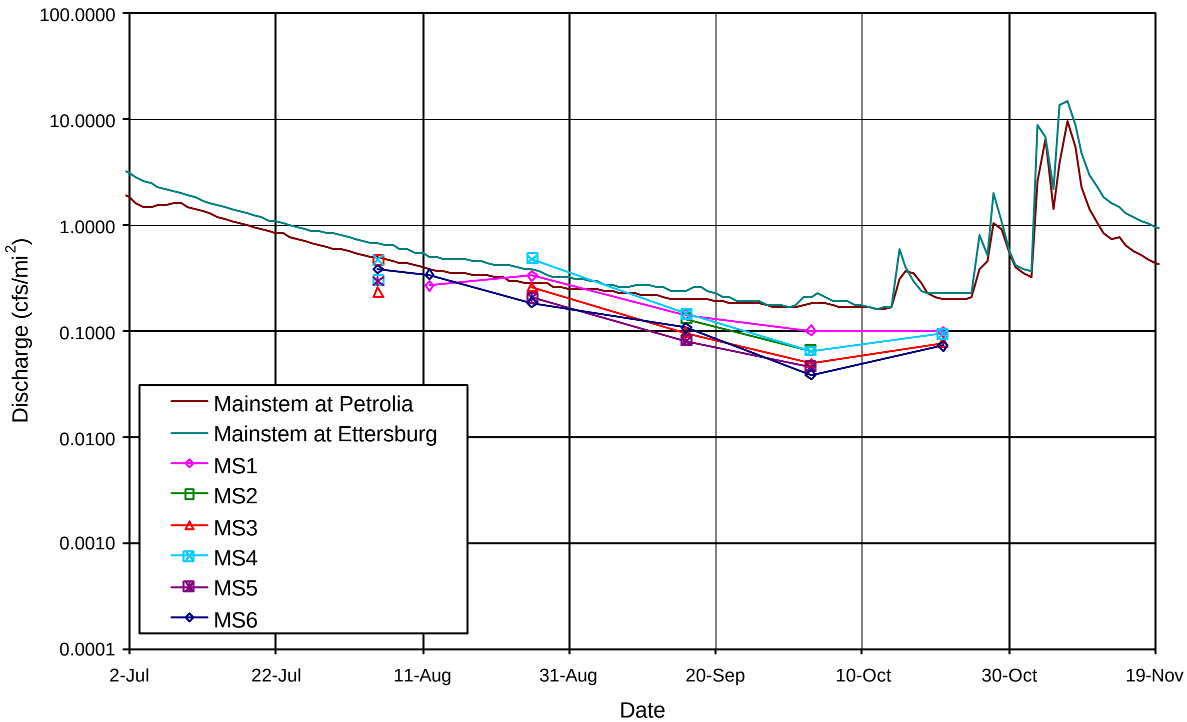


Figure 9. Unit discharge in Mainstem Mattole River, 2006

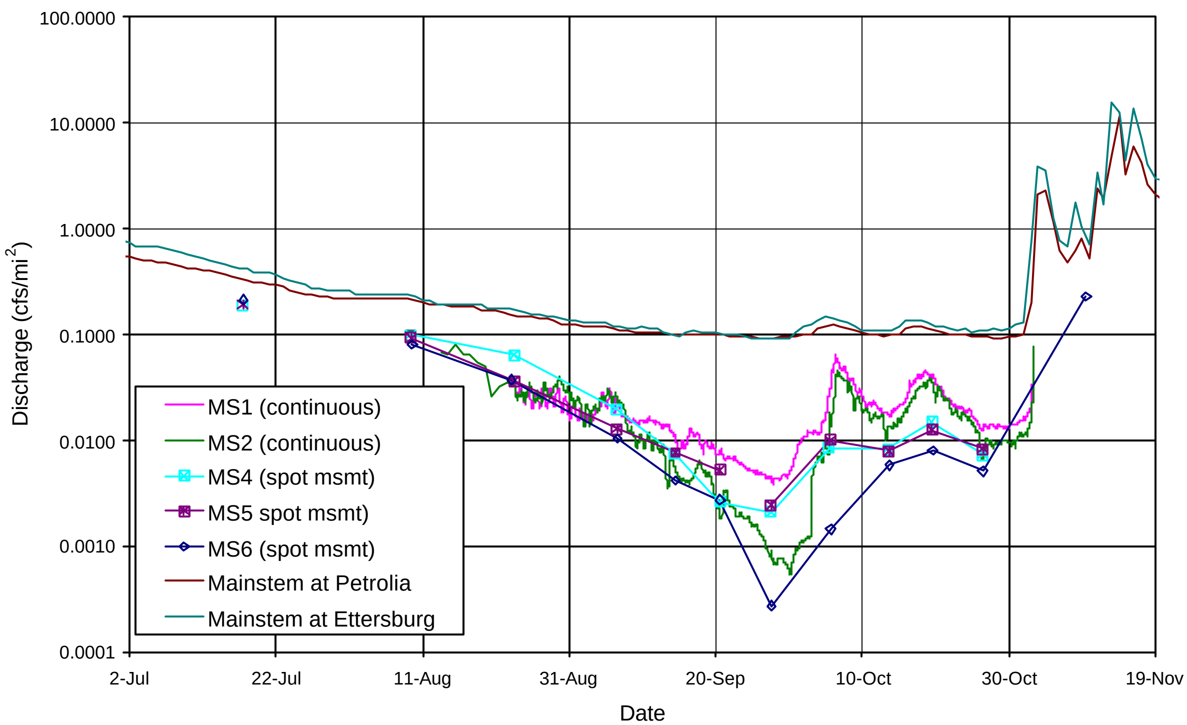
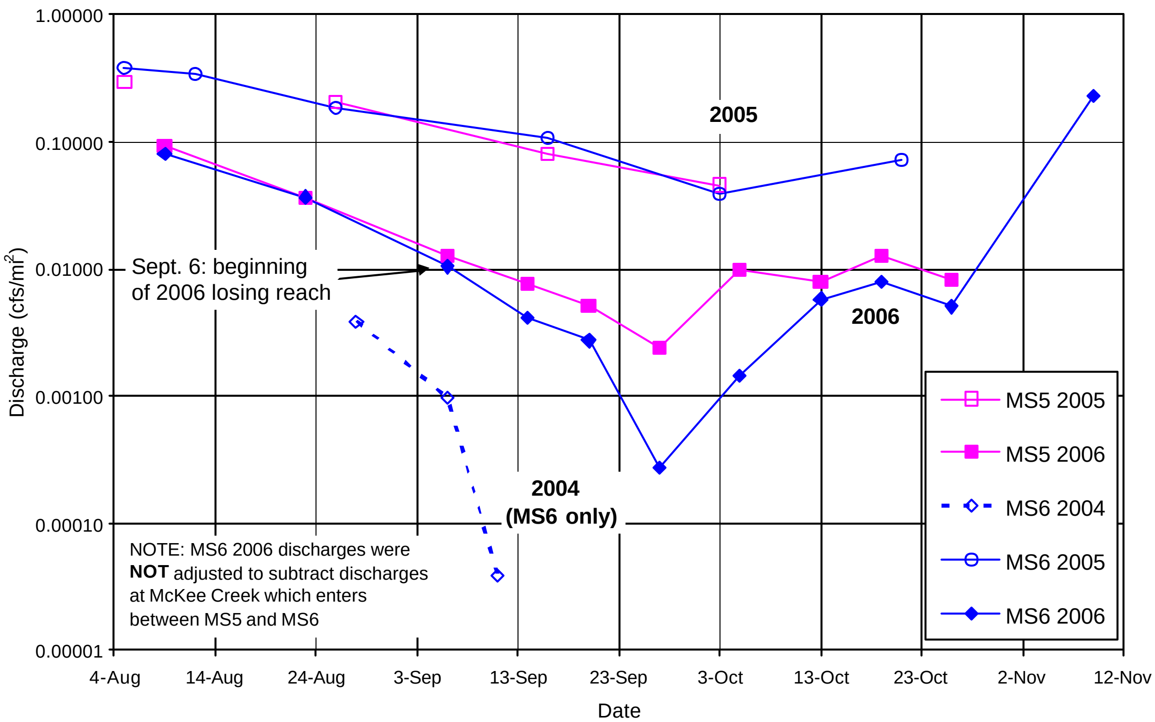


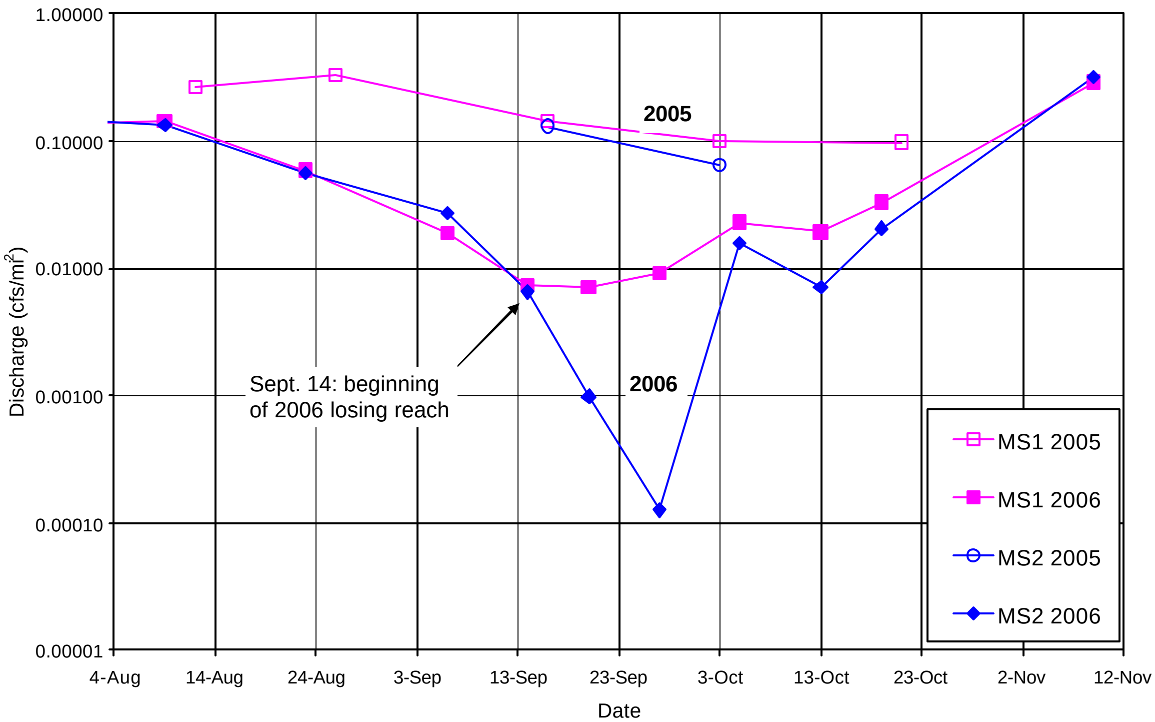
Figure 10 shows the flows at the upstream (MS5) and downstream end (MS6) of the Lower Critical Reach spanning 2004-06. As with Figures 2-9, data are plotted as unit discharge, or discharge (cfs) per square mile of contributing watershed area, for comparison. The trend in relative dryness of the three years is apparent, with 2005 being the wettest, 2004 being the driest, and 2006 moderately dry. Drier years achieve minimum summer/fall discharges earlier, with surface flow ceasing altogether at some locations. Typically, flow is expected to increase with increasing drainage area, but the downstream-most site (MS6) had consistently lower discharges than the upstream site (MS5) during the low flow season.

Figure 10. Low flow discharge spot measurements in the Lower Critical Reach, 2004-2006



In Figure 11, spot measurements for sites MS1 and MS2, which comprise the upper and lower ends of the Upper Critical Reach, are plotted for 2005-06. Trends are similar to those that occurred in the Lower Critical Reach, except that the losing reach phenomenon began about one week later (Sept. 14) than in the Lower Critical Reach.

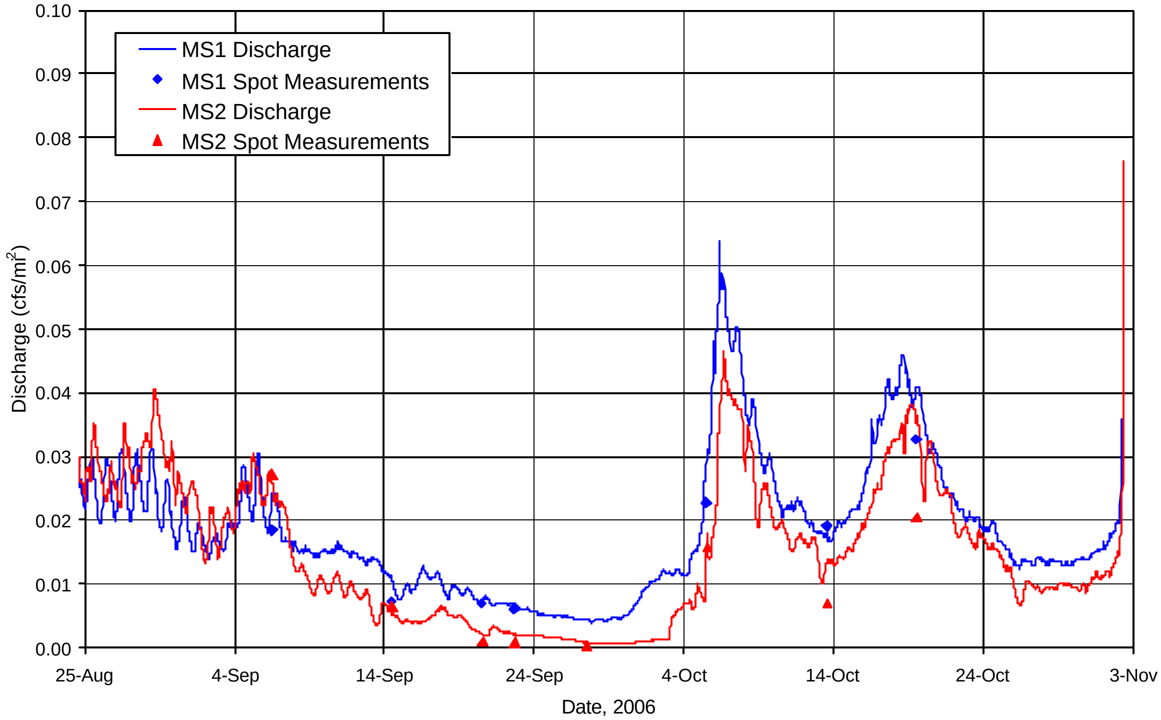
Figure 11. Low flow discharge spot measurements in the Upper Critical Reach, 2005-2006



Because continuous stage data were collected at the Upper Critical Reach, paired measurements of stage and discharge allowed development of stage-discharge curves, which in turn allowed estimation of continuous discharge for MS1 and MS2. The continuous data sets provided a far more detailed record of streamflow than did spot measurements, showing the degree of diurnal fluctuations due to changing evaporative demand from day to night (most pronounced in late August, 2006) and responses to even the small amounts of rainfall that occurred on October 4 and 18, 2006. Figure 12 plots these discharge estimates.

Although spot measurements suggest the Upper Critical Reach began losing on Sept 14, 2006, the continuous record suggests an earlier date (Sept. 7). The actual date is likely closer to Sept. 7, although inaccuracies in discharge-rating curves make a more precise determination impossible.

Figure 12. Continous discharge in Upper Critical Reach (MS1 and MS2), WY2006

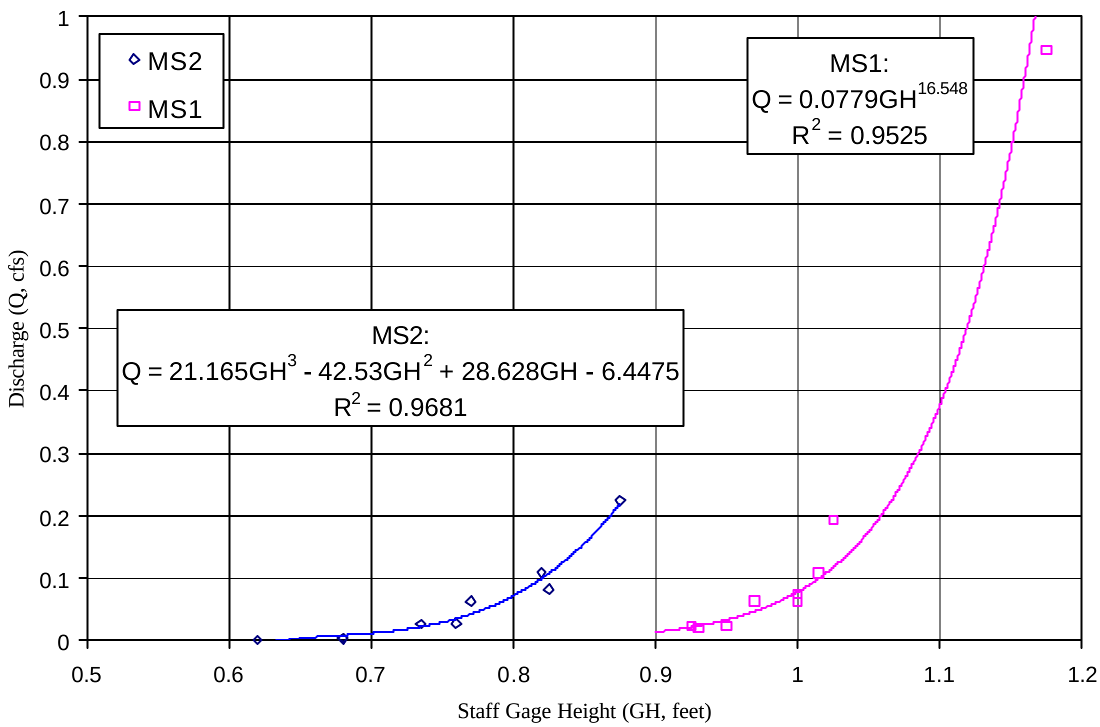


Early in the continuous record (which began in late August, 2006), stages were fluctuating on a diurnal basis, probably reflecting evapotranspiration changes from day to night. This tendency subsided by early September as drought conditions caused drought-induced dormancy of vegetation and reduced evapotranspiration. With the occurrence of significant rainfall on November 2, downstream discharge once again surpassed that upstream.

As a cautionary note, the stage-discharge curves are imperfect predictors of discharge, thus fine-scale comparisons of the hydrographs in Figure 12 may be unreliable. The spot discharge measurements included on the hydrographs in Figure 12 show deviations between flows estimated from continuous data and the spot measurements and serve as a means to evaluate the accuracy of the discharge estimates. Figure 13 shows the stage-discharge rating curves and equations used to estimate continuous discharge, with the best fit obtained with a power equation for MS1 and a third-order polynomial for MS2. Although the relationships are relatively strong (high R^2 values), the scatter of rating points around the curves demonstrates the potential for errors. In addition, the rating curve for MS1 extends to higher discharges than that for MS2, thus discharge estimates for the hydrograph spikes that occurred in October (see Fig. 12) are more reliable for MS1 than MS2.

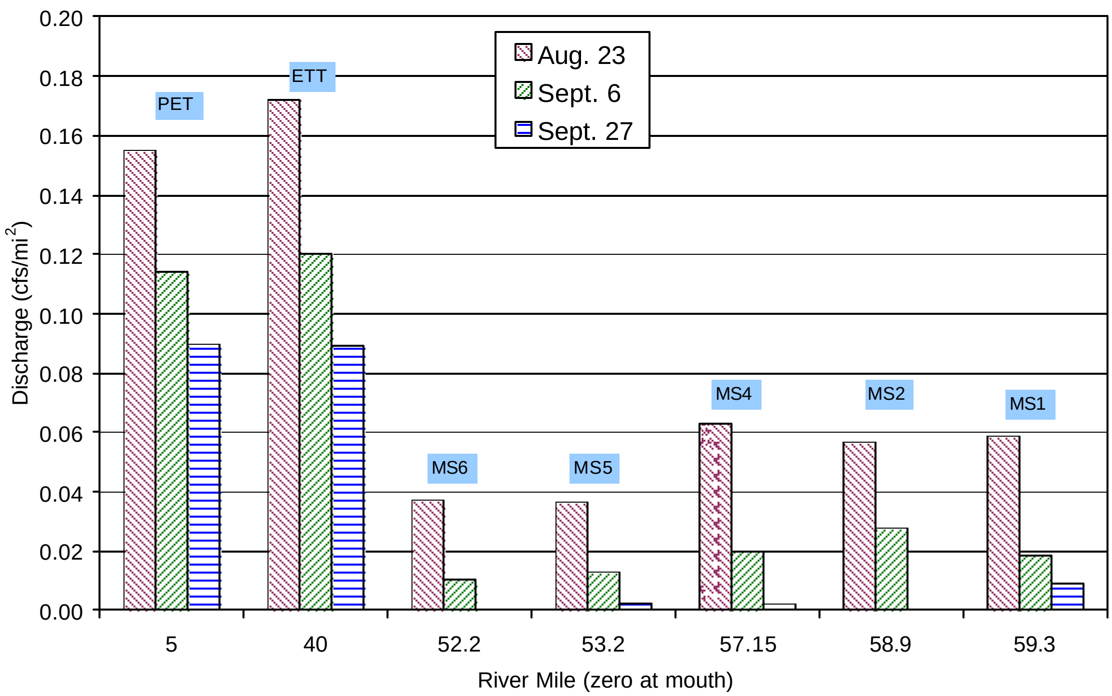
Sources of error exist in both the visual reading of stage and in measuring discharge, and these are especially acute at very low flows when flows are slow, shallow and narrow. Additional measures are considered for implementation in future monitoring that will improve accuracy. These include installation of temporary wing walls to better concentrate flow for increasing depth and velocity and to use sidewalls to avoid turbulence around the wing walls. Also, fine-scale cross section measurements will be used for determining flow area; this will avoid the inaccuracy of simply using wading rods for depth and vertical position of the velocity meter.

Figure 13. MS1 and MS2 discharge rating curves.



To examine spatial relationships, Figure 14 shows discharge at three points in time for seven locations along the mainstem Mattole during the driest part of 2006 (as with other plots, discharge is expressed on a unit area basis (cfs/mi^2) to facilitate comparison among locations with differing contributing area). The larger mainstem sites at Ettersburg and Petrolia are in good agreement, exhibiting the slow decline through time as expected. However, the mainstem sites higher in the watershed (MS1-6) show a more precipitous decline from August 23 to September 6, decreasing over that time by half or more, and with all but the upstream-most site (MS1) approaching zero discharge by September 27. The highest unit discharge during the time of minimum flow (Sept. 27) was at the upstream-most site, contradicting behavior typical in streams lacking significant water diversion or storage facilities.

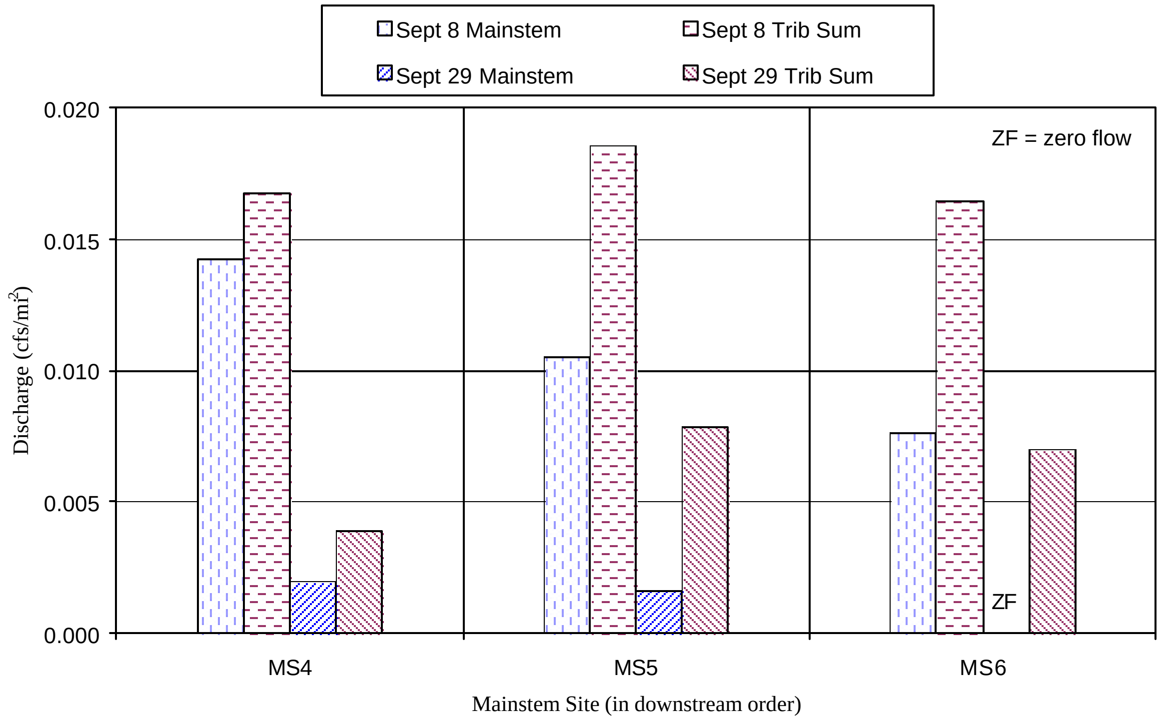
Figure 14. Discharge variation along the Mainstem Mattole River, 2006



In addition to mainstem flows, discharge at 15 tributaries was measured on September 8 and 29, 2006 (see Table 1 for site descriptions; see Appendix B for data). With the data collected, it was possible to compare the sums of tributary measurements with those made at three mainstem sites (MS4, MS5, and MS6). *[NOTE: because no spot measurements of discharge were made for mainstem sites MS4, MS5, and MS6 on these two days, estimates were made for 9/8/06 by interpolation from earlier and later spot measurements and by extrapolation for 9/29/06 from previous measurement]*. As shown below in Figure 15, on both dates and at all three sites the sum of tributary inflows to the main channel exceeded those at the mainstem site downstream, in some cases substantially so (MS5 and MS6 on Sept. 29). Site MS6, at the downstream end of the 'lower critical reach', exhibits the most severe case where mainstem flow was zero on September 29 despite substantial tributary inflows upstream.

The three most likely causes for this are: 1) evapotranspiration losses are greater along the mainstem than in tributaries, 2) surface flow is seeping out of the mainstem channel into the substrate (the 'losing reach' phenomenon), or 3) water withdrawals from the mainstem are preventing a portion of tributary inflows from sustaining mainstem flow. It is also possible that all three causes are contributing to reduced mainstem flows, however the prevalence of exposed bedrock in the Upper Mattole River suggests seepage loss is the least likely cause.

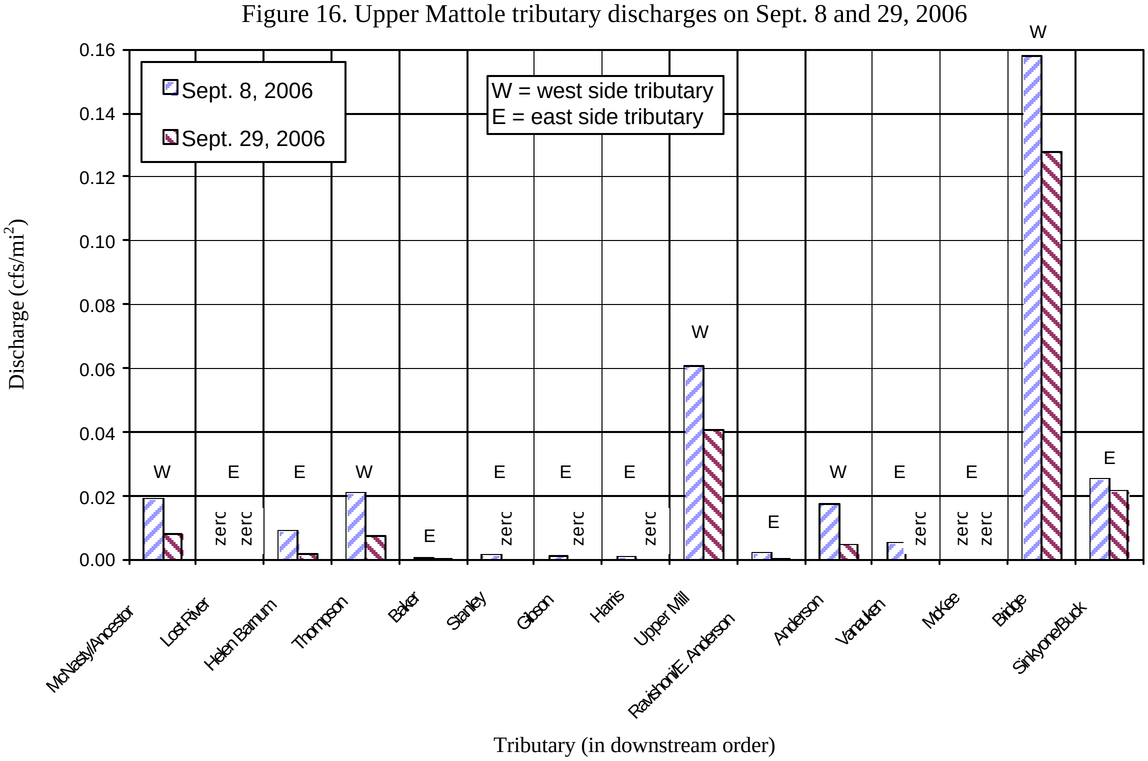
Figure 15. Comparison of mainstem discharge and sum of upstream tributary discharges, Sept. 8 and 29, 2006



NOTE: Discharges for mainstem sites MS4, MS5, and MS6 for 9/8/06 were interpolated from earlier and later spot measurements and extrapolated for 9/29/06 from previous measurement.

Figure 16 shows tributary discharge measurements taken on September 8 and 29, 2006. They are arranged in downstream order from left to right, and expressed in unit area terms (cfs/mi^2). The side (east or west) from which they enter the mainstem is also noted. In all cases, the west side tributaries contribute greater to mainstem flows than do east side tributaries. In particular, Upper Mill and Bridge Creeks contribute substantial flows to the mainstem. In the case of Upper Mill, contributions to the mainstem were substantial even in late September when many other tributaries were dry.

Figure 16. Upper Mattole tributary discharges on Sept. 8 and 29, 2006



Although actual water withdrawal data are not yet available for the Upper Mattole, Sanctuary Forest staff has made some estimates based on a questionnaire survey. Recognizing the potential inaccuracies in these data, comparisons are made in Table 2 of flows at the upstream and downstream ends of the Upper Critical Reach (MS1 and MS2, respectively, using continuous data) and estimated withdrawals for four weeks in the driest part of 2006 (Sept. 17 thought Oct. 14).

Table 2. Comparison of water losses from Upper Critical Reach with estimated water withdrawals

Dates	Upper End (MS1) (cubic feet)	Lower End (MS2) (cubic feet)	Reach Loss (cubic feet)	Water Withdrawal (cubic feet)	Loss Possibly Attributable to Withdrawal
9/17-23/06	15,623	8,156	7,467	9,018	100%
9/24-30/06	9,562	2,514	7,048	9,018	100%
10/1-7/06	49,352	34,198	15,154	9,018	60%
10/8-14/06	47,028	44,341	2,686	9,018	100%
Total =	**121,565**	**89,210**	**32,355**	**36,072**	**100%**

In each of the four weeks, the water volume supplied to the reach (MS1) was larger than that flowing out of the reach (MS2), resulting in a loss. Under normal circumstances, flow would be expected to increase with watershed area, so instead of a loss, flow at the downstream end should be greater than that upstream. Seepage losses could explain some of the loss, but water extraction is also a likely major factor. Using the estimated rates of water withdrawal, it appears that all of the loss (100%) could possibly be due to water withdrawal, except perhaps during the first week of October (10/1-7/06) when reach loss was greater than withdrawal. The foregoing assumes a constant estimated withdrawal rate, which almost certainly did not occur. Improvements in the accuracy of withdrawal information are anticipated in future years, along with improvements in the ability to fine-tune mitigation activities.

CONCLUSIONS

Conclusions from analyses of low flow discharge in the Upper Mattole River are:

1) With the exception of 2005, drought conditions have been unusually severe since 2002 in the Upper Mattole River.

2) Discharges in the Upper Mattole, expressed on a unit area basis (cfs/mi^2), are substantially lower than those measured downstream at the USGS gaging stations at Ettersburg and Petrolia. This is most likely due to differences in watershed characteristics between the Upper Mattole and the larger basin areas upstream of the USGS gaging stations, but water withdrawals may also play a role.

3) Substantial amounts of late spring rainfall postpone the date at which minimum low flows are attained, shortening the amount of time low flow conditions persist and possibly maintaining year-round flow at some reaches that might otherwise go dry.

4) Even small amounts of rainfall in the driest time of the year can increase discharge and provide temporary relief for fish from drought conditions.

5) Continuous discharge data, collected using electronic data loggers, provides a much more powerful data set for assessing low flows and examining causal relationships than do spot measurements. Improved discharge measurement accuracy will in turn improve rating curves, leading to greater accuracy.

6) Mainstem discharges in the Upper Mattole River were less than the sum of upstream tributary discharges, indicating that losses are occurring from the mainstem. Losses from the mainstem are likely due to some combination of enhanced evapotranspiration, seepage out of the channel, and water withdrawals.

7) The two critical reaches, the Upper (Gopherville) bracketed by MS1 and MS2 and the Lower (Junction) reach bracketed by MS5 and MS6, both experienced a losing reach period beginning in September. The likely explanations are a combination of human use becoming high relative to streamflow at that time, and reductions in downstream accretion (surface water and seepage contributions to the channel).

8) Quantitative data on actual water withdrawals are needed to assess the degree to which water withdrawals may be reducing flows and to optimize efforts to strategically reduce dry-season withdrawals in reaches where drought effects on salmonid habitat are most severe.

9) Groundwater monitoring is needed to determine the degree to which declining groundwater levels in late summer are contributing to losing reaches. If so, groundwater recharge projects should be evaluated for their potential for improving late summer flows.

LITERATURE CITED

Keppeler, E.T. 1998. The summer flow and water yield response to timber harvest. In Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story. May 6, 1998. Ukiah, Calif. USDA Gen. Tech. Report PSW-GTR-168. Pp. 35-43.

Klein, R.D. 2004. Preliminary hydrologic assessment of low flows in the Mattole River Basin. Report to Sanctuary Forest, Inc. 22 p.

Madej, M.A., and V.L. Ozaki. 1996. Channel response to sediment wave propagation and movement, Redwood Creek, California, USA. Earth Surface Processes and Landforms. v. 21. pp. 911-927.

North Coast watershed Assessment Program (NCWAP): Mattole River Assessment. 2000. Appendix C: Hydrology. 26 p.

Appendix A: Sanctuary Forest Low Flow Data, 2004-06, Mainstem Sites

Date	MS1 cfs	MS2 cfs	MS3 cfs	MS4 cfs	MS5 cfs	MS6 cfs	MS1 cfs/sqmi	MS2 cfs/sqmi	MS3 cfs/sqmi	MS4 cfs/sqmi	MS5 cfs/sqmi	MS6 cfs/sqmi
2004												
Former No.			*MS1*	*MS2*		*MS4*			*MS1*	*MS2*		*MS4*
28-Aug			0.067	0.160		0.100			0.011	0.013		0.004
6-Sep			0.008	0.039		0.025			0.001	0.003		0.001
11-Sep			0.004	0.020		0.001			0.001	0.002		0.000
21-Sep			0.002	0.006		0.000			0.000	0.000		0.000
28-Sep			0.000	0.001		0.000			0.000	0.000		0.000
2005												
5-Aug			1.400	5.800	6.910	9.880			0.233	0.470	0.299	0.385
12-Aug	0.870					8.800	0.267					0.343
26-Aug	1.080		1.570	5.950	4.750	4.800	0.331		0.261	0.483	0.206	0.187
16-Sep	0.470	0.520	0.580	1.800	1.860	2.750	0.144	0.131	0.097	0.146	0.080	0.107
3-Oct	0.330	0.260	0.300	0.800	1.060	1.000	0.101	0.066	0.050	0.065	0.046	0.039
21-Oct	0.320		0.470	1.160		1.850	0.098		0.078	0.094		0.072
2006												
17-Jul	1.123	1.178			4.400	5.470	0.344	0.297			0.190	0.213
2-Aug	0.449	0.576					0.138	0.145				
9-Aug	0.474	0.528		1.220	2.130	2.050	0.145	0.133		0.099	0.092	0.080
23-Aug	0.193	0.224		0.780	0.843	0.950	0.059	0.057		0.063	0.036	0.037
6-Sep	0.061	0.109		0.244	0.297	0.268	0.019	0.028		0.020	0.013	0.010
14-Sep	0.024	0.026		0.091	0.177	0.106	0.007	0.007		0.007	0.008	0.004
20-Sep	0.023	0.004		0.032	0.120	0.070	0.007	0.001		0.003	0.005	0.003
27-Sep	0.030	0.001		0.026	0.056	0.007	0.009	0.000		0.002	0.002	0.000
5-Oct	0.075	0.063		0.105	0.231	0.037	0.023	0.016		0.009	0.010	0.001
13-Oct	0.063	0.028		0.103	0.182	0.149	0.019	0.007		0.008	0.008	0.006
19-Oct	0.108	0.082		0.184	0.290	0.204	0.033	0.021		0.015	0.013	0.008
26-Oct				0.090	0.192	0.130				0.007	0.008	0.005
9-Nov	0.947	1.278				5.860	0.290	0.323				0.229

APPENDIX B: SANCTUARY FOREST LOW FLOW DATA, 2006, TRIBUTARIES

Tributary or Mainstem Site	DA (mi2)	Discharge (cfs) on Measurement Date							
		06/21/06	07/17/06	08/09/06	08/23/06	09/08/06	09/29/06	10/05/06	11/09/06
McNasty/Ancestor	1.0					0.019	0.008		
MS1	**3.3**					**0.049**	**0.009**		
MS2	**4.0**					**0.053**	**0.003**		
Helen Barnum	0.6					0.005	0.001		
Lost River	1.4					0.000	0.000		
Thompson	3.8					0.079	0.028		
Baker	1.6					0.001	0.001		
upstream trib sums	**8.3**					**0.139**	**0.032**		
MS4	**12.3**					**0.176**	**0.024**		
Stanley	0.8					0.001	0.000		
Gibson	0.7					0.001	0.000		
Harris	0.9					0.001	0.000		
Mill	2.3	1.729	1.040			0.142	0.095	0.170	
Ravishoni/E. Anderson	0.7					0.001	0.000		
Anderson	0.7					0.013	0.003		
Vanauken	2.2					0.012	0.000		
upstream trib sums	**16.7**					**0.309**	**0.131**		
MS5	**23.1**					**0.244**	**0.038**		
McKee	2.1			0.060	0.013	0.000	0.000		0.170
upstream trib sums	**18.8**					**0.309**	**0.131**		
MS6	**25.6**					**0.196**	**0.000**		
Bridge	4.28					0.676	0.548		
Sinkyone/Buck	0.75					0.019	0.016		

NOTE: Discharges for mainstem sites MS4, MS5, and MS6 for 9/8/06 were interpolated from earlier and later spot measurements and extrapolated for 9/29/06 from previous measurement.

NAPA RIVER FLOWS

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August 17, 2010

Mr. Thomas Lippe
329 Bryant Street, Suite 3D
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Re: Sufficiency of SFBRWQCB Staff *Napa River Sediment TMDL Appendix D: Responses to Comments*

Dear Mr. Lippe,

Comments below are once again prepared at your request and on behalf of your client the Living Rivers Council (LRC) and focus on the *Napa River Sediment TMDL Appendix D: Responses to Comments* (SFBRWQCB 2009b) by San Francisco Bay Regional Water Quality Control Board (Water Board) staff. I have now provided comments (Higgins 2006, 2007, 2008, 2009) for nearly four years on the draft and final *Napa River Watershed Sediment TMDL and Habitat Enhancement Plan: Staff Report* (Napolitano et al. 2009) (Napa TMDL), the related Basin Plan Amendment (SFBRWQCB 2009a) and previous Water Board staff response to comments. There is some progress with regard to cooperative efforts in the Napa River basin, such as installation and operation of the downstream migrant trap (NCRCD 2009) and good faith efforts by the Water Board staff to engage other agencies in resolving critical flow issues. I remain unconvinced; however, that best management practices (BMPs) embodied in Napa County conservation programs and Fish Friendly Farming can prevent excess sediment discharge and offset the cumulative effects of development in too wide an area of the watershed. In several cases I find Water Board staff response to my previous arguments, and those of Dennis Jackson (2009) offered on behalf of LRC, rhetorical rather than substantive. Main areas of clarification and disagreement are:

- Pacific salmon current and historic stock status,
- The need to apply TMDL measures in areas above reservoirs,
- Cumulative effects problems that are likely to confound successful TMDL implementation, and
- Sufficiency of monitoring and validity of using gravel permeability.

Pacific Salmon Stock Status and Trends

Water Board staff took issue with assertions in my previous comments with regard to Pacific salmon status and trends in the Napa River.

<u>Coho salmon</u>: Water Board staff asserts that coho salmon were lost from the Napa River in the 19^{th} Century because of a dam on the mainstem at Trancas Road that was demolished in the 1930s. Figure 1 is a gradient map from Stillwater and Dietrich (2002) that has been modified to

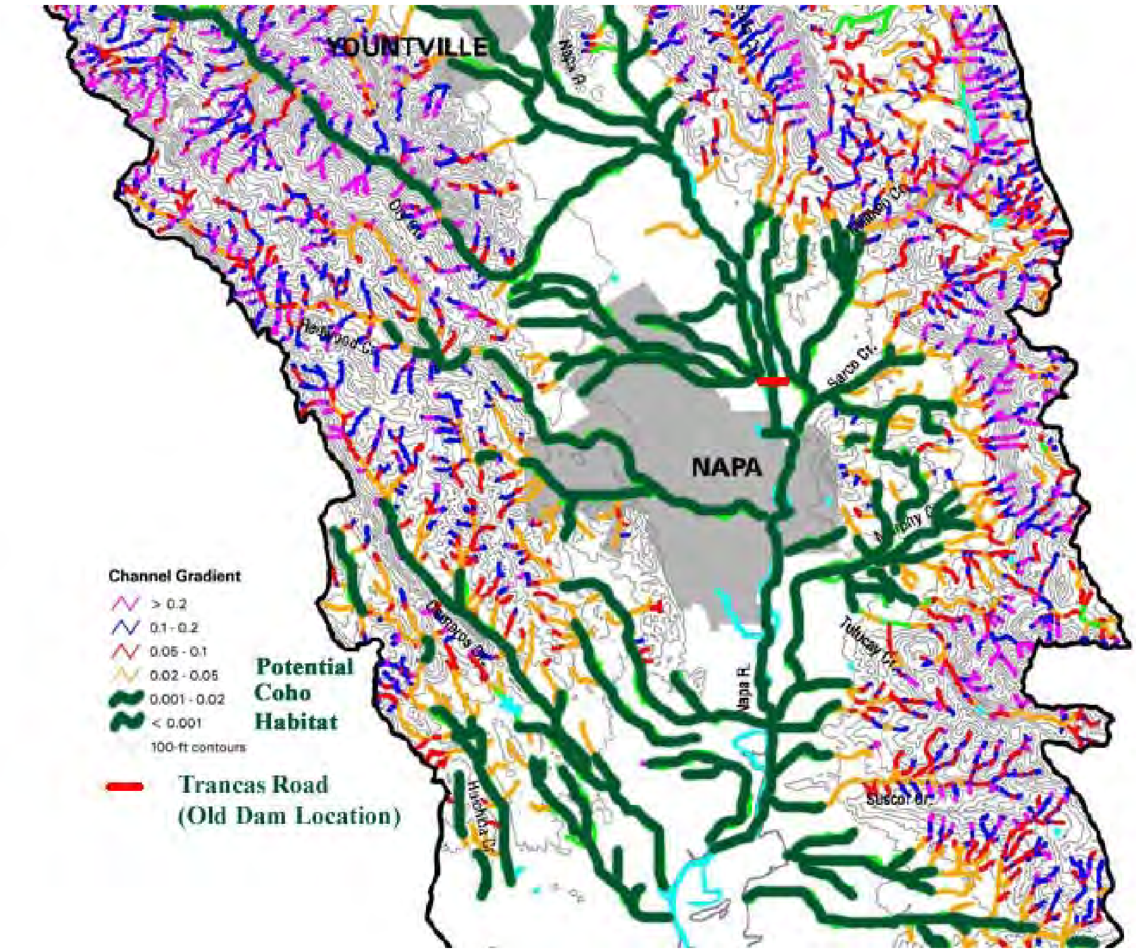


Figure 1. Map of stream gradient from Stillwater and Dietrich (2002)(Map 6) with an overlay of dark green on all reaches with gradient less than 2% (0.02) to show likely range of coho salmon prior to human disturbance and the approximate location of old dam at Trancas Road.

show optimal gradient for coho salmon (< 2%) and also includes the approximate location of the old dam. It is clear that many miles of optimal habitat below the dam in creeks like Redwood, Carneros, Huachica, Murphy, Tulucay and Sarco would have remained accessible and could have provided for sufficient spawning and rearing habitat to have maintained the Napa River coho salmon population into the 20th Century.

The Water Board staff also quibbled with my characterization of low gradient habitats on the Napa Valley floor as the center of former coho salmon production:

> "Finally, we do not agree with the commenter that the only or primary historical habitat for coho salmon was in the lower reaches of the tributaries, instead we hypothesize that coho salmon would have occupied tributary channel reaches with Coast redwood. Douglas fir forest cover including canyon reaches of Redwood and Dry Creeks in the Mount Veeder area, Sulphur, Mill, and Ritchie Creeks, and similar habitat along upper Conn Creek (several tens of miles of pool riffle habitat with perennial flow and closed canopy)."

I previously acknowledged that low gradient reaches in forested tributaries would have been ideal coho salmon, if there were no barriers downstream. The map in Figure 1 was submitted previously and shows suitable reaches on benches in forested tributaries, such as Redwood Creek. Spence et al. (2005) found the Napa River to have 466 kilometers (km) of high intrinsic potential (IP) coho salmon habitat and by far the largest extent of such habitat would have been on the valley floor. Side channels and beaver ponds cool with ample cool water due to hyporheic connections would have provided a huge amount of habitat prior to disturbance. Of all rivers in the Central California Coast (CCC) Evolutionarily Significant Unit (ESU), only the Russian River and Gualala River have more extensive high IP coho salmon habitat (Spence et al. 2005). NMFS not choosing to include the Napa River in the CCC likely has more to with politics or their professional opinion about the ability to recover coho salmon than potential historic productivity. Since all other populations of coho salmon in the San Francisco Bay have been extirpated and there are no other nearby source populations from which to draw gene resources, I agree that Napa River coho salmon are not likely recoverable.

<u>Chinook salmon</u>: The impacts to Chinook salmon from the historic dam at the approximate location of Trancas Road were likely greater than those to coho salmon because smaller tributaries below the dam would have been less suitable for spawning of the larger species. Therefore, the Water Board staff assertion that the dam may have eliminated native Chinook salmon runs has more merit. Erratic patterns of abundance, as reflected by Napa County Resource Conservation District (NCRCD 2009, 2010) downstream migrant trapping results (Figure 2 & 3), indicate that the population is not stable or secure. Only one Chinook salmon downstream migrant was trapped in 2009, but there were 1520 juveniles captured and counted in 2010. Very low flows in late 2008 and early 2009 may have lead to very low Chinook salmon spawning and the lack of downstream migrants trapped. The 2010 water year allowed greater potential for access and had higher counts. Water Board staff mention genetic studies to determine whether Napa River Chinook salmon are hatchery strays and results from such studies should be shared expeditiously when available.

<u>Steelhead Trout</u>: The NCRCD (2009) is doing a very professional job in operating a Napa River downstream migrant trap that will provide an excellent basis for developing population estimates of steelhead in the future. The first two years of results (Figure 2 & 3) show that steelhead production is relatively low and highly variable. The NCRCD (2009) captured 128 steelhead smolts and 910 young of the year in 2009, but total steelhead juveniles captured in 2010 was 388. The small number of fish marked and relocated upstream to calibrate trap efficiency and the low recapture rate do not allow for population estimation and greater effort in the future in this regard is needed.

The capture of only 388 juveniles in 2010 is likely indicative of low carrying capacity for older age juveniles during the 2009 water year when flows were very low. This is consistent with concerns raised in previous comments about carrying capacity for juvenile steelhead rearing in dry years. Dewberry (2001, 2003) organized dive counts of steelhead juveniles in many Napa River tributaries in 2001 and 2002 and found that only Dry Creek had consistently high juvenile steelhead standing crops (> 1 fish/meter^2 for >500 meters) in both years. Watersheds of secondary importance included Redwood, Pickle, Richie, Heath, Carneros, Bell and Huichica creeks. Dewberry's (FONR 2004) map of results is included with these comments as Appendix A. Even in watersheds where Dewberry (2001, 2003) found high concentrations of steelhead juveniles, there were many reaches in the same creeks with low or no steelhead present. Only 9% of reaches had high concentrations of steelhead in 2001, which was a severe drought year, but these highly productive reaches expanded to only 19% of habitat surveyed in 2002. This

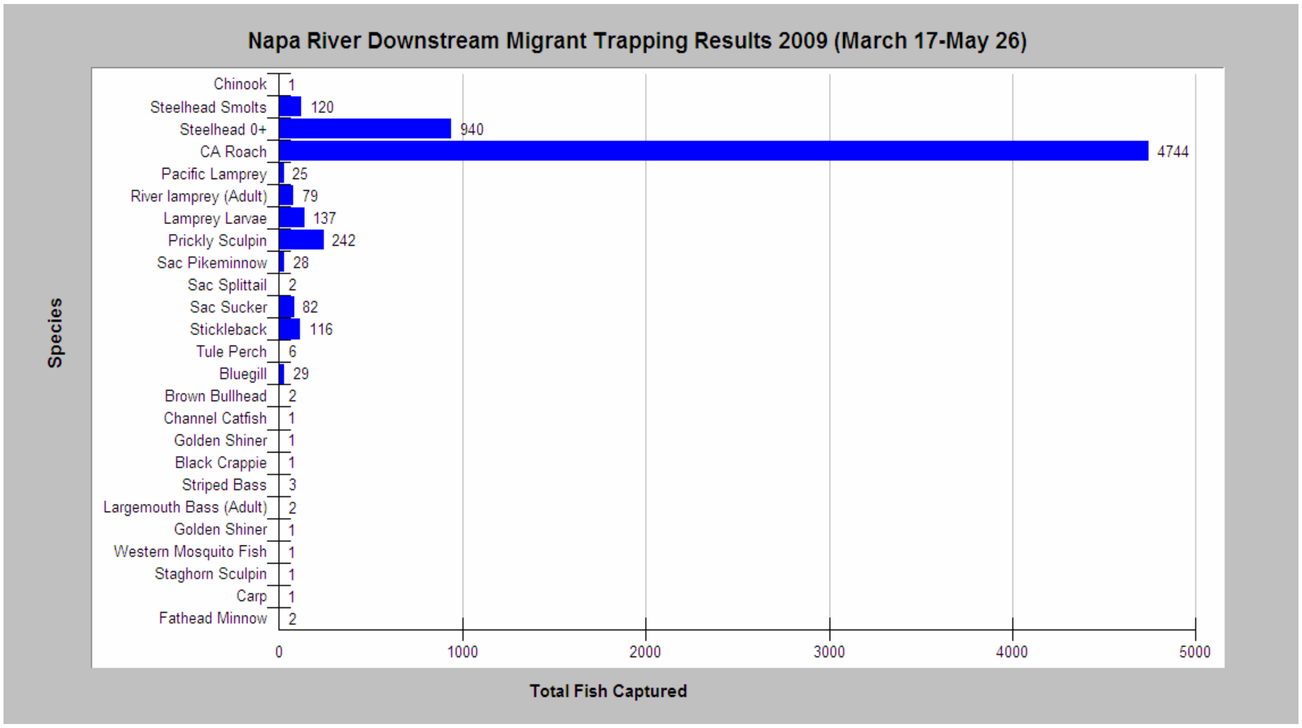


Figure 2. Downstream migrant trap results from NCRCD (2009) for the 2009 trapping season that extended from March 17 to May 26. There was only one Chinook juvenile captured but steelhead juveniles far outnumbered those in 2010.

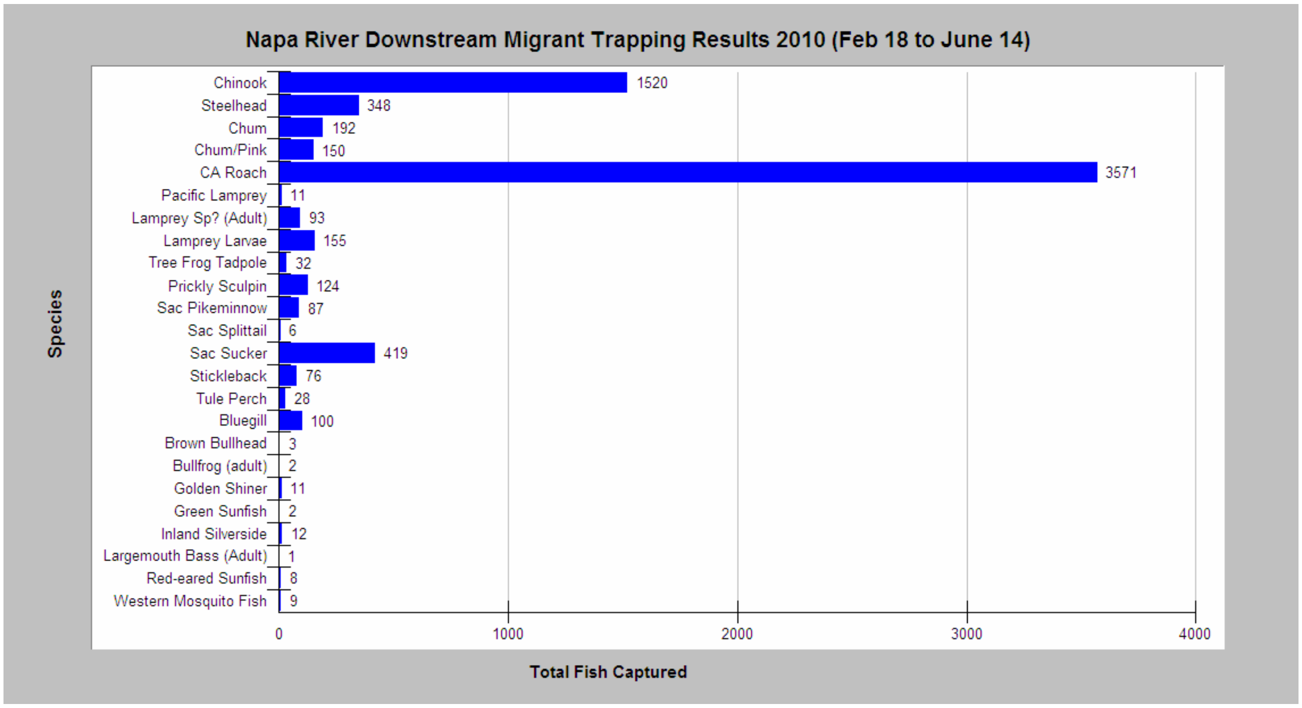


Figure 3. Downstream migrant trap results from NCRCD (2010) for the 2010 trapping season that extended from February 18 to June 14. More Chinook juveniles were captured than in 2009, but fewer steelhead.

indicates that even in good years that 80% of tributary habitat surveyed was marginally functional or non-functional. As mentioned in previous comments, the mainstem Napa River was formerly a very important nursery area for older age juvenile steelhead (Anderson 1969) that are most likely to survive to adulthood and that habitat is now completely non-functional for rearing. Therefore, all indications are that lack of older age steelhead rearing habitat is limiting the population and 2010 downstream migrant trap results show the influence of low water years in depressing smolt production.

Juvenile steelhead dive counts by the NCRCD (2010) in spring and fall of 2007 on York Creek show a pattern of substantial reduction in density except in pools, which indicates that flow depletion reduces seasonal and annual carrying capacity (Figure 4). This is likely a characteristic pattern throughout the basin and shows pervasive problems with over allocation of water. Although Water Board staff proposes a solutions to flow problems through cooperative efforts with other agencies, additional development of vineyards will be permitted under the TMDL if they comply with sediment mitigation measures embodied in Napa County ordinances and Fish Friendly Farming methods. Any additional vineyard development will increase water demand and further diminish steelhead habitat (see Cumulative Effects).

Fish Community Structure: The downstream migrant trap results show that warm water adapted species, such as the California roach are more numerous than salmonids, which is an indication of temperature impairment of the mainstem Napa River. Non-native fishes are numerous and diverse. Stillwater and Dietrich (2002) pointed out that the decreasing trend in salmonids in the Napa River has been accompanied by an increase in non-native warm water adapted species. That trend appears to be continuing. This is problematic because these fish not only compete for food and space with salmon and steelhead juveniles but also likely predate upon them. Occurrence of chum and possibly pink salmon juveniles in the 2010 downstream migrant trap catch indicates there may be a possible remnant population. Genetic work on these fish would be of interest for determining their origin.

Issue of Protection by TMDL of Areas Upstream of Reservoirs

Water Board staff reject Jackson's (2009) argument regarding the need to enforce TMDL standards above reservoirs to control increased peak flows stating that the reservoirs have the ability to capture flows and shave flood peaks. However, in other sections of the response to comments Water Board staff admits that the reservoirs are not operated for flood control and often pass flows through in late winter. Consequently, concerns about peak flow effects from lands upstream of reservoirs and bed incision of tributaries and the lower mainstem Napa River are valid and remain unresolved.

Water Board staff is incorrect in asserting that lack of steelhead passage above reservoirs means that there is no potential for steelhead production. Titus et al. (2006) found that non-anadromous resident rainbow trout high in southern and south central coastal California watersheds may exhibit an anadromous life history, if washed downstream to the ocean. Similarly, sea run

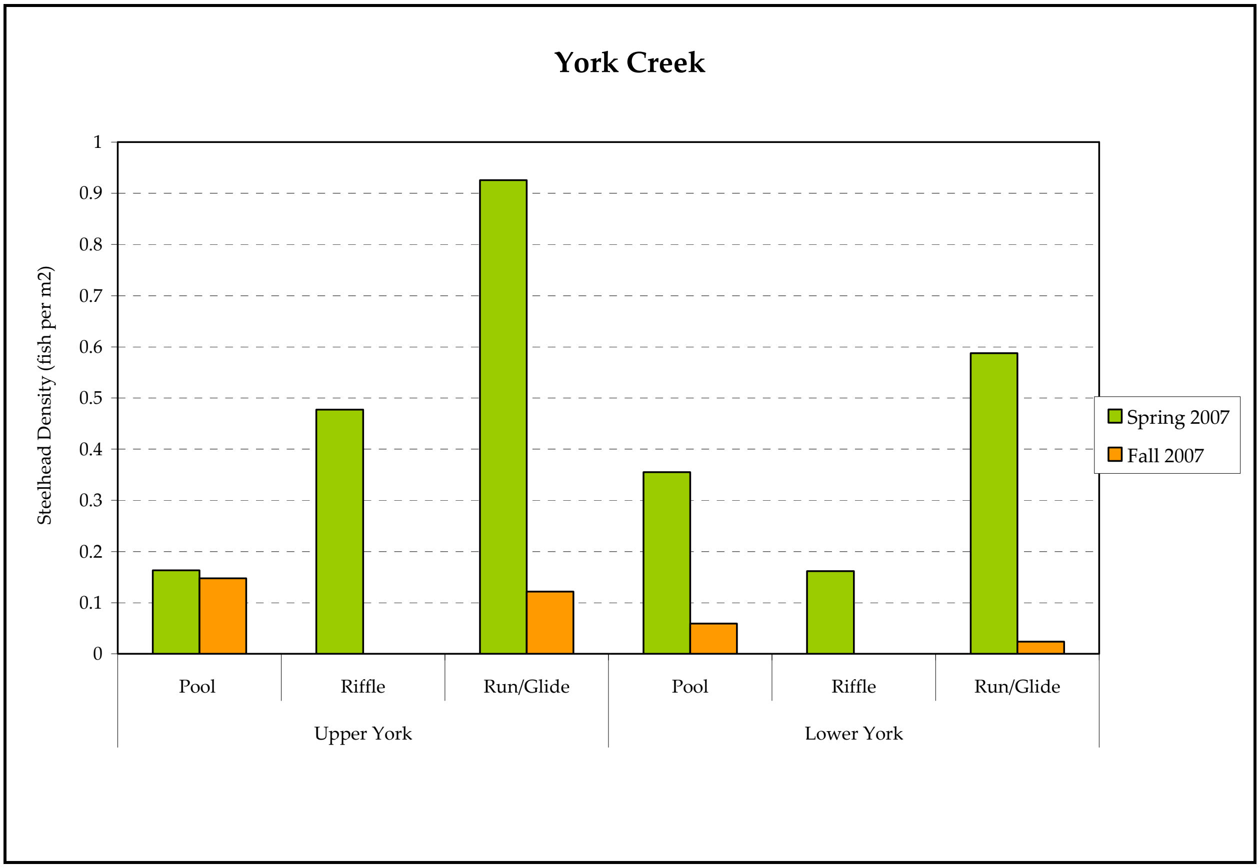


Figure 4. Standing crops of juvenile steelhead in York Creek in spring and fall 2007 show a substantial reduction likely as a result of flow depletion. Data from the NCRCD (2010)

steelhead may gain access to steep headwater streams in years of high flow and replenish "trout" populations. Populations of rainbow trout above dams in the Carmel River watershed are thought to have provided a mechanism for rebuilding anadromous steelhead runs after a prolonged drought had prevented steelhead spawning from 1987 to 1991 (Good et al. 2005, Boughton et al. 2006, Moyle et al. 2008). Landlocked populations of rainbow trout above Napa River dams likely have steelhead ancestry and should be fully protected.

Cumulative Effects Not Dealt With in Substance

As pointed out in previous comments, numerous scientific studies of the impacts of watershed disturbance on aquatic ecosystems in northern California indicate that damage cannot be prevented with on-site mitigation, if disturbance is too widespread (Ligon et al. 1999, Dunne et al. 2001, Collison et al. 2003). Water Board staff continues to argue that compliance with Napa County ordinances and Fish Friendly Farming measures during vineyard construction and operation will prevent increased sediment yield and elevated peak flows despite the fact that these activities cover tens of thousands of acres. Collison et al. (2003) point out that mitigation measures may appear to work until major storm events occur, at which time channel damage results.

It is disappointing that the Water Board staff refuses to consider a limit on road construction and road density, when roads likely contribute to increased peak flow and decreased baseflow (Wemple et al. 1996) by disrupting groundwater storage and increasing peak flows (Figure 5).

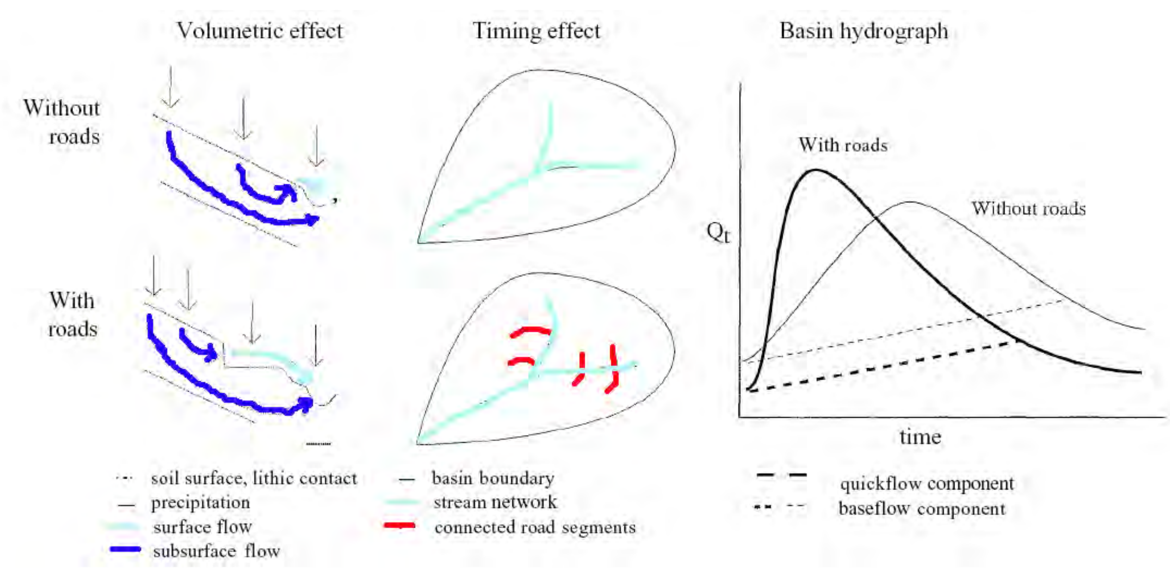


Figure 5. Illustration from Wemple et al. (1996) with color highlights added showing how groundwater storage can be decreased and the timing and magnitude of peak flow altered by road construction.

Wemple et al. (1996) point out that roads actually function to extend stream networks, which is one of the mechanisms for peak flow increase. Roads often cause gully erosion, particularly on steep ground, and these gullies not only contribute erosion but may also serve as channel extensions as well (Wemple et al. 1996).

The Water Board and NCRCD are conducting pilot projects in the Carneros and Sulfur Creek watersheds "to implement BMPs to identify, prioritize, and repair problem roads in the Carneros Creek and Sulphur Creek tributary watersheds", which is commendable. However, while incrementally reducing sediment contributions to the Napa River, cumulative effects damage is likely to continue because few or no roads or road segments are being decommissioned.

As pointed out above, additional development of vineyards or rural residential areas will increase water demand and, unless limits are set, ultimately there will be no water left for fish. It is highly commendable that the Water Board is a catalyst for a cooperative effort between the State Water Resources Control Board Water Rights Division (WRD), California Department of Fish and Game (CDFG), Napa County and the National Marine Fisheries Service (NMFS) to maintain stream flows. Furthermore, Water Board staff is recommending that compliance with all water rights laws be a criterion for eligibility for a waste discharge permit or to obtain a waiver of waste discharge requirements. The highest priority for flow protection needs to be in Dry Creek, as recommended by Dewberry (2003), because it has the highest standing crop of juvenile steelhead and represents the best remaining habitat (Bradbury et al. 1995).

The response to comments (SFBRWQCB 2009) states that "staff will propose that landowners develop a stream and riparian corridor management plan to passively or actively recover geomorphic and ecological processes in unstable channel reaches" as part of waste discharge permits or WDRs. The problem is that such on site treatment will not succeed because the footprint of development is too large and processes such as sediment flux and elevated peak flow will be confounding. Similarly, if groundwater withdrawals that effect surface flow and drop the near stream water table are not prevented or abated, then riparian tree mortality will occur or riparian restoration will become much more challenging.

Monitoring Tools and Their Application

The SFBRWQCB (2009) responded to criticism of monitoring tools in previous comments in the following way:

> "The US Environmental Protection Agency and independent peer reviewers have found the proposed sedimentation parameters (streambed permeability and redd scour) and the associated monitoring program acceptable. In response to previous comments by Living Rivers Council on this topic, we also have indicated our intent to monitor turbidity, and residual pool volume."

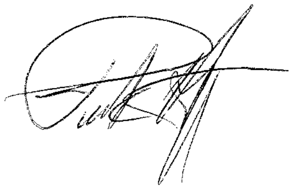
I agree that scour and fill of the stream bed is a reliable indicator of spawning success and that scour and fill targets of 15 cm are appropriate. However, recent literature (Horner et al. 2005, Kondolf et al. 2008) indicate that use of permeability as an indicator of spawning gravel quality and fish egg and alevin survival and growth remain problematic. Kondolf et al. (2008) point out that each permeability sample only represents the area within 20 cm radius and describe potential problems:

> "A small number of permeability tests may not accurately characterize a habitat zone such as a riffle, and the number of these tests required to accurately characterize the permeability of a habitat zone could be prohibitive. Field workers who have used these methods commonly report one or two orders of magnitude variability in permeability estimates within a habitat zone or over small intervals of the stream (Bush 2006). This variability may be a combination of leakage along the annulus of the standpipe, small zone of influence for individual tests, and a highly heterogeneous natural environment."

American River gravel quality studies by California State University at Sacramento (CSUS) (Horner et al. 2005) used three methods of measuring permeability, but results did not agree. They found values of permeability using the Terhune (1958) standpipe and methods of Barnard and McBain (1994) ranging from zero cm/hr to more than 100,000 cm/hr. Only three sites rated less than the 7000 cm/hr. target set in the Napa River TMDL. The 7000 cm/hr is not based on literature that correlates it with successful salmon or steelhead egg and alevin survival. Kondolf et al. (2008) recommend gauging the fitness of fry emerging from the gravel where measurements have been taken to establish the relationship of permeability and other gravel quality metrics and the growth and survival of salmonids. If metrics with better known relationships were used (McNeil and Ahnell 1964), then such difficult and expensive correlation studies would not be necessary.

While the Water Board staff has committed to measuring turbidity and residual pool depth due to requests from LRC, there is no defined plan for establishment of continuous recording turbidity stations or any indication of where residual pool depths will be measured. At least ten continuous recording turbidity meters need to be installed in Napa River tributaries as soon as possible to discern whether restoration measures are working. For example, Carneros Creek has well identified problems with excess sediment over supply (Pearce and Grossinger 2005) and the NCRCD and Water Board staff are treating roads to reduce sediment yield. Consequently, a continuous turbidity meter on Carneros Creek needs to be installed as soon as possible to facilitate adaptive management.

Sincerely,



Patrick Higgins

References

Anderson, K. R., CDFG. 1969. Steelhead Resource, Napa River Drainage, Napa County. California Department of Fish and Game, Yountville, CA.

Barnard, K. and S. McBain. 1994. Standpipe to Determine Permeability, Dissolved Oxygen, and Vertical Particle Size Distribution in Salmonid Spawning Gravels. As FHR Currents # 15. US Forest Service, Region 5. Eureka, CA. 12 pp.

Boughton, D.A., P.B. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelly, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Steelhead of South-Central/Southern California Coast: Population Characterization for Recovery Planning. NOAATM- NMFS-SWFSC-394. National Marine Fisheries Service Southwest Fisheries Science Center. 123 p.

Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D. L. Bottom, W.E. Weaver and R. L. Beschta. 1995. Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Pacific Salmon. Published by Pacific Rivers Council, Eugene, OR. 56 p.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

Dewberry, C. 2001. Whole-basin Snorkel Count for Steelhead Trout in the Napa Watershed, California (Year 2001). Performed under contract to Ecotrust and the Friends of Napa River by Dr. Charles Dewberry, Florence, OR. 6 p.

Dewberry, C. 2003. Development and Application of Anchor Habitat Approaches to Salmon Conservation: A synthesis of data and observations from the Napa watershed, California. Performed under contract to Ecotrust and the Friends of Napa River by Dr. Charles Dewberry, Florence, OR. 10 p.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of

California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.

Friends of Napa River. 2003. Map of reaches of high juvenile steelhead production in the Napa River. Prepared by Friends of Napa River in support of study by Dr. Charles Dewberry. Napa, CA 1 p.

Higgins, P.T. 2006. Comments on the Napa River Sediment TMDL and San Francisco Bay Regional Water Quality Control Board Basin Plan Amendment. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 21 p. 8/14/06.

Higgins, P.T. 2007. Napa River Sediment TMDL SFBRWQCB Staff Response to Comments. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 5 p. 01/22/07.

Higgins, P.T. 2008. Re: Final Napa River Watershed Sediment TMDL and Habitat Enhancement Plan Negotiations. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 3 p. 7/21/08

Higgins, P.T. 2009. Comments on Proposed Basin Plan Amendment for Napa River Sediment Total Maximum Daily Load, TMDL Implementation and Protecting and Restoring Pacific Salmon (Cold Water Beneficial Use). Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 25p. 6/27/09.

Horner, T., E. Morita, T. Bishop, M. Silver and A. Head. 2005. American River Gravel Studies 2005: Physical and geochemical characteristics of American River Spawning Gravels, Second year report (2003/2004 season). Submitted to US Bureau of Reclamation, Sacramento office by the CSUS Geology Department, Sacramento, CA. 147 p.
http://www.sacstate.mobi/indiv/h/hornert/American River gravel studies 2005.pdf

Jackson, D. 2009. Comments on Napa Sediment TMDL and Basin Plan Amendment. Performed for Thomas Lippe Attorney at Law and Living Rivers Council. July 2, 2009. By Dennis Jackson, Hydrologist, Santa Cruz, CA.

Kondolf, G.M., J.G. Williams, T.C. Horner, and D. Milan. 2008. Assessing Physical Quality of Spawning Habitat. American Fisheries Society Symposium 65:000–000, 2008. 27 p.
http://www.csus.edu/indiv/h/hornert/Kondolf et al 2008.pdf

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and salmonid habitat. Prepared for the Resources Agency of California and the National Marine Fisheries Service. Sacramento, CA. 181 pp. http://www.krisweb.com/biblio/cal_nmfs_ligonetal_1999_srprept.pdf

McNeil, W.J. and W.H. Ahnell, 1964. Success of pink salmon spawning relative to size of spawning bed materials. US Fish and Wildlife Service, Special Scientific Report-Fisheries No. 469. Washington, D.C. January 1964.

Moyle, P.B., J. A. Israel, and S. E. Purdy. 2008. Salmon, Steelhead, and Trout in California: Status of an Emblematic Fauna. Commissioned by California Trout. 316 pp.

Napa County Resource Conservation District (NCRCD). 2009. Napa River Steelhead and Steelhead Monitoring Program – Year 1 Report. NCRCD, Napa, CA. 16 p.

Napa County Resource Conservation District (NCRCD). 2010. Electronic files provided by Jonathan Koehler via email and posted to the Internet. NCRCD, Napa, CA.

Napolitano, M., S. Potter and D. Whyte. 2006. Draft Napa River Sediment Total Maximum Daily Load (TMDL) Staff Report. SF Bay Regional Water Quality Control Board, Oakland, CA. 131 pp.

Napolitano, M., S. Potter and D. Whyte. 2009. Napa River Watershed Sediment TMDL and Habitat Enhancement Plan: Staff Report. May 2009. SF Bay Regional Water Quality Control Board, Oakland, CA. 163 p.

Pearce, S.A. and R.M. Grossinger. 2004. Relative effects of fluvial processes and historical land use on channel morphology in three sub-basins, Napa River basin, California. San Francisco Estuary Institute, 7770 Pardee Lane, Oakland, CA 94621, USA.

Reeves, G.H., L.E.Benda, K.M.Burnett, P.A.Bisson, and J.R. Sedell. 1995. A Disturbance-Based Ecosystem Approach to Maintaining and Restoring Freshwater Habitats of Evolutionarily Significant Units of Anadromous Salmonids in the Pacific Northwest. American Fisheries Society Symposium 17:334-349, 1995.

Rieman, B., D. Lee, J. McIntyre, K. Overton, and R. Thurow. 1993. Consideration of extinction risks for salmonids. As FHR Currents # 14. U.S. Department of Agriculture, Forest Service, Region 5 . Eureka, CA. 12 pp.

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). 2009a. Napa River Sediment Reduction and Habitat Enhancement Plan. Basin Plan Amendment to Chapter 7 (Water Quality Attainment Strategies and TMDLs). 5/13/09. SFBRWQCB, San Francisco, CA. 20 p.

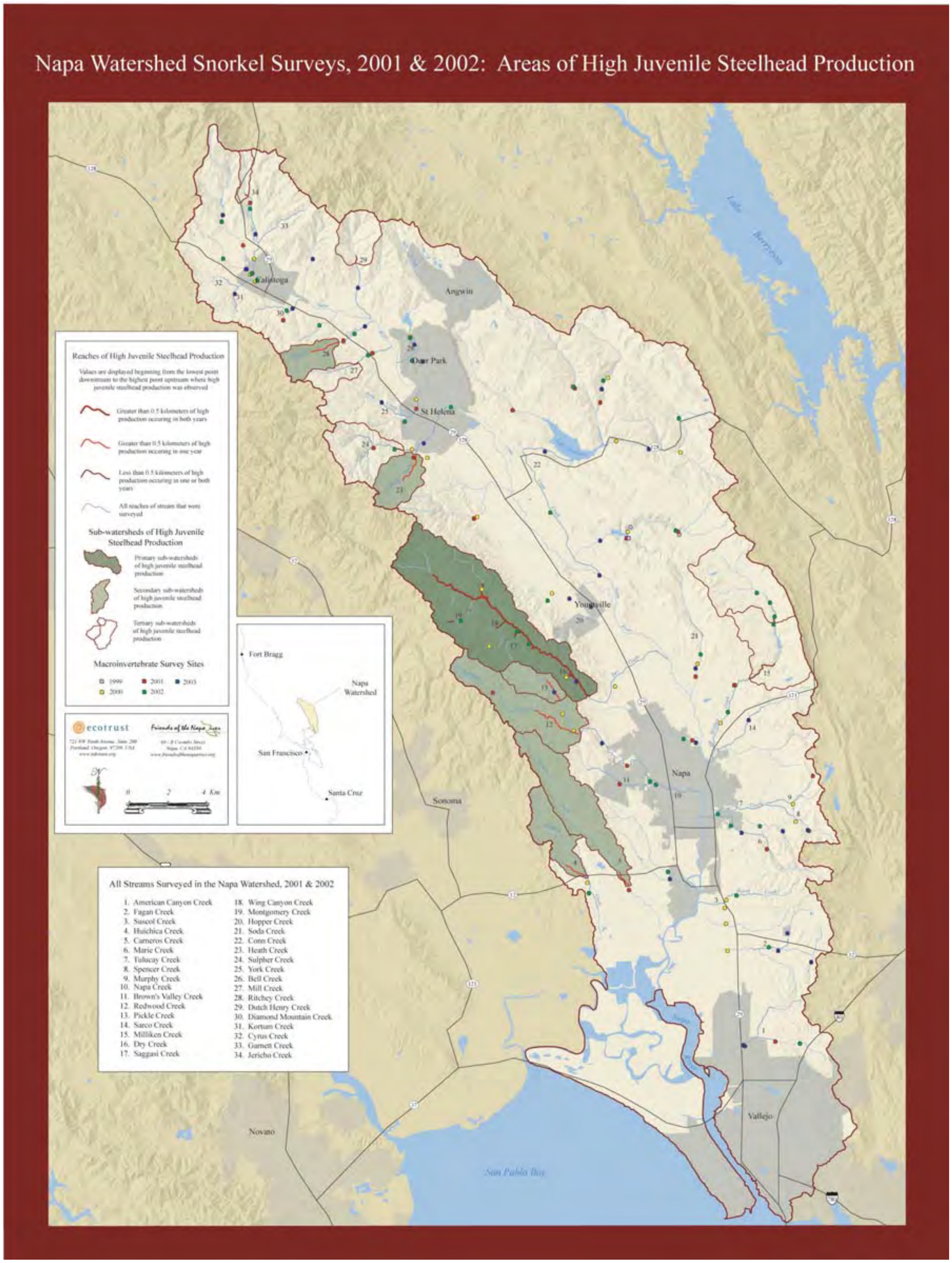
San Francisco Bay Regional Water Quality Control Board. 2009b. Napa River Sediment TMDL Appendix D: Responses to Comments. August 31, 2009, SFBRWQCB, San Francisco, CA. 84 p.

Spence, B.C., S.L. Harris, W.E. Jones, M.N. Goslin, A. Agrawal and E. Mora. 2005. Historical Occurrence of Coho Salmon of the Central California Coast Coho Salmon evolutionarily Significant Unit. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-383. NMFS SW Region, Long Beach, CA. 89 p.

Stillwater Sciences and W.E. Dietrich, 2002. Napa River Basin Limiting Factors Analysis. Final Technical Report prepared for San Francisco Bay Water Quality Control Board, Oakland, Calif., and California State Coastal Conservancy, Oakland, Calif.. June 14, 2002.

Titus, R. G., D. C. Erman, and W. M. Snider. 2006. History and status of steelhead in California coastal drainages south of San Francisco Bay. In draft for publication as a Department of Fish and Game, Fish Bulletin. 293 p.

Appendix A. Map of reaches of high juvenile steelhead production in the Napa River (FONR)



NAVARRO RIVER FLOWS

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April 2, 2008

Karen Niiya
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Re: Comments on *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams*

Dear Ms. Niiya,

I have reviewed the *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams* on behalf of the Redwood Chapter of the Sierra Club and provide comments on their behalf below. In addition to commenting specifically on the proposed *Policy*, I provide information on the status of Pacific salmon species in northern California, climatic cycles that affect salmon abundance, and on the interplay of cumulative watershed effects caused by land use management and those caused by diversion. I also provide case studies of several northern California watersheds where water diversion is limiting Pacific salmon, including ones outside the area defined by the *Policy*.

I have read the *Draft Policy* and read peer review comments from Dr. Lawrence Band (2008), Dr. Margaret Lang (2008), Dr. Robert Gearheart (2008), Dr. Charles Burt (2008), and Dr. Thomas McMahon (2008). In addition I read or reviewed McBain and Trush and Trout Unlimited (MTTU, 2000), California Department of Fish and Game and National Marine Fisheries Service (2002) guidelines for central California coastal streams and Appendices to the *Policy* (Stetson Engineering, 2007a; 2007b; R2 Consulting, 2007a; 2007b; 2007c). Although I find the *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams* to have substantial technical merit, much more action is needed on regulation of water use to prevent the further decline of Pacific salmon stocks and the likelihood of stock extinctions.

Qualifications

With regard to my qualifications, I have been a consulting fisheries biologist with an office in Arcata, California since 1989 and my specialty is salmon and steelhead restoration. I authored fisheries elements for several large northern California fisheries and watershed restoration plans (Kier Associates, 1991; Pacific Watershed Associates, 1994; Mendocino Resource Conservation District, 1992) and co-authored the northwestern California status review of Pacific salmon species on behalf of the American Fisheries Society (Higgins et al., 1992). Although I am not a hydrologist, I have considerable expertise in the area of water use and its effect on Pacific salmon.

Since 1994 I have been the project manager for a regional fisheries, water quality and watershed information database system, known as the Klamath Resource Information System or KRIS (www.krisweb.com). This custom program was originally devised to track restoration success in the Klamath and Trinity River basins, but has been applied to another dozen watersheds in northwestern California, including a number that fall within the targeted area of the *Policy*.

The California Department of Forestry (CDF) funded KRIS projects in the Mattole, Ten Mile, Noyo, Big and Gualala rivers as part of the North Coast Watershed Assessment Planning effort. The Sonoma County Water Agency (SCWA) also funded regional KRIS projects (IFR, 2003), including ones for the Garcia, Russian and Navarro rivers and tributaries of the Pacific Ocean and San Francisco Bay in Marin and Sonoma Counties. I am submitting a DVD including all KRIS projects for the geographic area covered by the *Policy*.

Since January 2004, I have been working under contract with the Klamath Basin Tribal Water Quality Work Group, a consortium of environmental departments of Lower Klamath River Basin Indian Tribes, to improve enforcement of the Clean Water Act. Through work on review of Total Maximum Daily Load (TMDL) reports, I have become further acquainted with factors limiting Pacific salmon, including those related to flow depletion.

I also have extensive field experience as a field biologist in the South Fork Trinity, Klamath, Eel, Navarro, Mattole and Garcia rivers as well as smaller coastal streams from Humboldt Bay to San Diego County.

Overview

The *Policy for Maintaining Instream Flows in Northern California Coastal Streams* (*Policy*) (SWRCB WRD, In Review) was created in response to California Assembly Bill 2121, which requires the State Water Resources Control Board (SWRCB) Water Rights Division (WRD) to adopt principles and guidelines for maintaining instream flows in coastal streams from the Mattole River to Marin County and in coastal streams entering northern San Pablo Bay (Figure 1). Much of the *Policy* is derived from a California Department of Fish and Game (CDFG) and National Marine Fisheries Service (NMFS) central California coast water supply paper (CDFG and NMFS, 2002). The *Policy* proposes to:

1) Restrict new appropriative rights for diversion of surface water to October 1 to March 15,
2) Establish minimum bypass flows,
3) Set cumulative diversion limits, and
4) Discontinue permitting dams on Class I and II streams.

The *Policy* also calls for universal screening of new diversions, construction of fish passage facilities, non-native species control and riparian restoration. Appropriate monitoring parameters are identified in the Policy and the adaptive management strategy is theoretically sound (Band, 2008; McMahon, 2008).

Unfortunately, the *Policy* will only be narrowly applied to new appropriative water right applications in a restricted geographic area and does not deal with other aspects of long recognized water supply problems. Shortcomings of the approach include:

- No action to assess summer and fall flows, when the most critical flow shortages for juvenile salmonid rearing are known to occur,
- No recognition of changes in stream channels and watershed hydrology due to land use nor the implications for salmonid suitability or surface water supply,
- Applies only to new diversions seeking appropriative water rights and does not discuss potential problems due unlimited riparian water rights that could be exercised at any time,

Figure 1. North Coast area defined by the *Policy* to which the statutes defined therein will be applied. It does not cover the Klamath or Eel River basins that have greater need of water rights reform and greater potential for salmon and steelhead recovery.

- Insufficient consideration of ground water extraction despite known linkage to diminished surface flow and carrying for Pacific salmon species regionally,
- Enforcement discussion shows the WRD refuses to enforce water law and to provide a disincentive for unpermitted water use, creating an epidemic problem of illegal diversions, and
- The *Policy* recommends recognizing Watershed Groups that are comprised of diverters and envisions transfer of many SWRCB WRD responsibilities to such local extraction interests.

Although AB 2121 has forced publication of this *Policy*, there seems to be a great deal of reluctance on behalf of the SWRCB WRD to fully engage in this effort as indicated by the tone of the report, a lack of willingness to set limits on diversion and to enforce CA Water Code § 1052, 1055, 1243, and 1375. Also the geographic area of the *Policy* does not cover some northern California watersheds with greater need for water rights reform for Pacific salmon species protection, such as the Scott, Shasta and Eel Rivers. Consequently, the *Policy* is not likely to recover coho salmon, Chinook salmon and steelhead in northern California.

Policy Framework

The SWRCB WRD has been working on this *Policy* for more than a decade (R2 Consultants, 2007a) and there is a great deal of merit in the theoretical basis for its minimum base flow and maximum cumulative diversion calculation. Dr. Lawrence Band (2008) summed limitations and benefits of the *Policy*:

> "The documents provided for review contain a set of references to the limited time and budget available for data collection and analysis, and present very limited field sampling at one specific time, with flow records drawn from different periods of time. Given these limitations, the approach adopted in the proposed policy, to provide more conservative restrictions on in-stream water use at the regional level, is a sound strategy."

There are, however, some instances where the *Policy* strays from a sound scientific basis and potential major data gaps will likely confound the application of the system. The five elements of the *Policy* framework are listed below with observations of peer reviewers and my own comments.

1. *"Water diversions shall be seasonally limited to periods in which instream flows are naturally high to prevent adverse effects to fish and fish habitat."*

In fact, the only limitation on water diversions would be on new appropriative water rights applicants and no study or action is envisioned for extraction from April through October, when flows are severely limiting for juvenile salmonid rearing. Dr. Thomas McMahon (2008) cautions that the entire exercise will be confounded due to this deficiency:

> "Implementation of a diversion season along with the proposed minimum base flow (MBF) and maximum cumulative diversion (MCD) standards to maintain the fall-winter hydrograph could offer a false sense of protection to the listed species if flow levels during other seasons are insufficient to support the completion of rest of the freshwater life cycle."

The Policy gives little or no scientific defense of its choice of October 1 versus December 15 as the start up of the winter water diversion:

> "Although the DFG-NMFS Draft Guidelines recommended a season of diversion from December 15 through March 31, an earlier diversion season start date is still protective of fishery resources when minimum instream flows and natural flow variability are maintained. This policy limits new water diversions in the policy area to a diversion season beginning on October 1 and ending on March 31 of the succeeding year."

Band (2008) points out that "the recommended limits of October 1 to March 31 is a compromise between the two other options (all year diversions and December 15-March 31), but places the beginning of the diversion season at the beginning of flow increases and Chinook migration in most years." Dr. Margaret Lang concurred and recommended the later start date: "The December 15 start date is much more likely to prevent water diversion during the extreme low flows present before the onset of consistent rainfall." She notes that numerous years there is little runoff on the first major storms of the season, as soil pores and the groundwater matrix soak up most early rainfall.

2. *"Water shall be diverted only when stream flows are higher than the minimum instream flows needed for fish spawning and passage."*

Peer reviewers (Lang, 2008; McMahon, 2008) suggest that impacts on rearing salmonids need equal consideration with those on migrating and spawning adults. Steelhead juveniles typically spend two years in freshwater (Barnhart, 1989) and coho salmon spend a full year feeding before migrating to the ocean (Groot and Margolis, 1991). Dr. Lang (2008) points out that factors such as "food availability, food delivery from upstream, and hiding cover, that are also important and not well characterized" by modeling exercises and cites Harvey et al. (2006) as demonstrating differences in growth rates of juvenile salmonids between diverted and undiverted streams.

Again there is no mention of limiting diversion from April through October, no limit proposed for riparian diversions that do not require off-stream storage, nor restrictions on ground water extraction to actually maintain and restore flows for salmon and steelhead, even if the *Policy* were enacted (Band, 2008; Gearheart, 2008).

3. *The maximum rate at which water is diverted in a watershed shall not adversely affect the natural flow variability needed for maintaining adequate channel structure and habitat for fish.*

This policy requires calculation of minimum base flow (MBF) and maximum cumulative diversion (MCD), but lack of recent or historic flow data and problems with application of models confound accurate estimates (Lang, 2008). Even if the MBF and MCD were accurately calculated, they do not properly account for interactions between diversions. Synergy between diversions in multiple tributaries will cause unintended consequences on flows, fish passage and alteration of substrate quality in downstream reaches that need to be more fully considered (Band, 2008; Gearheart, 2008).

4. *Construction or permitting of new on-stream dams shall be restricted. When allowed, on-stream dams shall be constructed and permitted in a manner that does not adversely affect fish and their habitat.*

Although future permit activities may restrict the construction of new dams, there are 1771 illegal dams already constructed within the geographic area covered by the *Policy* (Stetson Engineers, 2007a) (Figure 3) for which permits are being considered. Avoiding cumulative effects from thousands of impoundments, many of which are on Class I streams that contain salmonids, will not be possible without widespread enforcement action to remove a significant number of these illegal dams.

Several peer reviewers express reservations about damming and diversion of small headwater tributaries (Band, 2008; McMahon, 2008). Band (2008) notes a high risk of cumulative effects despite mitigations proposed for such projects in the *Policy*. According to McMahon (2008) "dams on ephemeral streams have the potential to greatly dampen the early fall/winter freshets important for access to the upper reaches of small spawning tributaries by their capture of the entire flow within the stream until the reservoir is filled, potentially resulting in significant dewatering downstream."

5. *The cumulative effects of water diversions on instream flows needed for the protection of fish and their habitat shall be considered and minimized.*

The *Policy* does not properly deal with cumulative effects of diversions (Gearheart, 2008; Band, 2008) nor those associated with long term changes to streams and watershed hydrology due to land use that effect surface and ground water availability (see Cumulative Effects). Gearheart expressed the following concern:

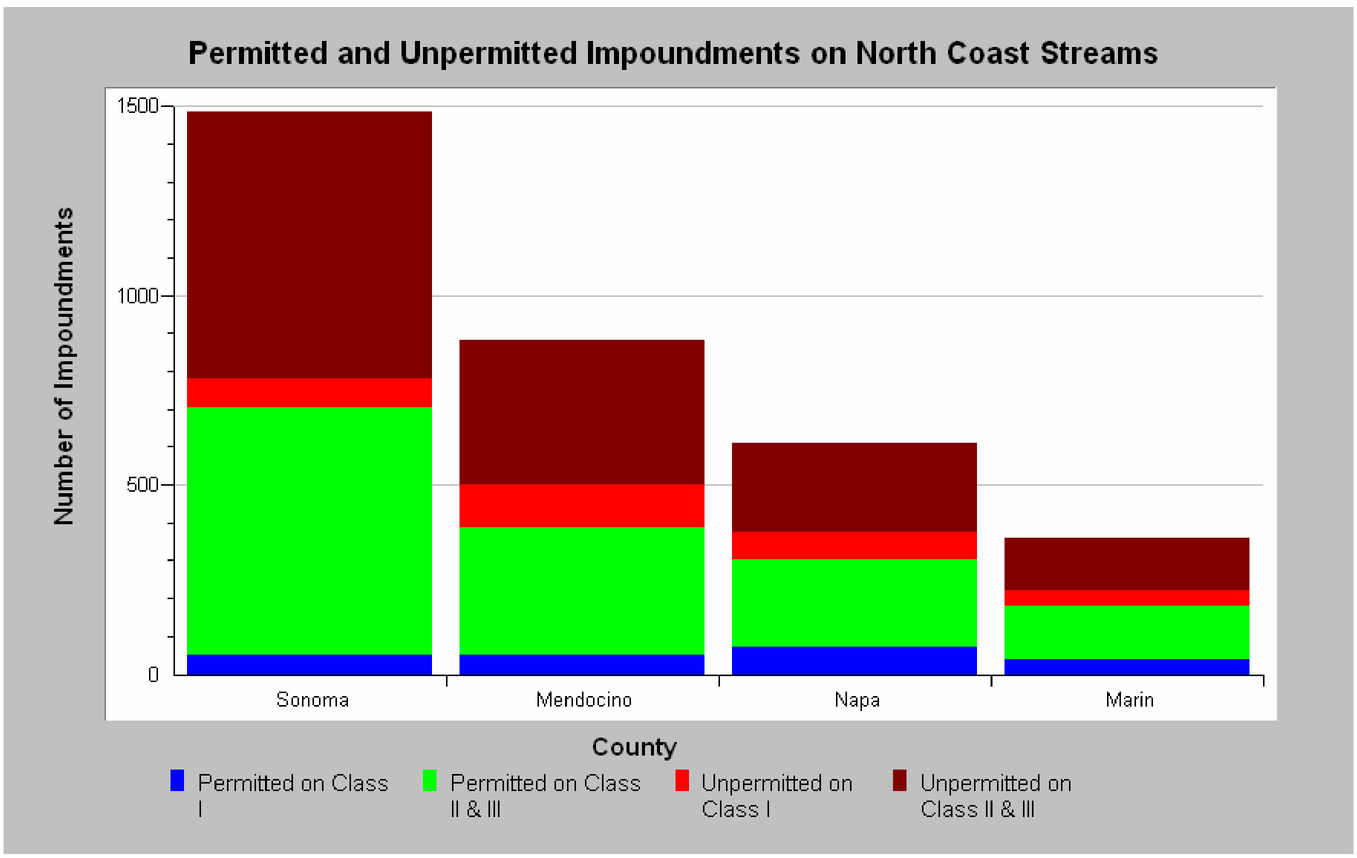


Figure 2. The number of permitted and unpermitted impoundments within the geographic area covered by the *Policy* is displayed above with illegal diversion impoundments outnumbering legal ones. Data from Stetson Engineers (2007a).

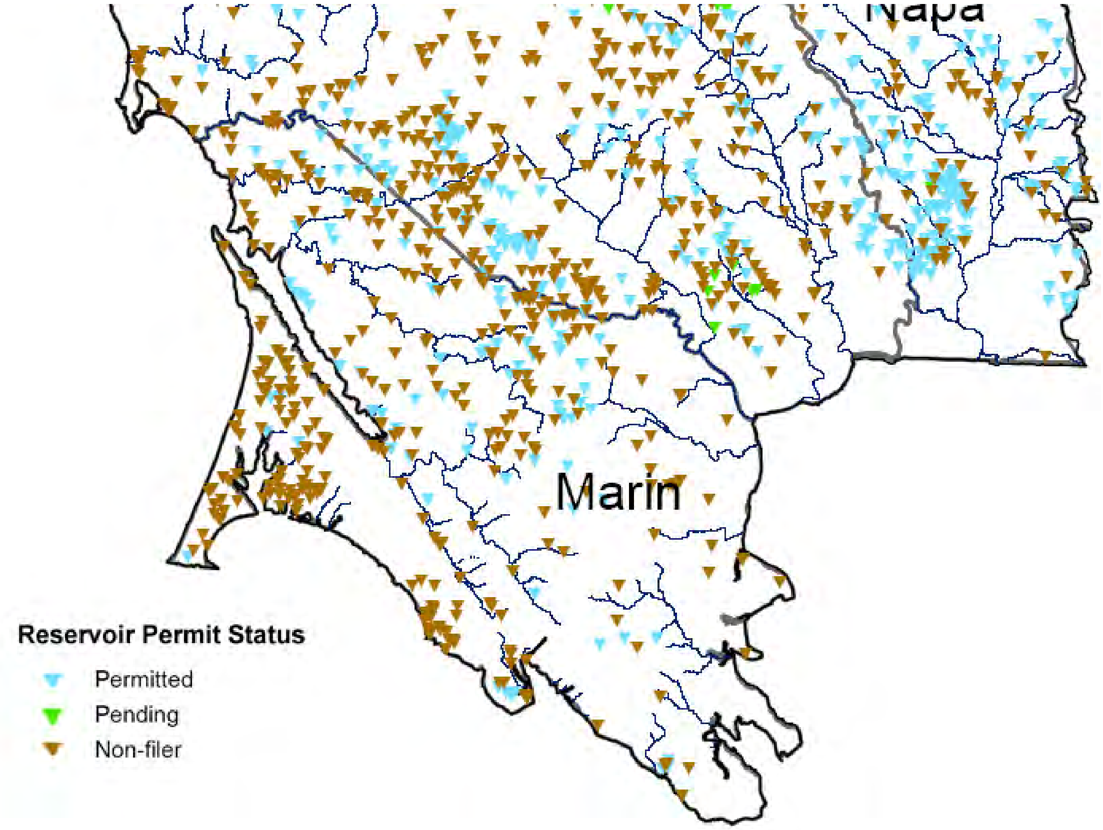


Figure 3. The number of Marin County, southern Sonoma and Napa County diversion impoundments displayed above demonstrate the challenge that an appropriative right water applicant faces in inventorying quantities diverted. Stetson Engineers (2007a) Figure A-3.

> "It appears to me as one evaluates the cumulative effect of scalping 5% of the peak as the storm hydrograph precedes down stream the reduction in the total flow reduces and the delay time (1/2 day recession -flow restricted) increases."

Band (2008) suggests that flow depletion below stream convergence points will magnify fluctuations. This in turn will cause depositions of fine sediment and other undesirable channel changes that could affect spawning salmon and steelhead downstream (see Cumulative Effects).

<u>Minimum Base Flow (MBF) and Maximum Cumulative Diversion (MCD)</u>: The Policy hinges on relatively accurate estimate of MBF and MCD. Although the scientific basis for calculation of these statistics is theoretically sound, accurate calculation is confounded by lack of historic records and problems with model simulations.

The *Policy* defines the MBF as "the minimum instantaneous flow rate of water that must be moving past the point of diversion (POD) before water may be diverted" and recommends 60% of the mean annual unimpaired flow (0.60 Q_m) as needed for flows and fish passage in watersheds greater than 290 square miles either at the point of diversion, or at the upper limit of anadromy. Lang (2007) states that 68% (0.68 Q_m) is actually needed for protection of fisheries resources and also points out that there may be substantial error in calculation of mean annual unimpaired flow because there are very sparse gauge data, often with periods of record of less than 10 years. Lang (2008) cautions additionally that model generated mean flow estimates may have significant error:

> "Scaling by watershed area and mean annual precipitation works reasonably well for peak and major storm flows dominated by the rainfall generated runoff (assuming the storm influences at nearby gauged sites are consistently similar to the watershed of interest) but at lower flows, more subtle factors such as watershed geology, slopes, ground cover, soil thickness, etc. influence the stream flow. The mean annual flow is as much a function of storm flows as low flows that do not generally correlate as well to drainage area."

The maximum cumulative diversion (MCD) is defined in the policy as "the largest value that the sum of the rates of diversion of all diversions upstream of a specific location in the watershed can be in order to maintain adequate peak stream flows. The maximum cumulative diversion criterion is equal to five percent of the 1.5-year instantaneous peak flow."

Lang (2008) recommended against the use of MCD in the Policy:

> "The analysis by R2 Resources (2007) and Stetson Engineers, Inc (2007) clearly shows that maximum cumulative diversion limits set as volumes failed to meet the stated criteria of providing for channel maintenance flows. Stating the criteria as a volume would not meet objectives of the policy."

Lang (2008) is joined by most other peer reviewers (Band, 2008; Gearheart, 2008; McMahon, 2008) in calling for additional data collection to better establish flow regime targets.

Water Availability Analysis: Before the SWRCB WRD can issue a permit for an appropriative water right, it must demonstrate that there is "unappropriated water available to supply the applicant" (CA Water Code § 1375) and that sufficient water for remains for "recreation and the preservation and enhancement of fish and wildlife resources" (CA Water Code § 1243). A multi-party regional assessment is laid out as part of the *Policy* plan, but it also envisions a great deal of information being contributed by permit applicants and permit holders (see Watershed Groups).

The *Policy* section entitled Data Submissions (4.1.1.1) repeatedly refers to public domain spreadsheets and programs. The issue is not whether data analysis and models are done using public or private software, but whether the raw data are made available and the computer codes for models are made available so that results can be fully audited. Any revision of the *Policy* should have clear language that specifies full raw data availability and model transparency.

Water Supply Reports and Instream Flow Analysis Required of Applicants: The *Policy* provides the following description of study requirements facing new applicants:

> "This policy requires a water right applicant to conduct a water availability analysis that includes (1) a Water Supply Report that quantifies the amount of water remaining instream after senior rights are accounted for, and (2) an Instream Flow Analysis that evaluates the effects of the proposed project, in combination with existing diversions, on instream flows needed for fishery resources protection."

The water supply report is *not* required to describe flow conditions in the stream or determine surplus availability for April through November. Applicants are asked, however, to hire consultants to make a case that there is surplus water available in winter. This will not only be expensive, the consultants may actually be unable to determine the amount of cumulative diversion without an extensive survey because of unregistered riparian rights, pre-1914 water rights and those that have been established illegally (Figure 3). They will also be forced to use models and simulated data that produce considerable error (Lang, 2008) as discussed above.

Effectiveness Monitoring: Most peer reviewers stress that extensive field data needed on an on-going basis to support adaptive management, or the implementation of the *Policy* will be seriously flawed (Lang, 2008; Band, 2008, Gearheart, 2008; McMahon, 2008). The tone of the *Policy* on this topic, however, is very disappointing and shows little commitment on behalf of the WRD with every passage in this section using *may* not will: "The State Water Board *may* develop and implement a policy effectiveness monitoring program."

Enforcement: The SWRCB WRD has clear authority to regulate water extraction and to penalize those who appropriate water without a permit:

> "Pursuant to Water Code section 1052, an unauthorized diversion or use of water is a trespass against the State subject to a maximum civil liability of $500 per each day of unauthorized diversion or use of water. Water Code section 1055, subdivision (a), provides that the Executive Director of the State Water Board may issue an Administrative Civil Liability (ACL) complaint."

The problem is the WRD's near absolute refusal to enforce the law. Stetson Engineering (2007a) lists 1771 unpermitted diversions in the North Coast region as defined by this project (Figure 2). They note the potential need to remove 1569 structures, but also note that 519 unpermitted structures now have pending permit applications. The pattern of non-enforcement is clear in a number of basins (Figure 3) and I have documented similar problems in northern California case studies below both inside and outside the *Policy* area (i.e. Napa, Navarro, Russian, Gualala, Scott, and Shasta).

The WRD has also been derelict in its duty with regard to CA Water Code § 1243 and 1375, which require that they protect recreation, fish and wildlife and that they establish a surplus before issuing permits, respectively. The WRD has failed to comply with these laws by simply not supplying permits other than after ponds and diversions have been illegally constructed. This has caused not only a loss of fish habitat but also treasured recreational opportunities enjoyed by past generations, such as swimming at the Scout Camp on the Wheatfield Fork of the Gualala or at Hendy Woods on the lower mainstem Navarro River.

Instead of active enforcement, the WRD relies on mechanisms like self-enforcement, whereby permit holders self-report violations, and on complaints from citizens. I know several individuals who have filed hundreds of complaints over several decades with the WRD and have had few resolved as a result (Bob Baiocchi; Stan Griffin, personal communication).

The reluctance to enforce the law is evident in the following passage from the Policy:

> "Every violation deserves an appropriate enforcement response. Because resources may be limited, however, the State Water Board will balance the need to complete its non-enforcement tasks with the need to address violations. It must also balance the importance or impact of each potential enforcement action with the cost of that action. Informal enforcement actions, described below, have been the most frequently used enforcement response. *Such informal actions will continue to be part of this policy for low priority violations*."

Figure 4. Navarro River at Hendy Woods State Redwood Park is so flow depleted that only a stagnant pool not suitable for human contact remains. The mainstem Navarro was formerly rearing habitat for juvenile steelhead (Kimsey, 1952) and a major recreational draw during the hot days of summer and fall. CA Water Code § 1243 is clearly not being upheld in this basin. Photo by Pat Higgins from KRIS Navarro. September 21, 2001.

Some of the WRD criteria for prioritization include any violations:

- On Class I or Class II streams,
- That threaten or cause a take of endangered species,
- That constitute waste, unreasonable use, or unreasonable method of use,
- That illegally take water in a fully appropriated stream system, or
- That injure a prior right holder.

Despite pages of text on enforcement, there is no specific plan mentioned for decommissioning dams that are high priority. Almost all dams in the region effect at-risk salmonids and 308 illegal impoundments are on Class I streams (Figure 2) (Stetson Engineering, 2007 a). The Sierra Club (Pennington et al., 2008) points out that allowing diverters to avoid permit fees and costs of compliance offers them an unfair business advantage as well.

Informal Enforcement: "The purpose of an informal enforcement action is to quickly bring a violation to the water diverter's attention and to give the diverter an opportunity to voluntarily correct the violation and return to compliance as soon as possible." While quickly and voluntarily correcting violations is desirable, as one reads further into the *Policy*, deficiencies become apparent. Informal enforcement may only mean that WRD staff calls or emails the violator and then creates a file as a record of contact.

Penalties: The lack of willingness to enforce extends into the realm of use of fines as a disincentive:

> "The ability to pay administrative civil liability is limited by diverter's revenues and assets. In some cases, it is in the public interest for the diverter to continue in business and bring operations into compliance. If there is strong evidence that administrative civil liability would result in widespread hardship to the *service population* or undue hardship to the diverter, it may be reduced on the grounds of ability to pay."

I have added emphasis to the term "service population" above because it shows the inherent bias of the WRD for diverters (their clients) as opposed to protection of public trust. They also express a willingness to skip the enforcement phase, if the diverters just agree to pay for cooperative management:

> "Accordingly, flexibility should be provided to groups of diverters who endeavor to work together to allow for cost sharing, real-time operation of water diversions, and implementation of mitigation measures."

Watershed Groups: The *Policy* proposes to use watershed groups to fund studies, assess flow availability, and mitigate all problems related to diversions. A watershed group is defined as follows:

> "A watershed group is a group of diverters in a watershed who enter into a formal agreement to effectively manage the water resources of a watershed by maximizing the beneficial use of water while protecting the environment and public trust resources."

Any watershed group formed by special interests that does not include public participation is unacceptable. Consultants working for water diverters would protect vested interests and the quality of science would not likely be as unbiased or equal to that collected by government scientists who have public trust responsibility.

The *Policy* defines further the role these watershed groups would play:

> "The watershed group shall provide the technical information necessary for the State Water Board to determine water availability, satisfy the requirements of CEQA (if applicable), evaluate the potential impacts of water appropriation on public trust resources, make decisions on whether and how to approve pending water right applications for diverters in the watershed group, and make decisions on whether to approve the watershed group's proposed watershed management plan."

In other words, they want to turn their job and that of other State agencies over to local diverters. There are numerous streams in northwestern California that are already so over-subscribed they are dry in summer and fall. Many of the diversions may be unpermitted or constructed illegally and have permit applications pending. This strategy is not going to do anything for public trust and fish and it is likely illegal.

Cumulative Watershed Effects

The California Environmental Policy Act (CEQA) requires that cumulative effects be considered and defines them as "indirect or secondary effects that are reasonably foreseeable and caused by a project, but occur at a different time or place." The *Policy* is subject to CEQA yet fails to meet its requirements in considering cumulative watershed effects. Discussions of this topic are parsed below into 1) discussion of cumulative effects from networks of diversion on downstream reaches, and 2) on how all the watersheds under consideration are cumulatively effected by land use. The emphasis in the latter discussion is on changes in stream channel form and watershed hydrology that effect surface water availability.

Water Use Related Cumulative Effects: Band (2008) described numerous cumulative watershed effects likely from the interaction of diversions, even if all were operating in accordance with minimum base flows (MBF).

> "The cumulative impacts of water diversions from all areas of the drainage network requires consideration of the network as an entity, and not just the sum of all individual reaches."

While each diversion might only capture less than 5% of the 1.5 recurrence interval flow at one location, Band (2008) calculated the interaction between diversions in the stream system could increase to 28% downstream. He sees the necessity of increasing model parameters "to analyze the impacts of sequential dependencies of reach conditions as they will not be randomly distributed."

If interactions of multiple diversions are not factored into consideration, Band (2008) predicts "perturbations to the downstream hydraulic geometry, as well as bed sediment grain size, and seasonal variations in bed composition." Of specific concern to Band (2008) is fine sediment delivery from early storms in streams where flow is depleted: "the first few increased flows of the year may flush fine grained sediment, perhaps without mobilizing coarser grain sizes, which may accumulate in reaches where discharge is drawn down." These reaches might be ones used for spawning.

Band (2008) and Gearheart (2008) expressed concern about cumulative effects potential associated with dams on ephemeral streams (Class III). These headwater swales may constitute 50% of a watershed's area and "the vast majority of coarse grained material delivered to larger streams with salmonid habitat are generated from small, headwater catchments" (Band, 2008). Figure 2 above shows permitted and unpermitted impoundments and there are 1357 permitted impoundments in the Policy's area of interest and another 1771 unpermitted ones (Stetson Engineering, 2007a). Therefore, there is significant likelihood of advanced cumulative effects from interactions of releases from diversions.

Stetson Engineering (2007a) estimates that the capacity of illegal impoundments in the North Coast watershed region, as defined by the Policy, is 48,515 acre feet and that 3,234 surface acres of reservoirs now submerge former stream reaches or headwaters. These impoundments in turn are ideal habitat for bull frogs, which decimate native amphibian populations. They are often stocked with warmwater game fish that escape into water bodies below and may predate upon salmonids or displace them through competition (Higgins et al., 1992).

Ground water is not considered in the *Policy*, yet over-extraction is known to contribute to diminished water quality and greatly reduced fish habitat in many streams within the region (see Case Studies). Peer reviewers (Band, 2008; Gearheart, 2008; McMahon, 2008) point out that no real water budget can be calculated without knowing the influence of ground water withdrawals. The Department of Water Resources, a separate State agency, has oversight over ground water withdrawal, but all well logs are treated as proprietary and restriction of ground water use is uncommon.

Potential additional water withdrawal under riparian water rights is another flow-related cumulative effect. Riparian rights are those where water is extracted for use on lands that directly boarder the stream and any owner of a parcel immediately adjacent to a water course has the right to take water for domestic and agricultural use at any time unless specific deed restrictions are stated in the title to the land. Riparian rights do not require a permit from the WRD. Although the WRD requests that riparian water users file a statement of diversion and use, there is no penalty for not complying and few are filed.

Band (2008) mentions tailwater as a major issue needing consideration by the WRD as a potential effect. Agricultural waste water may have elevated temperature and nutrients and its impact is recognized as substantial on the Shasta River (NCRWQCB, 2006a).

Upland Cumulative Effects and Surface Water Supply: Cumulative effects in northern California watersheds related to logging and associated road networks are well studied (Ligon et al., 1999; Dunne et al., 2001; Collison et al., 2003). Although much of the geographic area defined by the *Policy* is now in agricultural production, virtually all the watersheds have been logged at least historically. All of those logged after WW II have extensive road networks that alter watershed hydrology (Jones and Grant, 1996). High road densities act to extend stream networks and intercept ground water flows (Jones and Grant, 1996), resulting in increased peak flows and decreased base flows (Montgomery and Buffington, 1993).

Most of the streams within the *Policy* area are listed for sediment impairment on the SWRCB 303d list and targeted for remediation under the Clean Water Act TMDL program. A huge amount of sediment recognized as polluting north coast rivers is moving downstream in waves. The level of aggradation can be up to 25 feet (i.e. South Fork Trinity) (PWA, 1994) and high sediment yield has caused dozens of regional streams, such as those of the Lower Klamath (Voight and Gale, 1998), to lose surface flow even when there is no diversion (Figure 5).

The *Policy* needs to consider the question of water supply in a stream environment that is profoundly changed by cumulative effects. Increased flood peaks and excess sediment transport in North Coast rivers have caused a loss of pool habitat, an increased width to depth ratio, reduced large wood, and overall diminishment of salmon and steelhead habitat. Because the streams have become wider and shallower, they are more subject to warming (Poole and Berman, 2000). (The *Policy* skips the discussion of cumulative effects due to April-October flow depletion on stream temperatures by concerning itself only with the October-March time period.) The North Coast Regional Water Quality Control Board (NCRWQCB, 2006a) found that flow depletion in the Shasta River was contributing to temperature pollution and NRC (2004) found the same relationship on the Scott River (see Case Studies).

Anderson Creek in the Navarro River basin might serve as an example. When an early water right was granted for 2 cubic feet per second (cfs), pools were likely frequent with some 6-8 feet deep (CDFG, 1969), and the effect of the withdrawal was likely minimal. The stream has experienced substantial cumulative effects and pools are now infrequent and maximum pool depth is often 4 feet or less; *the effects on fish of the historically permitted quantity of water may now be significant*. Add to the equation decreased baseflows due to high road densities, recent logging and development and one can understand why streams are running dry and fish are going without water. All of these are factors that the *Policy* needs to consider in order to meet CEQA requirements and to determine water availability that truly reflects the needs of fish.

Cumulative effects should also be recognized as compromising recreational opportunities. Not only do north coast rivers lack sufficient flow for recreation, flow depletion and aggradation now cause stagnation that fosters toxic algae. Although the South Fork Eel River is not in the *Policy* area, it none the less serves as a regional example. Generations of Californians have vacationed on the South Fork Eel at Richardson's Grove Redwood State Park or at Benbow Lake, but toxic blue-green algae species now make surface water contact during low flows ill-advised. There have been several accounts in the local press of dogs dying after ingesting SF Eel River water. Rural development in the Eel River watershed has fostered a similar pattern of unpermitted water use as in *Policy* area basins, that when combined with aggradation, leads to major loss of recreational opportunities.

Figure 5. Lower Terwer Creek running underground in late fall 1990. High sediment yield related to watershed disturbance has caused massive aggradation. The stream loses surface flow in late summer and fall yet there is no diversion upstream. Photo by Paat Higgins from KRIS Klamath-Trinity Version 3.0. September 1991.

Case Studies

There are a number of watersheds in northwestern California that have flow levels that limit salmonid production and case studies are provided below for areas both inside and outside the geographic area covered by the *Policy*. Many of my reports are provided on the DVD that is being filed with these comments so that WRD can get more detailed information from them.

Napa River: I am intimately familiar with the Napa River watershed from having commented (Higgins, 2006a) on the *Napa River Sediment TMDL* (SFBWQCB, 2006) and on several proposed vineyard conversions (Higgins, 2006b; 2007). The diminishment of flow from historic levels is most clearly seen through examining what would have been coho salmon habitat. USFWS (1968) estimated the historic coho population in the Napa River at 2000-4000 fish. Coho prefer reaches with a gradient of less than <2% and suitable water temperature, with juveniles spending one year in freshwater. Figure 6 illustrates where coho are likely to have ranged in the middle Napa River watershed. The majority of low gradient mainstem and tributary reaches were found to be dry (Figure 7) or stagnant in 2001 by Stillwater and Dietrich (2002). Figure 8 is taken from Stetson Engineers (2007a) and shows the number of permitted and unpermitted diversions in the lower Napa River, including Carneros Creek. Stetson Engineers (2007a) noted that 43% of winter flow in Carneros Creek is likely diverted.

While Napa River coho are extinct, steelhead are still present, although there is a homogeneous disturbance in the watershed because of urbanization, timber harvest, vineyard development, dams for municipal water supply and changes in the stream channel. Steelhead are blocked from 30% of the Eastside of the watershed by large municipal water supply dams, the mainstem Napa River is now either dry or unsuitable for steelhead rearing, and Westside tributaries sustain steelhead in isolated pools. Stillwater and Dietrich (2002) noted that steelhead juveniles stranded in isolated pools lost weight during summer due to lack of insect drift delivered not being delivered by flows. Given the precipitous decline in steelhead habitat, it is my professional opinion that their population is likely dropping significantly. Chinook salmon still return to the Napa River, but their population is small and also at risk of loss.

My *Napa River TMDL* comments (Higgins, 2006a) conclude that sediment and flow problems cannot be remedied without limiting watershed disturbance and that temperature and fish problems cannot be remedied without additional flows:

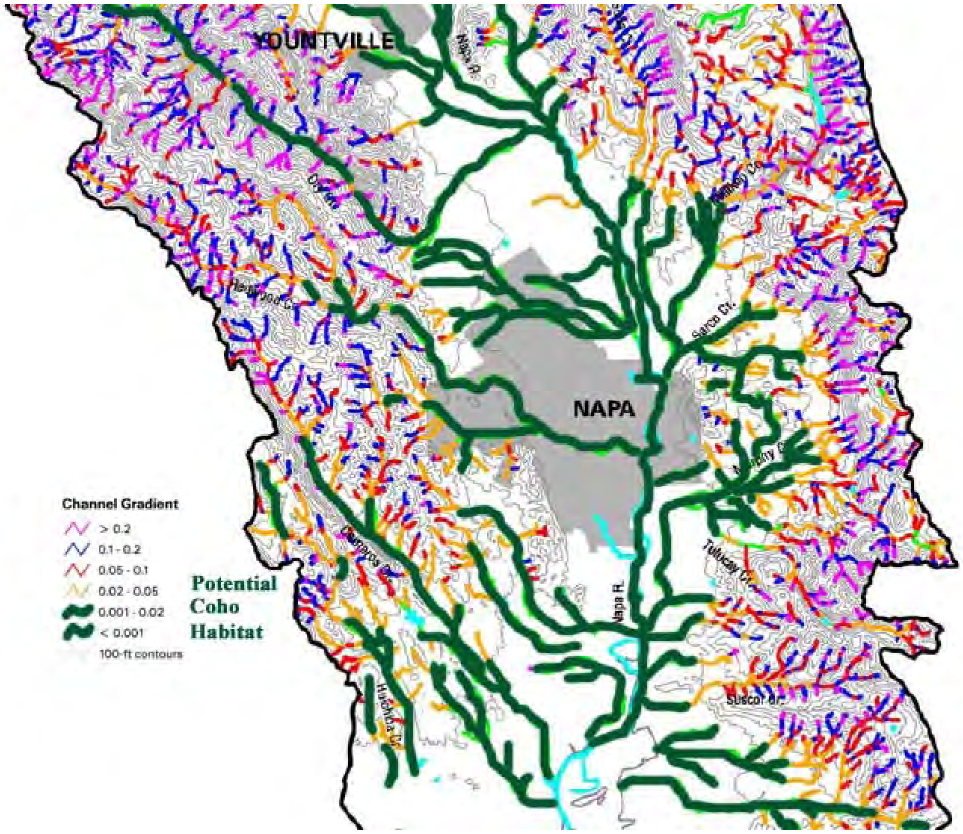


Figure 6. Stream gradient map of the Napa River is overlain with dark green on reaches with gradient less than 2% (0.02) to show likely range of coho salmon prior to human disturbance. Map 6 from Stillwater and Dietrich (2002).

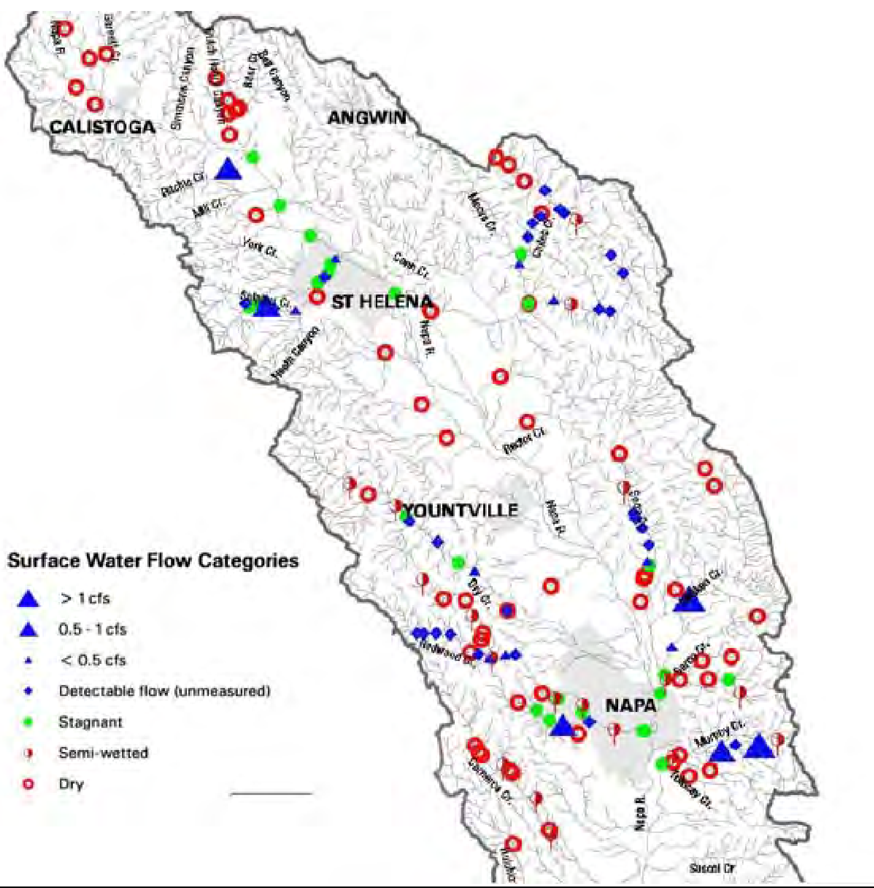


Figure 7. Symbols on this Napa River map indicate that reaches likely formerly inhabited by coho now lack surface flow or are stagnant. Taken from Stillwater and Dietrich (2002) where it appears as Map 13.

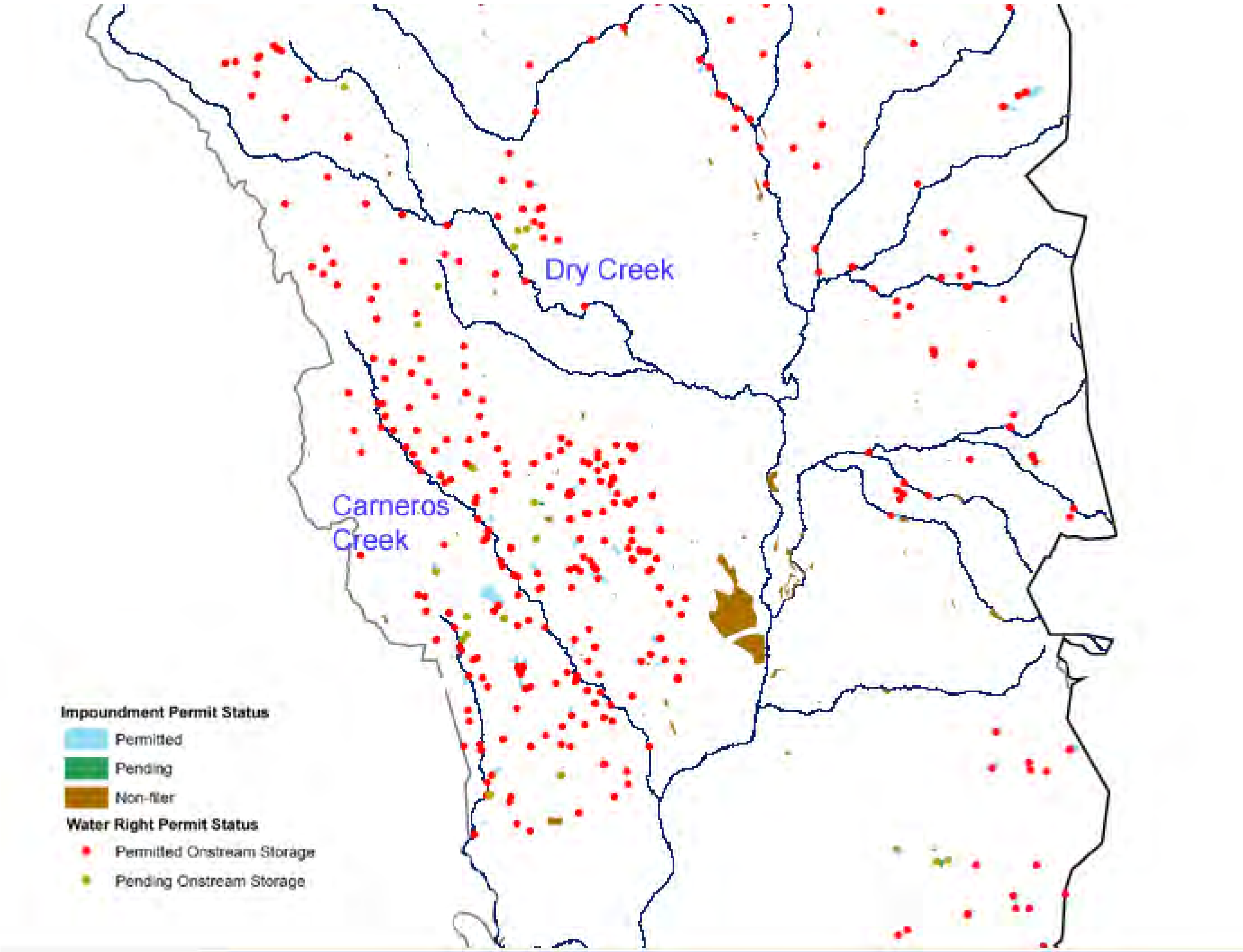


Figure 8. Diversions and impoundments in the lower Napa River basin in Huachuca, Carneros and Dry creeks at left. Impoundments include both those permitted and unpermitted. Stetson Engineers (2007a).

> "The State Water Resources Control Board Water Rights Division has the authority to install stream gages where ever necessary to insure protection of public trust, water quality and water rights. The TMDL should make explicit reference to reaches affected by low flows and call on the SWRCB WRD to take appropriate monitoring and enforcement actions."

Navarro River: I am familiar with the Navarro River having worked in the basin as a CDFG seasonal aid in 1972, commented on proposed timber harvests in Rancheria Creek and Indian Creek in 1993-1994, and more recently helped complete the KRIS Navarro project (IFR, 2003a). The WRD is intimately familiar with the Navarro River as documented in previous comments on regional flow policy by Friends of the Navarro River Watershed (Hall, 2006) and the Sierra Club (2006).

In 1994 the Sierra Club Legal Defense Fund (Volcker, 1994) filed a water rights complaint with the SWRCB WRD for failing to adequately address instream flow needs under the Public Trust Doctrine in the Navarro River basin. In the complaint, Volker (1994) stated that:

> "Illegal and unreasonable water diversions from the Navarro River and its tributaries, primarily for agricultural purposes, have significantly impaired instream fish and wildlife beneficial uses, to the point where the river was literally pumped dry during August and September of 1992. Such illegal and unreasonable diversions threaten again this fall to eliminate the natural flow of

> the river and its tributaries necessary to sustain constitutionally and statutorily protected instream fish and wildlife beneficial uses."

Volcker's (1994) assertion that the Navarro loses surface flow was correct at the time and the condition is still chronic in summer (Figure 9). In processing the complaint, the WRD (SWRCB, 1998) found 121 illegal impoundments (Figure 10), none of which were removed and many of which have now applied for permits (Pennington et al., 2008). The SWRCB (1998) declined to take public trust protection action:

> "The SWRCB could initiate a public trust action in the watershed. However, the cause of the anadromous fish decline may be principally due to factors other than flow, and there is not adequate information available regarding the flow needs of the fishery in the summer. Consequently, the Division recommends that a public trust action should not be initiated at this time. If the complainants, DFG, or some other entity develops adequate information regarding the summer flow needs of the anadromous fishery, this recommendation can be reevaluated."

Illegal diversions of two types for Mendocino County watersheds are shown in Figure 11, which is taken from Stetson Engineers (2007a). The Navarro River appears at left with a combination of regulatory dams, diversions that do not impound water, and illegal impoundments.

Russian River: I am familiar with the Russian River due to work on a KRIS Russian database (IFR, 2003a) and from having provided comments on the Bohemian Grove NTMP (Higgins, 2007b).

As one of the centers of the booming wine industry, the Russian River is one of the most heavily diverted streams in northwestern California, as indicated by the prevalence of unpermitted diversions (Figure 11). Major tributaries lose surface flow during summer and early fall (Figure 12) and significant numbers of large pumps have been installed to tap ground water, some immediately adjacent to the river (Figure 13). The Sierra Club (2006) documented problems with over-diversion and widespread illegal water use in Maacama Creek causing severe damage to public trust.

Coho salmon are increasingly rare in the Russian River, but still known to occur in some tributary sub-basins. Figure 14 shows the existing appropriative rights and those proposed for all tributaries known to have harbored coho salmon in the past. Coho were present in Green Valley Creek all three years of CDFG surveys from 2000-2002, but present in Dutch Bill Creek only one year in that period. While there is only one permit on Green Valley Creek, there were 17 applications as of 2001 and Dutch Bill had 7 water rights permitted, but an additional 10 in the application process. Figure 15 shows identified illegal water withdrawal specifically on these streams (Stetson Engineers, 2007a). Legal and illegal diversions pose significant risk to the last streams where coho still persist in the Russian River.

California Department of Fish and Game habitat typing surveys of Green Valley Creek and Dutch Bill Creek show that both streams lose surface flow in some reaches (Figure 15). Pool frequency is also low relative to the CDFG (2004) target of 40% as optimal for salmonids and coho juveniles are known to require pools for freshwater rearing (Reeves et al., 1988). Additional permitted extraction of surface water is likely to both raise water temperatures and decrease depth and cover for juvenile coho salmon. The extent of dry habitats suggests that both streams are fully or possibly over-allocated and that coho habitat is already significantly diminished.

Figure 9. The lower mainstem Navarro River near Flume Gulch is shown at left during low flow conditions on September 21, 2001. The USGS flow gauge indicated that the average flow on this day was 1.1 cubic feet per second. The algae on the margins of the stream indicate stagnation and no fish were present at the time of observation. Photo from KRIS Navarro by Pat Higgins.

Kimsey (1952) sampled this exact location in August 12, 1962 and found steelhead trout of two age classes (young-of-year, 1+) and a flow of 15 cfs during what was an average water year.

U.C. Davis (Johnson et al., 2002) found only seven suckers in many miles of Navarro stream surveys indicating that even this hardy species is disappearing.

Figure 10. Aerial photo of agricultural development in the Navarro River basin circa 1998 shows ten ponds of different types typical of water storage. Vineyard development and aggradation has almost completely eliminated salmonid summer rearing habitat. Photo from KRIS Navarro.

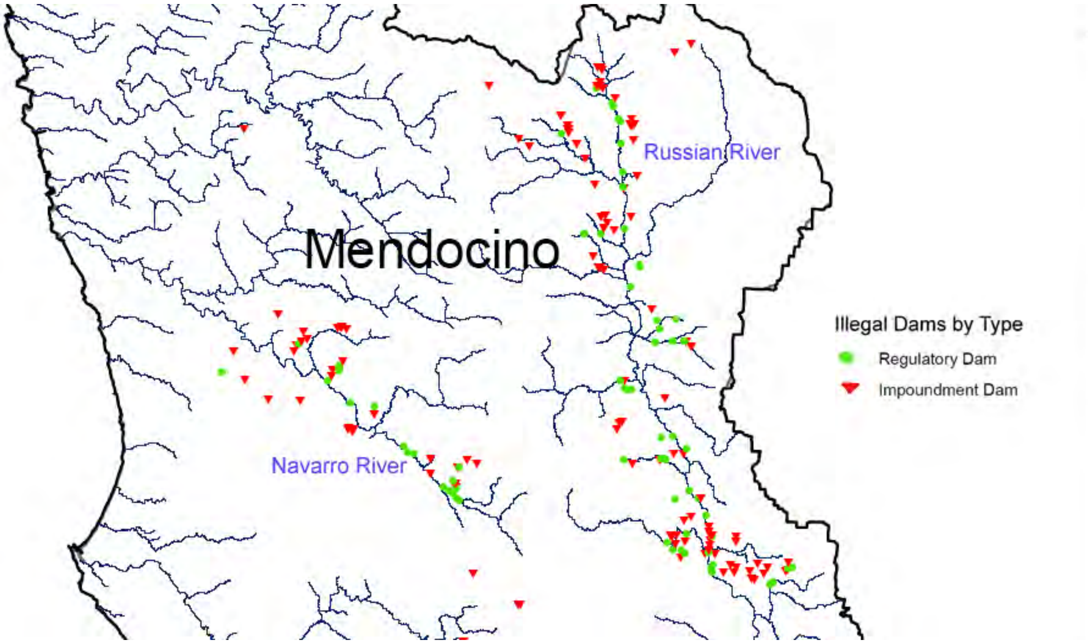


Figure 11. Locations of unpermitted diversion dams of two types in central Mendocino County with the Navarro at left and upper Russian River at right. Regulatory dams are diversions with no impoundments. From Stetson Engineering (2007a).

Figure 12. Looking downstream at the dry stream bed of the West Fork Russian River off the Eastside Road Bridge. The riparian vegetation lining both banks and extending back on the terrace at right is a result of a bioengineering project by Evan Engber. While trees have been successfully re-established to protect adjacent property and to stabilize channel conditions, over-diversion causes loss of flows. Photo by Patrick Higgins from KRIS Russian. July 13, 2003.

Figure 13. Large ground water pump appears right of center in the riparian zone of the Russian River looking west off East Side Road north of Hopland. KRIS Russian. Photo by Patrick Higgins. July 15, 2003.

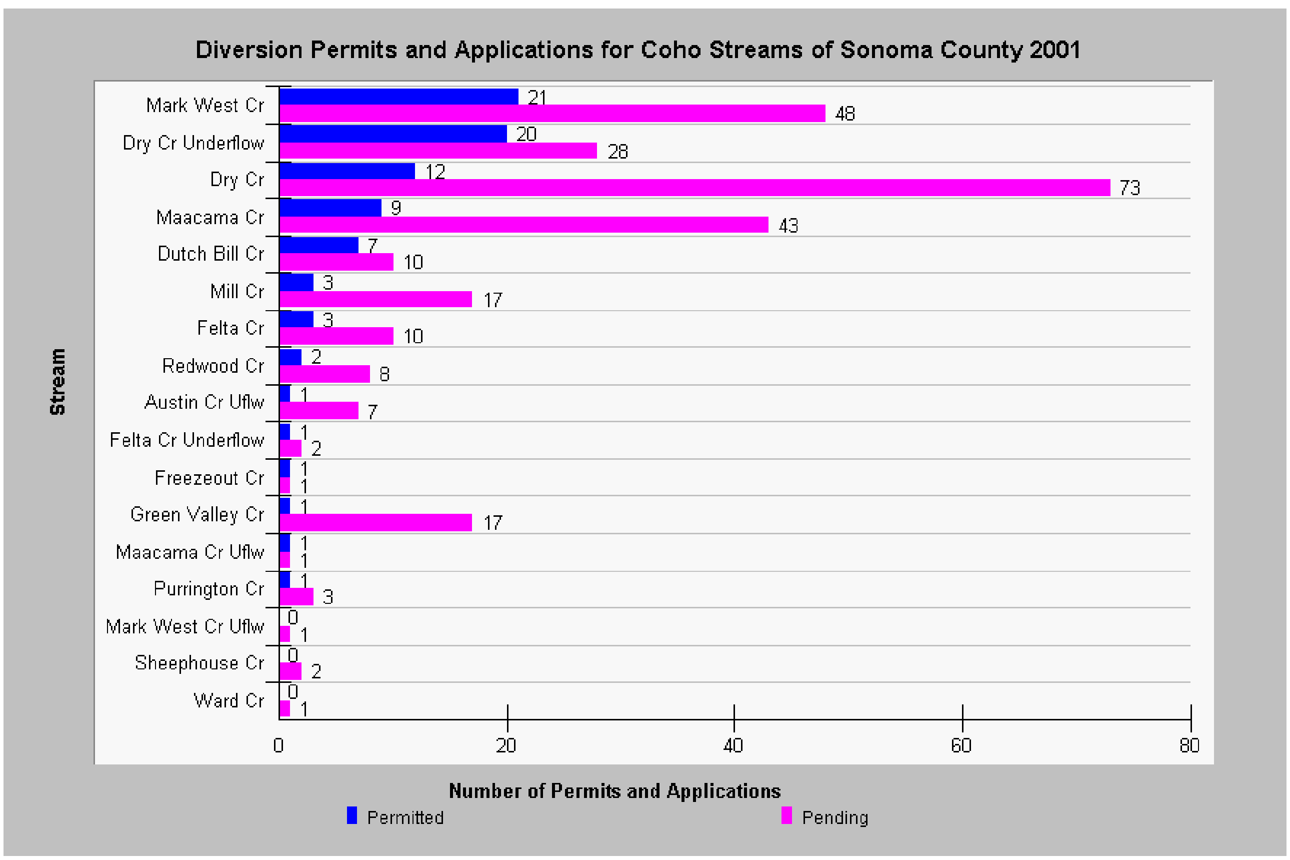


Figure 14. This chart displays the number of approved permits for appropriative water rights and those submitted for approval in Russian River tributaries known to have harbored coho salmon, including Green Valley Creek and Dutch Bill Creek. Data from the SWRCB WRD. March 2001. Chart from KRIS Russian.

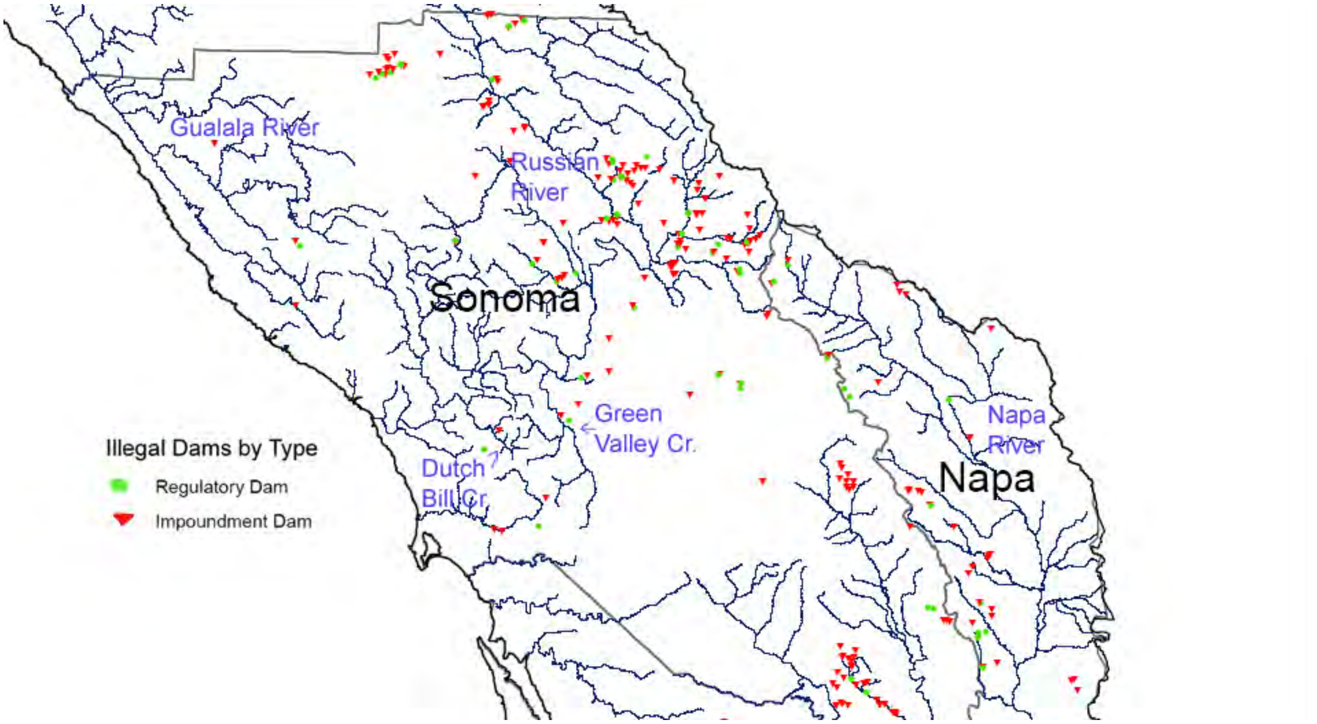


Figure 15. This map shows the locations of unpermitted diversion dams of two types in southern Sonoma and Napa counties, including lower Russian River tributaries Green Valley and Dutch Bill Creeks, which have recently harbored coho. Regulatory dams are diversions with no impoundments. From Stetson Engineering (2007a).

Sonoma Creek: My familiarity with Sonoma Creek is primarily due to my participation in the KRIS East Marin-Sonoma database project. Similar types of evidence are available to those used to demonstrate problems on the Russian River above. Habitat typing data (Figure 16) from upper Sonoma Creek indicates that reaches downstream of the headwaters go dry in summer. The cause of this loss of surface flow might be partially related to aggradation, but is still a sign that surface water availability has been diminished and that fish habitat is currently compromised. Figure 17 shows the dry bed of Carriger Creek, a tributary of Sonoma Creek, with what appears to be a large diversion pipe upstream. While Sonoma Creek itself has some problems with unpermitted diversion (Figure 18), diversion in the Tolay Creek basin indicates major illegal over-appropriation. It is likely that steelhead in Tolay Creek are at a very low level, if they persist at all.

Gualala River: I am familiar with the Gualala River from having worked on the KRIS Gualala database (IFR, 2003), completed a literature search and data assessment (Higgins, 1997), and commented on several proposed vineyard conversions (Higgins, 2003; 2004a, 2004b).

The Gualala River lies within southern Mendocino and northwestern Sonoma counties. It is recognized as impaired with regard to sediment (NCRWQCB, 2004) and has major problems with loss of surface flow and high water temperature (IFR, 2003b). CDFG (2001) characterized coho salmon in the Gualala River as "extirpated or nearly so."

The following passage from KRIS Gualala (IFR, 2003b) characterizes SWRCB WRD prior actions in the North Fork:

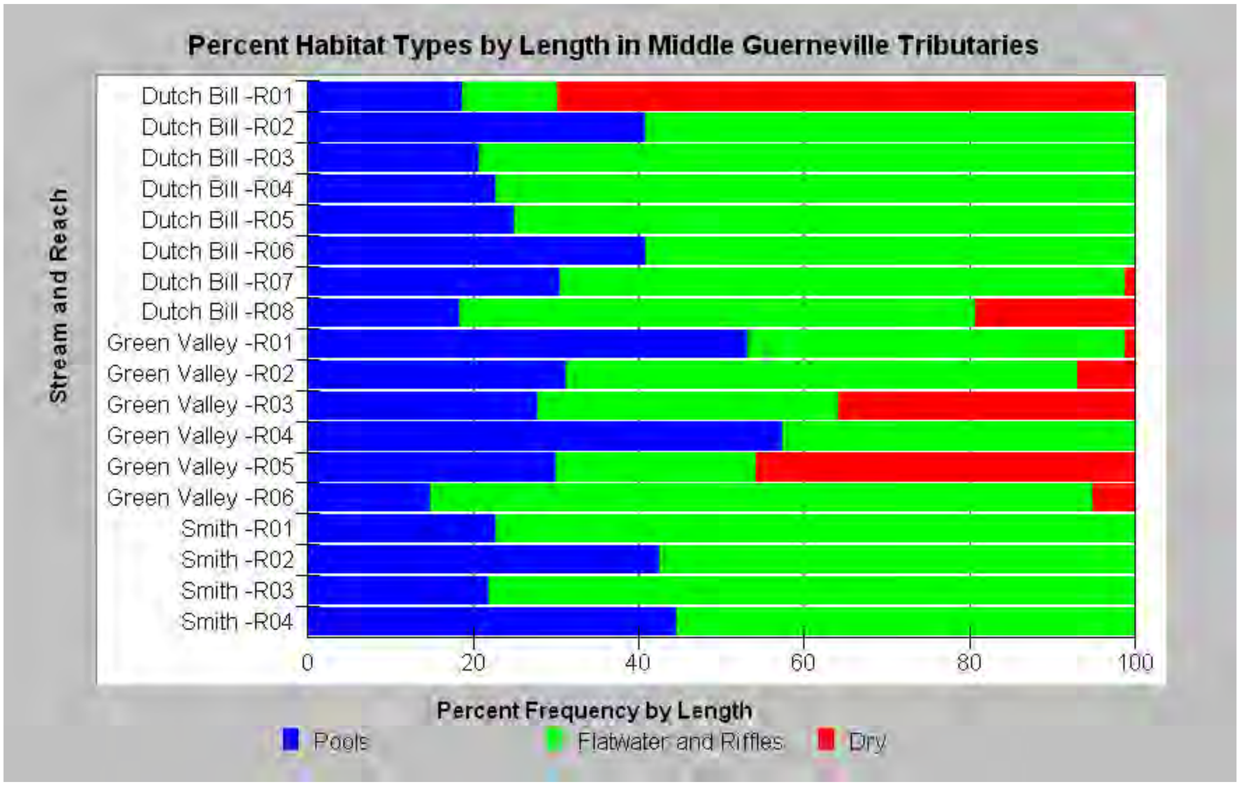


Figure 15. This chart shows CDFG habitat typing data for three lower Russian River tributaries. Notice that Dutch Bill and Green Valley Creek have significant dry reaches. Data from CDFG chart from KRIS Russian.

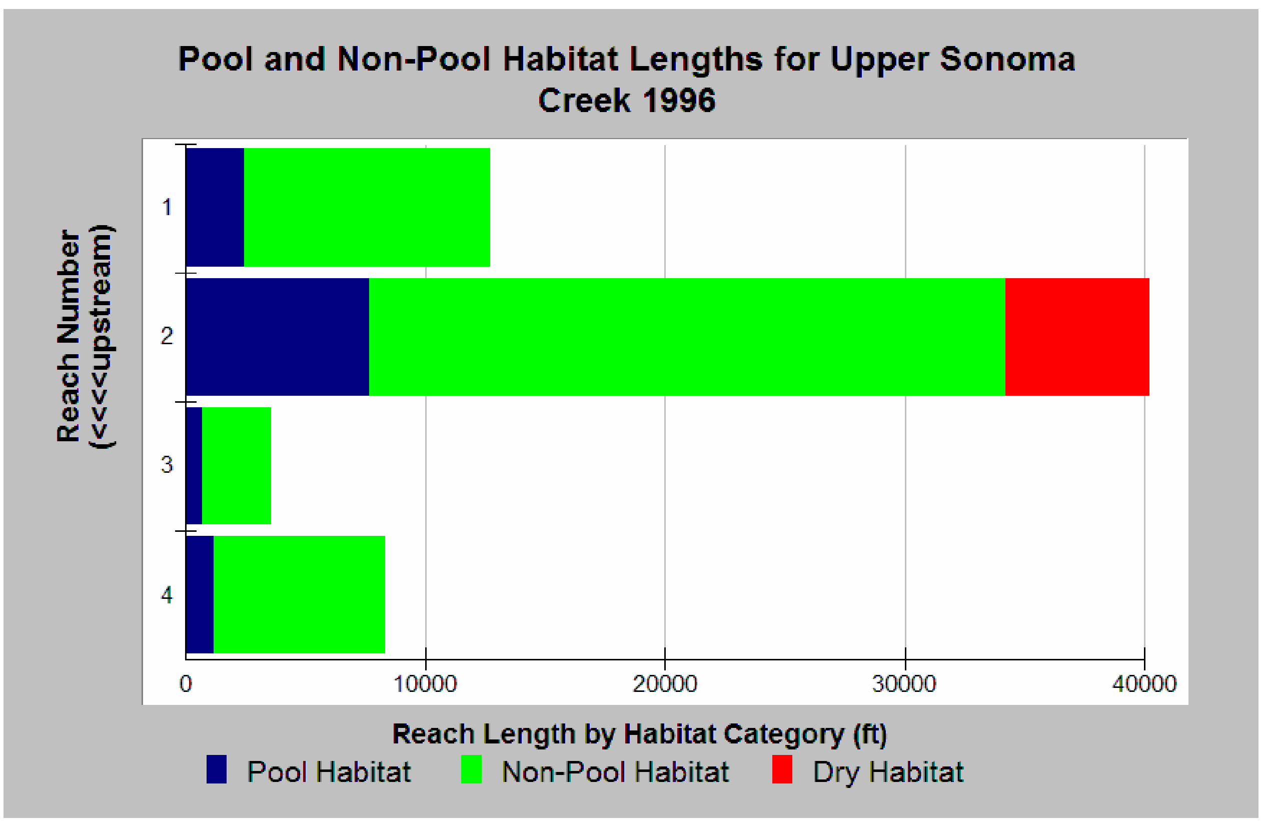


Figure 16. This chart shows Sonoma Creek Ecology Center habitat typing data for upper Sonoma Creek. The pool frequency is lower than optimal for salmonids (CDFG, 2004) and there are significant dry reaches. From KRIS East-Marin Sonoma.

Figure 17. This photo shows Carriger Creek, a tributary of Sonoma Creek, with a dry stream bed and what appears to be a large diversion pipe along cutbank upstream. From KRIS East-Marin Sonoma.

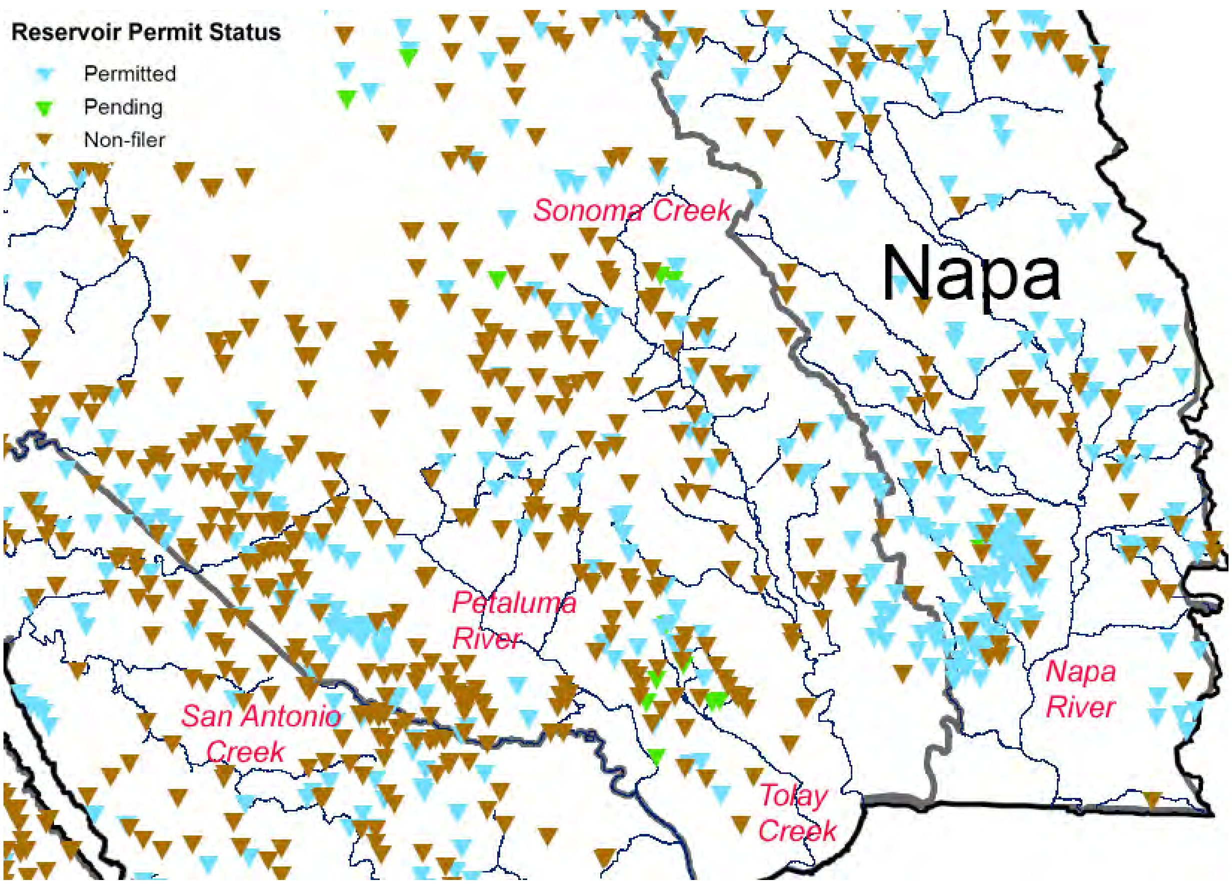


Figure 18. Locations of unpermitted diversion dams of two types, non-filers (brown) and pending (green). While there are many legal and illegal diversions on Sonoma Creek, cumulative effects risk is much greater in Tolay Creek, a much smaller basin, where there are 29 unpermitted diversions. From Stetson Engineering (2007a).

"The California Department of Fish and Game (Hunter, 1996) expressed concern about the diversion of the North Fork Gualala by the North Gualala Water Company, citing reduction in fish habitat if minimum stream flows were not retained. The State Water Resources Control Board (1999) prohibited diversion of surface water when the North Fork dropped below four cubic feet per second (cfs), then in August 2000, ruled that this order applied to two NGWC groundwater wells (SWRCB, 2000). This decision recognizes the importance of North Fork flows to the lower mainstem Gualala as well."

The Gualala River combination of aggradation and increased water use due to vineyard expansion has created an expanding problem with stream reaches in this basin losing surface flow (Figure 19), including the lower mainstem, Wheatfield Fork, South Fork, Buckeye Creek and Rockpile Creek (Higgins, 2003; 2004). Habitat typing surveys by CDFG (2001), as part of the North Coast Watershed Assessment Program, found mainstem reaches going dry (Figure 20) where they maintained surface flow during the 1976-77 drought (Boccione and Rowser, 1977). Although rainfall in 1976-77 was only 16.0 inches, total rainfall in 2001 was 24.6 inches, yet flows in 1976-77 were 12.5 cfs and all major tributaries contributed surface flow. This indicates a major decrease in water yield and water supply.

The extensive loss of surface flows in the Gualala River represents a major threat to the continuing survival of steelhead, which are still a major part of the local tourist-based economy.

Figure 19. The Wheatfield Fork, just upstream of its convergence with the South Fork, ran underground in 2001. Although the aggradation of the Wheatfield Fork is a factor contributing to lack of surface flows, water diversion for several vineyards and rural residential use exacerbate the problem. Photo by Pat Higgins from KRIS Gualala database.

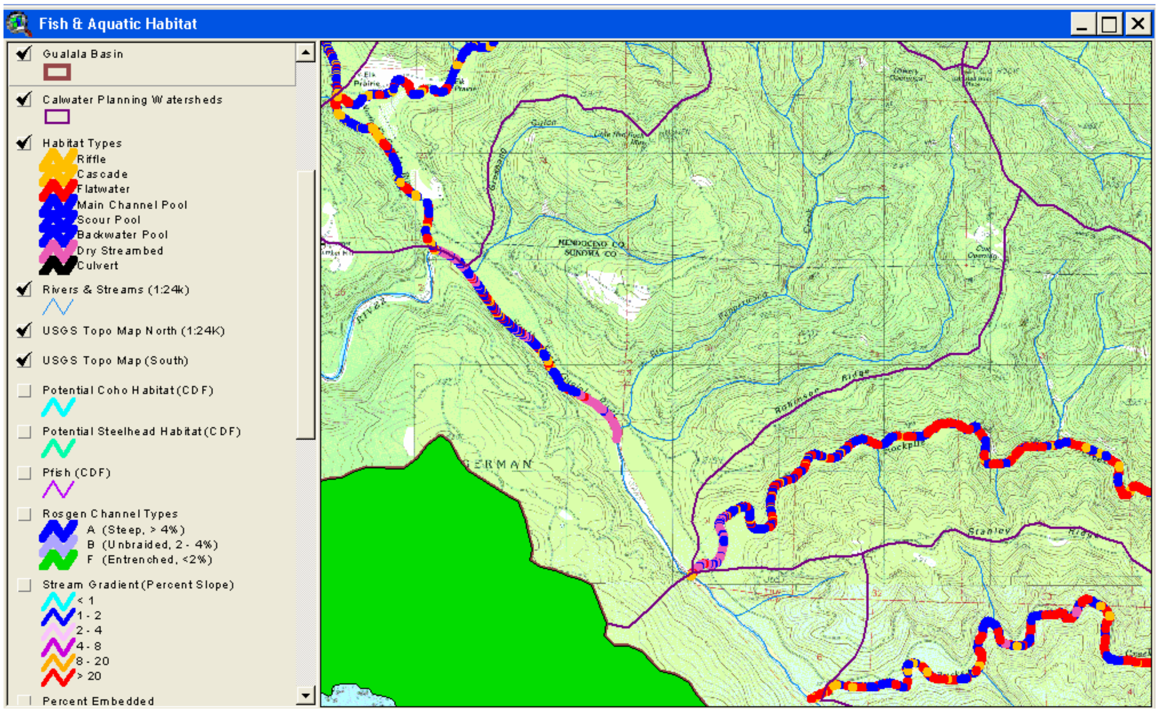


Figure 20. CDFG habitat typing of the Gualala River in 2001 shows the lower mainstem Gualala River below Big Pepperwood Creek ran underground for an extensive reach. Lower Rockpile Creek also lost surface flows in more than a quarter mile. KRIS Gualala and Higgins (2003).

<u>West Marin Tributaries</u>: Salmon, Americano, Stemple and Walker creeks all have agricultural water extraction that both compromises water quality and limits habitat for steelhead and coho salmon. Figure 21 shows a close up of these West Marin tributaries with all impoundments, 1) permitted, 2) those with applications pending, and 3) illegal diversions with no contact from the operator. The epidemic problem of over diversion and potential for cumulative effects is self-evident.

All these West Marin tributaries have extensive agricultural land use, mostly by dairies. Cattle may deposit fecal material directly into streams or it may enter as a result of overland flow. Grazing takes place up to stream banks leaving no riparian buffer capacity (Figure 22). Lack of canopy also promotes stream warming and flow depletion contributes promotion of both increased water temperatures and nutrient pollution.

Charts from KRIS West-Marin Sonoma (IFR, 2003a) show the degree of water quality impairment due to the cumulative effects of agricultural activity and flow depletion. Salmon Creek is the most northerly of tributaries considered, entering the Pacific Ocean north of Bodega Bay. Figure 23 shows dissolved oxygen (DO) values from several stations sampled by CDFG on Salmon Creek that are indicative of nutrient pollution. Super-saturated DO of greater than 10 mg/l at Highway 1 is linked to very high biological activity of algae blooms that thrive in the stagnant, nutrient-rich waters. Minimum DO levels at the Bodega location approached the recognized lethal limit for salmonids of 3.8 mg/l (WDOE, 2002). While D.O. is super-saturated during daylight hours due to photosynthesis, D.O. becomes depressed as algae respire at night or as algae dies off.

Merritt and Smith Consulting (1996) studied Americano Creek for the City of Santa Rosa. Figure 24 shows flow measurements indicating that surface flow near Garicke Road (Station E-6) was not present from April until November 1988 and from May-September 1989. Flow depletion also contributes to major pollution problems similar to those in neighboring creeks. Stemple Creek shows another symptom of nutrient pollution, high pH (Figure 25). A pH value of over 9.5 is directly lethal to rainbow trout (Wilkie and Wood, 1995).

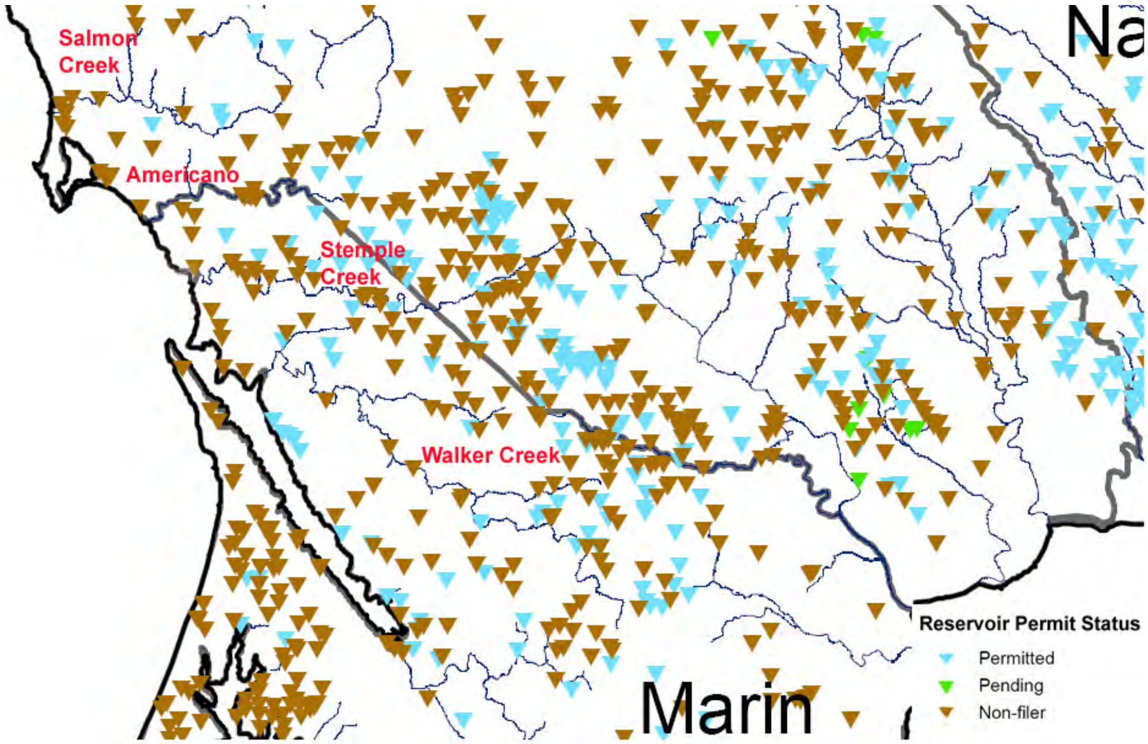


Figure 21. This map shows a zoom of the same type as Figure 2 with close up of West Marin County creek diversion impoundments that are permitted, have permits pending or are unpermitted (Non-filer). There is an obvious huge cumulative effects problem with diversion and water use. From Stetson Engineers (2007a).

Figure 22. The photo at left shows the lower mainstem of Walker Creek with very poor fish habitat as a result of livestock grazing and flow depletion. The shallow, wide stream channel and lack of riparian vegetation makes the stream subject to warming. Photo from KRIS West Marin-Sonoma.

Creel census data from 1949-1974 indicate that hundreds of adult steelhead were harvested in some years and adult coho were present in the catch (Kelley, 1976). Kelley (1976) interviewed long time residents and anglers, who said that the coho salmon run in Walker Creek was much more robust prior to 1950.

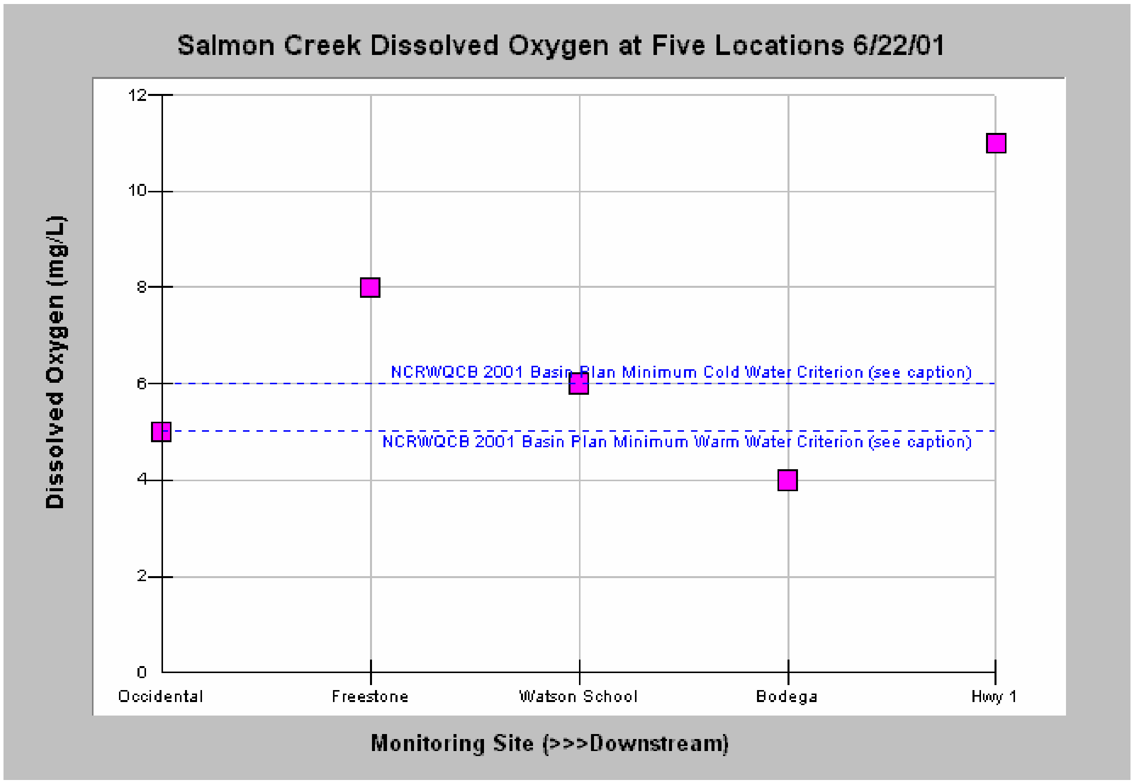


Figure 23. Dissolved oxygen at five stations (going downstream from left to right) in Salmon Creek. The high dissolved oxygen at Highway 1 is consistent with elevated pH values indicating photosynthetic activity characteristic of nutrient pollution. D.O. sags would occur at night. These data were collected by the North Coast Regional Water Quality Control Board as a part of the Surface Water Ambient Monitoring Program (SWAMP). June 22, 2001. From KRIS West Marin-Sonoma.

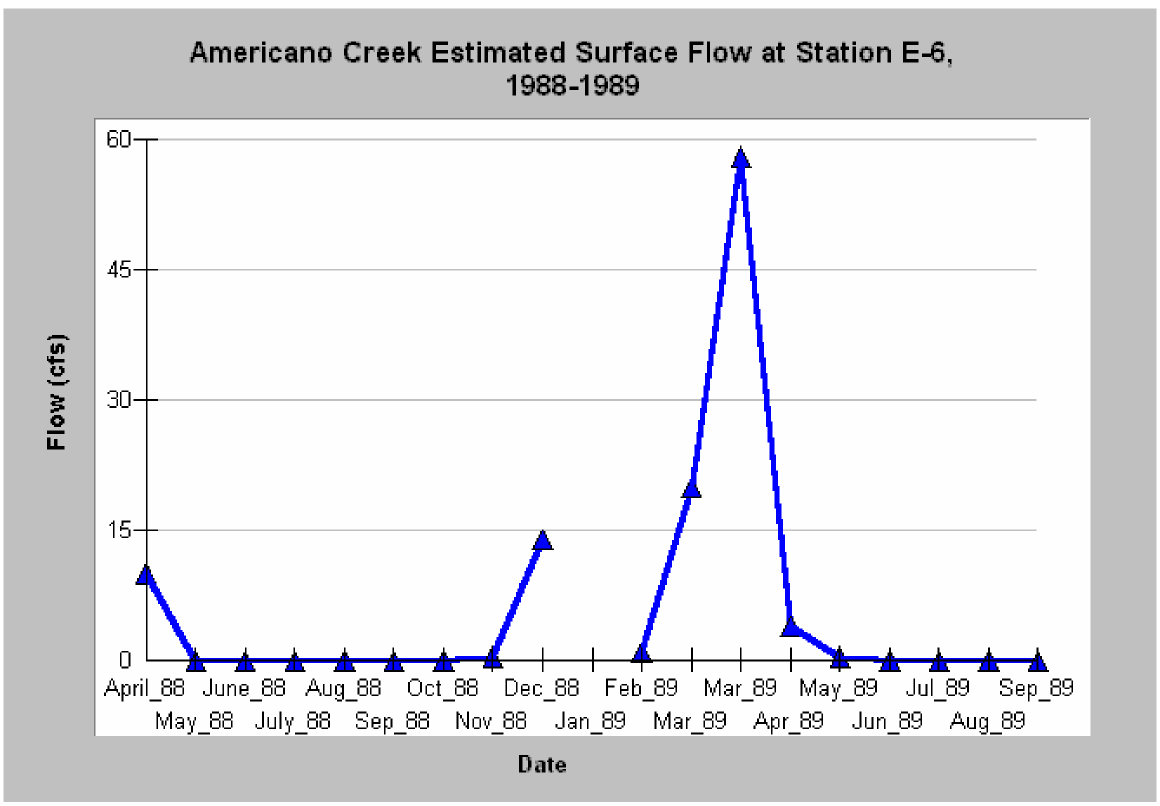


Figure 24. Surface flow was estimated approximately once monthly near Garicke Road (Station E-6) in Americano Creek from 1988-1989. Flow was not present after April in 1988 until November 1988 and from May-September 1989. Data from Merritt Smith Consulting for the City of Santa Rosa and U.S. Army Corps of Engineers. KRIS West Marin-Sonoma.

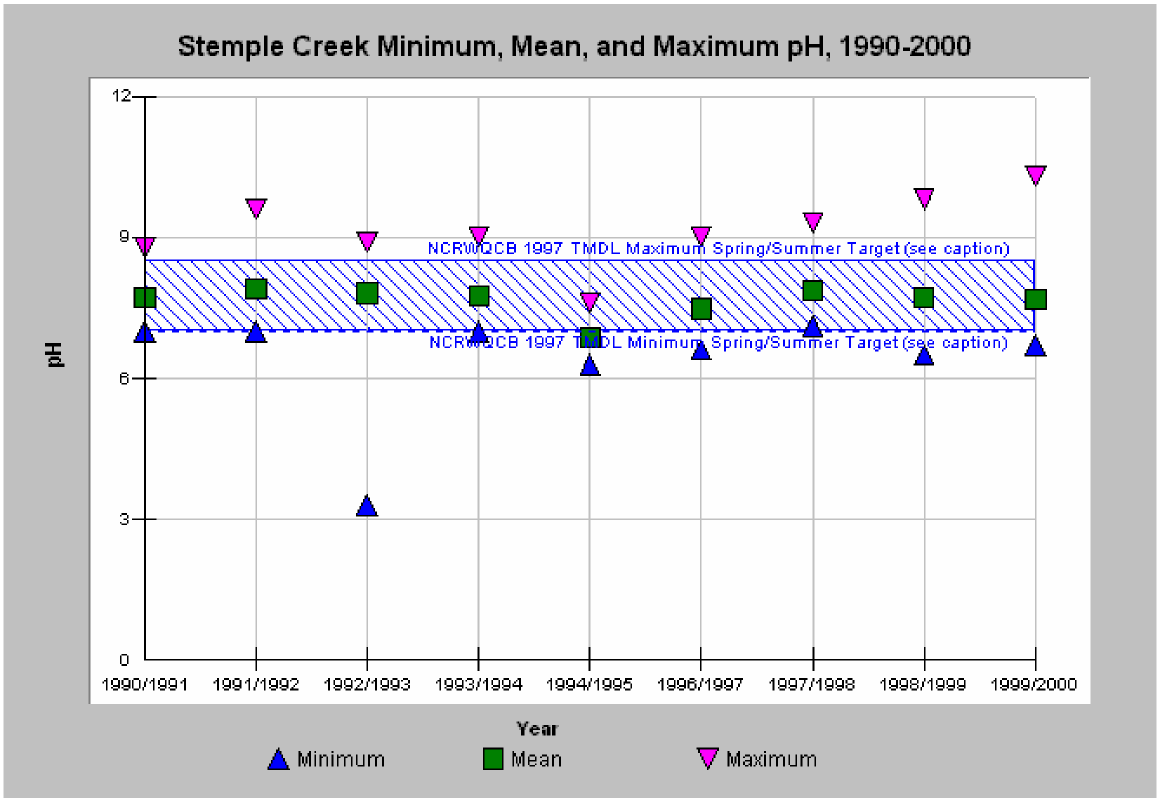


Figure 25. The pH of Stemple Creek exceeded stressful or lethal for salmonids (>9.5) as a result of nutrient enrichment from cattle waste in combination with flow depletion. Data from CDFG and chart from KRIS West Marin-Sonoma.

Walker Creek had coho salmon historically (Figure 26) but flow depletion and nutrient pollution have contributed to their disappearance. Kelly (1976) used electrofishing and netting for the Marin Municipal Water District sponsored studies that found coho, abundant Pacific lamprey juveniles and steelhead juveniles of all age classes in Walker Creek. Flows now annually fall to near 5 cfs or less from July through September (Figure 27). Reduced flow and grazing impacts have resulted in water quality problems similar to previously discussed tributaries related to nutrient pollution.

Scott River: Although the Scott River is not within the *Policy* area, it has very well recognized water quality and fisheries problems related to surface and ground water extraction (NRC, 2004). I am intimately familiar with this basin from helping with restoration planning (Kier Associates, 1991), restoration evaluation (Kier Associates, 1999), building three versions of KRIS databases, and four years of work on Scott River issues for the Klamath Basin Tribal Water Quality Work Group. Several papers on the Scott, Shasta and Klamath TMDLs are posted on their website and WRD can easily access documents on the Internet at www.klamathwaterquality.com.

I draw below from previous comments on the *Scott TMDL* (Higgins, 2006c) that are on the DVD with regional KRIS projects filed with these comments. The principal findings were as follows:

1. Flows have been decreased by ground water extraction,
2. Flows have declined to far below those required by the Scott River adjudication and often cause stream reaches and tributaries to go dry,
3. Low flow exacerbates water temperature problems, and
4. Flow and temperature problems combine with sediment to severely limit productivity of salmon and steelhead populations.

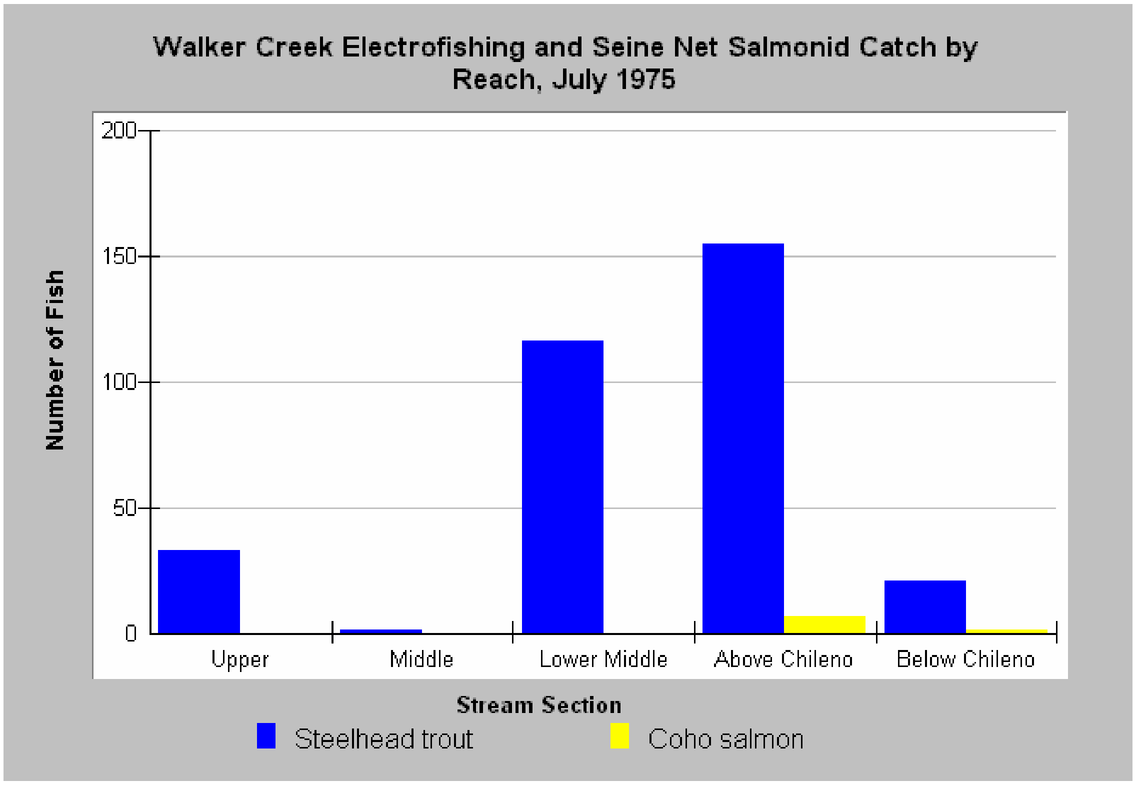


Figure 26. Fish sampling in Walker Creek in 1975 found coho salmon and numerous steelhead. Kelly (1976).

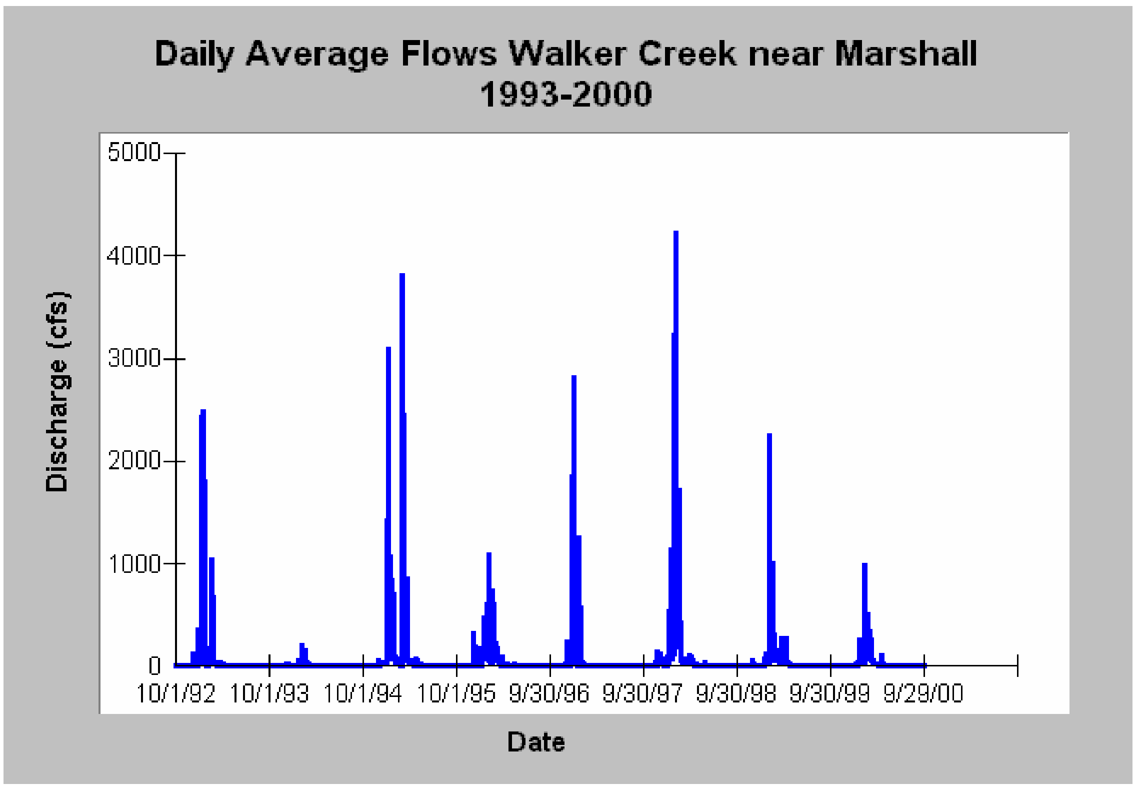


Figure 27. Flows in Walker Creek, tributary of Tomales Bay, dropped to 5 cfs or less on average annually according to USGS flow gauge records. Chart from KRIS West Marin-Sonoma.

The Scott River channel and many of its major tributaries are dried up annually, in violation of CDFG code 5937 (Figure 28 & 29), severely limiting rearing habitat for salmonids. Although the Scott River is adjudicated (SWRCB, 1980), flow levels fall below those required for months of the year (Figure 30). This causes major reductions in habitat quality in the lower Scott River, which formerly served as a summer refugia for juvenile salmonids.

The *Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program* (Kier Assoc., 1991) noted that ground water pumping in the Scott River valley depleted surface flows because of interconnections between surface and ground water. The Scott River has experienced major declines in surface flows coincident with installation of ground water pumps beginning in the 1970's. Pumps continue to be installed through NRCS and EQIP funding (Figure 31) and drops in ground water levels are becoming evident (Figure 32). The chart suggests that while annual maximum levels have remained relatively constant over time, annual minimum levels have declined since 1965, although they fluctuate with precipitation.

The National Research Council (2004) makes a clear case that flow depletion is at the root of temperature problems in the Scott River. As flows drop, transit time for water increases allowing an opportunity for stream warming. A thermal infrared radar (TIR) image of Shackleford Creek (Figure 33) was taken by Watershed Associates (2003) as part of the Scott River TMDL and shows dramatic effects of flow depletion on water temperature. Shackleford Creek is cool enough for juvenile salmonid rearing above points of diversion, then warms rapidly as its flow is depleted. Flow resumes below the major tributary Mill Creek, warms again as flow is reduced by irrigation until surface flows are lost, just upstream of the convergence with the Scott River.

Fall chinook salmon from the Scott River are an important component of the Klamath River run that supports ocean, sport and Native American fishing. Scott River fall chinook returns plummeted in 2004 and 2005 to the lowest level on record for two years in a row (Figure 34). Even after prolonged drought from 1986-1992 Scott River fall chinook returns ranged from 3000-5000 adults annually.

A major potential problem for chinook salmon is that they are stranded in the lowest reaches of the Scott River due to continuing stock water activities and other illegal diversions after October 1 (Figure 30). The fish are forced to spawn in lower reaches of the Scott River (Figure 35) where decomposed granitic sand levels are very high, which threatens egg survival as sand is transported during winter storms.

The SWRCB WRD needs to make the Scott River a priority for enforcement. Fall chinook are collapsing and coho salmon only have one strong year class of three, indicating a high risk of extinction. Immediate action is appropriate given the change in weather and flow patterns expected with a change of the Pacific Decadal Oscillation (PDO) expected sometime from 2015 to 2025 (Collision et al., 2003) and with longer term drought cycles expected with global warming (see Climate Cycles and Change).

<u>Shasta River</u>: My experience on the Shasta River parallels that described for the Scott River and my TMDL comments (Higgins, 2006d) also serve as the source for information below. The Shasta River Adjudication (CDPW, 1932) does not require a minimum flow level similar to the Scott River Adjudication (CSWRCB, 1980) and average daily flows can fall to near 20 cfs (Figure 36), which has major consequences for elevated stream temperatures (NRC, 2004). Lack of coordination of irrigation operations may sometimes cause flows to fall below the listed average and present an even greater challenge for fish survival. Dwinnell Reservoir (Figure 37) blocks the headwaters of the Shasta River and is a major source of pollution itself (NCRWQCB/UCD, 2005). Major tributaries like Parks Creek (Figure 38) and the Little Shasta River lose surface flows for several months a year.

Figure 28. The dry bed of the Scott River in a reach near the airport looking upstream. This is a violation of CDFG Code 5937. Photo from KRIS Klamath-Trinity V 3.0 taken by Michael Hentz. 2002.

Figure 29. Shackleford Creek is shown here running dry at its convergence with Scott River in August 1997. The creek has coho and chinook salmon and steelhead trout, but diversions dry it up annually during summer and fall. This is also in violation of CDFG Code 5937. Photo by Pat Higgins from KRIS V 3.0.

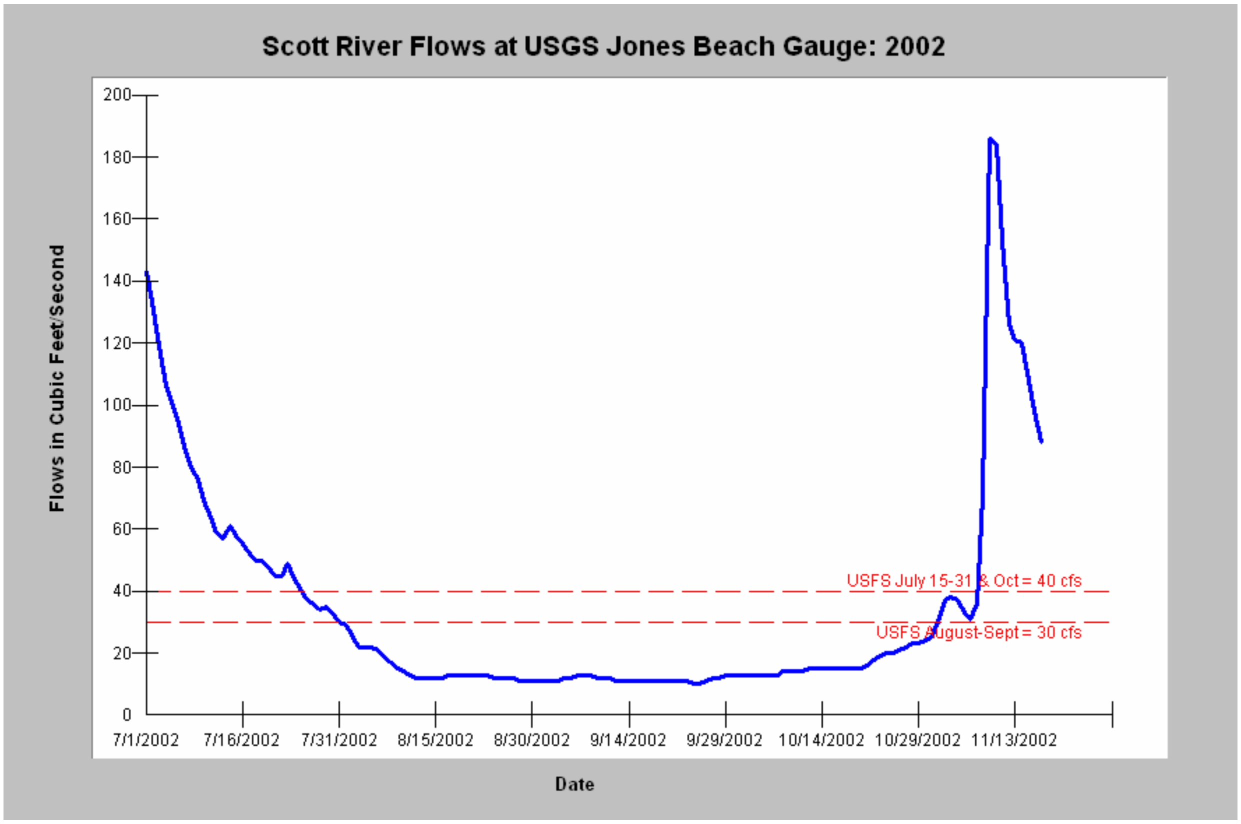


Figure 30. Jones Beach USGS flow gauge data from the irrigation season of 2002 show that flows failed to meet adjudicated levels for the USFS and flows needed for fish migration, spawning and rearing in August, September and October. Reference lines are those from the SWRCB (1980) adjudication.

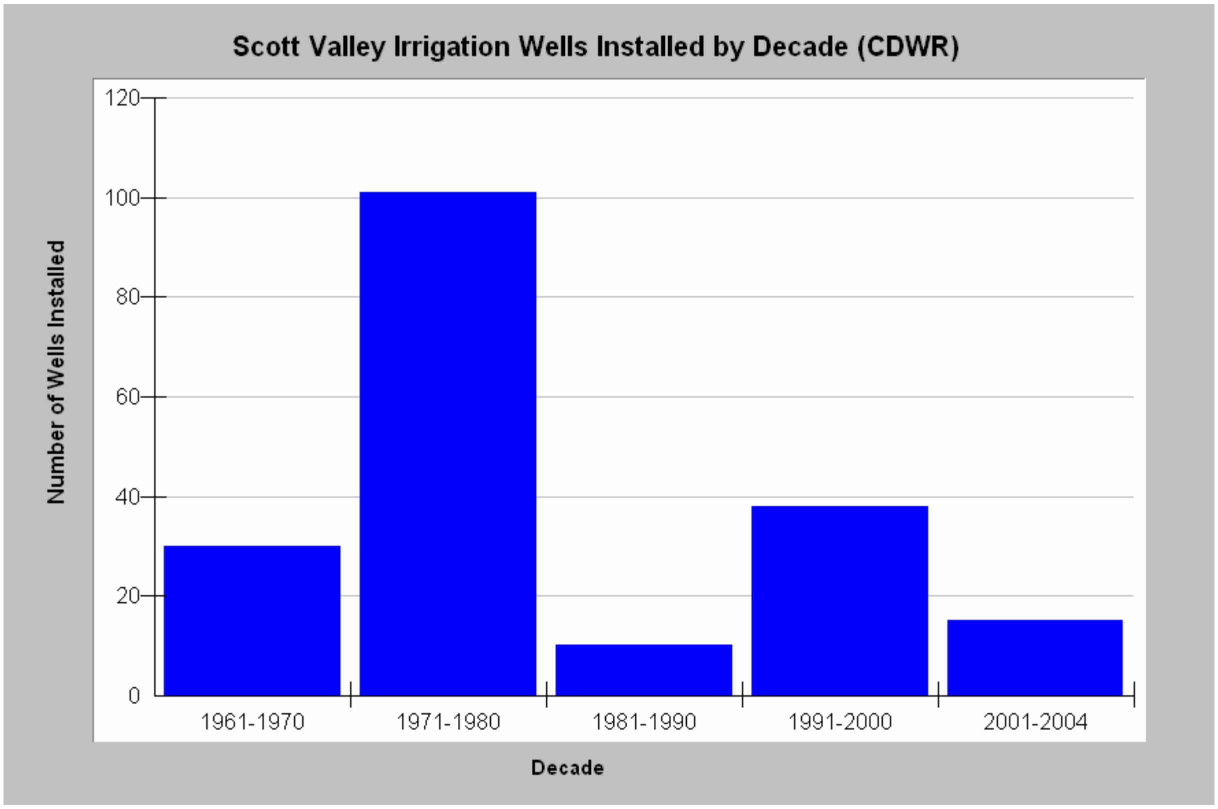


Figure 31. This chart shows the number of irrigation wells recorded by the California Department of Water Resources. Data may be only partial as not all parties installing wells file with DWR.

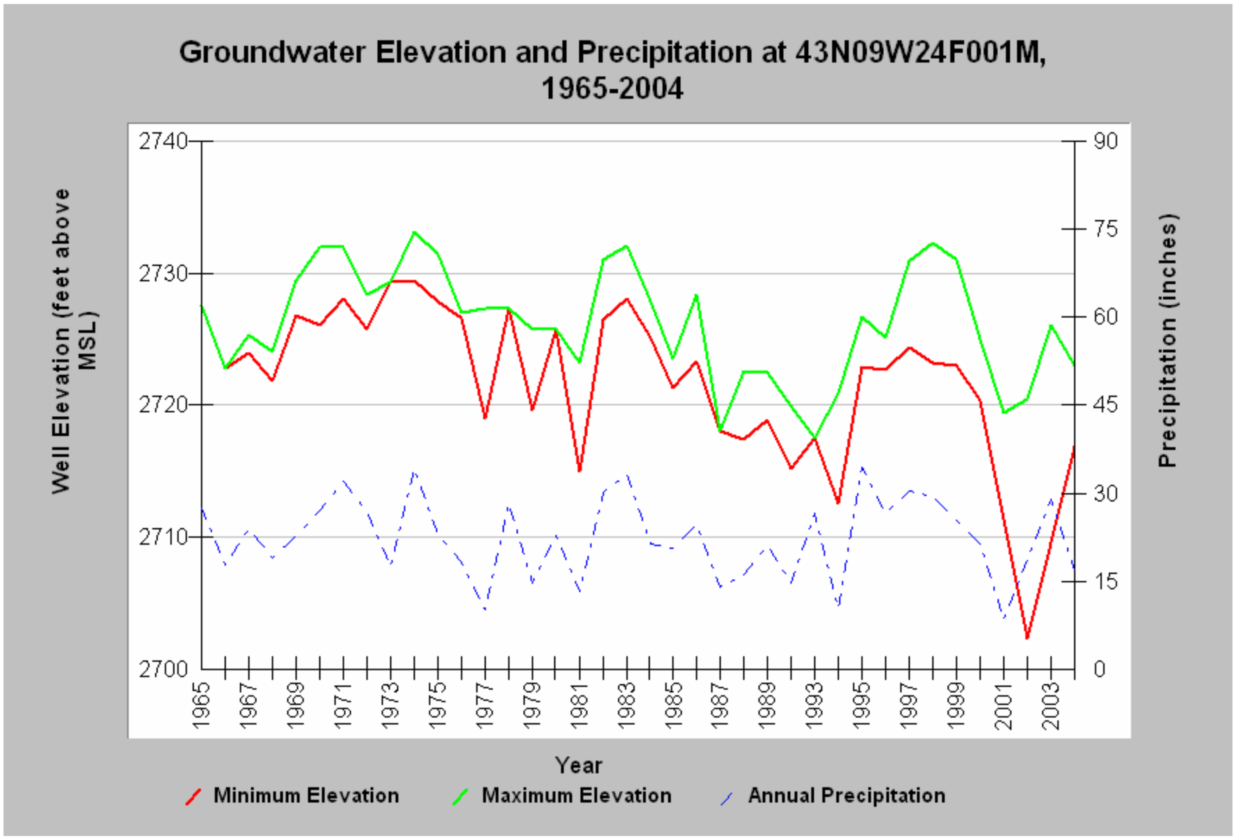


Figure 32. Department of Water Resources well 43N09W24F001M, approximately 5 kilometers south-southeast of Fort Jones, for the years 1965-2004. Minimum elevation declines are likely indicative of ground water depletion. From QVIC (2006).

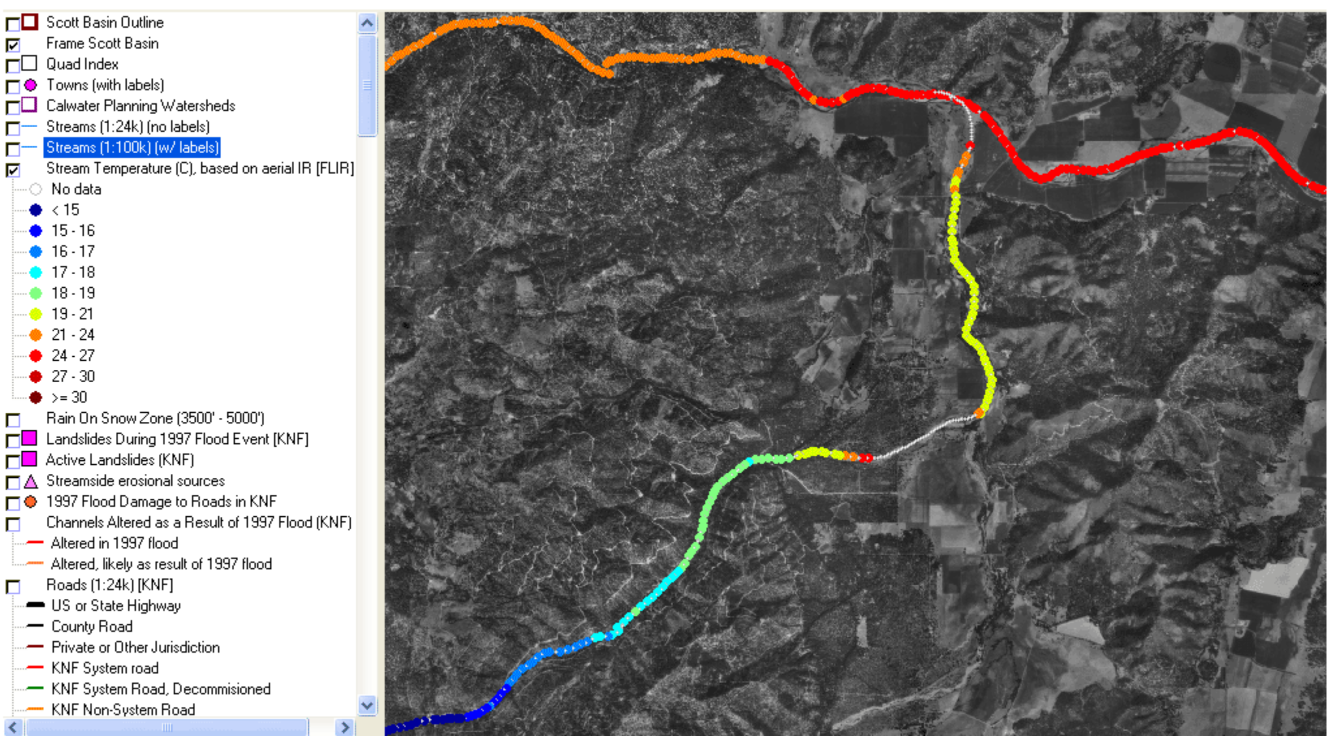


Figure 33. This map shows summary data of Scott River Thermal Infrared Radar (TIR) surveys for Shackleford Creek. Note that water temperature warms in a downstream direction as flow is depleted. Reaches with no temperature coded color are dry, indicating loss of surface flow in violation of CDFG Code 5937 and over-diversion in violation of SWRCB Codes 1243, and 1375. Data from Watershed Sciences (2003).

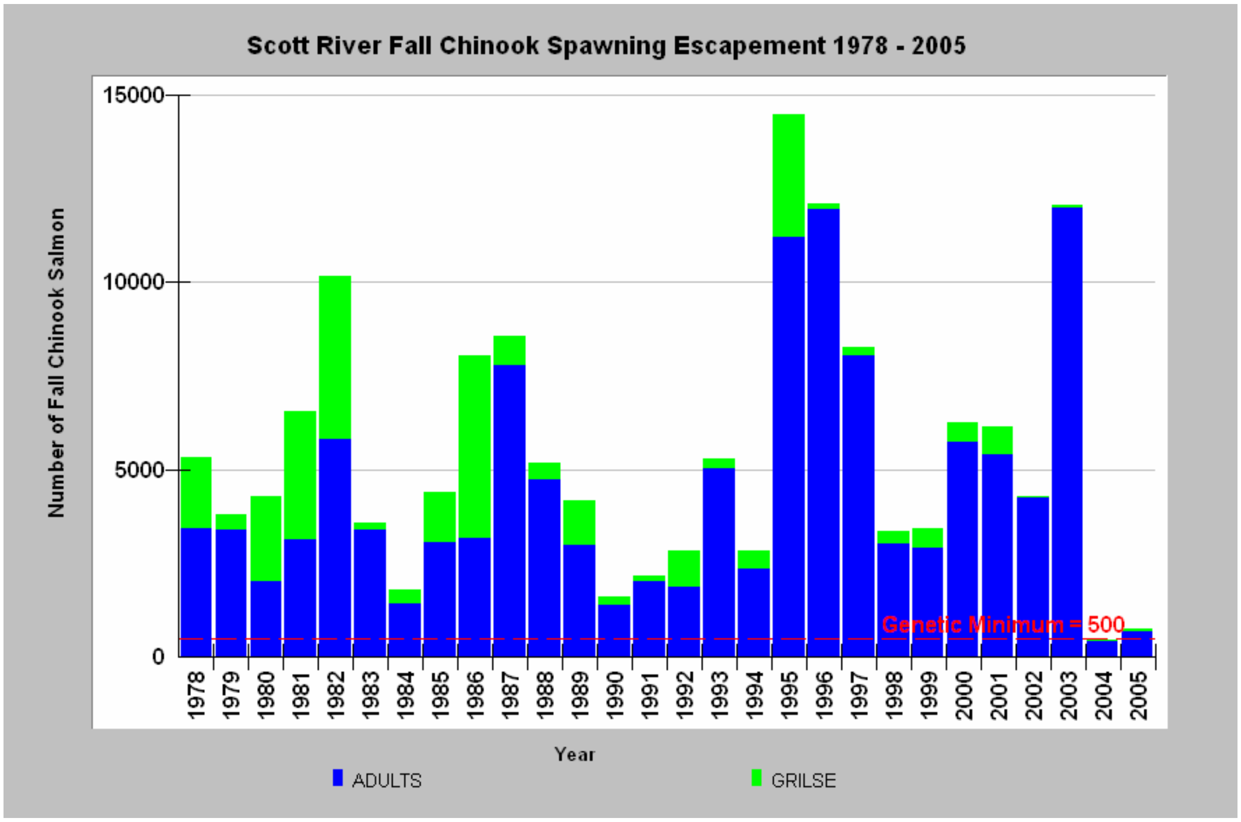


Figure 34. Scott River fall chinook spawning runs from 1978 to 2005 shows both 2004 and 2005 as the lowest years on record. Summer and fall flow conditions were near all time lows for preceding 2004-05 brood years (2001-2002). Data from CDFG.

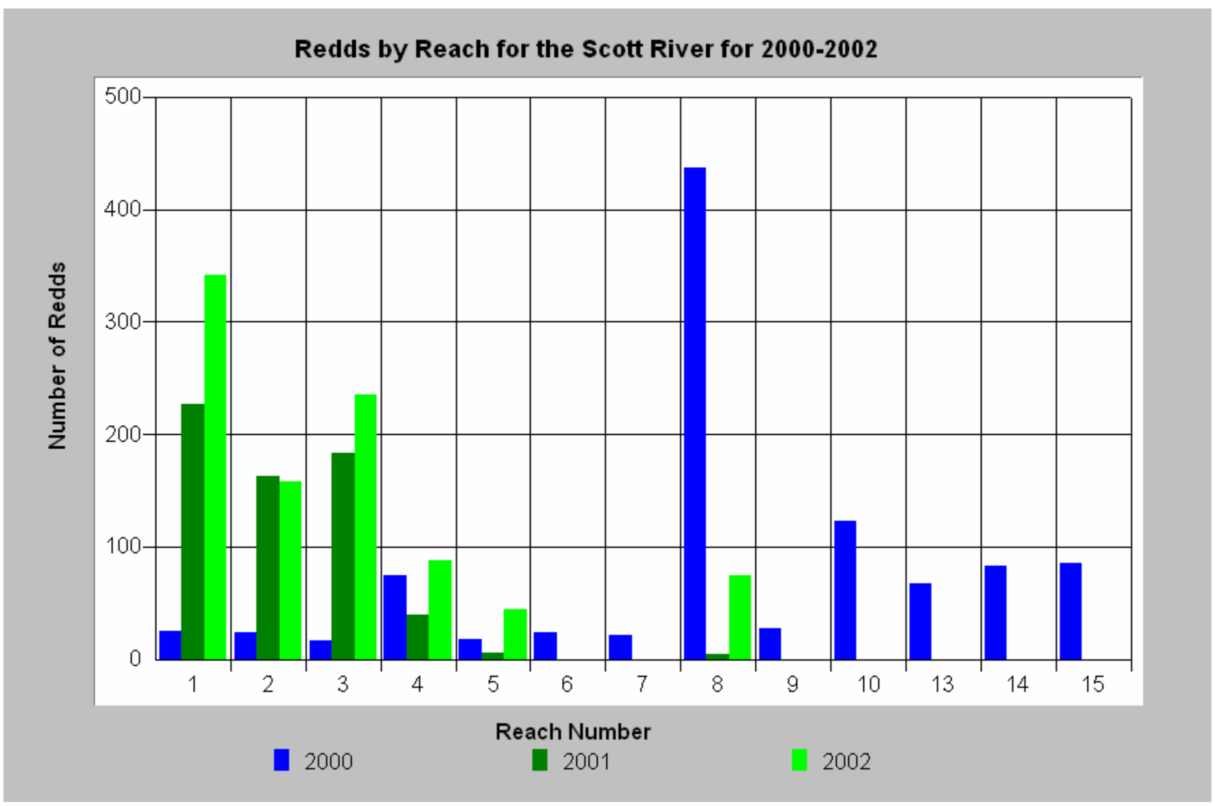


Figure 35. Data from CDFG spawner surveys show that fall chinook salmon spawned mostly in the lowest five reaches of the Scott River in 2001 and 2002, where eggs may be vulnerable due to potential for bed load movement or transport of decomposed granitic sands. Low flows in fall prevent salmon disbursement to upstream reaches where gravel conditions are superior and chances of egg survival greater. KRIS V 3.0.

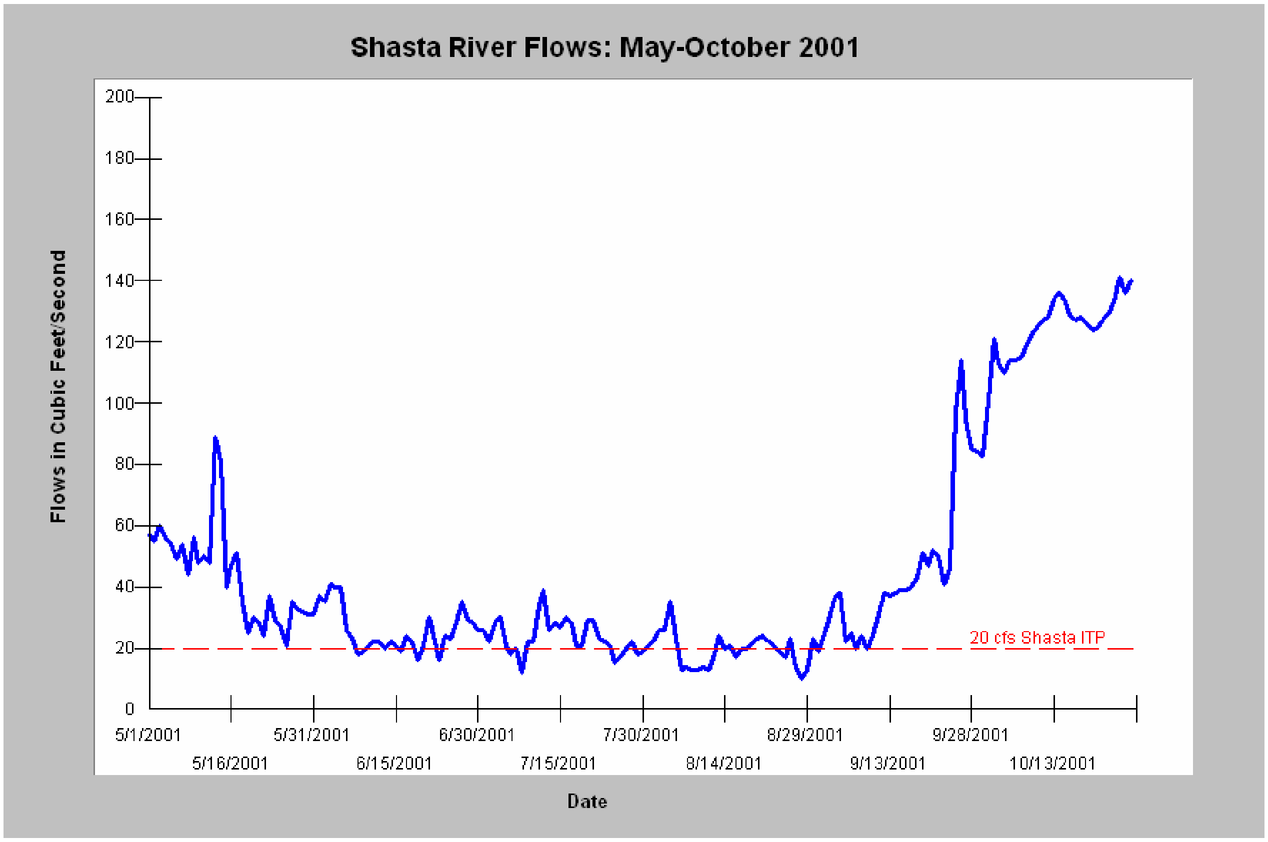


Figure 36. Average daily flow at the USGS Shasta River gauge for May through October 2001 shows a pattern of extremely low flows with many days falling below 20 cubic feet per second. This contributes to temperature problems as less water mass warms easily and agricultural runoff back to the river is hot.

Figure 37. Dwinnell Reservoir looking southeast off the dam with water levels at less than full pool in 2002. Long retention time and exposure to sunlight trigger algae blooms and nutrient pollution. Water releases from this reservoir are restricted to avoid adding to water pollution downstream. It has blocked downstream flow since 1928 in violation of CDFG 5937. Photo from KRIS V 3.0 by Michael Hentz.

Figure 38. Parks Creek is shown here below the diversion to Dwinnell Reservoir with surface flows almost completely depleted. This not only shuts off cool water that could buffer high Shasta River water temperatures. Winter flows are also diverted blocking adult fish passage and blocking spawning gravel recruitment to the mainstem Shasta River. Photo by Michael Hentz.

Mack (1958) measured flow in Big Springs Creek of 103 cfs, which is very similar to the measurements taken by the California Department of Public Works (1925) for the Shasta River Adjudication (CDPW, 1932). This spring source was at optimal temperatures for salmonid rearing and the California Department of Water Resources (1981) found that Big Springs Creek had the highest spawning use of any Shasta River reach or tributary. Kier Associates (1999) noted that the spring feeding Big Springs had been depleted due to ground water pumping to less than 20 cfs.

Major increases in diversion of surface and groundwater have changed the temperature regime of the Shasta River. Thermal infrared radar (TIR) imagery captured by Watershed Sciences (2003) illustrates how flow depletion affects Big Springs Creek and Shasta River water temperature (Figure 39). The image shows water temperatures below 20^{o} C only immediately downstream of Big Springs Lake, but warming to 21.7^{o} C (Watershed Sciences, 2003), which is stressful for salmonids (U.S. EPA, 2003). The NCRWQCB (2006b) recommends that flows increases at Big Springs to at least 50 cfs to restore water quality.

The Shasta River and Scott River will also be where new private Watermaster service will be pioneered. The service has been ineffective in protecting instream flows in these basins (Kier Associates, 1991; 1999). The cost of DWR Watermaster service is born by the water users and it has been rising in recent years. Recent legislation now allows the water users to hire private contractors to render the same service. Questions have been raised as to whether a private contractor working for the water users can be expected to elevate public trust interests over those of his clients.

The NRC (2004) asked for consideration of removal of Dwinnell Dam in order to restore fish passage and increase flows. Models of snow fall changes resulting from global warming indicate that only Mt. Shasta's snow pack will increase, which makes the Shasta River one of the best places to maintain salmonids in the Klamath Basin in the face of climate change.

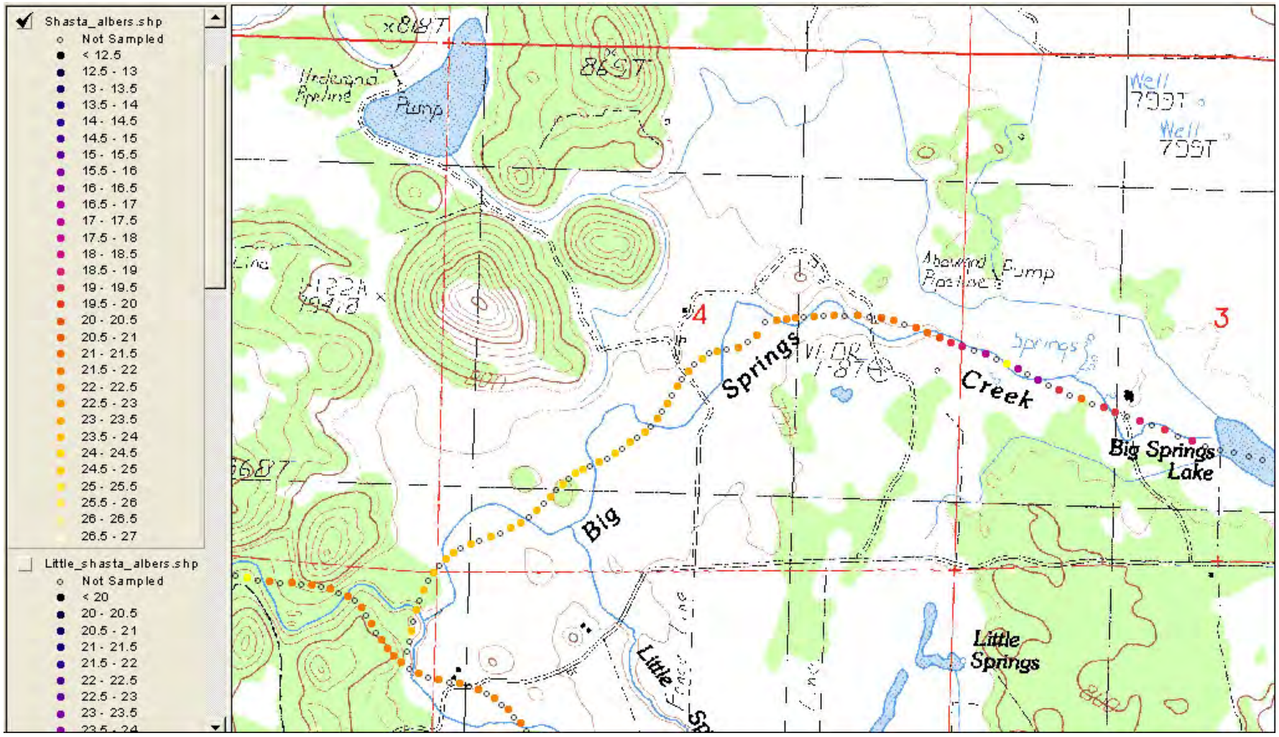


Figure 39. Thermal infrared radar (TIR) map of Big Springs Creek shows that the stream warms rapidly as a result of diversion and now is too warm for optimal salmonid rearing within a distance of less than three miles. Data from Watershed Sciences (2003) provided as GIS by NCRWQCB staff.

Climatic Cycles and Climate Change

The majority of the peer reviewers of the *Policy* (Lang, 2008; Gearheart, 2008; Band, 2008; McMahon; 2008) stated that SWRCB WRD needed to factor climate change into their planning. As mentioned above, NRC (2004) asserts that the Shasta River has the greatest restoration potential in the Klamath Basin in the face of global warming. Oscillations of climatic cycles will likely accentuate drought, which will act in concert with increased water demand from a growing population (Stetson Engineering, 2007b). While study of climate change is still progressing, shorter term cycles of rainfall and ocean productivity are now well recognized (Hare, 1998).

The Pacific Decadal Oscillation (PDO) cycle causes major shifts in ocean productivity from favorable to unfavorable for salmon approximately every 25 years off the coast of California, Oregon and Washington (Hare et al., 1999). Good ocean conditions are linked to wetter weather cycles and prevailed from 1900-1925 and 1950-1975 and returned to favorable again in 1995 (Collison et al., 2003). Poor ocean productivity and dry on-land cycles from 1925-1950 and 1976-1995 created very adverse conditions for salmon, particularly coho. The wet climatic cycle from 1950 to 1975 included the 1955 and 1964 floods. As the PDO cycle shifted, the 1976-1977 drought combined with highly aggraded stream beds to create a freshwater habitat bottleneck. Poor upwelling in the ocean also reduced growth and survival. Coho salmon populations on the California coast from Santa Cruz to Mendocino plummeted and many have never recovered (Figure 40).

The PDO influence is also evident in the Shasta River fall Chinook spawning returns (Figure 41). The highest return of 80,000 adults was just after Dwinnell Reservoir was built, despite being in a less productive ocean and climatic cycle (1925-1950). Even with access to less spawning habitat, runs in the 1960's exceeded 30,000 fall Chinook. The lowest ebb of the Shasta came during an extended drought from 1986-1992, when adult returns dropped to as low as 500 fish. Hopefully the WRD and DWR will get more water back in the Shasta River before the PDO switches in 2015-2025.

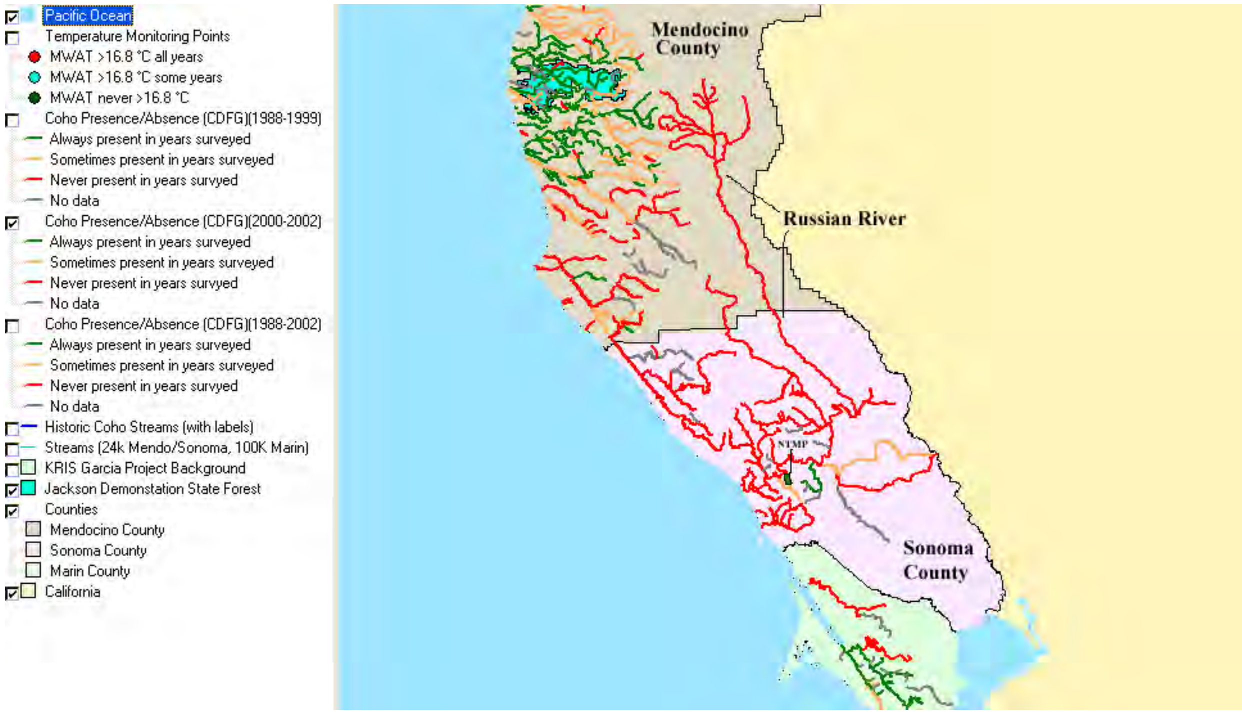


Figure 40. CDFG northern California coho salmon presence and absence maps show streams as green, if coho were always present, yellow if present in at least one year and red if absent in all three years from 2000-2002. Remaining populations are mostly near the coast within the redwood ecosystem and associated with more intact forests patches in coastal Marin County and around Jackson Demonstration State Forest. KRIS Russian.

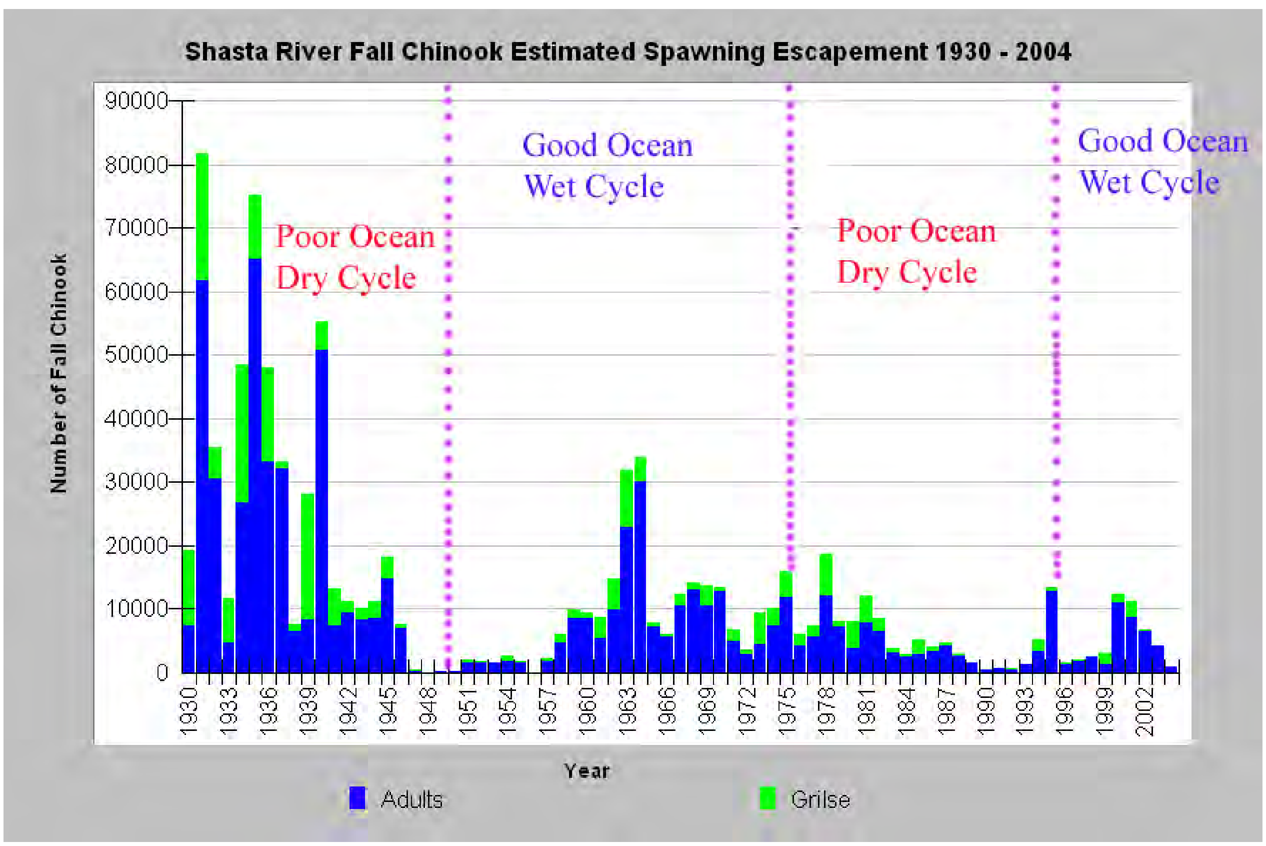


Figure 41. The CDFG Shasta Rack counts show fall Chinook returns from 1930 to 2004 with the PDO cycles overlaid. Returns fluctuate with climate and ocean cycles but the long term trend is down as a result of continuing loss and degradation of freshwater habitat. From Higgins (2006c) and KRIS V 3.0.

Restricted Geographic Scope Misses Basins With Greater Need

The *Policy* implementation is restricted to coastal watershed from the Mattole River south to San Francisco Bay (Figure 1) and does not include either the Klamath or the Eel River basins, which have enormous fisheries potential, more wildlands, and arguably greater need for help resolving flow issues.

The Shasta and Scott river basins are both recognized as water quality impaired to the degree that fisheries resources are compromised. CDFG is currently attempting to issue Incidental Take Permits (ITP) under the California Endangered Species Act for agricultural operations in these watersheds (CDFG, 2006a; 2006b). Lack of flows is confounding coho recovery under both State and federal ESA and, similarly, over-diversion is thwarting attainment of water quality standards under recently completed Scott and Shasta TMDLs (NCRWQCB, 2006a; 2006b). Despite the critical need for resolution of water supply issues, SWRCB WRD involvement is not apparent in either the ITP process or TMDL Implementation. California Department of Water Resources (DWR) staff have taken a similarly passive role in management of groundwater, which is directly linked to surface water supply problems in both basins. DWR has also failed to provide effective Watermaster Service and a new law permits the privatization of the service, which poses a potentially substantial impediment for insuring public trust oversight.

Timely action to restore flow and improve water quality in the Scott and Shasta Rivers could get the best return on investment for the WRD, if fish production is the index. The Shasta River has recently produced more than 10,000 adult Chinook salmon (Figure 41) and still has a run of coho salmon. Similarly, a restored Scott River could produce 10,000 fall chinook and viable populations of coho and steelhead as well. As NRC (2004) points out, increasing flow in the Shasta River would decrease water temperature. Functional Scott and Shasta River canyons would once again revitalize the rearing capacity of the both rivers for steelhead.

The Klamath River is recognized as being in crisis with regard to water quality and fish disease (Nichols and Foott, 2004) and the potential cumulative benefit of restoring flows and cold water from the Scott and Shasta Rivers should not be overlooked. Currently the Shasta and Scott contribute very little flow in summer to the mainstem Klamath River and what water they do contribute is warm and high in nutrients. McIntosh and Li (1998) used forward looking infra-red radar (FLIR) to examine water temperatures of the Klamath River. Figure 42 shows the FLIR image of the convergence with Shasta River water temperatures exceeding 29^{o} C (84^{o} F) and the Klamath River itself above lethal limits for salmonids. This influence is the opposite of the historic role the Shasta River played in moderating Klamath River water temperatures and nutrient loads.

The Eel River once had hundreds of thousands of salmon and steelhead, yet even the mainstem has gone dry in recent years just above Fernbridge in late summer. Flow depletion due to Pillsbury Dam reduces mainstem habitat, but the South Fork Eel is now also flow depleted. The latter has become so stagnant in recent years that blue green algae has proliferated that is toxic to dogs and makes recreational use impossible. Dozens of formerly productive tributaries for fisheries now run dry in summer and early fall. Because the Eel River watershed remains largely unpopulated and wild land, it has a great deal more chance for recovery than urbanizing watersheds or those with extensive agricultural activity.

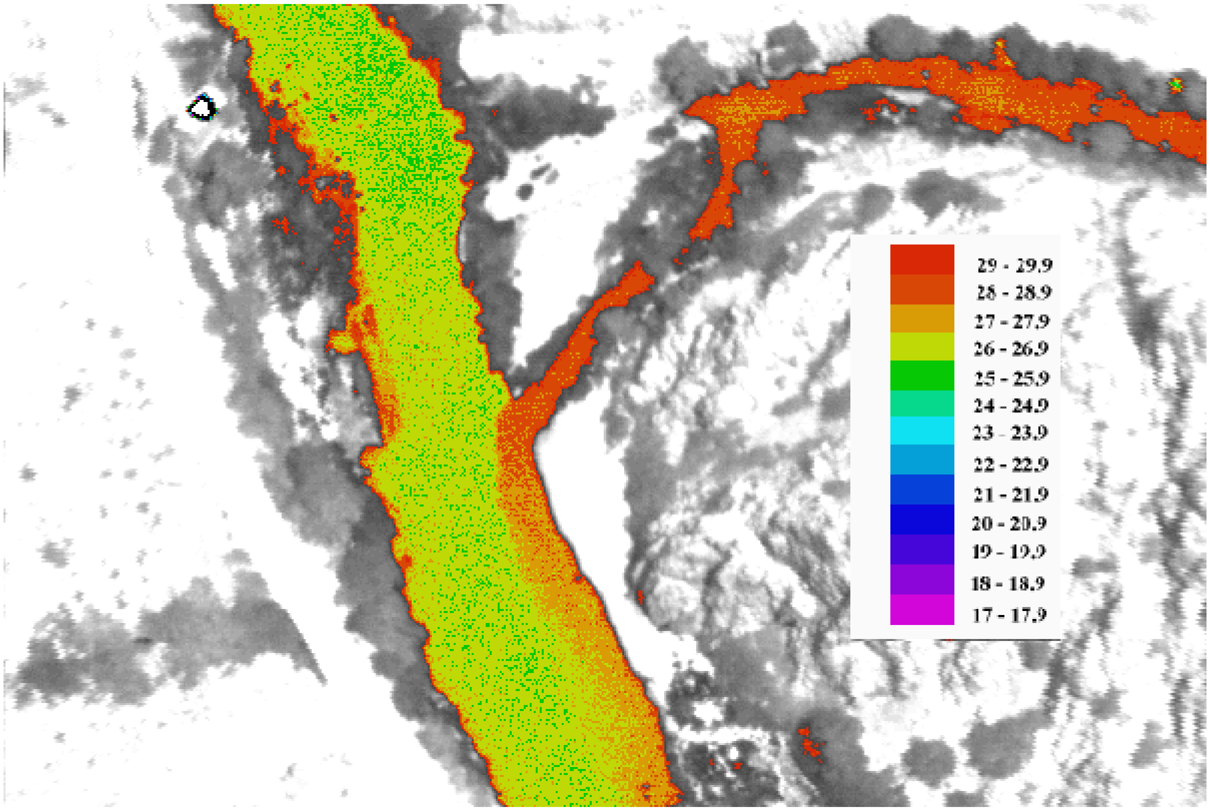


Figure 42. Thermal Forward Looking Infrared Radar Image (FLIR) showing the confluence of the Klamath River (flowing from the top of the image to the bottom of the image) and the Shasta River (flowing right to left in the image). The Shasta River is approximately 29 degrees C, which is well above lethal to salmonids. A warm water plume is observed in the Klamath River below. From McIntosh and Li (1998).

Monitoring, Data Management and Adaptive Management

Monitoring: The *Policy* calculation of protective base flows and water availability rely on fragmentary historical flow data and flawed synthetic data and “additional data collection on small stream hydrology and fish usage is needed to verify these relationships” (Lang, 2008). A major problem is that all monitoring envisioned is on winter flows (October-March) when surplus water is theoretically available, not on April-September flows that are known to be limiting fisheries.

There is a need for year around data collection in small and large streams throughout the region, with the priority identification of stream reaches where surface flows are lacking but where historically there was carrying capacity for salmon and steelhead. Band (2008) suggests gages “with real-time capability, likely co-funded with the USGS to take advantage of the National Water Information System (NWIS) real-time discharge system.”

McMahon (2008) recommends installation of inexpensive stage height and temperature sensors (www.trutrack.com) that can be purchased inexpensively ($200) and are easy to install. He also recommends that monitoring be focused on key salmon and steelhead reaches (biological hotspots). Band (2008) pointed out the necessity of monitoring for *Policy* implementation:

> “Monitoring and management of the finite water resource network calls for the development of a more advanced sensor network to monitor stream temperature, turbidity, suspended sediment transport in addition to flow. The State of California should be in the position to develop and implement this type of network in collaboration with federal agencies and the university system.”

In other words, to fully deal with the questions of cumulative effects of water diversion and water supply, many similar data elements are needed to those of other processes like the Clean Water Act (TMDL), Endangered Species Act (ITP) and the National Forest Management Act. The SWRCB WRD needs to co-participate with other agencies so that multiple objectives of different processes can be met and the WRD benefits from corollary data collected by its partners.

The SWRCB WRD shows little technical capacity, other than that provided by consultants, and no track record of extensive field data collection. There is no commitment to a schedule for monitoring and the effectiveness monitoring section of the Policy shows bureaucratic reluctance. DWR shows a similar lack of capacity with regard to ground water monitoring and regulation. Consequently, the State should solicit emergency help from the U.S. Geological Survey to assess water supply and surplus availability (see Conclusion for discussion on the need to re-organize WRD and DWR).

<u>Data Management</u>: Regardless of how data collection and agency coordination are structured, there needs to be a common database for sharing results, trend monitoring and implementation of adaptive management. KRIS projects submitted with these comments supply a great deal of useful data, including GIS information The SWRCB Water Rights Division should consider using this tool, already subsidized with over $1 million in public money, especially since the KRIS software allows easy cost-effective updating capacity for trend monitoring.

If *Policy* implementation involves partnerships with private parties or groups, all raw data, computer codes for models and other related information must be available to the scientific community and to the public in electronic form. Without full transparency, no model or study output is scientifically valid (Collison et al., 2003) and history shows that public trust resources, such as salmon and steelhead, cannot be fully protected without the ability of the public to participate in oversight.

Band (2008) envisions using the data collected in the field to increase the predictive capacity of the flow model:

> "An integrated GIS-spatial watershed model that incorporates natural runoff production, stream routing and all water diversions and return flows should be developed……As part of an adaptive management approach, the modeling system would provide a formal set of expectations of different water resources policies in the watersheds."

<u>Adaptive Management</u>: The National Research Council (2004), in recommending that adaptive management be used to recover the endangered fishes of the Klamath basin, described it as follows:

> "Adaptive management is a formal, systematic, and rigorous program of learning from the outcomes of management actions, accommodating change, and improving management (Holling, 1978). Its primary purpose is to establish a continuous, iterative process for increasing the probability that a plan for environmental restoration will be successful. In practice, adaptive management uses conceptual and numerical models and the scientific method to develop and test management options."

Dr. Carl Walters (1997) is credited with having coined the term adaptive management and has followed 25 case studies of riparian and coastal ecosystem restoration projects around the world, but found "only seven of these have resulted in relatively large-scale management experiments, and only two of these experiments would be considered well planned in terms of statistical design." He notes that too little change in anthropogenic stressors is carried out in most cases so that natural variation are not distinguishable from project effects.

"Various reasons have been offered for low success rates in implementing adaptive management, mainly having to do with cost and institutional barriers" (Walters, 1997).

The cost of monitoring associated with *Policy* implementation is not estimated nor are sources of funding identified. The institutional barriers that might impede successful adaptive management are well described above. The attempt to pass of monitoring costs to diverters (watershed groups) in exchange for their helping shape water management is unacceptable. The WRD needs to calculate staffing costs and define a partnership structure with other agencies that will satisfy data needs for adaptive management.

If 500 or 1,000 illegal dams are removed, we would have the potential to make a difference on the problem and would also frame an interesting and valid adaptive management exercise.

Instead of adaptive management, the SWRCB WRD has been exhibiting what NRC (2004) terms deferred action:

> "In the deferred-action approach, management methods are not changed until ecosystems are fully understood (Walters and Hillborn, 1978; Walters and Holling, 1990; Wilhere, 2002). This approach is cautious but has two notable drawbacks: deferral of management changes may magnify losses, and knowledge acquired by deferred action may reveal little about the response of ecosystems to changes in management. Stakeholder groups or agencies that are opposed to changes in management often are strong proponents of deferred action."

Conclusion

When one studies Appendix E (Stetson Engineering, 2007a), it becomes apparent that Dr. Bob Gearheart's (2008) characterization of his experience with water rights in the Upper Klamath in Oregon apply to the *Policy* area: "water rights were 1) over allocated, 2) unmeasured, and 3) mostly unregulated." Implicit in the *Draft Policy* is that there is surplus water in North Coast streams in the geographic area in question. An accurate inventory of water resources might find that many or most streams are fully allocated, given changes in watershed hydrology and channel morphology in conjunction with existing levels of diversion and groundwater use. When the geographic extent and severity of the problem is fully assessed, one can see that Pacific salmon species will not thrive or even survive into the future without profound change in California water policy and management.

<u>Recommendations</u>: If the *Policy* goes forward under current agency framework:

- Only consider diversions after December 15.
- WRD works with USGS to set up gauges for year around flow measurement region wide, share all data in the public domain.
- No additional permits issued by WRD for streams that formerly supported juvenile salmonid rearing but now are dry for any period of the year and were not historically intermittent.
- Conduct full inventory of all water extraction on the ground in cooperation with USGS, including riparian rights, pre-1914 and illegal diversions within one year.
- Stop post-permitting of illegal diversions and make fines sufficient to be a disincentive.
- Work cooperatively w/ CDFG using 5937 and get flows back. Don't reign in the wardens.
- DWR needs to work with USGS on collection of ground water data and more actively manage the resource and data needs to be made public.

- DWR should re-establish Watermaster Service so that it is done by a government agency not a private party due to public trust protection needs and provide more effective service.
- WDR, DWR, CDFG and NOAA Fisheries need to create a participatory data management system that has all data for the region, including spatial data, and can be used for adaptive management.

In light of over-diversion, critical shortages of water for fish, inexorably rising demand for water, and the rampant lawlessness of both surface and ground water diversion, it is clear that we have a regional crisis. The data and the case studies above show that there is a complete dereliction of duty by the WRD and a similar lapse in management of ground water by DWR.

In fact, much more profound reform is likely necessary, although there will be considerable opposition from agricultural interests and intransigent bureaucracies involved. What is really necessary is:

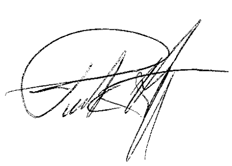
1) Change California Water Law to make riparian diversions require a permit,
2) Have Legislature request Attorney General investigation into lack of enforcement of SWRCB codes (1052, 1055, 1243, and 1375), including illegal extraction of ground water that is connected to surface water (i.e. Big Springs, Shasta River)
3) Consolidate surface water and ground water management and Watermaster Service under one State agency that has public trust as its over-riding objective, such as CDFG or Cal EPA.
4) Integrate planning with TMDL (Regional Boards), ESA/CESA (CDFG, NMFS), watershed restoration efforts (NRCS/NGO's), and NFMA and Northwest Forest Plan (U.S. Forest Service/Bureau of Land Management) implementation to pool resources and all agencies and processes targeting Pacific salmon recovery.

Given the institutional incapacity of both the SWRCB WRD and DWR, it is hard to recommend either as a future lead agency under which water management would be carried out, and it is time to consider shifting authority. Regardless of how bureaucratic responsibility might be reallocated, the new management perspective must hold public trust protection as a priority and allow water extraction only when it does not harm fisheries and water quality. Also under any scenario the USGS is needed immediately to lead data collection and analysis.

Urgent action is needed in reform of water management to avoid a wave of Pacific salmon stock losses due to climate change and recognized shifts in climatic regimes, such as the Pacific Decadal Oscillation (PDO) cycle (Hare et al., 1999). That means substantially improved freshwater habitat conditions by 2015-2025. It is time for State agencies to uphold the law, to begin cooperative work to remediate over-diversion of surface and groundwater, and to not only prevent fish stock extinctions, but to aim for restoration that provide a harvestable surplus of fish. Restoration of recreational beneficial uses will improve regional quality of life. Healthier rivers will also contribute to economic development related to tourism.

I would be happy to discuss any aspect of my comments with your staff.

Sincerely,



References

Barnhart, R. A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--steelhead. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.60). U.S. Army Corps of Engineers, TR EL-82-4. 26 pp.

Boccione, V and W. Rowser. 1977. Field Note: Gualala River Stream Flow Measurements Taken with Pygmy Flow Meter Using 6-Tenths Depth Method To Determine Mean Velocity At Ten Stations. Includes Stations from the South Fork, North Fork, Wheatfield Fork, and Mainstem Gualala River (maps, data sheets). California Department of Fish and Game, Region 3, Yountville, CA. 2 pp.

Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D. L. Bottom, W.E. Weaver and R. L. Beschta. 1995. Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Pacific Salmon. Published by Pacific Rivers Council, Eugene, OR. 56 p.

California Department of Fish and Game (CDFG). 1969. Anderson Creek (South Fork Navarro River tributary) stream survey, 25 June 1969. CDFG unpublished file memo by J. Thompson and J. Michaels. Yountville, CA. 5 pp.

CA Department of Fish and Game. 2002. Status Review of California Coho Salmon North of San Francisco . Report to the California Fish and Game Commission. California Department of Fish and Game, Sacramento , CA. 336pp.

California Department of Fish and Game (CDFG). 2004. California Salmonid Stream Habitat Restoration Manual. Fourth Edition. Inland Fisheries Division. California Department of Fish and Game. Sacramento, CA.

California Department of Fish and Game. 2006a. Draft Environmental Report for the Proposed Scott River Watershed-Wide Permitting Program for the Incidental Take of Coho Salmon. CDFG R 1, Redding, CA.

California Department of Fish and Game. 2006b. Draft Environmental Report for the Proposed Shasta River Watershed-Wide Permitting Program for the Incidental Take of Coho Salmon. CDFG R 1, Redding, CA.

CA Dept. of Fish and Game and National Marine Fisheries Service. 2002. Draft Guidelines for Maintaining Instream Flows to Protect Fisheries Resources Downstream of Water Diversions in Mid-California Coastal Streams. CDFG, Sacramento, CA and NMFS, Long Beach, CA. 23 p.

California Department of Public Works Div of Water Rights. 1925. Shasta River Adjudication Proceedings: Report on Water Supply and Use of Water from Shasta River and Tributaries, Siskiyou County. 7/1/1925. On file at Miriam Library at California State University, Chico, CA.

California Department of Public Works. 1932. Appropriation of Water Rights in the Shasta Basin. California Department of Public Works Division of Water Rights, Sacramento, CA.

California Department of Water Resources. 1981. Klamath and Shasta River spawning gravel enhancement study. CDWR, Northern District, Red Bluff, Calif. California

California State Water Resources Control Board. 1980. Scott River Adjudication Decree No. 30662, Superior Court for Siskiyou County. Scott River stream system within California in County of Siskiyou. Sacramento, 152p.

California State Water Resources Control Board, Water Rights Division. 1998. Report of investigation on the Navarro River watershed complaint in Mendocino County. Complaint Unit, Division of Water Rights, SWRCB . Sacramento, CA. 73 pp.

California State Water Resources Control Board, Water Rights Division. 1999. Order WR 99-011. Sacramento, CA. November, 1999.

California State Water Resources Control Board, Water Rights Division. 2000. Letter to John Bower, President, North Gualala Water Company. Sacramento, CA. August 23, 2000.

California Regional Water Quality Control Board (CRWQCB). 2001. Technical Support Document for the Gualala River Watershed Water Quality Attainment Action Plan. CRWQCB, Region 1. Santa Rosa, CA. 147 pp.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.

Good, T. P., R. S. Waples & P. B. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-66. 598 pp.

Groot, C. and L. Margolis (eds). 1991. Pacific salmon life histories. Univ. Of British Columbia Press, Vancouver, B. C.

Hagans, D.K., W.E. Weaver, and M.A. Madej. 1986. Long term on site and off site effects of logging and erosion in the Redwood Creek Basin in northern California. Nat. Council on Air and Streams, Tech. Bull. 460.260 Madison, Av., New York, NY.

Hall, S. 2006. Memo to SWRCB WRD re: Draft SED North Coast Instream Flow Policy. Friends of the Navarro Watershed, Philo, CA. 2 p.

Harvey, B.C., R. J. Nakamoto and J. L. White. 2006. Reduced Streamflow Lowers Dry-Season Growth of Rainbow Trout in a Small Stream. Transactions of the American Fisheries Society. Vol. 135:998–1005.

Hilton, S. and T.E Lisle. 1993. Measuring the Fraction of Pool Volume Filled with Fine Sediment. Res. Note PSW-RN-414. US Forest Service, Pacific Southwest Research Station. Albany, CA . 11 p.

Higgins, P.T. 1992. Restoration Feasibility Assessment of San Mateo Creek and the Santa Margarita River. Performed under contract to the California Council of Trout Unlimited. Available from Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA.

Higgins, P.T., S. Dobush, and D. Fuller. 1992. Factors in Northern California Threatening Stocks with Extinction. Humboldt Chapter of American Fisheries Society. Arcata, CA. 25pp.

Higgins, P.T. 1997. Gualala River Watershed Literature Search and Assimilation. Funded by the Coastal Conservancy under contract to Redwood Coast Land Conservancy. Gualala, CA. 59 pp.

Higgins, P.T. 2003. Comments on Negative Declaration for Sugarloaf Farming Corporation dba Peter Michael Winery, Timberland Conversion No. 524; THP 1-01-223 SON. Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA. 14 p. 12/12/03

Higgins, P.T. 2004a. Comments on Negative Declaration for THP 1-04-030SON, Hanson/Whistler Timberland Conversion Permit (TCP) #530. Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA. 13 p. 4/14/04

Higgins, P.T. 2004b. Comments on Negative Declaration for Timber Harvest Plan (THP 1-04-055 SON) / Zapar-Roessler Timberland Conversion Permit (TCP 04-533). Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA. 4 p. 8/16/04.

Higgins, P.T. 2006a. Comments on the Napa River Sediment TMDL and San Francisco Bay Regional Water Quality Control Board Basin Plan Amendment. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA. 21 p. 8/14/06.

Higgins, P.T. 2006b. Comments on the Proposed Mitigated Negative Declaration for Napa Canyon LLC Vineyard Project in American Canyon Creek Watershed. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA. 13 p. 10/7/06

Higgins, P.T. 2006c. Scott TMDL Related Data, Photos and Maps Regarding Flow and Temperature Problems. Attachment A to Klamath Coalition Joint Comments on the Proposed Action Plan for the Scott River Watershed Sediment and Temperature TMDL. 31 p. http://www.klamathwaterquality.com/ScottTMDLJointLtr06-12-06.pdf

Higgins, P.T. 2000d. Shasta River TMDL Supporting Information: Flow, Temperature, Nutrient Pollution and Potential for Loss of Pacific Salmon Stocks. Attachment A to Klamath Coalition Joint Comments on the Proposed Action Plan for the Shasta River Watershed Nutrient, Dissolved Oxygen and Temperature TMDL.

Higgins, P.T. 2007. Comments on Timber Harvest Plan and Timber Conversion Plan 1-06-134 NAPA or Abbott Wall Road Vineyard Project. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA. 21 p. 2/22/07

Higgins, P.T. 2007. Comments on Timber Harvest Plan and Timber Conversion Plan 1-06-134 NAPA or Abbott Wall Road Vineyard Project. Performed under contract to Thomas Lippe, Attorney by Patrick Higgins, Consulting Fisheries Bilogist, Arcata, CA. 21 p. 2/22/07

Hunter, B. 1996. Response to CDU 1 l-96; Applicant North Gualala Water Company, Proposed Upgrade of Water Pumping, Storage and Conveyance System; Affecting the North Fork Gualala River Watershed, Mendocino County. Memo to Charles Hudson, Mendocino County Planning and Building Services. California Department of Fish and Game, Region 3, Yountville, CA. 4 pp.

Institute for Fisheries Resources. 2003. KRIS Gualala Database and Map Project Two CD Set. Funded by the California Department of Forestry FRAP, Sacramento, CA. (www.krisweb.com).

Institute for Fisheries Resources. 2003a. KRIS Russian, Navarro, East Marin-Sonoma Database and Map Projects. Funded by the Sonoma County Water Agency, Santa Rosa, CA. (www.krisweb.com).

Jones, J.A. And G.E. Grant. 1996. Peak flow response to clear-cutting and roads in small and large basins, Western Cascades, Oregon. Water Resources Research, April 1996. Vol. 32, No. 4, Pages 959-974.

Johnson et al. 2004. Navarro River watershed sediment study. University of California, Davis. Performed under contract to CalTrans.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An Ecological Perspective of Riparian and Stream Restoration in the Western United States. Fisheries 22(5):12-24.

Kelley, D. W. 1976. The possibility of restoring salmon and steelhead runs in Walker Creek, Marin County . Prepared for the Marin Municipal Water District . Sacramento, CA. 64 p.

Kier Associates. 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program. Klamath River Basin Fisheries Task Force. Yreka, CA.

Kier Associates. 1999. Mid-term Evaluation off the Klamath River Basin Fisheries Restoration Program. Prepared for the Klamath River Basin Fisheries Task Force. Sausalito, CA.

Kimsey, J. B. 1953. Population sampling on three north coastal streams closed to summer trout fishing - 1952 season. First progress report. California Department of Fish and Game, Inland Fisheries Branch. Sacramento, CA. 28 pp.

Leidy, R.A., G.S. Becker, and B.N. Harvey, 2003. Historical Distribution and Current Status of Steelhead (Oncorhynchus mykiss), Coho Salmon (O. kisutch), and Chinook Salmon (O. tshawytscha) in Streams of the San Francisco Estuary, California. Center for Ecosystem Management and Restoration, 4179 Piedmont Avenue, Suite 325, Oakland, California 94611.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and salmonid habitat. Prepared for the Resources Agency of California and the National Marine Fisheries Service. Sacramento, CA. 181 pp.

Mack, S. 1958. Geology and ground-water features of Shasta Valley, Siskiyou County, California. U.S. Geological Survey, Water Supply Paper. Washington, D.C.

McIntosh, B. A. and H. W. Li. 1998. Final Report - Klamath Basin Pilot Project: Coldwater refugia study and videography. Oregon State University, Corvallis, OR.

Merritt Smith Consulting (MSC). 1996. Environmental conditions in west County waterways. Santa Rosa Subregional Long-term Wastewater Project. Prepared for City of Santa Rosa and U.S. Army Corps of Engineers. Prepared by MSC for Harland Bartholomew & Associates. Layfette, CA. 206 pp.

Montgomery, D. R. and J.M. Buffington, 1993. Channel classification, prediction of channel response, and assessment of channel condition. TFW-SH10-93-002. Prepared for the SHAMW committee of the Washington State Timber/Fish/Wildlife Agreement. Seattle, WA. 110 pp.

National Marine Fisheries Service. 1996b. Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast. US Dept. Commerce, NOAA. 4 pp.

National Marine Fisheries Service. 2001. Status Review Update for Coho Salmon (Oncorhynchus kisutch) from the Central California Coast and the California portion of the Southern Oregon/Northern California Coasts Evolutionarily Significant Units. Southwest Fisheries Science Center, Santa Cruz, CA. 43 p.

National Marine Fisheries Service. 2004. NOAA Fisheries Proposes to Designate Critical Habitat for Seven Evolutionarily Significant Units (ESUs) of Salmon and Steelhead in California. 69 FR 74572; December 14, 2004.

National Marine Fisheries Service. 2005. Endangered and threatened species: final listing determinations for 16 ESUs of West Coast Salmon, and final 4(d) protective regulations for threatened salmonid ESUs. Federal Register, 70: 37160-37204.

National Research Council (NRC). 2004. Endangered and threatened fishes in the Klamath River basin: causes of decline and strategies for recovery. Committee on endangered and threatened fishes in the Klamath River Basin, Board of Environmental Toxicology, Division on Earth and Life Studies, Washington D.C. 424 pp.

Nehlsen, W., J.E. Williams, J.A.Lichatowich. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

Nichols, K. and J.S. Foott. 2005. Health Monitoring of Juvenile Klamath River Chinook Salmon, FY 2004 Investigational Report. USFWS California-Nevada Fish Health Center, Red Bluff, CA.

North Coast Regional Water Quality Control Board. 2006a. Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads. North Coast Regional Water Quality Control Board. Santa Rosa, CA. 31 p.

North Coast Regional Water Quality Control Board. 2006b. Scott River Watershed Sediment and Temperature TMDL. North Coast Regional Water Quality Control Board. Santa Rosa, CA.

North Coast Regional Water Quality Control Board and University of California Davis. 2005. Lake Shastina Limnology. Performed as part of Shasta TMDL technical studies. NCRWQCB, Santa Rosa, CA and Information Center for the Environment, Univ. of California, Davis, CA.. 79 p.

Pacific Watershed Associates. 1994. Action plan for the restoration of the South Fork Trinity River watershed and its fisheries. Prepared for U.S. Bureau of Reclamation and the Trinity River Task Force, Contract No. 2-CS-20-01100. Arcata, CA.

Pennington, M., C. Malan, D. Myers. 2008. Memo to Ms. Karen Niiya, Director of SWRCB Division of Water Rights Re: Draft SED North Coast Instream Flow Policy Comments. Sierra Club Redwood Chapter, Santa Rosa, CA. 8p.

Poole, G.C., and C.H. Berman. 2000. Pathways of Human Influence on Water Temperature Dynamics in Stream Channels. U.S. Environmental Protection Agency, Region 10. Seattle, WA. 20 p.

R2 Resource Consultants. 2007a. Chronology and Technical Basis of the DFG-NMFS Draft Guidelines. Appendix A to Policy for Maintaining Instream Flows in Northern California Coastal Streams, SWRCB WRD.

R2 Resource Consultants. 2007b. Physical Hydrological, and Ecological Conditions Influencing Anadromous Salmonid Habitat in Policy Area Streams. Appendix B to Policy for Maintaining Instream Flows in Northern California Coastal Streams, SWRCB WRD.

R2 Resource Consultants. 2007c. Defining Protectiveness Levels of Flow Related Habitat Requirements of Anadromous Salmonids at a Regional Scale. Appendix D to Policy for Maintaining Instream Flows in Northern California Coastal Streams, SWRCB WRD.

R2 Resource Consultants. 2007d. Hydrologic Analysis of Validation Sites. Appendix F to Policy for Maintaining Instream Flows in Northern California Coastal Streams, SWRCB WRD.

Reeves, G.H., F.H. Everest, and T.E. Nickelson. 1988. Identification of physical habitat limiting the production of coho salmon in western Oregon and Washington. USDA Forest Service, Pacific Northwest Research Station, Portland, Ore. PNW-GTR-245.

Reeves, G.H., K.M. Burnett, and E.V. McGarry. 2003. Sources of large wood in the main stem of a fourth-order watershed in coastal Oregon. Can. J. For. Res. 33: 1363–1370.

Rieman, B. 1993. Consideration of Extinction Risks for Salmonids. As FHR Currents # 14. US Forest Service, Region 5. Eureka, CA. 12 pp.

San Francisco Bay Regional Water Quality Control Board. 2006. Proposed Basin Plan Amendment: Napa River Sediment Reduction and Habitat Enhancement Plan. SFBRWQCB, Oakland, CA. 20 pp.

Sierra Club. 2006. Comments on Draft SED North Coast Instream Flow Policy. Sierra Club, Redwood Chapter. Santa Rosa, CA. 11 p. 8/25/06.

Stetson Engineers Inc. 2007. Potential Indirect Impacts on Municipal, Industrial andAgricultural Water Use and Related Indirect Impacts on Other Environmental Resources. Appendix E to Policy for Maintaining Instream Flows in Northern California Coastal Streams Performed under contract to SWRCB WRD, December 2007. 63 p.

Stetson Engineers Inc. 2007. Potential Indirect Environmental Impacts of Modification or Removal of Existing Unauthorized Dams. Appendix to Policy for Maintaining Instream Flows in Northern California Coastal Streams Performed under contract to SWRCB WRD, December 2007. 71 p.

Stillwater Sciences and W.E. Dietrich, 2002. Napa River Basin Limiting Factors Analysis. Final Technical Report prepared for San Francisco Bay Water Quality Control Board, Oakland, Calif., and California State Coastal Conservancy, Oakland, Calif.. June 14, 2002.

U.S. Environmental Protection Agency. 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA 910-B-03-002. Region 10 Office of Water, Seattle, WA.

Voight, H.N. and D.B. Gale. 1998. Distribution of fish species in tributaries of the lower Klamath River: an interim report for FY 1996. Yurok Tribal Fisheries Program, Klamath, CA. 71 p. plus appendices.

Volker, S. 1994. Complaint and petition to restrain illegal diversions of water from, amend water appropriation licenses and permits to assure bypass flows sufficient to protect instream fish and wildlife, beneficial uses within, restrain unreasonable riparian uses and appropriations of, and declare fully appropriated, the Navarro River and its tributaries. August 24, 1994. Sierra Club Legal Defense Fund, Inc . San Francisco, CA. 21 pp. http://www.krisweb.com/biblio/navarro_scldf_volker_1994_swrcbcomplaint.pdf

Walters, C.J. 1997. Challenges in Adaptive Management of Riparian and Coastal Ecosystems. Draft circulated at the 1997 National American Fisheries Society Meeting, Monterey, CA. 23 p.

Walters, C.J., and R. Hilborn. 1978. Ecological optimization and adaptive management. Ann. Rev. Ecol. Syst. 8:157-188.

Walters, C.J., and C.S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology 71(6):2060-2068.

Washington Dept. of Ecology (WDOE). 2002. Evaluating Criteria for the Protection of Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen. WDOE, Olympia, WA. 97 pp.

Watershed Sciences LLC. 2003. Aerial Surveys using Thermal Infrared and Color Videography Scott River and Shasta River Sub-Basins. Performed under contract for U.C. Davis and the NCRWQCB. Watershed Sciences, Corvallis, OR. 59 p.

Wilkie, M.P and C.M. Wood. 1995. The adaptation of fish to extremely alkaline environments. Comparative Biochemical Physiology. Vol 113B, No. 4, p 665-673.

Hypothesis #5: Surface flows in the Navarro River basin have been diminished in recent decades, which reduces salmon and steelhead productivity.

Surface flow in Pacific Northwest streams can be influenced by rainfall and runoff patterns, dams and flow releases, but also by sediment yield. Streams draining northwestern California watersheds may sometime lose surface flow as a result of aggradation (Kier Associates, 1999). Coho salmon and Steelhead trout are aquatic creatures and, therefore, reduction in flow may decrease available habitat. Reduction in stream flows may also retard sediment transport, increase water temperatures, decrease dissolved oxygen and otherwise negatively influence salmonid fisheries productivity indirectly (Poole and Berman, 2000), however, secondary factors are not considered in this hypothesis. .

Support for the Hypothesis from the Navarro River Basin

The Friends of the Navarro Watershed and others (Volker, 1994) filed a water rights complaint with the California State Water Resources Control Board (SWRCB) Division Water Rights (DWR) for failing to adequately address instream flow needs under the Public Trust Doctrine in the Navarro River basin. In the complaint, Volker (1994) stated that:

> "Illegal and unreasonable water diversions from the Navarro River and its tributaries, primarily for agricultural purposes, have significantly impaired instream fish and wildlife beneficial uses, to the point where the river was literally pumped dry during August and September of 1992. Such illegal and unreasonable diversions threaten again this fall to eliminate the natural flow of the river and its tributaries necessary to sustain constitutionally and statutorily protected instream fish and wildlife beneficial uses."

Volker (1994) noted that the California Department of Fish and Game also had concerns over flow issues and protection of fisheries and aquatic resources and that as of 1992 CDFG was filing protests on all new water rights permit applications in the Navarro River basin. CDFG (1994) explicitly recommended that the "SWRCB consider classifying the upper Navarro River watershed as fully appropriated during all but winter months."

The Mendocino County Water Agency (MCWA) (Jackson, 1991) presented information to the SWRCB DWR that flows in relation to rainfall and runoff had decreased in the Navarro River basin between 1951 and 1988 (Figure 1), while "the pattern of declining annual minimum streamflow has not been observed on the Garcia, Noyo or Ten Mile Rivers."

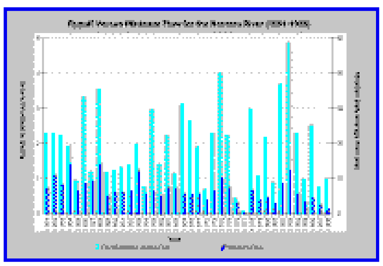


Figure 1. This chart shows the total estimated runoff from the Navarro River watershed as calculated by Jackson (1991) on the left axis in millions of acre feet (MAF) and minimum daily flow in cubic feet per second from the USGS stream gauge (11468000) near the mouth of the river from 1951 to 1988. Water years are defined from Oct 1 to Sept. 30 (i.e. water year 1951 = Oct 1, 1950-Sept 30, 1951). Jackson (1991) found that there was a pattern of lower surface flows for the amount of runoff between 1950 and 1988. A comparison of flow versus runoff for the water year 1955 (0.94 MAF and 6.2 cfs) with 1985 (0.99 MAF and 3.3 cfs) and 1988 (1 MAF and 1.1 cfs) illustrates this pattern.

The SWRCB DWR (1998) published the *Report of Investigation on the Navarro River Watershed Complaint* to address the instream flow issue and its effect on the decline of salmonids in the basin. Although the study did not agree that there was conclusive evidence that flow reductions related to agriculture were harming salmonids, flow measurements were taken that appear in Table 1. These data indicate that several tributaries lost surface flow and that many others had flows less than one cubic foot per second, despite the fact that both 1995 and 1996 were high rainfall years.

Table 1. Minimum flows measured at various locations in the Navarro River basin by the SWRCB DWR in 1995 and 1996. Flows are presented in cubic feet per second (cfs) with Dry indicating loss of surface flow at a location.

Stream/Station	**1995 Minimum Flow**	**1996 Minimum Flow**
Rancheria Creek @ Fish Rock Road	<0.5 cfs	<0.5 cfs
Anderson Creek @ Highway 253	0.5 cfs	0.55 cfs
Soda Creek @ Highway 253	Dry	Dry
Robinson Creek @ Mt View Rd	Dry	Dry
Con Creek @ Anderson Valley Way	<0.05	<0.05
Anderson Creek on Best Property	Dry	Dry
Rancheria Creek Above Anderson	<5 cfs	2.6 cfs
Anderson Creek Above Rancheria	<0.3 cfs	<0.3 cfs
Indian Creek @ Highway 128	<2.5 cfs	2 cfs
Navarro River @ Hendy Woods	<5 cfs	<5 cfs
Navarro River @ Husch	<3 cfs	5 cfs
Mill Creek @ Highway 128	<0.25 cfs	0.2 cfs
North Fork Navarro @ Hwy 128	<1 cfs	<1.5 cfs
Flynn Creek @ Highway 128	Dry	<0.5 cfs

NF Navarro River near Dimmick SP	<2.5 cfs	<2 cfs

A survey of water rights applications at the State Water Resources Control Board's Division of Water Rights (SWRCB DWR) in May, 2002, found 237 records on file for the Navarro River basin (Figure 2). By comparison, the nearby Garcia River watershed had only 12. Water appropriations are granted for different seasons at different amounts for multiple uses, which can all come under the same water rights application. In addition, "the SWRCB identified 121 reservoirs in the Navarro River Watershed without any apparent water rights" (SWRCB, 1998). Figure 3 shows typical off stream and on-stream storage reservoirs. The SWRCB (1998) concluded that the Navarro be listed as fully appropriated between April 1 and December 14. The SWRCB DWR (1998b) subsequently formally recognized the Navarro as fully allocated in summer.

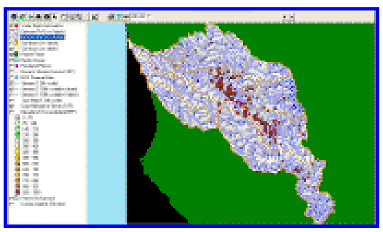


Figure 2. This is a map of water rights information from the State Water Resources Control Board displayed with USGS 1:100,000 hydrography, KRIS sub-basins, and a grayscale hillshade. Water rights listed may not be complete, since not all rights are registered, particularly riparian rights. Also, some water users may be extracting water or building retention ponds without permits.

Figure 3. This aerial photo of agricultural development in the Navarro River basin near Mill Creek shows ten water storage ponds of different types, which are typical of water storage in the Navarro River basin. Vineyard development in the Navarro River watershed has put added pressure on water availability for salmonids. Photo by Rixanne Wehren.

The California Department of Fish and Game conducted habitat typing surveys of North Fork Navarro River tributaries which demonstrate that surface flow in the Navarro River basin may be lost as a result of aggradation (Figure 4). There is very little water diversion in the North Fork Navarro because it is timberland with a low density of residential settlement or agriculture.

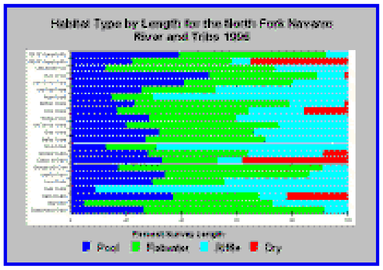


Figure 4. This chart shows habitat types by length for the North Fork Navarro River basin with frequency of pools, riffles, flatwater and dry reaches displayed. The extensive dry reaches in the North Branch North Fork, Camp 16 Gulch and Tank 4 Gulch all demonstrate that surface flow may be lost when a stream is buried deeply in sediment. Data from CDFG.

During field reconnaissance of the Navarro River basin in 2001 and 2002, the KRIS IFR team noted extensive reaches of the Navarro River and its tributaries, which lacked surface flows in summer and early fall (Figures 5-9).

Figure 5. This is a view of temporary road blocking Beebe Creek near Highway 128 above its convergence with Rancheria Creek. This crossing formed a dam which caused flows to pond on the upstream side and to block downstream flows. Dry reaches constitute a constraint on salmonid production whether the origin of flow loss is diversion, aggradation or changes in runoff patterns as a result of cumulative watershed effects. Photo by Pat Higgins, 9/21/01.

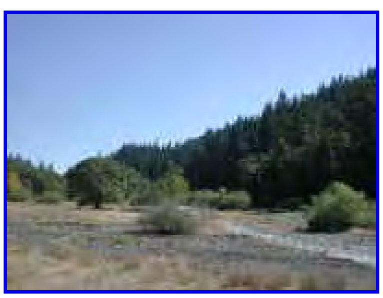


Figure 6. Shearing Creek enters Rancheria Creek from the left in this September 2001 photo, with both streams lacking surface flow at this location. Photo by Patrick Higgins, 9/21/01.

Figure 7. Flynn Creek at Highway 128 lacked surface flow in late September 2001, as illustrated by this photo taken just upstream of the highway bridge. The very fine particle size of the stream bed indicates sediment of recent origin burying Flynn Creek and causing it to lose surface flow. Flynn Creek is a North Fork Navarro River

tributary, a sub-basin that has little agricultural development or domestic water use yet has diminished fish habitat, possibly because of loss of surface flows. Photo by Patrick Higgins, 9/21/01.

Figure 8. Robinson Creek, a tributary of Anderson Creek, looses surface flows in late summer as indicated by this September 2001 photo. The cumulative loss of rearing habitat for salmonids due to dry reaches is significant. Photo by Patrick Higgins, 9/21/01.

Figure 9. This is a view looking downstream on the lower mainstem Navarro River near Flume Gulch during low flow conditions on September 21, 2001. The USGS flow gauge indicated that the average flow on this day was 1.1 cubic feet per second. The mainstem Navarro begins to get stagnant at this flow level as indicated by the algae on the margins of the stream. The shallow flows and wide stream channel combine to exacerbate water temperature problems in the mainstem. Photo courtesy of Pat Higgins, 9/21/01.

Topics Supporting the Hypotheses

The following is a list of Topics in KRIS Navarro where you can see data in its context, Metadata and associated Info Links. The large-case letters in parentheses indicate KRIS sub-basins.

(MN) Flow: Navarro River - Runoff vs. Flows, 1951-1988

(BW) Map: 5B Water Rights Locations, Navarro Project Area

(BW) Tour: Anderson Valley air photos 2001

(NF) Habitat: Habitat Types by Length North Fork Navarro Sub-basin 1996

(RC) Tour: Upper Rancheria Creek and Tributaries Channel Photos 2001 Part 3

(RC) Tour: Upper Rancheria Creek and Tributaries Channel Photos 2001 Part 4

(NF) Tour: Flynn Creek Dry Season Photos 2001

(AC) Tour: Robinson Creek channel photos 2001-02

(MN) Tour: Mainstem Navarro River photos 2001

Alternative Hypothesis: Factors other than flow are causing the problems related to salmonid productivity in the Navarro River basin.

The SWRCB (1998) favors this alternative hypothesis having stated: "the cause of the anadromous fish decline may be principally due to factors other than flow, and there is not enough information available regarding the needs of the fishery in the summer."

Monitoring Trends to Test the Hypotheses

To adequately address flow issues in the Navarro River watershed and test these hypotheses, a water balance analysis is necessary to investigate seasonal and yearly trends in precipitation, river flows, groundwater storage, and actual diversion volumes. Such an analysis could directly address water appropriation and instream flows as limiting factors for salmonid production. A comparative analysis involving other watersheds would also help clarify issues in the Navarro River basin by characterizing the local water budget in a regional context.

References

California Department of Fish and Game (CDFG). 1994. Letter from J.L. Turner to B. Fodge (California State Water Resources Control Board), 01 February 1994, regarding proposed 200 cfs bypass on Navarro River . CDFG unpublished file memo. Yountville, CA. 2 pp. [10kb]**

California State Water Resources Control Board (SWRCB). 1998. Report of investigation on the Navarro River watershed complaint in Mendocino County. Complaint Unit, Division of Water Rights, SWRCB . Sacramento, CA. 73 pp. [1.8Mb]**

Jackson, D. 1991. Letter to R. Swenerton (State Water Resources Control Board), 22 May 1991, regarding concern for Navarro River . Mendocino County Water Agency . Ukiah, CA . 7 pp. [120kb]**

Jackson, D. 1998. Letter to E. Anton (State Water Resources Control Board), 17 August 1998, regarding Report of investigation on the Navarro River watershed complaint in Mendocino County, July 1998. Santa Cruz, CA. 4 pp. [26kb]**

Kier Associates. 1999. Mid-term Evaluation off the Klamath River Basin Fisheries Restoration Program. Prepared for the Klamath River Basin Fisheries Task Force, USFWS, Yreka, CA by Kier Associates, Sausalito, CA. 303 pp.

Poole, G. C. and C. H. Berman. 2000. Pathways of human influence on water temperature dynamics in stream channels. Environmental Management. 20 pp. [250kb]

Volker, S. 1994. Complaint and petition to restrain illegal diversions of water from, amend water appropriation licenses and permits to assure bypass flows sufficient to protect instream fish and wildlife, beneficial uses within, restrain unreasonable riparian uses and appropriations of, and declare fully appropriated, the Navarro River and its tributaries. August 24, 1994. Sierra Club Legal Defense Fund, Inc . San Francisco, CA. 21 pp. [911kb]**

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REDWOOD AND MAACAMA CREEKS FLOWS

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December 29, 2008

Ms. Traci Tesconi
County of Sonoma
Permit and Resource Management Department
2550 Ventura Avenue
Santa Rosa, CA 95403

Re: Pelton House Winery Application #PLP05-0010 from Jess Jackson and Barbara Banke

Dear Ms. Tesconi,

I have reviewed Application # PLP05-0010 for a development of the Pelton House Winery for the Maacama Watershed Alliance and provide comments below on why the project proposes substantial risk to coho salmon (Oncorhynchus kisutch) and steelhead trout (Oncorhynchus mykiss). My conclusion is that there needs to be a full Environmental Impact Report (EIR) under the California Environmental Quality Act because of the need for study of cumulative effects of surface water and groundwater diversion on coho and steelhead in downstream areas. Existing cumulative effects in the Redwood Creek watershed are widespread and the project may contribute to these effects in ways that cannot be mitigated satisfactorily to meet CEQA requirements. Approval of a new discretionary use permit in a conservation area (Sonoma County 1979) where this project's specific land uses have previously been denied would also be a growth-inducing impact and potentially detrimental to critical habitat. Mitigation measures for the cumulative or growth-inducing impacts of this project have not been addressed in the Mitigated Negative Declaration.

In addition to the proposal itself, I have reviewed the Sonoma County (2008) proposed Mitigated Negative Declaration for the project and the November 10th, 2008 revised document, and I have also read or reviewed numerous other related documents, including those by Brelje and Race (2008), Siegal (2008), Richard Slade and Associates (2008), North Coast Regional Water Quality Control Board (NCRWQCB 2008, 2008 a), National Marine Fisheries Service (NMFS 2008), LSA Associates (2006), Curry and Jackson (2008) and Wiemeyer Ecological Services (2008). The project has two discrete sites and that are geographically separate and Figure 1 is adapted from Curry and Jackson (2008) to make the scale of impacts more clear.

My Qualifications

I have been a consulting fisheries biologist with an office in Arcata, California since 1989 and my specialty is salmon and steelhead restoration. I authored fisheries elements for several large northern California fisheries and watershed restoration plans (Kier Associates 1991, Pacific Watershed Associates 1994, Mendocino Resource Conservation District 1992) and co-authored the northwestern California status review of Pacific salmon species on behalf of the American Fisheries Society (Higgins et al. 1992).

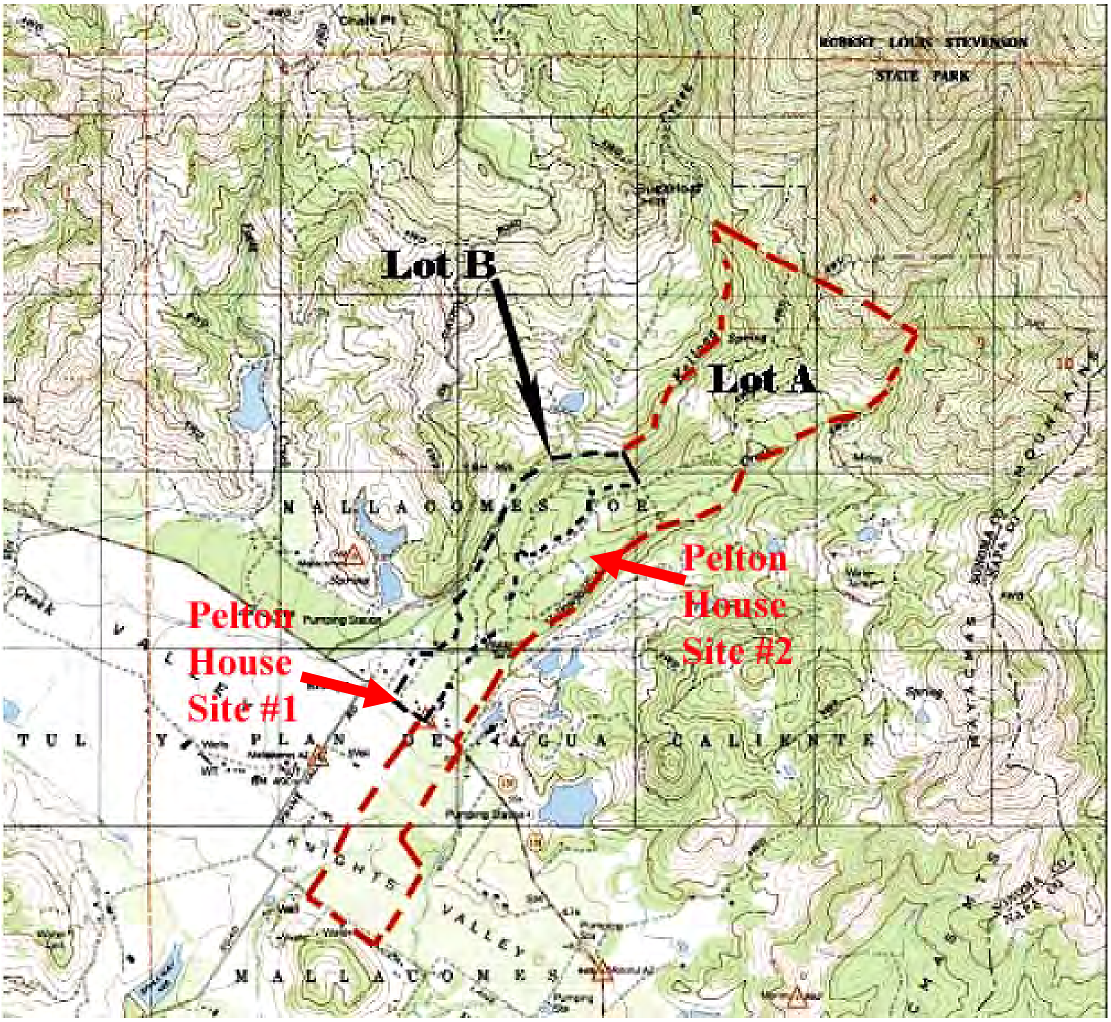

Figure 1. USGS topographic map showing the parcels involved in the Pelton House Winery project and the location of both sites slated for development (arrows).

Since 1994 I have been working on a regional fisheries, water quality and watershed information database system, known as the Klamath Resource Information System or KRIS (www.krisweb.com). This custom program was originally devised to track restoration success in the Klamath and Trinity River basins, but has been applied to another dozen watersheds in northwestern California. The California Department of Forestry (CDF) funded KRIS projects in six northern California watersheds as part of the North Coast Watershed Assessment Planning effort. The Sonoma County Water Agency (SCWA) also funded regional KRIS projects (IFR 2003), including one for the Russian River (KRIS Russian), in order to provide a seamless regional coverage for coho salmon recovery planning. The NCRWQCB served in an oversight capacity on the latter project for quality assurance and quality control. I draw extensively on information in KRIS Russian River and all data are available with metadata on-line at www.krisweb.com.

I have recently addressed the problems of illegal diversion of water in northwestern California, including Sonoma County, on behalf of the Redwood Chapter of the Sierra Club (Higgins 2008) in commenting on the California State Water Resources Control Board (SWRCB) Water Rights Division (WRD) *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams* (SWRCB WRD 2008). I draw on those comments herein, but also am providing them in their original form as Appendix A.

My comments on Mendocino County's updated Draft General Plan (Higgins 2008a), also for the Redwood Chapter of the Sierra Club, are included as Appendix B and are not only relevant to the Pelton House Winery project but may also be useful in your own plan updating process.

Pelton House Proposal and Negative Declaration Regarding Mitigation of Impacts

Sonoma County's (2008) Draft Mitigated Negative Declaration (MND) for the Pelton House Winery has language regarding CEQA compliance that serves as the focus of these comments, because assumptions are not met and the deficiencies are sufficient to warrant a full EIR on the project.

Migration of Native Fish and Wildlife Species: The MND states that the project may not:

> "Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites."

The response is rhetorical and inadequate: "The project site and surrounding areas are partially developed with existing structures, vineyards, and fencing. The project development does not include any work within a creek or wildlife corridor." In fact further withdrawal of water from Yellowjacket, Kellogg, and Redwood Creeks, which is a likely side effect of this project, is a highly significant impact to migration of coho salmon and steelhead adults and juveniles. The underlying issue being ignored here is contributions of the Pelton House Winery to cumulative effects of surface water and groundwater withdrawal on aquatic resources.

Endangered Fish and Wildlife: The CEQA question captured in the MND regarding endangered species is as follows:

> "Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?"

Coho salmon in the Redwood Creek drainage and in the Russian River as whole are on the verge of extirpation (CDFG 2001, Good et al. 2005) and they are present in some years downstream of the project. Withdrawing water from the alluvial aquifer at the convergence of Kellogg and Yellowjacket Creeks will very likely affect flows downstream in Redwood Creek. The tactic in the Initial Study was nothing more than denial, claiming that mitigations will lessen impact to less than significant, but the project proponents actually fail to deal with the subject of endangered coho very near the project site (NMFS 2008, CDFG 2001). The project and MND should at least consider these impacts on the scale of the Maacama Creek watershed where both coho and steelhead face local extirpations due to extensive dry stream reaches and major problems with habitat quality (CDFG 2005). See discussion of Status of Pacific Salmon species.

Cumulative Effects: CEQA requires full recognition of interaction between land uses past, present and foreseeable:

> "Does the project have impacts that are individually limited, but cumulatively considerable ('Cumulatively considerable' means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?"

Once again, there is no analysis in the MND: “No cumulative or long-term impacts have been identified that were not fully mitigated.” Numerous other projects with substantially greater impact that are already permitted or built are acknowledged but with the false assumption that all their impacts have been fully mitigated as well. Figure 2 shows the location of the proposed project with annotations illustrating the existing high level of cumulative watershed effects, to which the project will add. As a discretionary project, this application is subject to a higher level of review, requiring full disclosure of potential impacts and mitigation.

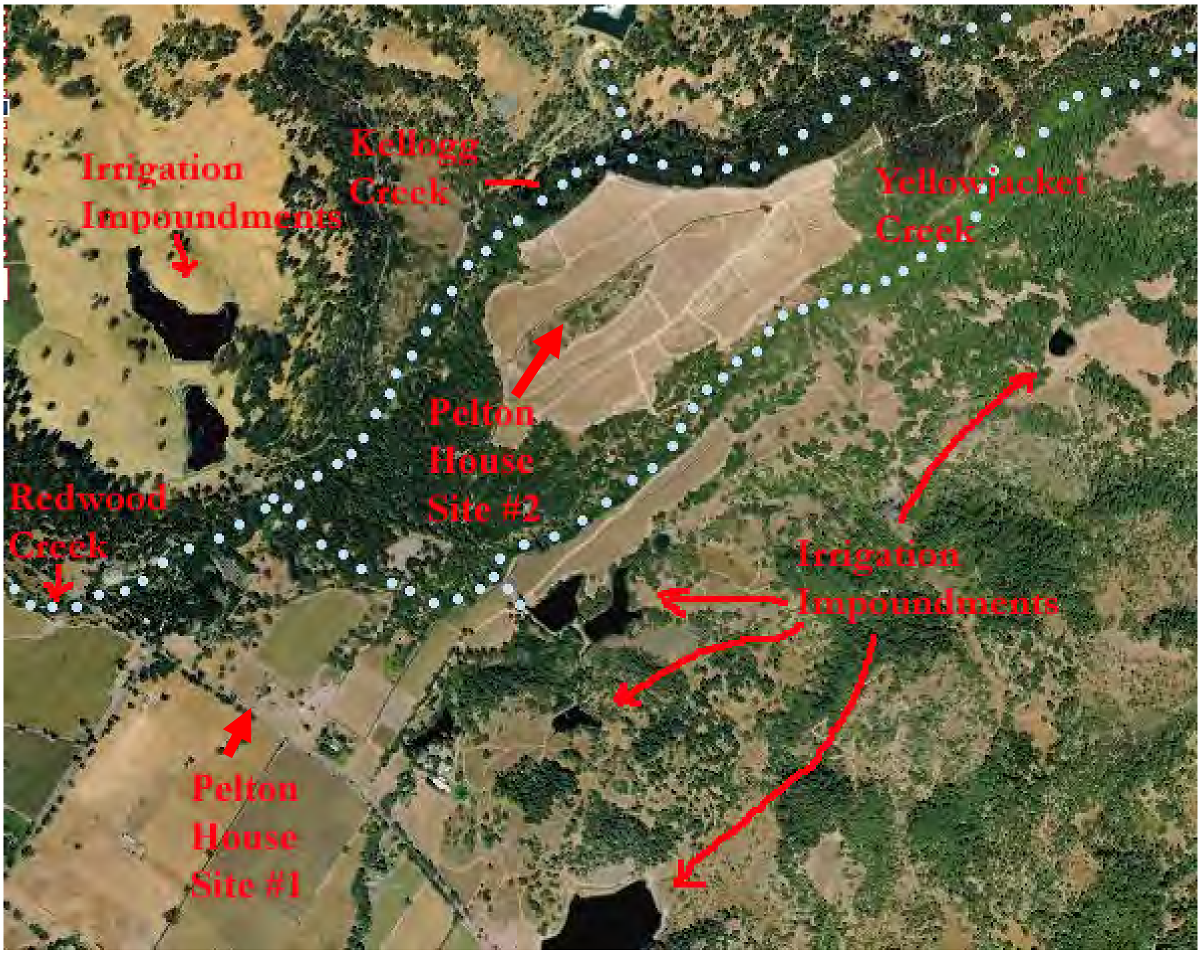

Figure 12. A number of impoundments adjacent to the proposed development sites are causing cumulative effects to downstream reaches of Redwood Creek (Band 2008), and water use associated with the Pelton House Winery will add to flow depletion endangering coho and steelhead. Blue dots approximate stream courses from USGS 1:24000 topographic maps.

Cumulative impacts from the project will be discussed at length below, but in summary they include groundwater withdrawal likely connected to surface water downstream and increased roads and total impervious caused by the project. The water use discussion also needs to acknowledge the extent of lawless use of water in the vicinity of the project (Stetson Engineers 2007, Ball 2005) and implications for cumulative watershed effects on coho salmon and steelhead.

Groundwater/Surface Water Connections in the Project Area and Downstream Flows

The project site is at the southern edge of the Kellogg Creek sub basin in the Maacama Creek watershed and Yellowjacket Creek is within the project site and Bidwell Creek is adjacent to the west. Waters on the project site (surface and subsurface) flow with the topography into Redwood Creek, thence Maacama Creek and the Russian River.

Curry and Jackson (2008) and Siegel (2008) point out that the aquifer under the proposed development site of the Pelton House Winery is in an alluvial valley likely connected upstream and downstream to surface water. Their criticism that pump tests were not conducted between July 15 and October 15, when other users would also be drawing on the aquifer, is valid and the response by Richard C. Slade & Associates (2008) is evasive. He claims a Sonoma County groundwater classification system as a basis for arguing that his client does not have to conduct the test during this period. In fact the MND is explicit that the applicant must show they do not "deplete groundwater supplies or interfere substantially with groundwater recharge," including prevention of decreasing supply for existing projects or users already permitted. This relationship cannot be discerned without data collection between July 15 and October 15. Sonoma County should require a full EIR for the Pelton House Winery project and make it consider the interaction of surface and groundwater interactions at least on the scale of the Kellogg Creek sub basin.

Sonoma County has direct evidence from neighbors (Ball 2005) that Yellowjacket Creek has been drying up as a result of illegal water extraction on or near the project site. Results of a recent consultants report (Stetson Engineers 2007) also show rampant illegal water diversion, including a number of unpermitted impoundments in the vicinity of the project. In fact there is an acute shortage of surface water supply in Yellowjacket Creek and in Redwood Creek downstream (see Habitat Condition). If surface and groundwater are connected, as hypothesized by Curry and Jackson (2008) and Siegel (2008), then additional water withdrawals at this time should not be allowed until such time as the SWRCB WRD can show there is a surplus of water as required by State Water Code.

Widespread Lawless Use of Water Needs Examination in Full EIS

The study by Stetson Engineers (2007), which was part of the SWRCB WRD (2007) *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams,* determined that there were 1357 permitted impoundments in the Policy's area of interest and another 1771 unpermitted ones (Figure 3). Hundreds of illegal diversions are located in Sonoma County, but furthermore, many of these diversions are adjacent to the project site (Figure 4). The data for these legal and illegal diversions must be in the public domain and it is recommended that Sonoma County obtain a copy of electronic data for consideration of this MND and for other land use decisions reliant on additional water use. Figure 4 is derived from a map image in Adobe Acrobat Portable Document File (pdf) format provided by Stetson Engineers (2007) and Figure 5 is a zoom in closer to the project area of the same map. Although the stream resolution of the close up is poor, a major problem with illegal impoundments immediately adjacent to the proposed project is clearly established. A cluster of illegal diversions appears to be within the Redwood Creek watershed, although it is possible that some are in adjacent Maacama tributary watershed of Franz Creek. Figure 6 shows one such impoundment off Franz Valley Road near Highway 128 and not far from the proposed project location. The permit status of the impoundment shown is unknown, but Sonoma County has evidence that implicates the permit applicant as being one of the "unpermitted" operators who surreptitiously deepened irrigation ponds (Ball 2005). There are clearly existing flow related cumulative effects issues that are being ignored by Sonoma County that do not comport with the requirements of CEQA. Your negligence in this regard extends to CEQA's requirements that coho salmon be protected from harm by this project.

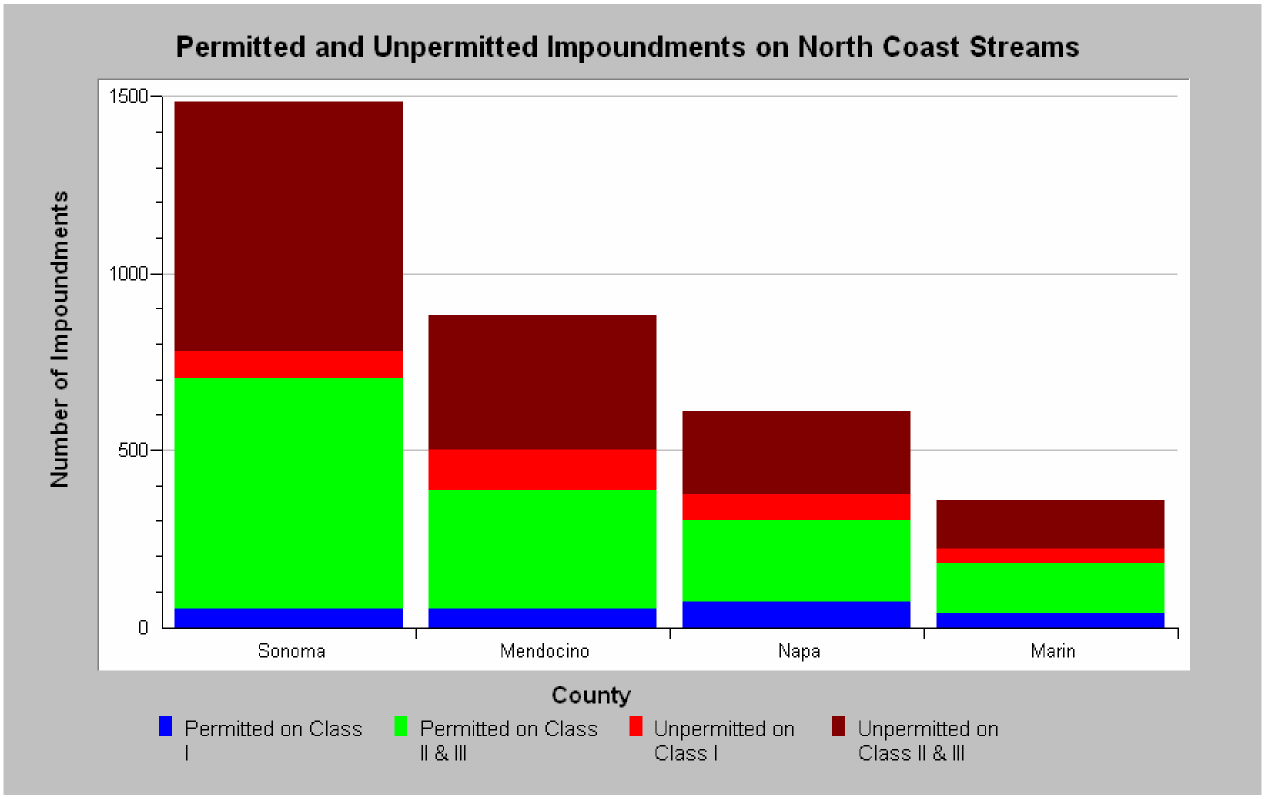

Figure 3. The number of permitted and unpermitted impoundments within the geographic area covered by the SWRCB WRD (2007) study is displayed above with illegal diversion impoundments outnumbering legal ones. Data from Stetson Engineers (2007a).

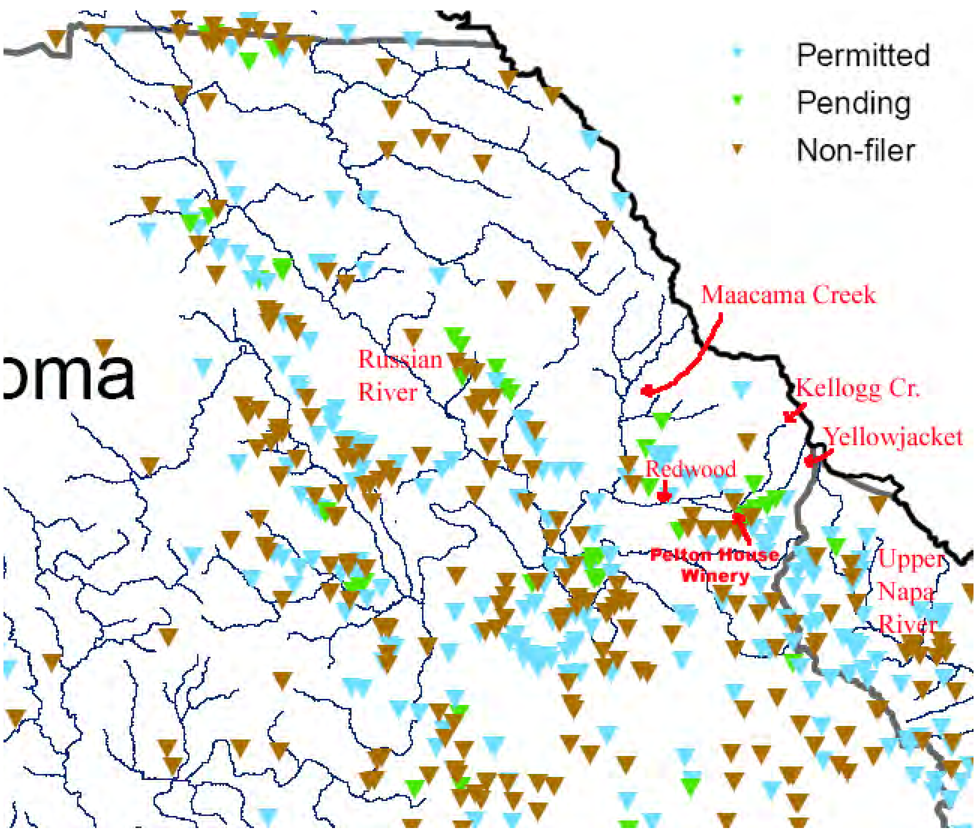

Figure 4. Map shows impoundments by categories of permitted, unpermitted and pending and is modified from Stetson Engineers (2007). Note the large number of unpermitted diversions near proposed site.

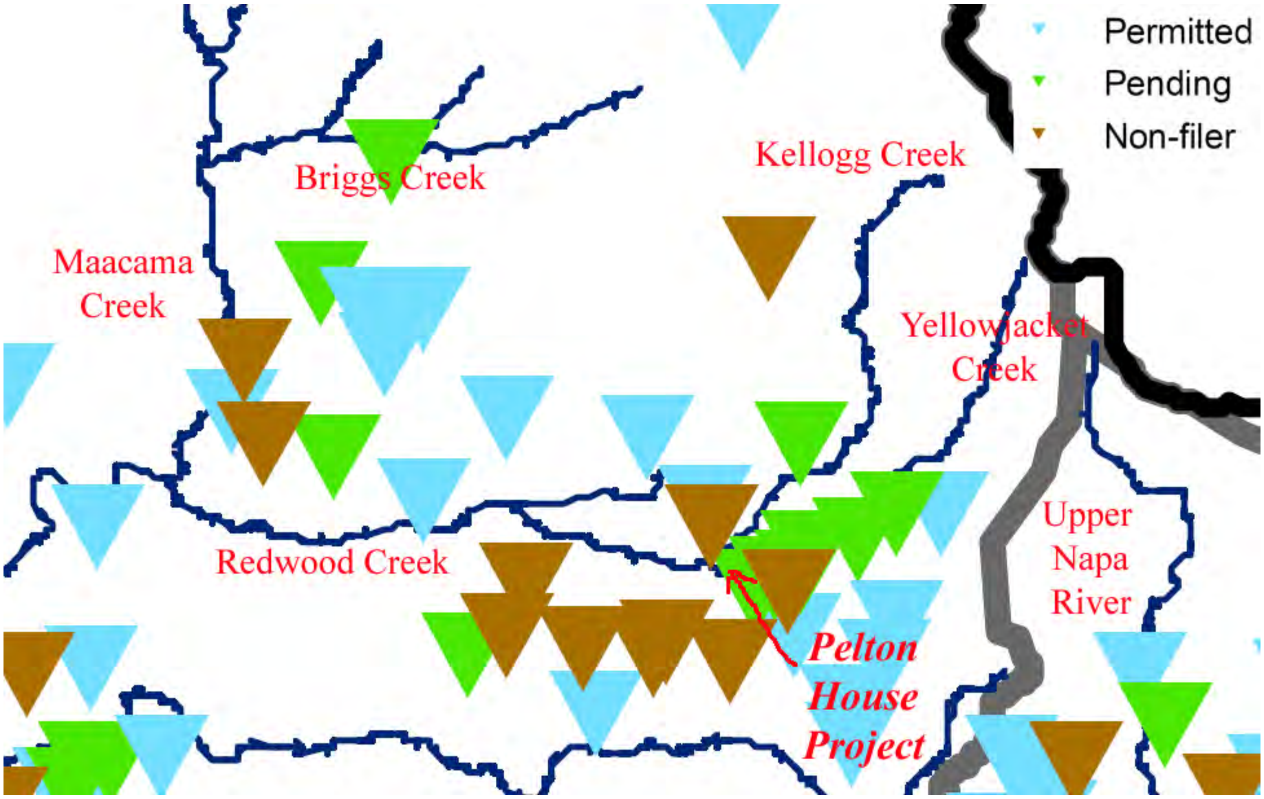

Figure 5. This close up map of legal and illegal impoundments shows clearly that there are a number of illegal ones on or near the project site, although the stream networks are not fully shown due to the scale of the original map by Stetson Engineers (2007).

Figure 6. Looking north off Franz Creek Road not far from Route 128. One of many permitted and unpermitted impoundments in the Redwood Creek drainage that affect stream flow and serve as sources of bull frogs and warmwater non-native fishes that can have undesirable effects on native species. Photo from KRIS Russian by Pat Higgins. 7/13/03.

As part of an EIR for this project's cumulative effects, impoundments and diversions in Redwood Creek and Maacama Creek below it need to be considered. When all reservoirs are filled simultaneously with the first rains of fall or winter, Chinook and coho salmon spawning migrations may be impeded (Band 2008). In a drought year, adult steelhead may be similarly stranded or unable to migrate to spawning grounds due to reservoir induced drops in flow. When reservoirs are filled in summer using stream flows or connected groundwater, nearby streams may dry up. Sonoma County has evidence that the permit applicant was apparently drying up Yellowjacket Creek in July 2005 (Ball 2005) in violation of CDFG Code 5937, and this incident is not likely isolated. Other impoundment related impacts that Sonoma County should be considering are effects of legal and illegal impoundments on water temperatures, the potential they have for introduction of bull frogs that decimate native frog populations, and their contribution to release of non-native warmwater fish that predate upon salmonids or displace them through competition (Higgins et al., 1992).

Status of Pacific Salmon Species in the Russian River and Potential Project Impacts

The MND has no in-depth discussion of the status of Pacific salmon species native to the Russian River and, particularly coho salmon and steelhead trout in the sub basins where impacts will occur. In fact, the Pelton House winery project will likely further deplete flows in reaches of Redwood Creek that have been known to recently support coho salmon and steelhead trout, which are both recognized as at risk of extinction in the Russian River basin. Flow depletion at the project site and in the Redwood Creek watershed also has ripple impacts on Chinook salmon that utilize Maacama Creek downstream.

<u>Status of Russian River Pacific Salmon Populations</u>: There are no baseline data for Russian River salmon and steelhead populations before the early 1960's when CDFG (Taylor, 1978) estimated that annual adult returns were 50,000 steelhead, 5,000 coho salmon and 500 Chinook salmon (<u>Oncorhynchus tshawyscha</u>). Pink salmon (<u>Oncorhynchus gorbuscha</u>) were also once native to the lower Russian River (Moyle et al. 1989), but no spawning has been documented since 1955 (Fry 1967). While pink salmon are not further discussed or likely restorable, they are worthy of note because they represent a species lost due to a much earlier wave of development and land use impacts. Substantial changes in land use will be necessary to prevent further extinctions, including enforcement of California Water Codes and CDFG Code 5937.

According to the National Marine Fisheries Service (1996, 1999, Good et al. 2005), Russian River coho salmon and steelhead fall into the Central Coast Evolutionarily Significant Unit (ESU), while Chinook salmon group with the California Coast ESU that extends south of the Klamath River. NMFS (1996) listed the Central California Coast coho salmon as threatened under the Endangered Species Act (ESA) and more recently upgraded their risk level to endangered (Good et al., 2005). Brown et al. (1994) noted that populations of coho salmon in California were at less than 5% of historic levels and that there were only seven streams with adult returns numbering in the hundreds.

CDFG (2002) acknowledge the need to list Central Coast ESU coho under the California ESA and surveys conducted annually from 2000-2002 indicated widespread regional extirpations (Figure 7). "Extant populations in this region appear to be small. Small population size along with large-scale fragmentation and collapse of range observed in data for this area indicate that metapopulation structure may be severely compromised and remaining populations may face greatly increased threats of extinction because of it."

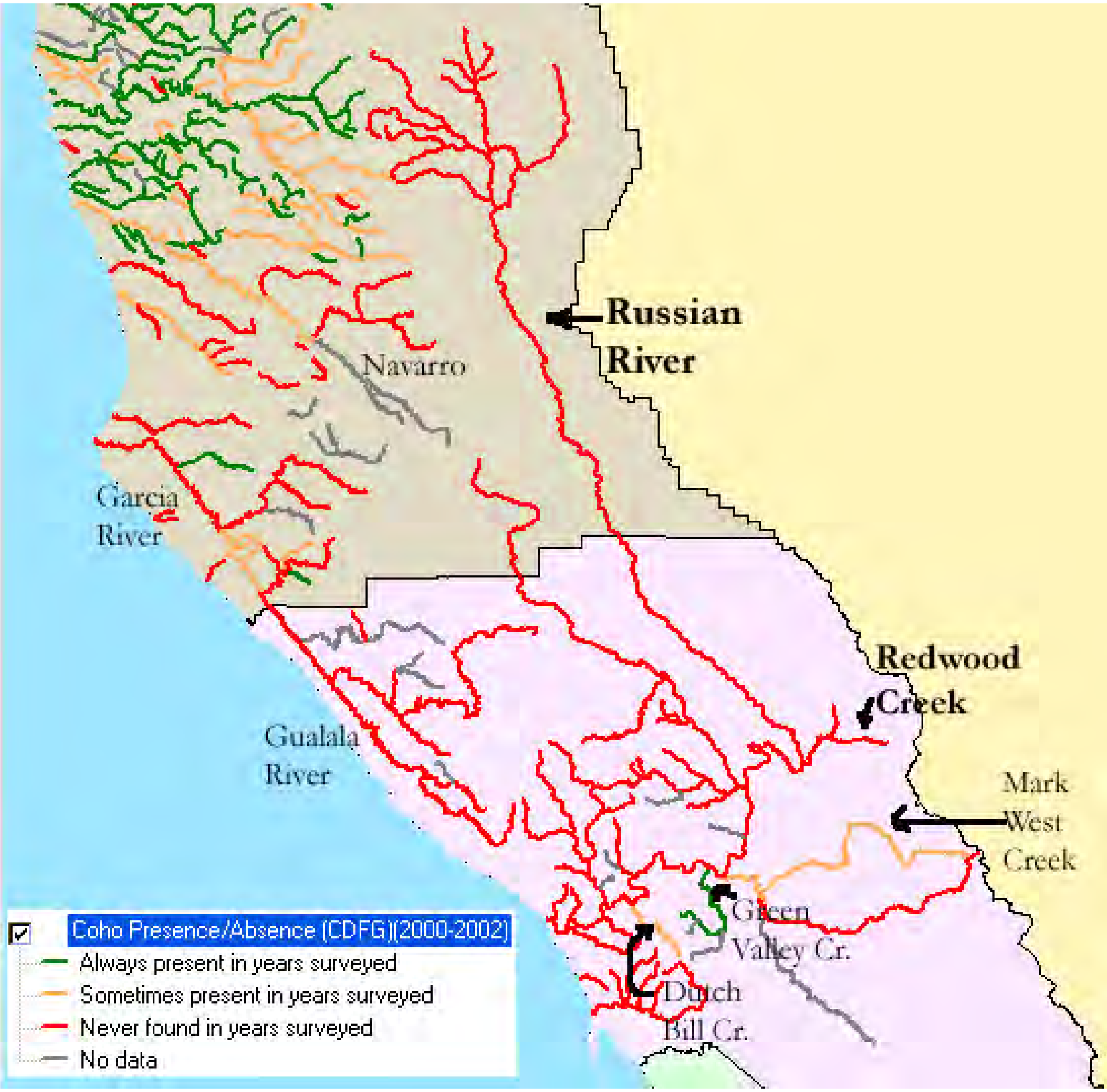

Figure 7. This map shows the CDFG coho salmon presence/absence survey results for the Russian River collected in years 2000-2002. Red = no coho found in all three years, orange = absent in at least one year and green = present all years. Only Green Valley Creek had coho all three years in the entire Russian River basin.

CDFG (2002) concluded that "coho salmon in the Central Coast Coho ESU are in serious danger of extinction throughout all or a significant portion of their range" and characterized the Russian River population as "extirpated or nearly so." Figure 8 is a summary chart of CDFG presence/absence coho salmon survey data from 2000-2002 showing a very high rate of coho extirpation in Sonoma County Coastal watersheds and the Russian River.

The recent NMFS (2008) Biological Opinion for large scale water users in the Russian River includes information on the viability of Russian River coho, including loss of genetic diversity that threatens their future existence:

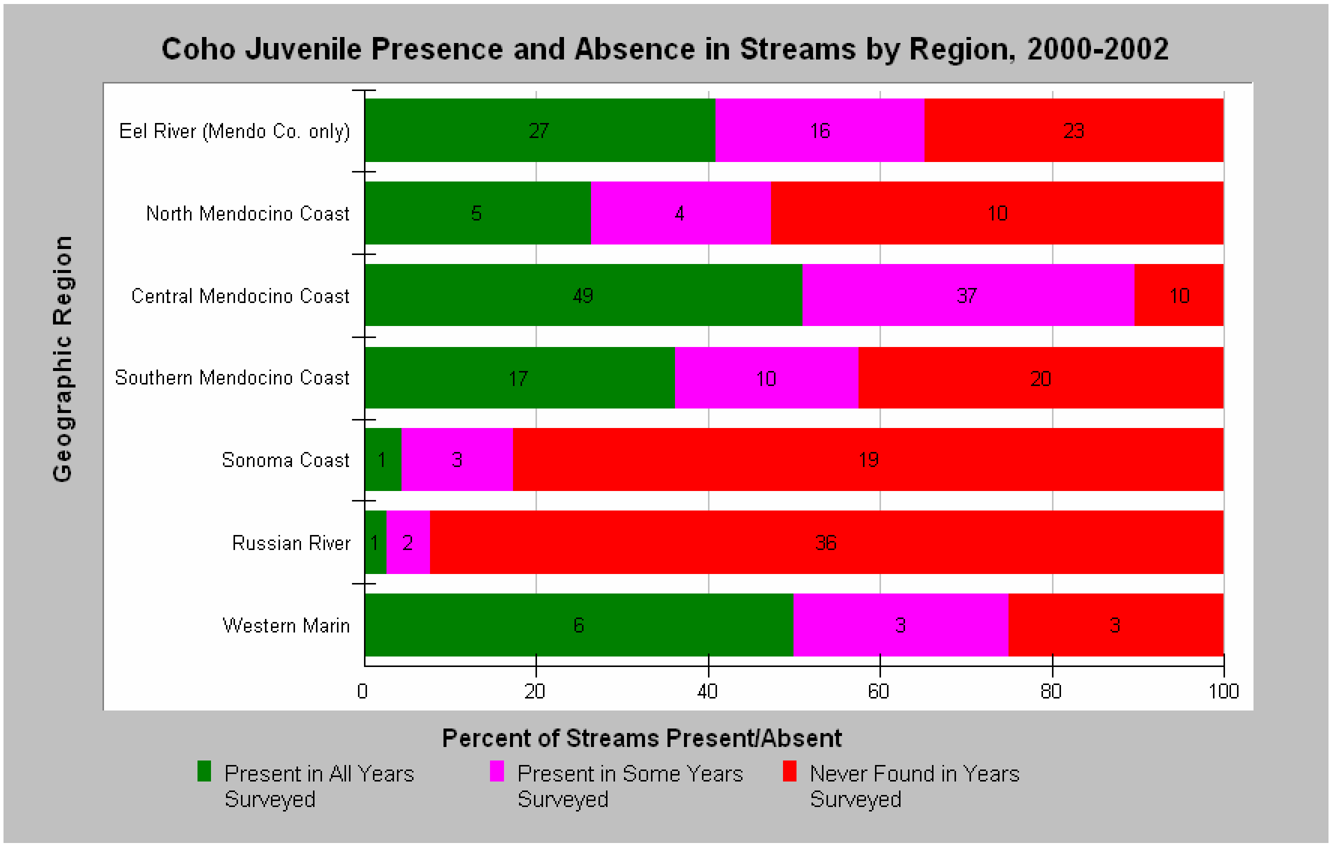

Figure 8. This chart shows a summary of the presence/absence of coho salmon juveniles in streams examined by CDFG in the years 2000-2002. The numbers shown on the chart bars indicate the number of streams in each region in which surveys always, never, or sometimes found coho. Note high absence rate for the Sonoma County Coast and Russian River basin.

> "Genetic analyses of coho salmon sampled from Russian River tributaries are consistent with what would be expected for a population with such extremely reduced abundance……This evidence suggests an acute loss of genetic diversity for the Russian River coho salmon population."

> "Based on its decline in abundance, restricted and fragmented distribution, and lack of genetic diversity, the Russian River population of coho salmon is likely in an *extinction vortex*, where the population has been reduced to a point where demographic instability and inbreeding lead to further declines in numbers, which in turn, feedback into further declines towards extinction."

Because of the scarcity of coho salmon in the Russian River basin, it would be highly undesirable to make Redwood Creek less able to support them at this critical juncture. See below for more discussion of salmonids in Maacama and Redwood Creeks based on KRIS Russian River data and other sources.

Steelhead in the Central California Coast ESU, including in the Russian River, were listed by NMFS (1997) as threatened and their status was reaffirmed in 2005 (Good et al., 2005). Similarly, the California Coastal Chinook salmon ESU were recognized as threatened in 1999 (NMFS, 1999) and their status confirmed in 2006 (NMFS, 2006).

<u>At Risk Salmonids Potentially Impacted by Pelton House Winery Project</u>: For the purpose of cumulative effects discussions related to Pacific salmon species, it is useful to focus on the scale of at least the Maacama Creek watershed, to which Redwood, Kellogg and Yellowjacket Creeks are tributary. Locally, coho would have utilized all habitats under 2% in gradient (Figure 9) and had easy access through gradients of at least 4%; therefore, coho were present historically in the project area.

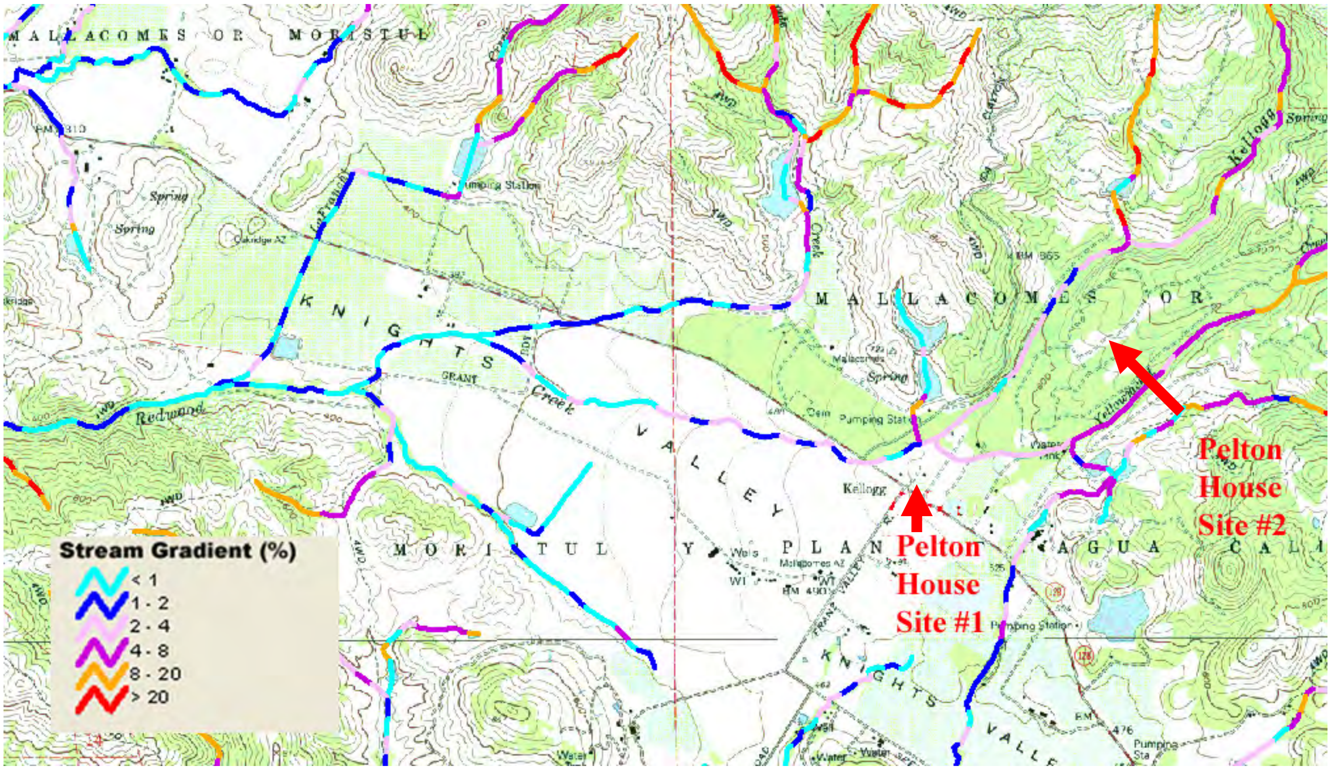

Figure 9. Stream gradient in Redwood Creek is 1-2% gradient, which would have made it ideal for coho salmon historically along with lower reaches of LaFranchi and Foote Creeks. Gradient constructed from 10 meter DEM. KRIS Russian River.

Headwaters of Kellogg and Yellowjacket Creeks rise too steeply for coho (4-20%), but they would have supplied spawning gravels, large wood and cold water that helped maintain coho in the mainstem of Redwood Creek just downstream. The alluvium that built up below Kellogg and Yellowjacket Creeks for millennia likely serves as a cold water storage bank that provided cold base flows during historic seasonal cycles. The Pelton House winery is tapping into this alluvial aquifer and diminishing whatever flow might remain to keep Redwood Creek functioning.

In Redwood Creek, CDFG (2001) collected biological data associated with a stream habitat inventory (CDFG 2004) and results of their electrofishing sample are displayed in Figure 10. While the sample collected reflects a diverse fish community, it is one dominated by warmwater adapted species such as the Sacramento sucker, stickleback and the California roach. A downstream migrant trap was operated in Redwood Creek and Maacama Creek in 1965 (CDFG 1965), likely to discern the effects of the 1964 Flood that devastated streams in the region. Although the trap on the mainstem of Maacama Creek and a tributary had large numbers of warmwater species, both native and introduced, the trap in Redwood Creek produced almost exclusively steelhead (146 of 148 fish captured). Thus, the ecological conditions in Redwood Creek have shifted away from favorable for cold water fish species due to changes in flow and channel conditions related to agricultural, particularly vineyard development (see Habitat Conditions). It should also be noted that coho salmon may have been absent from the 1965 Redwood Creek sample due to 1964 flood effects and the sample does not indicate that they were historically absent.

Maacama Creek is a substantially larger than Redwood Creek (4^{th} & 5^{th} Order) and its lower reaches would harbor native warm water adapted fish species from the adjacent mainstem Russian River during summer and early fall, such as Sacramento suckers, California roach and northern pikeminnow (then known as squawfish). In winter and spring Maacama Creek was dominated by salmonids as documented by CDFG memos (1954) that note spawning Chinook salmon in January of 1954, and the average angler catch on opening day of trout season in 1955 (three steelhead juveniles each) (CDFG

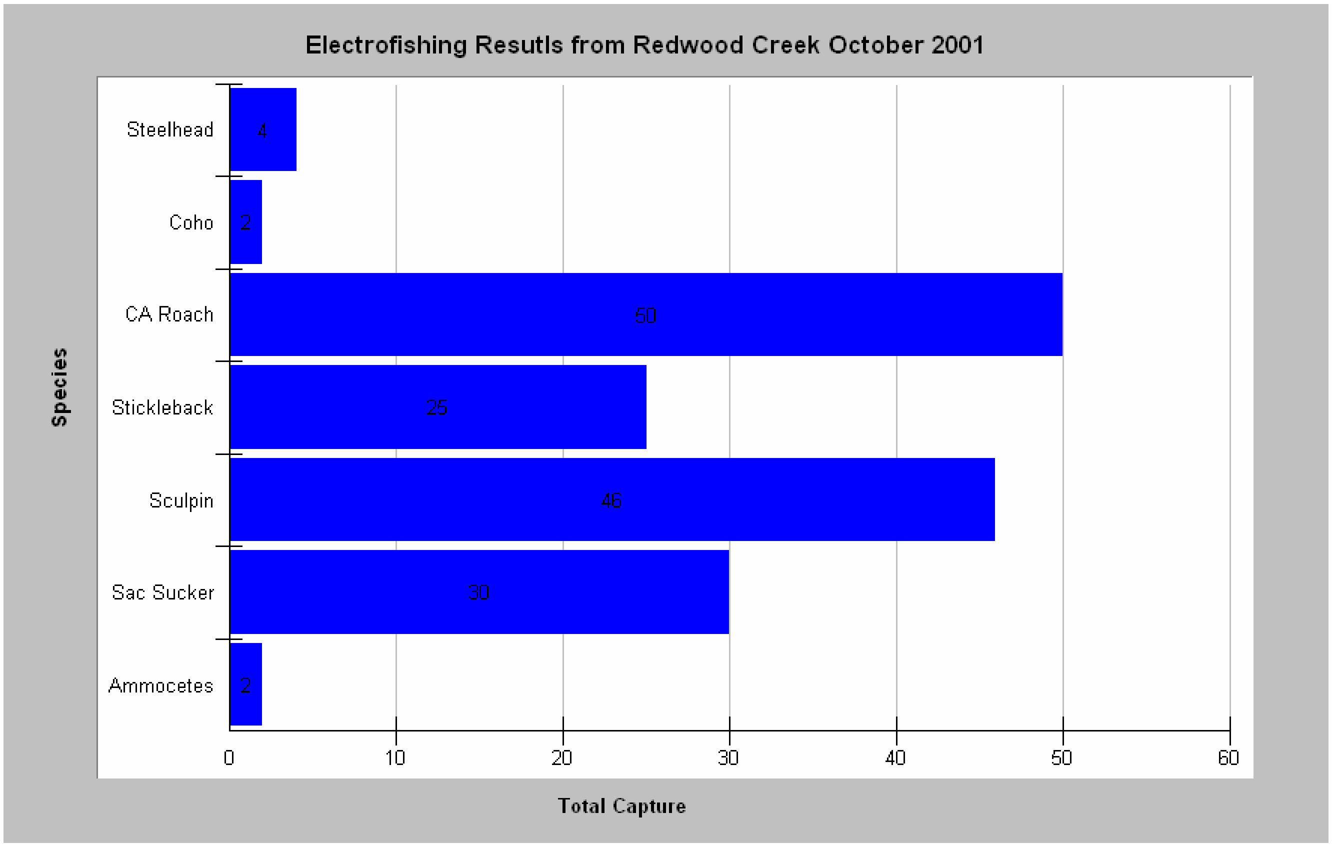

Figure 10. CDFG Redwood Creek electrofishing sample shows a fish community dominated by warmwater species but also containing two rare coho salmon juveniles and four steelhead trout juveniles.

1955). Angler catch was down from an average of nine "trout" each in 1953 (CDFG 1954) before the 1955 Flood. CDFG (1955) memos acknowledge "changing conditions" after the flood away from steelhead trout production, however, CDFG downstream migrant traps on Maacama Creek in 1965 caught four coho salmon along with hundreds of steelhead.

CDFG sampled an index site in Maacama Creek (IFR 2003) from 1993-2001 and data are useful in understanding standing crops of steelhead juveniles in summer and fall to determine survival during low flow periods (Figure 11). Maacama Creek summer carrying capacity for steelhead is much greater in wet years, such as 1995, 1996, 1998 and 1999, but survival is variable and appears to be declining. Standing crops of fall fish show a major reduction in many years, suggesting that low flow conditions are limiting, and these low flow conditions are likely linked to agricultural water use. Scientists (Hare et al. 1999, Collison et al. 2003) now recognize wet and dry climatic cycles that are linked to changes in ocean productivity and fish population dynamics and wet conditions in most years since 1995 are owing to a positive shift in the Pacific decadal oscillation cycle (PDO) (Hare et al. 1999).

Aquatic Habitat Conditions

Habitat data for Redwood and Maacama Creeks and other tributaries are available as a result of CDFG surveys conducted in accordance with their habitat typing protocols (CDFG 2004). Other lines of evidence presented below include remote sensing data and additional field reconnaissance photos. Pool frequency by length and average maximum depth are useful measures of stream health, particularly, since coho salmon juveniles prefer with a depth greater than three feet (Kier Associates and NMFS 2008). In an undisturbed Pacific Northwest streams, pool frequencies range from 37% to greater than 80% (Murphy et al. 1984 and Grette 1985) and CDFG (2004) rates frequencies greater than 40% as

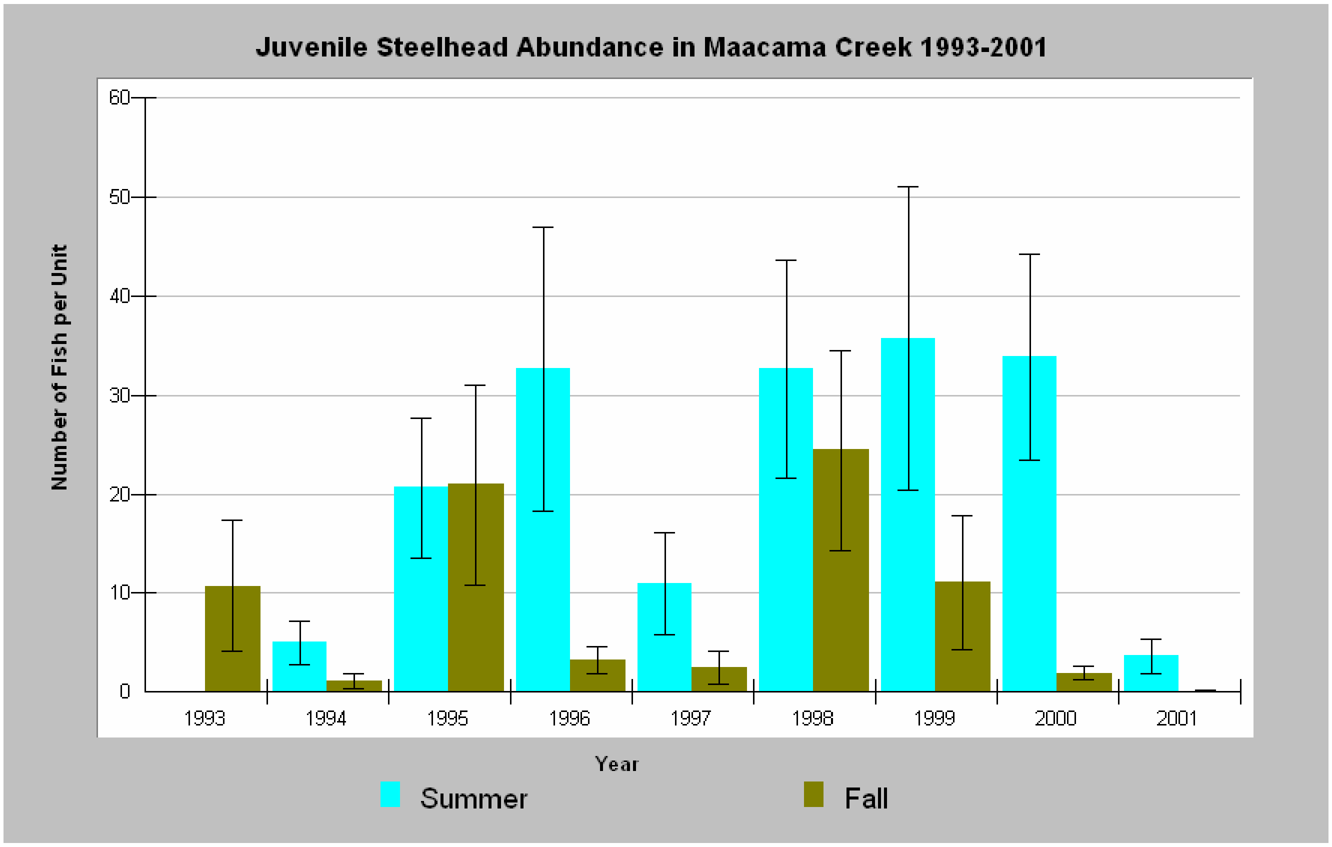

Figure 11. CDFG Maacama Creek electrofishing samples from 1993-2001 show summer and fall steelhead standing crops in a fish community dominated by warmwater species but also containing two rare coho salmon juveniles and four steelhead trout juveniles.

functioning for salmon and steelhead. Figure 12 shows that pool frequencies were under 10% on Redwood and Foote Creeks in some reaches and only about 25% of most Maacama Creek reaches. Pool depths are similarly compromised (Figure 13) with none over three feet deep in Foote Creek and the majority on Redwood Creek as well. Only Maacama Creek rates well on this scale and its pools should likely be 6-10 feet deep at least.

Habitat typing data also shed light on the problem of stream dewatering as indicated by almost 70% of habitats in Redwood Creek being dry (Figure 12) and all other streams showed signs of dewatering related to diversion of surface water and likely contributed to by over-use of groundwater. Riparian conditions on Maacama Creek and its tributaries (Figure 14). Upper reaches of some smaller Maacama Creek tributaries like upper McDonnel and Blue Gum have high conifer and shade components, but Redwood Creek has approximately 40% of its reaches exposed with no shade. Poor riparian conditions contributed to elevated water temperatures in Redwood and Maacama Creeks that will be discussed below. Coho salmon prefer pools formed by large wood (Reeves et al. 1988) and the high conifer components likely represent increased opportunity for large wood recruitment.

Landsat data provides another avenue for analysis of the riparian condition in and around the proposed Pelton House Winery project. The U.S. Forest Service Remote Sensing Lab and the California Department of Forestry analyzed 1999 Landsat images to formulate a California-wide electronic map layer of vegetation (Warbington et al., 1999). Figure 15 shows tree size classes in average diameter at breast height (dbh) for buffer strips that span 90 meters of each side of the stream center line. The alluvial valley reach of Redwood Creek and its tributaries provided 24 miles of habitat of low gradient, highly suitable habitat for coho salmon (CDFG 1954). The riparian zone before disturbance would have not only provided 100% shade, a gallery forest that extended back from the stream and a system

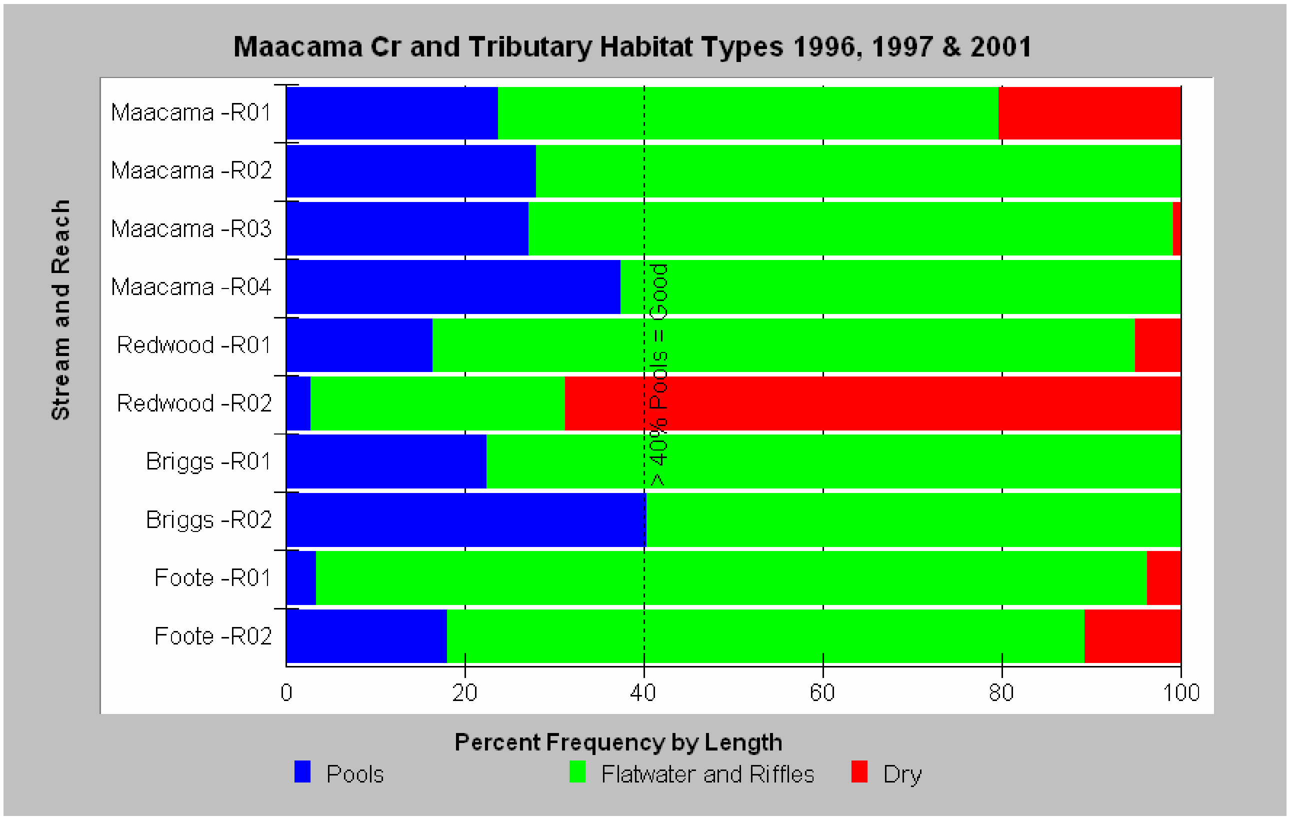

Figure 12. CDFG habitat typing data for Maacama Creek and its tributaries, including Redwood Creek, show low pool frequencies and a high percentage of dry habitats likely caused by stream diversions. Data from CDFG and chart from KRIS Russian River database.

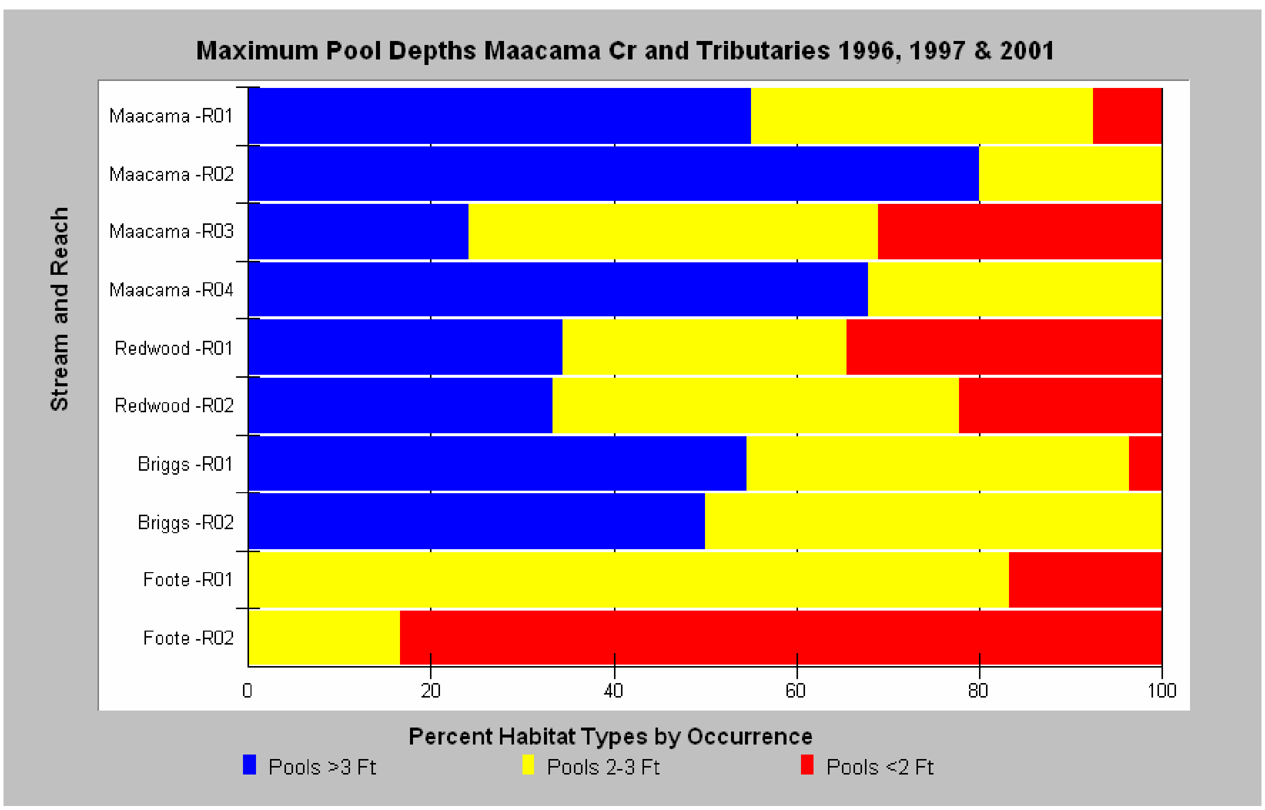

Figure 13. CDFG habitat typing data for Maacama Creek and its tributaries, including Redwood Creek, show pool depths are often restricted to less than two feet. Data from CDFG and chart from KRIS Russian River database.

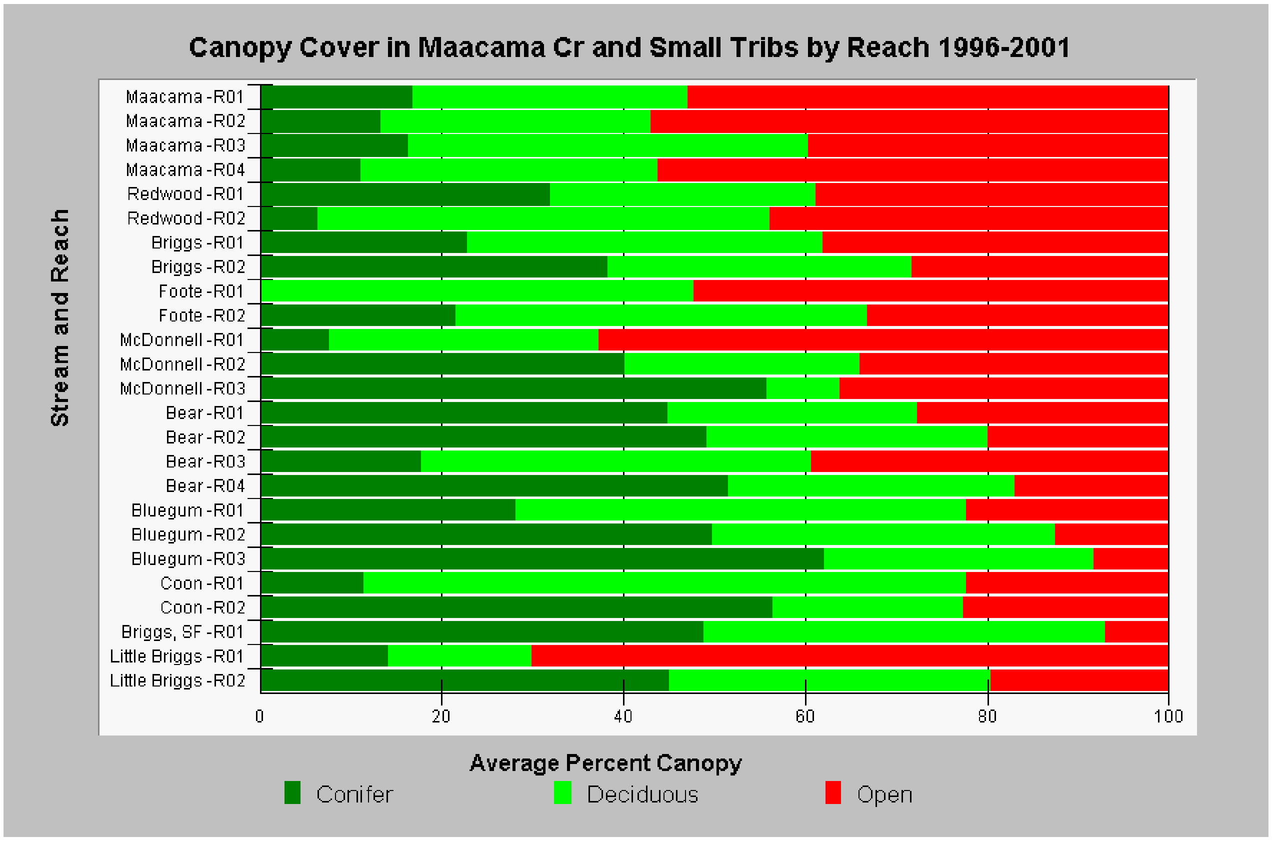

Figure 14. CDFG habitat typing survey data show shade canopy in Redwood Creek is deficient and that there are few large conifers adjacent to the stream. Data from CDFG and chart from KRIS Russian River database.

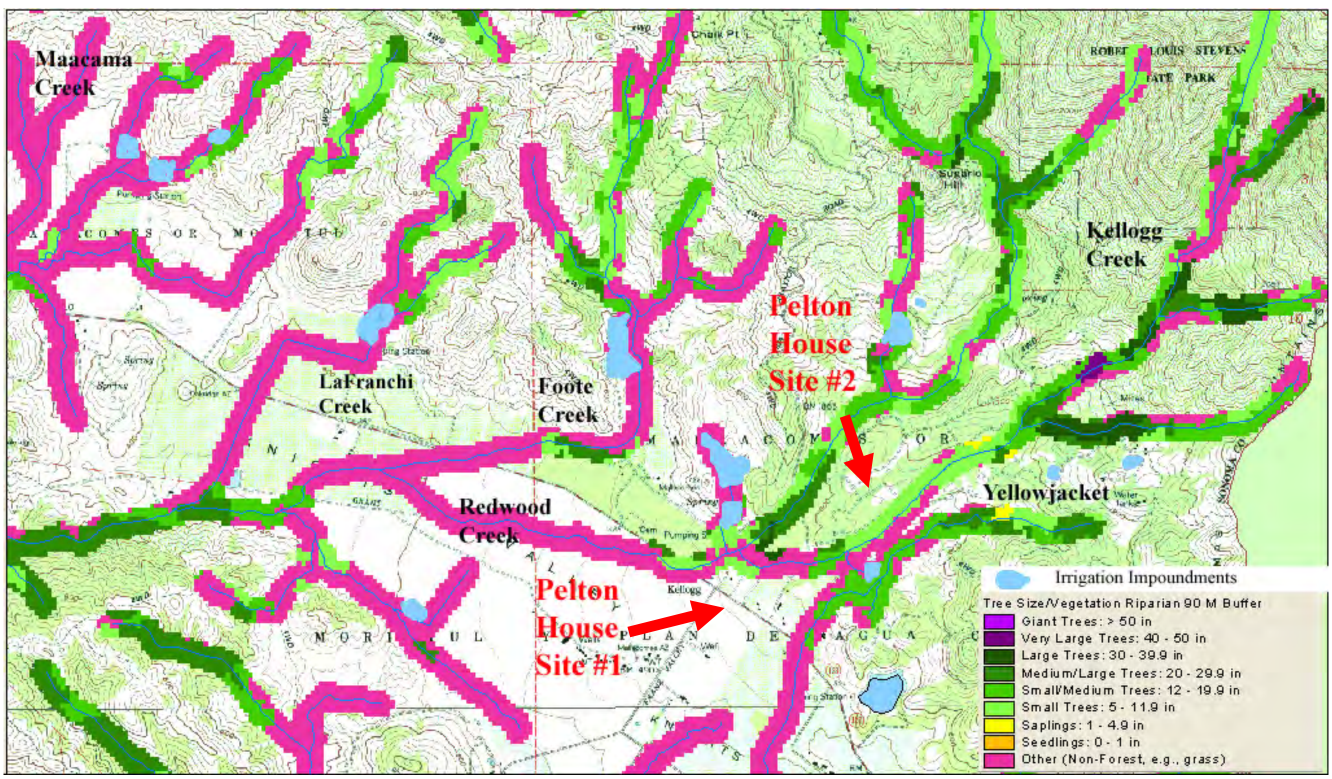

Figure 15. Classified Landsat imagery displays 90 meter (approx. 300') on each side of the stream channels of Redwood, Kellogg, Yellowjacket, Foote and LaFranchi Creeks and show that riparian zones are highly altered with spectral signature indicating grass or shrubs, not trees in most nearby stream side zones. Data from USFS (1999) and KRIS Russian River.

of inter-connected wetlands. Now they are reduced thin shade buffers or wholly lacking (Figures 16 and 17), which shows in Figure 15 as non-forest conditions indicative of riparian alteration by agriculture. Another major riparian disruption is construction of impoundments directly within the riparian zone and these are highlighted in Figure 15. Pool and Berman (2001) notes that surface water-groundwater connections in tributaries assist in maintaining cool water in streams during periods of low flow, and the capture of these cold water sources certainly has major consequences for both riparian function and carrying capacity of fish in downstream reaches.

Figure 16. LaFranchi Creek below Highway 128 shows a channelized stream bed and simplified riparian conditions indicative of fully non-functional salmonid habitat. Photo by Pat Higgins from KRIS Russian River. 7/14/03.

Figure 17. Foote Creek above Highway 128 is shown looking upstream with road adjacent, riprap confined bank, poor riparian conditions and vegetative cover on the stream bed indicative of chronic dewatering.

Original upland and riparian vegetation, at least on north facing slopes and areas of steep topography, would have included old growth redwoods and there are tiny patches of giant (>50” dbh) and very large trees (40-50” dbh) on upper Kellogg Creek. Medium-large (20-30” dbh) and large (30-40” dbh) mid-seral stands trees are also present in patches on Kellogg, Yellowjacket, Foote and LaFranchi Creeks, but most other riparian zones are predominantly small diameter conifers or hardwoods. However, some areas of sparse vegetation may be due to natural grasslands due to local geology.

When assessing impacts to Redwood Creek by the proposed Pelton House Winery project, one must also consider the health of proximate tributaries, such as LaFranchi and Foote Creek. Although historically likely productive because of their gradient, these streams are now severely disrupted by channelization by levees or dikes, which is evident both from the linear channels on the USGS stream maps (Figure 15) and in the ground reconnaissance photos (Figures 16-17). Disconnection from the floodplain and channel straightening causes loss of slow edge water habitats and side channels that would have been ideal coho salmon habitat, in part due to their connection with cold groundwater. Wetlands that have now been diked off or drained would have been inundated during flood flows and would have provided winter shelter for coho salmon that must spend at least one year in freshwater before going to the ocean. The disconnection of wetlands also diminishes their water storage and water filtration capacity. For example, both La Franchi and Foote Creeks have roads and field immediately adjacent with no buffer, which discharges of sediment and chemicals directly to these water courses and Redwood Creek just downstream.

Coho salmon prefer maximum floating weekly maximum water temperatures of no more than 18.4 C or 64 F (Welsh et al. 2001, McCullough 1999) and Redwood Creek is over this limit. According to data provided in the Russian River GIS (Circuit Rider Productions 2003) the maximum water temperature of Redwood Creek fluctuates from 65 F to 70 F , while Maacama, Briggs and lower Franz Creek are over 70 F (Figure 18).

Water temperature is a function in part of transit time and volume; therefore, any additional flow depletion should be prevented at this time to make sure that Redwood Creek doesn't depart further from coho requirements and into the acutely stressful range for steelhead.

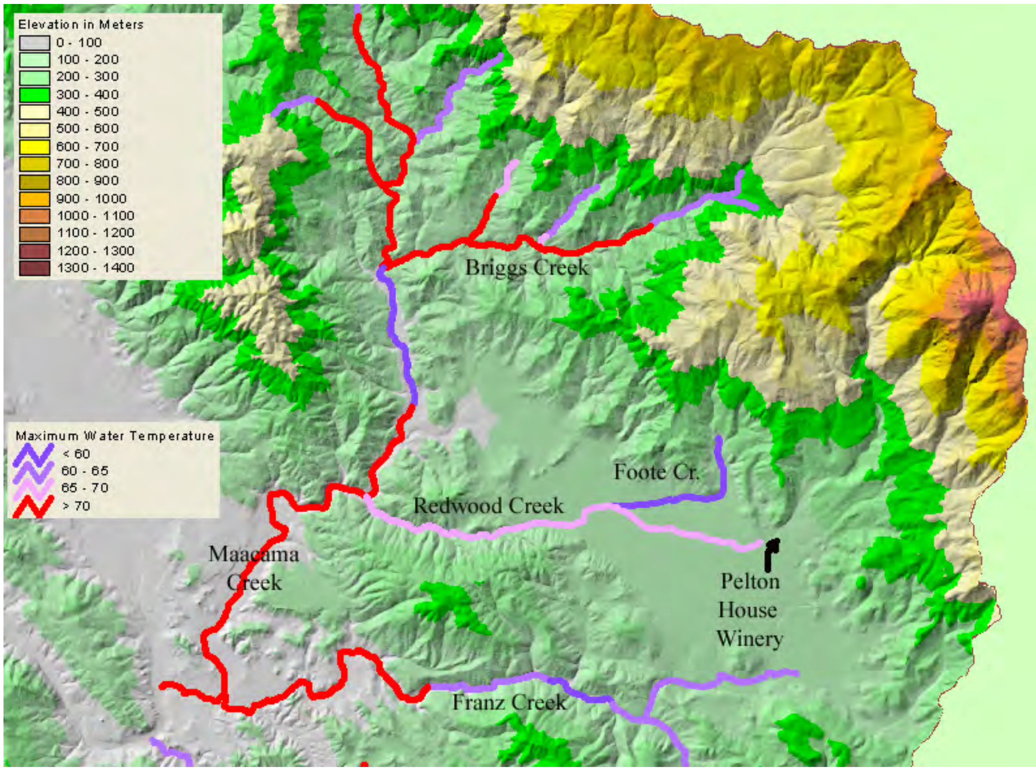

Figure 18. Elevation of surrounding terrain and maximum water temperature ranges for the Maacama Creek and its tributaries, including Redwood Creek. Data from Circuit Rider Productions and KRIS Russian River.

Cumulative Watershed Stress Due to Upland Disturbance

When considering the cumulative effects of the Pelton House Winery project, the full extent of development must be acknowledged as well as all other past, present and foreseeable off-site impacts. Sonoma County has information indicating non-discretionary land-uses and water diversions on the subject property have substantially impacted habitat and streams flows of Kellogg Creek and Yellowjacket Creek (Ball 2005), which flank the upper winery development site (#2). The project will take place in over ¾ in both the Kellogg and Yellow Jacket Creek riparian zones and the two sites must be linked with infrastructure that will cause further disruptions.

CDFG (1955) noted decreased suitability for salmonids in Maacama Creek, which was likely related to post WWII logging. Timber harvest for vineyard conversion continues on the slopes of Mt. St. Helena upstream from this project. Forest conversion for new vineyards in the upland areas of Knights Valley area is also projected to double as noted in the EIR for GP2020 (Sonoma County 2008a). These add to the already substantial impacts of road densities and road stream crossings left over from logging era or developed for on-going non-discretionary agricultural activities.

though timber harvest is no longer active in these watersheds, they have substantial road densities and road stream crossings left over from logging or developed for agricultural activities.

High road densities act to extend stream networks and intercept ground water flows (Jones and Grant, 1996), resulting in increased peak flows and decreased base flows (Montgomery and Buffington, 1993). U.S. Forest Service (1996) studies in the interior Columbia River basin found that bull trout were not found in basins with road densities greater than 1.7 mi/mi^2. They rank road-related cumulative effects risk as Extreme when road densities exceed 4.7 mi/mi^2 (Figure 19). National Marine Fisheries Service (1996) guidelines for salmon habitat characterize watersheds with road densities greater than 3 mi/mi^2 as "Not Properly Functioning" while "Properly Functioning Condition" is defined as less than or equal to 2 mi/mi^2 with no or few stream side roads.

Road densities were calculated as part of the KRIS Russian project on a large sub basin scale (Figure 20). Not surprisingly the urbanizing sub basins, such as Cloverdale Creek, have the highest densities (>5.0 mi/ mi$^{2)}$. The Kellogg Creek Calwater Planning Watershed actually encompasses all of Yellowjacket Creek and Redwood Creek to its mouth and has 4.2 mi/ mi^2 and falls into the High risk (USFS, 1996) category (1.7-4.7 mi/mi^2).

Existing high road densities and stream-side roads are likely contributing substantially to channel damage in Redwood Creek and other Maacama Creek tributaries and reaches that are manifesting low pool frequency and depth. The Pelton House Winery proposal will increase total impervious area by constructing driveways and converting naturally vegetated areas into parking lots for both Site #1 and Site #2 and these aspects of development need to be considered in conjunction with high pre-existing impacts.

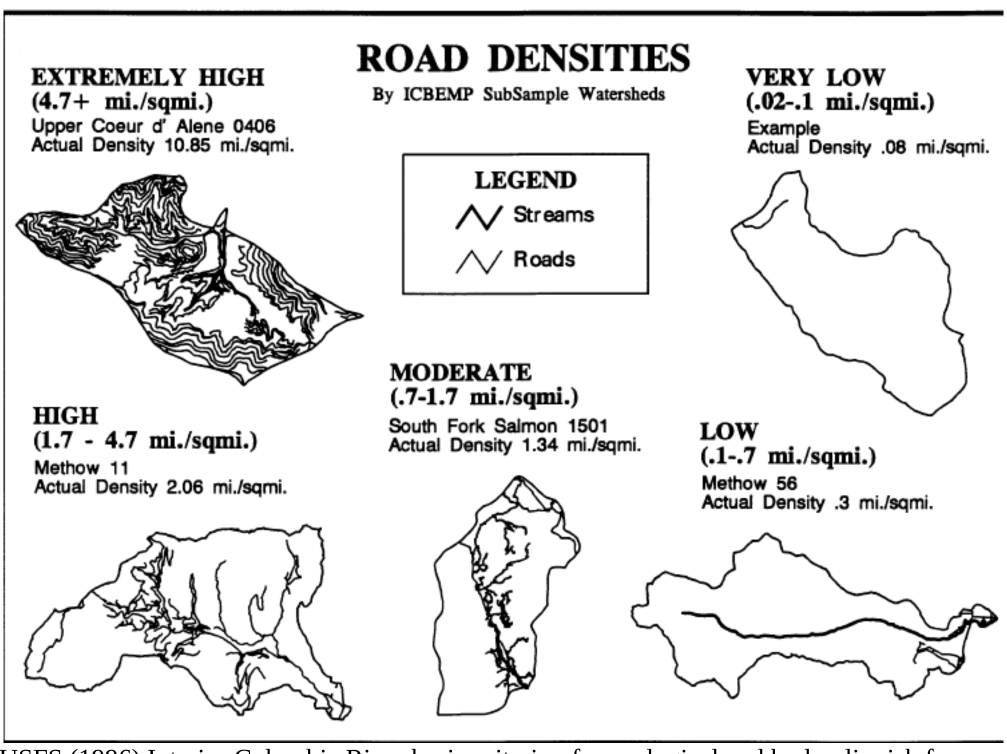

Figure 19 The USFS (1996) Interior Columbia River basin criterion for ecological and hydraulic risk from road densities is displayed here. The Bohemian Grove falls into the High (1.7-4.6 mi/mi^2) category.

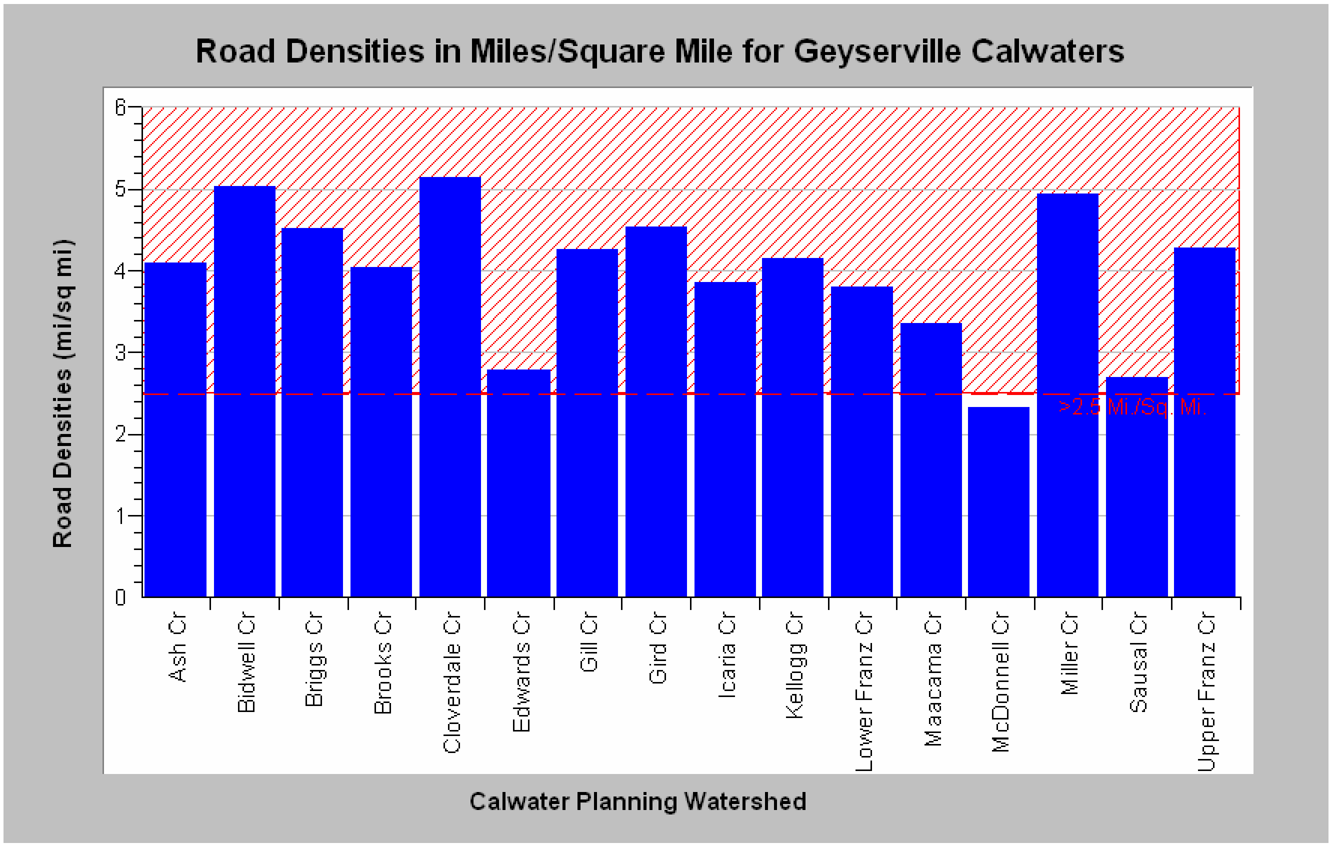

Figure 20. Road densities in various Calwater Planning watersheds are contrasted above based data from CDF. Kellogg Creek is over levels recommended for Properly Functioning watershed condition (2.5 mi/sq mi) for Pacific salmon (NMFS, 1996). KRIS Russian.

A further consideration under the topic of cumulative effects is that channel changes discussed above have likely diminished surface water availability. Highly aggraded stream channels may sometimes lose surface flow because of the depth of their bedload (Kier Associates 1991) and dry streambeds near the project area may be a reflection of both (Figures 21). Also compromised depth of pools may cause greater loss of fish habitat with the same amount of water withdrawn because of the changes in stream profile. Consequently, the SWRCB WRD needs to examine all pending and unpermitted use in light of this currently diminished surface water supply. If upland stresses are decreased through road decommissioning and allowing vegetation to approach its more normal range of variability, the channel will deepen and surface water availability could once again increase.

Thus, a combination of channel changes, adverse water quality and depleted flows are all acting synergistically to eliminate coho salmon. Redwood Creek (Figure 22) barely flows at present below the proposed project site and it is known to lose surface flow in more than half its length as it flows to Maacama Creek. All land use, including the proposed Pelton House Winery need to take these considerable impacts into consideration when considering the need for mitigation.

Conclusion

Coho salmon are at very high risk of extinction in the Russian River basin, yet NMFS (2008) considers their gene resources to be of extremely high importance for rebuilding of the entire CCC ESU. Expensive recovery efforts to restore Russian River coho salmon using captive broodstock from Green Valley Creek is failing to re-establish breeding populations in any Russian River tributary (NMFS2008). In fact, the problem is that there aren't any coho salmon refugia; perennial cold water streams with complex, deep pools. Problems are partially caused by development in uplands that exceed prudent risk thresholds, thereby increasing sediment yield and altering hydrology to the

Figure 21. Franz Creek running dry at its convergence with Maacama Creek, which may be caused by a combination of stream bed aggradation and upstream diversion. Photo by Pat Higgins from KRIS Russian River. 7/13/03.

Figure 22. Redwood Creek barely flowing upstream of Highway 128 just below the proposed project site. Photo by Pat Higgins from KRIS Russian River. 7/13/03.

the detriment of coho salmon. But the biggest problem is over-consumption of water to which the Pelton House Winery project will contribute

To meet CEQA requirements for use of best scientific information in analysis and for consideration of cumulative effects, the County of Sonoma needs to require development of a full EIR for the proposed Pelton House Winery project that covers topics above, including connections of groundwater to adjacent wells and connections to surface flow downstream in Redwood Creek in former and potential coho habitat. A full evaluation of fisheries resources and fish habitat within the project site should be provided with the EIR and survey results for sensitive amphibians, such as red-legged and yellow-legged frogs. Amphibians require moist riparian habitats for survival, and as shown above riparian habitat is profoundly altered and fragmented.

In light of existing road densities, the EIR needs to consider effects of increased impervious area, removal of naturally-vegetated areas, and the contribution of the event center's vehicular traffic and roadside parking areas to elevated sediment yield and altered hydrology that can both have negative impacts on downstream critical habitat. Finally, the EIR should address the projects growth-inducing stimulus for commercial destination development in a water-scarce area previously designated for resource conservation (Sonoma County 1979).

Sincerely,

Patrick Higgins

References

Ball, Gloria. 2005. Memo regarding flow depletion of Yellowjacket Creek to Lenny Stein. July 19, 2006. 1 p.

Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D. L. Bottom, W.E. Weaver and R. L. Beschta. 1995. Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Pacific Salmon. Published by Pacific Rivers Council, Eugene, OR. 56 p.

Brelje and Race. 2008. Memo to Karen Massey, Jackson Family Enterprises, re: response to comments on Pelton House Winery Application #PLP05-0010. By David Long and Thomas R. Jones. November 4, 1980. Brelje and Race Engineers. 4 p.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management. 14(2):237-261.

California Department of Fish and Game (CDFG). 1954. Maacama Creek (Russian River tributary) field notes from 1953 and 1954. Unpublished CDFG file memo compiled by W. Jones. Yountville, CA. 1 p.

California Department of Fish and Game (CDFG). 1955. Creel censuses on opening day of trout season, April 30, 1955 for four streams in Sonoma County. Unpublished CDFG memo by H.E. Pintler. Yountville, CA. 4 pp.

California Department of Fish and Game (CDFG). 1957. Russian River tributaries field notes, data tables and other sundry information, 1950's. Unpublished CDFG file memos. Yountville, CA. 14 pp.

California Department of Fish and Game (CDFG). 1965. Maacama Creek (Russian River tributary) trapping results. Unpublished CDFG file report. Yountville, CA. 6 pp.

California Department of Fish and Game (CDFG). 2002. Status Review of California Coho Salmon North of San Francisco . Report to the California Fish and Game Commission. California Department of Fish and Game, Sacramento , CA. 336pp.

California Department of Fish and Game (CDFG). 2004. California Salmonid Stream Habitat Restoration Manual. Fourth Edition. Inland Fisheries Division. California Department of Fish and Game. Sacramento, CA.

California Department of Fish and Game (CDFG). 2006. Redwood Creek Stream Inventory Report. CDFG, Yountville, CA. 16 p.

California State Water Resources Control Board, Water Rights Division. 2007. Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams. SWRCB WRD, Sacramento, CA.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

Curry, R. and D. Jackson. 2008. Draft Report on Pelton House Winery, PLP05-0010. October 5, 2008. Performed under contract to the Maacama Watershed Alliance by Watershed Systems, Soquel, CA. 27 p.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp. http://www.krisweb.com/biblio/gen_ucb_dunneetal_2001_cwe.pdf

Good, T. P., R. S. Waples & P. B. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-66. 598 pp.

Grette, G.B. 1985. The role of large organic debris in juvenile salmonid rearing habitat in small streams. Master's Thesis, University of Washington, Seattle, WA.

Higgins, P.T., S. Dobush, and D. Fuller. 1992. Factors in Northern California Threatening Stocks with Extinction. Humboldt Chapter of American Fisheries Society. Arcata, CA. 25pp.

Higgins, P.T. 2008. Comments on Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams. April 2, 2008. Performed under contract to the Redwood Chapter Sierra Club. Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 49 p.

Higgins, P.T. 2008a. Comments on Adequacy of Mendocino General Plan Update and Draft Environmental Impact Report (DEIR) with Regard to Pacific Salmon Recovery and Meeting CEQA Requirements. November 17, 2008. Performed under contract to the Redwood Chapter Sierra Club. Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 22 p.

Institute for Fisheries Resources. 2003a. KRIS Russian, Navarro, East Marin-Sonoma Database and Map Projects. Funded by the Sonoma County Water Agency, Santa Rosa, CA. (www.krisweb.com).

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An Ecological Perspective of Riparian and Stream Restoration in the Western United States. Fisheries 22(5):12-24.

Knopp, C. 1993. Testing Indices of Cold Water Fish Habitat. Final Report for Development of Techniques for Measuring Beneficial Use Protection and Inclusion into the North Coast Region's Basin Plan by Amendment. September 18, 1990. North Coast Regional Water Quality Control Board in cooperation with California Department of Forestry. 57 pp. http://www.krisweb.com/biblio/ncc_ncrwqcb_knopp_1993_sediment.pdf

Kier Associates. 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program. Klamath River Basin Fisheries Task Force. Yreka, CA.

LSA Associates, Inc. 2006. General Biotic Resources Assessment and Sensitive Resources Evaluation Pelton House Winery. Submitted to Jackson Enterprises, Santa Rosa, CA by LSA Associates, Inc., Pt Richmond, CA. 38 p.

Mendocino County Resource Conservation District (MCRCD). 1992. Garcia River watershed enhancement plan. Prepared for the California State Coastal Conservancy. Prepared by MCRCD, written by Jack Monschke and D. Caldon, Kier Associates. MCRCD, Ukiah, CA. 207 p.

Murphy, M.L., J.F. Thedinga, K.V. Koski and G.B. Grette. 1984. A stream ecosystem in an old growth forest in southeast Alaska: Part V. Seasonal changes in habitat utilization by juvenile salmonids. In Proceedings of Symposium on Fish and Wildlife in Relationships in Old Growth Forests. Eds. W.R.

Meehan, T.R. Merrill and T.A. Hanley. American Institute of Fishery Research Biologists, Asheville, North Carolina.

National Marine Fisheries Service. 2001. Status Review Update for Coho Salmon (Oncorhynchus kisutch) from the Central California Coast and the California portion of the Southern Oregon/Northern California Coasts Evolutionarily Significant Units. Southwest Fisheries Science Center, Santa Cruz, CA. 43 p.

National Marine Fisheries Service. 2005. Endangered and threatened species: final listing determinations for 16 ESUs of West Coast Salmon, and final 4(d) protective regulations for threatened salmonid ESUs. Federal Register, 70: 37160-37204.

National Marine Fisheries Service. 2008. Biological Opinion for ESA Section 7 Consultation on Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed. NMFS, Santa Rosa, CA. 386 p.

National Marine Fisheries Service (NMFS). 2008b. Environmental Protection Agency Registration of Pesticides Containing Chlorpyrifos, Diazinon, and Malathion. National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion. NMFS, Silver Springs Md. 478 p.

Nehlsen, W., J.E. Williams, J.A.Lichatowich. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

North Coast Regional Water Quality Control Board. 2008. Memo to Traci Tesconi, County of Sonoma, re: Pelton House Winery Application #PLP05-0010. From John Short, Senior Water Resources Engineer. October 14, 2008. NCRWQCB, Santa Rosa, CA. 6p.

North Coast Regional Water Quality Control Board. 2008a. Electronic Mail Memo to Traci Tesconi, County of Sonoma, re: Pelton House Winery Application #PLP05-0010. October 12, 2008. From Rhonda Raymond, NCRWQCB, Santa Rosa, CA. 6p.

Pacific Watershed Associates. 1994. Action plan for the restoration of the South Fork Trinity River watershed and its fisheries. Prepared for U.S. Bureau of Reclamation and the Trinity River Task Force, Contract No. 2-CS-20-01100. Arcata, CA.

Poole, G.C., and C.H. Berman. 2000. Pathways of Human Influence on Water Temperature Dynamics in Stream Channels. U.S. Environmental Protection Agency, Region 10. Seattle, WA. 20 p.

Richard C. Slade & Associates. 2008. Response to comments on Pelton House Winery Application #PLP05-0010. Correspondence to Jackson Family Enterprises. October 27, 2008. Richard C. Slade & Associates, Consulting Groundwater Geologist. 4 p.

Siegel, R. 2008. Memo re: Pelton House Winery Application# PLP05-0010 from Jess Jackson and Barbara Banke. Prepared for the Maacama Watershed Alliance. October 10, 2008. Randy Siegel, Registered Geologist/Hydrologist. 13 p.

Sonoma County. 1979. Franz Valley Area Plan. Sonoma County Planning Department, Santa Rosa, CA.

Sonoma County. 2008. Mitigated Negative Declaration Re-Circulated on Application# PLP05-0010 from Jess Jackson and Barbara Banke. Sonoma County Permit and Resource Management Department, Santa Rosa, CA. 90 p.

Sonoma County. 2008a. Mitigated Sonoma County General Plan 2020. Sonoma County Permit and Resource Management Department, Santa Rosa, CA.

Stetson Engineers Inc. 2007. Potential Indirect Environmental Impacts of Modification or Removal of Existing Unauthorized Dams. Appendix to Policy for Maintaining Instream Flows in Northern California Coastal Streams Performed under contract to SWRCB WRD, December 2007. 71 p.

U.S. Environmental Protection Agency. 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA 910-B-03-002. Region 10 Office of Water, Seattle, WA.

Wiemeyer Ecological Services. 2008. Comments on Pelton House Winery Application# PLP05-0010 from Jess Jackson and Barbara Banke. Prepared for the Maacama Watershed Alliance. October 10, 2008. Wiemeyer Ecological Services, Santa Rosa, CA. 95409. 6 p.

SALINAS RIVER FLOWS

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August 6, 2009

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Re: Comments on Salinas River Channel Maintenance Project (CMP) 404 Permit Application and Mitigated Negative Declaration

Dear Mr. Weeks,

Below you will find my comments for the Monterey Coastkeeper on the Monterey County Water Resources Agency's (MCWRA) *Salinas River Channel Maintenance Program Biological Assessment* (Entrex 2009) and the *Salinas River Channel Maintenance Program Initial Study with Proposed Mitigated Negative Declaration* (Entrex 2009a). In addition to the above documents, I have also read or reviewed:

- Salinas River Watershed Characterization Report 1999 (CCRWQCB 2000)
- Draft Environmental Impact Report/Environmental Impact Statement for the Salinas Valley Water Project, June 2001 (MCWRA 2001)
- Programmatic Biological Opinion for Monterey County Water Resources Agency – Channel Maintenance Program on the Salinas River in Monterey County, California (NMFS 2003)
- Final Report: Monterey County Water Resources Agency -Reclamation Ditch Watershed Assessment and Management Strategy (Casagrande and Watson 2006)
- Incidence and Tracking of Escherichia coli O157:H7 in a Major Produce Production Region in California (Colley et al. 2007)
- Total Maximum Daily Load for Fecal Coliform for the Lower Salinas River Watershed, Monterey County, California Phase-4: Project Analysis: Final Preliminary Project Report (CCRWQCB 2007)

Additionally, comments by Dr. Robert Curry and fisheries biologist Don Alley for the Monterey Coastkeeper on the same proposed action were read, and numerous other documents read or reviewed that provide background on the Salinas River, the status and trends of regional steelhead populations and actions needed for restoration (Moyle et al. 2008, Boughton et al. 2005, 2006, 2007, Titus et al. 2006, Good et al. 2005, Londquist 2001). My conclusion is that a Mitigated Negative Declaration (MND) for the reauthorization of a 404 permit for Salinas River Channel Maintenance Plan (CMP) cannot be justified under the California Environmental Quality Act (CEQA) and a full programmatic Environmental Impact Report (EIR) is needed because of cumulative effects and potential impacts to ESA-list steelhead trout (Oncorhynchus mykiss).

My Qualifications

I have been a consulting fisheries biologist with an office in Arcata, California since 1989 and my specialty is salmon and steelhead restoration. I authored fisheries elements for several large northern California fisheries and watershed restoration plans (Kier Associates, 1991; Pacific Watershed Associates, 1994; Mendocino Resource Conservation District, 1992) and wrote an assessment of prospects for restoration of southern California steelhead in San Mateo Creek and the Santa Margarita River watersheds (Higgins 1991). I also co-authored the northwestern California status review of Pacific salmon species on behalf of the American Fisheries Society (Higgins et al., 1992).

Since 1994 I have also been working on a regional fisheries, water quality and watershed information database system, known as the Klamath Resource Information System or KRIS (www.krisweb.com). This custom program was originally devised to track restoration success in the Klamath and Trinity River basins, but has been applied to another dozen watersheds in northwestern California. I have been a major participant in assembly of all these projects and have, therefore, developed expertise on the relationship of anthropogenic watershed disturbance and patterns of fish distribution and abundance. My studies of the Klamath River since 2004 for the Klamath Basin Water Quality Work Group, which is comprised of the environmental departments of five federally recognized Indian tribes (www.klamathwaterquality.com), are particularly helpful in understanding nutrient pollution and its effects on Pacific salmon species, a subject relevant to the Salinas River case study.

Since 2006 I have been working as a contractor for the National Marine Fisheries Service (NMFS) on recovery plan development support for Southern Oregon and Northern California Coast (SONCC) coho salmon and for South Central California Coast (SCCC) and Southern California Coast (SCC) steelhead. In the latter role I was a principal author of a white paper on reference values for assessing aquatic habitat condition and suitability for SCC and SCCC steelhead and the risk of upland stress in the various distinct population segment (DPS) watersheds (Kier Associates and NMFS 2008). The NMFS projects also entailed assimilation and archiving of all related data and documents used as the basis for planning. I am attaching Kier Associates and (NMFS 2008) to my comments as Appendix A because the standards provided apply to watersheds as far north as the Pajaro River, including the Salinas River.

Salinas River Steelhead Population Status and Trends

Titus et al (2006) cited Snyder (1913) who described “large numbers” numbers of steelhead entering all Monterey Bay tributaries, including the Salinas River and he found juveniles to be widespread in the Salinas River drainage. Snyder (1913 as cited by Titus et al. 2006) collected steelhead juveniles at three locations on the mainstem between Salinas and Soledad, at two locations in the San Antonio River sub-basin and in all reaches of the Nacimiento River. In the latter he noted a substantial number of large adult steelhead carcasses and also that steelhead fishing for adults and “trout” was very good in the upper reaches of both the Nacimiento and the San Antonio Rivers. Dettman (1988 as cited by NMFS 2003) found data indicating the catch of steelhead by anglers in 1946 was 3,600 steelhead yet the same source noted that by 1951 the run was down to 900 fish.

Pelgen and Fisk (1955 as cited by Titus et al. 2006) described "meager angling" opportunities for adult steelhead in the mid-1950s and in the mid-1960s CDFG (Titus et al. 2006) estimated the Salinas River steelhead population had drooped to just 500 fish. Good et al. (2005) note that SCCC steelhead are still widespread but that their persistence in the Salinas and Pajaro Rivers is of concern. The present population may be as low as 50 adults (NMFS 2003).

Although Gilpin and Soule (1991) found that populations of less than 500 fish to be at high risk of extinction due to loss of genetic diversity, further research on steelhead in the Salinas River basin has lead to the conclusion that above dam "rainbow trout" are genetically indistinguishable from below dam steelhead forms (Girman and Garza 2006). The three populations identified are found in the Nacimiento, San Antonio, and upper Salinas Rivers and Boughton et al. (2007) stress the importance of maintaining their gene resources and re-establishing migration corridors to allow populations to be recovered. Boughton et al. (2007) noted steelhead were in Gabilon Creek in the Reclamation Ditch watershed and Casagrande and Watson (2006) also confirmed rainbow trout in the stream's headwaters. These fish likely share steelhead ancestry and might constitute an additional population to the three identified by Girman and Garza (2006). The resident life history form of Salinas River steelhead is presently much more common because of flow problems and habitat disruption in the migration corridor that includes the CMP project area.

Extent of Project Manifests in Cumulative Effects That Cannot Be Mitigated On-site

The stated objective of the Salinas River CMP is to protect agricultural land and yet the project analysis contains no discussion of the impacts from these agricultural operations, such as flow, water quality and the effects on fish and wildlife of the Salinas River. The CMP also has a very distinct inter-relationship with the Salinas Valley Water Project (MCWRA 2001), as groundwater recharge flows stimulate growth of vegetation that reduces channel capacity and requires increased CMP activity. Therefore, not to consider operation of both projects together is piecemealing under CEQA. Similarly, the Reclamation Ditch and Old Salinas River channel are not considered in the MND, but they are formerly an important part of the lower Salinas River ecosystem. Moreover both areas are suffering from virulent E. coli outbreaks and have acute water quality problems that need a basin-wide solution. Discussion of cumulative watershed effects (CWE) from the response to the E. coli crisis, which are substantial, is also not found in the MND.

The MND (Entrix 2009a) states that:

- The proposed Project would have less than significant effects on aesthetics, geology and soils, land use and planning, noise, and recreation.
- Mitigation measures have been identified to reduce all potentially significant Project impacts to a less than significant level

Channel maintenance activities include vegetation removal, channel grading, removal of flow obstructions, and bank protection and stabilization, all of which have the potential to harm steelhead (NMFS 2003).The MND does not define the amount of habitat altering activities that would be carried out under the permit nor how much was altered under the previous permit, but there is the potential for dozens of sites covering many miles to be altered with each causing channel response. Major problems with bank erosion and changes in channel form from actions

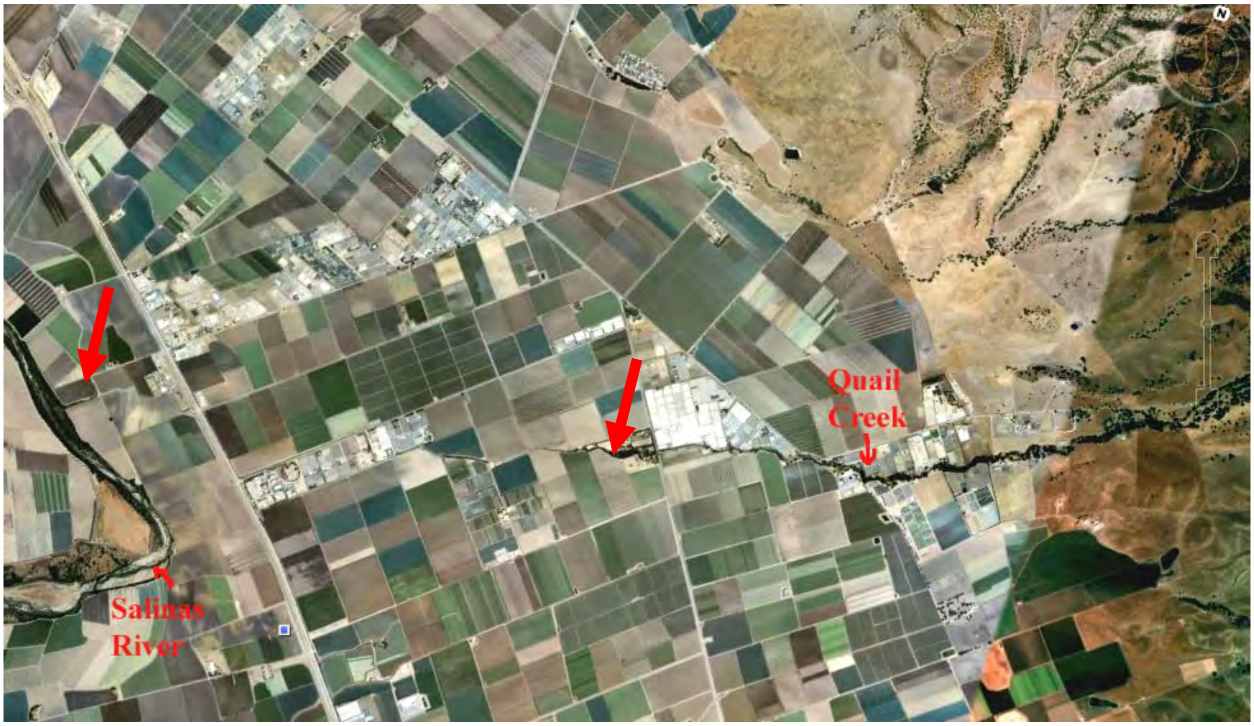

Figure 1. Aerial image of the Salinas River downstream of Chualar with Quail Creek flowing from eastern foothills at right. The valley floor is covered with agricultural activity and pockets of urbanization with no riparian buffer protection. Lower Quail Creek's channel is obliterated between the big red arrows. Image from Google Earth.

under the previous permit are described by Dr. Curry (2009) and they are likely to continue if the CMP is allowed to continue unchanged. When the extent of agricultural operations adjacent to the Salinas River is considered (Figure 1), the potential for CWE becomes even more apparent. Although Dunne et al. (2001) focused on forest harvest activities, their findings on the nature of CWE apply equally well to the lower Salinas River:

> "Generally speaking, the larger the proportion of the land surface that is disturbed at any time, and the larger the proportion of the land that is sensitive to severe disturbance, the larger is the downstream impact. These land-surface and channel changes can increase runoff, degrade water quality, and alter channel and riparian conditions to make them less favorable for a large number of species that are valued by society."

The widespread disturbance related to agriculture has profoundly altered the Salinas River channel and ecosystem and lead to the near extirpation of steelhead. Titus et al. (2006) state clearly that channel alteration and changes in flow regime have caused a virtual loss of the anadromous life history of three steelhead DPS in the Salinas River. The cumulative stresses from the Project activities are so great that they cannot be mitigated through on-site measures (Dunne et al. 2001, Collison et al. 2003) and the MND provides no evidence to demonstrate that previous mitigation activities have worked as intended. Many categories of impacts that the MND should have discussed are touched on below with an emphasis on how they relate to recovery of ESA listed steelhead.

Flow and Groundwater Issues

The flow levels and annual hydrograph of the Salinas River and its tributaries bear no resemblance to historic norms with which steelhead co-evolved (Titus et al. 2006). The MCWRA (2001) catches the runoff in the upper Salinas River, Nacimiento River and San Antonio Creek sub-basins in reservoirs. As a result flows in lower reaches for adult and juvenile steelhead passage are often lacking (Titus et al. 2006, Moyle et al. 2008) and USGS (2009) gauge logs indicate increasing dewatering at Spreckels especially since the 1990. Moyle et al. (2008) recommended “providing flows in the Salinas River to support establishment of functioning riparian corridors and floodplain habitats to increase the spatial distribution and productivity of SCC steelhead.” This is exactly the opposite of the CMP and Salinas River Project’s effects. Moyle et al. (2008) also point out that reduction of Salinas River winter and spring flows may prevent estuary breaching and thus block steelhead access in many years.

MCWRA reduces flows from San Antonio and Nacimiento Reservoirs from September 1 to October 15 annually to allow equipment operation in the lower Salinas River as part of the CMP. The disruption of flow associated with this activity causes the dewatering of reaches still accessible to native steelhead and yet the potential for stranding juveniles of this beleaguered fish population is no where discussed in the MND. Such omissions do not meet CEQA requirement for full disclosure of CWE and for use of “best science.”

Groundwater pumping related to agricultural activities, within the CMD area and adjacent to the lower Arroyo Seco River, cause the loss of surface flow in winter and spring when historically surface flows in that reach were much more prolonged (NMFS 2003). This is important because the Arroyo Seco River sub-population is considered to be one of the few with viability for restoration of anadromous steelhead because it has high quality freshwater habitat and no major dams that block access. I provide my recent comments on the State Water Resources Control Board Water Rights Division’s (SWRCB 2008) *Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams* as Appendix B because it defines the widespread nature of the problem of lack of regulation and oversight of both surface and groundwater and the consequences for salmon and steelhead.

CMP protection of agricultural lands that are in the active floodplain of the Salinas River contributes to the over-use of surface and groundwater in the lower basin. Consequently, the CMP, in combination with the operation of the Reclamation Ditch, also contributes indirectly to the problem with groundwater over-draught and intrusion of sea water below the lower Salinas River Valley (Figure 2). The issue of groundwater use on the vast expanse of agricultural lands served by the CMP needs to be addressed in a full EIR.

Flooding Issues and the CMP

While the levee system and channel capacity of the CMD in the lower 23 miles of the project can accommodate only 30,000 cfs or an 8 year recurrence interval storm event, the less confined river channel upstream (RM 23 to RM 92) has a design capacity of 77,000 cfs (25-year recurrence flow). Entrix (2009b) provides the following description of the two major CMP areas:

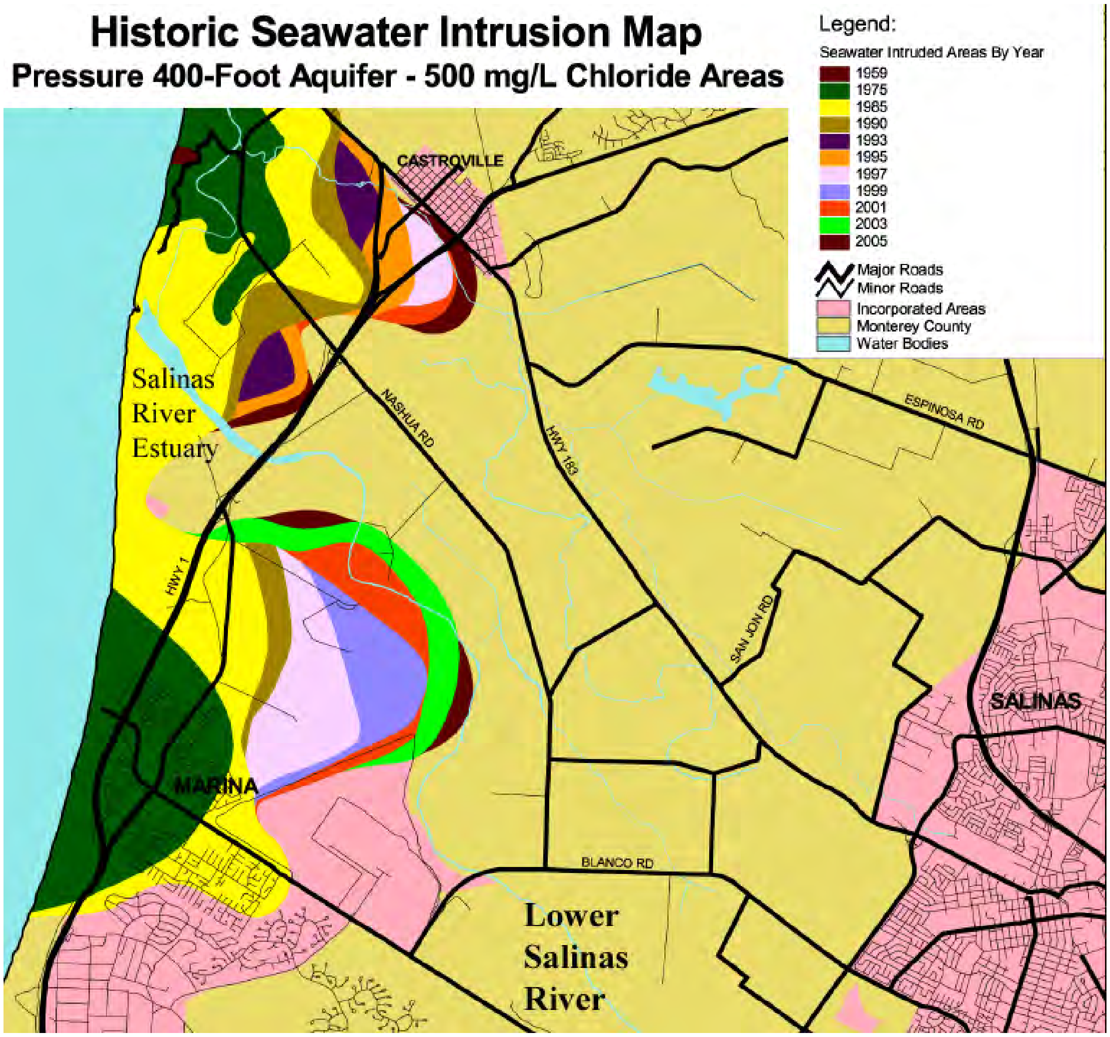

Figure 2. This map image shows the intrusion of salt water into the 400-Foot Aquifer of the lower Salinas River according to groundwater data collected by the MCWRA (2006).

> "Upstream of RM 23, the river channel is broad and weakly entrenched, typically resulting in a broad shallow flow under typical flow conditions and a relatively poorly defined low flow channel. Downstream of RM 23, the river is more constrained and, therefore, the braided channel form is less evident. Within the Salinas River, high bank erosion rates and lateral shifts in the position of the river have likely always been a natural stream process (ENTRIX 2001)."

The reduction in channel width and capacity at RM 23 is necessary in order to maximize agricultural productivity in the extremely rich lower Salinas River Valley with its ideal year-around growing climate (Figure 3). Unfortunately this design means that there will be recurring, major, unavoidable flood damage as Dr. Curry (2009) points out. The MCWRA needs to consider an Alternative in an EIR that involves acquisition of easements or land in fee title to vacate the flood zone of the Salinas River and allow restoration of natural riparian conditions and river processes. Figure 4 shows the footprint of the March 1995 storm (108,000 cfs) and this type of event is likely to recur. This may seem excessive in the mode of current thinking in the area, but I will argue below that restoring natural river and wetland processes is absolutely essential to restoring water quality on which a healthy agricultural industry relies. Similar action is needed to

Figure 3. Aerial photo of the lower Salinas River in a typical reach below RM 23 where flood channel capacity can only accommodate an 8 year recurrence flood interval event (33,000 cfs). Note dwellings and agricultural operations in natural flood zone. Image provided by Steve Shimek of Monterey Coastkeeper.

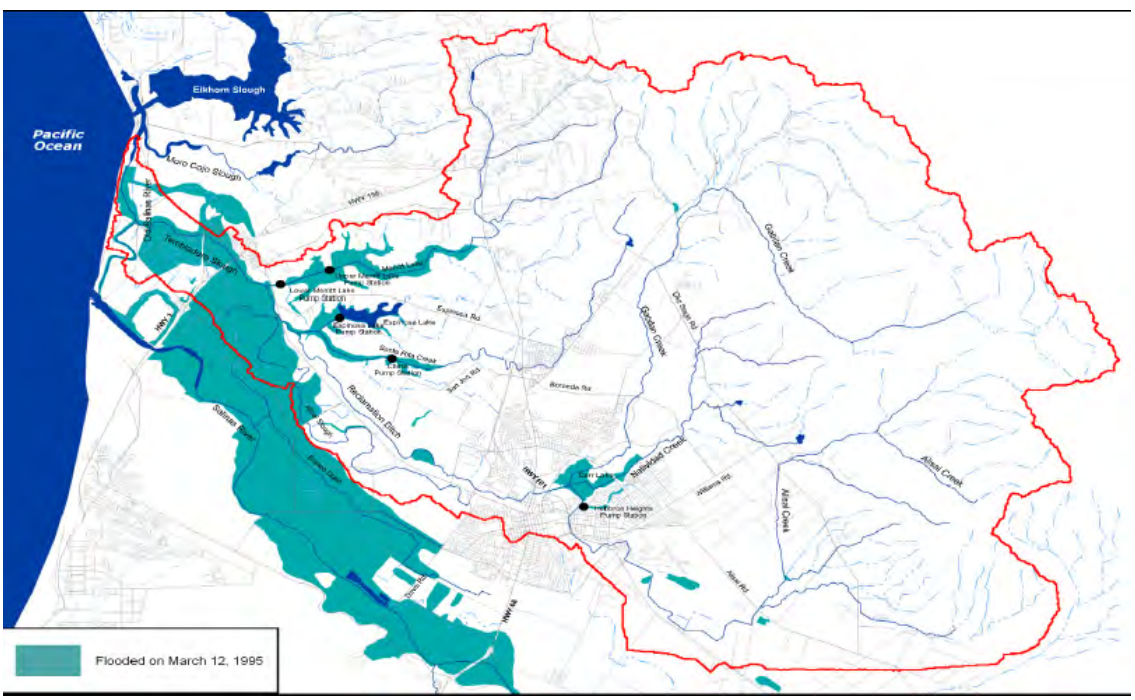

Figure 4. The teal colored area of this lower Salinas River Valley map is the area submerged by the March 1995 flood and can be expected to be periodically submerged; therefore, moving agricultural and urban and residential development out of the flood zone should be considered. From Casagrande and Watson (2006).

restore the health of the natural lakes and wetlands in the lower northern Salinas sub-basin or Reclamation Ditch watershed (Casagrande and Watson 2006) where these features should be buffered and protected as natural water filtration and storage systems. This would help to naturally recharge the groundwater aquifer and also allow some habitat for native fish and wildlife species. The assertion that bank erosion in the lower river is "natural" is specious since the current channel conditions are completely outside the historic range of variability and erosional processes are driven by the artificial confinement of the levees and CMP activities.

Riparian Habitat and Channel Disturbance of CMP and Impacts to Steelhead

Fisheries biologist Don Alley (D.W. Alley and Assoc. 2009) perfectly characterizes problems of riparian and channel disturbance that the CMP poses for Salinas River steelhead survival. Maintaining flood channel capacity by excavating vegetation and sediment from between the levees of the lower 23 miles of the CMP simplifies habitat and reduces chances for survival of steelhead. Factors include loss of riparian cover, removal of large wood that provides shelter for adult and juvenile fish and diminished depth needed for protection during upstream and downstream migration.

Both Entrix (2009b) and NMFS (2003) state that there will be annual monitoring reports on the effects of channel maintenance on fish habitat, but the conclusions from these reports are not apparent in any documents related to the CMP permit application or in the MND. As a condition of issuing its Section 7 permit to ACOE in 2003, NMFS (2003) required that a summary report be prepared by year 3 (2006) that would include "the extent, type and distribution of channel maintenance work conducted, and to assess cumulative trends in channel morphology and flow capacity." The summary report was to be the basis for issuance of the next Regional General Permit that would include the 404 permit, and a final report after year 5 (2008) was to be completed (NMFS 2003). NMFS staff was contacted to see if any of the monitoring reports were complete or available. They were not allowed to answer questions or to provide any of Salinas River CMP monitoring information without a formal request under the Freedom of Information Act (William Stevens personal communication). Cross section and scour chain data required in the original BO (NMFS 2003) need to be publicly disclosed and discussed in a full EIR.

The over-development of agriculture has had a devastating impact on the stream channel of the lower Salinas River and its tributaries, including the Reclamation Ditch sub-basin, to where they have little natural hydrologic or biological function (Figures 1,3,5 & 6). Not only is habitat unsuitable for steelhead but also all nutrient stripping and cycling and water filtration capacity has been lost and channels converted to agricultural drainage ditches.

Dr. Curry (2009) indicates that voluntary participation in the CMP leads to varying approaches to channel maintenance and random selection of treatment sites that in essence constitute a large uncontrolled experiment. He describes how reaches upstream and downstream of projects adjust due to river processes. The consequence of this flattening of the river profile to steelhead is reduced habitat depth and cover for juveniles and adults as described by Don Alley (D.W. Alley and Assoc. 2009). Dr. Curry (2009) also points out that the constant pattern of disturbance related to the MND fosters colonization by the highly invasive giant reed (Arundo donax) and this subject alone is of sufficient magnitude to warrant an EIR in and of itself. Ultimately the only way to successfully control Arundo is reestablish native riparian communities that can effectively compete.

Figure 5. Lower Santa Rita Creek photo taken from Casagrande and Watson (2006, Fig 4-17) shows this stream is completely channelized and excavation activities appear to have increased erosion risk.

Figure 6. Photo of lower Alisal Creek within the Reclamation Ditch sub-basin shows all natural channel features obliterated and most natural hydrological and ecological function disrupted. From Casagrande and Watson (2006).

<u>Alternative for Flood Control</u>: If the Salinas River were allowed to re-inhabit its flood plain as recommended above, then river meanders would naturally form and flood capacity and steelhead habitat would significantly increase. Meanders in low gradient reaches build up point bars on the

inside of turns but also scour deep pools along the river thalweg along the opposite bank. Natural riparian communities would also become re-established and provide steelhead cover and complex habitat due to overhanging vegetation and bank under cuts. Intact native riparian would also reduce bank erosion that is a chronic side effect of the perpetual regime of disturbance associated with the current CMP approach. Most importantly, restoring river processes will allow reconnection of surface and groundwater (ODEQ 2008) that can help moderate surface water temperatures and also to revive the river's natural nutrient stripping capacity.

Water Quality Impairment and Relationship to CMP

The MND describes water quality problems in the Salinas River but never addresses the interaction of agricultural operations that have lands protected by the CMP or the linkage between CMP activities and some increased pollution (i.e. turbidity). In fact the lower Salinas Rivers is one of the most polluted water bodies in the State of California as indicated by no less than 17 water quality impairments noted on the SWRCB (2005) *Clean Water Act Section 303(d) List of Water Quality Limited Segments*. Don Alley (D.W. Alley and Assoc. 2009) notes that discussion of water temperature is wholly lacking in the MND and that the CMP likely has potential to cause substantial warming that would negatively effect steelhead survival and I agree that this subject needs full treatment in a subsequent EIR. Discussion of water quality below is not exhaustive, but shows linkage between CMP activities and related agricultural operations to impaired conditions. As described above, remediation of many of these water quality problems could be brought about by restoring natural Salinas River processes and wholly reshaping the MCWRA approach to flood control.

<u>Nutrients and Unionized Ammonia</u>: The agricultural operations in and around the lower Salinas River use huge amounts of fertilizers to stimulate growth of crops and runoff from fields is causing substantial nutrient loading (CCRWQCB 2000). This water quality problem is manifest in several ways including elevated phosphorous, nitrogen and pH and the latter also plays a role in conversion of ammonium to dissolved ammonia (Goldman and Horne 1982, USGS 1996), which is particularly toxic to salmonids (U.S. EPA 1986). Evidence of nutrient loading from agricultural runoff is clear from nitrate data presented by the CCRWQCB (2000) for the Salinas River at Chualar above Quail Creek, Quail Creek itself and the Salinas at Davis Road further downstream (Figure 7). These data show a major pulse of nutrients coming from Quail Creek with winter runoff and the Salinas River at Davis Road seems to be showing spikes with irrigation discharges. The 100 mg/l stockwater limit from the CCRWQCB (2005) *Basin Plan* referenced on Figure 7 is 400 times higher than the 0.25 mg/l limit imposed on the San Lorenzo River "to protect beneficial uses from adverse biostimulatory effects."

Dissolved or unionized ammonia levels were reported by Casagrande and Watson (2006) for the lower Salinas and Reclamation Ditch and data show a widespread problem with levels in some areas exceeding stressful or lethal levels for steelhead trout (Figure 8). Channelized rivers have lower rates of nutrient attenuation than do rivers with more natural channels (Bernot and Dodds 2005). Bernot and Dodds (2005) describe how surface water and groundwater interaction, in areas below the river bed known as the hyporheic zone, can diminish nitrogen through anaerobic denitrification. Mahugh et al. (2008) also discuss how riparian zones and wetlands adjoined to streams can capture both phosphorous and nitrogen and help maintain healthy water quality.

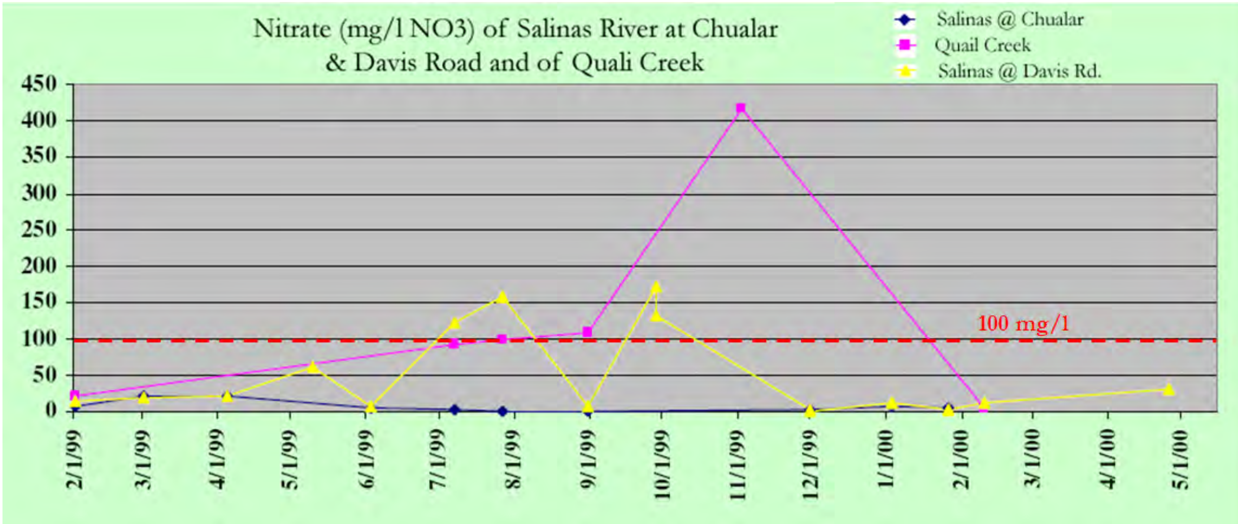

Figure 7. Nitrate levels of the Salinas River at Chualar and Davis Road as well as Quail Creek with CCRWQCB Basin Plan stock water limit for nitrates referenced. Data and chart adapted from CCRWQCB (2000).

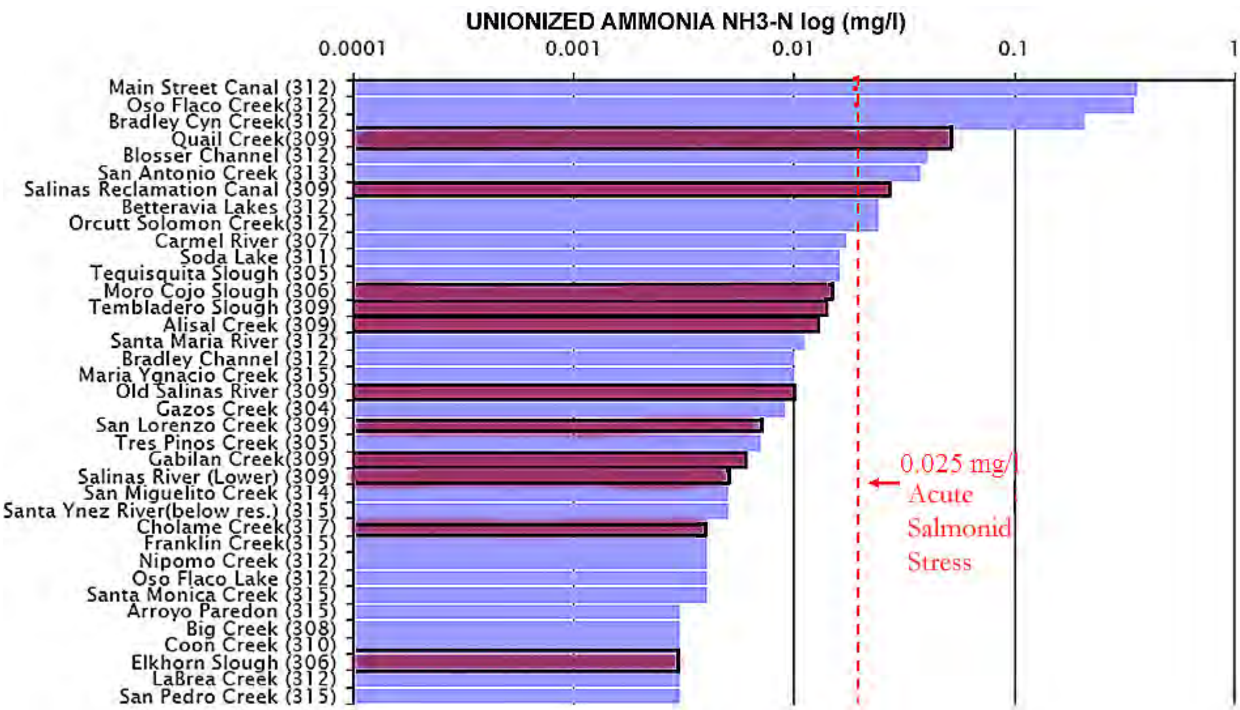

Figure 8. Unionized ammonia summary chart from Casagrande and Watson (2006) with annotation based on U.S. EPA (1986) for salmonid tolerance levels and additional highlighting (purple) denoting lower Salinas.

Both these functions have been completely disrupted on the lower Salinas River but could be recovered if more normative river processes were fostered.

Low flows in the Salinas River and Reclamation Ditch sub-basin promote stagnation and the addition of nutrients from runoff creates nuisance algae blooms (Figure 9). These blooms cause supersaturated dissolved oxygen (D.O.) conditions during day time hours of photosynthesis and then a D.O. crash at night due to algal respiration. The diurnal photosynthesis cycle also fuels elevated pH and some Salinas River and Reclamation Ditch waterbodies had values over 10 (Worcester et al. 2000). Goldman and Horne (1982) noted that when pH exceeds 9.5 that all

Figure 9. Photo of Reclamation Ditch at San Jon Road with nuisance algae bloom induced by low flow, nutrient loading and lack of shade. Photo from Casagrande and Watson (2006).

available ammonium will be converted to dissolved ammonia. Thus these algal nuisance blooms create very adverse conditions for salmonids and other pollution intolerant aquatic species.

Bacterial Pollution: The outbreak of the virulent Escherichia coli O157:H7 caused by lower Salinas Valley organic produce (Benbrook 2007, Colley et al. 2007) has vaulted the long standing problem of E. coli pollution of the Salinas River (Figure 10 & 11) into the news and stimulated the CCRWQCB (2007) to create a TMDL for this potential pathogen. The response to E. coli O157, however, also has major implications for the CMP because of extended zones of devegetation and fences (Figure 12) in or near the active channel to prevent wildlife from entering fields (Baumgartner 2008). This subject needs examination in a full EIR.

Pesticides Pollution and Land Use in the CMP and Reclamation Ditch: Just as cumulative effects problems related to flow and channel alteration are ignored in the MND, so too are those related to the industrial agricultural approach and side effects of pesticide pollution in the lower Salinas River. Pesticides and herbicides are increasingly recognized as inhibiting the growth and survival or salmonids (Ewing 1999) and a map (Figure 13) from the CCRWQCB (2000) shows the variety of pesticides used in the lower Salinas River basin. Interactions between pesticides can have even more serious impacts on aquatic biota (Ewing 1999) and this topic needs exploration in a full EIR. NMFS (2008) recently found in a Biological Opinion to the U.S. EPA that products containing diazinon, chlorpyrifos, and malathion have significant effects on endangered Pacific salmon species. CCRWQCB (2000) maps are also available for the lower Salinas River basin for the use of diazinon (Figure 14) and chlorpyrifos (Figure 15) indicating that use in the basin is widespread. Since NMFS (2008) now has expressed major reservations about the latter two pesticides that are widely used in the Salinas River on lands associated with the CMP, one would

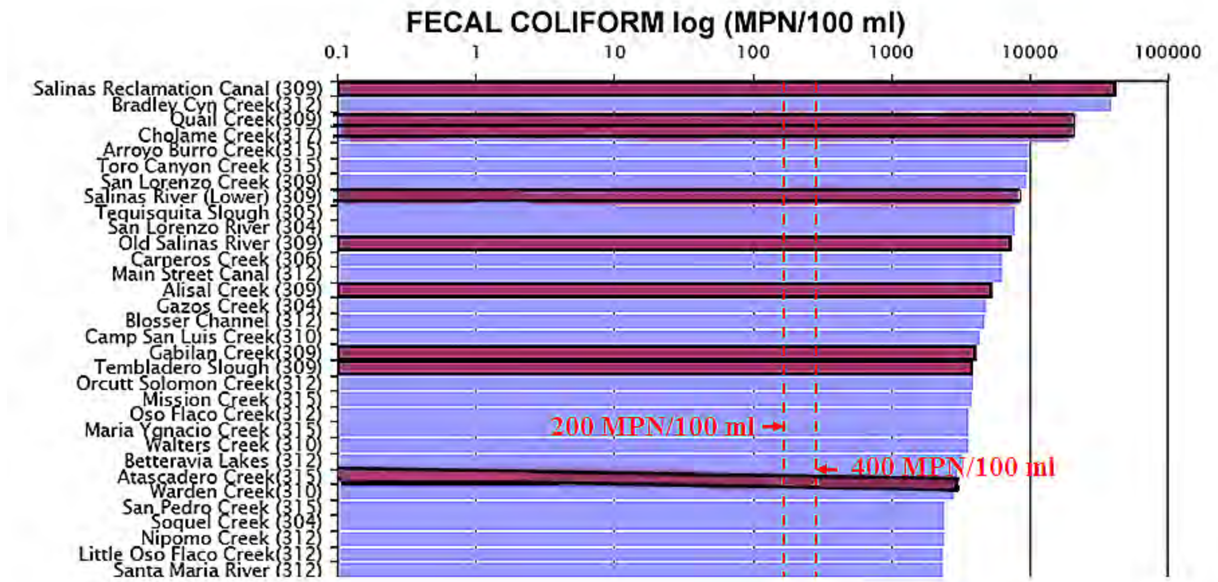

Figure 10. E. coli data and summary chart from Casagrande and Watson (2006) with purple bar highlights added for Salinas tributaries or reaches and CCRWQCB Basin Plan 50% (200 MPN/100ml) and 90%(400 MPN/100ml) limits.

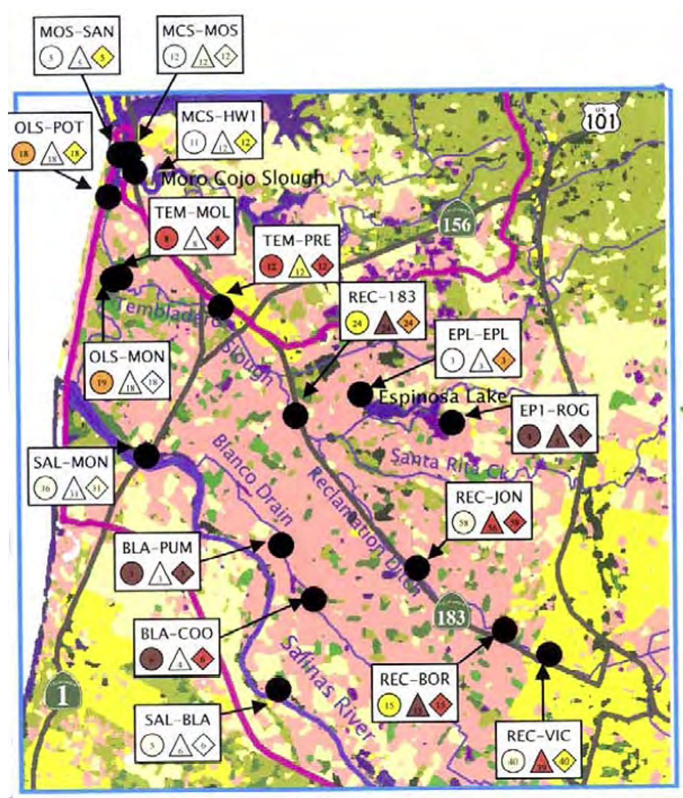

Figure 11. Impairment with regard to E coli is denoted by colored symbols for various lower Salinas River and Reclamation Ditch locations. Map taken from CCRWQCB (2005).

Figure 12. This USGS (2009) photo shows the Salinas River channel looking downstream at Spreckels gage site. Cyclone fence in the active channel (red arrow) is likely related to wildlife exclusion and is a potential impediment or hazard to steelhead during high flows.

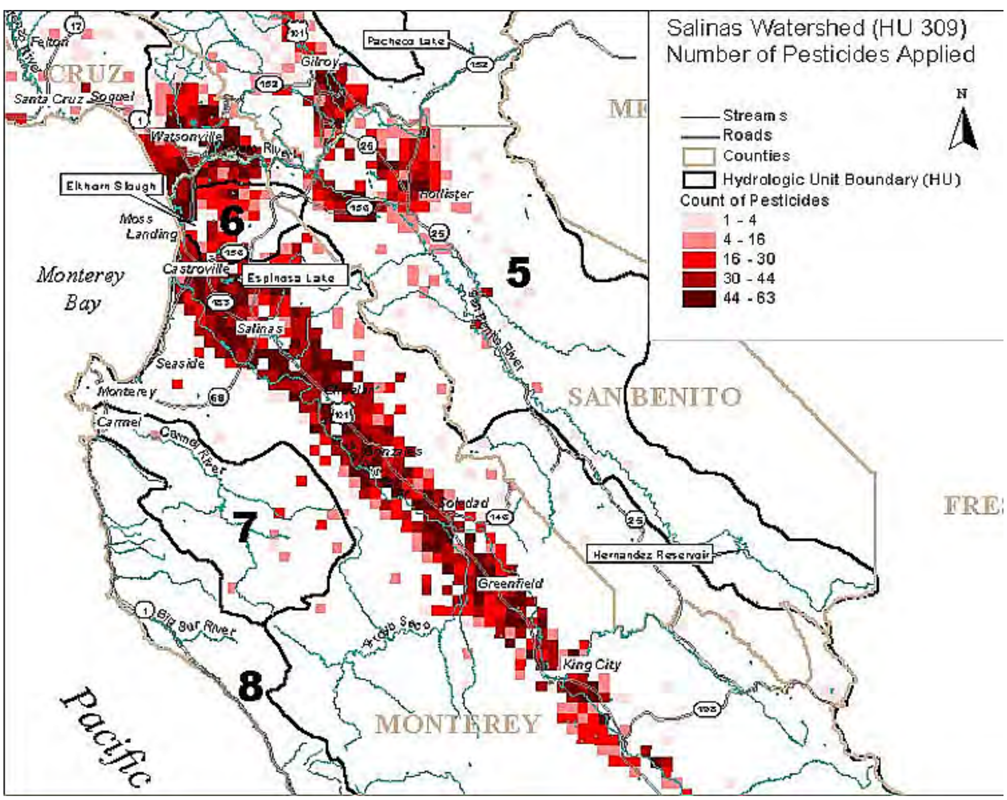

Figure 13. Map of the number of types of pesticides used in the lower Salinas River Valley. From CCRWQCB (2000).

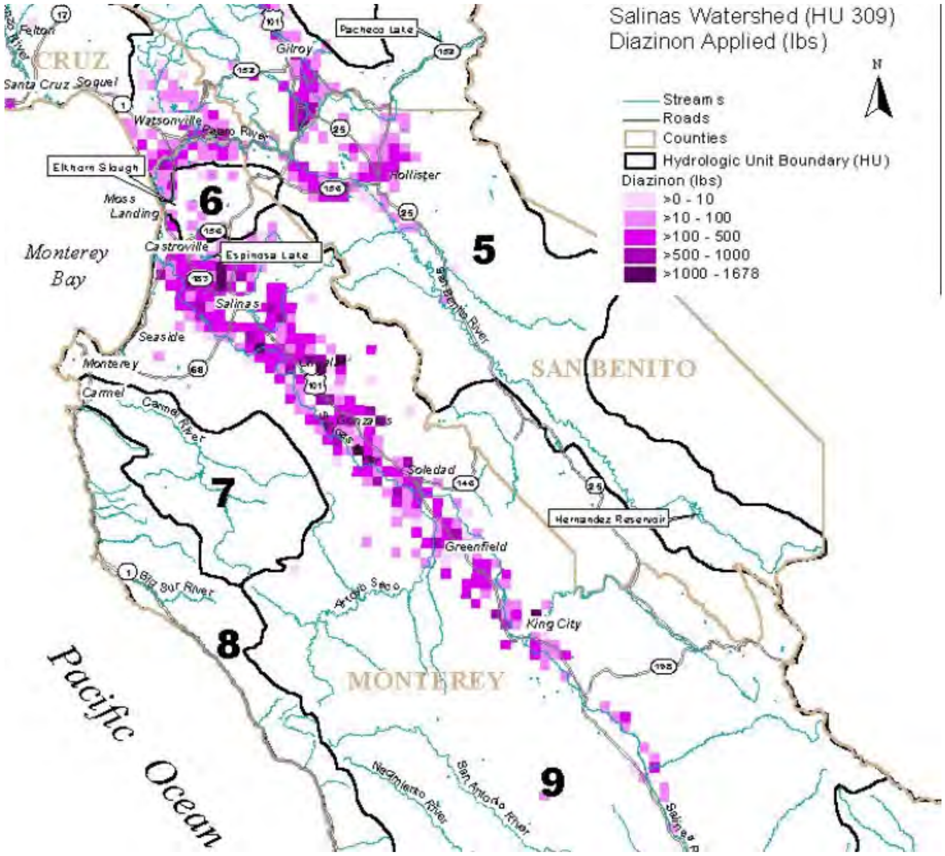

Figure 14. . Map of the number of pounds of diazinon used in Salinas River basin. From CCRWQCB (2000).

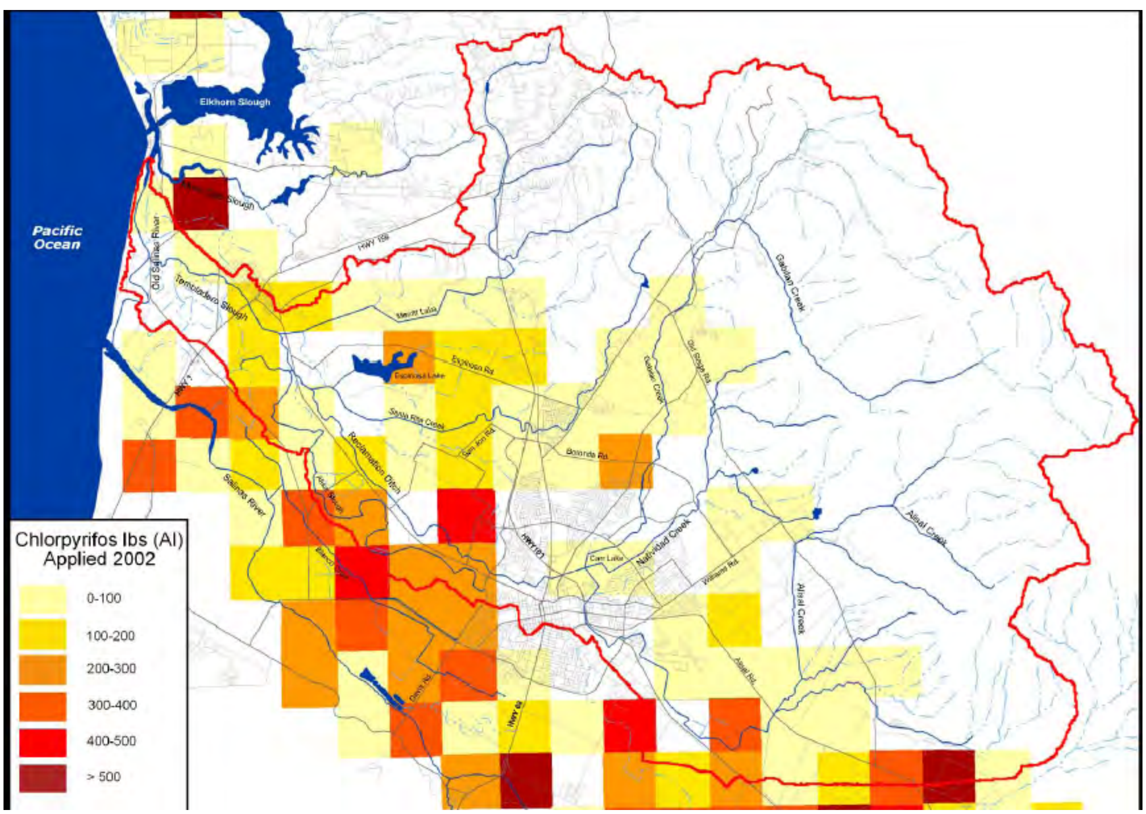

Figure 15. Pounds of chlorpyrifos used in 2002 in the lower Salinas River basin. From Casagrande and Watson (2006).

think the reauthorization of a RMP for the CMP would require discussion of these activities. Potential impacts to steelhead from pesticides within and adjacent to the CMP require discussion in a full EIR.

Turbidity: Suspended sediment in the water column causes turbidity. Sigler et al. (1984) found that turbidities as low as 25 nephelometric turbidity units (ntu) caused a reduction in juvenile steelhead and coho growth. High turbidity promoted by CMP activities during winter likely impacts the feeding ability of Salinas River steelhead juveniles and the longer the duration of high turbidity the more damage is likely to fish and other aquatic organisms (Newcombe and MacDonald, 1991). The perpetual state of disturbance associated with an endless cycle of bed excavations and riparian removal insures chronic, elevated turbidity that needs addressing in a full EIR.

The Salinas River may have been somewhat turbid due to sandstone bedrock geology, but present day turbidities are likely substantially elevated as a result of suspended materials in agricultural drain water. CCRWQCB (2000) turbidity results from Salinas River and Reclamation Ditch tributaries Quail and Gabilon Creeks (Figure 16) show major spikes in turbidity in what would be the agricultural irrigation season. The issue of turbidity related to agricultural waste discharges from within and near the CMP should be included in a full EIR.

Concluding Remarks

The CMP is geared to protect agricultural development that has so encroached on the lower Salinas River that its ecosystem functions are failing and the natural ability of the river to assimilate nutrients and buffer water pollution is almost completely impaired. Steelhead survival in the lower Salinas River is now nearly impossible, but there are other red lights that the MCWRA and agricultural operators are running by continuing to do business as usual and at the current scale. Water demand too great for supply, including urban and suburban development

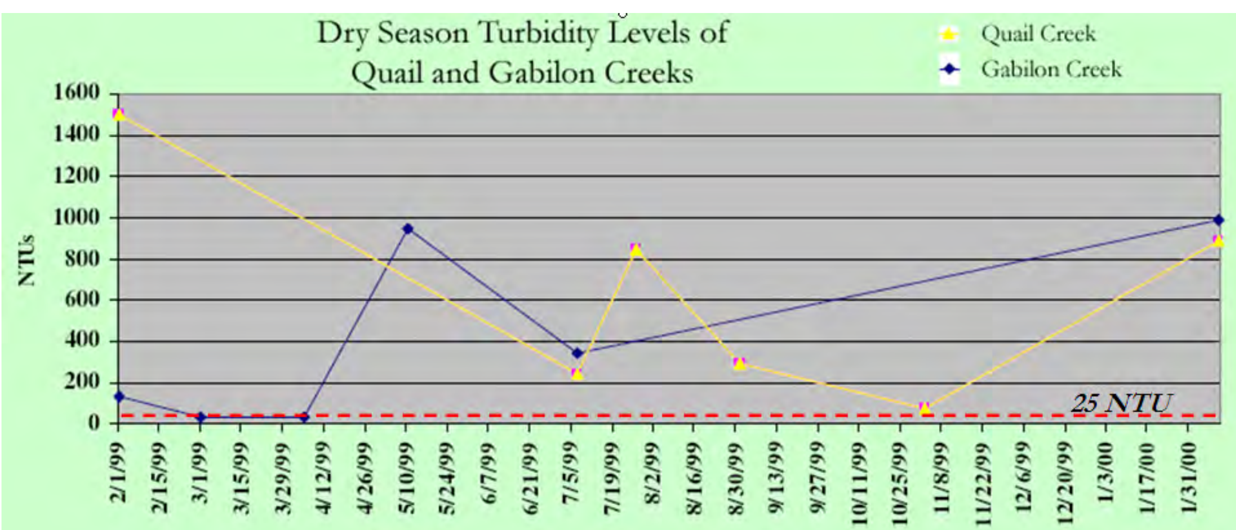

Figure 16. Turbidity in NTUs for Quail and Gabilon Creeks during 1999 with reference line of 25 NTU based on Sigler et al. (1984) and indicates levels above which steelhead growth would be impaired. Chart adapted from CCRWQCB (2000).

allowed by Monterey County, is not only causing Salinas River stagnation and dewatering but is now promoting seawater intrusions into the aquifer underneath one of the world's richest agricultural valleys. There is a water quality crisis that threatens the industry itself, of which E. coli O157 is only one example. Despite the CMP, flooding problems will continue on the lower Salinas River and all the expense and effort is futile because of the constraints of the channel below RM 23 (Curry 2009).

All the above problems could be resolved through allowing the Salinas River to re-expand into its floodplain through acquisition of land in fee title or through easements (see Alternative Flood Control above). Only by allowing the meander widths and lengths that mimic historic conditions can full hydrologic function be restored. Pacific salmon evolved over millennia with the continually changing California landscape and unless the Salinas River channel and flow move back towards their more normal range of variability steelhead cannot be restored (Reeves et al. 1995, Bradbury et al. 1995). Three (or four) distinct populations of Salinas River steelhead are now land-locked, but represent the distinct potential for restoration, but only if substantial cooperative efforts lead to cessation of anthropogenic stress (Kaufmann et al. 1997).

The National Research Council (1996) noted that Pacific salmon species could not be recovered without restoration of low gradient habitats in landscapes that are often very developed:

> "Lower river valleys or coastal lowlands and estuaries lack refugia with high quality habitat for salmon, and there seems to be little hope of future establishment of such areas without considerable public resolve and financial commitment."

The MCWRA needs a full EIR to comply with CEQA and likely to meet NMFS reauthorization of a new RMP for the CMP. In the EIR, an Alternative needs to be developed for restoring natural riverine processes by changing the footprint of agriculture in the lower Salinas River, including the Reclamation Ditch sub-basin.

Sincerely,

Patrick Higgins

REFERENCES

Alley, D.W. and Associates. 2009. Comments to the Salinas River Channel Maintenance Program Initial Study Mitigated Negative Declaration. Provided for the Monterey Coastkeeper by D.W. Alley and Associates, Brookdale, CA. 10 p.

Baumgartner, J. 2008. Highlights and Recommendations from 11/20 Food Safety War on Wildlife Teach-In. Wild farm Alliance, Watsonville, CA. 4 p. www.wildfarmalliance.org/Press%20Room/PR_Teach-In_Highlights.pdf

Benbrook, C. 2007. Unfinished Business: Preventing E. coli O157 Outbreaks in Leafy Greens. Organic Center. 21 p. http://www.organic-center.org/reportfiles/CIR-ecoli%20-2.pdf.

Bernot, MJ and WK Dodds. 2005. Nitrogen Retention, Removal, and Saturation in Lotic Ecosystems. Ecosystems 8: 442–453.

Booth, D.B and C.R. Jackson. 1997. Urbanization of Aquatic Systems--Degradation Thresholds, Stormwater Detention, and the Limits of Mitigation. Journal of the Amer. Water Res. Assoc. Vol. 22, No. 5 (October 1997).

Boughton, D.A., H. Fish, K. Pipal, J. Goin, F. Watson, J. Hager, J. Casagrande, and M. Stoecker. 2005. Contraction of the southern range limit for anadromous Oncorhynchus mykiss. NOAA Fisheries Technical Memorandum SWFSC 380. NOAA Fisheries SW Regional Science Center, Santa Cruz, CA.

Boughton, D.A., P.B. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelly, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Viability criteria for the steelhead of the South-Central and Southern California Coast. NOAA Fisheries SW Regional Science Center, Santa Cruz, CA. 33 p.

Boughton, D.A., P.B. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelly, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Steelhead of South-Central/Southern California Coast: Population Characterization for Recovery Planning. NOAA-TM-NMFS-SWFSC-394. National Marine Fisheries Service Southwest Fisheries Science Center. 123 p.

Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D. L. Bottom, W.E. Weaver and R. L. Beschta. 1995 Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Pacific Salmon. Published by Pacific Rivers Council, Eugene, OR. 56 p. Available online at: www.krisweb.com/biblio/gen_xxxx_bradburyetal_1995.pdf

California State Water Resources Control Board (SWRCB). 2005. Revision of the Clean Water Act Section 303(d) List of Water Quality Limited Segments. Updated Sept. 2005. SWRCB, Sacramento, CA. 322 p.

Casagrande and Watson. 2006. Final Report: Monterey County Water Resources Agency - Reclamation Ditch Watershed Assessment and Management Strategy. Performed under contract to MCWRA by Central Coast Watershed Studies Program, CSU Monterey, Monterey, CA. 197 p

Central Coast Regional Water Quality Control Board. 2005. Central Coast Basin Plan. CCRWQCB, San Luis Obispo, CA.

Central Coast Regional Water Quality Control Board. 2005. Baseline data collection report for preparation of a Fecal Coliform TMDL for the Lower Salinas River Watershed. CCRWQCB, San Luis Obispo, CA. 11 p.

Central Coast Regional Water Quality Control Board. 2007. Draft Total Maximum Daily Load for Fecal Coliform for the Lower Salinas River Watershed, Monterey County, California Phase-4: Project Analysis: Final Preliminary Project Report. CCRWQCB, San Luis Obispo, CA. 74 p.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

Cooley, M., D. Carychao1, L. Crawford-Miksza, M.T. Jay, C. Myers, C. Rose, C. Keys, J. Farrar, R.E. Mandrell. 2007. Incidence and Tracking of Escherichia coli O157:H7 in a Major Produce Production Region in California. DOI: 10.1371. http://www.plosone.org/article/info:doi/10.1371/journal.pone.0001159

Curry, R. PhD. 2009. Technical Comments on sedimentologic and hydrologic aspects of the proposed Salinas River Channel Maintenance Program - Mitigated Negative Declaration, MCWRA. Provided for the Monterey Coastkeeper. 5 p.

Dettman, D.H. 1988. Reconnaissance of Effects of a Salinas Diversion Dam on Fish and Other Aquatic Resources. Prepared for the Monterey County Water Resources Agency, Salinas, CA.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.

Entrix. 2009. Salinas River Channel Maintenance Program Biological Assessment. Performed under contract to the MCWRA. Entrix, Concord, CA 97 p.\

Entrix. 2009a. Salinas River Channel Maintenance Program Initial Study with Proposed Mitigated Negative Declaration. Performed under contract to the MCWRA. Entrix, Concord, CA 81 p.

Ewing, R.D. 1999. Diminishing Returns: Salmon Decline and Pesticides. Funded by the Oregon Pesticide Education Network, Biotech Research and Consulting, Inc., Corvallis, OR. 55 p.

Gilpin, M. E., and M. E. Soule 1986. Minimum viable populations: processes of species extinction. Pages 19-34 in M. Soule, ed. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Inc., Sunderland, MA.

Girman, D.J. and J.C. Garza. 2006. Population structure and ancestry of O. mykiss populations in South-Central California based on genetic analysis of microsatellite data. California Department of Fish and Game and Pacific State Marine Fisheries Commission. NMFS SW Science Center, Santa Cruz, CA.

Goldman, C.R. and A.J. Horne. 1983. Limnology. McGraw-Hill, Inc. New York. 464 pp.

Good, T. P., R. S. Waples and P. B. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-66. 598 pp.

Hagar, J.M. 1996. Salinas River steelhead status and migration flow requirements. Monterey County Water Resources Agency, Salinas, CA. 41 p.

Higgins, P.T. 1991. Southern California Steelhead Recovery Assessment: San Mateo Creek (San Diego Co.) and the Santa Margarita River. Study performed under contract with the South Coast Chapter of Trout Unlimited by Patrick Higgins, Consulting Fisheries Biologist, Arcata, CA. 34 p.

Higgins, P.T., S. Dobush, and D. Fuller. 1992. Factors in Northern California Threatening Stocks with Extinction. Humboldt Chapter of American Fisheries Society. Arcata, CA. 25 p.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An Ecological Perspective of Riparian and Stream Restoration in the Western United States. Fisheries 22(5):12-24.

Kier Associates. 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program. U.S. Fish and Wildlife Service, Klamath River Fishery Resource Office. Yreka, CA. 403 pp.

Kier Associates. 1999. Mid-term evaluation of the Klamath River Basin Fisheries Restoration Program. Sausalito, CA . Prepared for the Klamath River Basin Fisheries Task Force. 303 pp.

Kier Associates and National Marine Fisheries Service (NMFS). 2008. Updated Guide to Reference Values used in the Southern Oregon / Northern California Coho Salmon Recovery Conservation Action Planning (CAP) Workbook. Kier Associates, Blue Lake, CA and National Marine Fisheries Service, Arcata, CA. 31 pp.

Londquist, B. 2001. Steelhead (Oncorhynchus mykiss) Habitat Assessment Along the Arroyo Seco River. A Capstone Project of CSU Monterey Bay, Monterey, CA. 32 p. http://ccows.csumb.edu/pubs/capstones/BLondquist_FinalThesis.pdf

Mahugh, S, M.L. Deas, R.A. Gearheart, J. Vaughn, R. Piaskowski, and A. Rabe. 2008. Keno Reservoir Feasibility Study, Phase II – Identification and Assessment of Potential Treatment Wetland Sites in the Upper Klamath River. Prepared for U.S. Bureau of Reclamation, Klamath Basin Area Office. Proposal No. 07SF200051. June 18. 49 pp.

Monterey County Water Resources Agency. 2001. Draft Environmental Impact Report/Environmental Impact Statement for the Salinas Valley Water Project, June 2001. MCWRA, Salinas, CA.

Monterey County Water Resources Agency. 2006. Map of 400 Foot Aquifer Salt Intrusion from 2005 Water Quality Data. MCWRA, Salinas, CA.

Montgomery, D. R. and J.M. Buffington, 1993. Channel classification, prediction of channel response, and assessment of channel condition. TFW-SH10-93-002. Prepared for the SHAMW committee of the Washington State Timber/Fish/Wildlife Agreement. Seattle, WA. 110 pp.

National Marine Fisheries Service. 2003. Programmatic Biological Opinion for Monterey County Water Resources Agency – Channel Maintenance Program on the Salinas River in Monterey County, California. Memo signed by Rod McInnis, Acting Regional Director, NMFS SW Region, Long Beach, CA. 41 p.

National Marine Fisheries Service (NMFS). 2008. Environmental Protection Agency Registration of Pesticides Containing Chlorpyrifos, Diazinon, and Malathion. National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion. NMFS, Silver Springs Md. 478 p.

National Research Council. 1996. Upstream: Salmon and Society in the Pacific Northwest. National Academy Press.

Newcombe, C.P. and D.D. MacDonald. 1991. Effects of Suspended Sediments on Aquatic Ecosystems. North American Journal of Fisheries Management. 11: 72-82.

Oregon Department of Environmental Quality (ODEQ). 2008. Rogue River Total Maximum Daily Load (TMDL). Accepted by U.S. EPA on 12/28/08. ODEQ, Medford, OR. www.deq.state.or.us/WQ/TMDLs/rogue.htm

Pacific Watershed Associates. 1994. Action plan for the restoration of the South Fork Trinity River watershed and its fisheries. Prepared for U.S. Bureau of Reclamation and the Trinity River Task Force, Contract No. 2-CS-20-01100. Arcata, CA.

Pelgen, D. E., and L. O. Fisk. 1955. Fish, wildlife, and recreation in the Salinas River basin. Appendix report by Calif. Dept. Fish Game. Prepared with Calif. Dept. Public Works, Div. Water Resour. 18 pp.

Poole, G.C., and C.H. Berman. 2000. Pathways of Human Influence on Water Temperature Dynamics in Stream Channels. U.S. Environmental Protection Agency, Region 10. Seattle, WA. 20 p.
http://www.krisweb.com/biblio/gen_usepa_pooleetal_2000_pathways.pdf

Reeves, G.H., L.E.Benda, K.M.Burnett, P.A.Bisson, and J.R. Sedell. 1995. A Disturbance-Based Ecosystem Approach to Maintaining and Restoring Freshwater Habitats of Evolutionarily Significant Units of Anadromous Salmonids in the Pacific Northwest. American Fisheries Society Symposium 17:334-349, 1995.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of Chronic Turbidity on Density and Growth of Steelheads and Coho Salmon. Transactions of the American Fisheries Society. 113:142-150.

Snyder, J. O. 1913. The fishes of the streams tributary to Monterey Bay, California. Bull. U.S. Bur. Fish. 32:49–72.

Titus, R. G., D. C. Erman, and W. M. Snider. 2006. History and status of steelhead in California coastal drainages south of San Francisco Bay. In draft for publication as a Department of Fish and Game, Fish Bulletin. 293 p.

U.S. Environmental Protection Agency (U.S. EPA). 1986. Quality criteria for water 1986: EPA 440/5-86-001. Office of Water Regulations and Standards, Washington, DC. 477 p.

U.S. Environmental Protection Agency. 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA Project # 910-B-03-002. Region 10 U.S. EPA, Seattle WA. 57 p.

U.S. Geologic Survey. 1996. Assessment of Water Quality, Nutrients, Algal Productivity, and Management Alternatives for Low-Flow Conditions, South Umpqua River Basin, Oregon, 1990–92. Water-Resources Investigations Report 96–4082. Performed with Douglas County, OR. USGS, Portland, OR. 80 p.

U.S. Geologic Survey. 2009. Internet metadata posting for Salinas River Gauge 11152500 near Spreckels, California. http://waterdata.usgs.gov/usa/nwis/uv?site_no=11152500

Worcester, K., D. Paradies, M. Adams and D. Berman. 2001. Salinas River Watershed Characterization Report 1999. Central Coast Ambient Monitoring Program. CCRWQCB, San Luis Obispo, CA. 97 p.

SCOTT RIVER FLOWS

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Stream Flow Needs for Anadromous Salmonids in the Scott River Basin, Siskiyou County - A Summarized Report

I. Introduction

At the request of the State Water Resources Control Board, Division of Water Rights, the California Department of Fish and Game conducted a study in the Scott River Basin to determine minimum flow needs for preserving fishery values in this drainage. This report is being submitted to fulfill this request. It represents a brief summary of the findings, which are dealt with in more detail in a typewritten report filed at the Department of Fish and Game, Region 1 Headquarters in Redding, California.

The study was restricted to flow needs for anadromous salmonids, because the numbers of these fishes have, and continue to be, in a state of decline. The study encompassed the needs of silver salmon, king salmon (two runs), and steelhead rainbow trout (three runs, two races). It did not encompass the stream systems in this area that have already been adjudicated, i.e., the French Creek drainage, and the Shackleford-Mill Creek drainage, nor those streams with value only as resident trout streams, e.g., Clark Creek. The streams considered have current anadromous values. Two streams, Patterson Creek, near old Meamber School, and Indian Creek, were deleted from consideration even though they had recent value for anadromous use. They are currently extremely deteriorated due to stream channel manipulations and heavy off-stream consumption of water.

II. The Study Area - Scott River Basin Watershed

The area encompassed by this study is outlined on Figure 1. The tributary streams descend a gradient from 150 - 400 feet per mile to join and

SOURCE: SARI SONMARSTROM
ETNA, CALIF

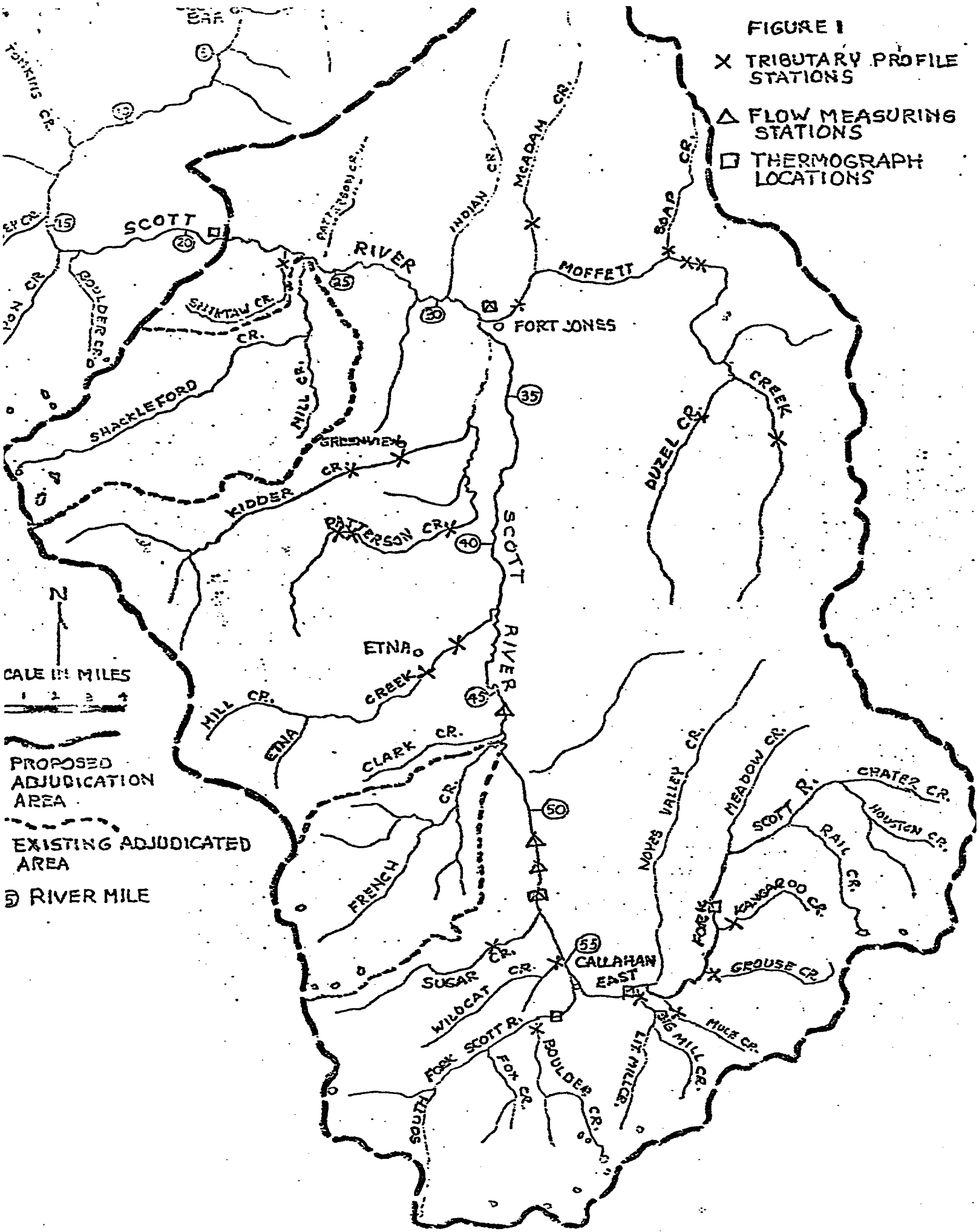


FIGURE 1
TRIBUTARY PROFILE STATIONS
FLOW MEASURING STATIONS
THERMOGRAPH LOCATIONS
N
CALE IN MILES
1 2 3 4
PROPOSED ADJUDICATION AREA
EXISTING ADJUDICATED AREA
RIVER MILE
TOMPKINS CR.
SCOTT
RIVER
SHACKLEFORD
CR.
SHIKTAW CR.
BOULDER CR.
MILL CR.
PATTERSON CR.
INDIAN CR.
MCADAM CR.
SOAP CR.
MOFFETT
FORT JONES
DUZEL CR.
CREEK
GREENVIEW
KIDDER
PATTERSON CR.
SCOTT RIVER
ETNA
CREEK
HILL CR.
ETNA
CLARK CR.
CR.
FRENCH
NOYES VALLEY CR.
MEADOW CR.
SCOTT R.
CRATER CR.
HOUSTON CR.
RAIL CR.
KANGAROO CR.
FORK
GROUSE CR.
SUGAR CR.
WILDCAT CR.
CALLAHAN
EAST
SOUTH FORK SCOTT R.
FOX CR.
BOULDER CR.
LIT. MILL CR.
BIG MILL CR.
MULE CR.
15
20
25
30
35
40
45
50
55

form the Scott River on the Valley floor. Many of these streams show a rapid decrease in gradient at the valley's edge, and these areas suffer the greatest amount of interrelated natural and artificial stream channel disturbances.

The streams in the study area to the west and south of the Scott River mainstem and thence the East Fork, drain areas of similar patterned precipitation, as well as higher levels of precipitation than the streams to the north and east. The McAdam Creek watershed to the north, is intermediate in terms of rainfall, between the low area drained by Moffett Creek, and the higher level areas to the west and south.

III. Status of the Anadromous Salmonid Populations

The California Fish and Wildlife Plan (1965) gives estimates for the annual adult spawning escapement into the Scott River as follows:

King salmon	8,000
Silver salmon	800
Steelhead	5,000

A fish counting fence was installed near the mouth of the Scott River during the summer of 1973 to enumerate the salmon escapement. The fence was lost in high November waters. The king salmon count can be considered as complete, with an adult enumeration of 1,847 fish. The river was also sampled by methods normally used to provide an index of population numbers. This index showed that this was the lowest escapement on record for the ten years that the river has been sampled in this manner. The silver salmon run was near its peak when the fence was washed out by high waters, so no count can be given. A second and larger flood occurred in early January, which removed any opportunity to estimate numbers of adult steelhead.

California Fish and Wildlife Plan. Volume 3. Supporting data. Part B. Inventory of salmon, steelhead, and Marine Resources. October 1, 1965.

The Fish and Wildlife Plan escapement estimates do not break down into runs or races for each species of fish. The following approximations were made on a judgmental basis:

King salmon, fall-run		7,800
King salmon, spring-run		50-200
Steelhead, winter race, winter-run		5,500
Steelhead, summer race,	fall-run	1,500
	spring-run	50-200

Table 1 is presented to qualitatively show various limiting conditions due to flow volume and stream temperature on the stream-associated life history events for these fishes. In general, all of the anadromous runs are still declining in the Scott River system. The spring-run king salmon, which may have been a dominant run in the Klamath system, is presently a remnant run in the Scott River. The spring and fall-run steelheads are probably the most reduced of the steelheads, with the former suffering the heaviest. These population declines reflect the conditions shown in Table 1.

V. Some Economic Considerations of the Scott River Anadromous Runs

This section follows the methodology used by Everest 1/. Catch/escapement ratios for both the silver salmon and king salmon are taken from figures derived for southern Oregon rivers by the National Marine Fisheries Service. The catch/escapement ratio for both salmons is given as five to one. The catch is subdivided into 29 percent sport and 71 percent commercial. The following table was constructed to

1/ Everest, Fred H. 1973. An Economic Evaluation of Anadromous Fishery Resources of the Siskiyou National Forest. (Mimeographed Report-U.S.F.S.)

Table 1. A qualitative summary of how current stream flow and/or temperature conditions meet flow and/or temperature needs for various freshwater life history aspects of the anadromous salmonid populations in the Scott River system

Species and Run	Holdover of Adults Prior to Spawning	Spawning	Juvenile Rearing
Steelhead			
Summer			
Spring-run	Poor	Good	Poor
Fall-run	Fair	Good	Poor
Winter			
Winter-run	Good	Good	Poor
Silver Salmon	Fair	Fair	Poor
King Salmon			
Spring-run	Poor	Poor	Fair
Fall-run	Poor to Fair	Poor to Fair	Fair

give the constants used in calculating the economic values of these fishes:

Table 2. Table of Constants for determining economic values (derived from Everest's text)

Sport Fish	Catch	Value	
King salmon	29% of total	$28/angler day,	1.3 days/fish
Silver salmon	29% of total	$28/angler day,	1.3 days/fish
Steelhead	15% of escape.	$20/angler day,	2.2 days/fish
Commercial			
King salmon	71% of total	$1.10/lb.,	10.2 lbs./fish
Silver salmon	71% of total	$ .90/lb.,	5.9 lbs./fish

Using the escapement size estimates given earlier and the values from Table 2, the following table was constructed:

Table 3. Annual economic values of Scott River anadromous fishes

Fish	Sport	Commercial	Species Total
Steelhead	$ 33,000	--	$ 33,000
King salmon	422,240	$318,648	740,888
Silver salmon	42,224	15,080	57,304
		Total	$831,192

V. Distribution and Life History Aspects of the Anadromous Salmonids Utilizing the Scott River Basin

Many of the major factors which affect population numbers of these anadromous salmonids occur in the freshwater stream habitat. The adult fish ascend the rivers and tributary streams to spawn in the stream gravels.

Adequate flows must remain following spawning to provide enough circulation of oxygen-rich water through the gravels to the incubating eggs and pre-emergent fry. Following emergence, the young salmons and steelheads depend on the stream habitat for growth to smolt size when seaward migration begins.

The steelhead fry will spend from one to three years in the streams where spawned before smolting at an average size of approximately seven inches in length. They will then spend from one to three years at sea before initiating their first spawning run. Not all of the steelheads die after spawning. A portion re-descend to the sea and later return again. The geographic distribution of spawning areas utilized by steelhead is delineated on Figure 2. The rearing area generally incorporates the upstream reach of the spawning activity and most of the stream system below.

The silver salmon fry generally spend one full year in the stream system where spawned before smolting in the spring at a size of five to seven inches in length. They spend two to three years at sea before maturation and stream reentry to spawn and die. The upstream extent of the silver salmon spawning areas are delineated on Figure 3. Rearing can be assumed to occur from the upstream extent of the spawning, down through the stream reach. Additionally, some of the fry will ascend the stream from the point of emergence.

The king salmon fry usually spend from four to eight months in the streams growing to a size of three to four inches in length before descending the stream system to the ocean. They spend two to five years (major portion three years) at sea before maturation and reentry to the stream system to

FIGURE 2
STEELHEAD SPAWNING AREAS

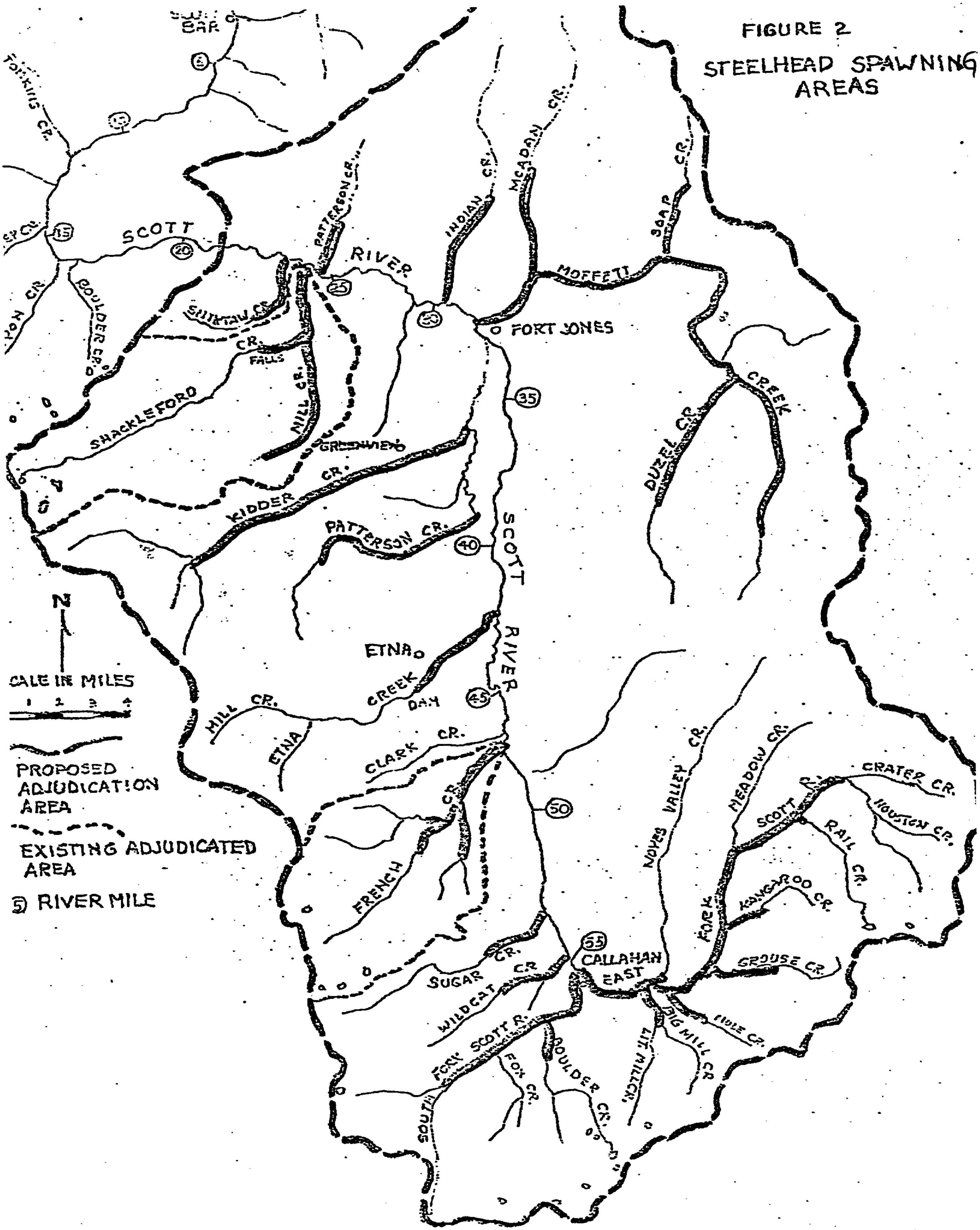
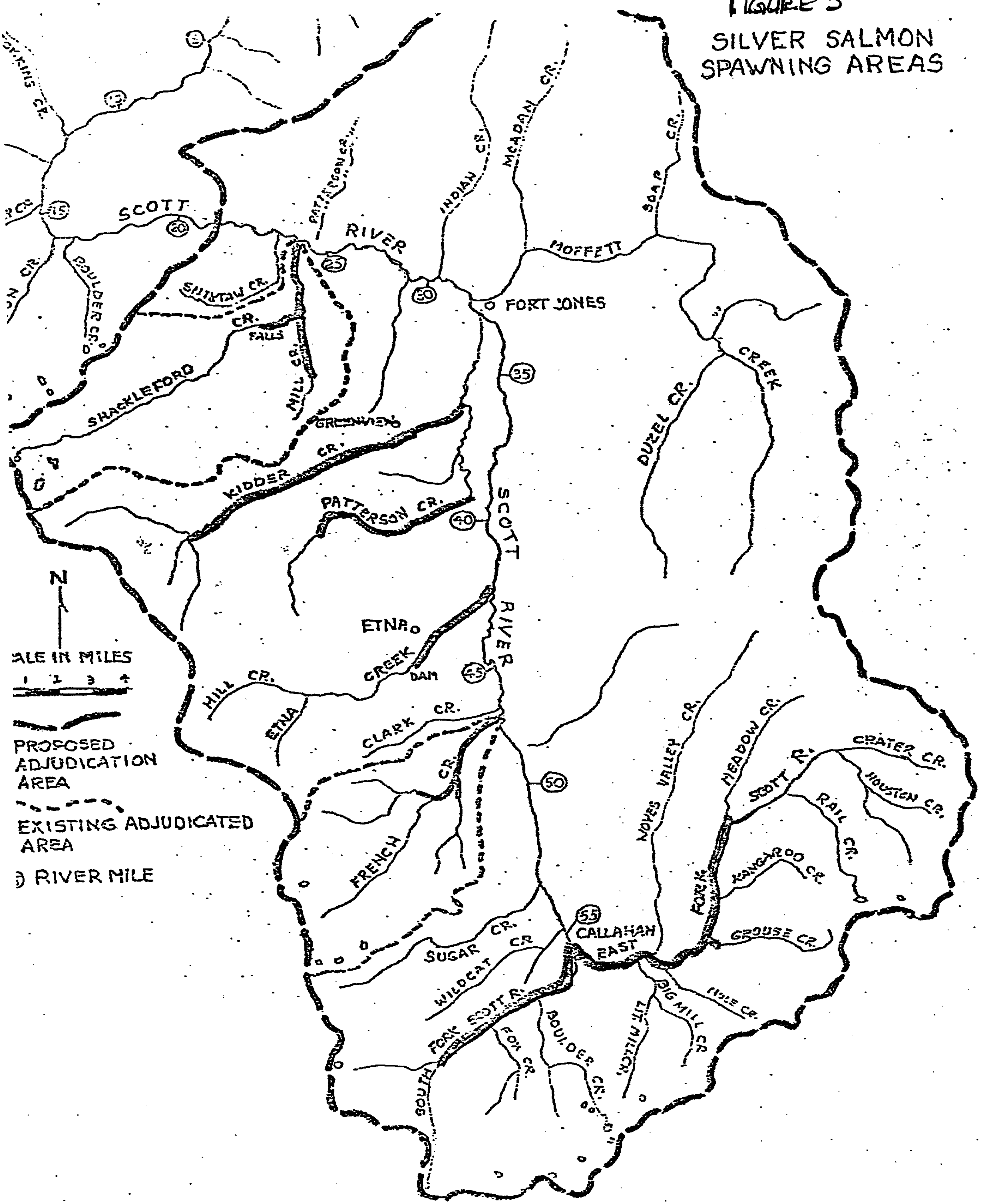


FIGURE 3

SILVER SALMON SPAWNING AREAS



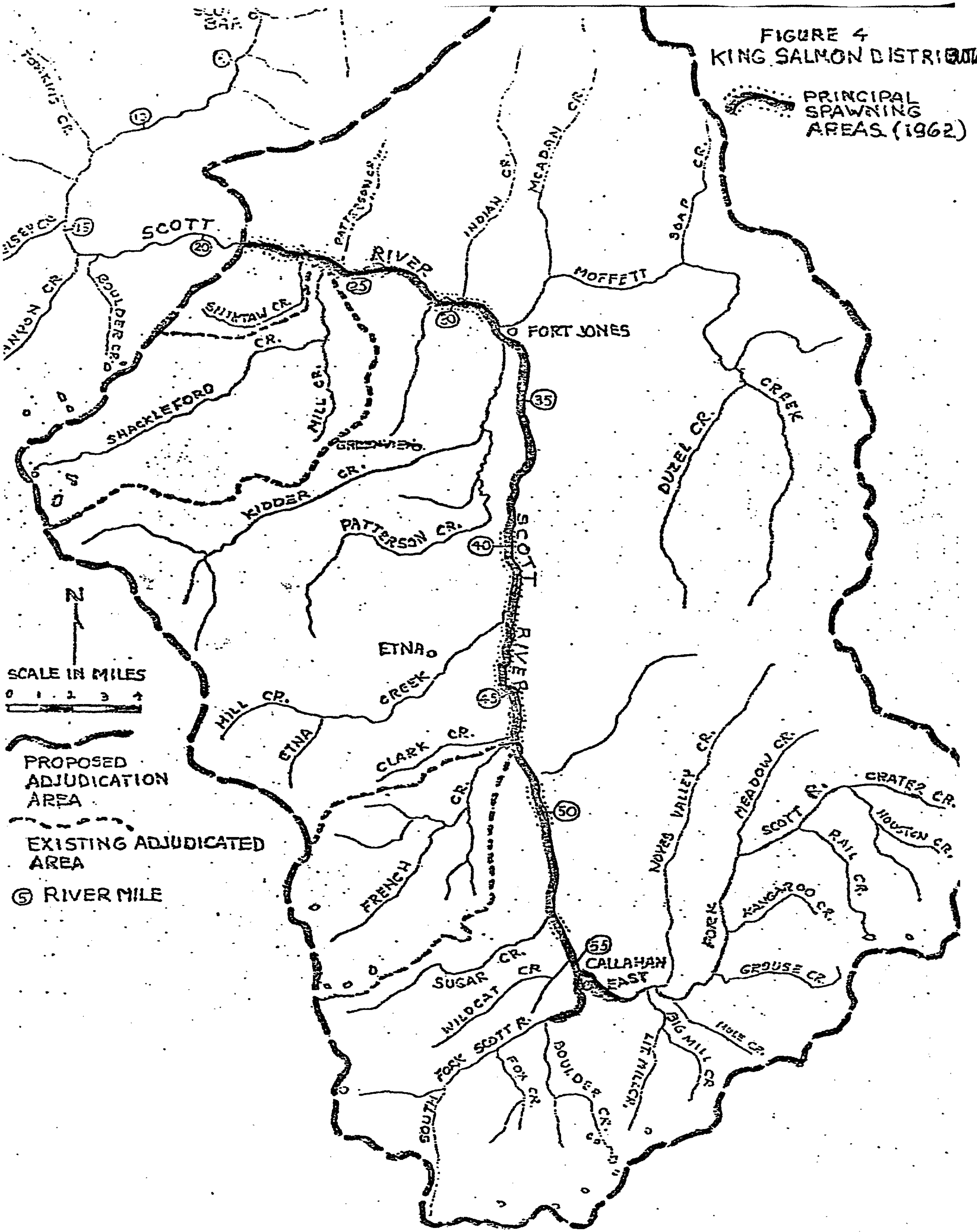


FIGURE 4
KING SALMON DISTRIBUTION
PRINCIPAL SPAWNING AREAS (1962)
SCALE IN MILES
0 1 2 3 4
PROPOSED ADJUDICATION AREA
EXISTING ADJUDICATED AREA
⑤ RIVER MILE
N
SCOTT RIVER
FORT JONES
ETNA
CALLAHAN
EAST
SHACKLEFORD
KIDDER CR.
PATTERSON CR.
MILL CR.
INDIAN CR.
MCADAM CR.
MOFFETT CREEK
DUZEL CR.
SOAP CR.
BOULDER CR.
HILL CR.
ETNA CREEK
CLARK CR.
FRENCH CR.
SUGAR CR.
WILDCAT CR.
SOUTH FORK SCOTT R.
FOX CR.
NOYES VALLEY CR.
MEADOW CR.
CRATER CR.
HOUSTON CR.
RAIL CR.
KANGAROO CR.
GROUSE CR.
BIG MILL CR.
LIT. MILL CR.
EAST FORK SCOTT R.
15
20
25
30
35
40
45
50
55

spawn and die. Upon stream reentry, they require adequate flows and suitable water temperatures for both holding in the stream system and later spawning. The bulk of the spawning area for these fish is delineated on Figure 4. Some will ascend side streams if enough flow is present. The nursery area for the king salmon ranges from at least the upstream extent of the spawning activity (some fry will move upstream) down through the stream reaches.

Figure 5 is given to diagrammatically show the timing of the spawning runs, spawning, egg incubation, and juvenile downstream migration for these salmonids. The summary diagram shows that adult salmonids are running in the Scott system to a lesser or greater degree, eleven months of the year, and adults are present in the system twelve months of the year.

VI. Definitions and Methods Used for the Determination of Flow Needs

For purposes of determining flow needs for spawning and rearing, cross sectional stream transects were made on the tributaries at sites denoted by x's on Figure 1. For spawning, a single cross sectional profile was established through the "best" or "key" area over a potential spawning bar that was considered as representative of that stream section. Flows and resultant velocities for flows larger and smaller than the one measured on the field sampling date were determined by assuming and incorporating the power functional relationship between flow volume and mean velocity. The range in stream velocities present in the profile were assumed to be a reasonably constant fraction of the mean velocity at any flow volume for a given cross section. The values for these variances were determined from the profile data. A normal distribution was assumed for the cross section velocities, and a usable spawning fraction of the

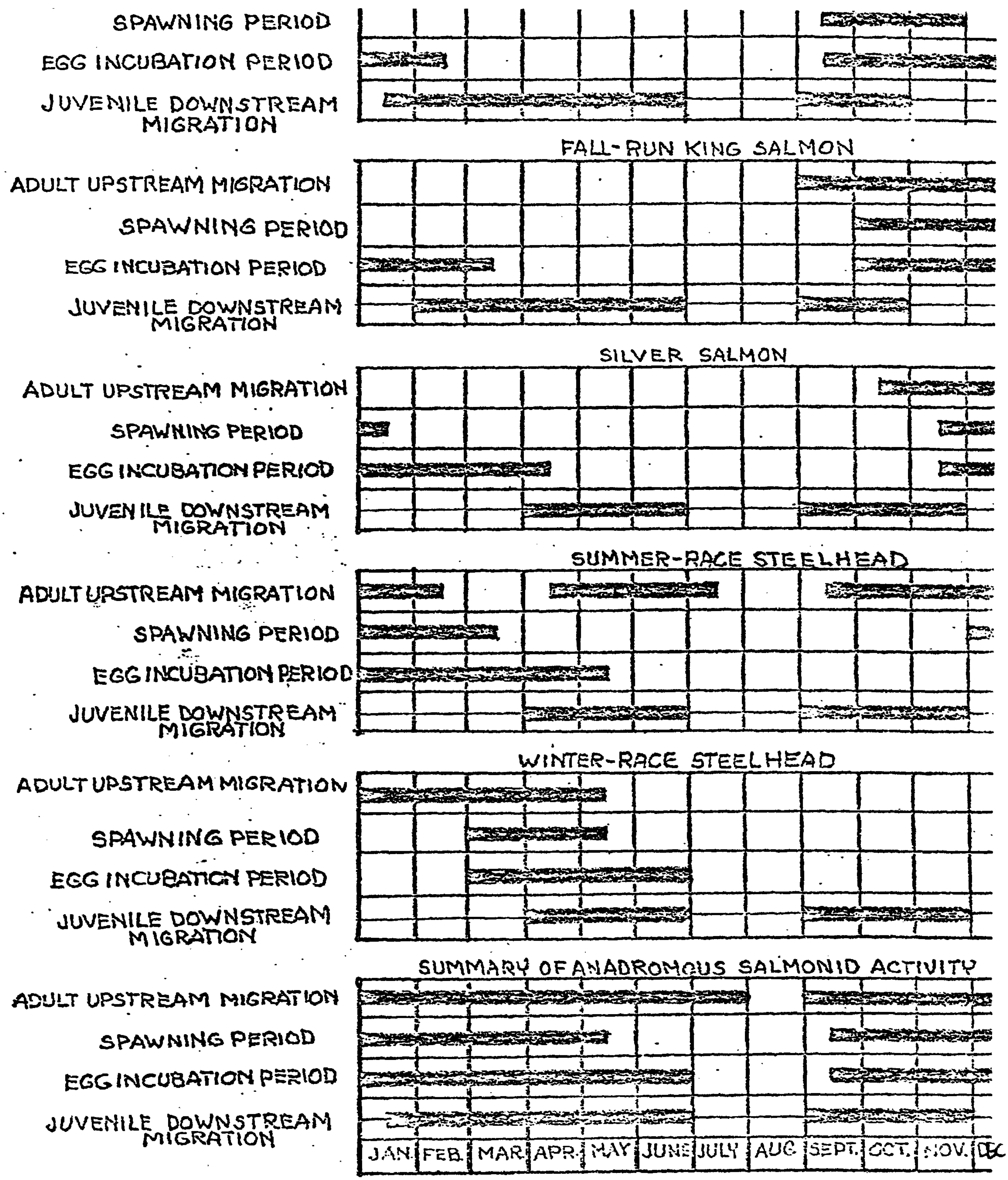


FIGURE 5.

SPAWNING, EGG INCUBATION, AND MIGRATION PER
SCOTT RIVER BASIN, SISKIYOU COUNTY.

... ... as the area under a normal curve that would include the velocity range required for the species of fish in question. The usable fraction values were plotted against their corresponding calculated flow volumes. Minimum spawning flow need for each stream was then defined as that flow present where the spawning area gain is not significant in terms of the increase in flow volume that is required for that gain.

For rearing, a single cross sectional profile was established through a deep-fast cover area, at the "best" or "key" use point. Similar data handling and assumptions were utilized for rearing flows as with spawning flows, except that the rearing flow minimum was defined as one which had a representation of the entire velocity range defined in the literature, as required for the range in size of juvenile salmonids normally occurring in these rearing streams. This resulted in the calculation of a single flow value which is lower than an optimum flow. An optimum rearing flow can be considered as the mean annual flow, i.e., a "bank full". The values later recommended here ranged from a high of 54 percent of the mean annual flow to 41 percent of the mean annual flow on the two gaged tributary streams, Sugar Creek and Etna Creek, respectively. An overview of the data obtained appears to reveal that as the streams became larger in size, a decreasing percentage of the mean annual flow was required to provide minimum rearing flow. This relationship has also been shown to hypothetically occur when examining the hydraulic geometry of streams and rivers, i.e., a general increase in mean velocity proceeding down a given stream reach. These minimal summer or lowest water rearing flows and the minimized spawning flows obtained as outlined earlier are tabulated in Table 4 for the tributary streams.

Table 4. Scott River tributary rearing and spawning flow needs for anadromous salmonids

Stream	Location	Stream Mile	CFS Summer Rearing	Spawning SR	Spawning SS	Approximate age Area (Sq Mi)
Moffett Cr.	Near Fort Jones	0.5	a.2	45	(a)	125.0
Moffett Cr.	Hwy. 3 bridge	7.3	7.4	(a)	(a)	70.0
Moffett Cr.	Sissel Gl.	18.6	2.4	7.7	(a)	17.3
McAdam Cr.	Near mouth	0.0	12.0	34.0	(a)	28.2
Soap Cr.	Near mouth	0.0	1.7	7.0	(a)	0.a
Duzel Cr.	Near mouth	0.0	2.2	5.5	(a)	18.0
Boulder Cr.	Near mouth	0.0	8.5	26.0	(a)	12.6
Etna Cr.	Etna City diversion	7.3	23.0	110.0	65	20.25
Etna Cr.	Hwy. 3 bridge	2.6	23.0	90.0	51	25.1
Grouse Cr.	Near mouth	0.0	7.2	23.0	(a)	11.0
Kangaroo Cr.	Near mouth	0.0	4.4	16.0	(a)	6.5
Kidder Cr.	Hwy. 3 bridge	5.0	25.0	80.0	55	31.[illegible]
Mill Big Cr.	Near mouth	0.0	5.5	17.0	(a)	9.[illegible]
Mule Cr.	Near mouth	0.0	2.5	12.0	(a)	3.9
Patterson Cr.	Hwy. 3 bridge	6.3	10.0	30.0	20.0	14.4
Sniktaw Cr.	One mile from mouth	1.0	4.5	9.2	(a)	-
Sugar Cr.	Hwy. 3 bridge	0.6	10.0	32.0	(a)	13.2
Wildcat Cr.	Hwy. 3 bridge,	0.01	5.0	23.0	(a)	a.2

(a) No spawning determinations made.

SH: Steelhead
SS: Silver salmon

Flow recommendations for the East and South Fork of the Scott River were not obtained by stream transect data because of generally high flows during the periods when the transects were taken. Judgmental reductions in the fraction of the mean annual flow required on the tributary streams for rearing and spawning were made for these larger streams. These fractions and resulting flows are tabulated on Table 5. The flow in the Scott River mainstem was monitored during the summer of 1973 at critical points along the river. These flow stations are denoted by triangles on Figure 1. The transect-flow data for the gaging site at Farmer's diversion, river mile 53, supports the flow values for rearing obtained arbitrarily by a percentage of the mean annual flow.

The flow requirements for rearing and spawning were combined with the seasonal life history events given in Figure 5 to give a table of flow needs by month (Table 6). The steelhead normally ascend the tributary streams from the Scott River to spawn on rain freshets and snow melt peaks. To add realism to the flows Table 7 was prepared to give minimum flow values that should be maintained between these naturally fluctuating peaks. They are considered to be incubation flow volumes which is 2/3 of the spawning minimum, a value currently used by the Oregon Fish Commission biologists.

VII. Stream Temperature Conditions

Thermographs were installed along the East Fork, South Fork, and Scott River mainstem to determine stream temperature conditions during the summer of 1973. These sites are denoted by squares on Figure 1. The minimum and maximum temperatures are graphically depicted on Figures 6 and 7. A sustained mean value of 68°F. (or less), with daily maximums

Table 5. Flow requirements for spawning and rearing in the Scott River and East and South Forks

		% Mean Annual	King Salmon	% Mean Annual Flow	Silver Salmon	% Mean Annual Flow	S
)		33.3	--	100			
)	32	33.3	95				
)	62						
							Fort

(a) U.S.G.S. Records 10/56 - 9/60
(b) U.S.G.S. Records 10/59 - 9/60
(c) The sum of East Fork, South Fork, and Sugar Creek; does not include Wildcat Creek runoff.
(d) U.S.G.S. Records 10/59 - 9/68

Table 6. Minimum Streamflow Recommendations by the Month for the Scott River Basin Streams

M	Location	River or Stream Mile	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
›tt Cr.	Near Ft. Jones	0.5			45.0	45.0	38.0	30.0	8.2	8.2	8.2	8.2	30.0	45.0
›tt Cr. (a)	Stream gage	7.31	22.0	22.0	22.0	22.0	15.0	15.0	7.4	7.4	7.4	7.4	15.0	22.0
›tt Cr.	Sissel Gl.	18.6	7.7	7.7	7.7	7.7	6.4	5.1	2.4	2.4	2.4	2.4	5.1	7.7
ˋdam Cr.	Near mouth	0.0	34.0	34.0	34.0	34.0	28.0	23.0	12.0	12.0	12.0	12.0	23.0	34.0
ıp Cr.	Near mouth	0.0	7.0	7.0	7.0	7.0	5.9	4.7	1.7	1.7	1.7	1.7	4.7	7.0
ˊel Cr.	Near mouth	0.0	5.5	5.5	5.5	5.5	4.6	3.7	2.2	2.2	2.2	2.2	3.7	5.5
ler Cr.	Near mouth	0.0	26.0	26.0	26.0	26.0	22.0	17.0	8.5	8.5	8.5	8.5	17.0	26.0
Cr.	City diversion	7.3	110.0	110.0	110.0	110.0	92.0	73.0	23.0	23.0	23.0	23.0	43.0	65.0
Cr.	Hwy. 3 bridge	2.6	90.0	90.0	90.0	90.0	75.0	60.0	23.0	23.0	23.0	23.0	34.0	51.0
›e Cr.	Near mouth	0.0			23.0	23.0	19.0	15.0	7.2	7.2	7.2	7.2	15.0	23.0
›r Cr.	Hwy. 3 bridge	5.0			80.0	80.0	67.0	53.0	25.0	25.0	25.0	25.0	37.0	55.0
Big Cr.	Near mouth	0.0	17.0	17.0	17.0	17.0	14.0	11.0	5.5	5.5	5.5	5.5	11.0	17.0
Cr.	Near mouth	0.0	12.0	12.0	12.0	12.0	10.0	8.0	2.5	2.5	2.5	2.5	8.0	12.0
›aroo Cr.	Near mouth	0.0	16.0	16.0	16.0	16.0	13.0	11.0	4.4	4.4	4.4	4.4	11.0	16.0
›rson Cr.	Hwy. 3 bridge	6.3	30.0	30.0	30.0	30.0	25.0	20.0	10.0	10.0	10.0	10.0	13.0	20.0
›aw Cr.	1 mile from mouth	1.0	9.0	9.0	9.0	9.0	7.7	6.1	4.5	4.5	4.5	4.5	6.1	9.2
r Cr.	Hwy. 3 bridge	0.6	32.0	32.0	32.0	32.0	27.0	21'0	10.0	10.0	10.0	10.0	21.3	32.0
›at Cr.	Hwy. 3 bridge	0.01	23.0	23.0	23.0	23.0	19.0	15.0	5.0	5.0	5.0	5.0	15.3	23.0
Scott R.	Callahan	0.0	95.0	95.0	95.0	95.0	95.0	63.0	32.0	32.0	32.0	63.0	95.0	95.0
Scott R.	Callahan	0.0	93.0	93.0	93.0	93.0	93.0	62.0	31.0	31.0	31.0	62.0	93.0	93.0
t R.	Farmer's diversion	53.4	155.0	155.0	155.0	155.0	155.0	103.0	62.0	62.0	62.0	103.0	155.0	55.0
t R.	Stream gage station	21.0	426.0	426.0	426.0	426.0	426.0	284.0	192.0	192.0	.92.0	284.0	426.0	26.0

(a) No spawning recommendations used.

Table 7. Minimum flows required between spawning pedis (natural flow peaking) for steelhead in the Scott River and tributary streams

Stream	Location	Stream Mile	CFS Dec.	Jan.	Feb.	Mar.	April
Moffett Cr.	Near Ft. Jones	0.5	30.0	30.0	30.0	30.0	30.0
Moffett Cr. (a)	Hwy. 3 bridge	7.3	22.0	22.0	22.0	22.0	22.0
Moffett Cr.	Below Sissel Gl.	18.6	5.2	5.1	5.1	5.1	5.1
McAdam Cr.	Near mouth	0.0	23.0	23.0	23.0	23.0	23.0
Soap Cr.	Near mouth	0.0	4.7	4.7	4.7	4.7	4.7
Duzel Cr.	Near mouth	0.0	3.7	3.7	3.7	3.7	3.7
Boulder Cr.	Near mouth	0.0	17.0	17.0	17.0	17.0	17.0
Etna Cr.	Etna City diversion	7.3	65.0	73.0	73.0	73.0	73.0
Etna Cr.	Hwy. 3 bridge	2.6	51.0	60.0	60.0	60.0	60.0
Grouse Cr.	Near mouth	.0.0	15.0	15.0	15.0	15.0	15.0
Kangaroo Cr.	Near mouth	0.0	11.0	11.0	11.0	11.0	11.0
Kidder Cr.	Hwy. 3 bridge	5.0	55.0	53.0	53.0	53.0	53.0
Mill, Big Cr.	Near mouth	0.0	11.0	11.0	11.0	11.0	11.0
Mule Cr.	Near mouth	0.0	8.0	8.0	8.0	8.0	8.0
Patterson Cr.	Near mouth	0.0	20.0	20.0	20.0	20.0	20.0
Sniktaw Cr.	One mile from mouth	1.0	6.0	6.0	6.0	6.0	6.0
Sugar Cr.	Near mouth	0.0	21.0	21.0	21.0	21.0	21.0
Wildcat Cr.	Near mouth	0.0	15.0	15.0	15.0	15.0	15.0
E. F. Scott R.	Callahan	0.0	95.0	63.0	63.0	63.0	63.0
S. F. Scott R.	Callahan	0.0	93.0	62.0	62.0	62.0	62.0
Scott R.	Farmer's diversion	53.4	155.0	103.0	103.0	103.0	103.0
Scott R.	Stream gage station	21.0	426.0	284.0	284.0	204.0	284.0

(a) No spawning habitat determinations made.

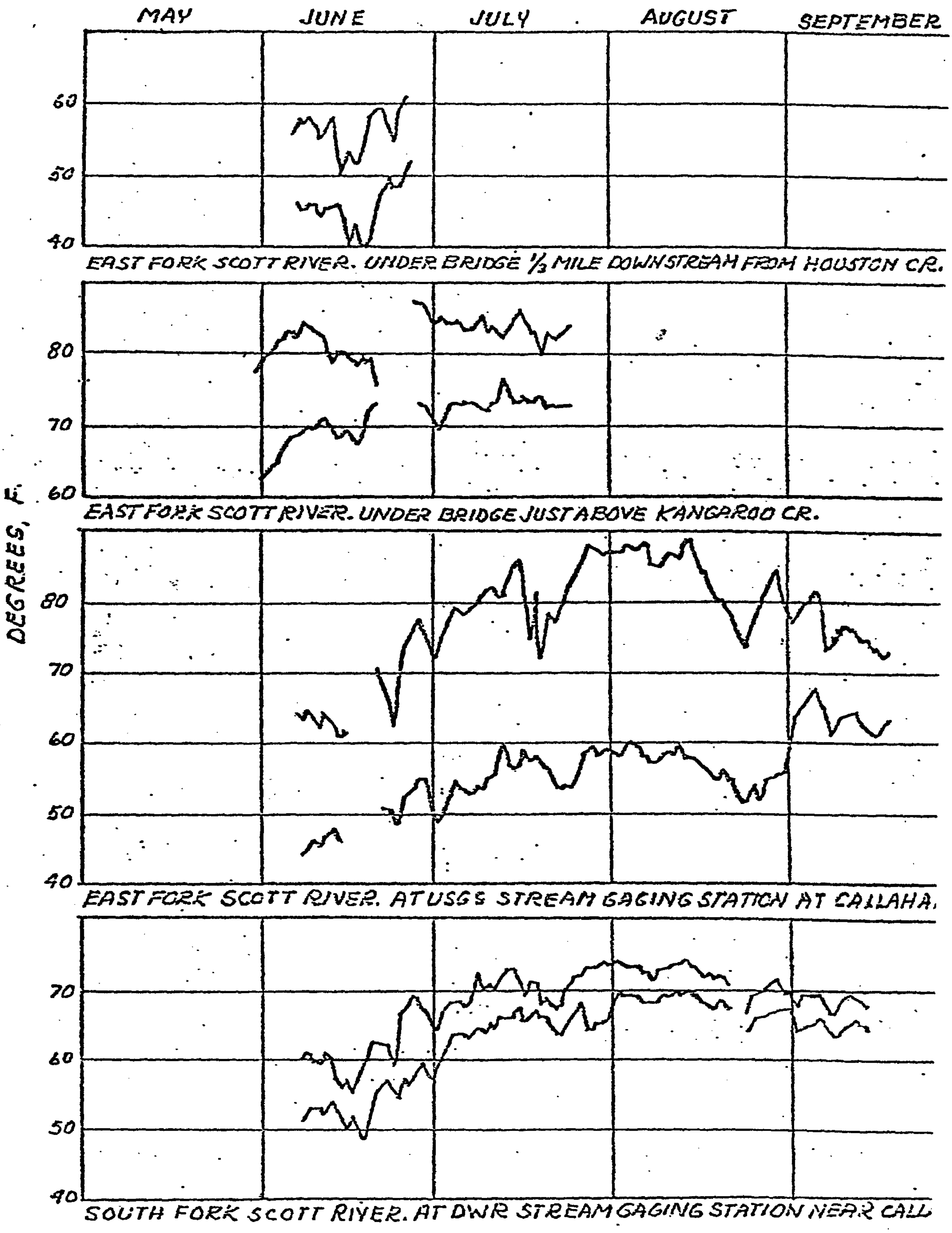


FIGURE 6. 1973 MAXIMUM AND MINIMUM WATER TEMPERATURE. EAST FORK AND SOUTH FORK SCOTT RIVERS.

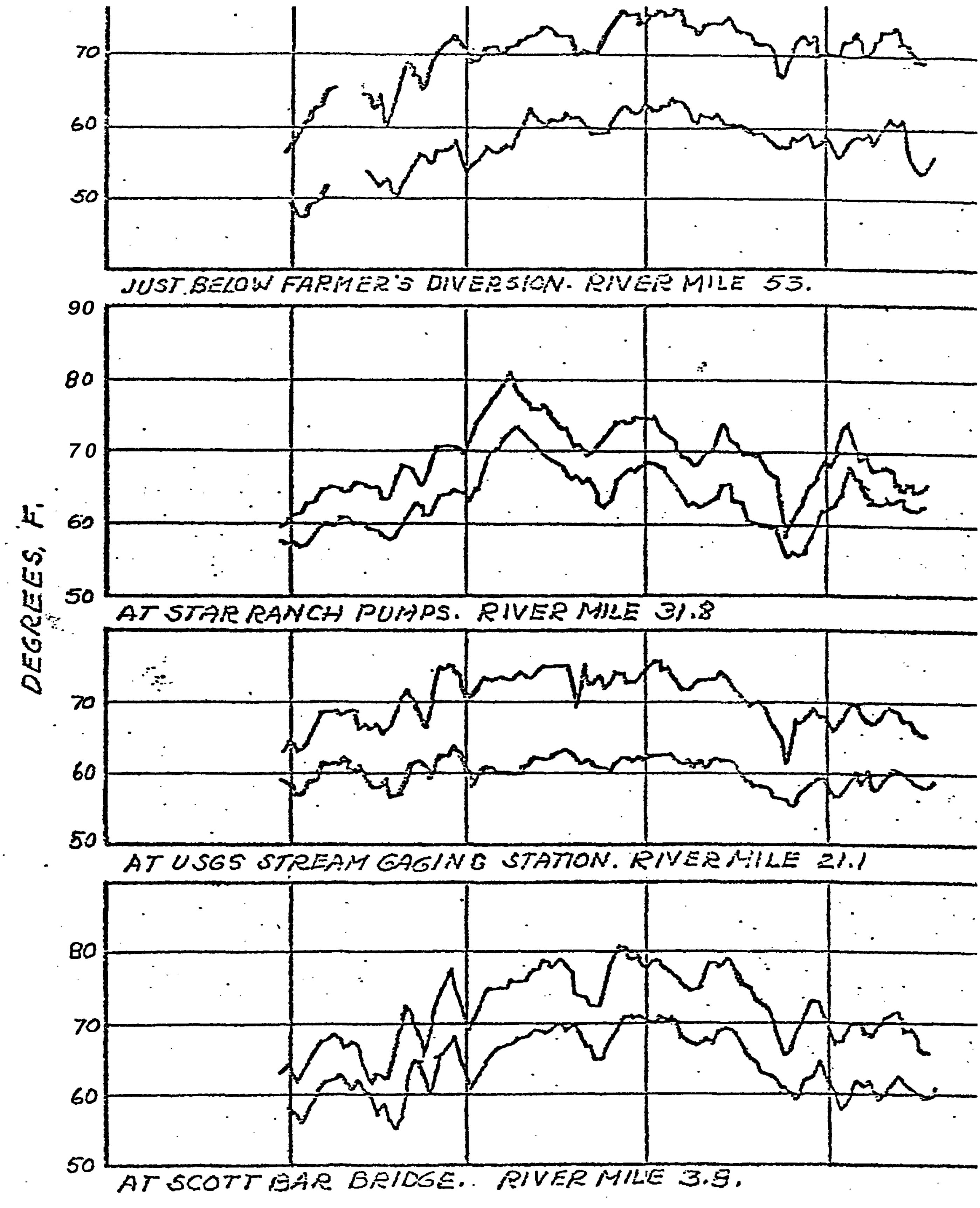


FIGURE 7. 1973 MAXIMUM AND MINIMUM SCOTT RIVER WATER TEMPERATURES.

not exceeding 75^{o}, gives a realistic criteria for an upper limit of temperature for sustaining salmonids in this river system. While this upper maximum as a mean value was not frequently exceeded, several areas had too severe an amplitude in daily temperatures, and lethal conditions existed. In summary, the South Fork of the Scott provided the best overall temperature conditions and the lower East Fork, the worst. The amplitude of daily temperature fluctuation, which caused the lethal conditions, was the most severe at the East Fork U.S.F.S. gaging station near Callahan. Severe conditions also existed above Kangaroo Creek on the East Fork. Figure 8 gives the means of the daily amplitude of temperature fluctuations and a confidence interval about each mean. It could not be determined if the extremes noted for the East Fork were due to its east-west exposure, flood irrigation practices, i.e., return of warm irrigation water, or both. The Department was denied access to much of the upper East Fork area for purposes of obtaining data for this adjudication.

VIII. The Department of Fish and Game's Activities and Expenditures in the Scott River Basin

Due to extensive diversion activity in the Scott River basin the Department has a continuous program of screening diversions and salvage trapping of juvenile salmonids from the Scott River and tributaries. These activities are summarized in Tables 8 and 9.

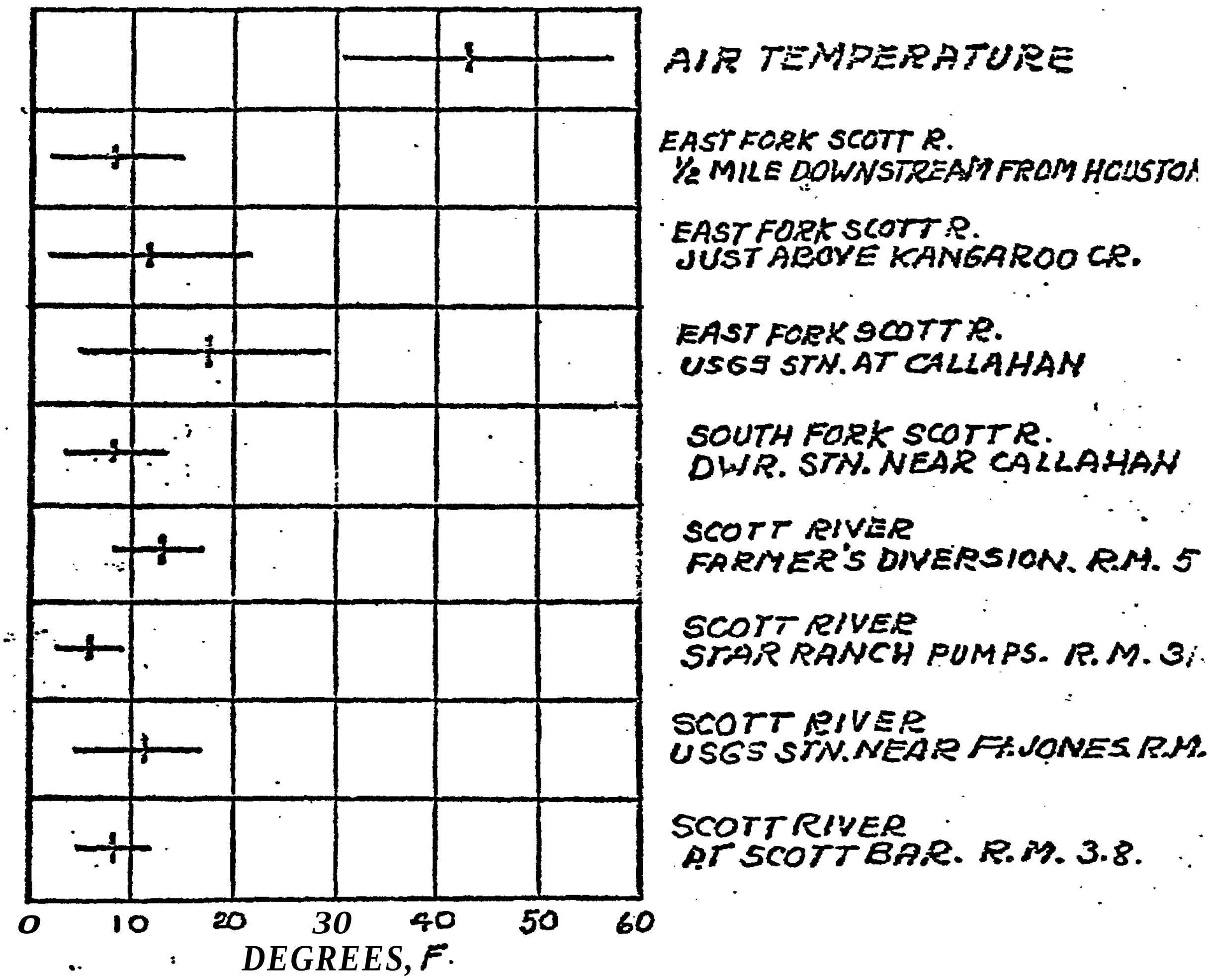


FIGURE 18. MEAN AMPLITUDE OF DAILY TEMPERATURE FLUCTUATIONS (VERTICAL BARS) DURING THE SUMMER OF 1973. HORIZONTAL BARS REPRESENT A RANGE OF ± 2 UNITS OF THE STANDARD DEVIATION.

Table 8, Numbers of juvenile salmonids rescued from drying streams in the Scott River basin in 1371 and 1972.

Water Course	Numbers of Fish 1971	1972
Kidder Creek	77,519	25,351
Shackleford Creek	115,053	131,763
McAdams Creek	44,834	111,210
Etna Creek	7,410	6,432
French	21,450	10,164
Scott River	23,644	30,025
	295,175	317,948

Table 9. Percentage distribution of Yreka Screen Shop expenditures in the Scott River Basin 1973.[1]

	percent
New Construction	7
Construction and Maintenance of fishways	1
Fish Salvage	8
Operation and Maintenance of Fish Screens	18.5
Fisheries Management Activities	15
Scott River Fish Counting Rack[2]	10
Total	45

(1) The annual budget for this facility was $100,000 of which 45 percent or $45,000 was spent in the basin.

(2) During most years, this time would be spent on the other listed activfties.

Table 8 provides the number of juvenile salmonids trapped and salvaged from drying stream sections in 1971 and 1972. The rescued fish are transported downriver and released into the river below Meamber Bridge, river mile 24. In addition to these fish an average of 264,390 juvenile salmonids are trapped at some of the fish screens and transported and released downriver.

Table 9 gives a percentage breakdown of the expenditures by the Yreka Screen Shop whose activities include fish protection and salvage in Siskiyou County. Out of an annual budget of $100,000, approximately $45,000 is allotted to fish salvage and fish screens in the Scott River basin.

The Department has 16 permanent fish screen installations in the basin. The cost of fabrication and installation amounts to $139,444. Additional installations are planned in the future. Table 10 provides information on the location and cost of each fish screen.

IX. An Overview

In general, many of the methods and extent of diversion and irrigation currently in practice in the Scott River Basin have created a large degree of incompatibility between agriculture and fisheries. The flows required to maintain fishery values and support heavy agricultural diversions clearly are not in the system during the latter part of July, August, and often in September. Many of the streams would have critical level flows (less than minimum) during this time period even if no water is diverted.

Table 10. Fish screens installed and maintained by the California Department of Fish and Game, Yreka Screen Shop, which are currently in use in the Scott River Basin,

Name	Date of Installation	Location	Cost
Lower Tozier	1956	Shackleford Cr.	$ 863
Upper Tozier	1965	" "	3,475
Burton	1966	" "	6,283
Berrys	1969	" "	5,100
Elliot	1963	" "	5,650
Lower Dangle	1965	Mill Creek	3,075
Upper Dangle	1965	" "	2,675
Perreira	1954	" "	812
Young	1958	Patterson Creek	990
East French	1970	French Creek	4,550
West French	1966	" "	3,400
Scott Valley I.D. and Star Ranch pumps	1365	Scott River	7'1,000
Scott Valley I.D.	1950	" "	12,000
Denny	1973	" "	6.700
Farmers	1963	" "	10,096
Messners	1964	" "	3.075
			$139,744

There are presently many pronounced problem areas in the basin. The Scott River at approximately river mile 50, goes dry or intermittent for one to three miles annually during the month of June or early July, due to the heavy upstream consumptive use of water. The East Fork is routinely reduced to a wet stream bottom, with intermittent dry sections below diversion dams during the summer months. Etna, Kidder, and Patterson Creeks are rendered dry over several miles of their lower reaches. Sniktaw and Shackleford Creeks are dried annually near their mouths on the Scott River. The mouth of Shackleford Creek often is still dry during the major portion of the king salmon runs which prevent their entrance and utilization of the spawning gravels in this stream. Summer dams and diversions in other streams are left in place and divert unneeded water during the spawning season which may prevent the entrance of salmon to those tributaries. Some irrigation practices involve diversion of water in the early spring prior to snow-melt runoff and the growing season presumably to exercise their water rights and exploit the flows before seasonal depletion limits availability. Such practices interfere with steelhead spawning activity. Kidder Creek is an example.

During the water-short period the stretching of the water supply for irrigation requires maximum conservation. Water economies in irrigation are possible. These potentials lie largely in greater efficiency of water application to the soil, in reduction of conveyance losses, in recapture and reuse of excess water and in general efficiency in the layout of the whole irrigation system. Soil nutrients are lost by using too much water. The use of sprinklers in the valley economizes in water use. According to McCreary-Koretsky Engineers (1967)[1/] most of the irrigated acreage in the drainage is irrigated by the flooding method which usually uses excessive amounts of water in relation to the moisture needs of the plants and low irrigation efficiencies result. Their report noted a wide application of water ranging from 1 to 50 acre-feet per acre. Conveyance losses are high, especially from the many canals and ditches. While solutions for satisfying instream and offstream water needs are seemingly intractable at the present time, answers may probably be had. It will, however, require a cooperative effort between agricultural interests and several resource management agencies at municipal, county, state, and federal levels.

1/ Report on comprehensive planning study - Siskiyou Soil Conservation District. McCreary-Koretsky Engineers. March 1967.

State of California
Department of Fish and Game

MEMORANDUM

To: Mark Pisano **Date:** September 28, 2009

From: Mark Hampton

Subject: Chinook salmon reconnaissance survey on the Scott River

On Monday, September 28, 2009, Mark Clifford and I conducted a reconnaissance survey on the lower Scott River to determine the location and condition of adult Chinook salmon in the lower Scott River. Flows at the USGS gage near Fort Jones were 7 cfs. Large numbers of adult Chinook salmon were observed holding in two pools in the lower Scott River downstream of Scott Bar (Figure 1). We estimated that there were about 150 ± adult Chinook salmon holding in the pool below the Highway 96 Bridge and about 120± adult Chinook salmon holding in the pool at river mile 0.75 (Figure 2). No salmon were observed further upstream in pools at approximately river mile 2.4 (Midpoint) or at the Pat Ford Cabin access point upstream of Scott Bar.

Figure 1. Location where adult Chinook salmon were observed holding in the lower Scott River on September 28, 2009.

Two adult Chinook salmon, one male (102cm) and one female (78cm) were found dead downstream of the Highway 96 Bridge crossing (Figure 3). Both fish appeared to be fresh (clear eyes) and were collected for pathological examination which was conducted by Mark Clifford (Figure 5). The fish were retrieved at approximately 13:15 hours and the water temperature at the time of collection was 62˚F (16.7˚C). Both fish were infected with Columnaris bacteria and Ich trophonts. For details refer to Mark Clifford's Fish Pathologist Report. Neither of the fish had spawned, and a scale sample was collected and provided to the Klamath River Project for age determination.

Figure 2. Adult Chinook salmon holding the pool underneath the Highway 96 Bridge near the mouth of the Scott River.

Figure 3. Chinook salmon mortalities retrieved from the lower Scott River downstream of the Highway 96 Bridge crossing. The large fish is a male (102 cm) and the smaller fish is an unspawned female (78 cm).

Figure 4. Note the erosion of the gills and signs of Columnaris infection present on the gills.

Figure 5. Mark Clifford, Ph.D., Associate Fish Pathologist with the Department conducting a clinical examination of the two adult Chinook salmon recovered from the lower Scott River, September 28, 2009.

The Pacific Coast Federation of Fishermen's Associations (PCFFA), Institute for Fisheries Resources, Coast Action Group, Northcoast Environmental Center (NEC), Environmental Protection and Information Center (EPIC), Mendocino Group of the Redwood Chapter of the Sierra Club, and the Sierra Club of California

Chair Tam Doduc and Members of the Board
C/o Selica Potter, Acting Clerk of the Board
State Water Resources Control Board – Executive Office
1001 "I" Street, 24th Floor
Sacramento, CA 95814

12 June 2006
Via Email and Mail

Re: Joint Comments on the Proposed Action Plan for the Scott River Watershed Sediment and Temperature TMDL

Dear Board Members:

The Board's decision to adopt an Action Plan (Plan) for the Scott River Watershed Sediment and Temperature TMDL offers a tremendous opportunity. When it enacted the Porter-Cologne Water Quality Control Act, the Legislature assigned the State Board jurisdiction over both water quality and water *quantity* for the agency to take each into account when determining what pollutants may go in and what water may come out of a watershed. To date, the State Board's divisional structure and the sharp separation between the water quality and water rights divisions' proceedings and staffing has resulted in the regulatory distancing of water quality and water quantity issues for most of the State's rivers. Although the State's involvement in water quality certifications provided by the federal Clean Water Act, for example in dam licensing proceedings, have bridged the gap on occasion, those few occasions are very project specific, subject to the scheduling licensing proceedings, and include water quality issues only as a secondary issues. The TMDL proceedings currently underway around the state provide a much more integrated and timely opportunity for the State Board to realize Porter-Cologne's goals of integrating its water quality *and* water quantity management and assuring water quality standards and beneficial uses are attained as soon as possible for hundreds of degraded rivers and streams throughout the State.

Although many of the technical TMDLs produced for the North Coast region have identified sufficiently the sediment and temperature problems confronting rivers and creeks throughout that region, with the exception of the Garcia River, the Regional Board has failed to adopt any implementation plans specific to any of the other listed waterbodies. The Regional Board's failure appears to be a combination of lack of political will to confront the facts presented in these watersheds and, in regard to temperature issues, a lack of authority to directly address flows.

The Scott River Action Plan could be a model of how to integrate its water quality *and* water quantity responsibilities in a manner that reflects the natural connection between a river's flow volumes and the quality of that water rather than allow the Board's divisional structure to serve as a roadblock to effective implementation of needed regulatory requirements.

c/o The Klamath Basin Coalition, PO Box 1375, Eugene, OR 97440
(541)689-2000, Fax: (541)689-2500, Email: klamathcoalition@aol.com
Web Page: www.klamathbasin.info

Unfortunately, the proposed Plan does not contain sufficient enforceable actions to protect public trust and beneficial water uses, including fisheries protections, in the Scott River. In light of the ongoing collapse of Klamath River salmon resources, and ample evidence that particularly for state and federally ESA-listed coho salmon these issues are particularly important in the Scott River, the Plan needs measurable and definite actions that the State can apply to reduce controllable temperature and sediment pollutants. Temperature pollution in particular needs to be reduced to achieve applicable water quality standards, and thus restore protected beneficial uses.

The most egregious and indefensible omission in the current proposed Implementation Plan (the “Plan”) is the failure to recognize the nexus between increasing water use (surface and groundwater) and declining instream flows that have led to temperature impairment throughout the Scott River watershed.

Reduced surface flows and elevated water temperatures are significant factors in the decline of the Scott River’s anadromous salmonid fisheries, particularly state and federally protected coho salmon (see ATTACHMENT A). The Plan should confront the problem of temperature impairment and address the need for adequate instream flows for the Scott River and its tributaries to enable the recovery of at-risk anadromous salmonids.

Diminished flows in the Scott River are clearly linked not only to temperature impairment but also to the concentration of chemical pollutants, low dissolved oxygen (DO) levels, and high nutrient levels. The almost completely unenforceable voluntary actions proposed in the Plan are not consistent with the State and Basin Plan’s Anti-degradation Policy which applies to all waters of the state, including ground water; specifically it is the State’s responsibility to regulate land use activities that may reasonably be controlled, such as surface diversions, ground water pumping, grading, clearing riparian habitat, and grazing, which singly or cumulatively influence the quality of waters of the State.

General TMDL Comments:

The Regional Water Board needs to develop/adopt a Temperature TMDL Implementation Policy similar to its Sediment TMDL Implementation Policy that identifies what actions the Board will take to control activities that elevate water temperature, resulting in non-attainment of water quality standards.

The State Water Resources Control Board (SWRCB), in addition to its Regional Boards, are also charged by the federal Clean Water Act and California Porter-Cologne Act to control waste discharges and ensure attainment of water quality standards.

Porter-Cologne does not allow mere voluntarism (which by its very nature is uncertain and unreliable as well as unenforceable) as the means for the Boards to address discharges of pollution to the State’s waters. Porter-Cologne provides three primary tools to the SWRCB and RWQCBs to control any waste discharges to waters of the State, including the Scott River, and assure attainment of water quality standards. These three tools are: 1) waste discharge requirements, 2) conditional waivers of waste discharge requirements, or 3) discharge prohibitions.

In addition to these three fundamental regulatory tools, Porter-Cologne allows for additional layers of activity to supplement the regulatory scheme, including funding provisions, voluntary actions, guidance authority, etc. However, in no case do any of these additional authorities supplant the three options the Board must turn to when pollution is being discharged. Every discharger of the state, large or small, good or bad, simple or complex, must report its waste discharge to the applicable Regional Board. The Regional Board then must take one of the three required actions. The choice of action and the appropriate regulatory conditions to be included can then take into account the severity (or lack thereof) of any reported discharge. But, as a matter of law, one of these three basic tools must be used wherever a discharge is occurring.

The three fundamental regulatory tools described above are recognized by the State Board's existing Nonpoint Source Policy. The tools available to the Boards are no different when developing a TMDL implementation plan. Every TMDL implementation plan must employ the three categories for every pollutant source identified by the TMDL. Every TMDL implementation plan must be consistent with the State Board's Nonpoint Source Policy.

Similarly, the Legislature delegated to the State Board the authority to regulate water diversions, including the regulation of bypass flows and enforcement of diversion limitations via water rights licenses. Given the State Board's authority over all activities affecting water quality and quantity in any given waterbody, it would be antithetical to the goals of Porter-Cologne not to integrate these two components of ecosystem health into proceedings purporting to address impairments to that health right now.

However, where an implementation plan attempts to justify holding any of these three mandated water quality tools (WDRs, Conditional Waivers or Prohibitions) or the State Board's water quantity tools at bay, based on mere speculations of the efficacy of future voluntary efforts or future potential challenges of any water right proceedings, this turns "implementation" into hesitation. Instead of eliminating pollution problems, such a plan simply institutionalizes them.

Comments on the Action Plan for the Scott River Watershed Sediment and Temperature TMDL

The Plan identifies several implementation actions that the Regional Board believes will achieve sediment and temperature TMDL, and thus meet minimum water quality standards. However, it will take higher standards than just meeting the minimum to actually recover the Scott River's beneficial uses such as those that support its anadromous salmonid resources. The Scott River has been classified as impaired now for nine to fourteen years; the Plan expects another forty years to attain water quality standards, yet no quantifiable goals nor targets have been identified in the Plan for instream flows, temperature, or sediment. Some beneficial uses that support recovery of state and federally listed anadromous salmonid populations (RARE) simply cannot wait until 2046. Entire generations of citizens will be denied their right to enjoy the Scott River's un-impaired beneficial uses: (REC-1, REC-2, COMM, COLD, RARE, MIGR, and SPWN).

Additionally, at least 13 three-year lifecycles of coho salmon will pass between now and 2046, with ESA-listed coho continuing at risk of extinction throughout that period. Threatened salmon runs may well go extinct long before those 40-year goals are ever attained. More aggressive achievement goals are more than warranted, they are required by law. Adoption of a Plan that fails to attain water quality standards until 2046 violates federal and state Endangered Species Act prohibitions on “take” of protected species such as listed salmonids and the degradation of designated critical habitat.

The Plan fails to adequately address the issue of excessive consumption of water, thus its adoption will merely legitimize all the existing uses that currently degrade instream habitat and minimum flow needs of salmonids, and are detrimental to the recovery of these species. Likewise the Plan fails to require pro-active and enforceable measures to protect and restore federally designated critical riparian and aquatic habitats, including by excluding grazing in these critical habitats.

The proposed Plan will be an amendment to the Basin Plan; therefore, it must meet requirements of water quality control plan statutes, particularly Section 13242 of the CA Water Code. In order for the Plan to achieve both narrative and numeric water quality objectives, it must at a minimum include: (1) a description of what actions will implemented; (2) when those actions will be implemented, and; (3) how compliance with the objectives will determined. The proposed Plan relies excessively on actions that are by their very nature entirely unenforceable because they are entirely voluntary implementation actions delegated to entities other than to the Board, which is inconsistent with State water law. Encouraging voluntary actions is commendable, but they do not supplant the Boards’ obligations to issue either WDRs, conditional waivers (where appropriate) or prohibitions, and cannot be effective unless there are definitive standards and goals to be met.

Comments on the Plan’s Proposed Actions to Achieve Temperature TMDL

The Plan’s temperature source analysis identifies three controllable anthropogenic activities that adversely affect water temperature: stream shade, stream flow, and stream channel geometry or morphology. Yet, the Plan provides no facts to support its unsupported finding that reductions in stream flow have only a small temperature impact and that reduction of shade is the primary cause of increased water temperatures in the Scott River. There is in fact considerable scientific evidence and monitoring data that shows that reductions in flows throughout the Scott River have had a far greater impact on water temperatures than the Plan acknowledges (see ATTACHMENT A).

The Plan also does not address the severity of direct or indirect impacts of anthropogenic changes to stream morphology on water temperature. These impacts too can be severe.

The Plan’s implementation actions, to protect or restore effective shade to achieve temperature TMDLs, reference the State’s Nonpoint Source Policy (NPS) to develop and take appropriate permitting and enforcement actions to address human-caused removal and suppression of vegetation that provides shade to a water body. The NPS Policy relies on the three regulatory tools provided by Porter-Cologne – WDRs, conditional waivers of WDRs, or prohibitions - to regulate all current and proposed nonpoint sources of stormwater pollution. The Plan should declare that all current and future nonpoint sources of pollution, regardless of the affected acreage, will be required to secure WDR permits, conditional waivers, and/or be subject to a Basin Plan prohibition, or be subject to its enforcement actions via cease and desist or cleanup and abatement orders. These are the only legal options available under California water law. In contrast to the proposed Plan, the word “voluntary” is not in the lexicon of the NPS, and the Plan and SWRCB should be in conformance with this NPS Policy.

The Plan's focus on the relationship of shade to water temperature completely ignores the excessive diversion of surface flows and pumping of groundwater. Both activities are controllable. The connection between flow and temperature is well established and is in no way controversial. The State has long failed to adequately regulate surface water diversions and bypass flows in the Scott River pursuant to its own Water and Fish & Game Codes, allowing conditions in the river to deteriorate; these laws must now be aggressively enforced if this deterioration is to be reversed. Adequate flow standards for each life-cycle of salmonids are needed throughout the Scott River Basin (for example to ensure spawning flows in areas where spawning occurs). The Board should have the Division of Water Rights study the impacts of surface water diversions on water temperature, fisheries, aquatic life and riparian vegetation in the Scott River Watershed, and establish adequate flow needs, particularly during critical low flow periods. This is a state responsibility: it cannot be delegated to the County, which is ill equipped to make such an analysis.

An analysis of the best available scientific information will lead to the finding that flows and temperature in the Scott River have been severely compromised by surface diversions and an increasing number of groundwater pumping projects for irrigation. It is highly likely that the sustainable draw levels of the local aquifers have been exceeded. The Board should request that the County declare a moratorium on new well drilling and well deepening in the Scott Valley bottoms pending further studies to ascertain if this is the case. Again, these studies are the responsibility of the State – the County has neither the expertise, funding, nor the inclination to conduct such studies.

The Board should also request that the County, through its General Plan and Zoning Ordinance, better regulate agricultural uses and the density of wells by land use/zoning districts to protect instream flows and thus water temperature. The rate of decline in flows in the Scott River at the USGS gauge below Scott Valley has accelerated during the period of record 1950-2000. The decline in flows corresponds closely to an increase in the number of irrigation wells and increased consumptive irrigation water use throughout this same period.

In other words, the Scott River is being incrementally dewatered through excessive and unregulated groundwater pumping. The Board should have the Division of Water Rights study the impacts of ground water use on water temperature, fisheries, aquatic life and riparian vegetation in the Scott River watershed, and establish adequate minimum instream flows throughout the watershed.

The Board should also re-examine all existing water rights for stream diversions for adherence to the terms regarding bypass conditions and compliance with Statements of Use, and correct any non-compliance, particularly diversions in excess of license conditions. Both monitoring and enforcement have been lax in the Scott River watershed for some time, and water permit violations are very common. The Scott River Adjudication must be enforced, particularly quantity and period of diversion (for example it states that irrigation is to end about October 15th yet in practice it does not).

The Board should review the record for compliance with the terms of the Adjudication for diversion and bypass requirements, and take appropriate enforcement actions in cases of non-compliance or usage in excess of license conditions. Surveys of other similar watersheds have disclosed more un-permitted diversions than permitted diversions. The continued decline of summer flows since the adjudication indicates that same pattern exists on the Scott. The watershed should be surveyed for un-permitted diversions or impoundments and enforcement actions taken to correct illegal diversions. Landowners who are in compliance should not be penalized by allowing those who are not to continue illegal uses. The Board should also reopen adjudication and reallocate water rights, as necessary, to achieve water quality standards and restore beneficial uses, including instream minimum flow protections for ESA-protected salmonids, in the Scott River Watershed.

Ultimately, the Plan has no goal, for it does not provide a measurable water temperature TMDL standard that it will use to determine the effectiveness of its implementation measures even in 40 years. The Plan must not only have a goal but it must require that the Scott River watershed have an adequate number of stream gages to continually monitor discharge, temperature, turbidity, and verify whether instream flow and temperature goals are being achieved.

Enforcement of violations of the Plan cannot be limited as proposed to enforceable restrictions contained in new water quality certifications or WDR permits, but must require certifications and WDRs or appropriate conditional waivers for existing uses that are contributing to the impairment of two water quality attributes: temperature and sediment. Enforcement of the Plan must parallel the Endangered Species Acts prohibition on “take” of listed species, since many pre-existing land uses clearly impair the Scott River. Achieving TMDL Action Plan objectives or attaining water quality standards for temperature and sediment is not possible if existing activities that degrade water quality simply are allowed to continue.

Comments on Other Proposed Actions

The Plan identifies twenty implementation actions. Unfortunately, few contain regulatory or physical recommendations that the Board can implement to achieve sediment or temperature TMDLs, and more importantly, reach minimum thresholds for water quality standards, which mean achieving beneficial uses or Basin Plan objectives. The majority of the implementation actions simply encourage others to take actions or to engage in planning exercises or management agreements such as MOUs. Thus these many voluntary actions sought in the Plan are unenforceable, and therefore inconsistent with Cal. Water Code Section 13242, as these examples demonstrate:

- Roads: The Plan’s implementation action for roads at the County level is restricted to merely encouraging the County to address their roads issues but does not address problems with the far more numerous private roads. The Board should inform the County that their General Plan and Zoning Ordinance are not in compliance with the proposed Plan or the Basin Plan, and require that the County develop and adopt by a date certain a comprehensive grading ordinance for roads, including land disturbances activities inclusive of clearing vegetation, and grading. The Board should set a date to issue county-wide WDRs or federal NPDES permits to the county and private roads. Many of the discharges associated with these roads are through point source discharges. For example, Caltrans roads currently are regulated through a NPDES permit. The road WDRs/permits should set forth necessary road construction and maintenance conditions, including other land disturbances activities inclusive of clearing vegetation, and grading and taking into account cumulative impacts of road sin the watershed.

- Dredging: The implementation action for dredging is one of the few that the Board itself will implement if necessary; DFG already regulates such activities.

- Water Use: If no study as proposed is undertaken then there is no implementation action addressing the most significant and controllable adverse impact to water quality: water use.

- Flood Control & Bank Stabilization: The over-reliance on WQC via a federal nexus with the Army Corps of Engineers to control water quality impacts from flood control or bank stabilization activities will fail to prevent the removal or suppression of stream-side vegetation, which is an activity that is rarely subjected to federal regulatory oversight. In fact, clearing vegetation is often mandated in federally funded/constructed flood control projects, in which case riparian vegetation is not protected. These activities should be addressed in appropriate WDRs or conditional waivers. The Plan should set forth a timeline for developing such WDRs or waivers.

- Grazing: The Plan's action for grazing again relies on simply encouraging others to act, yet the Plan should require that cattle be excluded from riparian areas, and that degraded riparian corridors be restored along the tributaries and mainstem of the Scott River. The Plan needs a more definitive description of desired near-stream conditions with a description of specific actions that can achieve these conditions within finite time periods. The Plan should require that the County adopt a stream management ordinance to regulate all land uses within a specified stream management zone, and that all such uses regardless of the acreage affected be required to secure WDRs or conditional waiver).

- Federal Agencies: The Plan proposes no actions to develop an MOU to coordinate regulation of activities with NOAA Fisheries to protect designated critical habitat pursuant to the federal Endangered Species Act nor essential fish habitat pursuant to the Magnuson-Stevens Fishery Management Act.

- CDFG: Lastly, the Plan should develop an MOU with DFG to inventory the Scott River and its tributaries to locate existing water diversions, determine bypass flow needs, assess whether present rates of diversion create low flow barriers to migration of anadromous salmonids, and to implement/apply the Coho Recovery Strategy Guidelines in the Scott River watershed. The Coho Recovery Strategy Guidelines and measures were developed with considerably Scott River watershed stakeholder input and approval, and should be incorporated into and/or coordinated with actions in the Plan.

Conclusion

The Clean Water Act charges the State with ensuring that necessary actions are taken to meet water quality standards and restore beneficial uses in the Scott River Watershed. Both the federal and state ESA listings of Scott River coho salmon also require similar actions, as does the CESA Coho Recovery Strategy long since adopted by the Fish and Game Commission.

In the 1983 Mono Lake case, the federal court stated that the Public Trust Doctrine requires the state to exercise continual supervision whenever feasible to protect the public's right to use and enjoy the State's waters and their associated resources. The Plan as proposed will cause significant adverse impacts to the distribution and abundance of state and federally protected anadromous salmonids in the Scott River watershed. This is a resource that many in-river Tribal communities, and many coast fishing ports, depend upon for their sustenance and livelihoods.

Further, the Plan as currently proposed will significantly reduce the probability of recovery of these already seriously depressed salmonid species because it fails to provide or protect adequate instream flows, improve elevated water temperatures, or restore/protect riparian corridors.

Lastly, the public's ability to enjoy the waters of the Scott River for recreation are significantly threatened by health risks associated with toxic algae blooms now proliferating throughout the Klamath River in waters with elevated temperatures. Deteriorating water quality in the Scott River, much of it triggered by decreasing instream flows, can only encourage the growth of these toxic algae species, posing a serious health risk to members of the general public.

In short, the Board must request an Action Plan where the State establishes adequate flows and regulates controllable consumptive water uses, and land disturbance activities that impair water quality if it wants to restore beneficial uses which are Public Trust uses in the Scott River.

Please make these comments part of the public record in this proceeding, and we hope they will be helpful to Staff as they prepare their recommendations.

Sincerely,

Glen H. Spain, J.D., for the Pacific Coast Federation
of Fishermen's Associations and the Institute
for Fisheries Resources, and the organizations below:

Coast Action Group
By Alan Levine, Executive Director

Northcoast Environmental Center (NEC)
By Tim McKay, Executive Director

Environmental Protection and Information Center (EPIC)
By Larry Evans, Executive Director

Mendocino Group of the Redwood Chapter of the Sierra Club
By David Myers, Water Committee Chair

The Sierra Club of California
By Paul Mason, Legislative Representative

Enclosed: Attachment A: Scott TMDL Related Data, Photos and Maps Regarding Flow and Temperature Problems

ScottTMDLJointLtr06-12-06.doc

Attachment A

Scott TMDL Related Data, Photos and Maps Regarding Flow and Temperature Problems

Below are summary charts, photos and map images that provide support for arguments regarding the impact of diminished flows in the Scott River basin as follows:

1. Flows have been progressively decreased by ground water extraction;
2. Flows have declined to far below those required by the Scott River Adjudication and now often cause stream reaches and tributaries to go dry;
3. Low flow exacerbates water temperature problems, and;
4. Flow and temperature problems combine with sediment to severely limit productivity of salmon and steelhead populations.

Scott River salmon and steelhead stocks are at high risk of extinction and evidence is presented herein to demonstrate the need for immediate action to prevent loss of locally adapted salmonid populations. This is only a sampling of such supporting data, which is voluminous, but of which only this small portion could be included herein.

Data are from the California Department of Fish and Game, California Department of Water Resources, U.S. Geologic Survey, Siskiyou Resource Conservation District, U.S. Forest Service, North Coast Regional Water Quality Control Board and private contractors. These data along with photos and maps were often extracted from the Klamath Resource Information System Version 3.0, which is also available on-line at www.krisweb.com.

Ground Water Pumping and Lack of Sufficient Scott River Flows

The *Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program* (Kier Assoc., 1991) noted that ground water pumping in the Scott River valley depleted surface flows because of interconnections between surface and ground water. This fact was also clearly noted in the *Scott River Adjudication* (CSWRCB, 1980) and by earlier work by the U.S. Geologic Survey (Mack, 1958).

California Department of Water Resources (CDWR) unpublished well log data (Eaves, personal communication) indicate that installation of irrigation wells continues in the Scott River Valley (Figure 1). Data show that the highest number of wells installed occurred from 1971-1980. After a decrease in installations between 1981 and 1990, well construction resurged during the 1990's and continues to the present. Not all well installations are reported and CDWR estimates their records may be 30-50% low as a result. Data from 2005 and 2006 have not been recorded and data from 2001-2004 is provisional.

Long term flow records show a substantial decrease in surface flows at the USGS flow gauge at Fort Jones after the number of ground water pumps began to increase in the 1970's. Figure 2 shows the number of days by water year that flows in the Scott River fell below 20 cubic feet per second. The pattern in the data shows that before ground water pumps were installed river flows rarely fell to this level, but that now there are sometimes more than 100 days/year with average flows less than 20 cfs. Probably the most telling pattern is the high number of days with extremely low flows even in years with moderate rainfall. Rainfall data by which water years are grouped are based on the California Data Exchange Center gauge in Fort Jones.

Kier Associates (1991) pointed out that the *Scott River Adjudication* allotted instream water rights to the U.S. Forest Service as a riparian owner for its lands downstream of the valley

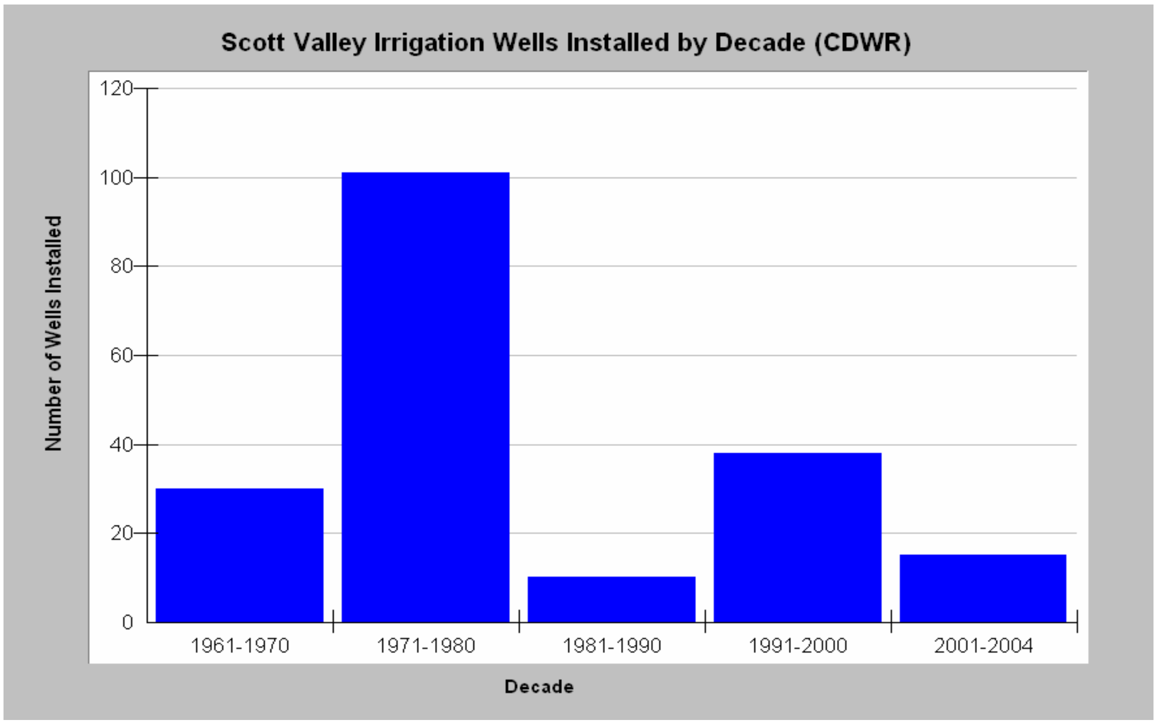


Figure 1. This chart shows the number of irrigation wells recorded by the California Department of Water Resources (Eaves, personal communication).

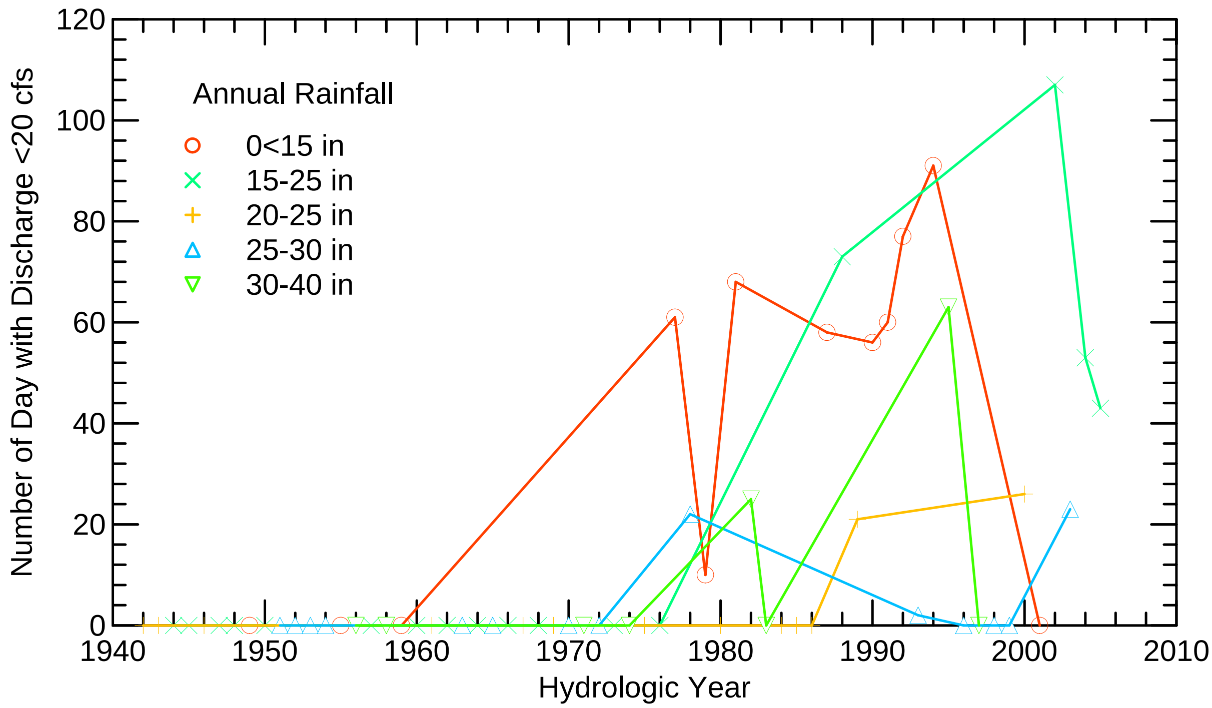


Figure 2. USGS flow gauge data are the basis for this chart showing the number of days/yr. with flows less than 20 cfs at Jones Beach in the lower Scott River. Annual rainfall from Ft. Jones CDEC gauge allows identification of associated rainfall in various years.

(CSWRCB, 1980) as shown in Table 1. "These amounts are necessary to provide minimum subsistence-level fishery conditions including spawning, egg incubation, rearing, downstream migration, and summer survival of anadromous fish, and can be experienced only in critically dry years without resulting in depletion of the fishery resource."

Table 1. Scott River Adjudication instream flow allotment for U.S. Forest Service needs for instream flow in Scott River canyon (CSWRCD, 1980 as cited in Kier Assoc., 1991).

Period	**Flow Requirement in Cubic Feet per Second**
November – March	200 cfs
April - June 15	150 cfs
June 16 - June 30	100 cfs
July 1 - July 15	60 cfs
July 16 - July 31	40 cfs
August - September	30 cfs
October	40 cfs

Flow records from summer periods in 2002 and 2004 are charted against low flow allotments for the U.S. Forest Service in the *Scott River Adjudication* in Figure 3 and Figure 4, respectively. These data show that the requirements of the adjudication are not being met, thus greatly decreasing carrying capacity for salmonids in the Scott River canyon and jeopardizing their future existence. This important habitat area has until recently served as a refugia for juvenile salmonids during summer when many reaches of the Scott River in Scott Valley and tributaries lack surface flow (see De-Watering section). Low flow conditions exacerbate water temperature problems throughout the lower Scott River (see Temperature section).

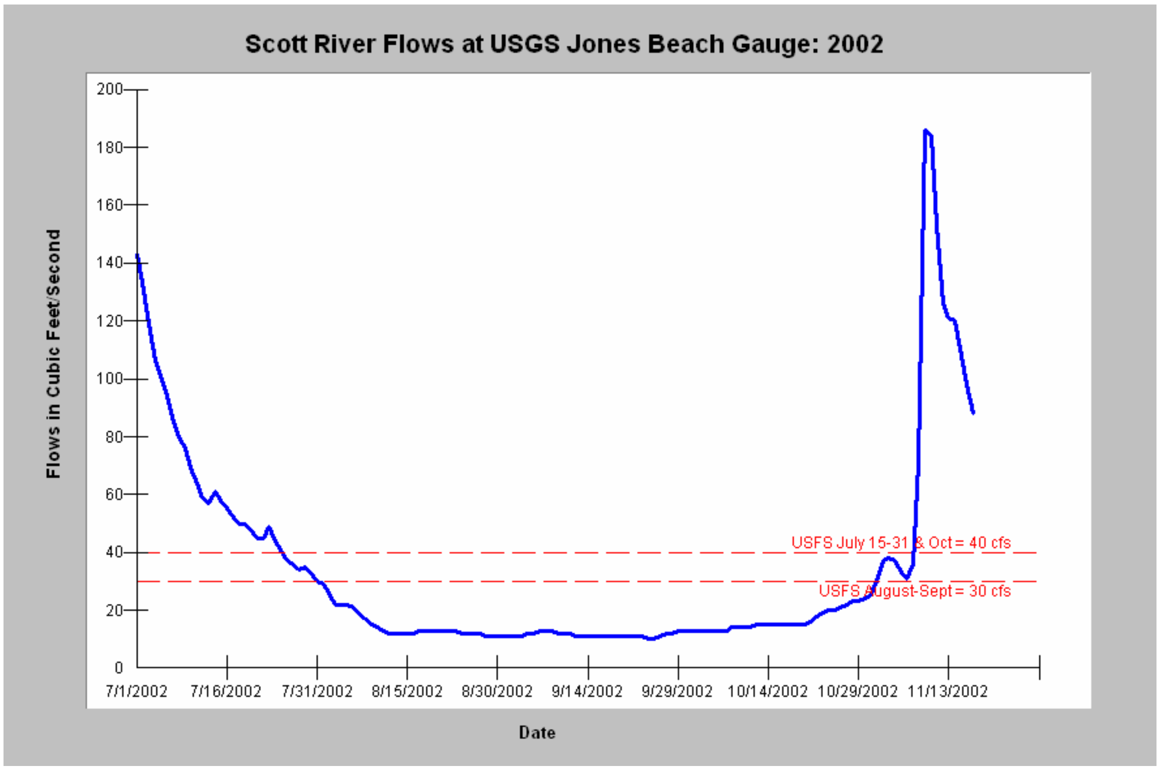


Figure 3. Jones Beach USGS flow gauge data from the irrigation season of 2002 show that flows failed to meet adjudicated levels for the USFS and flows needed for fish migration, spawning and rearing in August, September and October.

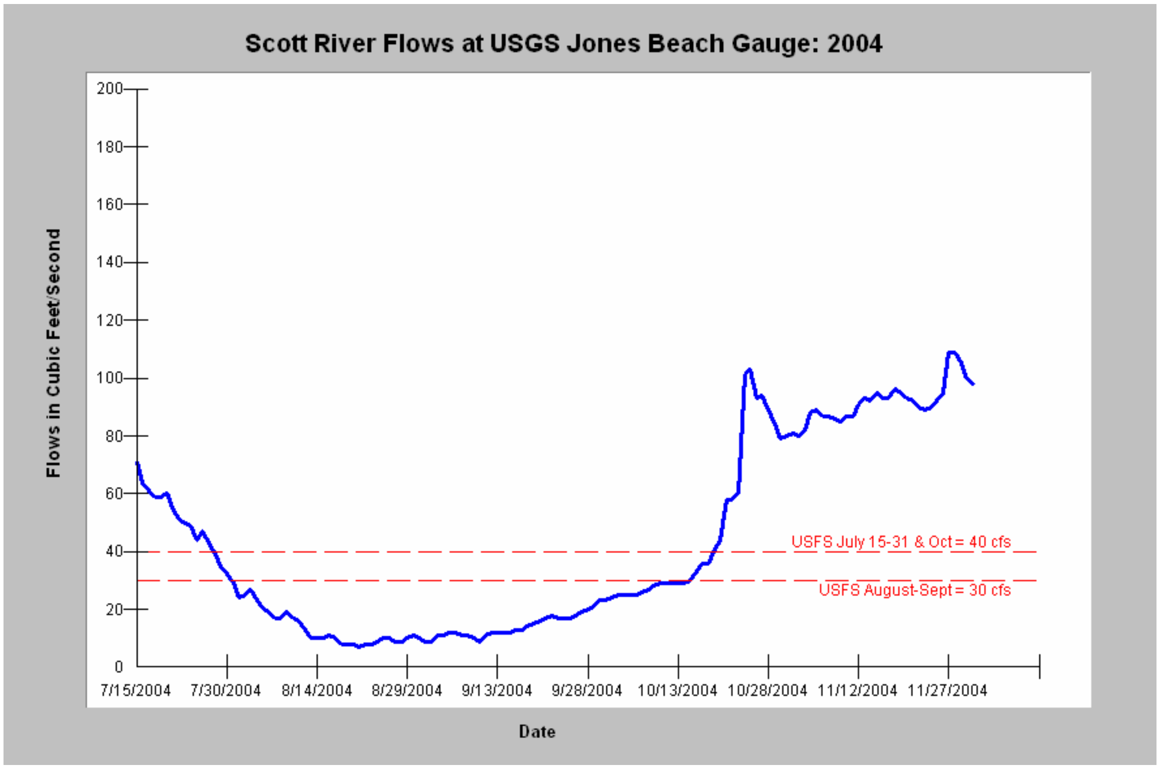


Figure 4. Jones Beach USGS flow gauge data from the summer and fall of 2004 show that flows failed to meet adjudicates levels for the USFS and flows needed for fish migration, spawning and rearing in August, September and the first half of October.

CDWR well data show a pattern of decline of minimum ground water levels over the last several decades as a greater number irrigation wells were installed. Figures 5 and 6 show the annual minimum and maximum measurements at a well, along with annual precipitation at the Fort Jones rain gage. The charts suggest that while annual maximum levels have remained relatively constant over time, annual minimum levels have declined since 1965, although they fluctuate with precipitation. Decreased ground water levels are likely linked to reduced cold water inflows into the Scott River.

De-Watering of Mainstem Scott River Reaches and Major Tributaries

While flows are often too low in the canyon of the Scott River, surface flows are sometimes completely lacking in mainstem reaches in Scott Valley and in tributaries that harbor salmon and steelhead. Photographic evidence from the KRIS project documents the loss of summer surface flow in numerous stream reaches, completely negating their ability to support cold water fisheries and other beneficial uses.

Mainstem Scott River reaches often go dry in irrigation season, such as the reach near the airport shown in Figure 7 in a photo taken by Michael Hentz in summer 2002. A photo from the same year near Fort Jones shows very little water in the Scott River channel below Highway 3. The photo also shows a stream bed with extremely fine average particle size distribution, an indication of recent sediment contributions and aggradation. Massive aggradation of some stream beds in the Scott River contributes to decreased available surface flow or complete loss of flow in some cases.

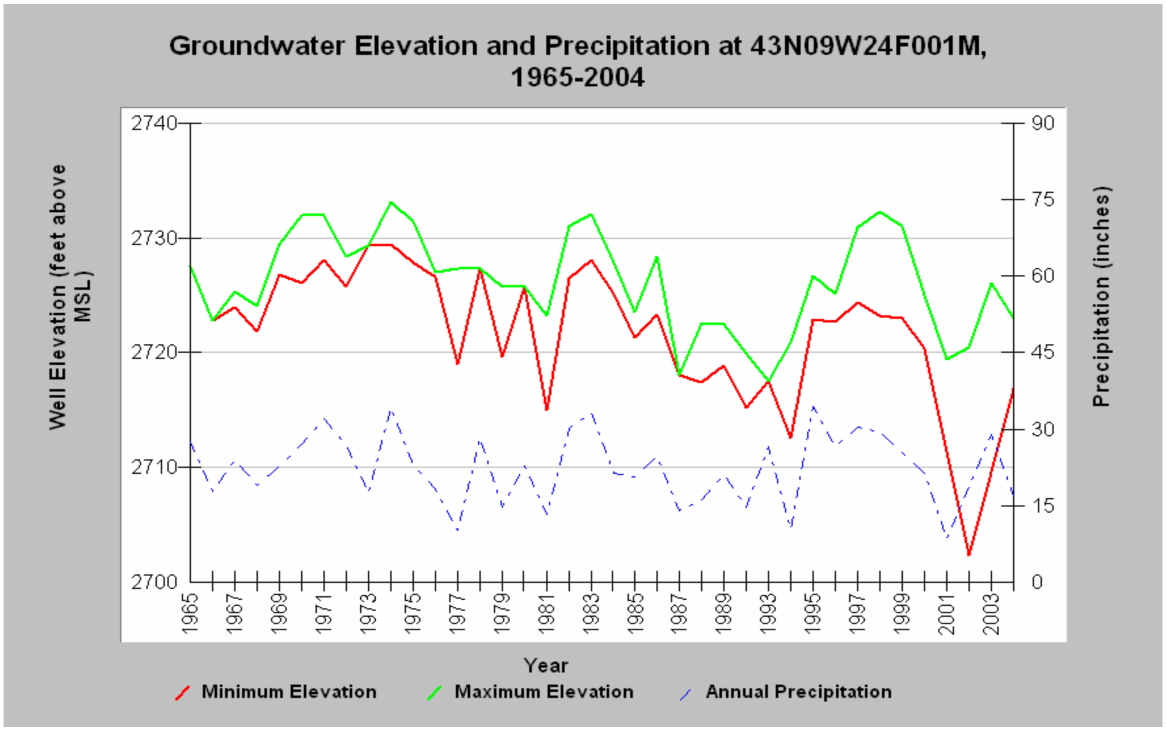


Figure 5. Department of Water Resources well 43N09W24F001M, approximately 5 kilometers south-southeast of Fort Jones, for the years 1965-2004.

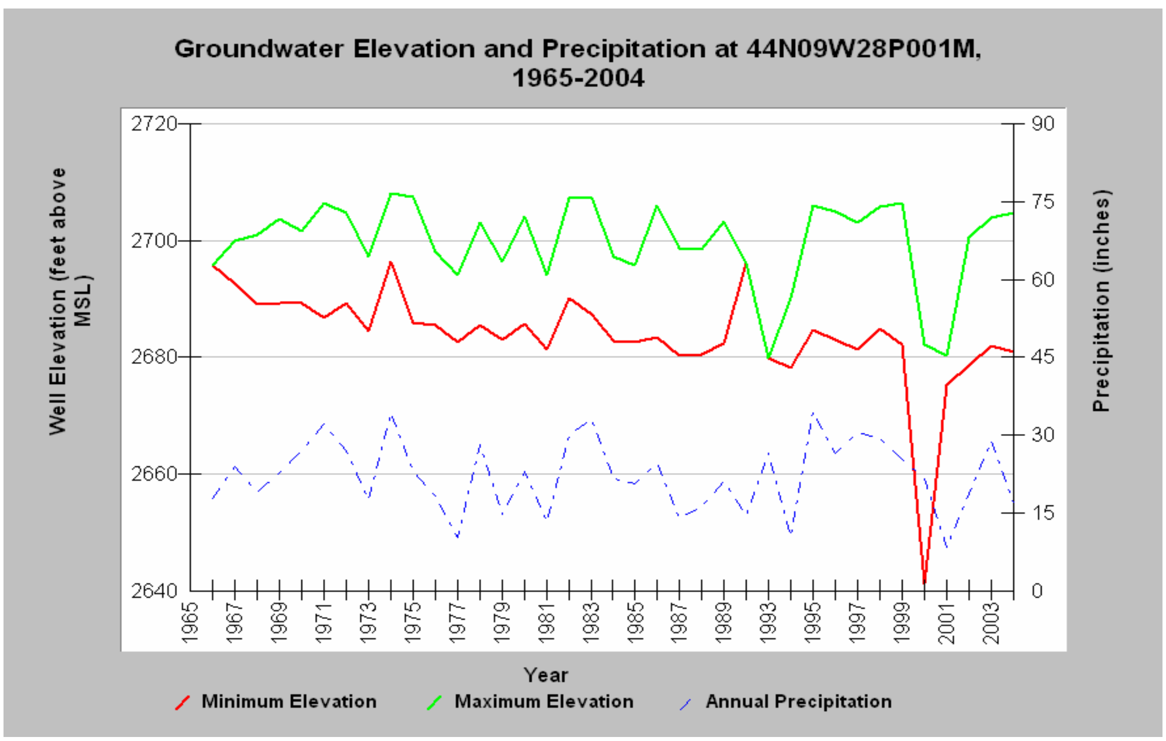


Figure 6. California Department of Water Resources well 44N09W28P001M, approximately 8 kilometers northwest of Fort Jones, for the years 1965-2004.

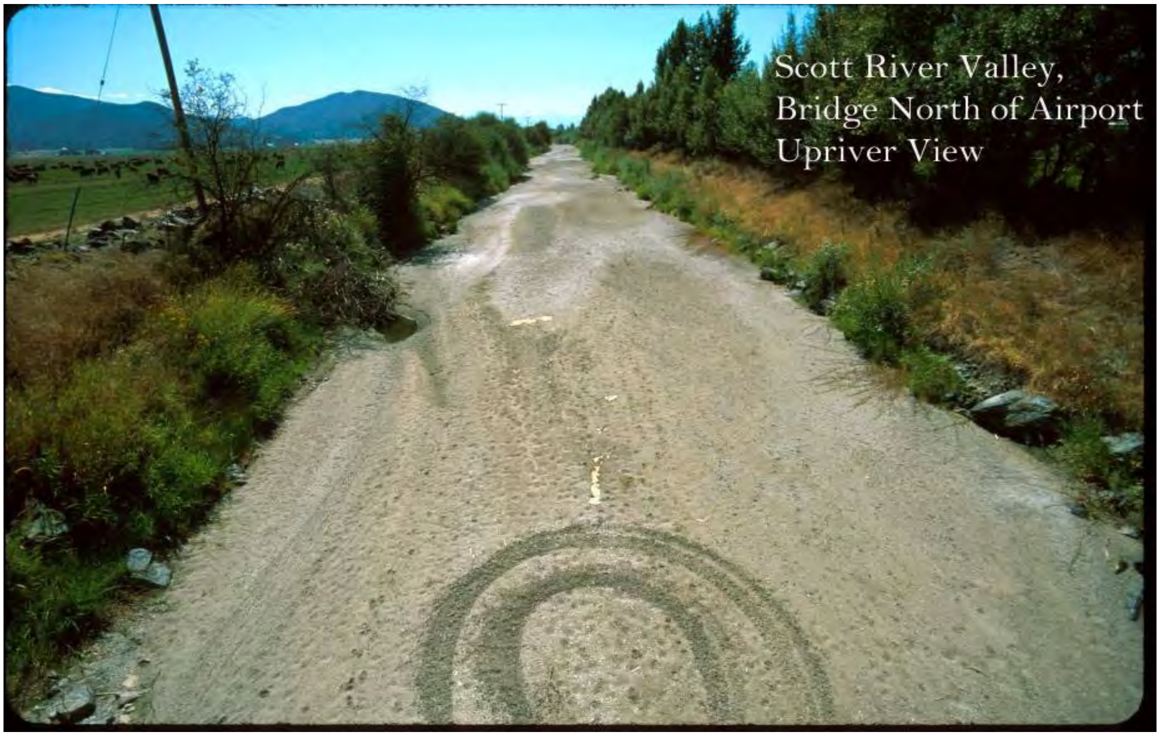


Figure 7. This photo shows the dry bed of the Scott River in a reach near the airport looking upstream. Photo from KRIS taken by Michael Hentz. 2002.

Figure 8. Scott River at Fort Jones Bridge looking downstream. Note streambed is comprised of mostly sand. Photo from KRIS taken by Michael Hentz. 2002.

Many tributaries of the Scott River that are known to harbor steelhead and coho salmon (see Fish section below) are routinely de-watered as a result of water extraction for irrigation. Figure 9 shows Moffett Creek where a combination of surface water extraction and ground water extraction combines to cause a loss of surface flow (Kier Associates, 1999).

Figure 9. Moffett Creek in August 1997 after the January 1997 Storm and subsequent excavation. Note lack of riparian trees due to drop in ground water levels (Kier Associates, 1999). Photo from KRIS Version 3.0.

Other major salmon and steelhead bearing tributaries that now typically lose surface flow due to diversion are Shackleford Creek (Figure 10 and 11), Kidder Creek (Figure 12) and Etna Creek (Figure 13). All stream reaches that are currently de-watered were formerly excellent salmonid rearing areas. The National Academy of Sciences (2003) makes it clear that “dewatering of tributaries eliminates potential rearing habitat for coho and causes loss of connectivity and reduction of base flow in the main stem.”

Low Flow Adds to Water Temperature and Water Quality Problems

The National Academy of Sciences (2003) makes a clear case that flow depletion is at the root of temperature problems in the Scott River. As flows drop, transit time for water increases, allowing an opportunity for stream warming. Figure 14 shows maximum daily water temperatures at several mainstem Scott River locations during 1996. The South Fork has the coolest temperatures because it flows from U.S. Forest Service lands and has few diversions. The East Fork is much warmer by comparison and has a substantial number of diversions. The Scott River warms as it flows downstream, with temperatures well over stressful (McCullough, 1999) and sometimes over lethal (Sullivan et al, 2001) levels.

A thermal infrared radar (TIR) image of Shackleford Creek (Figure 15) was taken by Watershed Associates (2003) as part of the Scott River TMDL study process, and shows dramatic effects of flow depletion on water temperature. Shackleford Creek is cool enough for juvenile salmonid

Figure 10. Shackleford Creek looking downstream at a bridge over a middle reach showing complete loss of flow due to diversion. Photo from KRIS V 3.0 taken by Michael Hentz.

Figure 11. This photo shows the dry creek bed of Shackleford Creek at its convergence with the Scott River in August 1997. Photo from KRIS Version 3.0.

Figure 12. Photo shows Kidder Creek looking upstream off the Highway #3 Bridge in Greenview. Photo from KRIS V 3.0 by Michael Hentz. 2002.

Figure 13. Photo shows Etna Creek looking downstream off the Highway 3 Bridge. Photo from KRIS V 3.0 by Michael Hentz. 2002.

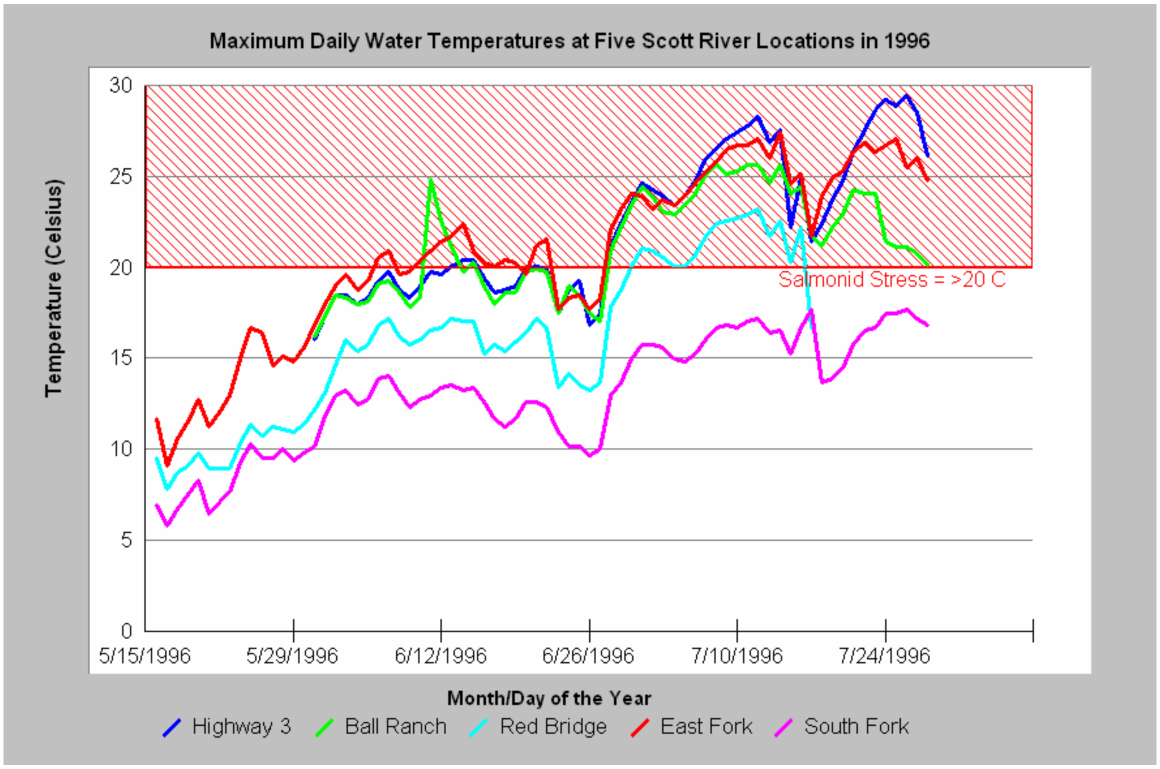


Figure 14. Water temperature at various Scott River mainstem locations in 1996. Chart from KRIS V 3.0 and data from the Siskiyou Resource Conservation District.

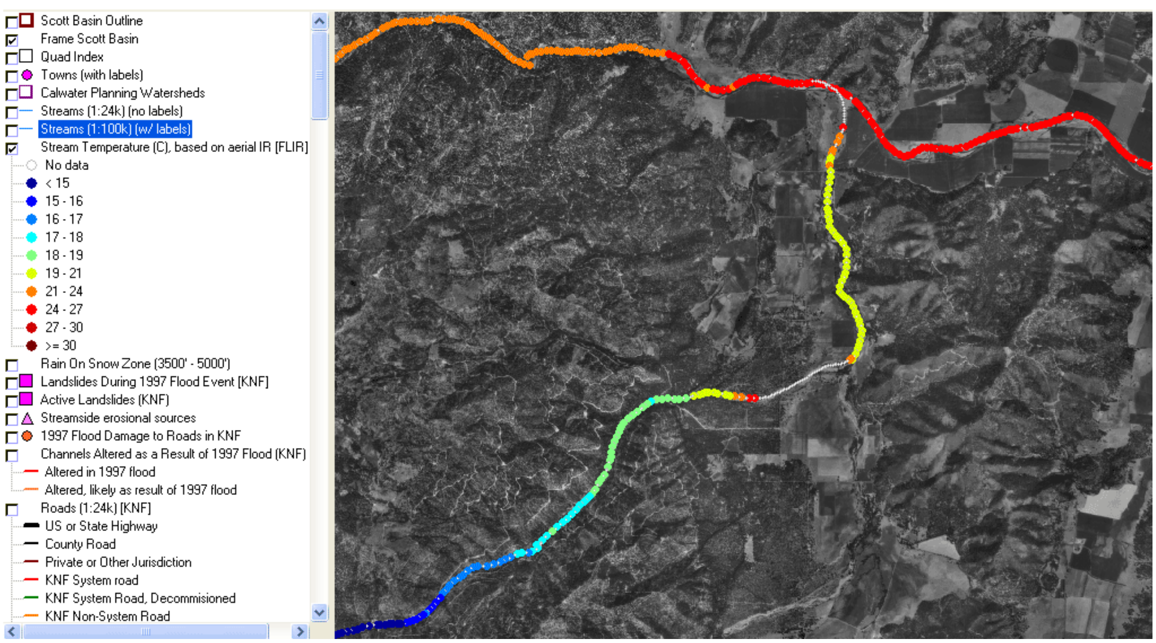


Figure 15. This map shows summary data of Scott River Thermal Infrared Radar (TIR) surveys for Shackleford Creek. Note that water temperature warms in a downstream direction as flow is depleted. Reaches with no temperature coded color (i.e., gray) are dry. Data from Watershed Sciences (2003).

rearing above points of diversion, then warms rapidly as its flow is depleted. Flow resumes below the major tributary Mill Creek, warms again as flow is further reduced by irrigation until surface flows are again entirely lost, just upstream of the convergence with the Scott River.

Although the Scott River is not yet listed as "water quality limited" for nutrients, dissolved oxygen (DO) or pH, these problems may arise if flows drop low enough to cause stagnation. Figure 16 shows a reach of the Scott River with much depleted flows due to irrigation. The algae blooms seen forming here can cause a diurnal increase in pH associated with high rates of photosynthesis and very low nocturnal dissolved oxygen (DO) levels as algae respires.

Figure 16. Photo shows the mainstem Scott River looking downstream with significant signs of algae blooms evident. Algae growth may alter water chemistry. Photo from KRIS V 3.0 by Michael Hentz.

Sediment and Increased Peak Flows Cause Channel Scour and Lead to Stream Warming

Kier Associates (2005) point out that changes in sediment yield and watershed hydrology related to logging and road building in the Scott River basin can also contribute to water temperature problems. The January 1997, flood damage report by the Klamath National Forest (de la Fuente and Elder, 1998) indicated that debris torrents caused 437 miles of stream channel scour, which in turn made these streams more subject to warming. Landslides were most frequently triggered by road failures, but were also well above background occurrence levels in recently logged or burned areas. Water temperature data from the Karuk Tribe and Klamath National Forest show that some tributaries of the lower Scott River increased in water temperature as a result of debris torrents associated with the January 1997 storm (Figure 17). Canyon Creek and Boulder Creek

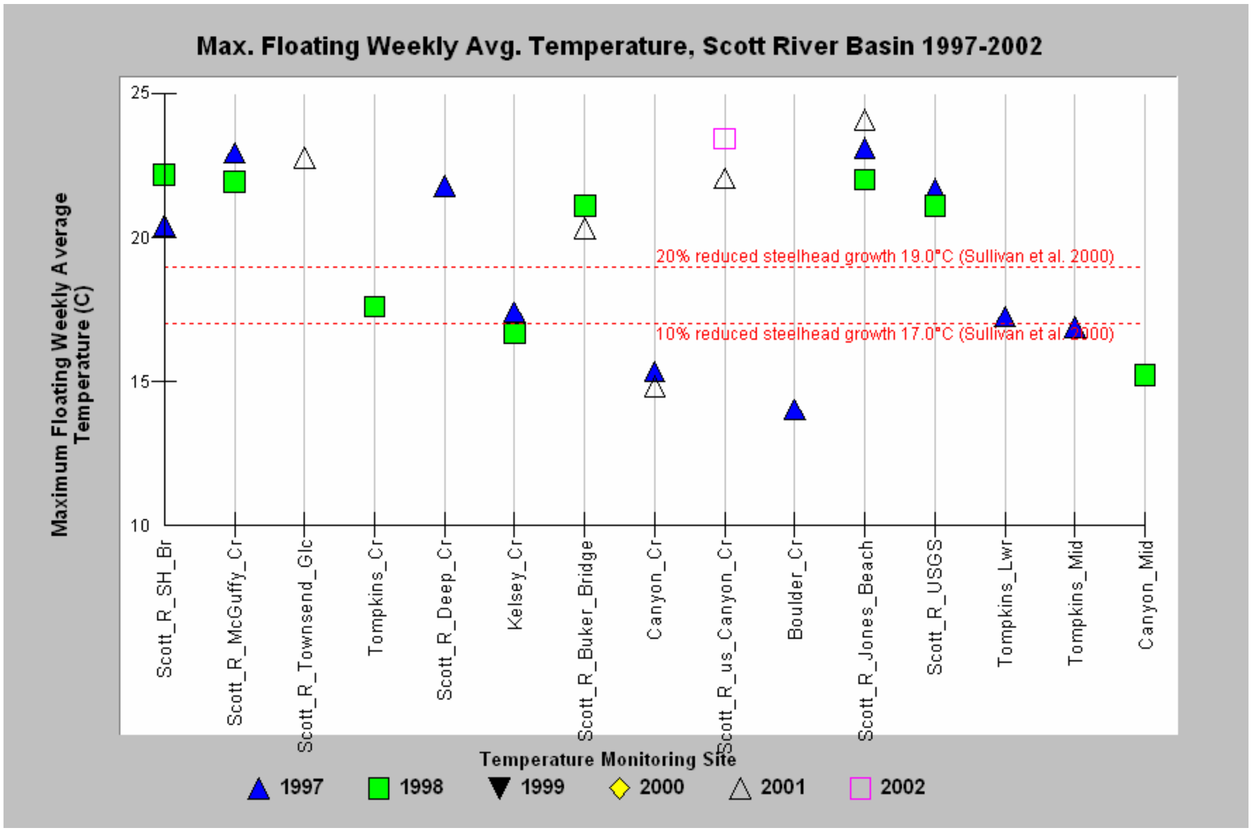


Figure 17. Maximum floating weekly average water temperature (MWAT) for several mainstem Scott River and tributary locations. Data from the Karuk Tribe and USFS.

did not experience debris torrenting and thus still maintain water temperature sufficiently cool to support coho salmon. Welsh et al. (2001) found that coho were present in streams that did not attain a maximum floating weekly average water temperature (MWAT) of greater than 16.8 C. Figure 17 shows reference lines from Sullivan et al. (2001) that indicate suppressed growth in steelhead juveniles at temperatures higher than 17 C.

Kelsey Creek and Tompkins Gulch both had major channel alterations as a result of the January 1997 storm which likewise triggered stream warming. Figure 17 indicates that neither of these streams was sufficiently cool to support coho juveniles after 1997. The Klamath National Forest flood study (de la Fuente and Elder, 1997) noted that the stream damage was high given the fairly low recurrence interval of the storm event, which was judged to be a 14-35 year event. Extensive logging, road building and fires all combine to elevate flood risk (Figure 18) and resulting increased flows and sediment yield caused major channel adjustments (Figure 19).

The lower reach of McGuffy Gulch, a tributary of the lower Scott River, serves as an example of what type of damage debris torrents can cause. Damage to this stream went well beyond loss of channel depth and increased channel width (Figure 20). The channel was buried so deeply that it lost surface flow. Kier Associates (2005) point out that channel scour can also occur due to increased peak flows related to rain-on-snow events (Berris and Harr, 1987; Coffin and Harr, 1991). Jones and Grant (1996) describe how road cuts intercepting ground water pathways can shunt water into road ditches, thus increasing peak flows and cutting off ground water recharge downhill, in turn resulting in decreased summer base flows.

Figure 18. Patch clear cuts, areas burned by forest fires, plantations and road networks in upper Kelsey Creek set the stage for flood damage and 70% channel scour by the January 1, 1997 storm. Photo by Patrick Higgins from KRIS V 3.0.

Figure 19. Kelsey Creek, just upstream of its mouth in early 1997, with snapped alder trees, large rubble and bank erosion near the house indicative of recent debris torrent damage. KRIS V 3.0.

Figure 20. Photo shows McGuffy Creek, a lower the Scott River tributary, just upstream of the Scott River Road. From KRIS V 3.0 by Michael Hentz. 2002.

Fish Population Status, Trends and Need for Immediate Action

The low gradient of the mainstem Scott River and its major tributaries made it ideal habitat for summer and winter steelhead, spring and fall chinook and coho salmon. Long term declines in these populations have been well documented (Kier Associates, 1991; CH2Mhill, 1985). Scott River spring chinook and summer steelhead populations are at remnant levels and are only sighted infrequently in surveys.

The low flows coming out of the lower Scott River Valley today not only reduce carrying capacity for juvenile salmonids but would also prevent any successful attempts by summer steelhead or spring chinook adults to hold over during summer. The Scott TMDL needs to recognize also that spring chinook and summer steelhead recovery may be attainable, due to metapopulation function (Rieman et al., 1993), if cold water refugia are restored in the lower Scott River, sediment diminished and water flows improved.

The Scott River TMDL should also specifically target recovery of coho salmon, which are recognized as “threatened” under both the federal and California Endangered Species Acts. The distribution of coho spawning is known (Figure 21), yet the TMDL does not specifically focus protection or restoration on reaches or tributaries that presently harbor ESA-listed coho as “best science” restoration efforts must (Bradbury et al., 1996).

Scott River adult coho returns are now only robust in one out of three year-classes, which is an indicator that the population is trending towards extinction (Rieman et al., 1993; NMFS, 2001; CDFG, 2003). Table 2 shows downstream migrant trapping results from CDFG indicating that coho juveniles are only abundant in one of three years following high spawner years.

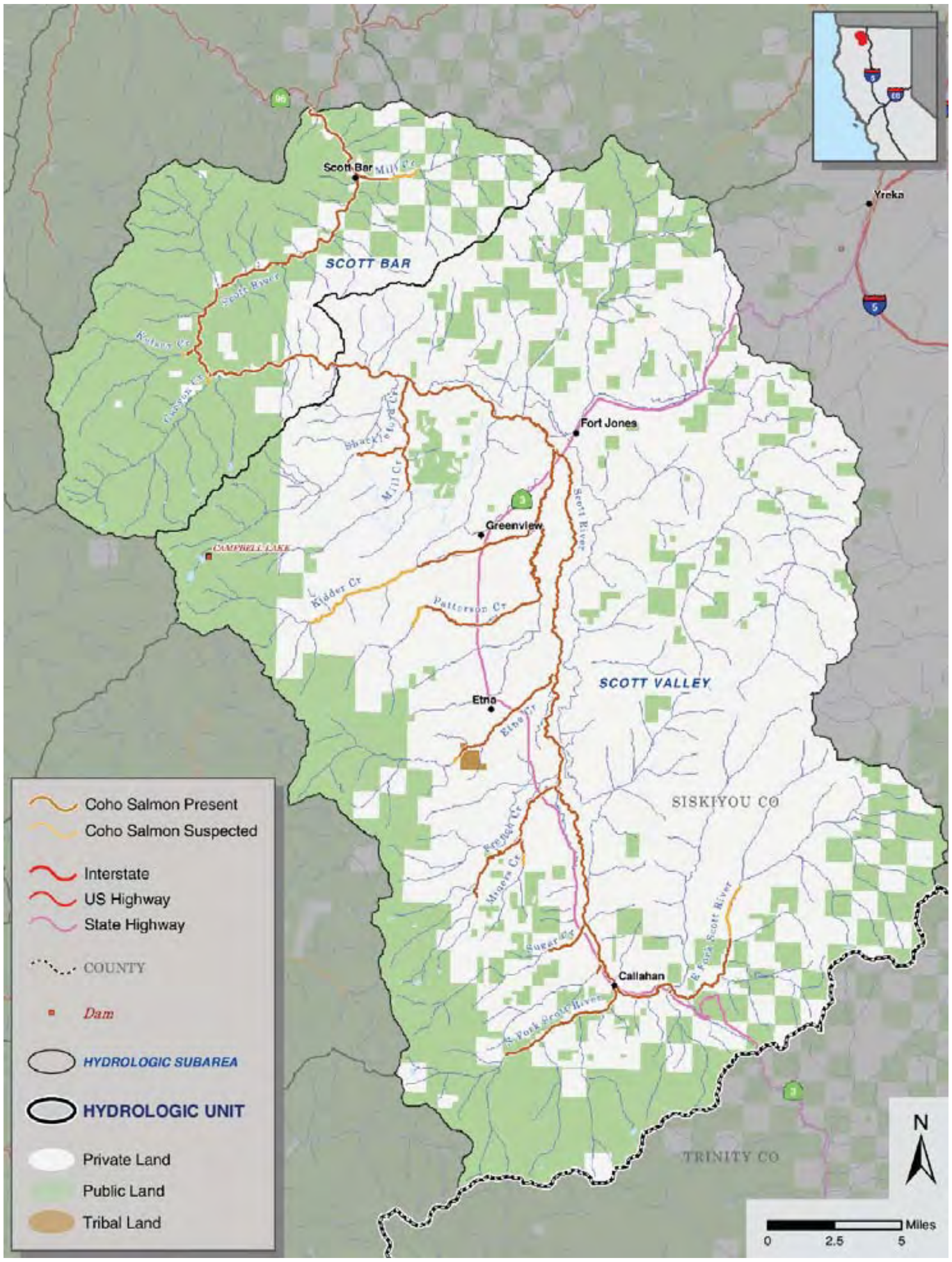


Figure 21. Coho salmon distribution map for known or potential Scott River spawning locations (from Maurer, 2001).

Grand Total by Species:	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	TOTALS
Steelhead	10181	17693	5943	7127	7980	4158	5008	21982	79887	135319	69823	**365101**
Coho	15	433	0	253	3	8	538	30	69	30019	50	**31418**
Chinook	2	266	0	3	1	0	0	365	3191	0	0	**3828**
Totals =>	**10198**	**18392**	**5943**	**7383**	**7984**	**4166**	**5546**	**22377**	**83147**	**165338**	**69873**	**400347**

Table 2. Coho in California Department of Fish and Game trap records as taken from Siskiyou RCD (2004) Table 6c.

Scott River fall chinook returns likewise plummeted in 2004 and 2005 to the lowest level on record for two years in a row (Figure 22). Higgins et al. (1992) discussed the risk of extinction of northwestern California Pacific salmon stocks and discussed minimum viable population sizes, noting that:

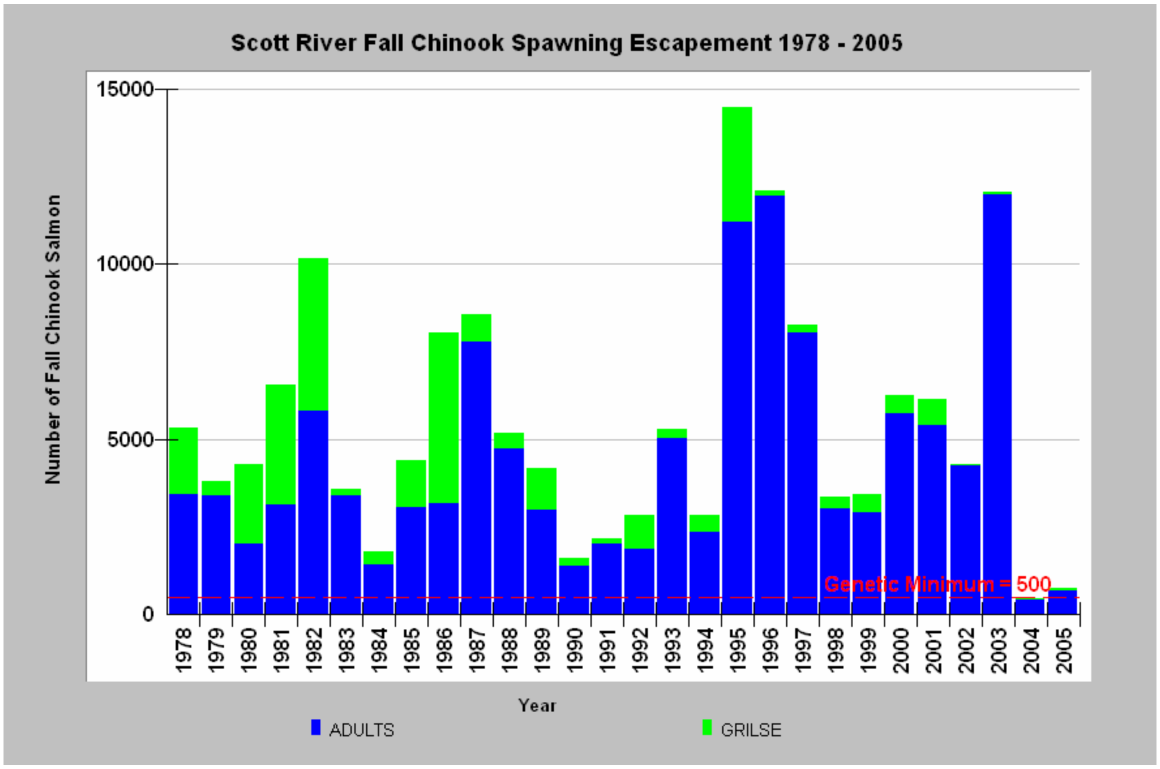


Figure 22. Scott River fall chinook escapement shows both 2004 and 2005 as the lowest years on record. Data from CDFG.

> "When a stock declines to fewer than 500 individuals, it may face a risk of loss of genetic diversity which could hinder its ability to cope with future environmental changes (Nelson and Soule, 1986). A random event such as a drought or variation in sex ratios may lead to extinction if a stock is at an extremely low level (Gilpin and Soule, 1990). The National Marine Fisheries Service (NMFS, 1987) acknowledged that, while 200 adults might be sufficient to maintain genetic diversity in a hatchery population, the actual number of Sacramento River winter run chinook needed to maintain genetic diversity in the wild would be 400 - 1,100."

In other words, despite favorable or average ocean conditions (Collison et al. 2003) and wet years with at least average flows, the population of fall chinook in the Scott River has fallen to critically low levels. These populations have some additional ability to rebound without loss of genetic diversity because chinook spawn at different ages (Simon et al. 1986), but the low adult returns should be viewed with considerable alarm. Low flow, water temperature problems and high sediment yield are all playing a role, although mainstem Klamath River water quality problems are also a factor in the decline of Scott River fall chinook (Kier Associates, 2006).

Discussions above show that flows in the lower Scott River in October do not even meet requirements of the *Scott River Adjudication* in October, when fall chinook salmon adults would be migrating upstream and spawning. Very low flows in the Scott River canyon cause a concentration of spawning by fall chinook in the lowest reaches (Figure 23). This concentration poses higher risk for egg survival than if flows were sufficient for chinook spawners to disburse upstream (Kier Associates, 2005). Epidemic transmission of disease also becomes a higher risk under such densities. Risk of increased peak flows that might mobilize the stream bed is also higher in the lower mainstem than in upstream reaches or tributaries. Large quantities of decomposed granitic sand in transport through the Scott River canyon may also be mobilized by high flows and smother eggs or entomb alevin.

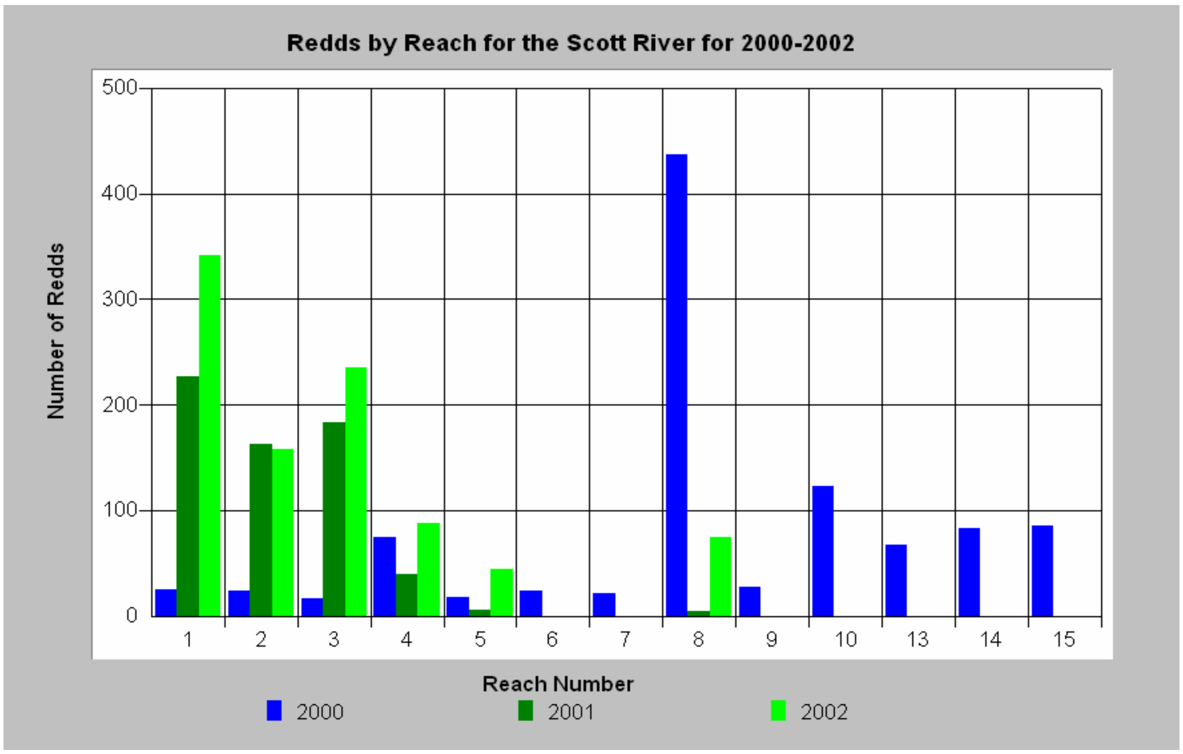


Figure 23. Data from CDFG spawner surveys show that fall chinook salmon spawned mostly in the lowest five reaches of the Scott River in 2001 and 2002, where eggs may be vulnerable due to potential for bed load movement or transport of decomposed granitic sands.

Collison et al. (2003) noted that we are presently experiencing relatively favorable conditions for salmonids in the ocean and in a wet on-land cycle that will likely reverse sometime between 2015 and 2025 in what is known as the Pacific Decadal Oscillation (PDO) cycle (Hare et al. 1999). That coho salmon and fall chinook salmon populations are at such low levels or showing declines during the positive cycle of the PDO is not a good sign. In order to restore Scott River chinook and coho salmon stocks, flow and water quality problems must be remedied by 2015 or whenever the PDO switches to less favorable conditions for salmon stocks or further extinctions are likely to occur.

References

Berris, S. N. and Harr, R. D., 1987. Comparative snow accumulation and melt during rainfall in forested and clear-cut plots in the western Cascades of Oregon: Water Resources Research. Y. 23, p. 135- 142.

Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D. L. Bottom, W.E. Weaver and R. L. Beschta. 1995 Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Pacific Salmon. Published by Pacific Rivers Council, Eugene, OR. 56 p. Available online at: http://www.krisweb.com/biblio/gen_xxxx_bradburyetal_1995.pdf.

California State Water Resources Control Board. (CSWRCD), 1980. Scott River Adjudication Decree No. 30662, Superior Court for Siskiyou County. Scott River stream system within California in County of Siskiyou. Sacramento, 152p.

Coffin, B. A. and Harr, R. D., 1991. Effects of forest cover on rate of water delivery to soil during rain-on-snow: Final Report for Project SH-1 (Rain-on-Snow Field Study) submitted to Sediment, Hydrology, and Mass Wasting Steering Committee, Timber/Fish/Wildlife Agreement, State of Washington Department of Natural Resources, 106 p.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

de la Fuente, J. and D. Elder. 1998. The Flood of 1997 Klamath National Forest - Phase I Final Report. November 24, 1998. USDA Forest Service, Klamath National Forest, Yreka, CA.

Dunne, T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resh, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. The University of California Committee on Cumulative Watershed Effects. University of California Wildland Resource Center Report No. 46. June 2001. 107 pp.
http://www.krisweb.com/biblio/gen_ucb_dunneetal_2001_cwe.pdf

Gilpin, M.E. and M.E. Soule. 1990. Minimum Viable Populations: Processes of Species Extinction. In: M. Soule (ed) Conservation Biology: The Science of Scarcity and Diversity University of Michigan Press. pp 19-36.

Higgins, P.T., S. Dobush, and D. Fuller. 1992. Factors in Northern California Threatening Stocks with Extinction. Humboldt Chapter of American Fisheries Society. Arcata, CA. 25p.

Jones, J.A. and G.E. Grant. 1996. Peak flow response to clear-cutting and roads in small and large basins, Western Cascades, Oregon. Water Resources Research, April 1996. Vol. 32, No. 4, Pages 959-974.

Kier Associates. 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program. U.S. Fish and Wildlife Service, Klamath River Fishery Resource Office. Yreka, CA. 403 pp.

Kier Associates. 1999. Mid-term evaluation of the Klamath River Basin Fisheries Restoration Program. Sausalito, CA . Prepared for the Klamath River Basin Fisheries Task Force. 303 pp.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat. Prepared for the Resources Agency of California and the National Marine Fisheries Service; Sacramento, CA. Available online at: http://www.krisweb.com/biblio/cal_nmfs_ligonetal_1999_srprept.pdf

Mack, S. 1958. Geology and ground-water features of Scott Valley, Siskiyou County, California. U.S. Geological Survey, Water Supply Paper 1462. Washington, D.C., 95p.

Maurer, S. 2002. Scott River watershed adult coho salmon spawning survey: December 2001-January 2002. Prepared for U.S. Department of Agriculture Forest Service, Klamath National Forest, Scott River Ranger District. Fort Jones, CA. 121 pp.

McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to chinook salmon. Published as EPA 910-R-99-010 . Prepared for the U.S. Environmental Protection Agency (EPA), Region 10. Seattle, Washington . 291 pp. http://www.krisweb.com/biblio/gen_usepa_mccullough_1999.pdf

Montgomery, D. R. and J.M. Buffington, 1993. Channel classification, prediction of channel response, and assessment of channel condition. TFW-SH10-93-002. Prepared for the SHAMW committee of the Washington State Timber, Fish and Wildlife Agreement. Seattle, WA. 110 pp.

National Academies of Science (NAS). 2003. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. Prepared for the NAS by the National Research Council, Division on Earth and Life Studies, Board on Environmental Studies and Toxicology, Committee on Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. 358 pp.

Nelson, K. and M. Soule. 1987. Genetic Conservation of Exploited Fishes. In: N. Ryman and F.Utter (eds). Population Genetics and Fisheries Management University of Washington Press. Seattle, WA.

Poole, G.C. and C.H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. *Environmental Management* 27: 787-802.

Quartz Valley Indian Community. 2005. Comments on Hypothesis Testing for Approach to Groundwater Studies, by Scott River Watershed Council – Water Committee. Quartz Valley Indian Community, Fort Jones, CA.

Quigley, D., S. Farber, K. Conner, J. Power, and L. Bundy. 2001. Water Temperatures in the Scott River Watershed in Northern California. Performed under contract to the Siskiyou Resource Conservation District with funding from U.S.W.S., Yreka, CA. 59 p.

Sommarstrom, Sari, Kellogg, Elizabeth, and Kellogg, Jim, 1990, Scott River watershed granitic sediment study: Report for Siskiyou Resource Conservation District, 152 p. plus appendices. Available online at: http://www.krisweb.com/biblio/klamath_srcd_sommarstrometal_1990.pdf.

Spence, B.C., G.A. Lomnicky, R.M. Hughes and R. P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation. Funded jointly by the U.S. EPA, U.S. Fish and Wildlife Service and National Marine Fisheries Service. TR-4501-96-6057. Man Tech Environmental Research Services Corp., Corvallis, OR.

Sullivan, K., D. J. Martin, R. D. Cardwell, J. E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute . Portland, OR. 192 pp. Available online at: http://www.krisweb.com/biblio/gen_sei_sullivanetal_2000_tempfinal.pdf.

Rieman, B., D. Lee, J. McIntyre, K. Overton, and R. Thurow. 1993. Consideration of extinction risks for salmonids. As FHR Currents # 14. U.S. Department of Agriculture, Forest Service, Region 5 . Eureka, CA. 12 pp.

Sommarstrom, Sari. 2001. Scott River monitoring plan: Sediment sampling and analysis 2000. Prepared for the Siskiyou Resource Conservation District and Scott River Watershed Council. 15 p. plus appendices.

U.S. Environmental Protection Agency. 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA 910-B-03-002. Region 10 Office of Water, Seattle, WA.

Watershed Sciences. 2003. Aerial Surveys using Thermal Infrared and Color Videography Scott River and Shasta River Sub-Basins. Performed under contract to the NCRWQCB and U.C. Davis by Watershed Sciences LLC, Corvallis, OR.

Welsh, H.W., Jr., Hodgson, G.R., Harvey, B.R., and Roche, M.F., 2001, Distribution of juvenile coho salmon in relation to water temperatures in tributaries of the Mattole River, California: North American Journal of Fisheries of Management, v. 21, p. 464-470. Available online at: http://www.krisweb.com/biblio/gen_usfs_welshetal_2001.pdf.

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SHASTA RIVER FLOWS

Pacific Coast Federation of Fishermen's Associations
and the Institute for Fisheries Resources

Watershed Conservation Office
850 Greenwood Hts. Dr.
Kneeland, CA 95549

State Water Resources Control Board
Attn: Song Her, Clerk to the Board
1001 "I" Street
Sacramento, CA 95814
Email: comments@waterboards.ca.gov

29 October 2006
Emailed and mailed

Re: Comment Letter - Shasta River Watershed DO and Temperature TMDLs

Dear State Water Board Members:

The Klamath River was once the third most productive salmon river system in the world. As you know, the ongoing and accelerating collapse of the Klamath River's once-abundant salmon runs, particularly for ESA-listed coho salmon (which is not commercially harvested), but also for chinook salmon, is in no small part caused by serious water quality problems in its major tributaries (including the Shasta River) that currently limit salmonid production or threaten to eliminate it altogether in those important river reaches. PCFFA, as the west coast's largest trade association of commercial fishing families, and it's many member family fishing businesses, have too long borne the brunt of all these human-caused Klamath Basin water problems, now losing tens to hundreds of millions of dollars each year in coastal community revenues because of these water problems. This year's near-total Klamath ocean fishery closure is only the latest and worst of many Klamath-driven fishery failures.

The Regional Board's Draft Resolution R1-2006-0052 recognized the essential inseparability of water quality and water quantity in amendment number nine. One clear fact of hydrology is that high temperatures and low dissolved oxygen are always exacerbated by low flows.

Thus low flows in the Shasta River are a problem that cannot be ignored, and no TMDL can validly address the various water quality problems linked to low flows without taking low flows into account and mitigating through minimum instream flow requirements for this most fundamental problem.

The Regional Board staff has been thorough in their analysis and their conclusion is scientifically and legally sound that maintaining the recommended 45 cfs flows as an absolute minimum flow requirement must be accomplished in order to reduce high temperatures and meet water quality standards. This standard is the minimum in-stream flow that should be adopted by the State Board.

Specific actions to achieve the minimum flows for fish are not delineated, yet immediate steps are needed now to preserve remaining salmonid stocks. We are presently experiencing relatively favorable conditions for salmonids in the ocean and in a wet on-land cycle that will likely reverse sometime between 2015 and 2025 in what is known as the Pacific Decadal Oscillation (PDO) cycle. That coho salmon and fall chinook salmon populations are at such low levels or showing serious declines during the positive cycle of the PDO is not a good sign. In order to restore Shasta River chinook and coho salmon stocks, low flow and water quality problems must be remedied by 2015 or whenever the PDO switches to less favorable conditions for salmon stocks or further extinctions are likely to occur. A population that is already severely stressed even under relatively good oceans conditions will disappear when, as is inevitable, those cyclical conditions shift for the worse.

The Shasta River TMDL should also specifically target recovery of coho salmon, which are recognized as “threatened” under both the federal and California Endangered Species Act (CESA). Coho, unlike chinook salmon, spend up to 18 months in our river systems, and are thus especially susceptible to poor water quality and river dewatering during the summer months. Coho are also exceptionally tributary dependent. Coho spawning is well known in the Shasta (in fact, the Shasta represents some of the most historically important coho spawning areas), *yet the TMDL Action Plan proposal does not specifically focus protection or restoration on reaches or tributaries that presently harbor ESA-listed coho or which are important for coho recovery.* Coho restoration in the Shasta is a policy goal that is required under both federal and CESA listings for this stock.

Attachment A of this letter further details the link between water quantity, nutrients, high pH, high temperatures and low DO throughout the Shasta River. High temperatures stressful to salmon at the Shasta River’s mouth also flow into the mainstem Klamath and add to the water temperature problems there.

To implement the TMDL and comply with the Basin Plan Objectives, the Action Plan must adequately describe specific and measurable actions to achieve water quality standards, with reasonable assurance of success. Timelines with milestones and monitoring are needed to determine whether these actions are working over time.

Thousands of businesses and families downstream and along the coast are relying on the Water Boards to improve the illegally degraded condition of tributaries to the Klamath River and restore the beneficial uses, jobs and dollars this fishery traditionally provides. The ocean fishery has faced twenty-seven years of increasingly restrictive closures as Klamath River stocks continued to decline. Commercial fishing ports in California and most of Oregon, related fishing-dependent businesses, as well as the ocean and river sport fishing-related businesses and basic subsistence support fisheries for the Tribes, are all dependent on the Water Boards to restore conditions that will support viable salmon populations, and to do this soon -- while it is still possible at all.

We live in a time of rapid change, and people are often uncomfortable with and even fearful of change. Instream dedicated flows do not have to mean farmers and ranchers going out of business, nor is there any evidence to support such hysterical scare stories. There are in fact plenty of creative solutions, including working through the many existing water conservation programs to make better and more efficient use of the water already available for irrigation, curtailing illegal usages, and to use willing seller water bank or water trust programs as temporary solutions until more permanent solutions can be implemented.

However, one thing is clear: without sufficient cold water in the Shasta River, the once-abundant salmon runs originating in or dependent upon the Shasta will go extinct. This would further jeopardize thousands of coastal and in-river fishing-dependent jobs that are also threatened with extinction. Where the salmon go, so go the fishing men and women who depend on the salmon for their livelihoods.

We know that with community involvement and public funding, salmon runs can be restored. For example, the endangered spring run chinook on Butte Creek in the Sacramento River rebounded from less than 50 fish to between ten and twenty thousand adults in each of the last nine years. After the ESA listing, local organizations, landowners and agencies removed 5 dams, established minimum flows, installed 10 flow-monitoring stations, 11 fish ladders, and 5 fish screens.

Six local salmon fishing boats just left Eureka this June for Alaska, and five of them for the first time – in other words, these fishermen has to leave the state to try to earn a living. The permit costs $30,000, and it is a dangerous trip for a small fishing boat that takes ten days to get there under good weather conditions. One Bodega Bay fisherman fished the open area down south and caught only 31 fish for the entire month. The current salmon fishing season is a major disaster. I asked one of the fishermen who was leaving what he would like me to say to the Water Board about water quality in Klamath tributaries, and he replied: “Get with it.”

I also enclose Governor Schwarzenegger’s 6 June 2006 Proclamation of Disaster for ten California counties (Monterey, Santa Cruz, San Mateo, San Francisco, Marin, Sonoma, Mendocino, Humboldt, Del Norte and Siskiyou Counties), as Attachment B. Poor water quality and poor water flows are specifically cited in his Declaration as some of the underlying causes of the failure of the Klamath fishery and resultant near total closures of the rest of the coast. The least this Board can do is address those Shasta River water quality and quantity problems within its control.

We also recommend that the Regional Board adopt an Action Plan for the Shasta River that incorporates the recommendations of Coast Action Group, provided in their separate letter. Please refer to Attachment A for additional information on the importance of restoring minimum flows to the Shasta River as part of this process. The need for a baseline minimum flow with most reaches of the Shasta River, and the importance to salmon production (and the jobs that production represents) of maintaining minimum flows even during low water years cannot be over-stated.

As this letter is filed within the deadline for comment (comments are due by November 1st at Noon) please include this letter, with Attachments A and B, in the administrative record of this proceeding.

Sincerely,

Vivian Helliwell, for the
Watershed Conservation Office, PCFFA/IFR
850 Greenwood Heights Drive
Kneeland, CA 95549
(707) 445-1976

Attachment A -- Shasta River TMDL Supporting Information: Flow, Temperature, Nutrient Pollution and Potential for Loss of Pacific Salmon Stocks

Attachment B – A Proclamation by the Governor of California of Fisheries Disaster in the Klamath (6 June 2006)

Attachment A to PCFFA/IFR Comments

Shasta River TMDL Supporting Information: Flow, Temperature, Nutrient Pollution and Potential for Loss of Pacific Salmon Stocks

This attachment is to provide information related to the *Shasta River TMDL* demonstrating relationships of flow reduction on water quality impairment. Water quality in the Shasta River is severely impaired with regard to temperature, pH and dissolved oxygen and remediation will require increased flows. Pacific salmon population status in the Shasta River basin is discussed and information presented to show that the TMDL's 40 year time line for restoring water quality may not be sufficiently speedy to prevent major salmonid stock loss. The impacts of Dwinnell Reservoir on water quality and other flow issues related to salmon recovery are also covered below.

Low Flows in the Shasta River

The *Shasta River Adjudication* (CDPW, 1932) does not require a minimum flow level similar to the Scott River Adjudication (CSWRCB, 1980), which provides baseline targets for flow to support aquatic habitat on U.S. Forest Service lands. Consequently, the Bureau of Land Management holdings in the lower Shasta River (Figure 1) are not given flow allocations. Lower reaches of the Shasta River have appropriate gradient and habitat complexity to support juvenile salmonids, but show temperatures and water quality problems that are chronically stressful or lethal throughout summer. Although the *Draft Shasta Valley Resource Conservation District Master Incidental Take Permit Application for Coho Salmon* (ITP) sets a minimum flow target of 20 cfs to be met by 2015, that level of flow will not likely attain beneficial uses such as restoration of coho salmon or

Figure 1. This photo shows the Shasta River flowing through BLM land in the canyon reach in an area referred to as Salmon Heaven. Boulders were placed to improve fish habitat, but water quality is too poor to support salmonid juveniles during most of summer. Photo from KRIS Version 3.0 (TCRCD, 2003).

steelhead trout (see Temperature section). North Coast Regional Water Quality Control Board studies related to the TMDL support increasing minimum flows to 45 cfs to abate pervasive water quality problems.

Flow records from 2001 and 2004 from the U.S. Geologic Survey flow gauge just upstream of the convergence with the Klamath are displayed as Figures 2-3. These charts provide a reference for temperature and water quality summaries for the same years presented later in this paper. Average daily flows in dry years like 2001 fall to near 20 cfs or less for weeks at a time (Figure 2). Hourly data are not available, but lack of coordination of irrigation operations may sometimes cause flows to fall below the listed average and present an even greater challenge for fish survival.

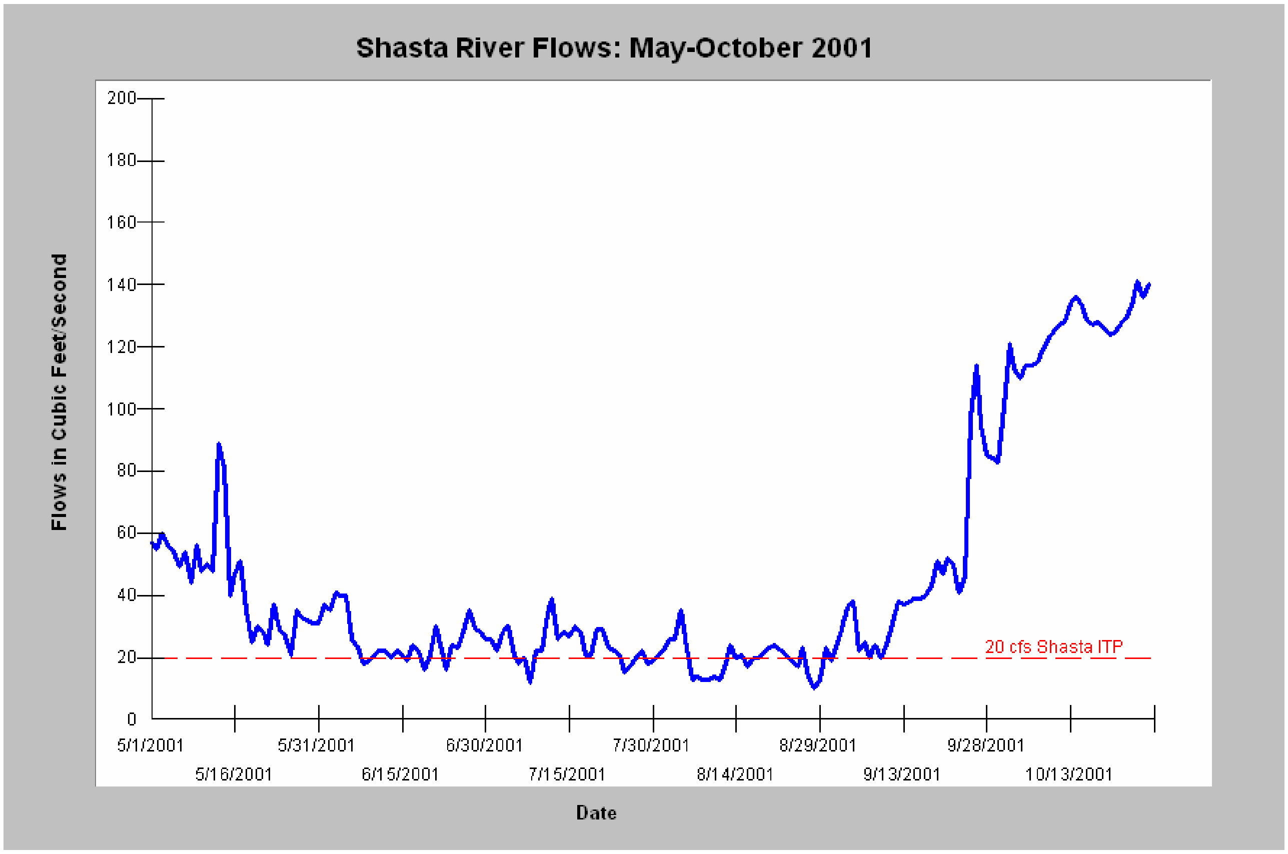

Figure 2. Average daily flow at the USGS Shasta River gauge for May through October 2001 shows a pattern of extremely low flows with many days falling below 20 cubic feet per second.

Average daily flow in years with more precipitation like 2004 may be much greater than 20 cfs on most days within the irrigation season (April 15-October 1), but can fall below that level on any given day. Summer rainfall may decrease the need to irrigate and summer thunderstorms are the cause of periodic increased flows.

The original need for adjudication on the Shasta River was driven by over-allocation, leading to water rights holders in the lower reaches being deprived of sufficient flow (CDPW, 1925). The Shasta River was blocked mid-way by the construction of Dwinnell Dam (Figure 4) in 1928. Flows are routed into a canal and down the east side of the valley for irrigation and there is no requirement for minimum flow in the reach of the Shasta River immediately below the dam. Water stored in the reservoir is augmented by diversion of Parks Creek into the Shasta River at Edgewood, even during winter when salmon and steelhead could otherwise be using this tributary. Storage capacity in the reservoir was increased through reinforcement of Dwinnell Dam in 1958 (Figure 5) leading to less need to spill excess winter flows in most years. The resulting lack of winter flood peaks decreases channel scour, which can lead to a build up of organic material (Gwynne, 1993) and increased biological activity with the resultant adverse water quality impacts.

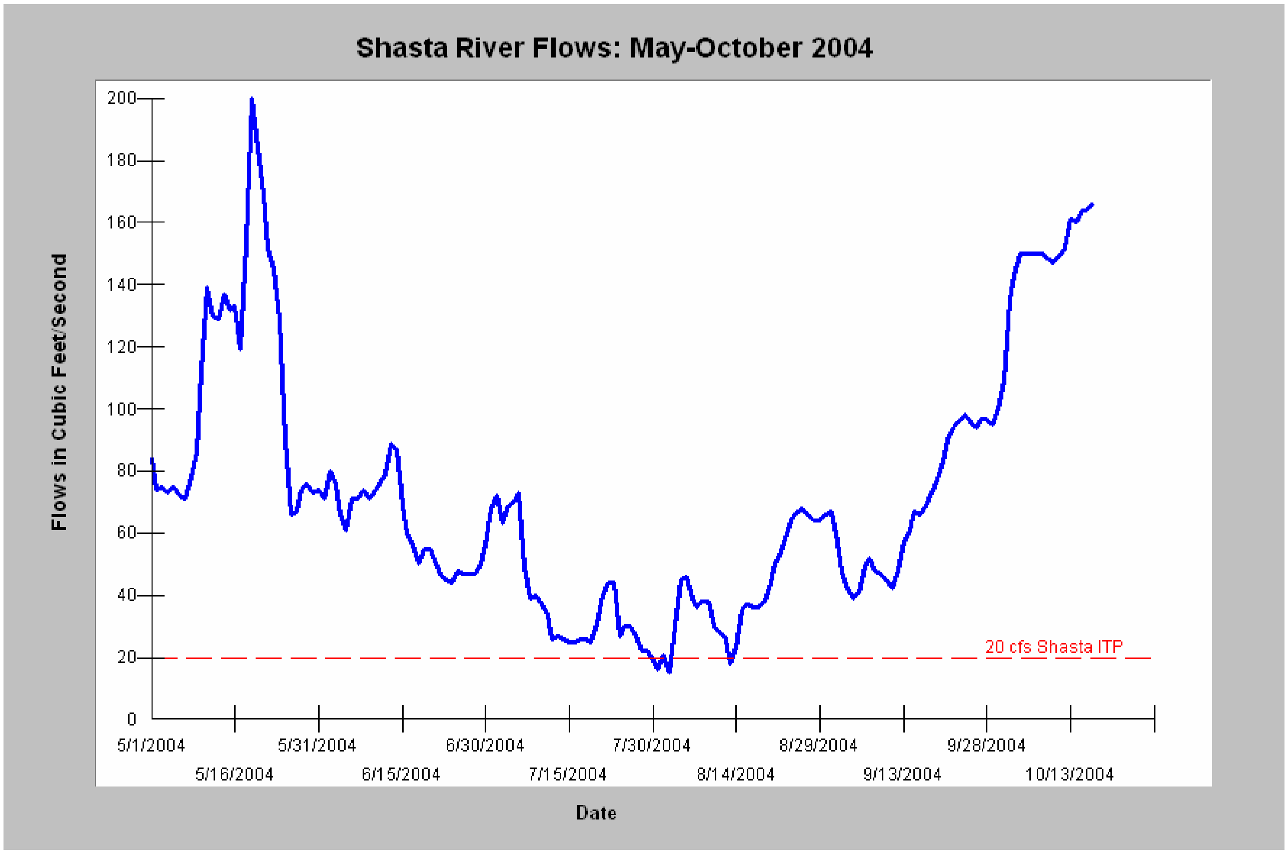

Figure 3. Average daily flow of the lower Shasta River from May to October 2004. Data from USGS.

Figure 4. Dwinnell Dam looking south with the canal at left into which almost all flows from the reservoir are diverted. Photo from KRIS Version 3.0 (TCRCD, 2003).

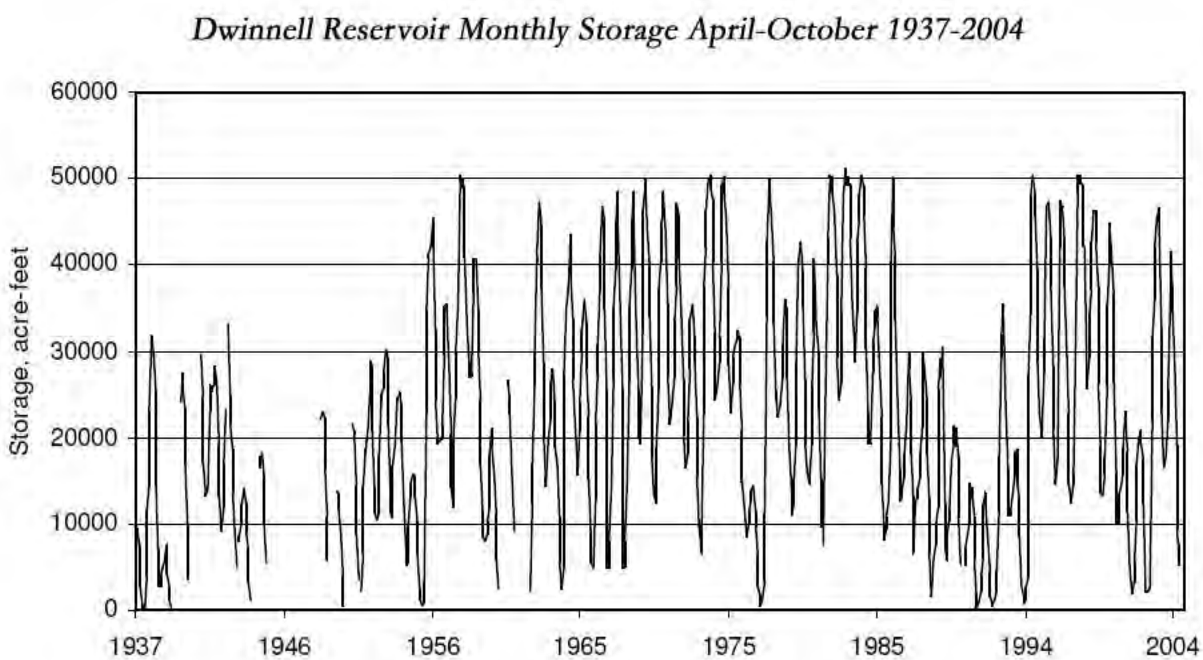

Figure 5. This chart was taken from the report *Lake Shastina Limnology* (NCRWQCB and UCD, 2005) and shows the storage capacity in acre-feet of Dwinnell Reservoir with a major increase after dam reinforcement in 1958.

There are major water quality problems in Dwinnell Reservoir (Figure 6) as a result of photosynthetic activity (NCRWQCB and UCD, 2005). Algae blooms cause very alkaline conditions, fluctuations in dissolved oxygen and periodic problems with dissolved ammonia. There is substantial seepage loss from the Dwinnell Reservoir and the reach of the Shasta River below the dam shows similar patterns of water quality impairment to those within the reservoir (NCRWQCB and UCD, 2005).

Dwinnell Dam blocks gravel transport downstream into reaches above Big Springs Creek, thus restricting supply of spawning gravels for salmonids. Similarly, the dewatering of Parks Creek (Figure 7) and other tributaries such as Willow Creek, Julian Creek and the Little Shasta River also reduces spawning gravel availability. Coutant (2005) pointed out that cumulatively gravel deprivation may have changed hydrologic function by decreasing the hyporheic zone and exchanges of surface and subsurface water that may have formerly cooled the Shasta River. Restoring access to cool headwater areas by removing Dwinnell Dam would also increase chances for restoring Pacific salmon.

Temperature Impairment and Relationship to Flow

The *Shasta TMDL* relies heavily on increasing shade and decreasing contributions of warm agricultural drain water, but also recognizes that decreased transit time from increased flows must also be used to attain beneficial uses. The National Research Council (NRC 2003) report entitled *Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery* described the relationship of water flow to temperature in the Shasta River:

> "Low flows with long transit times typical of those now occurring in the summer on the Shasta River cause rapid equilibration of water with air temperatures, which produces water temperatures exceeding acute and chronic thresholds for salmonids well above the

Figure 6. Dwinnell Reservoir looking southeast off the dam with water levels at less than full pool in 2002. Long retention time and exposure to sunlight trigger algae blooms and nutrient pollution. Photo from KRIS V 3.0 by Michael Hentz.

Figure 7. Parks Creek is shown here below the diversion to Dwinnell Reservoir with surface flows almost completely depleted. This not only shuts off cool water that could buffer high Shasta River water temperatures but also blocks spawning gravel recruitment. Photo by Michael Hentz.

mouth of the river. Small increases in flow could reduce transit time substantially and thus increase the area of the river that maintains tolerable temperatures."

Water temperatures in the entire length of the Shasta River become unsuitable for salmonid juvenile rearing for most of each summer. Figure 8 shows maximum daily water temperatures of the Shasta River from Louie Road just below Dwinnell Reservoir downstream to Anderson Grade Road at the bottom of the Shasta Valley. While there may be some isolated refugia due to spring flows, most of the reach attains stressful or lethal temperatures for Pacific salmon species. McCullough (1999) found that all Pacific salmon species were stressed at temperatures greater than 20^{O} C and Welsh et al. (2001) noted that coho salmon are only found in rearing areas with an average weekly maximum temperature (MWAT) of 16.8^{O} C or less. Sullivan et al. (2000) recognized 25^{O} C as lethal for Pacific salmon.

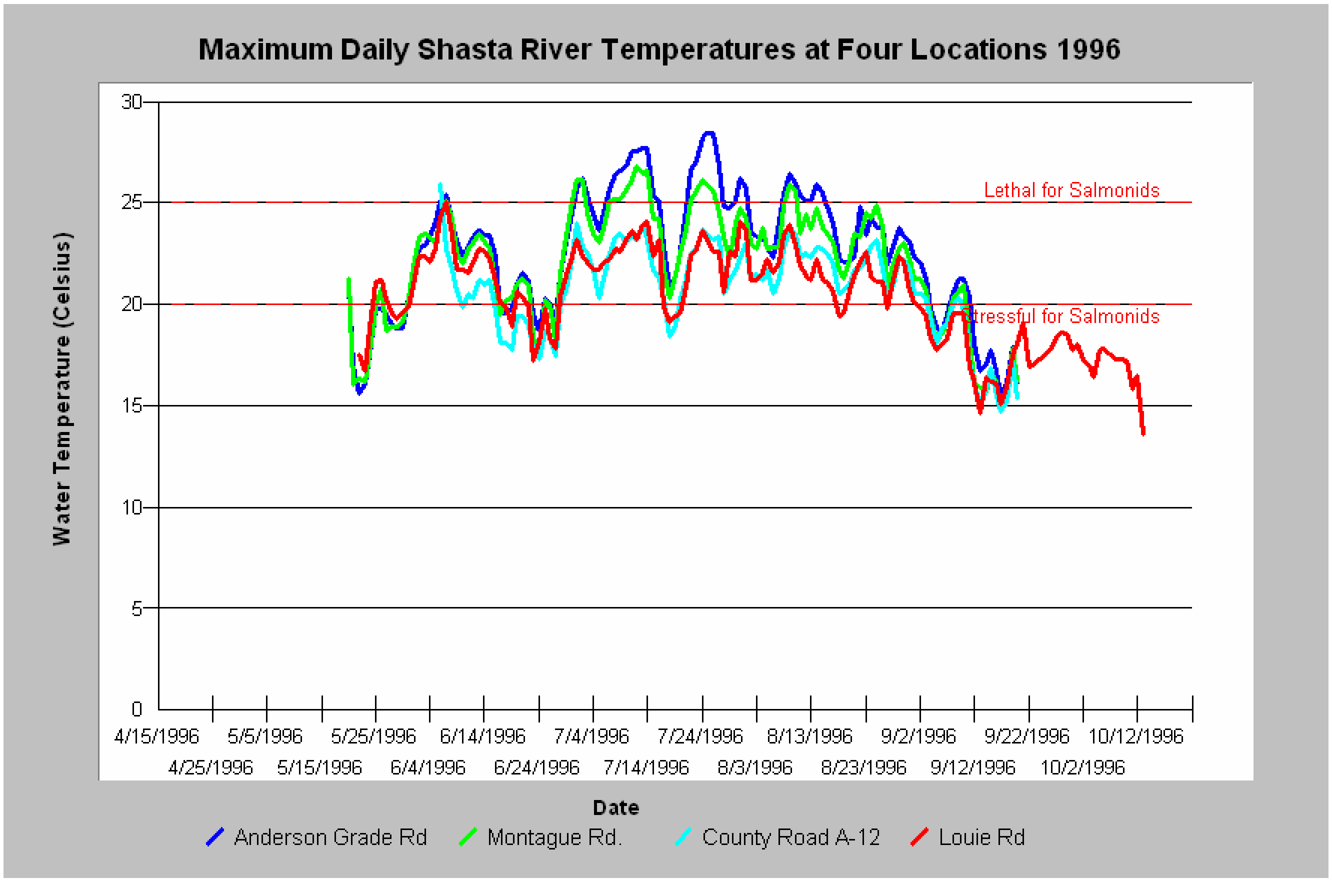

Figure 8. Maximum daily water temperatures are displayed above for the Shasta River at four locations from May through October of 1996. Temperatures exceeded stressful or lethal levels at all locations from June through August. Chart from KRIS V 3.0 and data from CDFG.

Lower mainstem Shasta River water temperatures and water quality have been measured by the U.S. Fish and Wildlife Service, the U.S. Bureau of Reclamation and USGS. Figure 9 shows minimum, average and maximum water temperature of the Shasta River just above its convergence with the Klamath River from May to October 2001. Even minimum temperatures exceeded stressful levels for salmonids and maximums often exceeded lethal levels. Fall chinook salmon use the lower Shasta River to spawn and the U.S. EPA (2003) defines the maximum temperature suitable for spawning as 13^{O} C or less as a seven day floating average. Water temperatures were above optimal for salmon spawning and egg incubation through the first week in October.

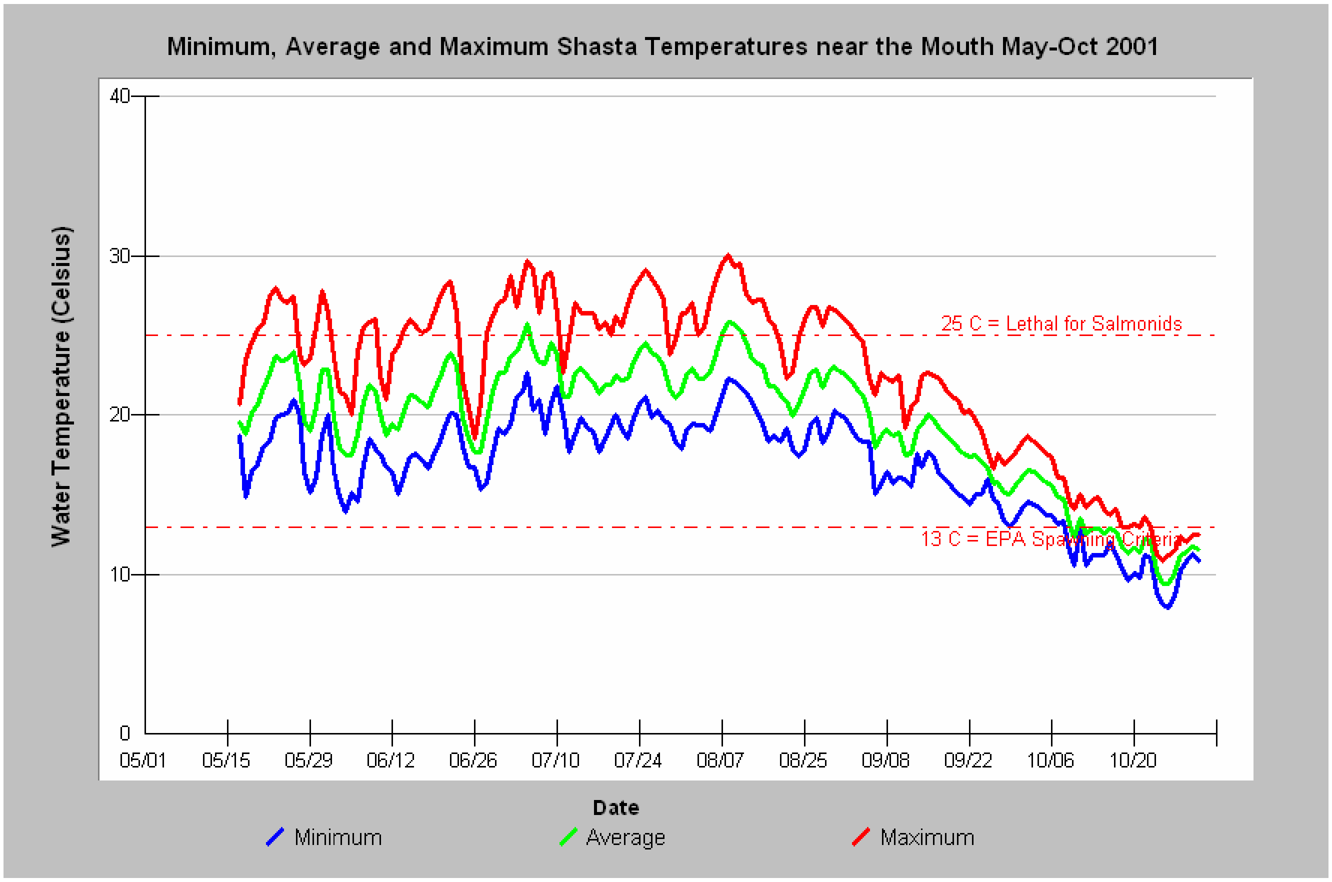

Figure 9. Minimum, average and maximum daily water temperature of the Shasta River above its convergence with the Klamath River in 2001. Chart from KRIS V 3.0 and data from USFWS.

Water temperatures patterns in the lower Shasta River in 2004 (Figure 10) showed a very similar pattern to those of 2001 despite higher flow levels. This indicates that other measures called for in the Shasta River TMDL such as improving riparian shade and reducing warm agricultural tail water contributions will also be necessary to reduce water temperatures and restore beneficial uses. Maximum water temperatures exceeded lethal levels for months at a time in 2004 and even minimum water temperatures failed to drop below stressful levels for much of June, July and August. Although water temperatures dropped with the end of irrigation season on October 1, they still were greater than optimal for salmon spawning until the second week in October.

Major increases in diversion of both surface and groundwater have greatly changed the temperature regime of the Shasta River. Mack (1958) measured flow in Big Springs Creek of 103 cfs, which is very similar to the measurements taken by the California Department of Public Works (1925) for the *Shasta River Adjudication* (CDPW, 1932). This spring source was at optimal temperatures for salmonid rearing and the California Department of Water Resources (1981) found that it was also the reach of the Shasta River with the highest spawning use. Kier Associates (1999) noted that increased ground water pumping and additional surface diversions in Big Springs and Little Springs Creeks were depleting surface flows and reducing salmonid carrying capacity.

The NRC (2003) report characterized the Big Springs area before increased groundwater extraction and surface diversion and its potential benefit to Shasta River water quality as follows:

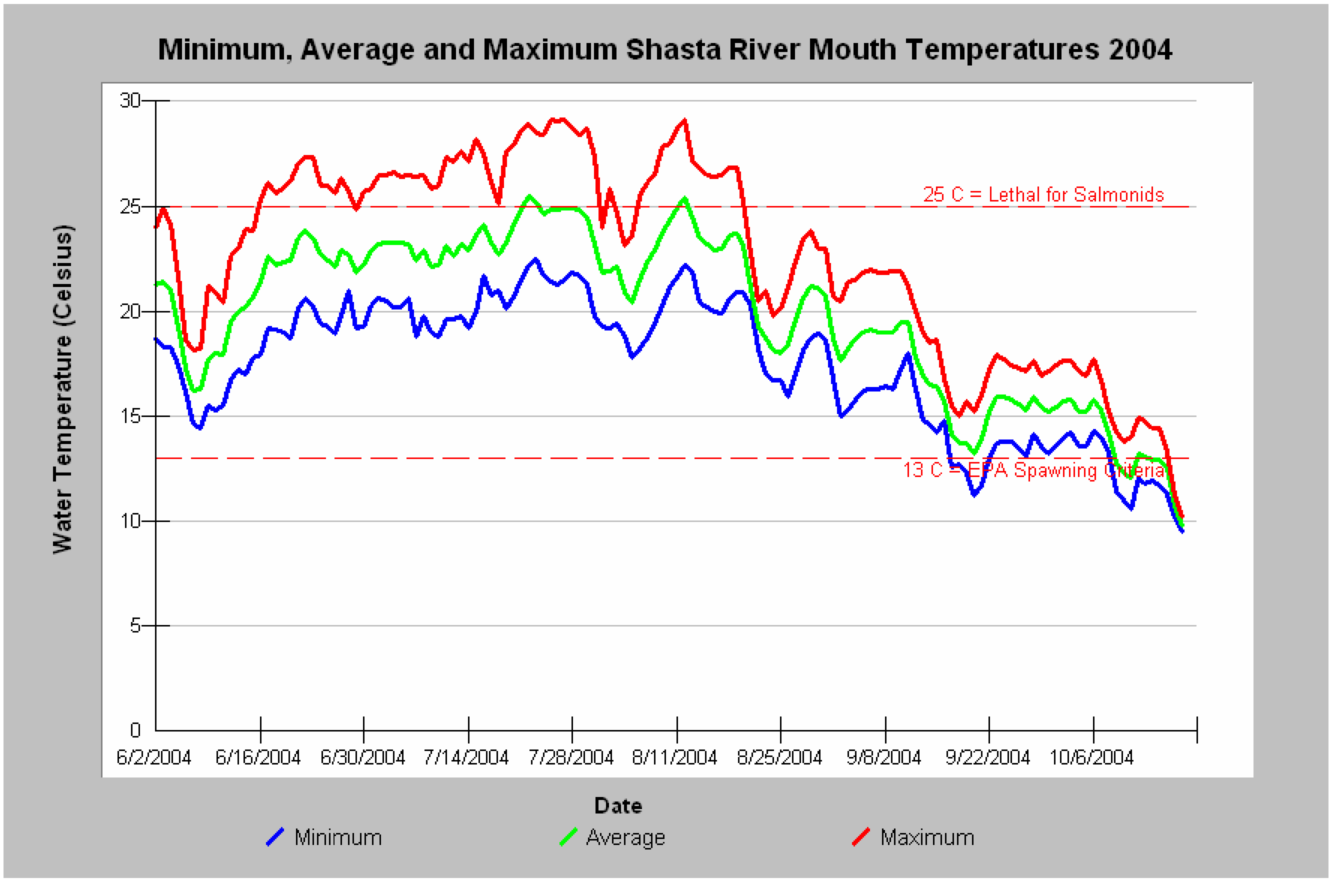

Figure 10. Minimum, average and maximum daily water temperature of the Shasta River above its convergence with the Klamath River in 2004. Data from USFWS.

> "Flows of that magnitude would have had very short transit times (less than 1 day to the Klamath River), thus maintaining cool water throughout summer for the entire river. Consistency of flow and cool summer water were the principal reasons that the Shasta River was historically highly productive of salmonids."

Thermal infrared radar (TIR) imagery captured by Watershed Sciences (2003) illustrates how flow depletion affects water temperature (Figure 11). The image shows water temperatures below 20 ^{O} C only immediately downstream of Big Springs Lake. Instead of having water temperatures sufficiently cool to support coho, Figure 12 shows that Big Springs Creek warms to 21.7 ^{O} C (Watershed Sciences, 2003).

The reach of the Shasta River below Dwinnell Dam was formerly cooled significantly by Big Springs Creek (CDWR, 1981; CH2M Hill, 1985; Kier Associates, 1991). Figure 11 shows that the Shasta River and Big Springs Creek were essentially the same temperature on July 27, 2003, when the TIR data were collected. Consequently, flow depletion in the Big Springs Creek drainage decreases thermal buffering of the mainstem Shasta River and decreases suitability and carrying capacity for salmonids.

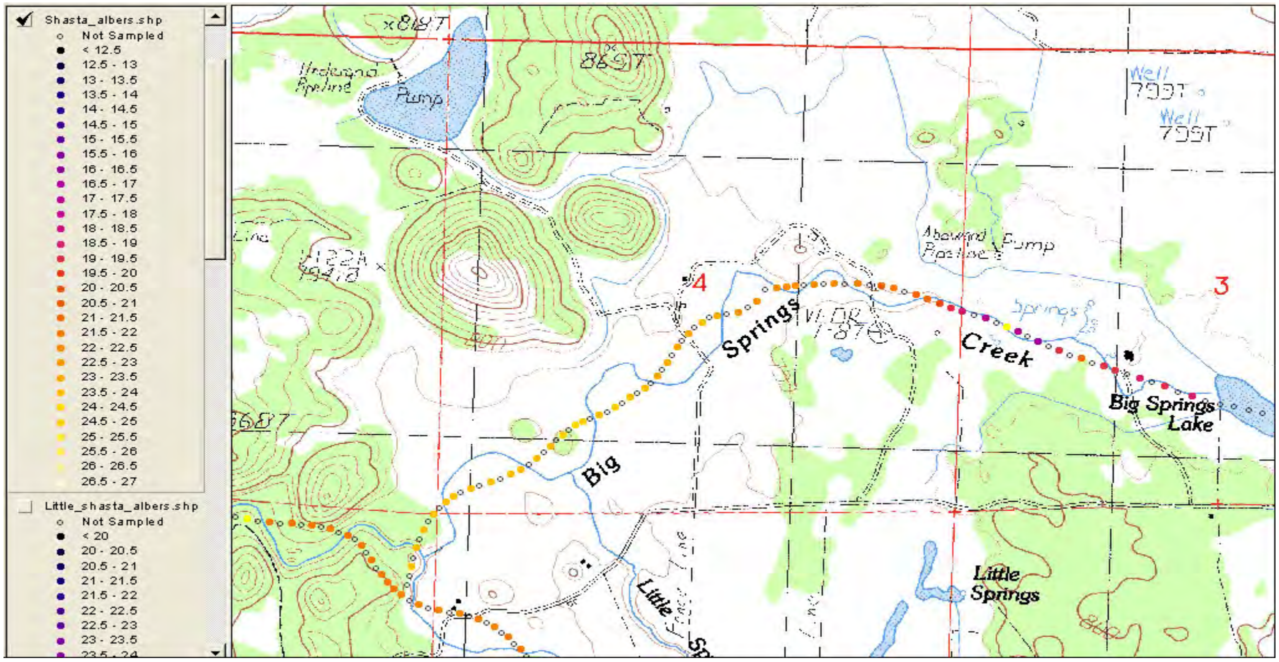

Figure 11. Thermal infrared radar (TIR) map of Big Springs Creek shows that the stream warms rapidly as a result of diversion and now is too warm for optimal salmonid rearing. Data from Watershed Sciences (2003) provided as GIS by NCRWQCB staff.

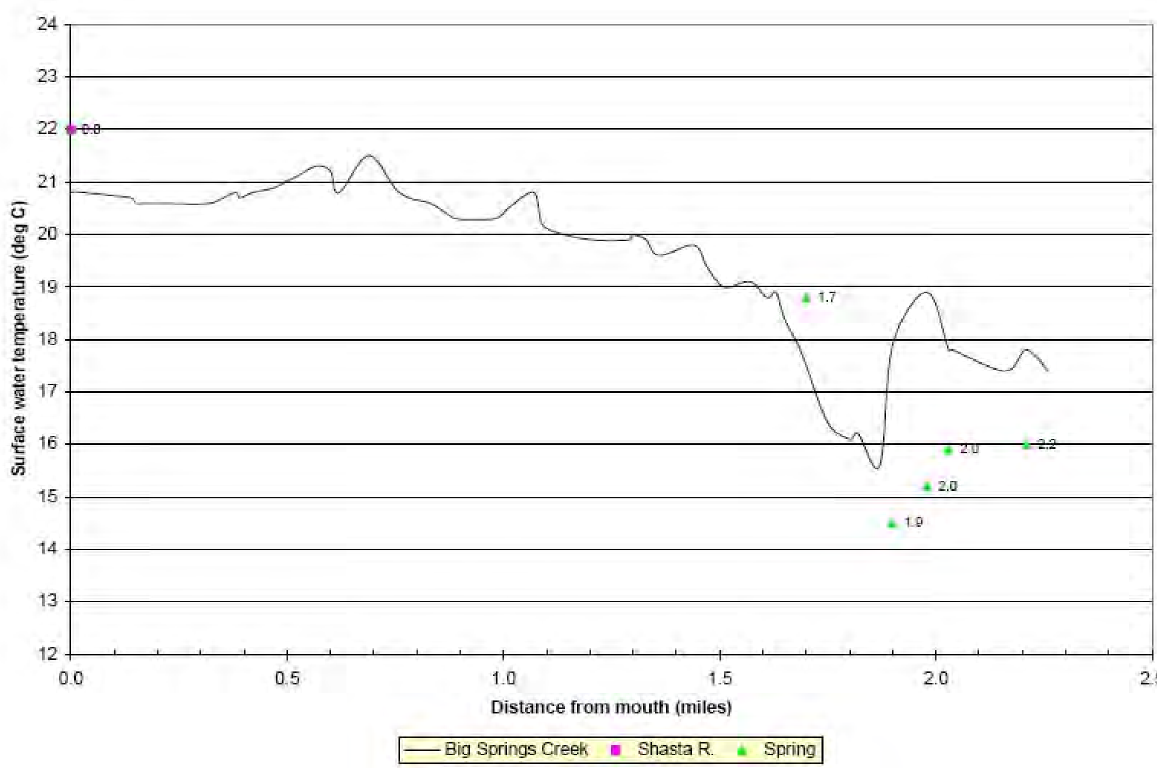

Figure 12. Temperature profile of Big Springs Creek by stream mile according to TIR data. Taken from Watershed Sciences (2003) where it appears as Figure 25.

Parks Creek springs create reaches with temperatures somewhat suitable for salmonids (22 ^{O} C), but irrigation diversions in the lower reach depicted in Figure 13 cause the stream to go dry (Watershed Sciences, 2003). TIR data show Parks Creek temperatures of nearly 30 ^{O} C as it meets the Shasta River. Warm water below the dry reach is likely a result of agricultural return water. Parks Creek could serve as a refugia in combination with Big Springs Creek, if flows were restored (see Recovering Pacific Salmon).

The Shasta River itself has dry reaches below Dwinnell Dam (Figure 13) and water temperatures in flowing reaches largely unsuitable for salmonids. Discussions below on nutrient enrichment cover other impairments to water quality caused by tail water releases from the reservoir.

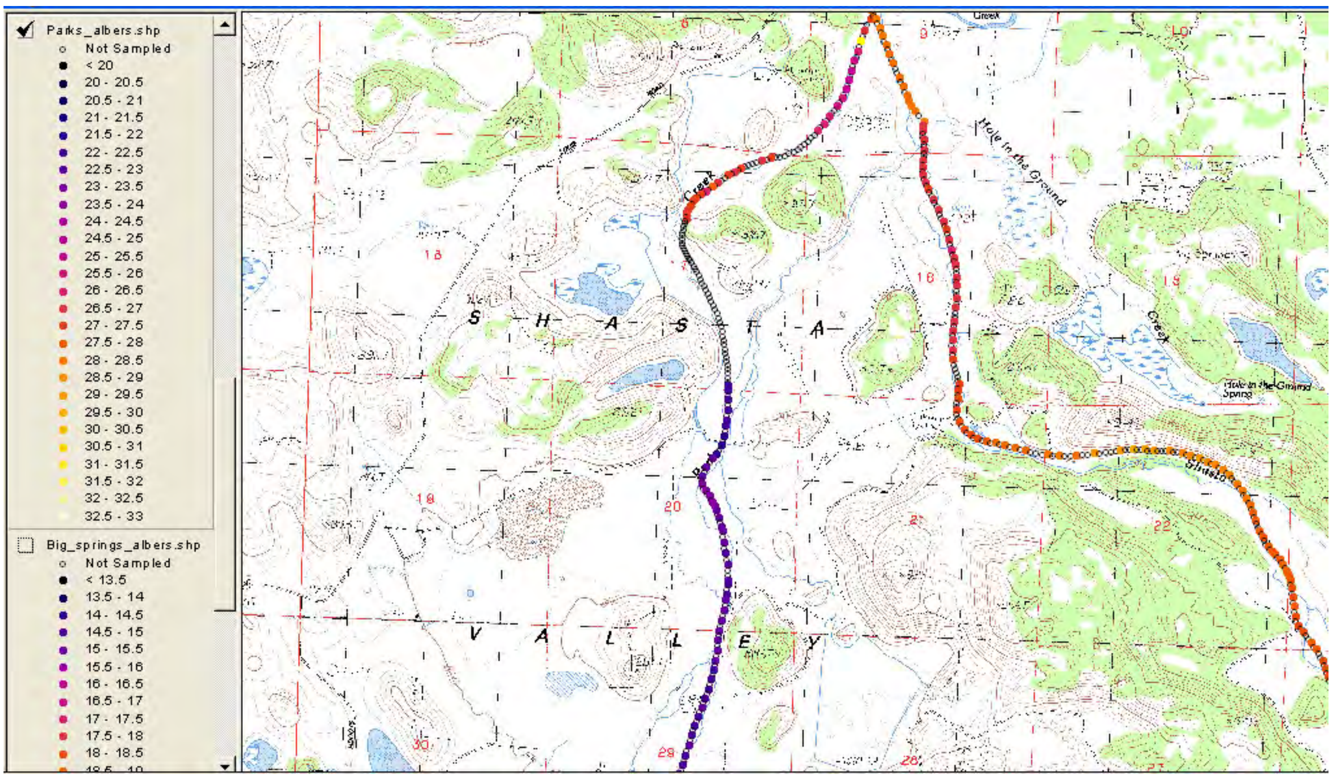

Figure 13. Thermal infrared radar (TIR) map of Parks Creek and the mainstem Shasta River downstream of Dwinnell Reservoir show little habitat with temperatures cool enough to support salmonids. Gray areas are dewatered. Data from Watershed Sciences (2003) provided as GIS by NCRWQCB staff.

The upstream extent of the Parks Creek TIR data from Watershed Sciences (2003) actually begins in a reach already impacted by flow depletion. The China Ditch is a major diversion that routes water down the west side of the Shasta Valley from Parks Creek just below where it emerges from forest lands. This ditch was built to supply water to Yreka and for mining activities but now supplies agricultural water to land south of Gazelle. Figure 14 from Watershed Sciences (2003) shows lethal water temperature conditions for salmonids (> 30 ^{O} C) at the top of the survey reach as a result of low flows. Dramatic cooling is as a result of springs, but diversion dries up Parks Creek just over two miles upstream of its convergence with the Shasta River.

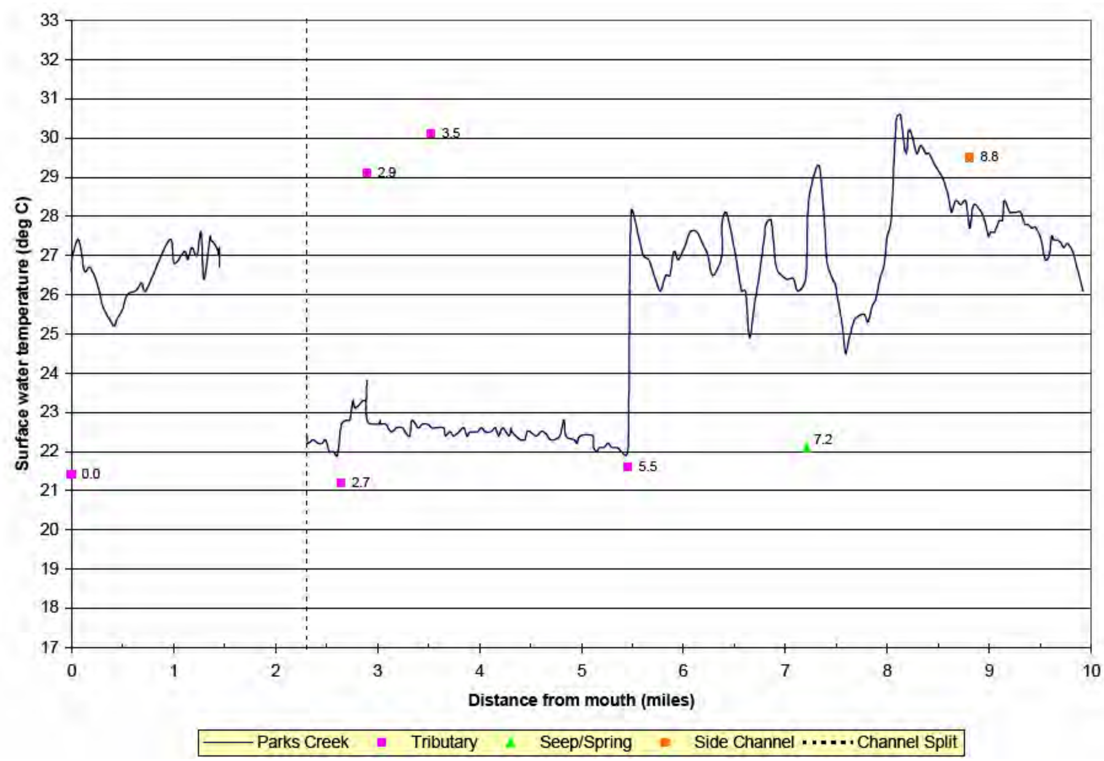

Figure 14. This temperature profile of Parks Creek shows that water temperatures are already elevated at the top of the reach as a result of flow depletion by upstream diversions. Spring flows feed the stream above river mile 5 (RM 5), but diversions dry the channel just above river mile 2 (RM 2.3). From Watershed Sciences (2003) where it appears as Figure 24.

Nutrient Pollution Problems Increase With Decreasing Flows

Nutrients themselves do not harm Pacific salmon, but as they stimulate excessive algae growth, dissolved oxygen decreases while pH and dissolved ammonia increase and may cause stress or mortality (U.S. EPA, 2000). Low flows in the Shasta River allow build up of aquatic plants and promote warming that stimulates plant growth. Gwynne (1993) noted that lack of winter flood peaks because of Dwinnell Dam also inhibited flushing of nutrients and promoted high biological activity in the Shasta River.

pH: High maximum pH and high diurnal ranges of pH are often symptomatic of nutrient enrichment and excessive growth of aquatic plants, which makes pH a highly useful index of photosynthesis. The *Shasta River TMDL* failed to note that the river regularly exceeds NCRWQCB *Basin Plan* (2002) standards for pH, which is a maximum of 8.5. Evidence from laboratory studies indicates that any pH over 8.5 is stressful to salmonids and 9.6 is lethal (Wilkie and Wood, 1995). Studies show that as water reaches a pH of 9.5, salmonids are acutely stressed and use substantial energy to maintain pH balance in their bloodstream (Wilkie and Wood, 1995), while pH in the range of 6.0 to 8.0 is normative.

The mouth of the Shasta River has been monitored with automated water quality probes since 2000 and shows that maximum pH typically exceeds 8.5 for most days from June through September (Figure 15). Pulses of extreme pH occurred in seasons of downstream juvenile migration (June) and during periods when adult Chinook salmon may be holding (September) in the lower Shasta River or downstream of the mouth in the Klamath River. The early spike in pH to 9.5 is of particular concern because of the findings of Goldman and Horne (1983) that under these conditions nearly all ammonium ions would be converted to dissolved ammonia, which is highly toxic to salmonids (U.S. EPA, 1986; 1999).

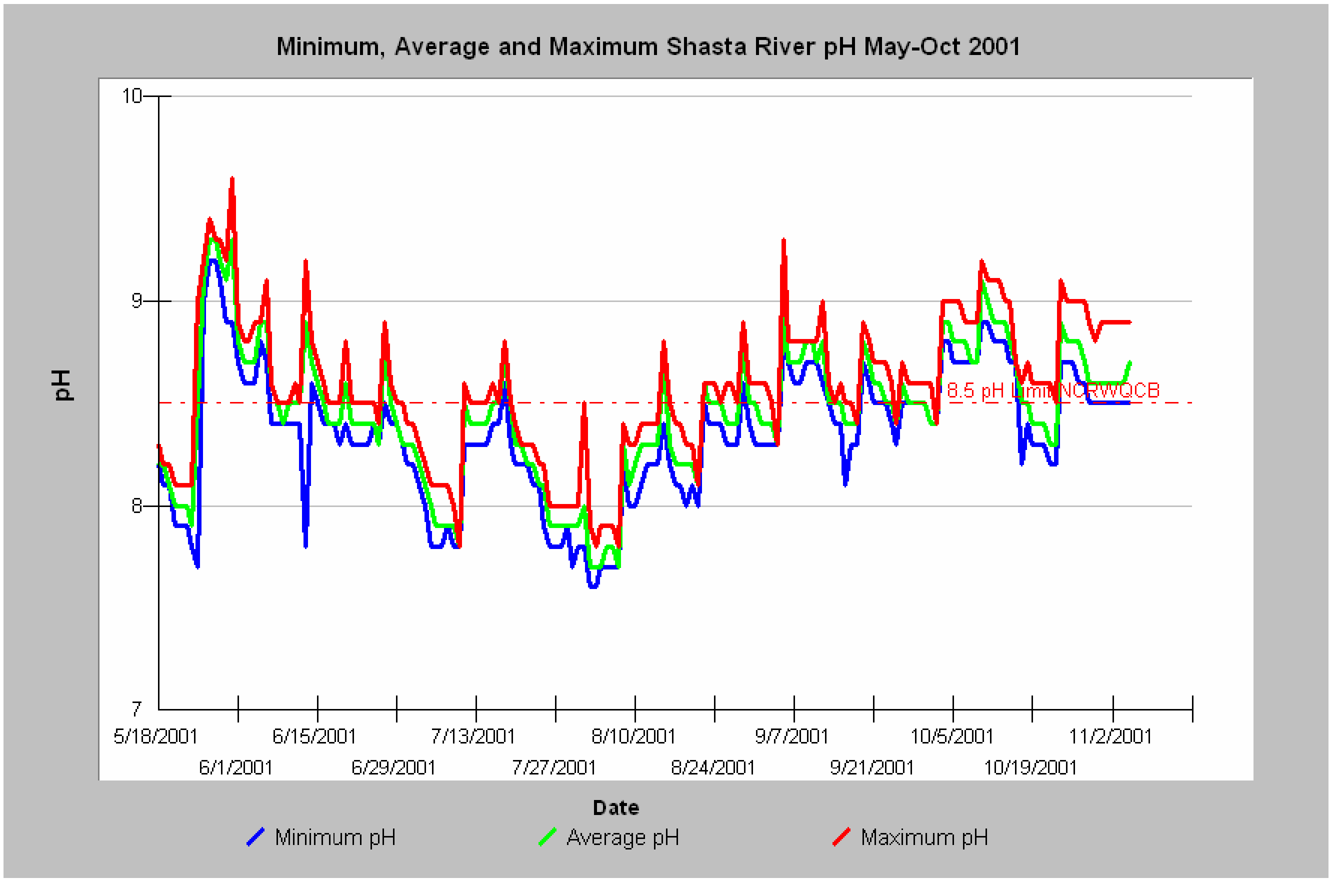

Figure 15. This chart shows pH for the Shasta River near its mouth for May through November 2001 with a reference value showing the NCRWQCB (2002) maximum pH *Basin Plan* standard of 8.5. Data are from the *Klamath TMDL* database, with data originally collected by the U.S. Fish and Wildlife Service.

The minimum, average and maximum pH data for the same lower Shasta River location in 2004 is displayed as Figure 16 and shows a more moderate fluctuation, but with values still consistently above the NCRWQCB *Basin Plan* (2002) standard of 8.5. The maximum pH was once again within stressful ranges for salmonids (>8.5) from June through October.

There are presently no data for dissolved ammonia in the Shasta River, but it is likely that such a problem exists because conditions of high water temperature and high pH coincide and agricultural tail waters are high in nitrogenous waste. Goldman and Horne (1983) show a logarithmic increase in conversion of ammonium ions to dissolved ammonia as pH increases above 8.0 and water temperatures exceed 25 C. (Figure 17). TMDL implementation should involve collecting further data on presence of dissolved ammonia and monitoring the abatement of this water quality impairment if it is found to exist. Dissolved ammonia is toxic to salmonids at levels as low as 0.025 mg/l (U.S. EPA, 1986).

Dissolved Oxygen (D.O.): The Shasta River TMDL clearly shows that tail water returns are increasing nitrogen levels, which increases growth of aquatic plants. Nocturnal respiration of aquatic plants is by far the largest contributor to dissolved oxygen demand in the Shasta River and creates major D.O. sags into ranges that are stressful for salmonids. Juvenile salmonids avoid areas with a D.O. of less than 5 mg/l, have impaired swimming ability at levels below 7.0 mg/l, and die at levels lower than 3.7 mg/l (White, 2002). Gwynne (1993) showed a pattern of elevated Shasta River D.O. during the day and depressed D.O. at night, indicative of high photosynthetic activity (Figure 18) indicating major problems for salmonid suitability in mainstem reaches throughout the Shasta Valley (Figure 19).

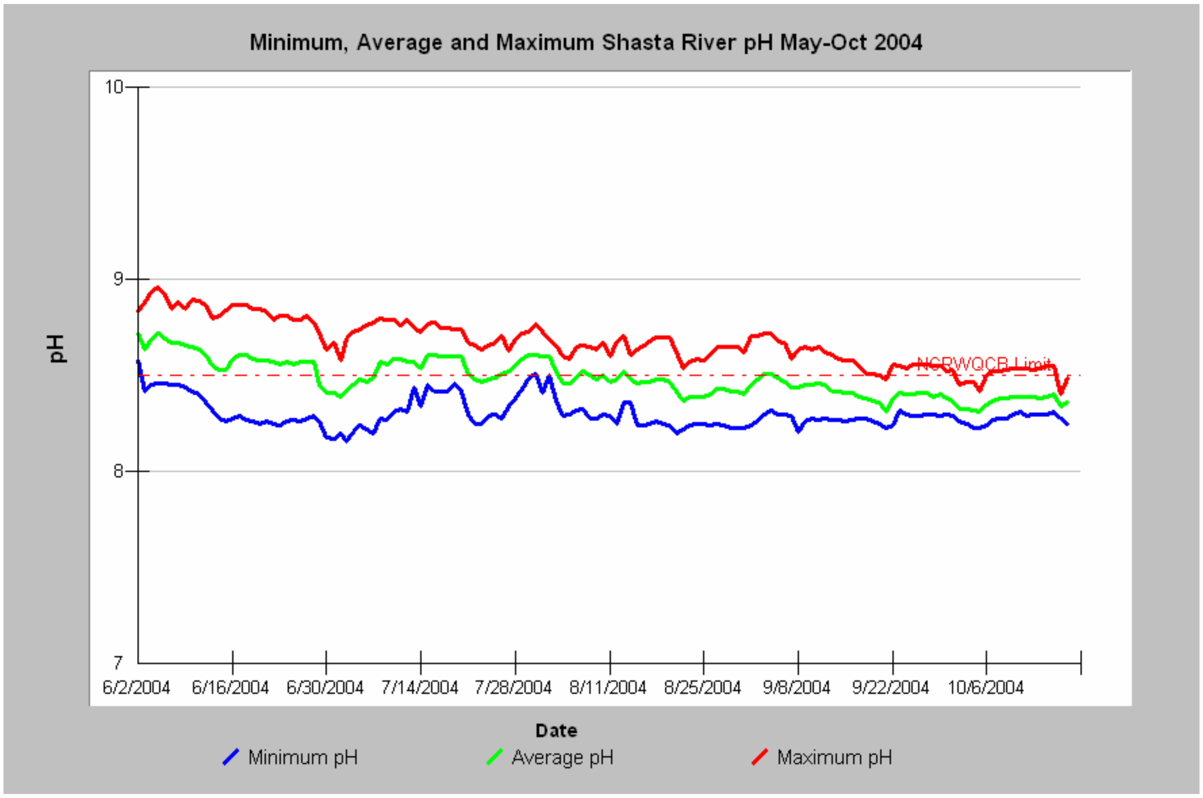

Figure 16. This chart shows pH for the Shasta River near its mouth for May through November 2004 with a reference values showing the NCRWQCB (2002) maximum pH *Basin Plan* standard of 8.5. Data are from U.S. Fish and Wildlife Service.

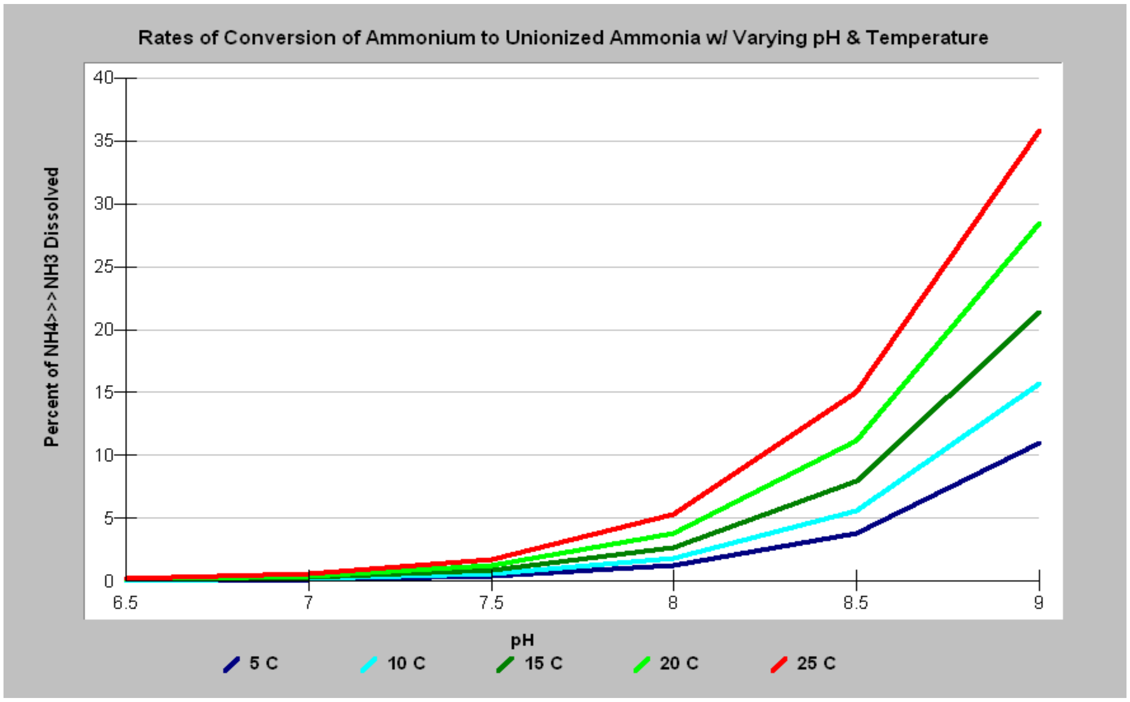

Figure 17. Chart showing the percent conversion of ammonium to dissolved ammonia with increasing pH and water temperature. Data from Goldman and Horne (1983).

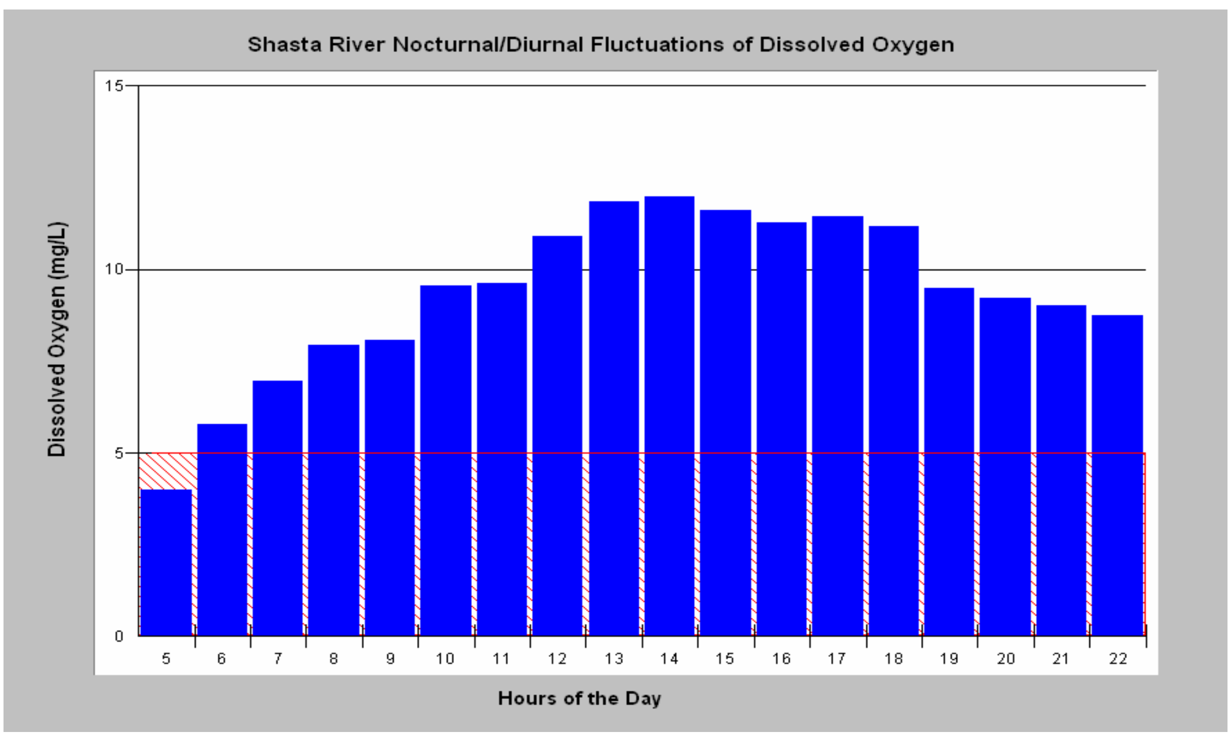

Figure 18. The chart above is based on data from Gwynne (1993) and shows supersaturated D.O. levels during the day but depressed D.O. before sunrise.

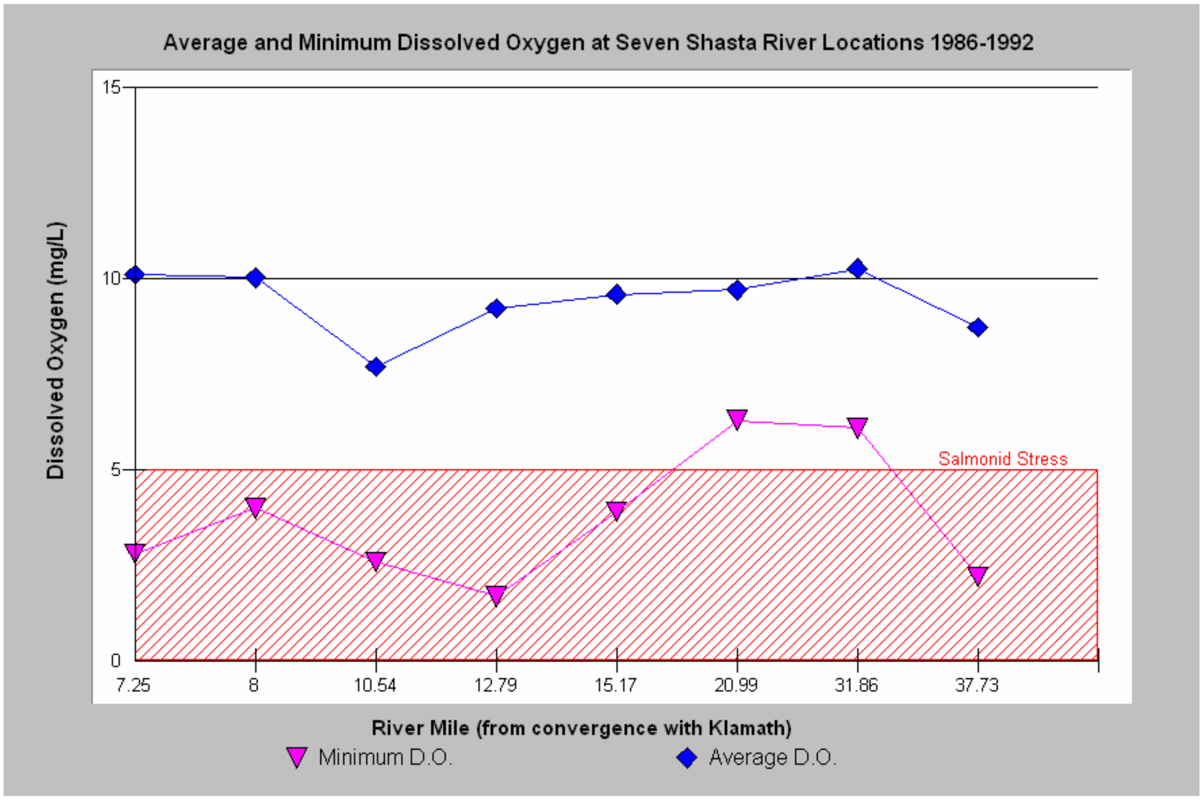

Figure 19. Average and minimum dissolved oxygen levels measured by Gwynne (1993) show that levels fell below those required for salmonid rearing at most locations. Chart from KRIS V 3.0.

Minimum dissolved oxygen readings shown in Figure 19 are the minimum of all readings for each station during the entire period of record (1986-1992). Acute problems with D.O. levels occur both in the upper Shasta Valley, just below Dwinnell Dam (RM 37.73), and in the reach from the Montague-Grenada Road (RM 15.17) to Highway 263 (RM 7.25). Dissolved oxygen problems may be moderated in the reach from Louie Road (RM 31.86) to below County Road A-12 (RM 20.99) by increased flows and cooler water from springs.

Continuous recorders placed near the mouth of the Shasta River have also captured dissolved oxygen data (Figure 20-21). Although this data shows that dissolved oxygen does not drop to levels lethal for salmonid juveniles, minimum and average levels often fall to stressful levels.

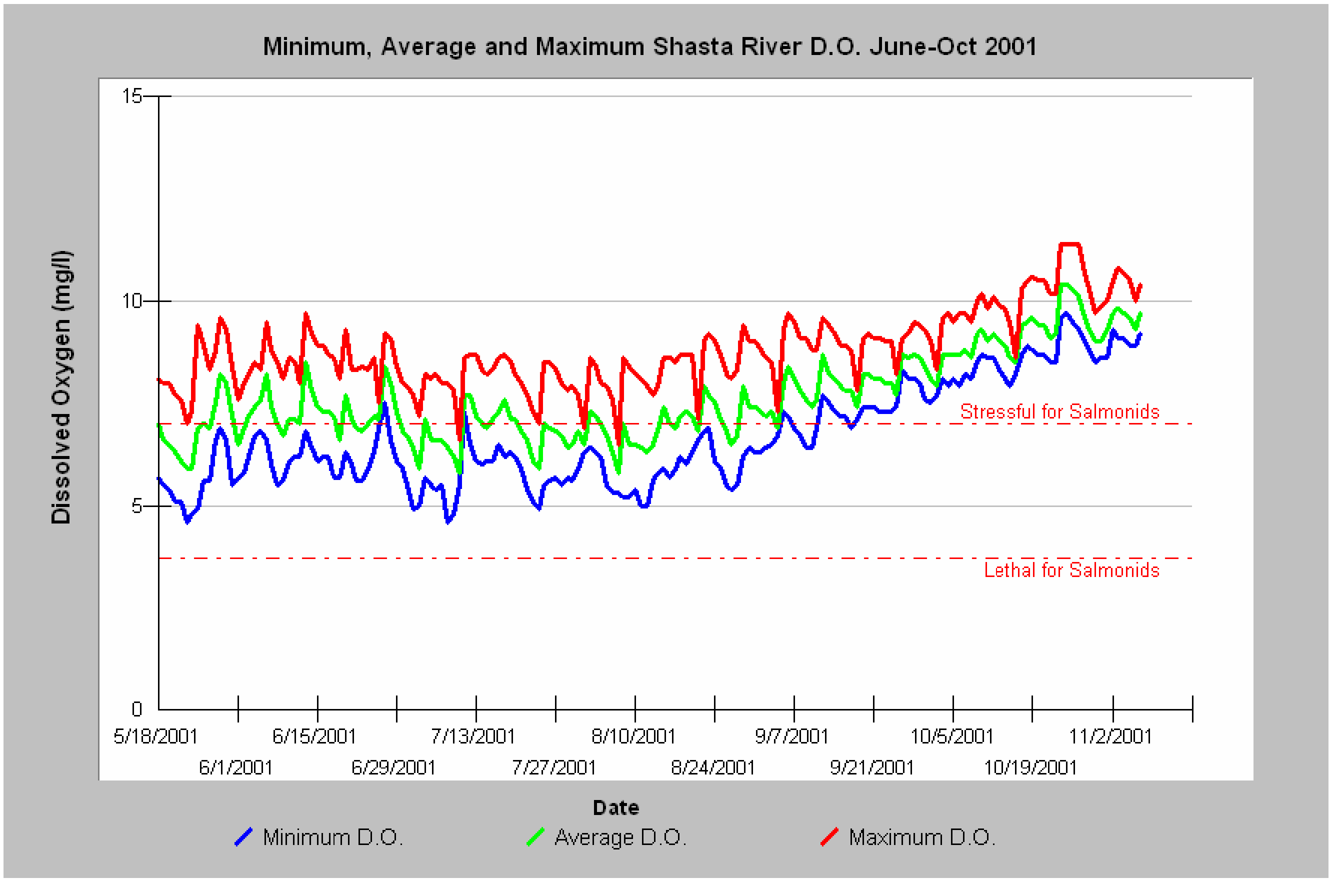

Figure 20. Minimum, average and maximum D.O. levels from May through November 2001 are displayed in the chart above indicating high levels of photosynthetic activity and nocturnal depressions likely to stress juvenile salmonids.

Although minimum dissolved oxygen levels in 2004 in the lower Shasta River (Figure 21) were slightly higher than in 2001, they still fell into stressful ranges for salmonids. White (2002) points out that salmonid egg incubation requires a dissolved oxygen of greater than 6.5 mg/l in the gravel matrix, which would require surface water D.O. of greater than 8.0 mg/l. Both 2001 and 2004 data suggest that D.O. sags are abated by October 1, although there was a brief late season depression in the spawning period in 2004.

Increased winter flows would increase scour and decrease embedded organic material that partially fuel nutrient enrichment. Increased flows of cold, clean spring water recommended by the Shasta TMDL would decrease water temperatures, decrease transit time and result in decreased problems with D.O.

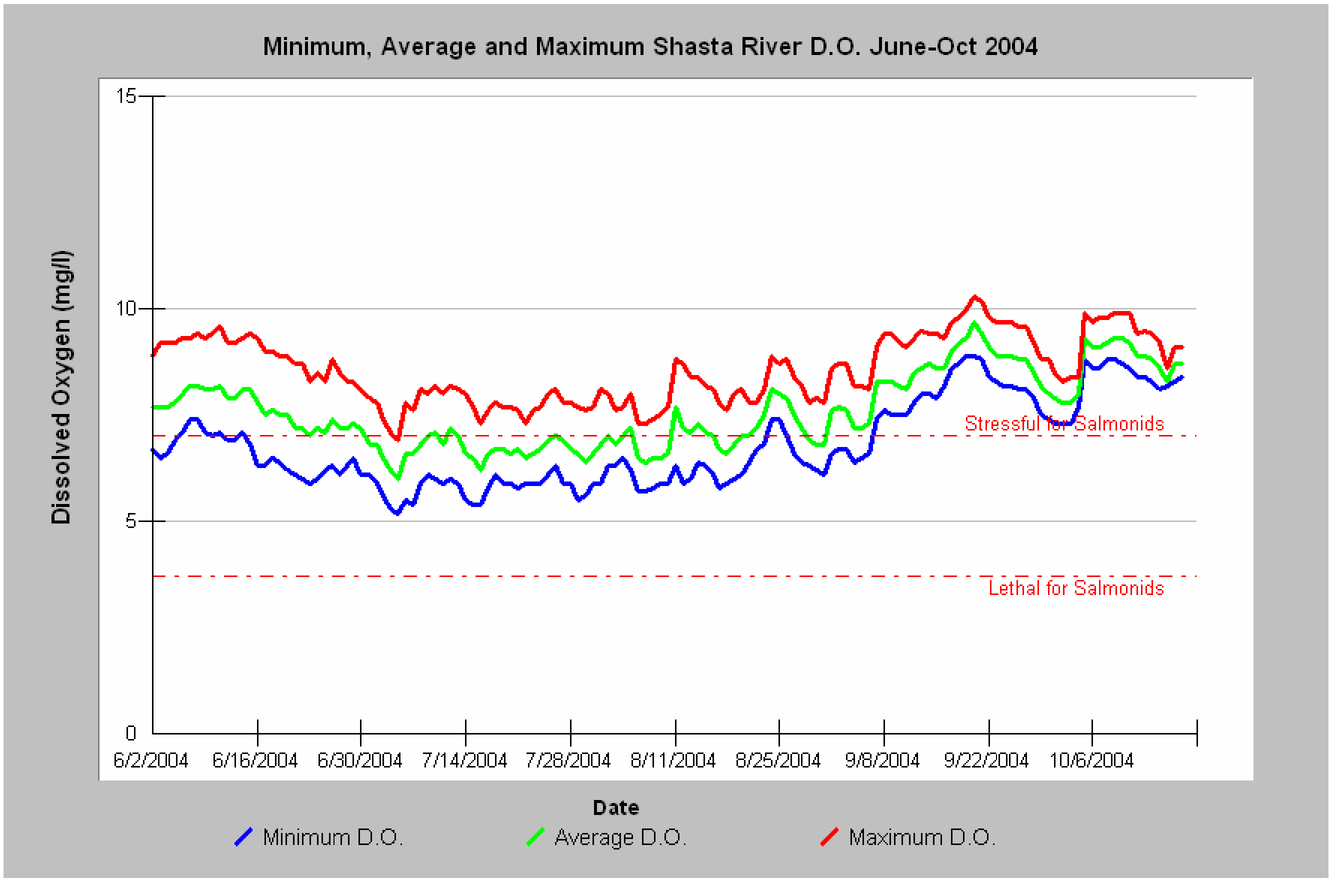

Figure 21. Minimum, average and maximum D.O. levels from June through October 2004 are displayed in the chart above indicating high levels of photosynthetic activity and nocturnal depressions likely to stress juvenile salmonids. Data from USFWS.

Shasta River Pollution and Klamath River Cumulative Watershed Effects

Studies related to Klamath Hydroelectric Project relicensing have demonstrated extreme problems with nutrient pollution in the mainstem Klamath River (Kier Associates, 2004; 2006). Nitrogen fixing algae in project reservoirs cause nutrient enrichment of reaches just below Iron Gate Dam. As algae beds below Iron Gate decay or shed segments, nutrients are transferred downstream where they trigger periphyton blooms in what is known as "nutrient spiraling." Acute salmonid stress from high pH, temperature and ammonia in combination with depressed D.O. result in immunosuppression in juvenile salmonids and massive annual die-offs. The very warm and nutrient-rich waters of the Shasta River add to these mainstem Klamath River problems. McIntosh and Li (1998) used forward-looking infrared radar (FLIR) to characterize the pattern of temperature problems in the mainstem Klamath River. Figure 22 shows a July 1998 FLIR image of the Shasta River joining the Klamath River. The thermal signature indicates that the Shasta River is approximately 29^{O} C and has a warming influence on the mainstem Klamath.

The *Shasta TMDL* should have pointed out that the Shasta River has the potential in a restored condition to buffer mainstem Klamath River water temperatures and provide a refugia for juvenile salmonids in its lower reaches. In its present condition, however, it exacerbates nutrient and temperature pollution instead of assisting in abating these problems in the mainstem Klamath River.

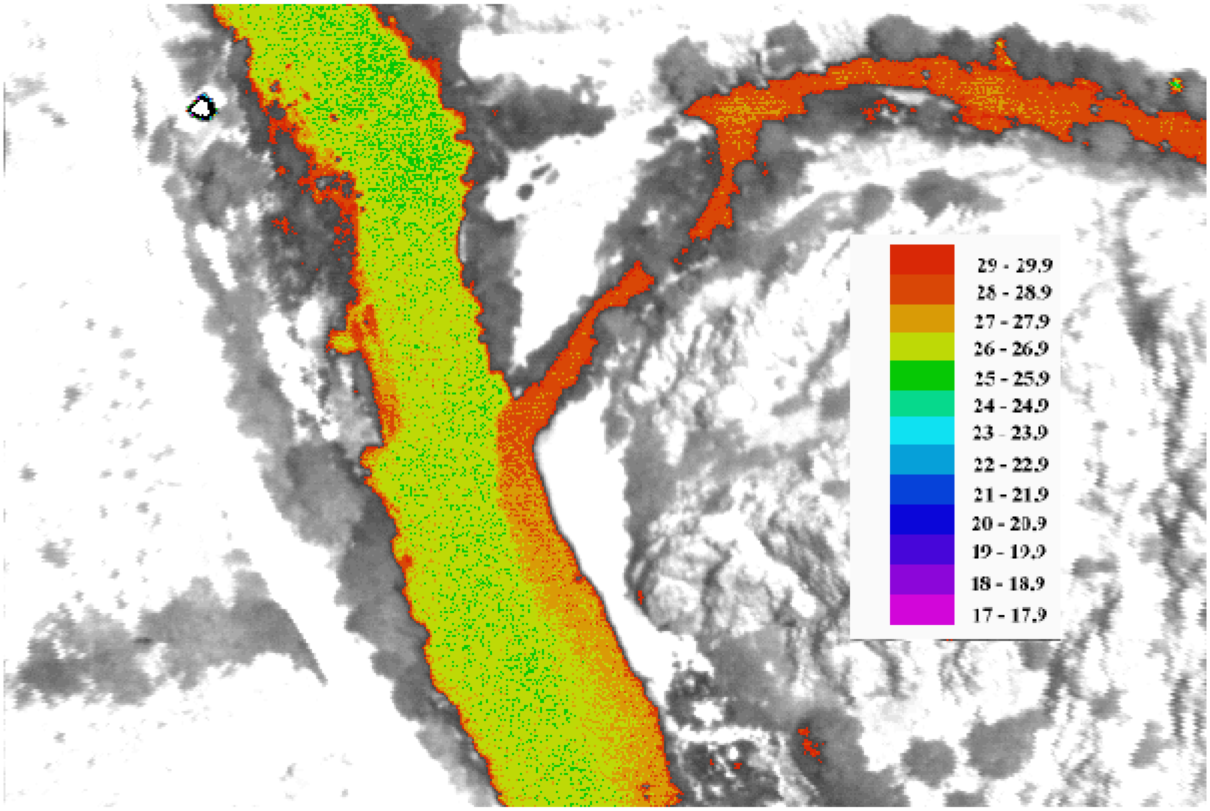

Figure 22. Thermal Forward Looking Infrared Radar Image (FLIR) showing the confluence of the Klamath River (flowing from the top of the image to the bottom of the image) and the Shasta River (flowing right to left in the image). The Shasta River is approximately 29 degrees C. and a warm water plume is observed in the Klamath River below. From McIntosh and Li (July 1998).

Shasta River Pacific Salmon Populations at Risk of Extinction

The *Shasta TMDL* goal of remediating water quality problems over a 40-year period ignores cycles of Pacific salmon productivity attendant with ocean conditions and climate. The Pacific Decadal Oscillation (PDO) cycle causes major shifts in ocean productivity and shifts from favorable for salmon to unfavorable conditions approximately every 25 years off the coast of California, Oregon and Washington. Good ocean conditions are linked to wetter weather cycles and prevailed from 1900-1925 and 1950-1975 and switched to favorable again in 1995 (Hare et al., 1999). Poor ocean productivity and dry on-land cycles from 1925-1950 and 1976-1995 created very adverse conditions for salmon. If freshwater habitat in the Shasta River basin is not improved by the time ocean conditions change back to less favorable and we enter a drier climatic cycle sometime between 2015 and 2025, major salmonid stock losses are likely to result (Collison et al, 2003). Likewise, any long-term TMDL program must take into account long-term climate cycle stressors in a precautionary approach to such trends. Populations must not already be stressed under what are currently favorable conditions, or these stresses will lead to extinctions when such cyclical conditions change, as they inevitably must, for the worse.

Coho salmon populations in the Shasta River are also at very low levels as indicated by downstream migrant trap data (Figure 23), with between 212-747 juveniles captured during several months of trapping from 2001-2003 (Chesney 2001; 2002; Chesney and Yokel, 2003). The requirement of juvenile coho for water temperatures under 16.8^{O} C makes it almost impossible for this species to survive throughout summer in any reach of the Shasta River. Favorable ocean conditions and more precipitation in most years since 1995 have allowed coho to rebound somewhat, but the population remains at remnant levels and is likely to go extinct in the next negative PDO cycle unless Shasta River conditions improve dramatically.

The Shasta River fall chinook population is failing to rebound in the recent favorable PDO cycle despite mostly above average rainfall and mostly favorable ocean conditions (Figure 24).

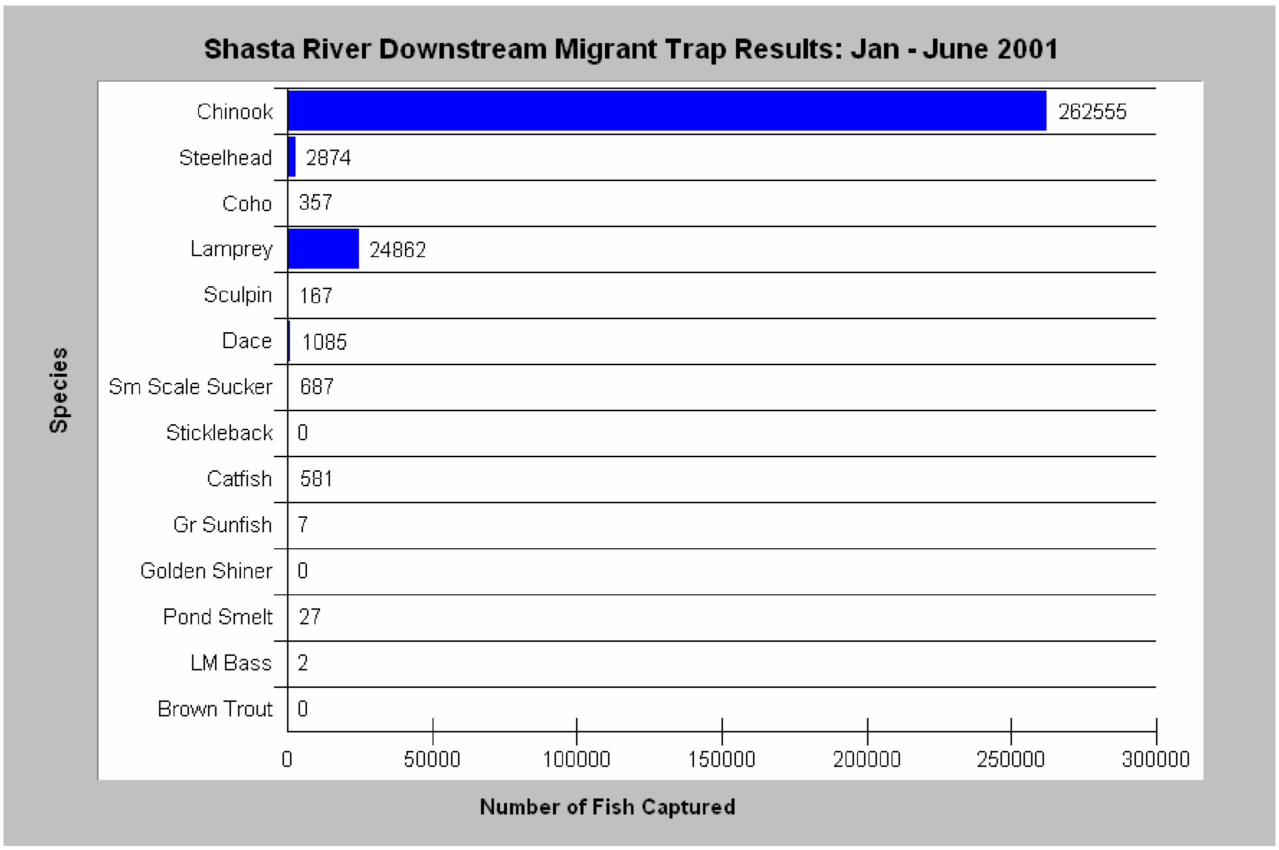

Figure 23. Downstream migrant trap results from the lower Shasta River for the period of January through June 2001 show chinook salmon juveniles to far out number steelhead and coho salmon. Chart from KRIS V 3.0 with data from CDFG.

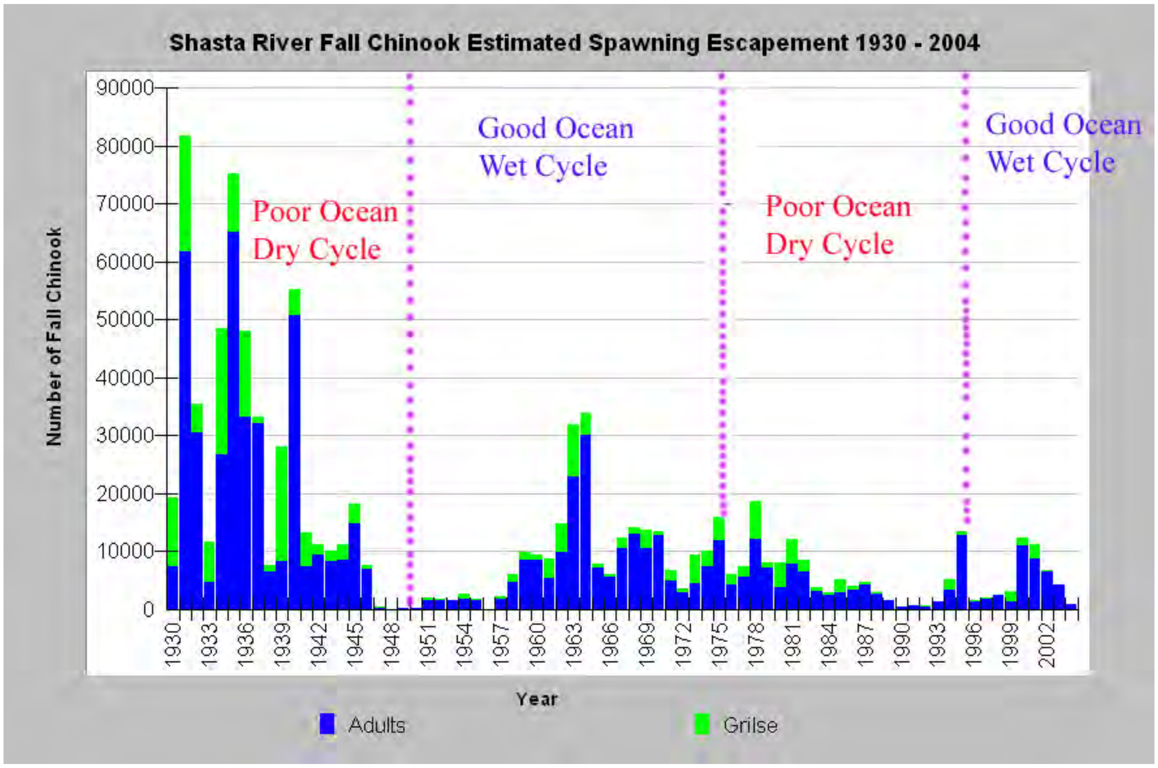

Figure 24. Shasta River Chinook salmon returns from1930 to 2005 are displayed in this chart along with known Pacific Decadal Oscillation cycles (Hare et al., 1999). Data from CDFG.

When long term population trends from the Shasta Racks are analyzed it becomes apparent that each successive positive cycle of the PDO has decreased peak returns and lower minimum returns.

Shasta fall chinook stocks ranged from lows of 533-726 from 1990-1992 during the last dry climatic cycle, a critically low level for maintaining genetic diversity (Gilpin and Soule, 1990). Consequently, if flow and water quality conditions are not improved for chinook salmon spawning and rearing in the Shasta River before the next switch to less productive ocean conditions and a period of less precipitation, there is a high risk that this important chinook salmon stock could be lost. The final *Shasta TMDL* should cite the findings of Hare et al. (1999) and use it as a reason for urgency to move forward on a TMDL Implementation Plan.

Steps Necessary for Salmon Recovery

This paper has demonstrated conclusively that low flow conditions resulting from agricultural diversions in the Shasta River compound water quality problems and that temperature impairment and nutrient pollution will not be abated unless water flows are increased. The *Shasta River TMDL* actions to restore Pacific salmon are dependent on parallel processes currently underway such as the Shasta River incidental take permit (ITP) for coho salmon (SVRCD, in review) and the California Department of Fish and Game (2004) *Coho Recovery Strategy*. These processes have very long time frames for action, often rely on voluntary measures and may achieve incremental improvements that are not sufficient for recovery of salmon and steelhead in a meaningful time frame.

Bradbury et al. (1995) provide one of the most scientifically valid approaches to restoring Pacific salmon populations and stress protecting the best habitats available as a priority. The NRC (2003) report points out that loss of cool water flows due to increased groundwater and surface water diversion in the Big Springs Creek drainage reduced the carrying capacity of this important salmonid spawning and rearing area. U.S. EPA (2003) cites the need to protect and restore well distributed refugia when other factors confound meeting temperature requirements of salmonids in mainstem environments. Restoration of cold water flows in Big Springs Creek should, therefore, be of the highest priority.

Lower Parks Creek converges with the Shasta River very near Big Springs Creek. Kier Associates (1999) suggested restoring flows and improving riparian conditions in lower Parks Creek could provide a core refuge area in the heart of the Shasta Valley. Reconnecting Parks Creek to the Shasta River would also help improve the supply of spawning gravels to the mainstem.

The NRC (2003) report recommends consideration of removal of Dwinnell Dam because the Shasta River will become increasingly important to the Klamath River as global warming advances, because Mount Shasta will be one of the few places where snowfall increases are likely in the entire West. The *Shasta TMDL* approach of attempting to mitigate water quality problems in Dwinnell Reservoir so that water quality could be improved and tail water flows augmented is not realistic or practical. The reservoir has the same suite of problems as Klamath Hydroelectric Project impoundments and only decommissioning can lead to substantial abatement of water quality impairment (Kier Associates, 2006).

Appropriate actions to restore salmon may be challenging because of resistance to changes in water use. Studies may be necessary that prove that unpermitted wells in the Pluto's Cave basalt formation around Big Springs are causing loss of surface flows. The existing adjudication and Watermaster services, which the NRC (2003) report found lacking, may have to be revisited. "The 1932 adjudication of surface waters in the basin, as currently administered, is insufficient to supply the quantity and quality of water necessary to sustain salmonid populations in the basin." The fact that riparian water rights below Dwinnell Dam are not part of adjudication means that the Watermaster has no authority over them. Consequently, increased flows gained through TMDL Implementation or other processes, including efforts by other landowners, could all be confounded by increased riparian diversions elsewhere. Despite these hurdles, the SWRCB must act to increase flows because they are clearly related to water quality impairment and beneficial uses will not be attained in the needed time frame unless this action is taken.

References

Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D. L. Bottom, W.E. Weaver and R. L. Beschta. 1995 Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Pacific Salmon. Published by Pacific Rivers Council, Eugene, OR. 56 pp.

California Department of Public Works Div of Water Rights. 1925. Shasta River Adjudication Proceedings: Report on Water Supply and Use of Water from Shasta River and Tributaries, Siskiyou County. 7/1/1925. On file at Miriam Library at California State University, Chico, CA.

California Department of Public Works. 1932. Appropriation of Water Rights in the Shasta Basin. California Department of Public Works Division of Water Rights, Sacramento, CA.

California Department of Water Resources. 1981. Klamath and Shasta River spawning gravel enhancement study. CDWR, Northern District, Red Bluff, Calif. California

California State Water Resources Control Board. 1980. Scott River Adjudication Decree No. 30662, Superior Court for Siskiyou County. Scott River stream system within California in County of Siskiyou. Sacramento, 152pp.

CH2M Hill. 1985. Klamath River Basin Fisheries Resource Plan. Prepared for the Bureau of Indian Affairs, Department of the Interior, Washington D.C.

Chesney, W. R. 2000. Annual report: Study 3a1- Shasta and Scott River juvenile steelhead trapping, 2000. California Department of Fish and Game, Northern California - North Coast Region, Steelhead Research and Monitoring Program . Yreka, CA. 37 pp.

Chesney, W. R. 2002. Annual report: Shasta and Scott River juvenile salmonid outmigrant study, 2000-2001. Project 2a1. California Department of Fish and Game, Northern California - North Coast Region, Steelhead Research and Monitoring Program . Arcata, CA. 38 pp.

Chesney, W. R. and E. M. Yokel. 2003. Annual report: Shasta and Scott River juvenile salmonid outmigrant study, 2001-2002. Project 2a1. California Department of Fish and Game, Northern California - North Coast Region, Steelhead Research and Monitoring Program . Arcata, CA. 44 pp.

Collison, A., W. Emmingham, F. Everest, W. Hanneberg, R. Martston, D. Tarboton, R. Twiss. 2003. Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks. Independent Science Review Panel performed analysis on retainer to the North Coast Regional water Quality Control Board, Santa Rosa, CA.

Coutant, C. 2005. Peer review comments on the Shasta River TMDL. Performed under contract to the North Coast Regional Water Quality Control Board, Santa Rosa, CA.

Gilpin, M.E. and M.E. Soule. 1990. Minimum Viable Populations: Processes of Species Extinction. In: M. Soule (ed) Conservation Biology: The Science of Scarcity and Diversity University of Michigan Press. pp 19-36.

Goldman, C.R. and A.J. Horne. 1983. Limnology. McGraw-Hill, Inc. New York. 464 pp.

Gwynne, B. 1993. North Investigation of Water Quality Conditions in the Shasta River, Siskiyou County. Interim Report. NCRWQCB, Santa Rosa, CA.

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

Kier Associates. 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program. U.S. Fish and Wildlife Service, Klamath River Fishery Resource Office. Yreka, CA. 403 pp.

Kier Associates. 1999. Mid-term evaluation of the Klamath River Basin Fisheries Restoration Program. Sausalito, CA . Prepared for the Klamath River Basin Fisheries Task Force. 303 pp.

Kier Associates. 2004. Review comments, Final License Agreement for the Klamath River Hydroelectric Project by PacifiCorp. April 4, 2004. Comments provided for the Klamath Basin Water Quality Work Group from Kier Assoc., Sausalito, CA. 33 pp.

Kier Associates. 2005a. Draft Nutrient Criteria for the Klamath River on the Hoopa Valley Indian Reservation. Prepared for the Hoopa Valley Tribal Environmental Protection Agency. Kier Associates, Mill Valley and Arcata, California.

Kier Associates. 2006. Draft terms and conditions to be recommended to the Federal Energy Regulatory Commission (FERC) for application to the Klamath Hydroelectric Project, FERC project license 2082-027, operated by PacifiCorp. Kier Associates, Mill Valley and Arcata, California. 60 pp.

Mack, S. 1958. Geology and ground-water features of Shasta Valley, Siskiyou County, California. U.S. Geological Survey, Water Supply Paper. Washington, D.C.

National Research Council (NRC). 2003. Endangered and threatened fishes in the Klamath River basin: causes of decline and strategies for recovery. Committee on endangered and threatened fishes in the Klamath River Basin, Board of Environmental Toxicology, Division on Earth and Life Studies, Washington D.C. 424 pp.

North Coast Regional Water Quality Control Board. 2002. Water Quality Control Plan for the North Coast Region. Staff report adopted by the North Coast Regional Water Quality Control Board. Santa Rosa, CA. 124 pp.

North Coast Regional Water Quality Control Board and University of California Davis. 2005. Lake Shastina Limnology. Performed as part of Shasta TMDL technical studies. NCRWQCB, Santa Rosa, CA and Information Center for the Environment, Univ. of California, Davis, CA.

McIntosh, B. A. and H. W. Li. 1998. Abstract and other information regarding the Final report - Klamath Basin Pilot Project: Coldwater refugia study and videography. Performed under contract for the Klamath River Basin Fisheries Task Force and USFWS, Yreka, CA. Oregon State University, Corvallis, OR.

McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to chinook salmon. Published as EPA 910-R-99-010 . Prepared for the U.S. Environmental Protection Agency (EPA), Region 10. Seattle, Washington. 291 pp.

Shasta Valley Resource Conservation District. 2005. Draft Shasta Valley Resource Conservation District Master Incidental Take Permit Application for Coho Salmon (Oncorhychus kisutch). SVRCD, Yreka, CA. 120 pp.

Sullivan, K., D. J. Martin, R. D. Cardwell, J. E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute . Portland, OR. 192 pp.

U.S. Environmental Protection Agency (U.S. EPA). 1986. Quality criteria for water 1986: EPA 440/5-86-001. Office of Water Regulations and Standards, Washington, DC. 477 pp.

U.S. Environmental Protection Agency (USEPA). 1999. 1999 update of Ambient water quality criteria for ammonia. EPA 822/R-99-014. U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 2000. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. Office of Water and Office of Science and Technology, Washington D.C. EPA-822-B-00-002.

U.S. Environmental Protection Agency. 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. Seattle, WA. 57 pp.

Watershed Sciences LLC. 2003. Aerial Surveys using Thermal Infrared and Color Videography Scott River and Shasta River Sub-Basins. Performed under contract for U.C. Davis and the NCRWQCB. Watershed Sciences, Corvallis, OR. 59 pp.

Welsh, H.W., Jr., Hodgson, G.R., Harvey, B.R., and Roche, M.F., 2001, Distribution of juvenile coho salmon in relation to water temperatures in tributaries of the Mattole River, California: North American Journal of Fisheries of Management, v. 21, p. 464-470.

Wilkie, M.P and C.M. Wood. 1995. The adaptation of fish to extremely alkaline environments. Comparative Biochemical Physiology. Vol 113B, No. 4, pp. 665-673.

White, M. 2002. Proposed Dissolved Oxygen Criteria Decision Process for the WA. Dept. of Ecology's Proposed Rules. Washington Dept. of Ecology, Olympia, WA. P. 6.

Wilkie, M.P and C.M. Wood. 1995. The adaptation of fish to extremely alkaline environments. Comparative Biochemical Physiology. Vol 113B, No. 4, p 665-673.

A PROCLAMATION

BY THE GOVERNOR OF THE STATE OF CALIFORNIA

WHEREAS California’s salmon runs are a vital component of our great State’s resources that provide significant environmental, recreational, commercial, and economic benefits to the people; and

WHEREAS Klamath River Basin Chinook Salmon have been significantly impacted by poor ocean conditions, drought, water management, water quality, water flows, disease, and the elimination of access to historical spawning habitat; and

WHEREAS the Klamath Basin Chinook Salmon that commingle with other runs of salmon in ocean waters off of California and Oregon have been declining in abundance to a point where California's and Oregon’s recreational, commercial, and tribal fisheries are being significantly constrained to conserve Klamath River Chinook Salmon; and

WHEREAS Klamath River Basin Chinook Salmon are predicted to have extremely low ocean abundance for 2006 in waters from Cape Falcon in Oregon to Point Sur in Monterey County, California, and in the Klamath River Basin; and

WHEREAS restoration of habitat and improved water quality and flows are critical to restoring an environment suitable to the long-term sustainability of the Klamath River Basin Chinook Salmon and other anadromous fish species; and

WHEREAS appropriate management of the Klamath River Basin Chinook Salmon population is critical to California’s businesses, and local communities that provide goods and services in support of California’s salmon fisheries; and

WHEREAS on April 5, 2006, I requested Secretary of Commerce Carlos Gutierrez to use his authority under the Magnusen-Stevens Fishery Conservation and Management Act to determine that there has been a commercial fishery failure due to a fishery resource disaster; and

WHEREAS on April 28, 2006, the National Marine Fisheries Service adopted an emergency rule to implement the recommendations of the Pacific Fisheries Management Council that resulted in severe restrictions on the commercial ocean salmon and Klamath Basin tribal and recreational fisheries and included restrictions on the recreational ocean salmon fishery; and

WHEREAS these restrictions will have significant impacts to California’s commercial ocean salmon and in-river salmon fisheries and will result in severe economic losses throughout the State; and

WHEREAS the Department of Finance has determined that approximately $778,000 is continuously appropriated and available in the Small Business Expansion Fund (Fund 918) for disaster purposes under the Corporations Code section 14030 et seq.; and

WHEREAS the Small Business Expansion Fund's available monies can be leveraged to guarantee up to approximately $9.2 million in loans for disasters, including guaranteeing loans to prevent business insolvencies and loss of employment in an area affected by a state of emergency within the state; and

WHEREAS Governor Ted Kulongoski of Oregon and I signed The Klamath River Watershed Coordination Agreement along with the responsible federal agencies in order to address the impacts to the fisheries in the region and to develop a long-term management approach, common vision, and integrated planning associated with the Klamath Basin; and

WHEREAS the serious circumstances of the Klamath River Chinook Salmon run put at risk the livelihoods of families and businesses dependent upon them.

NOW, THEREFORE, I, ARNOLD SCHWARZENEGGER, Governor of the State of California, find that conditions of disaster or of extreme peril to the safety of persons and property exist within the California counties of Monterey, Santa Cruz, San Mateo, San Francisco, Marin, Sonoma, Mendocino, Humboldt, Del Norte, and Siskiyou due to the poor ocean conditions, drought, water management, water quality, water flows, disease, and the elimination of access to historical spawning habitat and resulting from the significant restrictions that have been imposed on the State's salmon fisheries. Because the magnitude of this disaster will likely exceed the capabilities of the services, personnel, and facilities of these counties, I find these counties to be in a state of emergency, and under the authority of the California Emergency Services Act, I hereby proclaim that a State of Emergency exists in these counties.

Pursuant to this Proclamation, I hereby direct the Director of the California Department of Fish and Game and the Secretary of the Resources Agency to: (1) report to me immediately upon final action of the Department of Commerce and the California Fish and Game Commission on any further actions necessary to ensure the protection of the resource and of the economic livelihood of the fishery participants, tribes, and local communities; and (2) continue discussions for long-term restoration and management of the Klamath Basin with the State of Oregon, federal agencies (including the Secretaries of Commerce, the Interior, and Agriculture), tribal governments, and representatives from conservation, fishing, and agricultural organizations.

I FURTHER DIRECT the Secretary of the Business, Housing and Transportation Agency, with the cooperation of the Department of Finance, to activate the Small Business Disaster Assistance Loan Guarantee Program to guarantee loans to prevent business insolvencies and loss of employment in the counties of Monterey, Santa Cruz, San Mateo, San Francisco, Marin, Sonoma, Mendocino, Humboldt, Del Norte, and Siskiyou as a result of this State of Emergency.

I FURTHER DIRECT that as soon as hereafter possible, this proclamation be filed in the Office of the Secretary of State and that widespread publicity and notice be given of this proclamation.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 6th Day of June 2006.

____
ARNOLD SCHWARZENEGGER
Governor of California

ATTEST:

____
BRUCE McPHERSON
Secretary of State

DELTA FLOWS

State Water Resources Control Board
California Environmental Protection Agency

Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem

Prepared Pursuant to the Sacramento-San Joaquin Delta Reform Act of 2009

CALIFORNIA
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STATE WATER RESOURCES CONTROL BOARD
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August 3, 2010

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State Water Resources Control Board
California Environmental Protection Agency

Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem

Prepared Pursuant to the Sacramento-San Joaquin Delta Reform Act of 2009

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Acknowledgements

The State Water Resources Control Board (State Water Board or Board) acknowledges the following for their contributions and participation in the Board's Delta Flow Criteria proceding:

- The professors, researchers, and staff from various resource agencies that comprise the Delta Environmental Flows Group (DEFG) for providing valuable information and insights that informed the Delta flow criteria informational proceeding, and whose work was cited liberally throughout this report
- The UC Davis Delta Solutions Group, a subset of the DEFG for providing additional insights in their reports on habitat variability, flow presecriptions, and ecosystem investments
- The California Department of Fish and Game for working collaboratively with the State Water Board on development of species life history requirements and for reviewing portions of the draft report
- The United States Fish and Wildflie Service and National Marine Fisheries Service for reviewing portions of the draft report
- All the participants of the proceeding for providing information and serving on panels to answer questions during the proceeding

The State Water Board, however, is responsible for any errors and for all interpretations of the information in this report.

STATE WATER RESOURCES CONTROL BOARD
RESOLUTION NO. 2010-0039

DETERMINING DELTA FLOW CRITERIA PURSUANT TO THE DELTA REFORM ACT

WHEREAS:

1. Water Code section 85086, contained in the Sacramento-San Joaquin Delta Reform Act of 2009 (Stats. 2009 (7th Ex. Sess.) ch. 5) (commencing with Wat. Code, § 85000), requires the State Water Resources Control Board (State Water Board) to develop, within nine months of enactment of the statute, new flow criteria for the Sacramento-San Joaquin Delta (Delta) ecosystem that are necessary to protect public trust resources. The purpose of the flow criteria is to inform planning decisions for the Delta Plan and the Bay Delta Conservation Plan. The statute specifies that the flow criteria shall not predetermine any issue that may arise in the State Water Board's subsequent consideration of a permit.

2. In accordance with Water Code section 85086, subdivision (c)(1), the State Water Board conducted a public process in the form of an informational proceeding to collect information used to develop the flow criteria. The State Water Board conducted the informational proceeding on March 22-24, 2010, and considered the information submitted in connection with that proceeding in developing the flow criteria.

3. The State Water Board has prepared a report determining flow criteria for the Delta ecosystem necessary to protect public trust resources. In developing the flow criteria, the State Water Board reviewed existing water quality objectives and used the best available scientific information. The flow criteria include the volume, timing, and quality of flow necessary under different hydrologic conditions.

THEREFORE BE IT RESOLVED THAT:

1. In accordance with the Delta Reform Act, the State Water Board approves the report determining new flow criteria for the Delta ecosystem that are necessary to protect public trust resources.

2. The Executive Director is directed to submit the Delta flow criteria report to the Delta Stewardship Council for its information within 30 days of the adoption of this resolution.

CERTIFICATION

The undersigned Clerk to the Board does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Board held on August 3, 2010.

AYE:	Chairman Charles R. Hoppin Vice Chair Frances Spivy-Weber Board Member Arthur G. Baggett, Jr. Board Member Tam M. Doduc Board Member Walter G. Pettit
NAY:	None
ABSENT:	None
ABSTAIN:	None

Jeanine Townsend

Jeanine Townsend
Clerk to the Board

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Acronyms and Abbreviations

AFRP	Anadromous Fish Restoration Program
AR	American Rivers
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta Estuary including Suisun Marsh
Bay-Delta Plan	Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
BDCP	Bay Delta Conservation Program
CCWD	Contra Costa Water District
Central Valley Regional Board	Central Valley Regional Water Quality Control Board
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
Council	Delta Stewardship Council
CSPA	California Sportfishing Protection Alliance
CVP	Central Valley Project
CWIN	California Water Impact Network
DEFG	Delta Environmental Flows Group
Delta	Confluence of the Sacramento River and San Joaquin River (as defined in Water Code section 12220)
Delta Plan	Delta Stewardship Council comprehensive, long-term management plan for the Delta
Delta Reform Act	Sacramento-San Joaquin Delta Reform Act of 2009
DFG	California Department of Fish and Game
DO	dissolved oxygen
DOI	United States Department of the Interior
DSM2	Delta Simulation Model
DWR	California Department of Water Resources
DWSC	Stockton Deep Water Ship Channel
E/I	Export/Inflow ratio
EC	Electrical Conductivity
EDF	Environmental Defense Fund
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FMWG	Fisheries Management Work Group
FMWT	Fall mid-water trawl
IEP	Interagency Ecological Program
LSZ	Low Salinity Zone
MAF	million acre-feet
mg/L	milligrams per liter
mmhos/cm	millimhos per centimeter
NAS	National Academy of Sciences
NCCPA	State Natural Community Conservation Planning Act
NDOI	Net Delta Outflow Index
NEPA	National Environmental Policy Act
NHI	Natural Heritage Institute

NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council
OCAP	Long-Term Operations Criteria and Plan for Coordination of the Central Valley Project and the State Water Project
OMR	Old and Middle River
Opinion	Biological Opinion
PCFFA	Pacific Coast Federation of Fishermen's Associations
POD	Pelagic Organism Decline
ppt	parts per thousand
psu	practical salinity unit
PTM	Particle Tracking Model
RMP	Regional Monitoring Program
RPA	Reasonable and Prudent Alternatives
San Francisco Regional Board	San Francisco Bay Regional Water Quality Control Board
SB 1	Senate Bill No. 1 of the 2009-2010 Seventh Extraordinary Session (Stats. 2009 (7th Ex. Sess.) ch. 5, § 39)
SFWC	State and Federal Water Contractors
SJRA	San Joaquin River Agreement
SJRGA	San Joaquin River Group Authority
SJRRP	San Joaquin River Restoration Program
SRWTP	Sacramento Regional Wastewater Treatment Plant
State Water Board	State Water Resources Control Board
SWG	Smelt Working Group
SWP	State Water Project
TBI	The Bay Institute
TNC	The Nature Conservancy
USACE	U.S. Army Corps of Engineers
USBR	United States Bureau of Reclamation
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Plan
WOMT	Water Operations Management Team

1. Executive Summary

The Sacramento-San Joaquin Delta (Delta) is a critically important natural resource for California and the nation. It is both the hub of California's water supply system and the most valuable estuary and wetlands on the western coast of the Americas. The Delta is in ecological crisis, resulting in high levels of conflict that affect the sustainability of existing water policy in California. Several species of fish have been listed as protected species under the California Endangered Species Act (CESA) and under the federal Endangered Species Act (ESA). These two laws and other regulatory constraints have restricted water diversions from the Delta in an effort to prevent further harm to the protected species.

In November 2009, California enacted a comprehensive package of four policy bills and a bond measure intended to meet California's growing water challenges by adopting a policy of sustainable water supply management to ensure a reliable water supply for the State and to restore the Delta and other ecologically sensitive areas. One of these bills, Senate Bill No. 1 (SB 1) (Stats. 2009 (7th Ex. Sess.) ch 5, § 39) contains the Sacramento-San Joaquin Delta Reform Act of 2009 (Delta Reform Act), Water Code section 85000 et seq. The Delta Reform Act establishes a Delta Stewardship Council (Council), tasked with developing a comprehensive, long-term management plan for the Delta, known as the Delta Plan, and providing direction to multiple state and local agencies that take actions related to the Delta. The comprehensive bill package also sets water conservation policy, requires increased groundwater monitoring, and provides for increased enforcement against illegal water diversions.

The Delta Reform Act requires the State Water Board to use a public process to develop new flow criteria for the Delta ecosystem. During this process, participants cautioned the the State Water Board on the limitations of any flow criteria (Fleenor *et al*., 2010):

> "How much water do fish need?" has been a common refrain in Delta water management for many years… it is highly unlikely that any fixed or predetermined prescription will be a "silver bullet". The performance of native and desirable fish populations in the Delta requires much more than fresh water flows. Fish need enough water of appropriate quality over the temporal and spatial extent of habitats to which they adapted their life history strategies. Typically, this requires habitat having a particular range of physical characteristics, appropriate variability, adequate food supply and a diminished set of invasive species. While folks ask "How much water do fish need?" they might well also ask, "How much habitat of different types and locations, suitable water quality, improved food supply and fewer invasive species that is maintained by better governance institutions, competent implementation and directed research do fish need?" The answers to these questions are interdependent. We cannot know all of this now, perhaps ever, but we do know things that should help us move in a better direction, especially the urgency for being proactive. We do know that current policies have been disastrous for desirable fish. It took over a century to change the Delta's ecosystem to a less desirable state; it will take many decades to put it back together again with a different physical, biological, economic, and institutional environment."

The State Water Board concurs with this cautionary note. The State Water Board further cautions that flow and physical habitat interact in many ways, but they are not interchangeable.

The best available science suggests that current flows are insufficient to protect public trust resources.

1.1 Legislative Directive and State Water Board Approach

Legislative Directive

Water Code section 85086 (See Appendix B), contained in the Delta Reform Act, was enacted as part of the comprehensive package of water legislation adopted in November 2009. Water Code section 85086 requires the State Water Resources Control Board (State Water Board) to use the best available scientific information gathered as part of a public process conducted as an informational proceeding to develop new flow criteria for the Delta ecosystem to protect public trust resources. The purpose of the flow criteria is to inform planning decisions for the Delta Plan and the BDCP. The Legislature intended to establish an accelerated process to determine the instream flow needs of the Delta in order to facilitate the planning decisions required to meet the objectives of the Delta Plan. Accordingly, Water Code section 85086 requires the State Water Board to develop the flow criteria within nine months of enactment of the statute and to submit its flow criteria determinations to the Council within 30 days of their development.

State Water Board Approach

In determining the extent of protection to be afforded public trust resources through the development of the flow criteria, the State Water Board considered the broad goals of the planning efforts the criteria are intended to inform, including restoring and promoting viable, self-sustaining populations of aquatic species. Given the accelerated time frame in which to develop the criteria, the State Water Board's approach to developing criteria was limited to review of instream needs in the Delta ecosystem, specifically fish species and Delta outflows, while also receiving information on hydrodynamics and major tributary inflows. The State Water Board's flow criteria determinations are accordingly limited to protection of aquatic resources in the Delta.

Limitations of State Water Board Approach

When setting flow objectives with regulatory effect, the State Water Board reviews and considers all the effects of the flow objectives through a broad inquiry into all public trust and public interest concerns. For example, the State Water Board would consider other public trust resources potentially affected by Delta outflow requirements and impose measures for the protection of those resources, such as requiring sufficient water for cold water pool in reservoirs to maintain temperatures in Delta tributaries. The State Water Board would also consider a broad range of public interest matters, including economics, power production, human health and welfare requirements, and the effects of flow measures on non-aquatic resources (such as habitat for terrestrial species). The limited process adopted for this proceeding does not include this comprehensive review.

The State Water Board's Public Trust Responsibilities in this Proceeding

Under the public trust doctrine, the State Water Board must take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible. (*National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419, 446.) Public trust values include navigation, commerce, fisheries, recreation, scenic, and ecological values. "[I]n determining whether it is 'feasible' to protect public trust values like fish and wildlife in a particular instance, the [State Water] Board must determine whether protection of those values, or what level of protection, is 'consistent with the public interest.'" (*State Water Resources*

Control Bd. Cases (2006) 136 Cal.App.4th 674, 778.) The State Water Board does not make any determination regarding the feasibility of the public trust criteria and consistency with the public interest in this report.

In this forum, the State Water Board has not considered the allocation of water resources, the application of the public trust to a particular water diversion or use, water supply impacts, or any balancing between potentially competing public trust resources (such as potential adverse effects of increased Delta outflow on the maintenance of coldwater resources for salmonids in upstream areas). Any such application of the State Water Board's public trust responsibilities, including any balancing of public trust values and water rights, would be conducted through an adjudicative or regulatory proceeding. Instead, the State Water Board's focus here is solely on identifying public trust resources in the Delta ecosystem and determining the flow criteria, as directed by Water Code section 85086.

Future Use of This Report

None of the determinations in this report have regulatory or adjudicatory effect. Any process with regulatory or adjudicative effect must take place through the State Water Board's water quality control planning, water rights processes, or public trust proceedings in conformance with applicable law. In the State Water Board's development of Delta flow objectives with regulatory effect, it must ensure the reasonable protection of beneficial uses, which may entail balancing of competing beneficial uses of water, including municipal and industrial uses, agricultural uses, and other environmental uses. The State Water Board's evaluation will include an analysis of the effect of any changed flow objectives on the environment in the watersheds in which Delta flows originate, the Delta, and the areas in which Delta water is used. It will also include an analysis of the economic impacts that result from changed flow objectives.

Nothing in either the Delta Reform Act or in this report amends or otherwise affects the water rights of any person. In carrying out its water right responsibilities, the State Water Board may impose any conditions that in its judgment will best develop, conserve, and utilize in the public interest the water to be appropriated. In making this determination, the State Water Board considers the relative benefit to be derived from all beneficial uses of the water concerned and balances competing interests.

The State Water Board has continuing authority over water right permits and licenses it issues. In the exercise of that authority and duty, the State Water Board may, if appropriate, amend terms and conditions of water right permits and licenses to impose further limitations on the diversion and use of water by the water right holder to protect public trust uses or to meet water quality and flow objectives in Water Quality Control Plans it has adopted. The State Water Board must provide notice to the water permit or license holder and an opportunity for hearing before it may amend a water right permit or license.

If the DWR and/or the USBR in the future request the State Water Board to amend the water right permits for the State Water Project (SWP) and/or the Central Valley Project (CVP) to move the authorized points of diversion for the projects from the southern Delta to the Sacramento River, Water Code section 85086 directs the State Water Board to include in any order approving a change in the point of the diversion of the projects appropriate Delta flow criteria. At that time, the State Water Board will determine appropriate permit terms and conditions. That decision will be informed by the analysis in this report, but will also take many other factors into consideration, including any newly developed scientific information, habitat conditions at the time, and other policies of the State, including the relative benefit to be derived from all beneficial uses of water. The flow criteria in this report are not pre-decisional in regard to any State Water Board action. (See e.g., Wat. Code, § 85086, subd. (c)(1).)

The information in this report illustrates to the State Water Board the need for an integrated approach to management of the Delta. Best available science supports that it is important to directly address the negative effects of other stressors, including habitat, water quality, and invasive species, that contribute to higher demands for water to protect public trust resources. The flow criteria highlight the continued need for the BDCP to develop an integrated set of solutions and to implement non flow measures to protect public trust resources.

1.2 Summary Determinations

This report contains the State Water Board's determinations as to the flows that protect public trust resources in the Delta, under the narrow circumstances analyzed in this report. As required, the report includes the volume, timing, and quality of flow for protection of public trust resources under different hydrologic conditions. The flow criteria represent a technical assessment only of flow and operational requirements that provide fishery protection under existing conditions. The flow criteria contained in this report do not represent flows that might be protective under other conditions. The State Water Board recognizes that changes in existing conditions may alter the need for flow. Changes in existing conditions that may affect flow needs include, but are not limited to, reduced reverse flows in Delta channels, increased tidal habitat, improved water quality, reduced competition from invasive species, changes in the point of diversion of the SWP and CVP, and climate change.

<u>Flow Criteria and Conclusions</u>

The numeric criteria determinations in this report must be considered in the following context:

- The flow criteria in this report do not consider any balancing of public trust resource protection with public interest needs for water.
- The State Water Board does not intend that the criteria should supersede requirements for health and safety such as the need to manage water for flood control.
- There is sufficient scientific information to support the need for increased flows to protect public trust resources; while there is uncertainty regarding specific numeric criteria, scientific certainty is not the standard for agency decision making.

The State Water Board has considered the testimony presented during the Board's informational proceeding to develop flow criteria and to support the following summary conclusions. Several of these summary conclusions rely in whole or in part on conclusions and recommendations made to the State Water Board by the Delta Environmental Flows Group (DEFG)[1] and the University of California at Davis Delta Solutions Group[2].

1. The effects of non-flow changes in the Delta ecosystem, such as nutrient composition, channelization, habitat, invasive species, and water quality, need to be addressed and integrated with flow measures.

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[1] The Delta Environmental Flows Group of experts consists of William Bennett, Jon Burau, Cliff Dahm, Chris Enright, Fred Feyrer, William Fleenor, Bruce Herbold, Wim Kimmerer, Jay Lund, Peter Moyle, and Matthew Nobriga.

[2] The Delta Solutions Group consists of William Bennett, William Fleenor, Jay Lund, and Peter Moyle.

2. Recent Delta flows are insufficient to support native Delta fishes for today's habitats.[3] Flow modification is one of the immediate actions available although the links between flows and fish response are often indirect and are not fully resolved. Flow and physical habitat interact in many ways, but they are not interchangeable.

3. In order to preserve the attributes of a natural variable system to which native fish species are adapted, many of the criteria developed by the State Water Board are crafted as percentages of natural or unimpaired flows. These criteria include:

   - 75% of unimpaired Delta outflow from January through June;
   - 75% of unimpaired Sacramento River inflow from November through June; and
   - 60% of unimpaired San Joaquin River inflow from February through June.

   It is not the State Water Board's intent that these criteria be interpreted as precise flow requirements for fish under current conditions, but rather they reflect the general timing and magnitude of flows under the narrow circumstances analyzed in this report. In comparison, historic flows over the last 18 to 22 years have been:

   - approximately 30% in drier years to almost 100% of unimpaired flows in wetter years for Delta outflows;
   - about 50% on average from April through June for Sacramento River inflows; and
   - approximately 20% in drier years to almost 50% in wetter years for San Joaquin River inflows.

4. Other criteria include: increased fall Delta outflow in wet and above normal years; fall pulse flows on the Sacramento and San Joaquin Rivers; and flow criteria in the Delta to help protect fish from mortality in the central and southern Delta resulting from operations of the State and federal water export facilities.

5. The report also includes determinations regarding variability and the natural hydrograph, floodplain activation and other habitat improvements, water quality and contaminants, cold water pool management, and adaptive management:
   - Criteria should reflect the frequency, duration, timing, and rate of change of flows, and not just volumes or magnitudes. Accordingly, whenever possible, the criteria specified above are expressed as a percentage of the unimpaired hydrograph.

[3] This statement should not be construed as a critique of the basis for existing regulatory requirements included in the 2006 Bay-Delta Plan and biological opinions. Those requirements were developed pursuant to specific statutory requirements and considerations that differ from this proceeding. Particularly when developing water quality objectives, the State Water Board must consider many different factors including what constitutes reasonable protection of the beneficial use and economic considerations. In addition, the biological opinions for the SWP and CVP Operations Criteria and Plan were developed to prevent jeopardy to specific fish species listed pursuant to the federal Endangered Species Act; in contrast, the flow criteria developed in this proceeding are intended to halt population decline and increase populations of certain species.

- Inflows should generally be provided from tributaries to the Delta watershed in proportion to their contribution to unimpaired flow unless otherwise indicated.
- Studies and demonstration projects for, and implementation of, floodplain restoration, improved connectivity and passage, and other habitat improvements should proceed to provide additional protection of public trust uses and potentially allow for the reduction of flows otherwise needed to protect public trust resources in the Delta.
- The Central Valley and San Francisco Regional Water Quality Control Boards should continue developing Total Maximum Daily Loads (TMDLs) for all listed pollutants and adopting programs to implement control actions.
- The Central Valley Regional Water Quality Control Board should require additional studies and incorporate discharge limits and other controls into permits, as appropriate, for the control of nutrients and ammonia.
- Temperature and water supply modeling and analyses should be conducted to identify conflicting requirements to achieve both flow and cold water temperature goals.
- A strong science program and a flexible management regime are critical to improving flow criteria. The State Water Board should work with the Council, the Delta Science Program, BDCP, the Interagency Ecological Program (IEP), and others to develop the framework for adaptive management that could be relied upon for the management and regulation of Delta flows.
- The numeric criteria included in this report are all criteria that are only appropriate for the current physical system and climate; as other factors change the flow needs advanced in this report will also change. As physical changes occur to the environment and our understanding of species needs improves, the long-term flow needs will also change. Actual flows should be informed by adaptive management.
- Only the underlying principles for the numeric criteria and other measures are advanced as long term criteria.

6. Past changes in the Delta may influence migratory cues for some fishes. These cues are further scrambled by a reverse salinity gradient in the south Delta. It is important to establish seaward gradients and create more slough networks with natural channel geometry. Achieving a variable more complex estuary requires establishing seasonal gradients in salinity and other water quality variables and diverse habitats throughout the estuary. These goals in turn encourage policies which establish internal Delta flows that create a tidally-mixed upstream- downstream gradient (without cross-Delta flows) in water quality. Continued through-Delta conveyance is likely to continue the need for in-Delta flow requirements and restrictions to protect fish within the Delta.

7. Restoring environmental variability in the Delta is fundamentally inconsistent with continuing to move large volumes of water through the Delta for export. The drinking and agricultural water quality requirements of through-Delta exports, and perhaps even some current in-Delta uses, are at odds with the water quality and variability needs of desirable Delta species.

8. The Delta ecosystem is likely to dramatically shift within 50 years due to large scale levee collapse. Overall, these changes are likely to promote a more variable, heterogeneous estuary. This changed environment is likely to be better for desirable estuarine species; at least it is unlikely to be worse.

9. Positive changes in the Delta ecosystem resulting from improved flow or flow patterns will benefit humans as well as fish and wildlife.

10. In order to prevent further channelization of riparian corridors and infill of wetland habitats, the Delta Stewardship Council should consider developing a plan to coordinate land use policy within the Delta between the city, county, State, and federal governments.

Ecosystems are complex; there are many factors that affect the quality of the habitat that they provide. These factors combine in ways that can amplify the effect of the factors on aquatic resources. The habitat value of the Delta ecosystem for favorable species can be improved by habitat restoration, contaminant and nutrient reduction, changes in diversions, control of invasive species, and island flooding. Each of these non-flow factors has the potential to interact with flow to affect available aquatic habitat in Delta channels.

The State Water Board supports the most efficient use of water that can reasonably be made. The flow improvements that the State Water Board identifies in this report as being necessary to protect public trust resources illustrate the importance of addressing the negative effects of these other stressors that contribute to higher than necessary demands for water to provide resource protection. Future habitat improvements or changes in nutrients and contaminants, for example, may change the response of fishes to flow. Addressing other stressors directly will be necessary to assure protection of public trust resources and could change the demands for water to provide resource protection in the future. Uncertainty regarding the effects of habitat improvement and other stressors on flow demands for resource protection highlights the need for continued study and adaptive management to respond to changing conditions.

The flow criteria identified in this report highlight the need for the BDCP to develop an integrated set of solutions, to address ecosystem flow needs, including flow and non-flow measures. Although flow modification is an action that can be implemented in a relatively short time in order to improve the survival of desirable species and protect public trust resources, public trust resource protection cannot be achieved solely through flows – habitat restoration also is needed. One cannot substitute for the other; both flow improvements and habitat restoration are essential to protecting public trust resources.

1.3 Background and Next Steps

Informational Proceeding

The State Water Board held an informational proceeding on March 22, 23, and 24, 2010, to receive scientific information from technical experts on the Delta outflows needed to protect public trust resources. The State Water Board also received information at the proceeding on flow criteria for inflow to the Delta from the Sacramento and San Joaquin rivers and Delta hydrodynamics. The State Water Board did not solicit information on the need for water for other beneficial uses, including the amount of water needed for human health and safety, during the informational proceeding. Nor did the State Water Board consider other policy considerations, such as the state goal of providing a decent home and suitable living environment for every Californian.

Analytical Methods

The State Water Board received a wide range of recommendations for the volume, quantity and timing of flow necessary to protect public trust resources. Recommendations were also received on non-flow related measures. State Water Board determinations of flow criteria rely upon four types of information:

- Unimpaired flows
- Historical impaired inflows that supported more desirable ecological conditions
- Statistical relationships between flow and native species abundance
- Ecological functions-based analysis for desirable species and ecosystem attributes

The State Water Board emphasizes, however, information based on ecological functions, followed by information on statistical relationships between flow and native species abundance.

In all cases, the flow criteria contained in this report are those supported by the best available scientific information submitted into the record for this proceeding. The conceptual bases for all of the criteria in this report are supported by scientific information on function-based species or ecosystem needs. In other words, there is sufficiently strong scientific evidence to support the need for flows necessary to support particular functions. This does not necessarily mean that there is scientific evidence to support *specific* numeric criteria. Criteria are therefore divided into two categories: Category "A" criteria have more and better scientific information, with less uncertainty, to support specific numeric criteria than do Category "B" criteria. The State Water Board followed the following steps to develop flow criteria and other measures:

1. Establish general goals and objectives for protection of public trust resources in the Delta
2. Identify species to include based on ecological, recreational, or commercial importance.
3. Review and summarize species life history requirements
4. Summarize numeric and other criteria for each of: Delta outflow, Sacramento River inflow, San Joaquin River inflow, and Hydrodynamics, including Old and Middle River flows
5. Review other flow-related and non-flow measures that should be considered
6. Provide summary determinations for flow criteria and other measures

In developing its flow criteria, the State Water Board reviewed the life history requirements of the following pelagic and anadromous species:

- Chinook Salmon (various runs)
- American Shad.
- Longfin Smelt
- Delta Smelt
- Sacramento Splittail
- Starry Flounder
- Bay Shrimp
- Zooplankton

The flow criteria needed to protect public trust resources are more than just the sum of each species-specific flow need. The State Water Board also considered the following issues to make its flow criteria determinations:

- Variability, flow paths, and the natural hydrograph
- Floodplain activation and other habitat improvements

- Water quality and contaminants
- Cold water pool management
- Adaptive management

The Board also made other specific determinations for other measures based on review of these issues.

Regulatory Authority of the State Water Board

The State Water Board was established in 1967 as the State agency with jurisdiction to administer California's water resources. The State Water Board is responsible for water allocation as well as for water quality planning and water pollution control. In carrying out its water quality planning functions under both State and federal law, the State Water Board formulates and adopts state policy for water quality control, which includes water quality principles and guidelines for long-range resource planning, water quality objectives, and other principles and guidelines deemed essential by the State Water Board for water quality control. The State Water Board has adopted a Water Quality Control Plan for the Delta (Bay-Delta Plan). The plan is implemented in part through conditions imposed in both water quality and water right permits.

The State Water Board administers the water rights program for the State, including issuing water right permits. More than two-thirds of the residents of California and more than two million acres of highly productive farmlands receive water exported from the Delta, primarily, although not exclusively, through the SWP and CVP. In addition to the SWP and CVP, there are many other diversions from the Delta and from tributaries to the Delta including the East Bay Municipal Utilities District, the San Francisco Public Utilities Commission, and Contra Costa Water District, to name a few.

Regulatory Actions by Other Agencies

In addition to the State Water Board, other state and federal agencies have authority to take regulatory action that can affect Delta inflows, outflows, and hydrodynamics. As indicated below, the United States Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), and the California Department of Fish and Game (DFG) have authority to impose regulatory conditions that affect water diversions from the Delta. The Federal Energy Regulatory Commission (FERC) also has authority over non-federal hydropower projects that can change the timing and quantity of inflows to the Delta. Over the next six years, there are 16 hydropower projects on tributaries to the Sacramento and San Joaquin rivers with potential to affect Delta tributary flows that have ongoing or pending proceedings before the FERC.

Next Steps

The State Water Board will submit its flow criteria determinations to the Council for its information within 30 days of completing its determinations as required by Water Code section 85086.

The flow criteria contained in this report will be submitted to the Council to inform the Delta Plan. The Council is required to develop the Delta Plan to implement the State's co-equal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The Council is to develop the Delta Plan by January 2012.

The flow criteria will also inform the BDCP. The BDCP is a multispecies conservation plan being developed pursuant to the ESA and the State Natural Community Conservation Planning Act (NCCPA), administered by the USFWS and the NMFS and the DFG, respectively. The

CESA and the federal ESA generally prohibit the “take” of species protected pursuant to the acts. Both acts contain provisions that allow entities to seek approvals from the resources agencies, which approvals allow limited take of protected species under some circumstances. The BDCP is intended to meet all regulatory requirements necessary for USFWS and NMFS to issue Incidental Take Permits to allow incidental take of all proposed covered species as a result of covered activities undertaken by DWR, certain SWP contractors, and Mirant Corporation, and to issue biological opinions under the ESA to authorize incidental take for covered actions undertaken by USBR and CVP contractors. The BDCP is also intended to address all of the requirements of the NCCPA for aquatic, wetland, and terrestrial covered species of fish, wildlife, and plants and Delta natural communities affected by BDCP actions and is intended to provide sufficient information for DFG to issue permits under the CESA for the taking of the species proposed for coverage under the BDCP.

Finally, the flow criteria in this report will also inform the State Water Board’s on-going and subsequent proceedings, including the review and development of flow objectives in the San Joaquin River, a comprehensive update to the 2006 Bay-Delta Plan, and the associated water rights proceedings to implement these Bay-Delta Plan updates.

2. Introduction

The purpose of this report is to identify new flow criteria for the Sacramento-San Joaquin Delta (Delta) ecosystem to protect public trust resources in accordance with the Delta Reform Act of 2009, Water Code § 85000 et seq. The flow criteria, which do not have any regulatory or adjudicative effect, may be used to inform planning decisions for the new Delta Plan being prepared by the newly created Delta Stewardship Council (Council) and the Bay Delta Conservation Plan (BDCP). The public trust resources that are the subject of this proceeding include those resources affected by flow, namely, native and valued resident and migratory aquatic species, habitats, and ecosystem processes. The State Water Resources Control Board (State Water Board or Board) has developed flow criteria to protect these resources that incorporate measures regarding Delta outflows and Delta inflows and has recommended other measures relevant to the protection of public trust resources. After approval by the State Water Board, this report will be submitted to the Council.

3. Purpose and Background

3.1 Background and Scope of Report

Pursuant to Water Code section 85086, subdivision (c), enacted on November 12, 2009, in Senate Bill No. 1 of the 2009-2010 Seventh Extraordinary Session (Stats. 2009 (7^{th} Ex. Sess.) ch. 5, § 39) (SB 1), the State Water Board is required to “develop new flow criteria for the Delta ecosystem necessary to protect public trust resources.” The purpose of this report is to comply with the Legislature’s mandate to the State Water Board.

Given the limited amount of time the State Water Board had to develop the criteria, the Board initially focused on Delta outflow conditions as a primary driver of ecosystem functions in the Delta. In determining the extent of protection to be afforded public trust resources through the development of the flow criteria, the State Water Board considered the broad goals of the planning efforts the criteria are intended to inform, including restoring and promoting viable, self-sustaining populations of aquatic species. The specific goals for protection are discussed in more detail below.

The notice for this proceeding focused the proceeding on Delta outflows. During the proceeding, however, the State Water Board received useful information from participants regarding Sacramento River inflows, San Joaquin River inflows, and Delta hydrodynamics (including Old and Middle River flows, San Joaquin River at Jersey Point flows, and San Joaquin River inflow to export ratios) that is relevant to protection of public trust resources in the Delta ecosystem. The hydrodynamic criteria included in this reportare largely dependent on exports and on San Joaquin River inflows, and do not directly affect the outflows considered in this proceeding. The State Water Board believes, however, that this information should be transmitted to the Council for its use in informing the Delta Plan and BDCP. Because the notice for the proceeding focused on Delta outflows, and some of the participants did not submit scientific information on inflows and hydrodynamics for the State Water Board's consideration, the record for inflows and hydrodynamics may not be as complete, and the analyses for these flow parameters accordingly may be limited. As a result, these criteria do not constitute formal criteria within the scope of the informational proceeding as noticed, but instead are submitted to the Council with the acknowledgement that they are based on the limited information received by the State Water Board.

3.1.1 The Legislative Requirements

In November 2009, legislation was enacted comprising a comprehensive water package for California. In general, the legislation is designed to achieve a reliable water supply for future generations and to restore the Delta and other ecologically sensitive areas. The package includes a bond bill and four policy bills, one of which is SB 1.

In the Delta Reform Act, the Legislature found and declared, among other matters, that:

> "The Sacramento-San Joaquin Delta watershed and California's water infrastructure are in crisis and existing Delta policies are not sustainable. Resolving the crisis requires fundamental reorganization of the state's management of Delta watershed resources. (Wat. Code, § 85001, subd. (a).)
>
> By enacting this division, it is the intent of the Legislature to provide for the sustainable management of the Sacramento-San Joaquin Delta ecosystem, to provide for a more reliable water supply for the state, to protect and enhance the quality of water supply from the Delta, and to establish a governance structure that will direct efforts across state agencies to develop a legally enforceable Delta Plan." (Wat. Code, § 85001, subd. (c).)

Among other provisions, SB 1 establishes the Delta Stewardship Council, which is charged with responsibility to develop, adopt, and commence implementation of a Delta Plan, a comprehensive, long-term management plan for the Delta, by January 1, 2012. The legislation also establishes requirements for inclusion of the BDCP, a multispecies conservation plan, into the Delta Plan. For purposes of informing the planning efforts for the Delta Plan and BDCP, SB 1 requires the State Water Board, pursuant to its public trust obligations, to develop new flow criteria for the Delta ecosystem necessary to protect public trust resources. (Wat. Code, § 85086, subd. (c).) Regarding the flow criteria, the Legislature provided that the flow criteria shall:

- include the volume, quality, and timing of water necessary for the Delta ecosystem;
- be developed within nine months of enactment of SB 1;

- be submitted to the Council within 30 days of completion;
- inform planning decisions for the Delta Plan and the BDCP;
- be based on a review of existing water quality objectives and the use of the best available scientific information;
- be developed in a public process by the State Water Board as a result of an informational proceeding conducted under the board's regulations set forth at California Code of Regulations, title 23, sections 649-649.5, in which all interested persons have an opportunity to participate.
- not be considered predecisional with regard to any subsequent State Water Board consideration of a permit, including any permit in connection with a final BDCP;
- inform any State Water Board order approving a change in the point of diversion of the State Water Project or the federal Central Valley Project from the southern Delta to a point on the Sacramento River;

3.1.2 The State Water Board's Public Trust Obligations

As stated above, SB 1 requires the State Water Board to develop new flow criteria to protect public trust resources in the Delta ecosystem pursuant to the Board's public trust obligations. The purpose of the public trust is to protect commerce, navigation, fisheries, recreation, ecological values, and fish and wildlife habitat. Under the public trust doctrine, the State of California has sovereign authority to exercise continuous supervision and control over the navigable waters of the state and the lands underlying those waters. (*National Audubon Society v*. *Superior Court* (*Audubon*) (1983) 33 Cal.3d 419.) A variant of the public trust doctrine also applies to activities that harm a fishery in non-navigable waters. (*People v. Truckee Lumber Co.* (1897) 116 Cal. 397, see *California Trout, Inc. v. State Water Resources Control Board* (1989) 207 Cal.App.3d 585, 630.)

In *Audubon*, the California Supreme Court held that California water law is an integration of the public trust doctrine and the appropriative water right system. (*Audubon*, *supra*, 33 Cal.3d at p. 426.) The state has an affirmative duty to take the public trust into account in the planning and allocation of water resources. The public trust doctrine requires the State Water Board to consider the effect of a diversion or use of water on streams, lakes, or other bodies of water, and "preserve, so far as consistent with the public interest, the uses protected by the trust." (*Audubon*, *supra*, 33 Cal.3d at p. 447.) Thus, before the State Water Board approves a water diversion, it must consider the effect of the diversion on public trust resources and avoid or minimize any harm to those resources where feasible. (*Id.* at p. 426.) Even after an appropriation has been approved, the public trust imposes a duty of continuing supervision. (*Id.* at p. 447*.)*

The purpose of this proceeding is to receive scientific information and develop flow criteria pursuant to the State Water Board's public trust obligations. In this forum, the State Water Board will not consider the allocation of water resources, the application of the public trust to a particular water diversion or use, or any balancing between potentially competing public trust resources. The State Water Board has also not considered minimum or maximum flows needed to protect public health and safety. Any such application of the State Water Board's public trust responsibilities, including any balancing of public trust values and water rights, would be conducted through an adjudicative or regulatory proceeding. Instead, the State Water Board's focus here is solely on identifying public trust resources in the Delta ecosystem within the scope of SB 1 and determining the flows necessary to protect those resources.

3.1.3 Public Process

The Water Code directs the State Water Board to develop the flow criteria in a public process in the form of an informational proceeding conducted pursuant to the Board's regulations. (Wat. Code, § 85086, subd. (c)(1); Cal. Code Regs., tit. 23, §§ 649-649.5.) The State Water Board conducted this informational proceeding to receive the best available scientific information to use in carrying out its mandate to develop new flow criteria for the Delta ecosystem necessary to protect public trust resources. (Wat. Code, § 85086, subd. (c)(1).) On December 16, 2009, the State Water Board issued the notice for the public informational proceeding to develop the flow criteria. For the informational proceeding, the State Water Board required the participants to submit a Notice of Intent to Appear by January 5, 2010. The State Water Board received 55 Notices of Intent to Appear for the informational proceeding.

On January 7, 2010, the State Water Board conducted a pre-proceeding conference to discuss the procedures for the informational proceeding mandated by Water Code section 85086, subdivision (c). Topics for the pre-proceeding conference included coordination of joint presentations, use of presentation panels, time limits on presentations, and electronic submittal of written information. The conference was used only to discuss procedural matters and did not address any substantive issues.

On January 29, 2010, the State Water Board issued a revised notice amending certain procedural requirements and posted a preliminary list of reference documents. Written testimony, exhibits, and written summaries, along with lists of witnesses and lists of exhibits, were due on February 16, 2010. The State Water Board gave participants and interested parties an opportunity to submit written questions regarding the written testimony, exhibits, and written summaries by March 9, 2010. All submittals were posted on the State Water Board's website.

On March 22 through 24, the State Water Board held the public informational proceeding to develop flow criteria for the Delta ecosystem. The State Water Board received a technical introduction by the Delta Environmental Flows Group (DEFG)[4] at the beginning of the proceeding. The group prepared two documents and an associated list of references that were submitted as State Water Board exhibits:

- Key Points on Delta Environmental Flows for the State Water Resources Control Board, February 2010
- Changing Ecosystems: a Brief Ecological History of the Delta, February 2010

A subset of the group, the UC Davis Delta Solutions Group, prepared three additional papers (which were also submitted as State Water Board exhibits):

- Habitat Variability and Complexity in the Upper San Francisco Estuary
- On Developing Prescriptions for Freshwater Flows to Sustain Desirable Fishes in the Sacramento-San Joaquin Delta

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[4] The Delta Environmental Flows Group consists of William Bennett, Jon Burau, Cliff Dahm, Chris Enright, Fred Feyrer, William Fleenor, Bruce Herbold, Wim Kimmerer, Jay Lund, Peter Moyle, and Matthew Nobriga. This group of professors, researchers, and staff from various resource agencies was assembled by State Water Board staff with the intent of informing the Delta flow criteria informational proceeding.

- Ecosystem Investments for the Sacramento-San Joaquin Delta: Development of a Portfolio Framework

Over the course of the hearing, the State Water Board received information from expert witnesses in response to questions posed by Board members. The expert witnesses, representing various participants, as well as experts from the DEFG, were grouped into five panels in order to focus the discussions on specific aspects of the Delta flow criteria. These panels addressed the following topics: hydrology, pelagic fish, anadromous fish, other stressors, and hydrodynamics.

At the conclusion of the informational proceeding, participants were given approximately 20 days to submit closing comments. On July 21, 2010, the draft report was released for public review and comment.

3.1.4 Scope of This Report

Due to the limited nine-month time period in which the State Water Board must develop new flow criteria, the notice for the informational proceeding requested information on what volume, quality, and timing of Delta outflows are necessary under different hydrological conditions to protect public trust resources pursuant to the State Water Board's public trust obligations and the requirements of SB 1. Delta outflows are of critical importance to various ecosystem functions, water supply, habitat restoration, and other planning issues. The effect of Delta outflows in protecting public trust resources necessarily involves complex interactions with other flows in the Delta and with non-flow parameters including water quality and the physical configuration of the Delta. This report recognizes the role of source inflows used to meet Delta outflows, Delta hydrodynamics, tidal action, hydrology, water diversions, water project operations, and cold water pool storage in upstream reservoirs, and relies upon information submitted on these related topics to inform its determinations.

The State Water Board intends that the flow criteria developed in this proceeding should meet the following general goal regarding the protection of public trust resources:

- Halt the population decline and increase populations of native species as well as species of commercial and recreational importance by providing sufficient flow and water quality at appropriate times to promote viable life stages of these species.

To meet this goal, the State Water Board also sought to develop criteria that are comprehensive and that can be implemented without undue complexity. This report is limited to consideration of flow criteria needed under the existing physical conditions, so therefore does not consider or anticipate changes in habitat or modification of water conveyance facilities. The State Water Board does, however, identify other measures that should be considered in conjunction with, and to complement, the flow criteria.

A number of factors outside the scope of the legislative mandate to develop new flow criteria could affect public trust resources and some other factors could affect the interaction of flows with the environment. These factors include contaminants, water quality parameters, future habitat restoration measures, water conveyance facilities modification, and the presence of non-native species.

3.1.5 Concurrent State Water Board Processes

The State Water Board has a number of ongoing proceedings that may be informed by the development of flow criteria. Some of these proceedings will result in regulatory requirements that affect flow, or otherwise affect the volume, quality, or timing of flows into, within, or out of the Delta. In July 2008, the State Water Board adopted a strategic work plan for actions to protect beneficial uses of the San Francisco Bay/Delta (Bay-Delta). In accordance with the work plan, the State Water Board recently completed a periodic review of the 2006 Water Quality Control Plan for the Bay-DeltaEstuary (Bay-Delta Plan) that recommended the Delta Outflow objectives, as well as other flow objectives, for further review in the water quality control planning process. Currently, the State Water Board is in the process of reviewing the southern Delta salinity and the San Joaquin River flow objectives contained in the Bay-Delta Plan.

Clean Water Act Water Quality Certifications

Several non-federal hydropower projects with potential to affect Delta tributary flows have ongoing or pending proceedings before the Federal Energy Regulatory Commission (FERC) that will result in the issuance of new licenses that will govern operations for the 30-50 year term. The relicensing process allows state and federal agencies to prescribe conditions to achieve certain objectives such as state water quality standards and the protection of listed species. New license conditions may include instreams flows requirements or other conditions to protect aquatic species. For example, the new license for the Oroville Dam will require changes in minimum flow requirements and changes in facilities and operations to meet certain water temperature requirements to protect Chinook salmon, steelhead, and green sturgeon. By 2016, more than 25 Delta tributary dams will go through the relicensing process.

The State Water Board will rely upon the FERC license application and the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) documents prepared for the projects, and may require submittal of additional data or studies, to inform its Clean Water Act Section 401 Water Quality Certifications for the projects. The Board's water quality certification will be issued as soon as possible after the environmental documents and any other needed studies are complete, after which FERC will issue a new license. The conditions in the water quality certification are mandatory and must be included in the FERC license.

Information developed as part of the relicensing of these projects will be used to inform on-going Bay Delta proceedings, and any information developed in the State Water Board's Bay Delta proceedings will be used to inform the two water quality certifications.

Table 1 summarizes the dams, tributaries, and license expiration dates for FERC projects in the Delta watershed. Several of these projects are upstream of major dams and reservoirs in the Sacramento and San Joaquin river watershed so operational changes would have little or no direct effect upon Delta flows.

Table 1. Delta Watershed FERC Projects

River	Dam(s)	Storage Capacity (acre-feet)	Owner	Status of Proceeding	FERC License Expiration
Feather	Oroville	3.5 million	Department of Water Resources (DWR)	Near completion	January 2007
West Branch Feather	Philbrook, Round Valley	6,200	Pacific Gas and Electric Company (PG&E)	Near Completion	October 2009
South Feather	Little Grass Valley	90,000	South Feather Water and Power Agency	Near completion	March 2009
Upper North Fork Feather	Lake Almanor	1.1 million	PG&E	Near Completion	October 2004
Pit River	McCloud, Iron Canyon,Pit 6, 7	110,000	PG&E	Ongoing	July 2011
North Yuba	New Bullards Bar	970,000	Yuba County Water Agency	Pre-Licensing meetings started	March 2016
Middle and South Yuba, Bear	Yuba-Bear Project, 10+ dams	210,000	Nevada Irrigation District	Ongoing	April 2013
Middle & South Yuba, Bear	Drum-Spaulding Project, 10+ dams	150,000	PG&E	Ongoing	April 2013
Middle Fork American River	French Meadows, Hell Hole	340,000	Placer County Water Agency	Ongoing	February 2013
South Fork American River	Loon Lake, Slab Creek	400,000	Sacramento Municipal Utility District	Near completion	July 2007
South Fork American River	Chili Bar	1,300	PG&E	Near completion	July 2007
Tuolumne	New Don Pedro	2 million	Turlock Irrigation District	To commence late 2010	April 2016
Merced	New Exchequer/ McSwain	1 million	Merced Irrigation District	Ongoing	February 2014
Merced	Merced Falls	650	PG&E	Ongoing	February 2014
San Joaquin	Mammoth Pool	120,000	Southern California Edison	Near Completion	November 2007
San Joaquin	Huntington, Shaver, Florence	320,000	Southern California Edison	Near Completion	February 2009

3.1.6 Delta Stewardship Council and Use of This Report

In accordance with the legislative requirements described above, the State Water Board will submit this report, containing its Delta flow criteria determinations, to the Council within 30 days after this report has been completed. This report will be deemed complete on the date the State Water Board adopts a resolution approving transmittal of the report to the Council.

Additionally, SB 1 requires any order approving a change in the point of diversion of the State Water Project (SWP) or the Central Valley Project (CVP) from the southern Delta to a point on the Sacramento River to include appropriate flow criteria and to be informed by the analysis in this report. (Wat. Code, § 85086, subd. (c)(2).) The statute also specifies, however, that the criteria shall not be considered predecisional with respect to the State Water Board's subsequent consideration of a permit. (*Id*., § 85086, subd. (c)(1).) Thus, any process with regulatory or adjudicative effect must take place through the State Water Board's water quality control planning or water rights processes in conformance with applicable law. Any person who wishes to introduce information produced during this informational proceeding, or the State Water Board's ultimate determinations in this report, into a later rulemaking or adjudicative proceeding must comply with the rules for submission of information or evidence applicable to that proceeding.

3.2 Regulatory Setting

3.2.1 History of Delta Flow Requirements

The State Water Rights Board (a predecessor to the State Water Board) first had an opportunity to consider flow requirements in the Delta when it approved water rights for much of the U.S. Bureau of Reclamation's (USBR) CVP in Water Right Decision 990 (D-990) (adopted in 1961), but it did not impose any fish protection conditions in D-990. In 1967, the State Water Rights Board included fish protections in D-1275 approving the water right permits for the SWP. Effective December 1, 1967, the State Water Rights Board and the State Water Quality Control Board were merged in a new agency, the State Water Board, which exercises both the water quality and water rights adjudicatory and regulatory functions of the state. The State Water Board adopted a new water quality control policy for the Delta and Suisun Marsh in October 1968, in Resolution 68-17. The resolution specified that the objectives would be implemented through conditions on the water rights of the CVP and SWP.

To implement the water quality objectives, the State Water Board adopted Water Right Decision 1379 (D-1379) in 1971[5]. D-1379 established new water quality requirements in both the SWP and CVP permits, including fish flows, and rescinded the previous SWP requirements from D-1275 and D-1291. D-1379 was stayed by the courts and eventually was superseded by Water Right Decision 1485 (D-1485).

In April 1973, in Resolution 73-16, the State Water Board adopted a water quality control plan to supplement the State water quality control policies for the Delta.

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[5] In 1971, the State Water Board approved interim regional water quality control plans for the entire State, including the Delta and Suisun Marsh. Subsequently, the State Water Board approved long-term objectives for the Delta and Suisun Marsh in the regional plans for the Sacramento-San Joaquin Delta Basin and the San Francisco Bay Basin.

In August 1978, the State Water Board adopted both D-1485 and the 1978 Delta Plan. Together the 1978 Delta Plan and D-1485 revised existing objectives for flow and salinity in the Delta's channels and ordered USBR and DWR to meet the objectives. In 1987, the State Water Board commenced proceedings to review the 1978 Delta Plan and D-1485. The Board held a hearing at numerous venues in California and released a draft water quality control planin 1988, but subsequently withdrew it and resumed further proceedings.

In 1991, the State Water Board adopted the 1991 water quality control plan. This is the first Bay-Delta plan to adopt objectives for dissolved oxygen (DO) and temperature. The 1991 Bay-Delta plan did not amend either the flow or water project operations objectives adopted in the 1978 Delta Plan.[6] The United States Environmental Protection Agency (USEPA) approved the objectives in the plan for salinity for municipal, industrial, and agricultural uses, and approved the new DO objectives for fish and wildlife, but disapproved the Delta outflow objectives for the protection of fish and wildlife carried over from the 1978 Delta Plan. The USEPA adopted its own Delta outflow standards in 1994 to supersede the State's objectives.

In the summer of 1994, after the USEPA had initiated its process to develop standards for the Delta, the State and federal agencies with responsibility for management of Bay-Delta resources signed a Framework Agreement, agreeing that: (1) the State Water Board would update and revise its 1991 Bay-Delta Plan to meet federal requirements and would initiate a water right proceeding to implement the plan, after which the USEPA would withdraw its fish and wildlife objectives; (2) a group would be formed to coordinate operations of the SWP and CVP with all regulatory requirements in the Delta; and (3) the State and federal governments would undertake a joint long-term solution finding process to resolve issues in the Bay-Delta. In December 1994, representatives of the State and federal governments, water users, and environmental interests agreed to the implementation of a Bay-Delta protection plan. The plan and institutional documents to implement it are contained in a document titled "Principles for Agreement on Bay-Delta Standards between the State of California and the Federal Government." This is commonly referred to as the "Bay-Delta Accord" or "Principles Agreement."

In 1995 the State Water Board adopted the 1995 Bay-Delta Plan, which is consistent with the Principles Agreement.[7] In response to a water right change petition filed by DWR and USBR, the State Water Board then adopted Water Right orders that temporarily allowed DWR and USBR to operate the SWP and CVP in accordance with the 1995 Plan while the State Water Board conducted water right proceedings for a water right decision that would implement the 1995 Bay-Delta Plan. The hearing commenced in 1998 and concluded in 1999. During the 1998-99 water right hearing, DWR and USBR and their water supply contractors negotiated with a number of parties. In 1999, the State Water Board adopted Decision 1641 (D-1641) and subsequently revised D-1641 in 2000.

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[6] After adopting the 1991 Plan, the State Water Board conducted a proceeding to establish interim water right requirements for the protection of public trust uses in the Delta. The State Water Board released a draft water right decision known as "Decision 1630" (D-1630), but did not adopt it.

[7] USEPA approved the 1995 Bay-Delta Plan. By approving the 1995 Bay-Delta Plan, the USEPA supplanted its own water quality standards with the standards in the 1995 Bay-Delta Plan. (*State Water Resources Control Board Cases* (2006) 136 Cal.App.4th 674,774-775 [39 Cal.Rptr.3d 189]; 33 U.S.C. § 1313(c)(2)(A),(c)(3).)

3.2.2 Current State Water Board Flow Requirements

The current Bay-Delta flow requirements are contained in the 2006 Bay-Delta Plan and in D-1641. D-1641 implements portions of the 1995 Bay-Delta Plan. D-1641 accepts the contribution that certain entities, through their agreements, will make to meet the flow-dependent water quality objectives in the 1995 Plan, and continues the responsibility of DWR and USBR for the remaining measures to meet the flow-dependent objectives and other responsibilities. In addition, D-1641 recognizes the San Joaquin River Agreement (SJRA) and approves, for a period of twelve years, the conduct of the Vernalis Adaptive Management Plan (VAMP) under the SJRA instead of meeting the San Joaquin River pulse flow objectives in the 1995 Plan. The 2006 Bay-Delta Plan is consistent with D-1641 and makes only minor changes to the 1995 Bay-Delta Plan, allowing the staged implementation of the San Joaquin River spring pulse flow objectives and other minor changes. The 2006 Bay-Delta Plan also identifies a number of issues requiring additional review and planning including: the pelagic organism decline (POD), climate change, Delta and Central Valley salinity, and San Joaquin River flows.

Current Delta outflow requirements, set forth in Tables 3 and 4 in both the 2006 Bay-Delta Plan and D-1641, take two basic forms based on water year type and season: 1) specific numeric Delta outflow requirements; and 2) position of X2, the horizontal distance in kilometers up the axis of the estuary from the Golden Gate Bridge to where the tidally averaged near-bottom salinity is 2 practical salinity units (psu). The Delta outflow requirements are expressed in Table 3 as a Net Delta Outflow Index (NDOI). The NDOI is a calculated flow expressed as Delta Inflow, minus net Delta consumptive use, minus Delta exports. Each component is calculated as described in the 2006 Bay-Delta Plan and D-1641. An electrical conductivity (EC) measurement of 2.64 mmhos/cm at Collinsville station C2 can be substituted for the NDOI during February through June. The most downstream location of either the maximum daily average or the 14-day running average of this EC level is commonly referred to as the position of “X2” in the Delta. Table 4 specifies EC measurements at two specific locations and alternatively allows an NDOI calculation at these locations.

3.2.3 Special Status Species

The California Endangered Species Act (CESA) states that all native species of fishes, amphibians, reptiles, birds, mammals, invertebrates, and plants, and their habitats, threatened with extinction and those experiencing a significant decline which, if not halted, would lead to a threatened or endangered designation, will be protected or preserved. The federal Endangered Species Act of 1973 (ESA) provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. A number of species discussed in this report are afforded protections under CESA and ESA. These species and the protections are discussed below.

The longfin smelt (*Spirinchus thaleichthys*) is currently a candidate for threatened species status under the CESA. (DFG 1, p. 9.) In March 2009, the California Fish and Game Commission (Commission) made a final determination that the listing of longfin smelt as a threatened species was warranted and the rulemaking process to officially add the species to the CESA list of threatened species found in the California Code of Regulations was initiated. Upon completion of this rulemaking process, the longfin smelt’s status will officially change from candidate to threatened. (DFG 1, p. 9.) Its status remains unresolved at the federal level. (USFWS 2009.) The delta smelt (*Hypomesus transpacificus*) is listed as endangered and threatened pursuant to the CESA and ESA, respectively. (DFG 1, p. 14; USFWS 1993.) In April 2010, the United States Fish and Wildlife Service (USFWS) considered a petition to reclassify the delta smelt from threatened to endangered. After review of all available scientific and commercial information, the USFWS found that reclassifying the delta smelt from a threatened to an endangered species is warranted, but precluded by other higher priority listing actions. (USFWS 2010.)

Sacramento winter-run Chinook salmon *(Oncorhynchus tshawytscha)* is listed as endangered pursuant to the CESA and ESA. (NMFS 1994; NMFS 2005; DFG 2010.) Central Valley spring-run Chinook salmon (*O. tshawytscha*) is listed as threatened pursuant to both the CESA and ESA. (NMFS 1999; NMFS 2005; DFG 2010.) Central Valley fall/late fall-run Chinook salmon (*O. tshawytscha*) are classified as species of special concern by the National Marine Fisheries Service (NMFS). (NMFS 2004.) Central Valley steelhead (*O. mykiss*) is listed as threatened under the ESA (NMFS 1998; NMFS 2006a.) Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*) is listed as threatened under the ESA. (NMFS 2006b.)

3.2.4 State Incidental Take Permit for Longfin Smelt

The CESA prohibits the take[8] of any species of wildlife designated as an endangered, threatened, or candidate species[9] by the Commission. The Department of Fish and Game (DFG), however, may authorize the take of such species by permit if certain conditions are met (Cal. Code Regs., tit 14, § 783.4). In 2009, DFG issued an Incidental Take Permit for Longfin Smelt to the DWR for the on-going and long-term operation of the SWP. The permit specifies a number of conditions, including two flow measures (Conditions 5.1 and 5.2) intended to minimize take of the longfin smelt and provide partial mitigation for the remaining take by: 1) minimizing entrainment; 2) improving estuarine processes and flow; 3) improving downstream transport of longfin smelt larvae; and 4) providing more water that is used as habitat (increasing habitat quality and quantity) by longfin smelt than would otherwise be provided by the SWP.

Longfin Smelt Incidental Take Permit (2009), p. 9-10, Condition 5.1.
This Condition is not likely to occur in many years. To protect adult longfin smelt migration and spawning during December through February period, the Smelt Working Group (SWG) or DFG SWG personnel staff shall provide Old and Middle River (OMR) flow advice to the Water Operations Management Team (WOMT) and to Director of DFG weekly. The SWG will provide the advice when either: 1) the cumulative salvage index (defined as the total longfin smelt salvage at the CVP and SWP in the December through February period divided by the immediately previous FMWT longfin smelt annual abundance index) exceeds five (5); or 2) when a review of all abundance and distribution survey data and other pertinent biological factors that influence the entrainment risk of adult longfin smelt indicate OMR flow advise is warranted. Permittee shall ensure the OMR flow requirement is met by maintaining the OMR flow 14-day running average is no more negative than -5,000 cfs and the initial 5-day running average is not more negative than -6,250 cfs. During any time OMR flow restrictions for the USFWS's 2008 Biological Opinion for delta smelt are being implemented, this condition (5.1) shall not result in additional OMR flow requirements for protection of adult longfin smelt. Once spawning has been detected in the system, this Condition terminates and 5.2 begins. Condition 5.1 is not required or would cease if previously required when river flows are 1) > 55,000 cfs in

[8] Pursuant to Fish and Game Code section 86, "'Take' means hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture or kill."

[9] "Candidate species" are species of wildlife that have not yet been placed on the list of endangered species or the list of threatened species, but which are under formal consideration for listing pursuant to Fish and Game Code section 2074.2

the Sacramento River at Rio Vista; or 2) > 8,000 cfs in the San Joaquin River at Vernalis. If flows go below 40,000 cfs in the Sacramento River at Rio Vista or 5,000 cfs in the San Joaquin River at Vernalis, the OMR flow in Condition 5.1 shall resume if triggered previously. Review of survey data and other pertinent biological factors that influence the entrainment risk of adult longfin smelt may result in a recommendation to relax or cease an OMR flow requirement.

Longfin Smelt Incidental Take Permit (2009), p. 10-11, Condition 5.2.
To protect larval and juvenile longfin smelt during January -June period, the SWG or DFG SWG personnel shall provide OMR flow advice to the WOMT and the DFG Director weekly. The OMR flow advice shall be an OMR flow between -1,250 and -5,000 cfs and be based on review of survey data, including all of the distributional and abundance data, and other pertinent biological factors that influence the entrainment risk of larval and juvenile longfin smelt. When a single Smelt Larval Survey (SLS) or 20 mm Survey sampling period results in: 1) longfin smelt larvae or juveniles found in 8 or more of the 12 SLS or 20mm stations in the central and south Delta (Stations 809, 812, 901, 910, 912, 918, 919) or, 2) catch per tow exceeds 15 longfin smelt larvae or juveniles in 4 or more of the 12 survey stations listed above, OMR flow advice shall be warranted. Permittee shall ensure the OMR flow requirement is met by maintaining the OMR flow 14-day running average no more negative than the required OMR flow and the 5-day running average is within 25% of the required OMR. This Conditions OMR flow requirement is likely to vary throughout Jan through June. Based on prior analysis, DFG has identified three likely scenarios that illustrate the typical entrainment risk level and protective measures for larval smelt over the period: High Entrainment Risk Period - Jan through Mar OMR range from -1,250 to -5,000 cfs; Medium Entrainment Risk Period - April and May OMR range from -2000 to -5,000 cfs, and Low Entrainment Risk Period - June OMR -5,000 cfs. When river flows are: 1) greater than 55,000 cfs in the Sacramento River at Rio Vista; or 2) greater than 8,000 cfs in the San Joaquin River at Vernalis, the Condition would not trigger or would be relaxed if triggered previously. Should flows go below 40,000 cfs in Sacramento River at Rio Vista or 5,000 cfs in the San Joaquin River at Vernalis, the Condition shall resume if triggered previously. In addition to river flows, the SWG or DFG SWG personnel review of all abundance and distribution survey data and other pertinent biological factors that influence the entrainment risk of longfin smelt may result in a recommendation by DFG to WOMT to relax or cease an OMR flow requirement.

3.2.5 Biological Opinions

In 2008 and 2009, the USBR and the DWR concluded consultations regarding the effects of continued long-term operations of the Central CVP and SWP with the USFWS and the NMFS, respectively. Those consultations led to the issuance of biological opinions that require implementation of reasonable and prudent alternatives (RPAs) to avoid jeopardizing the continued existence and potential for recovery of delta smelt (*Hypomesus transpacificus*), Sacramento River winter-run Chinook salmon *(Oncorhynchus tshawytscha)*, Central Valley spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*), Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*), and Southern Resident killer whales *(Orcinus orca)*.

Pursuant to Section 7 of the ESA, federal agencies must insure that their actions do not jeopardize the continued existence of threatened or endangered species or adversely modify their designated critical habitat. The regulations (50 CFR 402.02) implementing Section 7 of the ESA define RPAs as alternative actions, identified during formal consultation, that: 1) can be implemented in a manner consistent with the intended purpose of the action; 2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; 3) are economically and technologically feasible; and, 4) would, the USFWS or NMFS believes, avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat. (USFWS 2008, p.279.)

Numerous anthropogenic and other factors (e.g., pollutants and non-native species) that may adversely affect listed fish species in the region are not under the direct control of the CVP or the SWP and as such are not addressed in the biological opinions.

USFWS Biological Opinion

On December 15, 2008, the USFWS issued a biological opinion on the Long-Term Operational Criteria and Plan (OCAP) for coordination of the CVP and SWP (UFWS Opinion). The RPA in the USFWS Opinion, divided into six actions, applies to delta smelt and focuses primarily on managing flow regimes to reduce entrainment of delta smelt and on the extent of suitable water conditions in the Delta, as well as on construction or restoration of habitat. (USFWS 2008, pp.329-381.) Flow related components of the RPA include:

- A fixed duration action to protect pre-spawning adult delta smelt from entrainment during the first flush, and to provide advantageous hydrodynamic conditions early in the migration period. This action limits exports so that the average daily net OMR flow is no more negative than -2,000 cubic-feet per second (cfs) for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent) (Action 1, p.329).

- An adaptive process to continue to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions after the action identified above. The range of net daily OMR flows will be more no more negative than -1,250 to -5,000 cfs. From the onset of this action through its termination, the Delta Smelt Working Group would provide weekly recommendations for specific net OMR flows based upon review of the sampling data, from real-time salvage data at the CVP and SWP, and utilizing the most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored variables of flow and turbidity. The USFWS will make the final determination (Action 2, p.352).

- Upon completion of Actions 1 and 2 or when Delta water temperatures reach 12°C (based on a 3-station average of daily average water temperature at Mossdale, Antioch, and Rio Vista) or when a spent female delta smelt is detected in the trawls or at the salvage facilities, the projects shall operate to maintain net OMR flows no more negative than -1,250 to -5000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25% of the applicable 14-day OMR flow requirement. Action continues until June 30th or when Delta water temperatures reach 25˚C, whichever comes first (Action 3, p.357).

- Improve fall habitat, both quality and quantity, for delta smelt through increasing Delta outflow during fall (fall X2). Subject to adaptive management, provide sufficient Delta outflow to maintain average X2 for September and October no greater (more eastward) than 74 km in the fall following wet years and 81km in the fall following above normal years. The monthly average X2 must be maintained at or seaward of these values for each individual month and not averaged over the two month period. In November, the inflow to CVP/SWP reservoirs in the Sacramento Basin will be added to reservoir releases to provide an added increment of Delta inflow and to augment Delta outflow up

- To minimize entrainment of larval and juvenile delta smelt at the State and federal south Delta export facilities or from being transported into the south and central Delta, where they could later become entrained, do not install the Head of Old River Barrier (HORB) if delta smelt entrainment is a concern. If installation of the HORB is not allowed, the agricultural barriers would be installed as described in the Project Description of the biological opinion. If installation of the HORB is allowed, the Temporary Barrier Project flap gates would be tied in the open position until May 15 (Action 5, p. 377).

- Implement habitat restoration activities designed to improve habitat conditions for delta smelt by enhancing food production and availability to supplement the benefits resulting from the flow actions described above. DWR shall implement a program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. The restoration efforts shall begin within 12 months of signature of this biological opinion and be completed within a 10 year period (Action 6, p. 379).

NMFS Biological Opinion

On June 4, 2009, NMFS issued its Biological and Conference Opinion on the OCAP (NMFS Opinion), which provides RPA actions to protect winter-run and spring-run Chinook salmon, Central Valley steelhead, green sturgeon, and killer whales from project effects in the Delta and upstream areas. (NMFS 3.) The RPA consists of five actions with a total of 72 subsidiary actions. Included within the RPA are actions related to: formation of technical teams, research and adaptive management, monitoring and reporting, flow management, temperature management, gravel augmentation, fish passage and reintroduction, gate operations and installation (Red Bluff Diversion Dam, Delta Cross Channel Gate, South Delta Improvement Program), funding for fish screening, floodplain and other habitat restoration, hatchery management, export restrictions, CVP and SWP fish collection facility modifications, and fish collection and handling. The flow related components of the opinion include:

- In the Sacramento River Basin – flow requirements for Clear Creek; release requirements from Whiskeytown Dam for temperature management; cold water pool management of Shasta Reservoir; development of flow requirements for Wilkins Slough; and restoration of floodplain habitat in the lower Sacramento River basin to better protect Chinook salmon, steelhead, and green sturgeon. (*Id at* pp.587-611.)

- In the American River - flow requirements and cold water pool management requirements to provide protection for steelhead. (*Id at* pp. 611-619.)

- In the San Joaquin River Basin – cold water pool management, floodplain inundation flows, and flow requirements for the Stanislaus River (NMFS 3, pp. 619-628, Appendix 2-E) and an interim minimum flow schedule for the San Joaquin River at Vernalis during April and May effective through 2011 for the protection of steelhead. (*Id at* pp. 641-645.)

- In the Delta – Delta Cross-Channel Gate operational requirements; net negative flow requirements toward the export pumps in Old and Middle rivers; and export limitations based on a ratio of San Joaquin River flows to combined SWP and CVP export during April and May for the protection of Chinook salmon and steelhead. (*Id. at* pp. 628-660.)

It is important to note that the flow protections described in the project description and RPA are the minimum flows necessary to avoid jeopardy. (NMFS written summary, p.3.) In addition, NMFS considered provision of water to senior water rights holders to be non-discretionary for purposes of the ESA as it applies to Section 7 consultation with the USBR, which constrained development of RPA Shasta storage actions and flow schedules. San Joaquin River flows at Vernalis were constrained by the NMFS Opinion's scope extending only to CVP New Melones operations. Operations on other San Joaquin tributaries were not within the scope of the consultation. (*Id.*)

<u>Recent Litigation</u>

Both the USFWS Opinion and the NMFS Opinion are the subject of ongoing litigation in the United States District Court for the Eastern District of California. Plaintiffs challenged the validity of the opinions under various legal theories, including claims under the ESA and the NEPA. Most recently, this year plaintiffs Westlands Water District and San Luis Delta Mendota Water Authority sought preliminary injunctions against the implementation of certain RPAs identified by NMFS and USFWS in their biological opinions for the protection of Delta smelt and Central Valley steelhead and salmonids. In May 2010, Judge Wanger issued a ruling concluding that injunctive relief was appropriate with respect to the NMFS biological opinion PRA Action IV.2.1, which limits pumping based on San Joaquin River inflow from April 1 through May 31, and RPA Action IV.2.3, which imposes restrictions on negative OMR flows in generally between January 1 and June 15. Later that month, he also ruled that injunctive relief was appropriate with respect to RPA Component 2 of Action 3 of the USFWS Opinion, which requires net OMR flows to remain between -1,250 and -5,000 cfs during a certain period for the protection of larval and juvenile delta smelt. The validity of the biological opinions likely will continue to be litigated in the foreseeable future, creating uncertainty about implementation of the RPAs.

3.3 Environmental Setting

Figure 1 is a map of the Bay-Delta Estuary that was included in the 2006 Bay-Delta Plan. The map depicts the location of monitoring stations used to collect baseline water quality data for the Bay-Delta Estuary and stations used to monitor compliance with water quality objectives set forth in the Bay-Delta Plan.

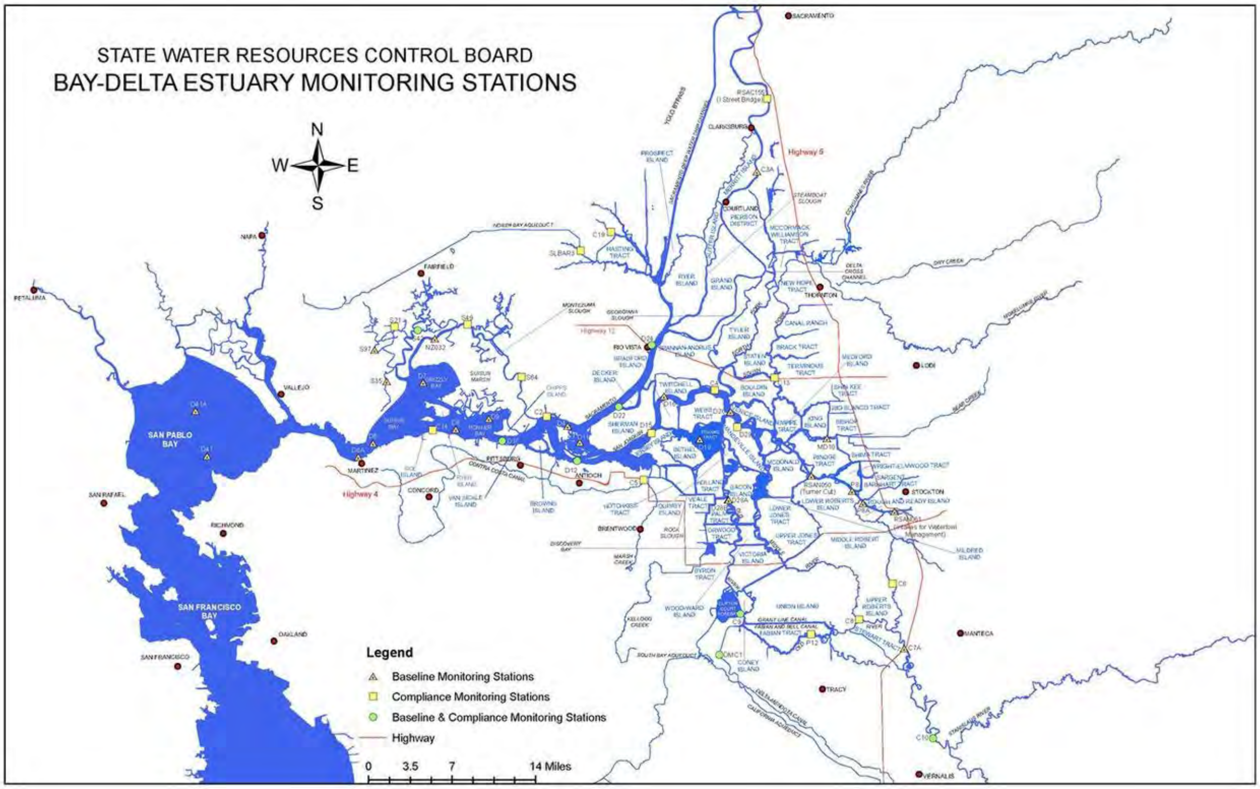


Figure 1. Map of the Bay-Delta Estuary

3.3.1 Physical Setting

The Delta is located where California's two major river systems, the Sacramento and San Joaquin rivers, converge from the north and south and are joined by several tributaries from the Central Sierras to the east, before flowing westward through the San Francisco Bay to the Pacific Ocean. The Sacramento and San Joaquin rivers drain water from the Central Valley Basin, which includes about 40 percent of California's land area.

Outflow from the Delta enters Suisun Bay just west of the confluence of the Sacramento and San Joaquin rivers. Suisun Marsh, which is located along the north shore of Suisun Bay, is one of the few major marshes remaining in California and is the largest remaining brackish wetland in Western North America. The marsh is subject to tidal influence and is directly affected by Delta outflow. Suisun Marsh covers approximately 85,000 acres of marshland and water ways and provides a unique diversity of habitats for fish and wildlife.

The Old Delta

The Delta formed as a freshwater marsh through the interaction of river inflow and the strong tidal influence of the Pacific Ocean and San Francisco Bay. The growth and decay of tules and other marsh plants resulted in the deposition of organic material, creating layers of peat that formed the soils of the marsh. Hydraulic mining during the Gold Rush era washed large amounts of sediment into the rivers, channels and bays, temporarily burying the wetlands. The former wetland areas were reclaimed into more than 60 islands and tracts that are devoted primarily to farming. A network of levees protects the islands and tracts from flooding, because most of the islands lie near or below sea level due to the erosion and oxidation of the peat soils.

As shown in Figure 2 (Courtesy, Chris Enright, DWR, using Atwater data), prior to reclamation, the channels in the Delta were connected in a dendritic, or tree-like, pattern and may have included 5 to 10 times as many miles of interconnected channels as it does today, with largely unidirectional flow.

Figure 2. The Old Delta (*ca.* 1860).

The Recent Delta

Today's Delta covers about 738,000 acres, of which about 48,000 acres are water surface area, and is interlaced with about 700 miles of waterways. As shown in Figure 3 (Courtesy, Chris Enright, DWR, using Atwater data), today's remaining Delta waterways have been greatly modified to facilitate the bi-directional movement of water and the river banks have been armored to protect against erosion, thus changing the geometry of the stream channels and eliminating most of the natural vegetation and habitat of the aquatic and riparian environment. The interconnected geometry and channelized sloughs of the present Delta result in much less variability in water quality than the past dendritic pattern, and today's mostly open ended sloughs results in water quality and habitat being relatively homogenous throughout the system. (Moyle et al. 2010.)

Figure 3. The Recent Delta

The Changing Delta
The Delta Environmental Flows Group (DEFG 2) describes in *Changing Ecosystems: a Brief Ecological History of the Delta* how the Delta has undergone significant physical and biological modification over the past 150 years. Initial development occurred during the Gold Rush when large amounts of sediment washed into the Delta, followed by diking and dredging of rivers. This was followed by increasing diversions and developments, including fixing of levees and channels, and most recently with large-scale dam development and diversions from the Delta. The Moyle et al. history also suggests what is likely to happen in the future:

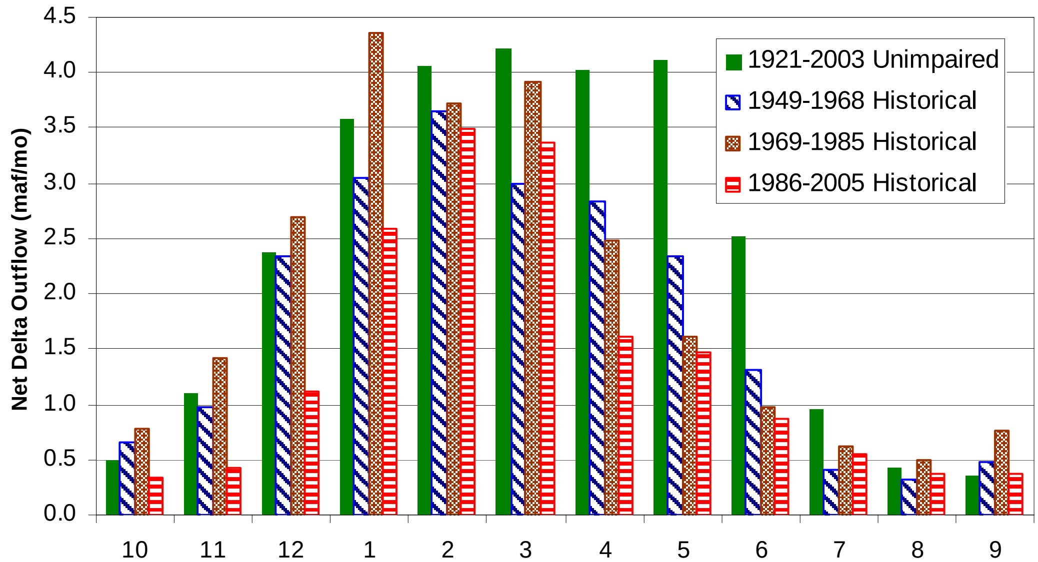
> "The Delta ecosystem is likely to dramatically shift again within 50 years due to large-scale levee collapse in the Delta and Suisun Marsh. Major levee failures are inevitable due to continued subsidence, sea level rise, increasing frequency of large floods, and high probability of earthquakes. These significant changes will create large areas of open water and increased salinity intrusion, as well as new tidal and subtidal marshes. Other likely changes include reduced freshwater inflow during prolonged droughts, altered hydraulics from reduced export pumping, and additional alien invaders (e.g., zebra and quagga mussels). The extent and effects of all these changes are unknown but much will depend on how the estuary is managed in response to change or even before change takes place. Overall, these major changes in the estuary's landscape are likely to promote a more variable, heterogeneous estuary, especially in the Delta and Suisun Marsh. This changed environment is likely to be better for desirable estuarine species; at least it is unlikely to be worse."

3.3.2 Hydrology/Hydrodynamics

California's climate and hydrology are Mediterranean, which is characterized by most precipitation falling during the winter-spring wet season, a dry season extending from late spring through early fall, and high inter-annual variation in total runoff. The life history strategies of all native estuarine Delta fishes are adapted to natural variability. (Moyle and Bennett 2008, as cited in Fleenor et al. 2010.) Although the unimpaired flow record does not indicate precise, or best, flow requirements for fish under current conditions, the general timing (e.g., seasonality), magnitudes, and directions of flows seen in the unimpaired flow record are likely to remain important for native species under contemporary and future conditions. (Fleenor et al. 2010.)

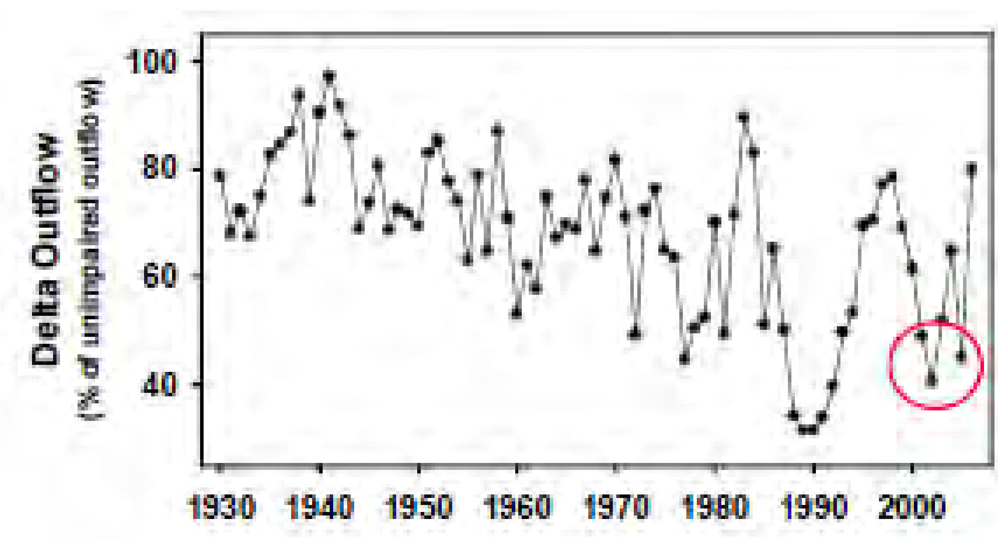
Inflow to the Delta comes primarily from the Central Valley Basin's Sacramento and San Joaquin river systems and is chiefly derived from winter and spring runoff originating in the Cascade and Sierra Nevada mountains, with minor amounts from the Coast Ranges. Precipitation totals vary annually with about 80 percent of the total occurring between the end of October and the beginning of April. Snow storage in the high Sierra delays the runoff from that area until the snow melts in April, May, and June. Normally, about half of the annual runoff from the Central Valley Basin occurs during this period. In recent years, the Sacramento River contributed roughly 75 to 80% of the Delta inflow in most years, while the San Joaquin River contributed about 10 to 15%. The minor flows of the Mokelumne, Cosumnes, and Calaveras rivers, which enter into the eastern side of the Delta, contributed the remainder of the inflow to the Delta.

Net Delta outflow represents the difference between the sum of freshwater inflows from tributaries to the Delta and the sum of exports and net in-Delta consumptive uses. (Kimmerer 2004, DOI 1, p.17.) As noted above, the majority of the freshwater flow into the Delta occurs in winter and spring; however, upstream storage and diversions have reduced the winter-spring flow and increased flow in summer and early fall. (Figure 4, Kimmerer 2002b; Kimmerer 2004; DOI 1, p. 16.) The April-June reductions are largely the result of the San Joaquin River diversions. (Fleenor et al. 2010.) During the summer-fall dry season the Delta channels essentially serve as a conveyance system for moving water from reservoirs in the north to the CVP and SWP export facilities, as well as the smaller Contra Costa Water District facility, for subsequent delivery to farms and cities in the San Joaquin Valley, southern California, and/or other areas outside the watershed. (Kimmerer 2002b.) Figure 5 shows the reduction in annual Delta outflow as a percentage of unimpaired outflow. The combined effects of water exports and upstream diversions reduced average annual net outflow from the Delta from unimpaired conditions by 33% and 48% during the 1948 – 1968 and 1986 – 2005 periods, respectively. (Fleenor et al. 2010.)



This figure shows monthly average net delta outflows (in million acre-feet per month) compared to the unimpaired flows from 1921-2003. Unimpaired flow data is from DWR (2006) and other from Dayflow web site. (Source: Fleenor et al. 2010, Figure 7.)

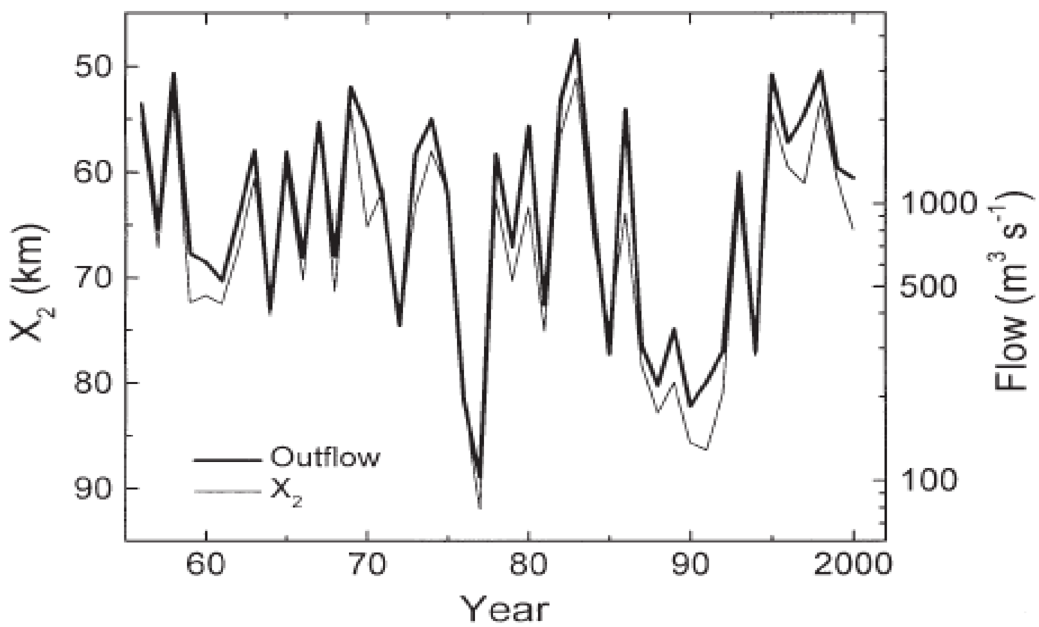
Figure 4. Monthly Average Net Delta Outflows from Fleenor et al. 2010



Delta outflow shown as a percentage of unimpaired outflow (1930-2005); in the last decade annual outflow is reduced by more than 50% in 2001, 2002, and 2005. (Source: TBI 2007, as cited in DOI 1, p. 17.)

Figure 5. Delta Outflow as a Percent of Unimpaired Outflow from TBI 2007

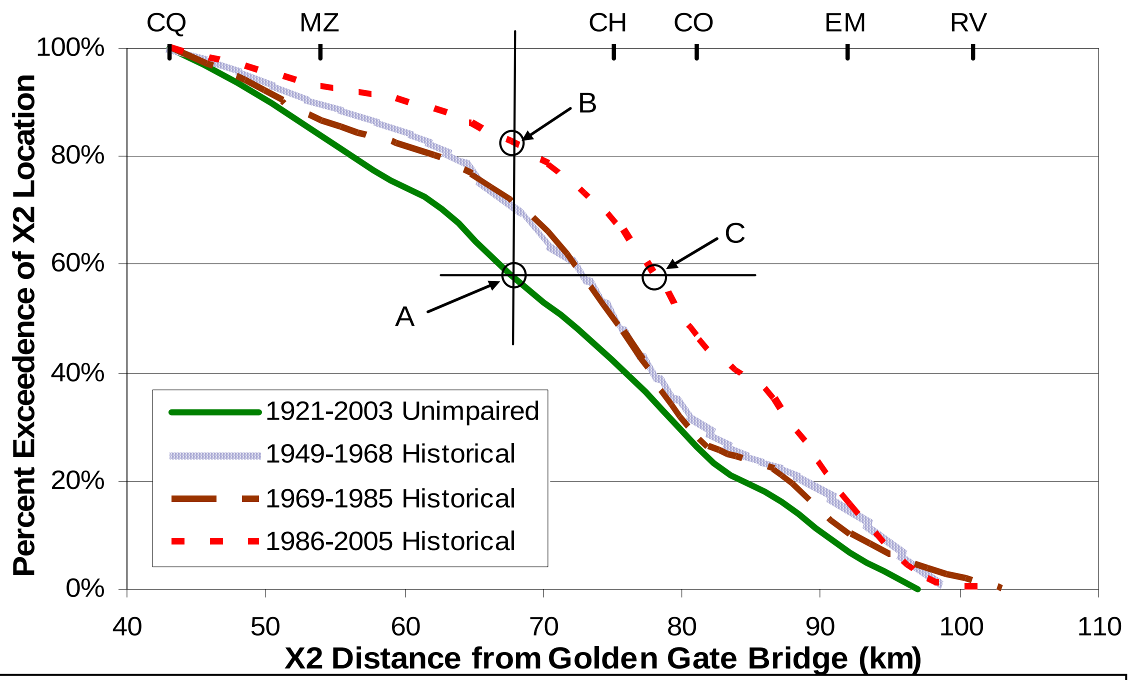
Delta outflows and the position of X2 are closely and inversely related, with a time lag of about two weeks. (Jassby et al. 1995; Kimmerer 2004.) A time series of the annual averages for January to June of X2 and Delta outflow is depicted in Figure 6. X2 is defined as the horizontal distance in kilometers up the axis of the estuary from the Golden Gate Bridge to where the tidally averaged near-bottom salinity is 2 practical salinity units (psu). (Jassby et al. 1995, Kimmerer 2002a.) The position of X2 roughly equates to the center of the low salinity zone (defined as salinity of 0.5 to 6 psu). (Kimmerer 2002a.) The X2 objectives in the 2006 Bay-Delta Plan were designed to restore a more natural hydrograph and salinity pattern by requiring maintenance of the low salinity zone at specified points and durations based on the previous month's Eight River Index. (State Water Board 2006a.) The relationships between outflow and several measures of the health of the Bay-Delta Estuary have been known for some time (Jassby *et al*. 1995) and are the basis for the current X2 objectives.



Time series of X2 (thin line, left axis, scale reversed) and flow (heavy line, right axis, log scale), annual averages for January to June; flow data from DWR; X2 calculated as in Jassby et al. (1995) (Source: Kimmerer 2002a, Figure 3).

Figure 6. X2 and Delta Outflow for January to June from Kimmerer 2002a

Both Delta outflow and the position of X2 have been altered as a result of numerous factors including development and operation of upstream storage and diversions, land use changes, and increasing water demand. Hydrodynamic simulations conducted by Fleenor et al. (2010) indicate that the position of X2 has been skewed eastward in the recent past, as compared to unimpaired conditions and earlier impaired periods, and that the variability of salinity in the western Delta and Suisun Bay has been significantly reduced (Figure 7). The higher X2 values shown in this figure (refer to Point 'B') indicate the low salinity zone is farther upstream for a more prolonged period of time. Point 'B' demonstrates that during the period from 1986 to 2005 the position of X2 was located upstream of 71 km nearly 80% of the time, as opposed to unimpaired flows which were equally likely to place X2 upstream or downstream of the 71 km location (50% probability). (Fleenor *et al*. 2010.) Historically, X2 exhibited a wide seasonal range tracking the unimpaired Delta outflows; however, seasonal variation in X2 range has been reduced by nearly 40%, as compared to pre-dam conditions. (TBI 2003, as cited in DOI 1, pp. 21-22.)



This graph shows the cumulative probability distributions of daily X2 locations showing unimpaired flows (green solid line) and three historical periods, 1949-1968 (light solid blue line), 1969-1985 (long-dashed brown line) and 1986-2005 (short-dashed red line), illustrating progressive reduction in salinity variability from unimpaired conditions. Paired letters indicate geographical landmarks: CQ, Carquinez Bridge; MZ, Martinez Bridge; CH, Chipps Island; CO, Collinsville; EM, Emmaton; and RV, Rio Vista (Source: Fleenor et al. 2010, Figure 8).

Figure 7. Cumulative Probability of Daily X2 Locations from Fleenor *et al*. 2010

In their key points on Delta environmental flows for the State Water Board, the DEFG (DEFG 1) noted that the recent flow regimes both harm native species and encourage non-native species and provided the following justification:

> "The major river systems of the arid western United States have highly variable natural flow regimes. The present-day flow regimes of western rivers, including the Sacramento and San Joaquin, are highly managed to increase water supply reliability for agriculture, urban use, and flood protection (Hughes et al. 2005, Lund et al. 2007). Recent Delta inflow and outflow regimes appear to both harm native species and encourage non-native species. Inflow patterns from the Sacramento River may help riverine native species in the north Delta, but inflow patterns from the San Joaquin River encourage non-native species. Ecological theory and observations overwhelmingly support the argument that enhancing variability and complexity across the estuarine landscape will support native species. However, the evidence that flow stabilization reduces native fish abundance in the upper estuary (incl. Delta) is circumstantial:
>
> 1) High winter-spring inflows to the Delta cue native fish spawning migrations (Harrell and Sommer 2003; Grimaldo et al. 2009), improve the reproductive success of resident native fishes (Meng et al. 1994; Sommer et al. 1997; Matern et al. 2002; Feyrer 2004), increase the survival of

juvenile anadromous fishes migrating seaward (Sommer *et al*. 2001; Newman 2003), and disperse native fishes spawned in prior years (Feyrer and Healey 2003; Nobriga et al. 2006).

2) High freshwater outflows (indexed by X2) during winter and spring provide similar benefits to species less tolerant of freshwater including starry flounder, bay shrimp, and longfin smelt (Kimmerer 2002; Kimmerer *et al*. 2009). Freshwater flows provide positive benefits to native fishes across a wide geographic area through various mechanisms including larval-juvenile dispersal, floodplain inundation, reduced entrainment, and increased up-estuary transport flows. Spring Delta inflows and outflow have declined since the early 20th century, but average winter-spring X2 has not had a time trend during the past 4-5 decades (Kimmerer 2004).

3) The estuary's fish assemblages vary along the salinity gradient (Matern et al. 2002; Kimmerer 2004), and along the gradient between predominantly tidal and purely river flow. In tidal freshwater regions, fish assemblages also vary along a gradient in water clarity and submerged vegetation (Nobriga et al. 2005; Brown & Michniuk 2007), and smaller scale, gradients of flow, turbidity, temperature and other habitat features (Matern et al. 2002; Feyrer & Healey 2003). Generally, native fishes have their highest relative abundance in Suisun Marsh and the Sacramento River side of the Delta, which are more spatially and temporally variable in salinity, turbidity, temperature, and nutrient concentration and form than other regions.

4) In both Suisun Marsh and the Delta, native fishes have declined faster than non-native fishes over the past several decades (Matern et al. 2002; Brown and Michniuk 2007). These declines have been linked to persistent low fall outflows (Feyrer et al. 2007) and the proliferation of submerged vegetation in the Delta (Brown and Michniuk 2007). However, many other factors also may be influencing native fish declines including differences in sensitivity to entrainment (sustained or episodic high "fishing pressure" as productivity declines), and greater sensitivity to combinations of food-limitation and contaminants, especially in summer-fall when many native fishes are near their thermal limits.

The weight of the circumstantial evidence summarized above strongly suggests flow stabilization harms native species and encourages non-native species, possibly in synergy with other stressors such as nutrient loading, contaminants, and food limitation."

Diversion and Use

Irrigation is the primary use of water in the Sacramento and San Joaquin river watershed. Water is used to a lesser extent to meet municipal, industrial, environmental, and instream needs. Water is also exported from the Central Valley Basin for many of these same purposes. Local irrigation districts, municipal utility districts, county agencies, private companies and corporations, and State and federal agencies have developed surface water projects throughout the basin to control and conserve the natural runoff and provide a reliable water supply for beneficial uses. Many of these projects are used to produce hydroelectric power and to enhance recreational opportunities. Flood control systems, water storage facilities, and diversion works exist on all major streams in the basin, altering the timing, location, and quantity of water and the habitat associated with the natural flow patterns of the basin. (State Water Board 1999.)

The major surface water supply developments of the Central Valley include the CVP, other federal projects built by the USBR and the U.S. Army Corps of Engineers (USACE), the SWP, and numerous local projects (including several major diversions). The big rim dams, developed mostly since the 1940s, dramatically changed river flow patterns. The dams were built to provide flood protection and a reliable water supply. Collection of water to storage decreased river flows in winter and spring, and changed the timing of high flow periods (except for extreme flood flows). The San Joaquin River has lost most of its natural summer flows because the majority of the water is exported via the Friant project or diverted from the major tributaries for use within the basin. Even though natural flows have been substantially reduced, agricultural return flows during the summer have actually resulted in higher flows than would have occurred under unimpaired conditions at times. Winter and spring flows collected to storage by the State and federal projects in the Sacramento Basin are released in the late spring and throughout the summer and fall, largely to be rediverted from the Delta for export. The federal pumping plants in the southern Delta started operating in the 1950s, exporting water into the Delta-Mendota Canal. The State pumps and the California Aqueduct started operating in the late 1960s, further increasing exports from the Delta. (Moyle, et al. 2010.)

In-Delta Diversions and Old and Middle River Reverse Flows

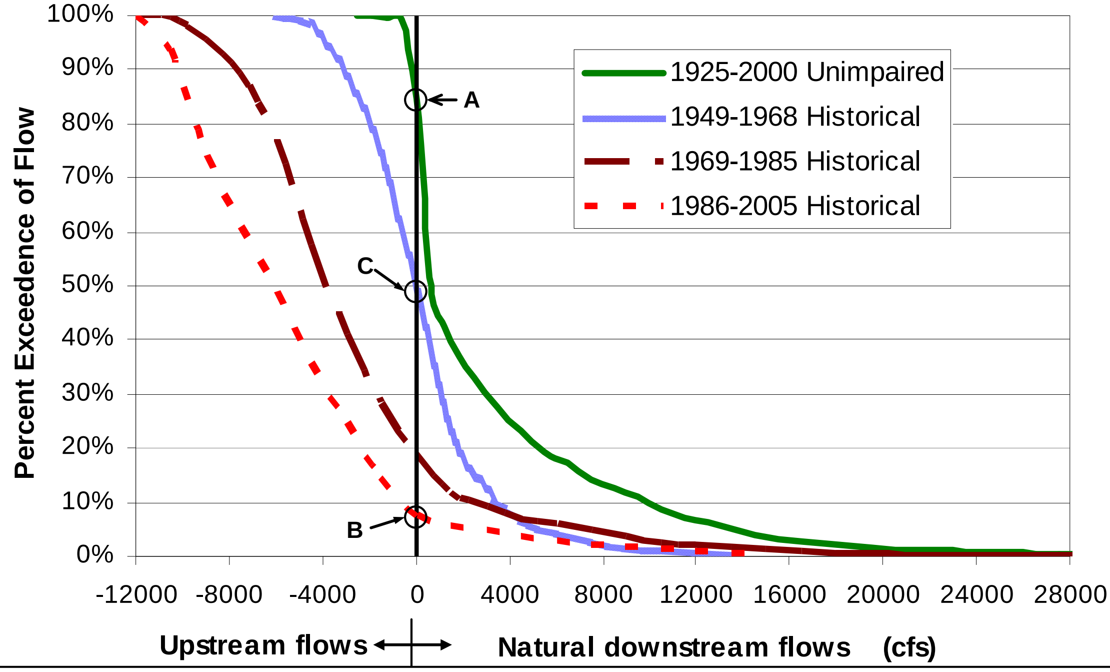
The USBR and the DWR are the major diverters in the Delta. The USBR exports water from the Delta at the Tracy Pumping Plant and the Contra Costa Water District diverts CVP water at Rock Slough and Old River under a water supply contract with the USBR. The DWR exports from the Delta at the Banks Delta Pumping Plant and Barker Slough to serve the SWP contractors. Operation of the CVP and SWP Delta export facilities are coordinated to meet water quality and flow standards set by the Board, the USACE, and by fisheries agencies. In addition, there are approximately 1,800 local diversions within the Delta that amount to a combined potential instantaneous flow rate of more than 4,000 cfs. (State Water Board 1999.)

Net OMR reverse flows are now a regular occurrence in the Delta (Figure 8). Net OMR reverse flows are caused by the fact that the major freshwater source, the Sacramento River, enters on the northern side of the Delta while the two major pumping facilites, the SWP and CVP, are located in the south (Figure 1). This results in a net water movement across the Delta in a north-south direction along a web of channels including Old and Middle rivers instead of the more natural pattern from east to west or from land to sea. Net OMR is calculated as half the flow of the San Joaquin River at Vernalis minus the combined SWP and CVP pumping rate. (CCWD closing comments, p. 2.) A negative value, or a reverse flow, indicates a net water movement across the Delta along Old and Middle river channels to the State and Federal pumping facilities. Fleenor *et al* (2010) has documented the change in both the magnitude and frequency of net OMR reverse flows as water development occurred in the Delta (Figure 8). The 1925-2000 unimpaired line in Figure 8 represents the best estimate of “quasi-natural” or net OMR values before most modern water development. (Fleenor et al. 2010.) The other three lines represent changes in the frequency and magnitude of net OMR flows with increasing development. Net OMR reverse flows are estimated to have occurred naturally about 15% of the time before most modern water development, including construction of the major pumping facilities in the South Delta (point A, Figure 8). The magnitude of net OMR reverse flows was seldom more negative than a couple of thousand cfs. In contrast, between1986-2005 net OMR reverse flows had become more frequent than 90 percent of the time (Point B). The magnitude of net OMR reverse flows may now be as much as -12,000 cfs. High net OMR reverse flows have several negative ecological consequences. First, net reverse OMR flows draw fish, especially the weaker swimming larval and juvenile forms, into the SWP and CVP export facilities. The export facilities have been documented to entrain most species of fish present in the upper estuary. (Brown *et al*. 1996,.) Approximately 110 million fish were salvaged at the SWP pumping facilities and returned to the Delta over a 15 year period, (Brown et al. 1996.) However, this number underestimates the actual number of fish entrained, as it does not include losses at the CVP nor does it account for fish less than 20 mm in length which are not collected and counted at the fish collection facilities. Second, net OMR reverse flows reduce spawning and rearing habitat for native species, like delta smelt. Any fish that enters the Central or Southern Delta has a high probability of being entrained and lost at the pumps. (Kimmerer and Nobriga, 2008.) This has restricted their habitat to the western Delta and Suisun and Grizzly bays. Third, net OMR reverse flows have led to a confusing environment for migrating juvenile salmon leaving the San Joaquin Basin. Through-Delta exports reduce salinity in the central and southern Delta and as a result juvenile salmon migrate from higher salinity in the San Joaquin River to lower salinity in the southern Delta, contrary to the natural historical conditions and their inherited migratory cues. Finally, net OMR reverse flows reduce the natural variability in the Delta by drawing Sacramento River water across and into the Central Delta. The UC Davis Delta Solutions Group recommends:

> "Achieving a variable, more complex estuary requires establishing seaward gradients in salinity and other water quality variables…These goals in turn encourage policies which… establish internal Delta flows that create a tidally-mixed, upstream-downstream gradient (without cross-Delta flows) in water quality… and … restoring environmental variability in the Delta is fundamentally inconsistent with continuing to move large volumes of water through the Delta for export. The drinking and agricultural water quality requirements of through-Delta exports, and perhaps even some current in-Delta uses, are at odds with the water quality and variability needs of desirable Delta species."
> (Moyle et al., 2010.)

Net OMR reverse flow restrictions are included in the USFWS Opinion (Actions 1 through 3), the NMFS Opinion (Action IV.2.3), and the DFG Incidental Take Permit (Conditions 5.1 and 5.2) for the protection of delta smelt, salmonids, and longfin smelt, respectively. (NMFS 3. p. 648; USFWS 2008, DFG 2009.) Additional net OMR reverse flow restrictions are recommended in this report for protection of longfin and delta smelt and Chinook salmon.

Further north in the Delta, the Delta Cross Channel is used to divert a portion of the Sacramento River flow into the interior Delta channels. The purpose of the Delta Cross Channel is to preserve the quality of water diverted from the Sacramento River by conveying it to southern Delta pumping plants through eastern Delta channels rather than allowing it to flow through more saline western Delta channels. The Delta Cross Channel is also operated to protect fish and wildlife beneficial uses (specifically Chinook salmon), while recognizing the need for fresh water to be moved through the system. With a capacity of 3,500 cfs, the Delta Cross Channel can divert a significant portion of the Sacramento River flows into the eastern Delta, particularly in the fall.



Cumulative probability distribution of sum of Old and Middle River flows (cfs) resulting from through Delta conveyance showing unimpaired flows (green solid line) and three historical periods, 1949-1968 (solid light blue line), 1969-1985 (long-dashed brown line) and 1986-2005 (short-dashed red line) (Source: Fleenor et al. 2010, Figure 9).

Figure 8. OMR Cumulative Probability Flows from Fleenor et al. 2010

3.3.3 Water Quality

Water quality in the Delta may be negatively impacted by contaminants in sediments and water, low DO levels, and blue green algal blooms. Additionally, changes in hydrology and hydrodynamics affect water quality. The conversion of tidal wetlands to leveed Delta islands has altered the tidal exchange and prism. These changes can contribute to spatial and temporal shifts in salinity and other physical and chemical water quality parameters (temperature, DO, contaminants, etc.).

Contaminants

The Delta and San Francisco Bay are listed under section 303(d) of the Federal Clean Water Act as impaired for a variety of toxic contaminants that may contribute to reduced population abundance of important fish and invertebrates. The contaminants include: organophosphate and pyrethrin pesticides, mercury, selenium and unknown toxicity. In addition, low DO levels periodically develop in the San Joaquin River in the Stockton Deep Water Ship Channel (DWSC) and in Old and Middle rivers. The low DO levels in the DWSC inhibit the upstream migration of adult fall-run Chinook salmon and adversely impact other resident aquatic organisms. The Central Valley and San Francisco Regional Boards are systematically developing Total Maximum Daily Loads (TMDLs) for all listed pollutants and adopting programs to implement control actions.

There is concern that a number of non-303(d) listed contaminants, such as ammonia, pharmaceuticals, endocrine disrupting compounds and blue-green algal blooms could also limit biological productivity and impair beneficial uses. More work is needed to determine their impact on the aquatic community. Sources of these contaminants include: agricultural, municipal, and industrial wastewater; urban storm water discharges; discharges from wetlands; and channel dredging activities.

Ammonia has emerged as a contaminant of special concern in the Delta. Recent hypotheses are that ammonia is causing toxicity to delta smelt, other local fish, and zooplankton, and is reducing primary production rates in the Sacramento River below the Sacramento Regional Wastewater Treatment Plant (SRWTP) and in Suisun Bay. A third, newer, hypothesis is that ammonia and nitrogen to phosphorus ratios have altered phytoplankton species composition, and these changes have had a detrimental effect on zooplankton and fish population abundance. (Glibert, 2010.)

The SRWTP is the primary source of ammonia to the Delta. (Jassby 2008.) The SRWTP has converted the Delta from a nitrate to an ammonia dominated nitrogen system. (Foe et al. 2010.) Seven-day flow-through bioassays by Werner et al. (2008, 2009) have demonstrated that ammonia concentrations in the Delta are not acutely toxic to delta smelt. Monthly nutrient monitoring by Foe *et al*. (2010) has demonstrated that ammonia concentrations are below the recommended USEPA (1999) chronic criterion for the protection of juvenile fish. Results from the nutrient monitoring suggest that ammonia-induced toxicity to fish is not regularly occurring in the Delta.

Elevated ammonia concentrations inhibit nitrate uptake and that appears to be one factor preventing spring diatom blooms from developing in Suisun Bay. (Dugdale et al. 2007; Wilkerson et al. 2006.) One of the primary hypotheses for the POD is a decrease in the availability of food at the base of the food web. (Sommer et al. 2007.) Staff from the San Francisco Regional Board has informed the Central Valley Regional Board that ammonia may be impairing aquatic life beneficial uses in Suisun Bay (letter to Kathy Harder with the Central Valley Regional Board from Bruce Wolfe of the San Francisco Regional Board dated June 4, 2010).

Ammonia concentrations are higher in the Sacramento River below the SRWTP than in Suisun Bay. This led to a hypothesis that ammonia might be inhibiting nitrate uptake and reducing primary production rates in the Sacramento River and downstream Delta, as occurs in Suisun Bay. Experimental results for the Sacramento River are more ambiguous than for Suisun Bay. (Parker *et al*., 2010.) Five-day cubitainer grow out experiments conducted using water collected above and below the SRWTP usually demonstrated more chlorophyll in water collected below the SRWTP. Short-term bottle primary production rate measurements conducted using water collected above and below the SRWTP also demonstrate no decrease in the rate when normalized by the amount of chlorophyll in the bottle. However, effluent dosed into upstream Sacramento River water at environmentally realistic concentrations does show a decrease in primary production. Elevated ammonia concentrations consistently decrease nitrate uptake. Whether the shift in nitrogen utilization indicates that different algal species are beginning to grow in the ammonia rich water is not known. A recent paper by Glibert (2010) demonstrates significant correlations between the form and concentration of nutrients discharged by the SRWTP, and changes in phytoplankton, zooplankton, and fish abundance in the Delta.

Salinity

Elevated salinity can impair the uses of water by municipal, industrial, and agricultural users and by organisms that require lower salinity levels. There are at least three factors that may cause salinity levels to exceed water quality objectives in the Delta: saltwater intrusion from the Pacific

Ocean and San Francisco Bay moving into the Delta on high tides during periods of relatively low flows of fresh water through the Delta; salts from agricultural return flows, municipalities, and other sources carried into the southern and eastern Delta with the waters of the San Joaquin River; and localized increases in salinity due to irrigation return flows into dead-end sloughs and low-capacity channels (null zones). The effects of saltwater intrusion are seen primarily in the western Delta. Due to the operation of the State and federal export pumping plants near Tracy, the higher salinity areas caused by salts in the San Joaquin River tend to be restricted to the southeast corner of the Delta. Null zones, and the localized areas of increased salinity associated with them, exist predominantly in three areas of the Delta: Old River between Sugar Cut and the CVP intake; Middle River between Victoria canal and Old River; and the San Joaquin River between the head of Old River and the City of Stockton.

Suspended Sediments and Turbidity

Turbidity in the Delta is caused by factors that include suspended material such as silts, clays, and organic matter coming from the major tributary rivers; planktonic algal populations; and sediments stirred up during dredging operations to maintain deep channels for shipping. Turbidity affects large river and estuarine fish assemblages because some fishes survive best in turbid (muddy) water, while other species do best in clear water. Studies suggest that changes in specific conductance and turbidity are associated with declines in upper estuary habitat for delta smelt, striped bass, and threadfin shad. Laboratory studies have shown that delta smelt require turbidity for successful feeding.

Turbidity in the Delta has decreased through time. The primary hypotheses to explain the turbidity decrease are: (1) reduced sediment supply; (2) sediment washout from very high inflows during the 1982 to 1983 El Nino; and (3) trapping of sediment by submerged aquatic vegetation. (Wright and Schoellhamer 2004, Jassby et al. 2005, Nobriga et al. 2005, and Brown and Michniuk 2007 as cited in Nobriga et al. 2008.)

Dissolved Oxygen

Low DO levels are found along the lower San Joaquin River and in certain localized areas of the Delta. Dissolved oxygen impairment is caused, in part, by loads of oxygen demanding substances such as dead algae or waste discharges. Low DO in the Delta occurs mainly in the late summer and coincides with low river flows and high temperatures. Fish vary greatly in their ability to tolerate low DO concentrations, based on the environmental conditions the species has evolved to inhabit. Salmonids are relatively intolerant of low DO concentrations. Within the lower San Joaquin River, DO concentrations can become sufficiently low to impair the passage and/or cause mortality of migratory salmonids. (DFG 3, p. 3; DOI 1, p. 25; TBI/NRDC 3, p. 26.)

The DWSC is a portion of the lower San Joaquin River between the City of Stockton and the San Francisco Bay that has been dredged to allow for the navigation of ocean-going vessels to the Port of Stockton. A 14-mile stretch of the DWSC, from the City of Stockton to Disappointment Slough, is listed as impaired for DO and, at times, does not meet the objectives set forth in the San Joaquin Riverwater quality control plan. Studies have identified three main contributing factors to the problem: loads of oxygen demanding substances that exert an oxygen demand (particularly the death and decay of algae); DWSC geometry, which reduces the assimilative capacity for loads of oxygen demanding substances by reducing the efficiency of natural re-aeration mechanisms and by magnifying the effect of oxygen demanding reactions; and, reduced flow through the DWSC, which reduces the assimilative capacity by reducing upstream inputs of oxygen and increasing the residence time for oxygen demanding reactions. (Central Valley Regional Board 2003.)

3.3.4 Biological Setting

The Bay-Delta Estuary is one of the largest, most important estuarine systems for fish and waterfowl production on the Pacific Coast of the United States. The Delta provides habitat for a wide variety of freshwater, estuarine, and marine fish species. Channels in the Delta range from dead-end sloughs to deep, open water areas that include several flooded islands that provide submerged vegetative shelter. The complex interface between land and water in the Delta provides rich and varied habitat for wildlife, especially birds. The Delta is particularly important to waterfowl migrating via the Pacific Flyway as these birds are attracted to the winter-flooded fields and seasonal wetlands. (State Water Board 1999.)

Existing Setting

A wide variety of fish are found throughout the waterways of the Central Valley and the Bay-Delta Estuary. About 90 species of fish are found in the Delta. Some species, such as the anadromous fish, are found in particular parts of the Bay-Delta Estuary and the tributary rivers and streams only during certain stages of their life cycle. The Delta's channels serve as a migratory route and nursery area for Chinook salmon, striped bass, white and green sturgeon, American shad, and steelhead trout. These anadromous fishes spend most of their adult lives either in the lower bays of the estuary or in the ocean, moving inland to spawn. Resident fishes in the Bay-Delta Estuary include delta smelt, longfin smelt, threadfin shad, Sacramento splittail, catfish, largemouth and other bass, crappie, and bluegill.

Food supplies for Delta fish communities consist of phytoplankton, zooplankton, benthic invertebrates, insects, and forage fish. The entrapment zone, where freshwater outflow meets and mixes with the more saline water of the Bay, concentrates sediments, nutrients, phytoplankton, some fish larvae, and other fish food organisms. Biological standing crop (biomass) of phytoplankton and zooplankton in the estuary has generally been highest in this zone. However, the overall productivity at the lower trophic levels has decreased over time. (State Water Board 1999.)

Non-Native and Invasive Species

Invasive aquatic organisms are known to have deleterious effects on the Delta ecosystem. These effects include reductions in habitat suitability, reductions in food supply, alteration of the aquatic food-web, and predation on or competition with native species. There are many notable examples of exotic species invasions in the Bay-Delta, so much so, that the Delta has been labeled "the most invaded estuary on earth."

Of particular importance potentially in the recent decline in pelagic organisms is the introduction of the Asian clam, *Corbula amurensis*. The introduction of the clam has lead to substantial declines in the lower trophic production of the Bay-Delta Estuary. In addition to reductions in planktonic production caused by *Corbula*, the planktonic food web composition has changed dramatically over the past decade or so. Once dominant copepods in the food web have declined leading to speculation that estuarine conditions have changed to favor alien species. The decrease in these desirable copepods may further increase the likelihood of larval fish starvation or result in decreased growth rates. (State Water Board 2008.)

The proliferation of invasive, aquatic weeds, such as *Egeria densa*, which filter out particulate materials and further reduce planktonic growth, are also having a impact on the Bay-Delta. Areas with low or no flow, such as warm, shallow, dead-end sloughs in the eastern Delta also support objectionable populations of plants during summer months including planktonic blue-green algae and floating and semi-attached aquatic plants such as water primrose, water hyacinth, and *Egeria densa*. All of these plants contribute organic matter that reduces DO levels in the fall, and the floating and semi-attached plants interfere with the passage of small boat traffic. In addition, native fishes in the Bay-Delta face growing challenges associated with competition and predation by non-native fish. (State Water Board 1999; State Water Board 2008.)

Recent Species Declines

Historical fisheries within the Central Valley and the Bay-Delta Estuary were considerably different than the fisheries present today. Many native species have declined in abundance and distribution, while several introduced species have become well established. The Sacramento perch is believed to have been extirpated from the Delta; however, striped bass and American shad are introduced species that, until recently, have been relatively abundant and have contributed substantially to California's recreational fishery. (State Water Board 1999.)

In 2005, scientists with the Interagency Ecological Program (IEP) announced observations of a precipitous decline in several pelagic organisms in the Delta, beginning in 2002, in addition to declining levels of zooplankton. Zooplankton are the primary food source for older life stages of species such as delta smelt. The decline in pelagic organisms included delta smelt, striped bass, longfin smelt, and threadfin shad. Scientists hypothesized that at least three general factors may be acting individually, or in concert, to cause this recent decline in pelagic productivity: 1) toxic effects; 2) exotic species effects; and 3) water project effects. Scientists and resources agencies have continued to investigate the causes of the decline, and have prepared plans that identify actions designed to help stabilize the Delta ecosystem and improve conditions for pelagic fish species. (State Water Board 2008.)

In January of 2008, the Pacific Fisheries Management Council reported unexpectedly low Chinook salmon returns to California, particularly to the Central Valley, for 2007. Adult returns to the Sacramento River, the largest of Central Valley Chinook salmon runs, failed to meet resource management goals (122,000-180,000 spawners) for the first time in 15 years. (State Water Board 2008.) The Sacramento River fall Chinook salmon escapement to the Central Valley was estimated to be 88,000 adults in 2007; 66,000 in 2008; and 39,530 – the lowest on record -- in 2009. (PCFFA 2.) The NMFS concluded that poor ocean conditions were a major factor contributing to the low fall-run abundance; however, other conditions may exacerbate these effects. (State Water Board 2008.)

In April 2008, the Pacific Fisheries Management Council and the Commission adopted the most restrictive ocean and coastal salmon seasons ever for California by closing the ocean and coastal fishery to commercial and recreation fishing for the 2008 fishing season. The Commission further banned salmon fishing in all Central Valley rivers, with the exception of limited fishing on a stretch of the Sacramento River. (State Water Board 2008.) The ban on all salmon fishing was extended through the 2009 season, but the restrictions were eased somewhat for 2010.

3.3.5 How Flow-Related Factors Affect Public Trust Resources

Flow is important to sustaining the ecological integrity of aquatic ecosystems, including the public trust resources that are the subject of this proceeding. Flow affects water quality, food resources, physical habitat, and biotic interactions. Alterations in the natural flow regime affect aquatic biodiversity and the structure and function of aquatic ecosystems.

In its key points on Delta environmental flows for the State Water Board, the DEFG (DEFG 1) noted that:

- Flow related factors that affect public trust resources include more than just volumes of inflow and outflow and no single rate of flow can protect all public trust resources at all times. The frequency, timing, duration, and rate of change of flows, the tides, and the occurrence of overbank flows, all are important. Seasonal, interannual, and spatial variability in flows, to which native species are adapted, are as important as the quantity of flow. Biological responses to flows rest on combinations of quantity, timing, duration, frequency and how these inputs vary spatially in the context of a Delta that is geometrically complex, highly altered by humans, and fundamentally tidally driven.

- Recent flow regimes in the Delta have contributed to the decline of native species and encouraged non-native species. Flows into and within the estuary affect turbidity, salinity, aquatic plant communities, and nutrients that are important to both native and non-native species. However, flows and habitat structure are often mismatched and now favor non-native species.

- Flow is a major determinant of habitat and transport. The effects of flow on transport and habitat are controlled by the geometry of the waterways. Further, because the geometry of the waterways will change through time, flow regimes needed to maintain desired habitat conditions will also change through time. Delta inflow is an important factor affecting the biological resources of the Delta because inflow has a direct effect on flood plain inundation, in-Delta net channel flows, and net Delta outflows.

- Flow modification is one of the few immediate actions available to improve conditions to benefit native species. However, habitat restoration, contaminant and nutrient reduction, changes in diversions, control of invasive species, as well as flood plain inundation and island flooding all interact with flow to affect aquatic habitats.

4. Methods and Data

The notice for the informational proceeding requested scientific information on the volume, quality, and timing of water needed for the Delta ecosystem under different hydrologic conditions to protect public trust resources pursuant to the State Water Board's public trust obligations and the requirements of SB 1. Specifically, the notice focused on Delta outflows, but also requested information concerning the importance of the source of those flows and information concerning adaptive management, monitoring, and special study programs. In addition to the requested information concerning Delta outflows, the State Water Board also received information on Sacramento River inflows, San Joaquin River inflows, hydrodynamics including Old and Middle River flows, and other information that is relevant to protection of public trust resources in the Delta ecosystem. This section presents the recommendations received by the State Water Board and discusses approaches used to evaluate the recommendations and develop flow criteria responsive to SB1.

4.1 Summary of Participants' Submittals

Information submitted by interested parties over the course of this proceeding has resulted in the development of a substantive record; submittals are available on the State Water Board's website at:
http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/entity_index.shtml

The exhibits include discussions pertaining to: the State Water Board's public trust obligations; methodologies that should be used to develop flow criteria; the importance of the source of flows when determining outflows; means by which uncertainty should be addressed; and specific recommendations concerning Delta outflows, Sacramento and San Joaquin river inflows, hydrodynamics, operation of the Delta Cross Channel Gates, and floodplain activation.

The State Water Board received a wide range of recommendations for the volume, quantity and timing of flow necessary to protect public trust resources. Delta outflow recommendations ranged from statements that the current state of scientific understanding does not support development of numeric Delta flow criteria that differ from the current outflow objectives included in D-1641 (DWR closing comments; SFWC closing comments) to flow volumes during above normal and wet water year types that are two to four times greater than currently required under D-1641 (TBI/NRDC closing comments; AR/NHI closing comments; EDF closing comments, CSPA closing comments; CWIN closing comments). Appendix A: Summary of Participant Recommendations, provides summary tables of the recommendations received for Delta outflows, Sacramento River inflows, San Joaquin River inflows, hydrodynamics, floodplain inundation, and Delta Cross Channel Gate closures.

4.2 Approach to Developing Flow Criteria

Fleenor et al. (2010) examined the following four approaches for prescribing environmental flows for the Delta:

- Unimpaired (quasi-natural) inflows
- Historical impaired inflows that supported more desirable ecological conditions
- Statistical relationships between flow and native species abundance
- The appropriate accumulation of flows estimated to provide specific ecological functions for desirable species and ecosystem attributes based on available literature.

Fleenor *et al*. (2010) concludes:

> "Generally, approaches that rely on data from the past will become more risky as the underlying changes in the Delta accumulate. However, since the objective is to provide flows for species which evolved under past conditions, information on past flows and life history strategies of fish provide considerable insight and context. Aggregate statistical approaches, which essentially establish correlations between past conditions and past species abundance, are likely to be less directly useful as the Delta changes. However, statistical approaches will continue to be useful, especially if developed for causal insights. More focused statistical relationships can be of more enduring value in the context of more causal models, even given underlying changes. In the absence of more process-based science, empirical relationships might be required for some locations and functions on an interim basis. Insights and information can be gained from each approach. Given the importance of the problem and the uncertainties involved,

the strengths of each approach should be employed to provide greater certainty or improve definition of uncertainties."

Among other things, the Fleenor report recommends:

1. Flow prescriptions should be supported preferably by causally or process-based science, rather than correlative empirical relationships or other statistical relationships without supporting ecological basis. Having a greater causal basis for flow prescriptions should make them more effective and readily adapted to improvements in knowledge and changing conditions in the Delta. A more explicit causal basis for flow prescriptions will also create incentives for improved scientific understanding of this system and its management as well as better integration of physical, chemical, and biological aspects of the problem.
2. Ongoing managed and unmanaged changes in the Delta will make any static set of flow standards increasingly irrelevant and obsolete for improving conditions for native fishes. Flows should be tied to habitat, fish, hydrologic, and other management conditions, as well as our knowledge of the system. Flows needed for fish native to the Delta will change.

Information received during this proceeding supports these conclusions and recommendations. The record for this proceeding contains a mix of data and analyses that uses the four approaches identified by Fleenor et al. (2010):

- Unimpaired flows
- Historical impaired inflows that supported more desirable ecological conditions
- Statistical relationships between flow and native species abundance
- Ecological functions-based analysis for desirable species and ecosystem attributes

All four types of information are relied upon to develop the flow criteria in this report. Emphasis, however, is placed on ecological function-based information, followed by information on statistical relationships between flow and native species abundance. In all cases, the criteria are supported by the best available scientific information submitted into the record for this proceeding. The species and ecosystem function-based needs assessments and criteria in this report are supported by references to specific scientific and empirical evidence, and cite to exhibits and testimony in the record or conclusions in published and peer reviewed articles. Criteria based upon statistical relationships between flow and native species abundance are also supported by references to specific scientific and empirical evidence, and cite to exhibits and testimony in the record or conclusions in published and peer reviewed articles.

Furthermore, the conceptual bases for all of the criteria in this report are supported by scientific information on function-based species or ecosystem needs. In other words, there is sufficiently strong scientific evidence to support the need for functional flows. This does not necessarily mean that there is scientific evidence to support *specific* numeric criteria. Recommendations are therefore divided into two categories: Category "A" criteria have more and better scientific information, with less uncertainty, to support specific numeric criteria than do Category "B" criteria. In all cases, the assumptions upon which the criteria are based are identified and discussed. The following steps were followed to develop flow criteria and other recommendations:

1. Establish general goals and objectives for protection of public trust resources in the Delta
2. Identify species to include based on ecological, recreational, or commercial importance
3. Review and summarize species life history requirements, including description of:
    - general life history and species needs
    - population distribution and abundance
    - population abundance and relationship to flow
    - specific population goals
    - species-specific basis for flow criteria
4. Summarize numeric and other criteria for each of: Delta outflows, Sacramento River inflows, San Joaquin River inflows, and hydrodynamics
5. Review other flow-related and non-flow measures that should be considered
6. Provide summary determinations for flow criteria and other measures

The following information was assembled and considered for each species, if available in the record for this proceeding:

- Life history information including timing of migrations
- Seasons or time periods when flow characteristics are most important
- Relationships of species abundance or habitat to Delta outflows, Delta inflows, hydrodynamics, or water quality parameters linked to flow, etc.
- Species environmental requirements (e.g., DO, temperature preferences, salinity, X2 location, turbidity, toxicity to specific pollutants, etc.)
- Relationship of species abundance to invasive species, to the extent possible
- Key quantifiable population responses or habitat characteristics linked to flow
- Mechanisms or hypotheses about mechanisms that link species abundance, habitat, and other metrics to flow or other variables

4.2.1 Biological and Management Goals

The goal of this report is discussed in Section 3.1.4 (Scope of this Report). The following biological and management goals are used to guide the development of criteria that support species life history requirements.

<u>Biological Goals</u>

- Depending on water year type or hydrologic condition, provide sufficient flow to increase abundance of desirable species that depend on the Delta (longfin smelt, delta smelt, starry flounder, bay shrimp, American shad, and zooplankton).

- Create shallow brackish water habitat for longfin smelt, delta smelt, starry flounder, bay shrimp, American shad, and zooplankton in Suisun Bay (and farther downstream).

- Provide floodplain inundation of appropriate timing and sufficient duration to enhance spawning and rearing opportunities to support Sacramento splittail, Chinook salmon, and other native species.

- Manage net OMR reverse flows and other hydrodynamic conditions to protect sensitive life stages of desirable species.

- Provide sufficient flow in the San Joaquin River to transport salmon smolts through the Delta during spring in order to contribute to attainment of the State Water Board's salmon protection water quality objective. (2009 Bay-Delta Plan, p. 14.)

- Provide sufficient flow in the Sacramento River to transport salmon smolts through the Delta during the spring in order to contribute to the attainment of the salmon protection water quality objective. (*Id.*)

- Provide sufficient flow in eastside streams that flow to the Delta, including the Mokelumne and Consumes rivers, to transport salmon smolts to the Delta during the spring in order to contribute to the attainment of the salmon protection water quality objective.

- Maintain water temperatures and DO in mainstem rivers that flow into the Delta and their tributaries at levels that will support adult Chinook salmon migration, egg incubation, smolting, and early-year and late-year juvenile rearing.

Management Goals

- Combine freshwater flows needed to protect species and ecosystem functions in a manner that is comprehensive, does not double count flows, uses an appropriate time step, and is well-documented

- Establish mechanisms to evaluate Delta environmental conditions, periodically review underpinnings of the biological objectives and flow criteria, and change biological objectives and flow criteria when warranted

- Periodically review new research and monitoring to evaluate the need to modify biological objectives and flow criteria

- Do not recommend overly complex flow criteria so as not to infer a greater understanding of specific numeric flow criteria than the available science supports

4.2.2 Selection of Species[10]

Information received during the informational proceeding links the abundance and habitat of several key species that live in, move through, or otherwise depend upon for their survival, the Delta and its ecosystem. DFG Exhibits 1 through 4 present information on the relationship between abundance and the quantity, quality, and timing of flow for the following species: (1) Chinook salmon, (2) Pacific herring, (3) longfin smelt, (4) prickly sculpin, (5) Sacramento splittail, (6) delta smelt, (7) starry flounder, (8) white sturgeon, (9) green sturgeon, (10) Pacific lamprey, (11) river lamprey, (12) bay shrimp, (13) mysid shrimp and a copepod, *Eurytemora affinis*, and (14) American shad. In general, the available data and information indicates:

- For many species, abundance is related to timing and quantity of flow (or the placement of X2).
- For many species, more flow translates into greater species production or abundance.
- Species are adapted to use the water resources of the Delta during all seasons of the year, yet for many species, important life history stages or processes consistently

[10] This section is largely drawn from DFG exhibits 1 through 4.

coincide with the winter-spring seasons and its associated increased flows because this is the reproductive season for most native fishes, and the time that most salmonid fishes are emigrating.

- The source, quantity, quality, and timing of Central Valley tributary outflow affects the same characteristics of mainstem river flow into and through the Delta. Flows in all three of these areas, Delta outflows, tributary inflows, and hydrodynamics, influence production and survival of Chinook salmon in both the San Joaquin River and Sacramento River basins.
- Some invasive species negatively influence native species abundance.

This report is consistent with DFG's recommendation to establish flow criteria for species of priority concern that will benefit most by improving flow conditions. (DFG closing comments, p. 3.) Table 2 (from DFG closing comments p.4) identifies select species that have the greatest ecological, commercial, or recreational importance and are influenced by Delta inflows (including mainstem river tributaries) or Delta outflows. The table identifies the species life stage most affected by flows, the mechanism most affected by flows, and the time when flows are most important to the species.

Table 2. Species of Importance (from DFG closing comments p.4)

Priority Species	Life Stage	Mechanism	Time When Water Flows are Most Important	Reference
Chinook salmon (San Joaquin River basin)	Smolt	Outmigration	March – June	DFG Exhibit 1 – page 2; DFG Exhibit 3 – pages 7-10, 21-35.
Chinook salmon (Sacramento River basin)	Juvenile	Outmigration	November – June	DFG Exhibit 1 – page 1-2, 6-8
Chinook salmon (San Joaquin River tributaries)	Egg/fry	Temperature, DO, upstream barrier avoidance	October – March	DFG Exhibit 3, pages 2-4; DFG Exhibit 4
Longfin smelt	Egg	Freshwater-brackish habitat	December – April	DFG Exhibit 1 – page 2, 9-12
Longfin smelt	Larvae	Freshwater-brackish habitat; transport; turbidity	December – May	DFG Exhibit 1 – page 2, 9-12
Sacramento Splittail	Adults	Floodplain inundating flows	January – April	DFG Exhibit 1 – page 2, 13-14
Sacramento Splittail	Eggs and larvae	Floodplain habitat persistence	January – May	DFG Exhibit 1 – page 3, 13-14

Priority Species	Life Stage	Mechanism	Time When Water Flows are Most Important	Reference
Delta smelt	Larvae and Pre-adult	Transport; habitat	March – November September – November	DFG Exhibit 1 – page 2,14-15
Starry flounder	Settled juvenile; Juvenile-2 yr old	Estuary attraction; habitat	February – May	DFG Exhibit 1 – page 3, 15-16
Bay shrimp	Late-stage larvae and small juveniles	Transport	February – June	DFG Exhibit 1 – page 4; 22-25
Bay shrimp	Juveniles	Nursery habitat	April – June	DFG Exhibit 1 – page 4; 22-25
Mysid shrimp (zooplankton)	All	Habitat	March – November	DFG Exhibit 1 – page 5; 25-26
Eurytemora affinis (zooplankton)	All	Habitat	March – May	DFG Exhibit 1 – page 5; 25-26
American shad	Egg/larvae	Transport; dispersal; habitat	March – June	DFG Exhibit 1 – page 5; 26-28

While many species found in the Delta are of ecological, commercial, and/or recreational interest, specific flow needs for some of those species may not be directly addressed in this report because: they overlap with the needs of more sensitive species otherwise addressed in the report; the relationships between flow and abundance of those species are not well understood; or the needs of those species may be outside the scope of this report. For example, placement of X2 at certain locations in the Delta to protect longfin smelt or starry flounder will also protect striped bass (*Morone saxatilis*). Striped bass survival from egg to 38 mm is significantly increased as X2 shifts downstream in the estuary. (Kimmerer 2002a.) Kimmerer et al. (2009) showed that as X2 location moved downstream, several measures of striped bass survival and abundance significantly increased, as did several measures of striped bass habitat. Similarly, it is assumed that improved stream flow conditions for Chinook salmon will benefit steelhead, but additional work is needed to assure that these flow criteria are adequate for the protection of steelhead. Adult steelhead in the Central Valley migrate upstream beginning in June, peaking in September, and continuing through February or March. (Hallock *et al*. 1961, Bailey 1954, McEwan and Jackson 1996, as cited in SJRRP FMWG 2009.) Spawning occurs primarily from January through March, but may begin as early as December and may extend through April. (Hallock et al. 1961, as cited in McEwan and Jackson 1996.) Steelhead also rear in tributaries to the Delta throughout the year. Consequently, additional inflow criteria may be needed to protect steelhead at times when flows are not specifically recommended to protect Chinook salmon. As will be discussed in the species needs section for Chinook salmon, additional flow criteria may also be needed to protect various runs and life-stages of Chinook salmon. Adequate information is not currently available, however, upon which to base criteria.

Other species are influenced by very high and infrequent flows, far in excess of what could be provided by the State and federal water projects because they occur only during very wet years when project operations are not controlling. For example, white sturgeon are influenced by high winter and spring Delta and river flows (March-June Delta outflow greater than 60,000 cfs) that attract migrating adults, cue spawning, transport larvae, and enhance nursery habitat. These types of flows occur episodically in very wet years. Historical flow patterns combined with the unique life history (long-lived, late maturing, long intervals between spawning, high fecundity) result in infrequent strong recruitment.

There is adequate information in the record, and adequate time to evaluate life history requirements and develop species-specific flow criteria for the following species:

- Chinook Salmon (various runs) (primarily mirgration flows)
- American Shad
- Longfin Smelt
- Delta Smelt
- Sacramento Splittail
- Starry Flounder
- Bay Shrimp
- Zooplankton

4.2.3 Life History Requirements – Anadromous Species

Following are life history and species-specific requirements for Chinook Salmon (including Sacramento River winter-run, Central Valley spring-run, Central Valley fall-run, and Central Valley late fall-run) and American shad.

Chinook Salmon (Sacramento River Winter-Run, Central Valley Spring-Run, Central Valley Fall-Run, and Central Valley Late Fall-Run)

Status

Sacramento River winter-run Chinook salmon is listed as endangered pursuant to the ESA and the CESA. Central Valley spring-run Chinook salmon is listed as threatened pursuant to both the ESA and the CESA. Central Valley fall/late fall-run Chinook salmon are classified as species of special concern pursuant to the ESA.[11]

Life History[12]

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). Adult “stream-type” Chinook salmon enter freshwater up to several months before spawning, and juveniles reside in freshwater for a year or more, whereas “ocean-type” Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. 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.

[11] Source: http://www.dfg.ca.gov/fish/Resources/Chinook/index.asp

[12] This section was largely extracted from NMFS 3, pages 76 through 79.

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 of the fish at the time of river entry, thermal regime, and flow characteristics of their spawning sites, and the actual time of spawning (Myers et al. 1998). Both winter-run and spring-run tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. Fall-run 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 38ºF to 56ºF (Bell 1991, DFG 1998). Boles (1988) recommends water temperatures below 65ºF for adult Chinook salmon migration, and Lindley et al. (2004) report that adult migration is blocked when temperatures reach 70ºF, and that fish can become stressed as temperatures approach 70ºF.

Information on the migration rates of adult Chinook salmon in freshwater is scant and primarily comes from the Columbia River basin (Matter and Sanford 2003). Keefer et al. (2004) found migration rates of Chinook salmon ranging from approximately 10 kilometers (km) per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter and Sanford (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River.

Adult Chinook salmon inserted with sonic tags and tracked throughout the Delta and lower Sacramento and San Joaquin rivers were observed exhibiting substantial upstream and downstream movement in a random fashion, for several days at a time, while migrating upstream (CALFED 2001). Adult salmonids migrating upstream are assumed to make greater use of pool and mid-channel habitat than channel margins (Stillwater Sciences 2004), particularly larger salmon such as Chinook salmon, as described by Hughes (2004). During their upstream migration, adults are thought to be primarily active during twilight hours.

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

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

During the 4 to 6 week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. Fry typically range from 25 mm to 40 mm at this stage. Upon emergence, fry swim or are displaced downstream (Healey 1991). The post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and other microcrustaceans. Some fry may take up residence in their natal stream for several weeks to a year or more, while others are displaced downstream by the stream's current. Once started downstream, fry may continue downstream to the estuary and rear there, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991).

Fry then seek nearshore habitats containing riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996). The benefits of shallow water habitats for salmonid rearing have been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer et al. 2001).

When juvenile Chinook salmon reach a length of 50 to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures (Healey 1991). Catches of juvenile salmon in the Sacramento River near West Sacramento exhibited larger-sized juveniles captured in the main channel and smaller-sized fry along the margins (USFWS 1997). When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams, may spur outmigration of juveniles from the upper Sacramento River basin when they have reached the appropriate stage of maturation (Kjelson et al. 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is crepuscular. Juvenile Chinook salmon migration rates vary considerably presumably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al*. (1982) found Chinook salmon fry to travel as fast as 30 km per day in the Sacramento River, and Sommer et *al.* (2001) found travel rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (ppt, Healey 1980, Levy and Northcote 1981).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries (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, Meyer 1979, Healey 1980). 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 54ºF to 57ºF (Brett 1952). In Suisun and San Pablo bays, water temperatures reach 54ºF by February in a typical year. Other portions of the Delta (*i.e*., South Delta and Central Delta) can reach 70ºF by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

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

Population Distribution and Abundance

Four seasonal runs of Chinook salmon occur in the Central Valley, with each run defined by a combination of adult migration timing, spawning period, and juvenile residency and smolt migration periods. (Fisher 1994 as cited in Yoshiyama et al. 2001 p. 73.) The runs are named after the season when adults move upstream to migrate-- winter, spring, fall, and late-fall. The Sacramento River basin supports all four runs resulting in adult salmon being present in the basin throughout the year. (Stone 1883a; Rutter 1904; Healey 1991; Vogel and Marine 1991 as cited in Yoshiyama *et. al,* 2001 p. 73.) Historically, different runs occurred in the same streams staggered in time to correspond to the appropriate stream flow regime for which that species evolved, but overlapping. (Vogel and Marine 1991; Fisher 1994 as cited in Yoshiyama et al*.,* 2001, p. 73.) Typically, fall and late-fall runs spawn soon after entering natal streams and spring and winter runs typically "hold" for up to several months before spawning. (Rutter 1904; Reynolds and others 1993 as cited in Yoshiyama *et. al,* 2001, p. 73.) These runs and their life-cycle timing are summarized in Table 3 and described in more detail below.

<u>Winter-Run</u> - Due to a need for cool summer flows, Sacramento River winter-run originally likely only spawned in the upper Sacramento River tributaries, including the McCloud, Pit, Fall, and Little Sacramento rivers and Battle Creek. (NMFS 5, p. 16.) As a result of construction of

Shasta and Keswick Dams, today all spawning habitat above Keswick Dam has been eliminated and approximately 47 of the 53 miles of habitat in Battle Creek has been eliminated. (Yoshiyama et al. 1996, as cited in NMFS 5, p. 16.) Currently, winter-run habitat is likely limited to the Sacramento River reach between Keswick Dam downstream of the Red Bluff Diversion Dam. (NMFS 5, p. 16.)

The winter-run population is currently very vulnerable due to its low population numbers and the fact that only one population exists. (Good et al. 2005, as cited in NMFS 5, p. 16.) In the late 1960s escapement was near 100,000 fish declining to fewer than 200 fish in the 1990s. (*Id*.) Recent escapement estimates from 2004 to 2006 averaged 13,700 fish. (DFG Website 2007, as cited in NMFS 5, p. 16.) However, in 2007 and 2008 escapements were less than 3,000 fish. Since 1998, hatchery produced winter-run have been released likely contributing to the observed increased escapement numbers. (Brown and Nichols 2003 as cited in NNFS 5, p. 16.) In addition, a temperature control device was installed on Shasta Dam in 1997 likely improving conditions for winter-run. (NMFS 5, p. 18.)

<u>Spring-Run</u> - Historically, spring-run were likely the most abundant salmonid in the Central Valley inhabiting headwater reaches of all major river systems in the Central Valley in the absence of natural migration barriers. (NMFS 5, p. 28.) Since the 1880s, construction of dams and other factors have significantly reduced the numbers and range of spring-run in the Central Valley. (*Id*.) Currently, the only viable populations occur on Mill, Deer, and Butte creeks, but those populations are small and isolated. (DFG 1998, as cited in NMFS 5, p. 28.) In addition, the Feather River Fish Hatchery which opened in 1967 produces spring-run salmon. However, significant hybridization of these hatchery fish with fall-run has occurred. (NMFS 5, p. 28-31.)

Historically, Central Valley spring-run numbers were estimated to be as large as 600,000 fish. (DFG 1998 as cited in NMFS 5, p. 28.) Nearly 50,000 spring-run adults were counted on the San Joaquin River prior to construction of Friant Dam. (Fry 1961 as cited in NMFS 5, p. 28.) Shortly after construction of Friant Dam, spring-run were extirpated on the San Joaquin River. (Yoshiyama et al. 1998 as cited in NMFS 5, p. 28.) Since 1970, estimates of spring-run populations in the Sacramento River have been as high as 30,000 fish and as low as 3,000 fish. (NMFS 5, p. 28.)

<u>Fall-Run</u> - Historically, fall run likely occurred in all Central Valley streams that had adequate flows during the fall months, even if the streams were intermittent during other parts of the year. (Yoshiyama *et. al* 2001, p. 74.) Due to their egg-laden and deteriorating physical condition, fall-run likely historically spawned in the valley floor and lower foothill reaches and probably were limited in their upstream migration. (Rutter 1904 as cited in Yoshiyama *et. al* 2001, p. 74.)

Currently, fall-run Chinook inhabit both the Sacramento and San Joaquin river basins and are currently the most abundant of the Central Valley races, contributing to large commercial and recreational fisheries in the ocean and popular sportfisheries in the freshwater streams. Fall-run Chinook are raised at five major Central Valley hatcheries which release more than 32 million smolts each year. In the past few years, there have been large declines in fall-run populations with escapements of 88,0000 and 66,000 fish in 2007 and 2008. (NMFS 2009, p. 4.) NMFS concluded that the recent declines were likely primarily due to poor ocean conditions in 2005 and 2006. (*Id*.) Other factors contributing to the decline of fall-run include: loss of spawning grounds due to dams and other factors, degradation of spawning habitat from water diversions, introduced species, altered sediment dynamics, hatchery practices, degraded water quality, and loss of riparian and estuarine habitat. (*Id*.)

Late-Fall Run - Historically, late fall-run probably spawned in the mainstem Sacramento River and major tributary reaches and possibly in the San Joaquin River upstream of its tributaries. (Hatton and Clark 1942; Van Cleve 1945; Fisher 1994 as cited in Yoshiyama *et. al* 2001.) Today, late-fall run are mostly found in the upper Sacramento River where the river remains deep and cool enough in the summer for juvenile rearing. (Moyle 2002, p. 254.) The late fall-run has continued low, but potentially stable abundance. (NMFS 2009, p. 4.) Estimates from 1992 ranged from 6,700 to 9,700 fish and in 1998 were 9,717 fish. However, changes in estimation methods, lack of data, and hatchery influences make it difficult to accurately estimate abundance trends for this run. (*Id.*)

Table 3. Generalized Life History Timing of Central Valley Chinook Salmon Runs

	Migration Period	**Peak Migration**	**Spawning Period**	**Peak Spawning**	**Juvenile Emergence Period**	**Juvenile Stream Residency**
Sacramento River Basin Late Fall-Run	October–April	December	Early January–April	February–March	April-June	7-13 months
Winter-Run	December-July	March	Late April-early August	May-June	July-October	5-10 months
Spring-Run	March-September	May- June	Late August-October	Mid-September	November-March	3-15 months
Fall Run	June-December	September-October	Late September-December	October-November	December-March	1-7 months
San Joaquin (Tuolumne River) Fall-Run	October-early January	November	Late October-January	November	December-April	1-5 months

Source: Yoshiyama *et al*. (1998) as cited in Moyle 2002, p. 255.

Population Abundance and Relationship to Flow

Delta outflows and inflows affect rearing conditions and migration patterns for Chinook salmon in the Delta watershed. Freshwater flow serves as an important cue for upstream adult migration and directly affects juvenile survival and abundance as they move downstream through the Delta. (DOI 1, p. 23.) Decreased flows may decrease migration rates and increase exposure to unsuitable water quality and temperature conditions, predators, and entrainment at water diversion facilities. (DFG 1, p. 1.) For the most part, relationships between salmon survival and abundance have been developed using tributary inflows rather than Delta outflows, however, the Delta is an extension of the riverine environment until salmon reach the salt water interface. (DOI 1, p. 29.) Prior to development and channelization, the Delta provided hospitable habitat for salmon. With channelization and other development, the environment is no longer hospitable for salmon. As a result, the most beneficial Delta outflow pattern for salmon may currently be one that moves salmon through the Delta faster. (*d*.)

Salmon respond behaviorally to variations in flows. Monitoring shows that juvenile and adult salmon begin migrating during the rising limb of the hydrograph. (DOI 1, p. 30.) For juveniles, pulse flows appear to be more important than for adults. (*Id*.) For adults, continuous flows through the Delta and up to each of the natal tributaries appears to be more important. (*Id*.) Flows and water temperatures are also important to maintain populations with varied life history strategies in different year types to insure continuation of the species over different hydrologic and other conditions. For salmon migrating as fry within a few days of emigration from redds, increased flows provide improved transport downstream and improved rearing habitat, and for salmon that stay in the rivers to rear, increased flows provide for increased habitat and food production. (DOI 1, 30.)

Population Abundance Goal

The immediate goal is to significantly improve survival of all existing runs of Chinook salmon that migrate through the Delta in order to facilitate positive population growth in the short term and subsequently achieve the narrative salmon protection objective identified in the 2006 Bay-Delta Plan to double the natural production of Chinook salmon from the average production from 1967 to 1991 consistent with the provisions of State and federal law. (State Water Board 2006a, p. 14.)

Species- Specific Recommendations

Delta Outflow

No specific Delta outflow criteria are recommended for Chinook salmon. Any flow needs would generally be met by the following inflow criteria and by the Delta outflow criteria determined for estuarine dependant species discussed elsewhere in this report.

Sacramento River Inflows

The 2006 Bay-Delta Plan includes flow objectives for the Sacramento River at Rio Vista for the protection of fish and wildlife beneficial uses from September through December ranging from 3,000 to 4,500 cfs. (State Water Board 2006a, p. 15.) These flow objectives are in part intended to provide attraction and transport flows and suitable habitat conditions for Chinook salmon. (State Water Board 2006b, p. 49.) The 2006 Bay-Delta Plan includes Delta outflow objectives for the remainder of the year, which effectively provide Sacramento River inflows. However, the Bay-Delta Plan does not include any specific Sacramento River flow requirements for the remainder of the year, including the critical spring period.

Habitat alterations in the Delta limit Sacramento River salmon production primarily through reduced survival during the outmigrant (smolt) stage. Decreases in flow through the estuary, increased temperatures, and the proportion of flow diverted through the Delta Cross Channel and Georgiana Slough on the Sacramento River are associated with lower survival in the Delta of marked juvenile fall-run Sacramento River salmon. (DOI 1, p. 24.) In 1981 (p. 17-18) and 1982 (p. 404), Kjelson et al. reported that flow was positively correlated with juvenile fall-run Chinook salmon survival through the Delta and that temperature was negatively correlated with survival. In testimony before the State Water Board in 1987 Kjelson presented additional analyses that again showed that survival of fall-run Chinook salmon smolts through the Delta between Sacramento and Suisun Bay was found to be positively correlated to flow and negatively correlated to water temperature. (p. 36.) Smolt survival increased with increasing Sacramento River flow at Rio Vista, with maximum survival observed at or above about 20,000 and 30,000 cfs from April through June (p. 36), while no apparent relationship was found at flows between 7,000 and 19,000 cfs (p. 27), suggesting a potential threshold response to flow. Smolt survival was also found to be highest when water temperatures were below 66ºF. (p. 61.) In addition to increased survival, juvenile abundance has also been found to be higher with greater Sacramento River flow. (DFG 3, pp. 1 and 6.) The abundance of juvenile Chinook salmon leaving the Delta at Chipps Island was found to be highest when Rio Vista flows averaged above 20,000 cfs from April through June. (*Id*.)

Dettman et al. (1987) reanalyzed data from the 1987 Kjelson experiments and found a positive correlation between an index of spawning returns, based on coded-wire tagged fish, and both

June and July outflow from the Delta. (p. 1.) In 1989, Kjelson and Brandes updated and confirmed Kjelson's 1987 findings again reporting that survival of smolts through the Delta from Sacramento to Suisun Bay was highly correlated to mean daily Sacramento River flow at Rio Vista. (p. 113.) In the State Water Board's 1992 hearings, USFWS (1992) presented additional evidence, based on data collected from 1988 to 1991, that increased flow in the Delta may increase migration rates of both wild and hatchery fish migrating from the North Delta (Sacramento and Courtland) to Chipps Island. (DOI 1, p. 26.)

In 2001, Brandes and McLain confirmed the relationships between water temperature, flow, and juvenile salmonid survival. (p. 95.) In 2006, Brandes et al. updated findings regarding the relationship between Sacramento River flows and survival and found that the catch of Chinook salmon smolts surveyed at Chipps Island between April and June of 1978 to 2005 was positively correlated with mean daily Sacramento River flow at Rio Vista between April and June. (p. 41-46.)

In addition to the flow versus juvenile fall-run Chinook salmon survival relationships discussed above, several studies show that loss of migrating salmonids within Georgiana Slough and the interior Delta is approximately twice that of fish remaining in the mainstem Sacramento River. (Kjelson and Brandes 1989; Brandes and McLain 2001; Vogel 2004, 2008; and Newman 2008 as cited in NMFS 3, p. 640). Recent studies and modeling efforts have found that increasing Sacramento River flow such that tidal reversal does not occur in the vicinity of Georgiana Slough and at the Cross Channel Gates would lessen the proportion of fish diverted into channels off the mainstem Sacramento River. (Perry et al. 2008, 2009.) Thus, closing the Delta Cross Channel and increasing the flow on the Sacramento River to levels where there is no upstream flow from the Sacramento River entering Georgiana Slough on the flood tide during the juvenile salmon migration period (November to June) will likely reduce the number of fish that enter the interior Delta and improve survival. (DOI 1, p. 24.) To achieve no bidirectional flow in the mainstem Sacramento River near Georgiana Slough, flow levels of 13,000 (personal communication Del Rosario) to 17,000 cfs at Freeport are needed. (DOI 1, p. 24.)

Monitoring of emigration of juvenile Chinook salmon on the lower Sacramento River near Knights Landing also indicates a relationship between timing and magnitude of flow in the Sacramento River and the migration timing and survival of Chinook salmon approaching the Delta from the upper Sacramento River basin. (Snider and Titus 1998, 2000a, 2000b, 2000c, and subsequent draft reports and data as cited in DFG 1, p. 7.) The emigration timing of juvenile late fall, winter, and spring-run Chinook salmon from the upper Sacramento River basin depends on increases in river flow through the lower Sacramento River in fall, with significant precipitation in the basin by November to sustain downstream migration of juvenile Chinook salmon approaching the Delta. (Titus 2004 as cited in DFG 1, p. 7.) Sacramento River flows at Wilkins Slough of 15,000 to 20,000 cfs following major precipitation events are associated with increased emigration. (DFG 1, p. 7 and NMFS 7, p. 2-4.)

Delays in precipitation producing flows result in delayed emigration which may result in increased susceptibility to in-river mortality from predation and poor water quality conditions. (DFG 1, p. 7.) Allen and Titus (2004) suggest that the longer the delay in migration, the lower the survival of juvenile salmon to the Delta. (as cited in DFG 1, p. 7.) DFG indicates that juvenile Chinook salmon appear to need increases in Sacramento River flow that correspond to flows in excess of 20,000 cfs at Wilkins Slough by November with similar peaks continuing past the first of the year. (DFG 1, p. 7.) Pulse flows in excess of 15,000 to 20,000 cfs may also be necessary to erode sediment in the upper Sacramento River downstream of Shasta to create turbid inflow pulses to the Delta. (AR/NHI 1, p. 32.)

Salmon are the only species considered for the Sacramento River inflow criteria; discussion of the flow criteria for Sacramento River inflows is therefore continued in Section 5.2, Sacramento River Inflow criteria.

San Joaquin River Inflows

Currently the Merced, Tuolumne, and Stanislaus river tributaries to the San Joaquin River support fall-run Chinook salmon. Historically spring-run also inhabited the basin. Pursuant to the San Joaquin River Restoration effort, there are plans to reintroduce spring-run Chinook salmon to the main-stem river beginning in 2012. Since the 1980s (1980-1989), San Joaquin basin fall-run Chinook salmon escapement numbers have declined from approximately 26,000 fish to 13,000 fish in the 2000s (2000-2008). (TBI/NRDC 3, p. 22.) Flow related conditions are believed to be a significant cause of this decline.

The 2006 Bay-Delta Plan includes flow objectives for the San Joaquin River at Vernalis, largely for the protection of fall-run Chinook salmon. The plan includes base flows during the spring (February through June with the exception of mid-April through mid-May) that vary between 700 and 3,420 cfs based on water year type and required location of X2. To improve juvenile fall-run Chinook salmon outmigration, the Plan also includes spring pulse flows (mid-April through mid-May) that vary between 3,110 and 8,620 cfs, however, those flows have never been implemented and have instead been replaced with the Vernalis Adaptive Management Plan (VAMP) flow targets for the past 10 years. The VAMP flows are lower than the pulse flow objectives and vary between 2,000 and 7,000 cfs based on existing flows and other conditions. (State Water Board 2006a, p. 24-26.) The 2006 Bay-Delta Plan also includes a flow objective of 1,000 to 2,000 cfs during October to support adult fall-run Chinook salmon migration. (State Water Board 2006b, p. 15-16.) The 2006 Bay-Delta Plan does not include any specific flow requirements during the remainder of the year. (State Water Board 2006b, pg. 50.)

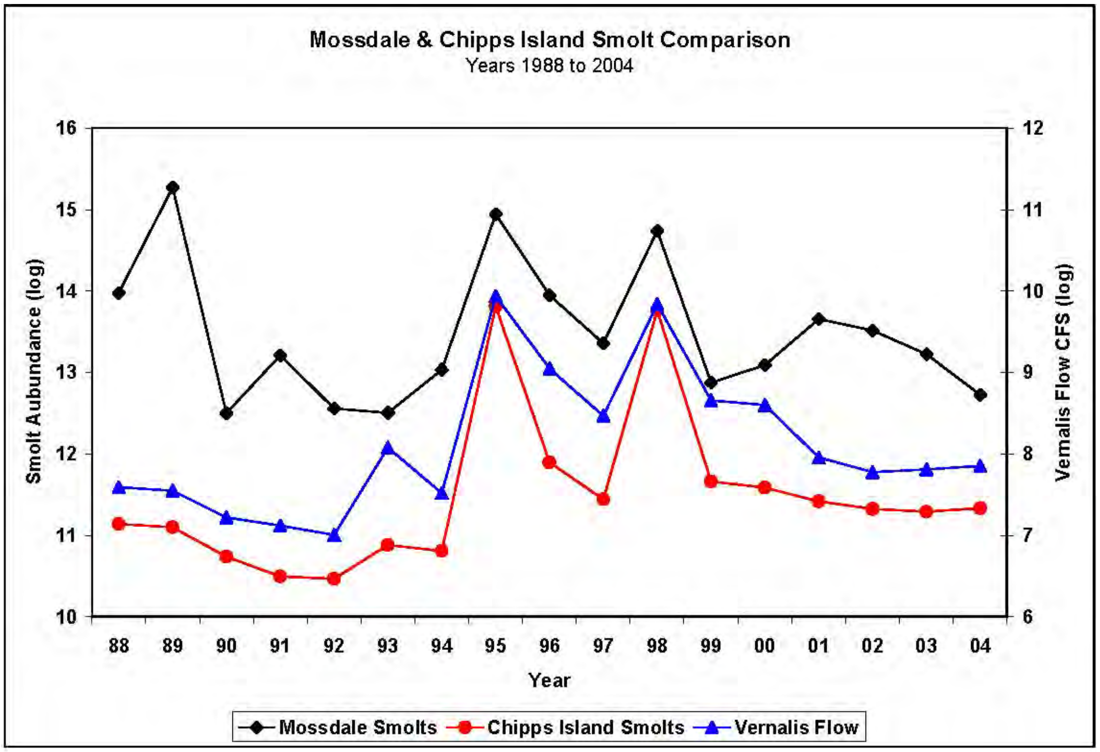
Inflows from the San Joaquin River affect various life stages of Chinook salmon including adult migration, spawning, egg incubation, juvenile rearing, and juvenile emigration to the ocean. Evidence indicates that to maintain a viable Chinook salmon population, escapements should not decline below approximately 833 adult salmon per year (a total of 2,500 salmon in 3 years), and fluctuations in escapement between wet and dry years should be reduced by increasing dry year escapements and the percentages of hatchery fish should be reduced to no more than 10%. (Lindley and others 2007, as cited in CSPA 14, p. 3-4.) Mesick estimates that the Tuolumne River population is currently at a high risk of extinction (Mesick 2009); and that the Stanislaus and Merced river populations are also likely soon to be at a high risk of extinction due to high percentages of hatchery fish. (CSPA 7, p.4.)

Mesick estimates that the decline in escapement on the Tuolumne River from 130,000 salmon in the 1940s to less than 500 in recent years is primarily due to inadequate minimum instream flow releases from La Grange Dam in late winter and spring during non-flood years. (CSPA 14, p. 1.) Mesick suggests that escapement has been primarily determined by the rate of juvenile survival, which is primarily determined by the magnitude and duration of late winter and spring flows since the 1940s. (CSPA 14, p. 2.) Mesick indicates that other analyses show that spawner abundance, spawning habitat degradation, and the harvest of adult salmon in the ocean have not caused the decline in escapement. (CSPA 14, p. 1.)

Successful adult Chinook salmon migration depends on environmental conditions that cue the response to return to natal streams. Optimal conditions help to reduce straying and maintain egg viability and fecundity rates. (DFG 3, p. 2 and CSPA 7, p. 1.) Analyses of flow needs for the protection of adult fall-run migration conducted by Hallock and others from 1964 to 1967 indicate that the presence of Sacramento River water in the central and south Delta channels results in migration delays for both San Joaquin River and Sacramento River basin salmon. (Hallock et al*.,* 1970 as cited in DOI 1, p. 25.) These analyses also show that reverse flows on the San Joaquin River delay and potentially hamper migration. (*Id.*) In addition, analyses by Hallock show that water temperatures in excess of 65˚ F and low DO conditions of less than 5 mg/l in the San Joaquin River near Stockton act as a barrier to adult migration. (as cited in AFRP 2005, p. 11.) Delayed migration may result in reduced gamete viability under elevated temperatures and mortality to adults prior to spawning. (AFRP 2005, p. 12.)

Mesick found that up to 58% of Merced River Hatchery Chinook salmon strayed to the Sacramento River Basin when flows in the San Joaquin River were less than 3,500 cfs for ten days in late October, but stray rates were less than 6% when flows were at least 3,500 cfs. (CSPA 14, p. 15 and CSPA 7, p. 1.) Mesick indicates that providing 1,200 cfs flows from the tributaries to the San Joaquin River (Merced, Tuolumne, and Stanislaus) for ten days in late October increases escapement by an average of 10%. (Mesick 2009 as cited in CSPA 7, p. 1.) The 2005 AFRP includes similar recommendations for flows of 1,000 cfs from each of the San Joaquin River tributaries. (AFRP, p. 12.) Such flows would likely improve DO conditions, temperatures, and olfactory homing fidelity for San Joaquin basin salmon. (Harden Jones 1968, Quinn et al. 1989, Quinn 1990 as cited in EDF 1, p. 48.) To achieve olfactory homing fidelity and continuous flows for adult migration, the physical source of this water is at least as important as the volume or rate of flow, especially given that the entire volume of the San Joaquin River during the fall period is typically diverted at the southern Delta export facilities. (EDF 1. p. 48.) Even in the absence of exports, it is necessary for the scent of the San Joaquin basin watershed to enter the Bay in order for adult salmonids to find their way back to their natal rivers. (NMFS 2009, p.407 as cited in EDF 1, p. 48.)

Outmigration success of juvenile Chinook salmon is affected by multiple factors, including water diversions and conditions related to flow. Data show that smolt survival and resulting adult production is better in wet years. (Kjelson and Brandes, 1989, SJRGA, 2007 as cited in DOI 1, p. 24.) VAMP analyses indicate that San Joaquin River flow at Vernalis is positively associated with the probability of survival for outmigrating smolts from Dos Reis (downstream of the Old River bifurcation) to the Delta (Jersey Point). (Newman, 2008 as cited in DOI 1, p. 24.) A positive relationship has also been shown between salmon survival indices and flow at Jersey Point for fish released at Jersey Point. (USFWS 1992, p. 21 as cited in DOI 1, p. 24.) Data indicate that maximum San Joaquin basin adult fall-run chinook salmon escapement may be achieved with flows exceeding 20,000 cfs at Vernalis during the smolt emigration period of April 15 through June 15. (2006 VAMP report page 65; DOI 1, p. 25.) As indicated below in Figure 9, DFG found that more spring flow from the San Joaquin River tributaries results in more juvenile salmon leaving the tributaries, more salmon successfully migrating to the South Delta, and more juvenile salmon surviving through the Delta. (DFG 3, p. 17.) DFG concludes that the primary mechanism needed to substantially produce more smolts at Jersey Point is to substantially increase the spring Vernalis flow level (magnitude, duration, and frequency) which will produce more smolts leaving the San Joaquin River tributaries, and produce more smolts surviving to, and through, the South Delta. (DFG 3, p. 17-18.) DFG indicates that random rare and unpredictable poor ocean conditions may cause stochastic high mortality of juvenile salmon entering the ocean, but that the overwhelming evidence is that more spring flow results in higher smolt abundance, and higher smolt abundance equates to higher adult production. (DFG 3, p.17.)



Note: This figure shows the relationship of smolt abundance (log transformed) at Mossdale to estimate smolt abundance at Chipps Island by average spring (3/15 to 6/15) Vernalis flow level (log transformed). To estimate the number of smolts at Chipps Island the smolt survival vs. flow level relationship developed by Dr. Hubbard was applied on a daily basis to the Mossdale smolt abundance and out-migration pattern. Smolt abundance at Chipps Island (or stated differently smolt survival through the Delta on an annual basis) can change by an order of magnitude pending Vernalis flow rate. (DFG 3, p. 16.)

Figure 9. Salmon Smolt Survival and San Joaquin River Vernalis Flows

Elevated flows during the smolt outmigration period function as an environmental cue to trigger migration, facilitate transport of juveniles downstream, improve migration corridor conditions to inundate floodplains, reduce predation and improve temperature and other water quality conditions; these are all functions that are currently extremely impaired on the San Joaquin River. (e.g., "Steelhead stressor matrix," NMFS 2009 as cited in TBI/NRDC 3, p. 7.) Under the 2006 Bay-Delta Plan, elevated flows are limited to approximately the mid-April to mid-May period. However, outmigration timing in the San Joaquin River basin occurs over a prolonged time frame from mid-March through June. (TBI/NRDC 3, p. 12-13.) This restricted window may impair population viability by limiting survival of fish that migrate outside of this time period, thus reducing the life history diversity and the genetic diversity of the population. (TBI/NRDC 3, p. 11-12.) Diverse migration timing increases population viability by making it more likely that at least some portion of the population is exposed to favorable ecological conditions in the Delta and into the ocean. (Smith et al. 1995 as cited in TBI/NRDC 3, p. 12.)

Temperature conditions in the San Joaquin River basin may limit smolt outmigration and survival. Lethal temperature thresholds for Pacific salmon depend, to some extent, on acclimation temperatures. (Myrick and Cech 2004 as cited in TBI/NRDC 3, p. 18.) Central Valley salmonids are generally temperature-stressed through at least some portion of their freshwater life-cycle. (e.g. Myrick and Cech 2004, 2005 as cited in TBI/NRDC 3, p. 18.) Lethal temperature effects commence in a range between 71.6˚ and 75.2˚ F (Baker et al.1995 as cited in TBI/NRDC 3, p. 18), with sub-lethal effects occurring at lower temperatures. Access to food also affects temperature responses. When fish have adequate access to food, growth increases with increasing temperature, but when food is limited (which is typical), optimal growth occurs at lower temperatures. (TBI/NRDC 3, p 18.) Marine and Cech (2004) observed decreased growth, smoltification success, and predator avoidance at temperatures above 68˚ F and that fish reared at temperatures between 62.6˚ and 68˚ F experienced increased predation compared to fish reared at between 55.4˚ and 60.8˚ F. (as cited in TBI/NRDC 3, p. 18.) Several studies indicate that optimal rearing temperatures for Chinook salmon range from 53.6˚ to 62.6F (Richter and Kolmes 2005 as cited in TBI/NRDC 3, p. 18.) Mesick found that Tuolumne River smolt outmigration rates and adult recruitment were highest when water temperatures were at or below 59˚F when smolts were migrating in the lower river. (Mesick 2009, p. 25.) Elevated temperatures may also affect competition between different species. (Reese and Harvey 2002 as cited in TBI/NRDC 3, p. 18.)

Temperature is determined by a number of factors including reservoir releases, channel geometry, and ambient air temperatures. As a result, a given flow may achieve different water temperatures depending on the other conditions listed above. Cain estimates that flows over 5,000 cfs in late spring (April to May) generally provide water temperatures (below 65˚ F) suitable for Chinook salmon, but that flows less than 5,000 cfs may be adequate to provide sufficient temperature conditions. (Cain 2003 as cited in TBI/NRDC 3, p 13-14.) Mesick indicates that salmon smolt survival can be improved by maintaining water temperatures near 59˚F from March 15 to May 15 and as low as practical from May 16 to June 15. (CSPA 7, p. 2-3.) To maintain mean water temperatures near 59˚F and maximum temperatures below 65˚F from March 15 to May 15 in the tributaries downstream to the confluence with the San Joaquin River, Mesick indicates that flows need to be increased in response to average air temperature. (CSPA 7, p. 3.)

There are several different estimates for flow needs on the San Joaquin River during the spring period to improve or double salmon populations on the San Joaquin River. The USFWS's 2005 *Recommended Streamflow Schedules to Meet the AFRP Doubling Goal in the San Joaquin River Basin* (2005 AFRP) concludes that the declines in salmon in the San Joaquin River basin primarily resulted from reductions in the frequency and magnitude of spring flooding in the basin from 1992-2004 compared to the baseline period of 1967-1991. (2005 AFRP, p. 1.) The AFRP states that the most likely method to increase production of fall-run Chinook salmon is to increase flows from February to March to increase survival of juveniles in the tributaries and smolts in the mainstem and then to increase flows from April to mid-June to increase smolt survival through the Delta. (*Id*.) Using salmon production models for the San Joaquin River Basin, the AFRP provides recommendations for the amount of flow at Vernalis that would be needed to double salmon production in the San Joaquin River basin. On average, over the four month period of February to May, the AFRP recommends that flows range from less than 4,000 cfs in critical years to a little more than 10,000 cfs in wet years. From March through June, AFRP recommends that flows average between about 4,500 cfs in critical years to more than 12,000 cfs in wet years. (2005 AFRP, p. 8-10.)

Using a non-linear regression empirical data driven fall-run Chinook salmon production model, DFG developed flow recommendations for the San Joaquin River from March 15 through June 15 to double Chinook salmon smolt production. DFG developed a variety of modeling scenarios to evaluate the effects of various combinations of flow magnitudes and durations in order to identify the combination of flow levels varied by water year type to achieve doubling of juveniles. Base flows for the March 15 through June 15 period vary between 1,500 cfs in critical years to

6,315 cfs in wet years. Pulse flow recommendations vary between 7,000 cfs and 15,000 cfs for durations of 31 to 70 days depending on water year type. (DFG 3, p. 34.)

In analyzing the relationship between Vernalis flow and cohort return ratios of San Joaquin River Chinook salmon, TBI/NRDC found that Vernalis average March through June flows of approximately 4,600 cfs corresponded to an equal probability for positive population growth or negative population growth. (TBI/NRDC 3, p. 24.) TBI/NRDC found that average March through June flows exceeding 5,000 cfs resulted in positive population growth in 84% of years with only 66% growth in years with flows less than 5,000 cfs. (*Id.)* TBI/NRDC found that flows of 6,000 cfs produced a similar response as the 5,000 cfs flows and flows of 4,000 cfs or lower resulted in significantly reduced population growth of only 37% of years. (*Id*.) The TBI/NRDC analysis suggests that 5,000 cfs may represent an important minimum flow threshold for salmon survival on the San Joaquin River. (*Id*.) Based on abundance to prior flow relationships, TBI/NRDC estimates that average March through June inflows of 10,000 cfs are likely to achieve the salmon doubling goal. (TBI/NRDC 3, p. 16-17.)

In addition to fall pulse flows for adult migration and spring flows to support juvenile emigration, additional flows on the San Joaquin River may be needed at other times of year to support Chinook salmon and their habitat. The 2006 Bay-Delta Plan does not include base flow objectives for the San Joaquin River. However, the Central Valley Regional Board's Water Quality Control Plan for the Sacramento and San Joaquin River Basins does include a year round DO objective of 5.0 mg/l at all times on the San Joaquin River within the Delta. (Central Valley Regional Board 2009,. III-5.0). The 2006 Bay-Delta Plan and the Central Valley Basin Plan also include a DO objective of 6.0 mg/L between Turner Cut and Stockton from September 1 through November 30. (*Id*.)

Current flow conditions on the San Joaquin River result in DO conditions below the existing DO objectives in the fall and winter in lower flow years. These conditions may result in delayed migration and mortality to San Joaquin River Chinook salmon, steelhead and other species. Increased flows would improve DO levels in the lower San Joaquin River. Additional flows at other times of year in the tributaries to the San Joaquin River would also provide improved conditions for steelhead inhabiting tributaries to the San Joaquin River (NMFS 3, p. 105) and would have additional benefits by reducing nutrients pollution and biological oxygen demand. (TBI/NRDC 3, p. 27.)

To reduce crowding of spawning adults during the fall, increased flows in the tributaries may also be needed from November through January to ensure protection of Chinook salmon. (AFRP, p. 12.) However, there is no evidence that increased flows would reduce spawner crowding or improve juvenile production. (*Id*.) Habitat modeling indicates that flows of up to 300 cfs on the San Joaquin River tributaries may provide optimum physical habitat during the fall. (AFRP 2005, p. 14.)

To maintain the ecosystem benefits of a healthy riparian forest, minimum flows and ramping rates for riparian recruitment may also be needed during late spring and early summer. (AFRP 2005, p. 14.) To protect over-summering steelhead and salmon, flows in the tributaries during the summer and fall are needed. To maintain minimal habitat of a suitable temperature (less than 65˚ F), flows between 150 and 325 cfs may be needed on each of the tributaries to the San Joaquin River. (AFRP 2005, pp. 14-15.)

The magnitude, duration, timing, and source of San Joaquin River inflows are important to San Joaquin River Chinook salmon migrating through the Delta and several different aspects of their life history. Inflows are needed to provide appropriate conditions to cue upstream adult migration to the San Joaquin River and its tributaries, adult holding, egg incubation, juvenile rearing, emigration from the San Joaquin River and its tributaries, and other functions. San Joaquin River inflows are important during the fall to provide attraction flows and are especially important during juvenile emigration periods. Flows on tributaries to the San Joaquin River are also important for egg incubation and rearing, in addition to migration.

As with the Sacramento River inflows, Chinook salmon are the only species considered for the San Joaquin River inflow criteria; discussion of flow criteria for San Joaquin River inflows is therefore continued in Section 5.3, San Joaquin River inflow criteria.

Hydrodynamics

All Central Valley Chinook salmon must migrate out of the Delta as juveniles and back through the Delta as adults returning to spawn. In addition, many Central Valley Chinook salmon also rear in the Delta for a period of time. (DOI 1, p. 53.) Delta exports affect salmon migrating through and rearing in the Delta by modifying tidally dominated flows in the channels. It is, however, difficult to quantitatively evaluate the direct and indirect effects of these hydrodynamic changes. Delta exports can cause a false attraction flow drawing fish to the export facilities where direct mortality from entrainment may occur. (DOI 1, p. 29.) More important than direct entrainment effects, however, may be the indirect effects caused by export operations increasing the amount of time salmon spend in channelized habitats where predation is high. (*Id*.) Steady flows during drier periods (as opposed to pulse flows that occur during wetter periods) may increase these residence time effects. (DOI 1.)

Direct mortality from entrainment at the south Delta export facilities is most important for San Joaquin River and eastside tributary salmon (and steelhead). (DOI 1, p. 29.) Juvenile salmonids emigrate downstream on the San Joaquin River during the winter and spring. Salmonids from the Calaveras River basin and the Mokelumne River basin also use the lower San Joaquin River as a migration corridor. This lower reach of the San Joaquin River between the Port of Stockton and Jersey Point has many side channels leading toward the export facilities that draw water through the channels to the export pumps. (NMFS 3, p. 651.) Particle tracking model (PTM) simulations and acoustic tagging studies indicate that migrating fish may be diverted into these channels and may be affected by flow in these channels. (Vogel 2004, SJRGA 2006, p. 68, SJRGA 2007, pp. 76-77, and NMFS 3, p. 651.) Analyses indicate that tagged fish may be more likely to choose to migrate south toward the export facilities during periods of elevated diversions than when exports are reduced. (Vogel 2004.)

Similarly, salmon that enter the San Joaquin River through Georgiana Slough from the Sacramento River may also be vulnerable to export effects. (NMFS 3, p. 652.) While fish may eventually find their way out of the Central Delta channels after entering them, migratory paths through the Central Delta channels increase the length and time that fish take to migrate to the ocean increasing their exposure to predation, increased temperatures, contaminants, and unscreened diversions. (NMFS 3, p. 651-652.)

PTM analyses indicate that as net reverse flows in Old and Middle rivers increase from -2,500 cfs to -3,500 cfs, particle entrainment changes from 10% to 20% and then again to 40% when flows are -5,000 cfs and 90% when flows are -7,000 cfs. (*Id*.) Based on these findings, NMFS's Opinion includes requirements that exports be reduced to limit negative net Old and Middle river flows to -2,500 cfs to -5,000 cfs depending on the presence of salmonids from January 1 through June 15. (NMFS 3, p. 648.)

In addition to effects of net reverse flows in Old and Middle rivers, analyses concerning the effects of net reverse flows in the San Joaquin River at Jersey Point were also conducted and documented in the USFWS, 1995 *Working Paper on Restoration Needs, Habitat Restoration Actions to Double the Natural Production of Anadromous Fish in the Central Valley California* (1995Working Paper). These analyses show that net reverse flows at Jersey Point decrease the survival of smolts migrating through the lower San Joaquin River. (USFWS 1992b as cited in USFWS 1995b, p. 3Xe-19.) Net reverse flows on the lower San Joaquin River and diversions into the central Delta may also result in reduced survival for Sacramento River fall-run Chinook salmon. (USFWS 1995b, p. 3Xe-19) Based on these factors, the 1995 Working Paper includes a recommendation to maintain positive flows at Jersey Point of 1,000 cfs in critical and dry years, 2,000 cfs in below- and above-normal years, and 3,000 cfs in wet years from October 1 through June 30 to improve survival for all races and stocks of juvenile salmon and steelhead migrating through and rearing in the Delta. (*Id.*)

In addition to relationships between reverse flows and entrainment effects, flows on the San Joaquin River versus exports also appear to be an important factor in protecting San Joaquin River Chinook salmon. Various studies show that, in general, juvenile salmon released downstream of the effects of the export facilities (Jersey Point) have higher survival out of the Delta than those released closer to the export facilities. (NMFS 3-Appendix 3, p. 74.) Studies also indicate that San Joaquin basin Chinook salmon production increases when the ratio of spring flows to exports increases. (DFG 2005, SJRGA 2007 as cited in NMFS 3-Appendix 3, p. 74.) However, it should be noted that flow at Vernalis appears to be the controlling factor. Increased flows in the San Joaquin River in the Delta may also benefit Sacramento basin salmon by reducing the amount of Sacramento River water that is pulled into the central Delta and increasing the amount of Sacramento River water that flows out to the Bay. (NMFS 3, Appendix 3, p. 74-75.) Based on these findings, the NMFS Opinion calls for export restrictions from April 1 through May 31 with Vernalis flows to export ratios ranging from 1.0 to 4.0 based on water year type, with unrestricted exports above flows of 21,750 cfs at Vernalis, in addition to other provisions for health and safety requirements. (NMFS 3, Appendix 3, p.73-74.)

Analyses by TBI/NRDC indicate that Vernalis flow to export ratios above 1.0 during the San Joaquin basin juvenile salmon outmigration period in the spring consistently correspond to higher escapement estimates two and half years later, with more than 10,000 fish in 76% of years. (TBI/NRDC 4, p. 11.) Vernalis flows to export ratios of less than 1.0 correspond to lower escapement estimates two and half years later, with more than 10,000 fish in only 33% of years. (*Id.*) TBI/NRDC estimates that Vernalis flows to export ratios of greater than 4.0 would reach population abundance goals. (TBI/NRDC 4, pp. 11-12.)

Vernalis flows to export ratios also appear to be important during the fall period to provide improved migration conditions for adult fall-run San Joaquin basin Chinook salmon. Adult fall-run San Joaquin basin Chinook salmon migrate upstream through the Delta primarily during October when San Joaquin River flows are typically low. (AFRP 2005, p. 12.) As a result, when exports are high, little if any flow from the San Joaquin basin may make it out to the ocean to help guide San Joaquin basin salmon back to the basin to spawn. (*Id.*) Analyses indicate that increased straying occurs when more than 400% of the flow at Vernalis is exported at the Delta pumping facilities (equivalent to a Vernalis flow to export ratio of 0.25). (*Id.*) Straying rates decreased substantially when export rates were less than 300% of Vernalis flow. (*Id.*)

Export related criteria for salmon are provided in section 5.4, Hydrodynamic Recommendations.

Floodplain Flows

Juvenile salmon will rear on seasonally inundated floodplains when available. Such rearing in the Central Valley, in the Yolo Bypass and the Cosumnes River floodplain, has been found to have a positive effect on growth and apparent survival of juvenile Central Valley salmon through the Delta. (Sommer *et al*. 2001 and Jeffres *et al*. 2005 as cited in DOI 1, p. 27 and Sommer *et al*. 2005 and Jeffres *et al*. 2008 as cited in NMFS 3, p. 609.) The increased growth rates may be due to increased temperatures and increased food supplies. (DOI 1, p. 27, DFG 3, p. 3.) Floodplain rearing provides conditions that promote larger and faster growth which improves outmigration, predator avoidance, and ultimately survival. (Stillwater Science 2003 as cited in DFG 3, p. 6.) Increased survival may also be related to the fact that ephemeral floodplain habitat and other side-channels provide better habitat conditions for juvenile salmon than intertidal river channels during high flow events when, in the absence of such habitat, juvenile salmon may be displaced to these intertidal areas. (Grosholz and Gallo 2006 as cited in DOI 1, p. 27 and Stillwater Science as cited in DFG 3, p. 6.) The improved growing conditions provided by floodplain habitat are also believed to improve ocean survival resulting in higher adult return rates. (Healy 1982, Parker 1971 as cited in DOI 1, p. 28.)

While floodplain habitat is generally beneficial to salmon, it may also be detrimental under certain conditions. Areas with engineered water control structures have comparatively higher rates of stranding. (Sommer *et al*. 2005 as cited in DOI 1, p. 28.) In addition, high temperatures, low DO, and other water quality conditions that may occur on floodplains may adversely affect salmon. (DFG 3, p. 6.) Reduced depth may also make salmon more susceptible to predation. (*Id*.) Water depths of 30 cm or more are believed to reduce the risk of avian predation. (Gawlik 2002 as cited in DFG 3, p. 6.) Further, the most successful native fish are those that use the floodplain for rearing, but leave before the floodplain becomes disconnected to the river. (Moyle *et al*. 2007, DFG 3, p. 6.) From a restoration perspective, projects should be designed to drain completely to minimize formation of ponds in order to avoid stranding. (Jones and Stokes, 1999 as cited in DOI 1, p. 28.) Bioenergetic modeling indicates that with regard to increased temperatures, increased food availability may be sufficient to offset increased metabolic demands from higher water temperatures. (DFG 3, p. 6.) However, as temperatures increase, juveniles may be unable to migrate to areas of lower temperatures due to reduced swimming ability. (DFG 3, p. 7.) As a result, as summer temperatures increase, floodplain habitat should also decrease. (*Id*.)

The timing of floodplain inundation for the protection of Central Valley Chinook salmon should generally occur from winter to mid-spring to coincide with the peak juvenile Chinook salmon outmigration period (which itself generally coincides with peak flows) and to avoid non-native access to the floodplain (which would generally occur in late-spring). (AR/NHI 1, p. 25.) The benefits of floodplain inundation generally increase with increasing duration, with even relatively short periods of two-weeks providing potential benefits to salmon. (Jeffres *et al*., 2008 as cited in AR/NHI 1, p. 25.) Benefits to salmon may also increase with increasing inter-annual frequency of flooding. Repeated pulse flows and associated increased residence times may be associated with increased productivity which would benefit salmon growth rates and potentially reduce stranding. (*Id*.)

Table 4, developed by AR/NHI, provides estimated thresholds for inundating floodplain habitat under existing and potentially modified conditions. Inundation threshold refers to the discharge when floodwaters begin to inundate the floodplain. Target discharge is the amount of water necessary to produce substantial inundation and flow across the floodplain. (Source: AR/NHI 1, p. 30.)

Floodplain inundation criteria for protection of salmon are provided in section 5.6.2, Floodplain Activation, under Other Measures.

Table 4. Inundation Thresholds for Floodplains and Side Channels at Various Locations Along the Sacramento River

Location	Stage (in feet)	Inundation Threshold (cfs)	Target Discharge (avg. cfs)	Gauge Location	Source
Freemont Weir Existing crest Proposed notch	 33.5 17.5	 56,000 23,100	 63,000 35,000	 Verona Verona	 USGS USGS
Sutter Bypass Tisdale weir Tisdail with notch Lower Sutter Bypass	 45.5 25	 21,000 30,000	 30,000	 Colusa Verona	 NOAA; Feyrer USGS
Upper Sacramento Meander belt side channels	 Various	 10,000	 12,000	 Red Bluff	 USGS

American Shad (*Alosa sapidissima*)

Status

This species is not listed pursuant to either the ESA or CESA.

Life History[13]

The American shad (*Alosa sapidissima*) is an anadromous fish, introduced into California in the late 1880s, that has become an important sport fish within the San Francisco Estuary. American shad range from Alaska to Mexico and use major rivers between British Columbia and the Sacramento watershed for spawning. (Moyle 2002.)

American shad adults, at 3 to 5 years of age, return from the ocean and migrate into the freshwater reaches of the Sacramento and San Joaquin rivers during March through May, with peak migration occurring in May (Stevens *et al*. 1987). Within California, the major spawning run occurs in the Sacramento River up to Red Bluff and in the adjoining American, Feather, and Yuba rivers with lesser use of the Mokelumne, Cosumnes, and Stanislaus rivers and the Delta (Moyle 2002). Spawning takes place from May through early July (Stevens *et al*. 1987). Following their first spawning event, American shad will return annually to spawn up to seven years of age (Stevens *et al*. 1987). It is believed that river flow will affect the distribution of first time spawners, with numbers of newly mature adults spawning in rivers proportional to flows at the time of arrival (Stevens *et al*. 1987). Spawning takes place in the main channels of the rivers with flows washing negatively buoyant eggs downstream. Depending upon temperature, larvae hatch from eggs in 3 to 12 days and will remain planktonic for 4 weeks (Moyle 2002).

[13] This section was largely extracted from DFG Exhibit 1, pages 26-27.

The lower Feather River and the Sacramento River from Colusa to the northern Delta provide the major summer nursery for larvae and juveniles. Flows drive the transport of young downstream, with wet years changing the location of the concentration of young and their nursery area further downstream into the northern Delta (Stevens *et al*. 1987). Out migration of young American shad through the Delta occurs from June through November (Stevens 1966). American shad spawned and rearing in the Delta and those that travel through the Delta during out migration are vulnerable to entrainment at the State and federal pumping facilities; catches at the facilities in some years have numbered in the millions (Stevens and Miller 1983). During migration to the ocean, young fish feed upon zooplankton, including copepods, mysids, and cladocerans, as well as amphipods (Stevens 1966, Moyle 2002). Most American shad migrate to the ocean by the end of their first year, but some remain in the estuary (Stevens *et al*. 1987).

Population Abundance and its Relationship to Flow
Year class strength correlates positively with river flow during the spawning and nursery period (April-June). (Stevens and Miller 1983.) American shad exhibit a weak but significant relationship to X2, (Kimmerer 2002a). After 1987, the relationship changed such that abundance increased per unit flow. (Kimmerer 2002a, Kimmerer 2009.) The X2 versus abundance relationship has remained intact into recent years. (Kimmerer *et al*. 2009.) In addition, Kimmerer *et al*. (2009) found that American shad had a habitat relationship (defined by salinity and Secchi depth) to X2 that appeared consistent with its relationship of abundance to X2 (i.e., slopes for abundance versus X2 and habitat versus X2 were similar), which provides some support for the idea that increasing quantity of habitat could explain the X2 relationship for this species (a possible causal mechanism for the abundance versus X2 relationship). Stevens and Miller (1983) determined that the apparent general effect of high flow on all of the species they examined, including American shad, is to increase the quality and quantity of nursery habitat and more widely disperse the young fish, thus reducing density-dependent mortality.

Population Goal
The immediate goal is to maintain viable populations of this species by providing sufficient flows to facilitate attraction of spawners, survival of eggs and larvae, and dispersal of young fish to suitable nursery habitats.

Species-Specific Recommendations
Delta Outflow

The DFG's current science-based conceptual model is that placement of X2 in Suisun Bay represents the best interaction of water quality and landscape for fisheries production given the current estuary geometry. (DFG 2, p. 6.) Maintaining X2 at 75 km and 64 km corresponds to net Delta outflows of approximately 11,400 cfs and 29,200 cfs, respectively. As noted by DFG, X2, in this instance, is a surrogate for tributary and mainstem river inflows to the Delta that support egg and larval survival. The species specific flow criteria to protect American shad shown in Table 5 are consistent with those submitted by DFG. (closing comments, p. 7.)

Inflows

No explicit recommendations for inflows to support American shad were identified in the record. The DFG provided outflow criteria for this species based on positioning X2 in Suisun Bay (DFG closing comments, p. 7); noting that in this instance X2 is a surrogate for tributary and mainstem river inflows. As noted above, year class strength correlates positively with river flow during the spawning and nursery period (April to June). (Steven and Miller 1983.) Flows must be sufficient to attract American shad spawners into Sacramento River tributaries, transport and disperse the young fish to suitable nursery habitat, and reduce the probability of entrainment of young fish and their food organisms in water diversions. (DFG 1987 [Exh 23, p. 23].) Water development has reduced flows during the spring and early summer periods which are most critical in this respect. (*Id.*) The spawning and nursery period, during which inflows appear to be most critical for this species, generally correspond to important periods for other more sensitive species (e.g., salmon outmigration, longfin smelt spawning and rearing). It is anticipated that by providing sufficient flows to meet the outflow criteria recommended above, favorable river conditions will be provided to support American shad spawning and rearing.

Old and Middle River Flows
American shad spawned and rearing in the Delta and those that travel through the Delta during out migration are vulnerable to entrainment at the State and Federal export facilities; in some years catches at the facilities have numbered in the millions. (Stevens and Miller 1983.) Although evaluations of screening efficiency comparable to studies for striped bass and salmon had not been completed for American shad, DFG believed in 1987 that larger fish in the fall were screened fairly efficiently, while screening efficiencies for newly metamorphosed juveniles in the late spring and early summer were quite low. (DFG 1987 [Exh 23, p. 20].) American shad are notoriously intolerant of handling. Tests have shown that losses of American shad that were successfully screened exceeded 50%during the summer months, with slightly lower mortalities during the cooler fall months. (DFG 1987 [Exh 23, p. 22].) These high handling mortalities suggest the only practical strategy for reducing losses may be pumping schedules that minimize shad entrainment. (*Id.*). However, no recommendations specific to American shad for net OMR flows or pumping restrictions were identified in the record. Net OMR flow criteria are intended to protect salmon, delta smelt, and longfin smelt populations and are also likely to reduce the number of American shad entrained at the export facilities. In addition, restrictions stipulated in the OCAP Biological Opinions (NMFS 3, pp. 648-653; USFWS 2008) will also reduce entrainment of American shad.

Table 5. Delta Outflows to Protect American Shad

Effect or Mechanism	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning; Nursery	All	--	--	--	X2[1] – 75 to 64 km (~11400 – 29200 cfs)			--	--	--	--	--	--

[1] For this species, X2 is a surrogate for tributary and mainstem river inflows to the Delta that support egg and larval survival. Source: DFG 1, p. 26; DFG 2, p. 6, DFG closing comments, p. 7.

4.2.4 Life History Requirements – Pelagic Species

Following are life history and species-specific requirements for longfin smelt, Delta smelt, Sacramento splittail, starry flounder, Bay shrimp, and zooplankton

Longfin Smelt (*Spirinchus thaleichthys*)

Status
Longfin smelt is listed as a candidate for threatened status under the CESA. (DFG 2010.)

Life History
Longfin smelt are a native species that live two years with females reproducing in their second year. Both juveniles and adults feed on zooplankton. Longfin smelt is an anadromous, open water species moving between fresh and salt water. Adults spend time in San Francisco Bay and may go outside the Golden Gate for short periods. Adults aggregate in Suisun Bay and the

western Delta in late fall and migrate upstream to spawn in freshwater as water temperatures drop below 18˚C. (Baxter *et al*. 2009.) The spawning habitat is between the confluence of the Sacramento and San Joaquin rivers (around Point Sacramento) to Rio Vista on the Sacramento side and Medford Island on the San Joaquin River. Spawning activity appears to decrease with distance from the low salinity zone, so the location of X2 influences how far spawning migrations extend into the Delta. (Baxter *et al*. 2009.) Spawning takes place between November and April with peak reproduction in January. Eggs are deposited on the bottom and hatch between December and May into buoyant larvae. Peak hatch is in February. Net Delta outflow transports the larvae and juvenile fish to higher salinity water.

Population Abundance and its Relationship to Flow

The population abundance of longfin smelt is positively correlated with spring Delta outflow and inversely related to net OMR spring reverse flows. The correlations are interpreted to mean that net Delta outflow and net reverse OMR flows are, at least partially, responsible for controlling the abundance of longfin smelt. Modifications in the two flow regimes are intended to begin to stabilize and increase the population abundance of longfin smelt. Each correlation is discussed below.

The population abundance of longfin smelt is positively related to Delta outflow during winter and spring. (Jassby *et al*. 1995; Rosenfield and Baxter 2007; Kimmerer 2002a; Kimmerer *et al*. 2009.) The statistically strongest outflow averaging period is January-June. The abundance relationships are from the fall mid-water trawl (FMWT) survey, the bay study mid-water trawl, and the bay study otter trawl. All three surveys show statistically significant positive relationships between the abundance of juveniles/adults and Delta outflow. There has been a decrease in the carrying capacity of the estuary since 1988, presumably because of the invasion of the clam *Corbula*, but the overall winter spring relationship is still statistically significant. More spring outflow results in more smelt as measured by all three indices. The biological basis for the spring outflow relationship is not known. Baxter et al. (2009) speculate that the larvae may benefit from increased downstream transport, increased food production, and a reduction in entrainment losses at the SWP and CVP pumps.

The population abundance of juvenile and adult longfin smelt, as measured by the FMWT index, is also inversely related to the number of fish salvaged at the SWP and CVP pumping facilities. (TBI/NRDC 4, pp. 19-20.) High pumping rates at the two facilities cause net OMR reverse flows which passively move all age groups of longfin smelt toward entrainment at the pumps. A subset of the juvenile and adult populations are counted at the pumping facilities. Larval longfin smelt (<20 mm) pass through the louvers and are not counted. Peak adult and juvenile longfin smelt salvage occurs in January and April to May, respectively. (Baxter *et al*. 2009.) Entrainment of larval smelt, although not counted, are likely greatest between March and April. (TBI/NRDC 4, p.16.) Adult and juvenile longfin smelt salvage is an inverse logarithmic function of net OMR flows. (Grimaldo *et al*. 2009.) Increasing OMR reverse flows results in an exponential increase in salvage loss. Juvenile longfin smelt salvage is a negative function of Delta outflow between March and May. (TBI/NRDC 4, p.17.) Higher outflow in these three months results in lower entrainment loss. This may result from the fact that during low outflow years spawning occurs higher in the system, placing adults and subsequent larvae and juveniles closer to the pumps. Also, negative net OMR flows can either passively draw fish to the pumps or at high levels mis-cue them as to the direction of higher salinity. A consequence is that juvenile longfin smelt are most in danger of entrainment at the CVP and SWP pumping facilities during low outflow years with high net negative OMR flows.

The OMR flow results discussed above are consistent with the findings of Baxter *et al* (2009). The authors used the Delta Simulation Model (DSM2, PTM subroutine) to predict the fate of larval longfin smelt. The PTM predicted that larval entrainment at the SWP might be substantial (2 to10%), particularly during the relatively low outflow conditions modeled. Baxter *et al*. (2009) also identified a significant negative relationship between spring (April to June) net negative OMR flows and the sum of combined SWP and CVP juvenile longfin smelt salvage. Juvenile longfin smelt salvage increased rapidly as OMR became more negative than -2,000 cfs. However, as winter-spring or just spring outflows increased, shifting the position of X2 downstream, the salvage of juvenile longfin smelt decreased significantly. Also, particle entrapment decreased, even with a high negative net OMR, when the flow of the Sacramento River at Rio Vista increased above 40,000 cfs. Entrainment of particles almost ceased at flows of 55,000 cfs.

TBI/NRDC (TBI/NRDC 2, pp. 15-19) conducted a generation to generation population abundance analysis for longfin smelt versus Delta outflow. The authors found that the probability of an increase in the FMWT longfin smelt index was greater than 50% in years when Delta outflow averaged 51,000 and 35,000-cfs between January to March and March to May, respectively. The analysis is important because it suggests a potential outflow trigger for growing the population.

There is also evidence that longfin smelt is food limited. (SFWC 1, p.59.) The FMWT index for longfin smelt is positively correlated in a multiple linear regression with the previous spring's *Eurytemora affinis* abundance (an important prey organism) after weighting the data by the proportion of smelt at each *Eurytemora* sampling station and normalizing by the previous years FMWT index. The spring population abundance of *Eurytemora* has itself been positively correlated with outflow between March and May since the introduction of *Corbula.* (Kimmerer, 2002a.) The positive correlation between *Eurytemora* abundance and spring outflow provides further support for a spring outflow criterion.

Longfin smelt populations are at an all time low. The average FMWT index for years 2001-2009 are only 3 percent of the average value for 1967 to 1987, a time period when pelagic fish did better in the estuary. The FMWT index for two of the last three years is the lowest on record.

Delta outflow recommendations to protect longfin smelt received from participants are summarized in Table 6. The DFG (DFG closing comments, p.7) recommended a Delta outflow between 12,400 and 28,000 cfs from January to June of all water year types to help transport larval/juvenile longfin smelt seaward in the estuary. TBI/NRDC (TBI/NRDC 2, pp. 19-26; TBI/NRDC Closing Comments, pp. 6-7) also made spring Delta outflow recommendations based on five sets of hydrologic conditions for the Central Valley. The TBI/NRDC recommendations range between 14,000 and 140,000 cfs for January through March and 10,000 to 110,000 cfs between April and May. The TBI/NRDC recommendations are based on their longfin smelt population abundance analysis which demonstrated positive growth in years with high spring outflow.

The four sets of OMR recommendations to protect longfin smelt received from participants are summarized in Table 7. TBI/NRDC (TBI/NRDC 4, pp. 21 and 30; TBI/NRDC closing comments, p. 11) recommended reducing entrainment losses of longfin smelt in dry years (March to May when outflow is less than 18,000 cfs) and population abundance is low (FMWT index less than 500) by maintaining positive net OMR flows in April and May. Alternatively, if the index is greater than 500 and Delta outflow is low, then net OMR flows should not be more negative than -1,500 cfs. The DOI (DOI 1, p.53) made a non-species specific recommendation that OMR flows should be positive in all months between January and June. CSPA/CWIN made a non-species specific recommendations that combined export rates equal zero from mid-March through June. (CSPA 1, p.8; CWIN 2, p. 26.) Finally, the DFG has issued an Incidental Take Permit for longfin smelt (2081-2009-001-03) that restricts net OMR flows in some years based on the recommendations of the Delta Smelt Workgroup. (Baxter *et al*. 2009.)

Table 6. Participant Recommendations for Delta Outflow to Protect Longfin Smelt

Organization	Water Year	Jan	Feb	Mar	April	May	Jun
TBI/NRDC	81-100% (driest years)	14,000 – 21,000			10,000 – 17,500		3000 – 4200
	61-80%	21,000 – 35,200			17,500 – 29,000		4200 – 5000
	41-60%	35,200 – 55,000			29,000 – 42,000		5000 – 8500
	21-40%	55,000 – 87,500			42,000 – 62,500		8500 – 25000
	0-20% (wettest years)	87,500 – 140,000			62,500 – 110,000		25000 – 50000
DFG	all	12,400 to 28,000					

Population Goal

The immediate goal is to stabilize the longfin smelt population, as measured by the FMWT index, and to begin to grow the population. The long-term goal is to achieve the objective of the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (USFWS 1996). The plan states that longfin smelt will be considered recovered when its abundance is similar to the 1967 to 1984 period.

Species- Specific Recommendations

Table 8 contains the species-specific flow criteria to protect longfin smelt. The purpose of the Delta outflow criteria is to stabilize and begin to grow the longfin smelt population; positive population growth is expected in half of all years with these flows. The net OMR flow criteria are intended to protect the longfin smelt population from entrainment in the CVP and SWP pumping facilities during years with limited Delta outflow (dry and critically dry years). As noted above, longfin smelt spawn in the Delta on both the Sacramento and San Joaquin rivers. Longfin smelt optimally need positive flow on both river systems to move buoyant larvae downstream and away from the influence of the pumps.

Table 7. Participant Recommendations for Net OMR Reverse Flows to Protect Longfin Smelt

Organization	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2006 Bay-Delta Plan	all	Some restrictions, given in terms of E/I ratios											
DFG Take Permit	all	-1,250 to -5,000[1]											
TBI/NRDC	C/D				>0[2] or -1,500[3]								
DOI	all	>0											
CSPA/CWIN	all			Combined export rates = 0									

[1] This condition is not likely to occur in many years and is based on requirements in the DFG Incidental Take Permit 2081-2009-001-03 and the advice of the Smelt Working Team. The condition is most likely to occur in dry or critical years when longfin smelt spawn higher in the Delta and hydrology does not rapidly transport hatched larvae from the central and south Delta.

[2] If FMWT index is less than 500

[3] If FMWT index is greater than 500

Table 8. Delta Outflows to Protect Longfin Smelt

Flow Type	Water Year Type	Jan	Feb	Mar	April	May	Jun
Net Delta Outflow	C	14,000 – 21,000			10,000 – 17,500		3,000 – 4,200
	D	21,000 – 35,200			17,500 – 29,000		4,200 – 5,000
	BN	35,200 – >50,000			29,000 – 42,000		5,000 – 8,500
	AN	>50,000			>42,000		8,500 – 25,000
	W	>50,000			>42,000		25,000 – 50,000
OMR	C/D				>0[1] or -1,500[2]		

[1] If FMWT index is less than 500

[2] If FMWT index is greater than 500

Delta Smelt (*Hypomesus transpacificus*)

Status

Delta smelt is listed as endangered under the CESA and threatened under the ESA. (DFG 2010.)

Life History

Delta smelt are endemic to the Delta. Delta smelt have an annual, one-year life cycle although some females may live and reproduce in their second year. (Bennett 2005.) Delta smelt complete their entire life cycle in the Delta and upper estuary. Delta smelt feed primarily on planktonic copepods, cladocerans, and amphipods. (Baxter *et al*. 2008.) In September or October delta smelt begin a slow upstream migration toward their freshwater spawning areas in the upper Delta, a process that may take several months. (Moyle 2002.) The upstream migration may be triggered by Sacramento River flows in excess of 25,000 cfs. (DSWG 2006.) Spawning can occur from late February to July, although most reproduction appears to take place between early April and mid-May. (Moyle 2002.) Spawning areas include the lower Sacramento, Mokelumne, and San Joaquin rivers, the west and south Delta, Suisun Bay, Suisun Marsh, and occasionally in wet years, the Napa River. (Wang 2007.) Eggs are negatively buoyant and adhesive with larvae hatching in about 13 days. (Wang, 1986; Mager 1996.) Upon hatching, the larvae are semi-buoyant staying near the bottom. Within a few weeks, larvae develop an air bladder and become pelagic, utilizing vertical water column movement to maintain their longitudinal position in the estuary. (Moyle 2002.)

Freshwater outflow during spring (March to June) affects the distribution of larvae by transporting them seaward toward the low salinity zone. (Dege and Brown 2004.) High Delta outflow during spring can carry some smelt downstream of their traditional rearing areas in the west Delta and Suisun Bay and into San Pablo Bay where long-term growth and survival may not be optimal. Conversely, periods of low outflow increase residence time in the Delta. Increasing residence time in the Delta probably prolongs the exposure of delta smelt to higher water temperatures and increased risk of entrainment at the State and Federal pumping facilities. (Moyle 2002.) Ideal rearing habitat conditions are believed to be shallow water areas most commonly found in Suisun Bay. (Bennett 2005.) When the mixing zone was located in Suisun Bay, it may in the past have provided optimal conditions for algal and zooplankton growth, an important food source for delta smelt. (Moyle 2002.) However, the quality of habitat in Suisun Bay appears to have deteriorated with the introduction of the clam *Corbula* which now consumes much of the phytoplankton that previously supported large populations of zooplankton. Since 2005, approximately 40% of the delta smelt population now remains in the Cache Slough complex north of the Delta. This may represent an alternative life history strategy in which the fish stay upstream of the low salinity zone (LSZ) through maturity. (Sommer et al., 2009.)

Population Abundance and Relationship to Flow

Delta smelt population abundance is measured in the summer tow net survey, the FMWT survey and the 20-mm spring-summer survey of juvenile fish. (Kimmerer et al. 2009.) All three indices indicate that delta smelt populations are at an all time low and may be in danger of extinction. The average FMWT index for 2001-2009 is only 20% of the value measured between 1967 and 1987, a time period when pelagic fish did better in the estuary. FMWT indices for the last six years (2004 to 2009) include all of the lowest values on record. The cause of the decline is unclear but likely includes some combination of flow, export pumping, food limitation, and introduced species.

Three types of flow have been hypothesized to affect delta smelt abundance. These are spring and fall Delta outflow and net OMR reverse flow. Testimony was received at the public proceeding recommending management changes to all three types of flow (Table 9 and Table 10). In the past, there has been a weak negative relationship between spring Delta outflow and delta smelt abundance as measured by the FMWT, however, the relationship has now disappeared. (Kimmerer *et al*. 2009.) The cause for the disappearance of the spring outflow-abundance relationship is not known but may result from the deterioration of rearing habitat in Suisun Bay because of colonization by the clam *Corbula.*

Several organizations recommend fall Delta outflow criteria for protection of delta smelt (Table 9). The primary purpose of a fall Delta outflow criterion is to increase the quality and quantity of rearing habitat for Delta smelt. (Nobriga et al. 2008; Feyrer et al. 2007; Feyrer et al., in review.) Rearing habitat is hypothesized to increase when the fall LSZ is downstream of the confluence of the Sacramento and San Joaquin rivers. This corresponds to Delta outflows greater than about 7,500 cfs between September and November, which would have to be achieved by release of water from upstream reservoirs in most years. Grimaldo et al. (2009) found that X2 was a predictor for salvage of adult delta smelt at the intra-annual scale when net OMR flows were negative. Moving X2 westward in the fall serves to increase the geographic and hydrologic distance of delta smelt from the influence of the export facilities and therefore likely reduces the risk of entrainment. (DOI 1, p. 34.) The USFWS (2008) recommended in their Opinion that the LSZ be maintained in the fall of above normal and wet water year types in Suisun Bay (Action 4). The action was restricted to above average water years to insure that sufficient cold water pool resources remained for steelhead and salmon and because these are the years in which SWP and CVP operations have most significantly affected fall conditions. (USFWS 2008.) The National Academy of Sciences (NAS) (2010) commented on this action in their review:

> ”The statistical relationship is complex. When the area of highly suitable habitat …is low, either high or low FMWT indices can occur. In other words, delta smelt can be successful even when habitat is restricted. More important, however, is that the lowest abundances all occurred when the habitat-area index was less than 6,000 ha. This could mean that reduced habitat area is a necessary condition for the worst population collapses, but it is not the only cause of the collapse… The … action is conceptually sound … to the degree that the amount of habitat available for smelt limits their abundance… however…the weak statistical relationship between the location of X2 and the size of smelt populations makes the justification for this action difficult to understand.” The National Academy of Sciences noted approvingly that the U.S. Fish and Wildlife Service (2008) required “additional studies addressing elements of the habitat conceptual model to be formulated … and … implemented promptly.”

Table 9. Participant Recommendations for Delta Outflows to Protect Delta Smelt

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2006 Bay-Delta Plan [1]	C	4500 [2]	7100 – 29200 [3]					4000	3000	3000	3000	3500	
	D	4500	7100 - 29200					5000	3500	3000	4000	4500	
	BN	4500	7100 - 29200					6500	4000	3000	4000	4500	
	AN	4500	7100 - 29200					8000	4000	3000	4000	4500	
	W	4500	7100 - 29200					8000	4000	3000	4000	4500	
USFWS Opinion[1]	AN									7000 [4]			
	W									12400			
EDF/Stillwater Sciences	C			26800	17500	17500	7500	4800	4800	4800	4800	4800	
	D			26800	17500	17500	7500	4800	4800	4800	4800	4800	
	BN			26800	26800	26800	11500	7500	7500	7500	7500	7500	
	AN			26800	26800	26800	11500	11500	11500	11500	11500	11500	
	W			26800	26800	26800	17500	17500	17500	17500	17500	17500	
TBI/NRDC	81-100%									5750 - 7500			
	61-80%									7500 - 9000			
	41-60%									9700 - 12400			
	21-40%									12400 - 16100			
	0-20%									16100 - 19000			

[1] 2006 Bay-Delta Plan and USFWS Opinion flows shown for comparative purposes.

[2] All water year types - Increase to 6000 if the December Eight River Index is > than 800 thousand acre-feet (TAF).

[3] Minimum Delta outflow calculated from a series of rules that are described in Tables 3 and 4 of the 2006 Bay-Delta Plan.

[4] USFWS Opinion (RPA concerning Fall X2 requirements [pp282-283] - improve fall habitat [quality and quantity] for delta smelt) (references USFWS 2008, Feyrer *et al* 2007, Feyrer *et al* in revision) - September-October in years when the preceding precipitation and runoff period was wet or above normal, as defined by the Sacramento Basin 40-30-30 Index, USBR and DWR shall provide sufficient Delta outflow to maintain monthly average X2 no greater than 74 km and 81 km in Wet and Above Normal years, respectively. During any November when the preceding water year was wet or above normal, as defined by Sacramento Basin 40-30-30 index, all inflow into the CVP/SWP reservoirs in the Sacramento Basin shall be added to reservoir releases in November to provide additional increment of outflow from Delta to augment Delta outflow up to the fall X2 of 74 km and 81 km for wet and above normal water years, respectively. In the event there is an increase in storage during any November this action applies, the increase in reservoir storage shall be released in December to augment the December outflow requirements in the 2006 Bay-Delta Plan.

Table 10. Participant Recommendations for Net OMR Flows to Protect Delta Smelt

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2006 Bay-Delta Plan	all	Some restrictions, given in terms of exports to inflow ratios											
USFWS - Opinion	all	Action 1: -2000 cfs for 14 days once turbidity or salvage trigger has been met; Action 2: range btw -1250 and -5000 cfs [1]			Range between -1,250 and -5,000 [2]								See Jan-Mar
USFWS	all	>0 [3]											
CSPA/ CWIN				Combined Export Rates = 0[3]									
TBI/ NRDC	all	>-1,500 cfs											>-1500 cfs

[1] USFWS Opinion - RPA re: net OMR flows. Component 1 - Adults (December - March) - Action 1 (protect upmigrating delta smelt) - once turbidity or salvage trigger has been met, -2000 cfs OMR flow for 14 days to reduce flows towards the pumps. Action 2 (protect delta smelt after migration prior to spawning) – Net OMR flow range between -1250 and -5000 cfs determined using adaptive process until spawning detected. (pp.280-282.)

[2] USFWS Opinion - RPA re: net OMR flows. Component 2 - Larvae/juveniles - action starts once temperatures hit 12˚ C at three Delta monitoring stations or when spent female is caught. Net OMR flow range between -1250 and -5000 cfs determined using adaptive process. OMR flow restrictions continue until June 30 or when Delta water temperatures reach 25˚ C, whichever comes first. (pp. 280-282.)

[3] Recommendations by the USFWS and CSPA/CWIN were not species specific.

It should be reiterated that this measure should be implemented within an adaptive framework, including completing studies designed to clarify the mechanism(s) underlying the effects of fall habitat on the delta smelt population, and a comprehensive review of the outcomes of the action and its effectiveness. Until additional studies are conducted demonstrating the importance of fall X2 to the survival of delta smelt, additional fall flows, beyond those stipulated in the fall X2criteria, for the protection of delta smelt are not recommended if it will compete with preservation of cold water pool resources needed for the protection of salmonids.

Net negative OMR flows can affect delta smelt by pulling them into the central Delta where they are at risk of entrainment in the SWP and CVP pumps. Recent studies have shown that entrainment of delta smelt and other pelagic species increases as net OMR flows become more negative. (Grimaldo et al. 2009; Kimmerer 2008.) Delta smelt are at risk as juveniles in the spring during downstream migration to their rearing area, and as adults between the fall and early spring as they move upstream to spawn. Salvage of age-0 delta smelt at the SWP /CVP fish collection facilities at the intra-annual scale has been found to be related to the abundance of these fish in the Delta, while net OMR flows and turbidity were also strong predictors. (Grimaldo et al. 2009.) This suggests that within a given year, the mechanism influencing entrainment is probably a measure of the degree to which their habitat overlaps with the hydrodynamic “footprint” of net negative OMR flows. (Grimaldo et al. 2009.) PTM results suggest that entrainment is a function of both net OMR flows and river outflows. (Kimmerer and Nobriga 2008.) PTM results may be more applicable to neutrally buoyant larvae and poorly swimming juveniles than adult delta smelt. Particle entrainment increased as a logarithmic function of increasing net negative OMR flows and decreases in river outflows. The highest entrainment was observed at high net negative OMR flows and low outflows. PTM results suggest that entrainment losses might be as high as 40% of the total delta smelt population in some years. (Kimmerer 2008.) Similar results were obtained by Baxter et al. (2009) when evaluating entrainment of longfin smelt using PTM. Juvenile longfin smelt salvage increased rapidly as net OMR flows became more negative than -2,000 cfs. Also, particle entrapment decreased, even with high net negative OMR flows, when the flow of the Sacramento River at Rio Vista increased above 40,000 cfs. Entrainment of particles almost ceased at flows of 55,000 cfs.

Field population investigations support some of the spring PTM results. Gravid females and larvae are present in the Delta as early as March and April. (Bennett 2005.) However, analysis of otolith data on individuals collected later in the year by Bennett *et al*. (unpublished data) show that few of the early progeny survived if spawned prior to the VAMP time period (typically April 15 to May 15). The hydrodynamic data showed high net negative OMR flows in the months preceding and after the VAMP, leading the researchers to conclude that high winter and early spring net negative OMR flows were selectively entraining the early spawning and/or early hatching cohort of the delta smelt population. However, Baxter *et al*. (2008) stated that “under this hypothesis, the most important result of the loss of early spawning females would manifest itself in the year following the loss, and would therefore not necessarily be detected by analyses relating fall abundance indices to same-year predictors.” No statistical relationships have been found between either OMR flows or CVP and SWP pumping rates and Delta smelt population abundance. (Bennett 2005.)

Entrainment of adult delta smelt occurs following the first substantial precipitation event (“first flush”), characterized by sudden increases in river inflows and turbidity, in the estuary as they begin their migration into the tidal freshwater areas of the Delta. (Grimaldo *et al*. 2009.) Patterns of adult entrainment are distinctly unimodal, suggesting that migration is a large population-level event, as opposed to being intermittent or random. (DOI 1, p. 36.) Grimaldo *et al*. (2009) provided evidence suggesting that entrainment during these "first flush" periods could be reduced if export reductions were made at the onset of such periods.

The USFWS Opinion identifies turbidity criteria for which to trigger first flush export reductions, but total Delta outflow greater than 25,000 cfs could serve as an alternate or additional trigger since such flows are highly correlated with turbidity. (Grimaldo *et al*. 2009, DOI 1, p. 36.) Managing OMR flows to thresholds at which entrainment or populations losses increase rapidly, represents a strategy for providing additional protection for adult delta smelt in the winter period (Dec-Mar). (DOI 1, p.36.). The USFWS Opinion identified the lower net OMR flow threshold as - 5000 cfs based on observed OMR flow versus salvage relationships from a longer data period (USFWS 2008) and additional data summarized over a more recent period. (Grimaldo et al. 2009.) The -5000 cfs OMR flow threshold is appropriate because it is the level where population losses consistently exceed 10%. (USFWS 2008, DOI 1, p. 36.) Adult delta smelt entrainment varies according to their distribution in the Delta following their upstream migration. The population is at higher entrainment risk if the majority of the population migrates into the south Delta, which may require net OMR flows to be more positive than -5000 cfs to reduce high entrainment. Conversely, if the majority of the population migrates up the lower Sacramento River or north Delta, a smaller entrainment risk is presumed, which would allow for OMR flows to be more negative than -5000 cfs for an extended period of time, or until conditions warrant a more protective OMR flow. (DOI 1, p.36.)

The USFWS Opinion for delta smelt includes net negative OMR flow restrictions to protect both spawning adult and out-migrating young. Component 1 of the USFWS Opinion has two action items; both are to protect adult delta smelt. Action 1 restricts OMR flow in fall to -2,000 cfs for 14 days when a turbidity or salvage trigger has been met. Both triggers have previously been correlated with the upstream movement of spawning adult smelt. Action 2 commences immediately after Action 1. Action 2 is to protect adult delta smelt after migration, but prior to spawning, by restricting net OMR flows to between -1250 and -5,000 cfs based on the recommendations of the Delta Smelt Workgroup. Component 2 of the USFWS Opinion is to protect larval and juvenile fish. Component 2 actions start once water temperatures hit 12^{o}C at three monitoring stations in the Delta or when a spent female is caught. OMR flows during this phase are to be maintained more positive than -1,250 to -5000 cfs based on a 14-day running average. Component 2 actions are to continue until June 30 or when the 3-day-mean water temperature at Clifton Court Forebay is 25^{o}C. The Delta Smelt Working Group is to make recommendations on the specific OMR flow restrictions between -1250 and -5000 cfs.

The NAS (2010) reviewed the USFWS Opinion OMR flow restrictions and concluded:

> "…it is scientifically reasonable to conclude that high negative OMR flows in winter probably adversely affect smelt populations. Thus, the concept of reducing OMR negative flows to reduce mortality of smelt at the SWP and CVP facilities is scientifically justified … but the data do not permit a confident identification of the threshold values to use … and … do not

> permit a confident assessment of the benefits to the population…As a result, the implementation of this action needs to be accompanied by careful monitoring, adaptive management and additional analyses that permit regular review and adjustment of strategies as knowledge improves."

The negative impact of negative OMR flows on delta smelt, like on longfin smelt, is likely to be greatest during time periods with high negative OMR flows and low Sacramento River outflow. (Baxter *et al*. 2009; Kimmerer and Nobriga 2008.) The work of Grimaldo *et al*, (2009) suggests that impacts associated with the export facilities can be mitigated on a larger scale by altering the timing and magnitude of exports based on the biology of the fishes and changes in key physical and biological variables.

For the protection of longfin smelt, Delta outflow criteria between January and March range from 35,000 cfs in below normal water years to greater than 50,000 cfs in wet water years (Table 8). For the protection of longfin smelt, flow criteria between April and May range from 29,000 cfs to more than 42,000 cfs. These flows should also afford protection for larval delta smelt from excessive negative OMR flows and entrainment at the CVP and SWP pumping facilities. Under this criterion, lower outflows will still likely occur during critically dry and dry water year types (Table 6). These outflows may not be sufficient to prevent longfin and delta smelt entrainment at the pumping facilities. Therefore, the recommended criterion for longfin smelt specifies that net OMR flows should not be more negative than -1500 cfs in April and May of dry and critically dry water years to protect longfin smelt. The State Water Board determines that this criterion should be extended to include March and June of dry and critically dry water years to protect early and late spawning delta smelt (Table 11).

Minimizing net negative OMR flows during periods when adult delta smelt are migrating into the Delta could also substantially reduce mortality of the critical life stage. For example, one potential strategy is to reduce exports during the period immediately following the "first flush", based on a turbidity or flow trigger. (Grimaldo et al. 2009.) This supports a recommendation that net OMR flows be more positive than -5000 cfs during the period between December and March. Additional OMR flow restrictions may be warranted during periods when a significant portion of the adult delta smelt population migrates into the south or central Delta. In such instances, the determination of specific thresholds should be made through an adaptive approach that takes into account a variety of factors including relative risk (e.g., biology, distribution and abundance of fishes), hydrodynamics, water quality, and key physical and biological variables. The State Water Board agrees with the NAS (2010) that the data, as currently available, do not permit a confident assessment of the threshold OMR flow values nor of the overall benefit to the delta smelt population. Development of a comprehensive life-cycle model for delta smelt would be valuable in that it would allow for an assessment of population level impacts associated with entrainment. Such life-cycle models for delta smelt are currently under development. Therefore, net OMR flow criteria need to be accompanied by a strong monitoring program and adaptive management to adjust OMR flow criteria as more knowledge becomes available.

Delta smelt are food limited. Delta smelt survival is positively correlated with zooplankton abundance. (Feyrer et al., 2007; Kimmerer 2008; Grimaldo et al., 2009.) A new analysis by the SFWC (SFWC 1, p.60) also demonstrates a positive relationship between FMWT delta smelt indices and the previous spring and summer abundance of

Eurytemora and *Psuedodiaptomus.* There are several hypotheses for the cause of the decline in zooplankton abundance. First, zooplankton abundance in Suisun and Grizzly bays, prime habitat for delta smelt, declined after the introduction of the invasive clam *Corbula.* *Corbula* is thought to compete directly with zooplankton for phytoplankton food and lower phytoplankton levels may limit zooplankton abundance. A second hypothesis is that changes in nutrient loading and nutrient form in the Delta that result from the SRWTP discharge can have major impacts on food webs, from primary producers through secondary producers to fish. (Glibert, 2010.) Changes in nutrient concentrations and their ratios may have caused the documented shift in phytoplankton species composition from large diatoms to smaller, less nutritious algal forms for filter feeding organisms like zooplankton. If true, both of the above hypotheses could indirectly result in lower densities of delta smelt. Therefore, all recommended flow modifications should be accompanied by a strong monitoring and adaptive management process to determine whether changes in OMR flows result in an improvement in delta smelt population levels.

Population Abundance Goal
The immediate goal is to stabilize delta smelt populations, as measured by the FMWT index, and begin to grow the population. The long term goal should be to achieve the objective of the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (USFWS 1996.)

Species-Specific Recommendations
Although a positive correlation between Delta outflows and delta smelt is lacking, Delta outflows do have significant positive effects on several measures of delta smelt habitat. (Kimmerer *et al*. 2009), and spring outflow is positively correlated with spring abundance of *Eurytemora affinis* (Kimmerer 2002a), an important delta smelt prey item. No specific spring Delta outflow criteria are therefore recommended for delta smelt. Flow criteria to protect longfin smelt in the spring of wetter years (Table 8) may, however, afford some additional protection for the Delta smelt population.

The State Water Board advances the OMR flow criteria in Table 11 for dry and critically dry years to protect the delta smelt population from entrainment in the CVP and SWP pumping facilities during years with limited Delta outflow. The OMR flow restrictions are an extension of the criteria for longfin smelt. In addition, the State Water Board includes criteria for OMR flows to be more positive than -5,000 cfs between December and February of all water year types to protect upstream migrating adult delta smelt. The -5,000 cfs criteria may need to be made more protective in years when delta smelt move into the central Delta to spawn. The more restrictive OMR flows would be recommended after consultation with the USFWS's Delta Smelt Working Group. In the absence of any other specific information, the State Water Board determines that the existing 2006 Bay-Delta Plan Delta outflow objectives for July through December are needed to protect delta smelt.

Table 11. Net OMR Flows for the Protection of Delta Smelt

Flow Type	Water Year Type	Dec	Jan	Feb	Mar - June
Net OMR flows	C/D				> -1,500 cfs
Net OMR flows	All	> - 5000 cfs (thresholds determined through adaptive management)			

Sacramento Splittail (*Pogonichthys macrolepidotus*)

Status

Sacramento splittail is currently recognized by the DFG as a species of special concern. Splittail was listed as a threatened species pursuant to the ESA in 1999; however, its status was remanded in 2003 on the premise of recent increases in abundance and population stability. This decision was subsequently challenged and the USFWS is revisiting the status of splittail and will make a new 12-month finding on whether listing is warranted by September 30, 2010.

Life History

Sacramento splittail (*Pogonichthys macrolepidotus*) is a cyprinid native to California that can live seven to nine years and has a high tolerance to a wide variety of water quality parameters including moderate salinity levels. (Moyle 2002, Moyle et al. 2004.)

Adult splittail are found predominantly in Suisun Marsh, Suisun Bay, and the western Delta, but are also found in other brackish water marshes in the San Francisco Estuary as well as the fresher Delta. Splittail feed on detritus and a wide variety of invertebrates; non-detrital food starts with cladocerans and aquatic fly larvae on the floodplains, progresses to insects and copepods in the rivers, and to mysid shrimps, amphipods and clams for older juveniles and adults. (Daniels and Moyle 1983, Feyrer et al. 2003, Feyrer et al. 2007a, as cited in DFG 1, p. 13.) In winter and spring when California's Central Valley experiences increased runoff from rainfall and snowmelt, adult splittail move onto inundated floodplains to forage and spawn. (Meng and Moyle 1995; Sommer et al. 1997, Moyle et al. 2004, as cited in DFG 1, p. 13.) Spawning takes place primarily between late February and early July, and most frequently during March and April (Wang 1986, Moyle 2002) and occasionally as early as January. (Feyrer et al. 2006a.) Splittail eggs, laid on submerged vegetation, begin to hatch in a few days and the larval fish grow fast in the warm and food rich environment. (e.g., Moyle et al. 2004, Ribeiro et al. 2004.) After spawning, the adult fish move back downstream.

Once they have grown a few centimeters, the juvenile splittail begin moving off of the floodplain and downstream into similar habitats as the adults. These juveniles become mature in two to three years. In the Yolo Bypass, two flow components appear necessary for substantial splittail production (Feyrer et al. 2006a): (1) inundating flows in winter (January to February) to stimulate and attract migrating adults; and (2) sustained floodplain inundation for 30 or more days from March through May or June to allow successful incubation through hatching (3 to 7 days, see Moyle 2002), and extended rearing until larvae are competent swimmers (10 to 14 days; Sommer et al. 1997) and beyond to maximize recruitment. (DFG 1, p. 13.)

Large-scale spawning and juvenile recruitment occurs only in years with significant protracted (greater than or equal to 30 days) floodplain inundation, particularly in the

Sutter and Yolo bypasses. (Meng and Moyle 1995, Sommer et al. 1997, Feyrer et al. 2006a, as cited in DFG 1, p. 13.) Some spawning also occurs in perennial marshes and along the vegetated edges of the Sacramento and San Joaquin rivers. (Moyle et al. 2004.) During periods of low outflow, splittail appear to migrate farther upstream to find suitable spawning and rearing habitats. (Feyrer et al. 2005.) Moyle et al. (2004) noted that though modeling shows splittail to be resilient, managing floodplains to promote frequent successful spawning is needed to keep them abundant.

Population Abundance and its Relationship to Flow

Age-0 splittail abundance has been significantly correlated to mean February through May Delta outflow and days of Yolo Bypass floodplain inundation, representing flow/inundation during the incubation and early rearing periods. (Meng and Moyle 1995, Sommer et al. 1997.) The flow-abundance relationship is characterized by increased abundance (measured by the FMWT) as mean February–May X2 decreases, indicating a significant positive relationship between FMWT abundance and flow entering the estuary during February–May. (Kimmerer 2002a.)

Feyrer et al. (2006a) proposed the following lines of evidence to suggest the mechanism supporting this relationship for splittail lies within the covarying relationship between X2 and flow patterns upstream entering the estuary: the vast majority of splittail spawning occurs upstream of the estuary in freshwater rivers and floodplains (Moyle et al. 2004); the averaging time frame (February–May) for X2 coincides with the primary spawning and upstream rearing period for splittail; the availability of floodplain habitat, as indexed by Yolo Bypass stage, is directly related to X2 during February–May ($y = 4.38 - 2.21x$; $p<0.001$; $r^2 = 0.97$); the center of age-0 splittail distribution does not reach the estuary until summer (Feyrer et al. 2005); and the splittail X2-abundance relationship has not been affected by dramatic food web changes (Kimmerer 2002a) that have significantly altered the diet of young splittail in the estuary. (Feyrer et al. 2003.)

Population Abundance Goal

The immediate goal is to stabilize the Sacramento Splittail population, as measured by the FMWT index, and to begin to grow the population. The long-term goal is to maintain population abundance index as measured by FMWT in half of all years above the long term population index value.

Species- Specific Recommendations

Delta Outflow - Upstream covariates of X2, such as the availability of suitable floodplain and off-channel spawning and nursery habitat, appear to be the attributes supporting the flow-abundance relationship for splittail. Therefore, the flow needs of this species, with respect to spawning and rearing habitat, are most effectively dealt with through establishment of flow criteria that address the timing, duration, and magnitude of floodplain inundation from a river inflow standpoint.

Delta Inflow - Information in the record on conditions conducive to successful spawning and recruitment of splittail shows that the species depends on inundation of off-channel areas. Sufficient flows are therefore needed to maintain continuous inundation for at least 30 consecutive days in the Yolo Bypass, once floodplain inundation has been achieved based on runoff and discharge for ten days between late-February and May, during above normal and wet years (Table 12). (DFG closing comments, p. 7.)

Opportunities to provide floodplain inundation in other locations (e.g., the San Joaquin River) warrant further examination.

Feyrer *et al* (2006a) noted that manipulating flows entering Yolo Bypass such that floodplain inundation is maximized during January through June will likely provide the greatest overall benefit for splittail, especially in relatively dry years when overall production is lowest. Within the Yolo Bypass, floodplain inundation of at least a month appears to be necessary for a strong year class of splittail (Sommer *et al*. 1997); however, abundance was highest when the period of inundation extended 50 days or more. (Meng and Moyle 1995.) Floodplain inundation during the months of March, April, and May appears to be most important. (Wang 1986, Moyle 2002.) Managing the frequency and duration of floodplain inundation during the winter and spring, followed by complete drainage by the end of the flooding season, could favor splittail and other native fish over non-natives. (Moyle et al. 2007, Grimaldo et al. 2004.) Duration and timing of inundation are important factors that influence ecological benefits of floodplains.

<u>Yolo Bypass Inundation</u> – The Fremont Weir is a passive facility that begins to spill into the Yolo Bypass when the Sacramento River flow at Verona exceeds 55,000 to 56,000 cfs. (AR/NHI 1, p. 21; EDF 1, p. 50; TBI/NRDC 3, p. 35; Sommer et al. 2001b.) Water also enters the bypass at the Sacramento Weir and from the west via high flow events in small west-side tributaries. (Feyrer et al. 2006b.) Each of these sources joins the Toe Drain, a perennial channel along the east side of the Yolo Bypass floodplain, and water spills onto the floodplain when the Toe Drain flow exceeds approximately 3,500 cfs. (Feyrer et al. 2006b.) The Yolo Bypass typically floods in winter and spring in about 60% of years (DOI 1, p. 54; Sommer et al. 2001a; Feyrer et al. 2006a), with inundation occurring as early as October and as late as June, with typical peak period of inundation during January-March. (Sommer et al. 2001b.) In addition, studies suggest phytoplankton, zooplankton, and other organic material transported from the Yolo Bypass enhances the food web of the San Francisco Estuary. (Jassby and Cloern 2000; Mueller-Solger et al. 2002; Sommer et al. 2004.) Much of the water diverted into the bypass drains back into the north Delta near Rio Vista. Besides the Yolo Bypass, the only other Delta region with substantial connectivity to portions of the historical floodplain is the Cosumnes River, a small undammed watershed. (Sommer et al. 2001b.)

Multiple participants provided recommendations concerning the magnitude and duration of floodplain inundation along the Sacramento River, lower San Joaquin River, and within the Yolo and Sutter bypasses. (AR/NHI 1, p. 32; DFG closing comments; DOI 1, p. 54, EDF 1, pp. 50-52, 53-55; SFWC closing comments; TBI/NRDC 3, p. 36.) In addition, the draft recovery plan for the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley Steelhead (NMFS 2009) calls for the creation of annual spring inundation of at least 8,000 cfs to fully activate the Yolo Bypass floodplain. (NMFS 5, p.157.)

Overtopping the existing weirs and flooding the bypasses (e.g., Yolo and Sutter) to achieve prolonged periods (30 to 60 days) of floodplain inundation in below normal and dry water years would require excessive amounts flows given the typical runoff patterns during those year types. (AR/NHI 1, p. 29.) From a practical standpoint, it is probably only realistic to achieve prolonged inundation during drier water year types by notching the upstream weirs and possibly implementing other modifications to the existing system. (AR/NHI 1, p. 29.)

The BDCP is currently evaluating structural modifications to the Fremont Weir (e.g., notch the weir and install operable "inundation gates"), as a means of increasing the interannual frequency and duration of floodplain inundation in the Yolo Bypass. (BDCP 2009.) TBI/NRDC (TBI/NRDC 3, p. 36) and AR/NHI (AR/NHI 1, p. 32) provided floodplain inundation recommendations for the Yolo Bypass assuming structural modifications to the Fremont Weir were implemented. A potential negative impact of notching the Fremont Weir is that it will affect stage height and Sutter Bypass flooding, and the resulting spawning and rearing of splittail and spring-run Chinook salmon. (personal communication R. Baxter.)

The NMFS Opinion stipulates that USBR and DWR, in cooperation with DFG, USFWS, NMFS, and USACE, shall, to the maximum extent of their authorities (excluding condemnation authority), provide significantly increased acreage of seasonal floodplain rearing habitat, with biologically appropriate durations and magnitudes, from December through April, in the lower Sacramento River basin, on a return rate of approximately one to three years, depending on water year type. (NMFS 3, p.608.) USBR and DWR are to submit a plan to implement this action to NMFS by December 31, 2011. (NMFS 3, p. 608.) This plan is to include an evaluation of options to, among other things, increase inundation of publicly and privately owned suitable acreage within the Yolo Bypass and modify operations of the Sacramento Weir or Fremont Weir to increase rearing habitat. (NMFS 3, p. 608.) The NMFS Opinion specifies that in the event that this action conflicts with Shasta Operations Actions I.2.1 to I.2.3 (e.g., carryover storage requirements), the Shasta Operations Actions shall prevail. (NMFS 3, p. 608.)

<u>OMR Flows</u> - Entrainment of splittail at the SWP and CVP export facilities is highest during adult spawning migrations and periods of peak juvenile abundance in the Delta. (Meng and Moyle 1995, Sommer et al. 1997.) The incidence of age-0 splittail entrainment increased during wet years when abundance was also high (Sommer et al. 1997.) However, analyses conducted by Sommer et al. (1997) suggested that entrainment at the export facilities did not have an important population-level effect. However, Sommer et al. (1997) noted that their evidence does not demonstrate that entrainment never affects the species. For example, if the core of the population's distribution were to shift toward the south Delta export facilities during a dry year, there could be substantial entrainment effects to a year-class. (Sommer et al. 1997.) Criteria for net OMR flows intended to protect salmon, delta smelt, and longfin smelt populations, as well as restrictions stipulated in the Opinions (NMFS 3, pp. 648-653; USFWS 2008) are likely to reduce the number of splittail entrained at the export facilities.

Table 12. Floodplain Inundation Criteria for Sacramento Splittail

Mechanism	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning and Rearing Habitat	AN / W	--	$\geq$ 30 day floodplain inundation				--	--	--	--	--	--	--

Starry Flounder (*Platichthys stellatus*)

Status

Starry flounder is not listed pursuant to either the ESA or CESA.

Life History

Starry flounder is a native to the Bay-Delta Estuary. The geographic distribution of flounder is from Santa Barbara, California, to Alaska and in the western Pacific as far south as the Sea of Japan. (Miller and Lea 1972.) Starry flounder are important in both the recreational and commercial catch in both central and northern California. (Haugen 1992; Karpov et al. 1995.)

Starry flounder is an estuarine dependent species. (Emmett et al. 1991.) Spawning occurs in the Pacific Ocean near the entrance to estuaries and other freshwater sources between November and February. (Orcutt 1950.) Juveniles migrate from marine to fresh water between March and June and remain through at least their second year of life before returning to the ocean. (Baxter 1999.) Young individuals are found in Suisun Bay and Marsh and in the Delta. Older individuals range from Suisun to San Pablo bays. Maturity is reached by males at the end of their second year and by females in their third or fourth years. (Orcott 1950.)

Population abundance of young of the year and one year old starry flounder have been measured by the San Francisco Otter Trawl Study since 1980 and reported as an annual index. (Kimmerer et al. 2009.) The index declined between 2000 and 2002 but has since recovered to values in the 300 to 500 range. The median index value for the 29 years of record is 293.

Population Abundance Relationship to Flow

Starry flounder age-1 abundance in the San Francisco Bay otter trawl study is positively correlated with the March through June outflow of the previous year. (Kimmerer et al. 2009.) The mechanism underlying the abundance outflow relationship is not known but may be increased passive transport of juvenile flounder by strong bottom currents during high outflow years. (Moyle 2002.) There has been a decline in the abundance of flounder for any given outflow volume since 1987, presumably because of the invasion by the clam Corbula, however, the overall abundance-flow relationship is still statistically significant. (Kimmerer 2002a.)

Population Abundance Goal

The goal is to maintain the starry flounder population abundance index, as measured by the San Francisco Otter Trawl Study, in half of all years above the long term population median index value of 293.

Species-Specific Recommendations

Outflow recommendations were only received from the DFG. (DFG 1, p. 16.) DFG recommends maintaining X2 between 65 and 74 km between February and June. This corresponds to an average outflow of 11,400 to 26,815 cfs. Table 13 contains the criteria needed for protection of starry flounder. The purpose of this outflow criteria is to maintain population abundance near the long term median index value of 293. This net Delta outflow criteria is similar to those proposed for the protection of longfin smelt, delta smelt, and *Crangon sp*. The State Water Board's criteria for Delta outflow for the protection of both longfin and delta smelt and *Crangon* will also protect starry flounder. The proposed outflow is consistent with DFG's recommendation for starry flounder. There is no information in the record to support criteria for inflows or hydrodynamics to protect starry flounder.

Table 13. Criteria for Delta Outflow to Protect Starry Flounder

Flow Type	Water Year Type	Jan	Feb	Mar	April	May	Jun
Net Delta Outflow	C	14,000 – 21,000			10,000 – 17,500		
	D	21,000 – 35,200			17,500 – 29,000		
	BN	35,200 – >50,000			29,000 – 42,000		
	AN	>50,000			>42,000		
	W	>50,000			>42,000		

California Bay Shrimp (*Crangon franciscorum*)

Status

The California bay shrimp is not listed pursuant to either ESA or CESA.

Life History

There are three native species of Crangon, collectively known as bay shrimp or grass shrimp, common to the San Francisco Estuary: *Crangon franciscorum, C. nigricauda*, and *C. nigromaculata.* (Hieb 1999.) Bay shrimp are fished commercially in the lower estuary and sold as bait. (Reilly et al. 2001.) *C. franciscorum* species is targeted by the commercial fishery because of its larger size. Bay shrimp are also important prey organisms for many fish in the estuary. (Hatfield, 1995.)

The California bay shrimp (*Crangon franciscorum*) is an estuary dependent species that is distributed along the west coast of North America from Alaska to San Diego. Larvae hatch from eggs carried by females in winter in the lower estuary or offshore in the Pacific Ocean. Most late-stage larvae and juvenile *C. franciscorum* migrate into the estuary and upstream to nursery areas between April and June. Juvenile shrimp are common in San Pablo and Suisun bays in high outflow years. Their center of distribution moves upstream to Honker Bay and the lower Sacramento and San Joaquin rivers during low flow years. (Hieb 1999.) Mature shrimp migrate back down to higher salinity waters after a four to six month residence in the upper estuary. (Hatfield 1985.) *C. franciscornum* mature at one year and may live up to two years. Some females hatch more than one brood of eggs during a breeding season.

Population abundance of juvenile *C. franiscorum* is measured by DFG's San Francisco Bay Study and is reported as an annual index. (Jassby et al. 1995, Hieb 1999.) Indices over the 29 years of record have varied from 31 to 588 with a median value of about 103.

Population Abundance and Relationship to Flow

There is a positive correlation between the abundance of *C. franciscorum* and net Delta outflow from March to May of the same year. (Jassby et al. 1995; Kimmerer et al. 2009.) The statistical relationship has remained constant since the early years of the San Francisco Bay Study, which began in 1980. The mechanism underlying the abundance relationship is not known but may be an increase in the passive transport of juvenile shrimp up-estuary by strong bottom currents during high outflows years. (Kimmerer et al. 2009, Moyle 2002, DFG 1992.) Other potential mechanisms include the effects of freshwater outflow on the amount and location of habitat, the abundance of food organisms and predators, and the timing of the downstream movement of mature shrimp. (DFG 1, p. 23.)

Delta outflow recommendations (Table 14) were received from both the DFG (DFG 1, p. 23) and TBI/NRDC. (TBI/NRDC 2, p. 17). TBI/NRDC analyzed the productivity of *C. franciscorum* as a function of net Delta outflow between March and May. The analysis suggests that estuary populations increased in about half of all years when flows between March and May were approximately 5 million acre-feet (MAF), or about 28,000 cfs per month. TBI/NRDC recommended that flow be maintained in most years above 28,000 cfs during these three months to insure population growth about half the time. The DFG recommended a net Delta outflow criterion of 11,400 to 26,800 cfs between February and June of all water years to aid immigration of late stage larvae and small juveniles.

Table 14. Participant Recommendations for Delta Outflows to Protect Bay Shrimp

	Water Year	**Feb**	**Mar**	**Apr**	**May**	**Jun**
TBI/NRDC Exhibit 2	Most years		28,000			
Fish and Game Exhibit 1	all	11,400 to 26,815				

Population Abundance Goal

The goal is to maintain the juvenile C*. franciscorum* population abundance index, as measured by the San Francisco Bay Study otter trawl, in half of all years above a target value of 103. An index of 103 is the median longterm index value for this species in the San Francisco Estuary.

Species-Specific Recommendations

The State Water Board determines the Delta outflow criteria in Table 15 are needed to protect C*rangon franciscorum*. The purpose of the outflow criteria is to maintain population abundance at a long term median index value of 103. Positive population growth is expected in half of all years under these flow conditions. The Delta outflow criteria are similar to those proposed for protection of both longfin smelt and delta smelt. The nursery area for C*. franciscorum* is usually downstream of the influence of the pumps, therefore no OMR flow recommendations were received and no review was conducted.

Table 15. Criteria for Delta Outflows to Protect Bay Shrimp

Flow Type	Water Year Type	Jan	Feb	Mar	April	May
Net Delta Outflow	C	14,000 – 21,000			10,000 – 17,500	
	D	21,000 – 35,200			17,500 – 29,000	
	BN	35,200 – >50,000			29,000 – 42,000	
	AN	>50,000			>42,000	
	W	>50,000			>42,000	

Zooplankton (*E. affinis* and *N. mercedis*)

Status

Eurytemora affinis is a non-native species that is not listed pursuant to either the ESA or CESA. *Neomysis mercedis* is a native species that is not listed pursuant to either the ESA or CESA.

Life History[14]

Zooplankton is a general term for small aquatic animals that constitute an essential food source for fish, especially young fish and all stages of pelagic fishes that mature at a small size, such as longfin smelt and delta smelt (DFG 1987b). Although DFG follows trends of numerous zooplankton taxa (e.g., Hennessy 2009), two upper estuary zooplankton taxa of particular importance to pelagic fishes have exhibited abundance relationships to Delta outflow. The first is the mysid shrimp *Neomysis mercedis*, which before its decline, beginning in the late 1980s, was an important food of most small fishes in the upper estuary (see Feyrer et al. 2003). Prior to 1988, *N. mercedis* mean summer abundance (June through October) increased significantly as X2 moved downstream (mean March through November location, Kimmerer 2002a. Table 1). After 1987, *N. mercedis* abundance declined rapidly and is currently barely detectable (Kimmerer 2002a, Hennessy 2009). The second is a calanoid copepod, *Eurytemora affinis*, which also declined sharply after 1987, but more so in summer than in spring (Kimmerer 2002a). Before 1987, *E. affinis* was abundant in the low salinity habitat (0.8-6.3 ‰) throughout the estuary (Orsi and Mecum 1986). *E. affinis* is an important food for most small fishes, particularly those with winter and early spring larvae, such as longfin smelt, delta smelt and striped bass (Lott 1998, Nobriga 2002, Bryant and Arnold 2007, DFG unpublished).

Population Abundance and Relationship to Flow

E. affinis was historically abundant throughout the year, particularly in spring and summer, but after 1987 abundance declined in all seasons, most notably in summer and fall. (Hennessy 2009, as cited in DFG 1, p. 26.) After 1987, *E. affinis* spring abundance (March through May) has significantly increased as spring X2 has moved downstream. (Kimmerer 2002a. Table 1, as cited in DFG 1, p. 26.) Relative abundance in recent years is highest in spring and persistence of abundance is related to spring outflow. As flows decrease in late spring, abundance decreases to extremely low levels throughout the estuary. (Hennessey 2009, as cited in DFG 1, p. 26.)

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[14] This section was largely extracted from DFG Exhibit 1, page 25.

The only outflow recommendation identified in the record specifically for *E. affinis* and *N. mercedis* was submitted by DFG, in their closing comments (Table 16). According to DFG, their current science-based conceptual model is that placement of X2 in Suisun Bay represents the best interaction of water quality and landscape for fisheries production given the current estuary geometry. (DFG 2, p. 6.) Maintaining X2 at 75 km and 64 km corresponds to net Delta outflows of approximately 11,400 cfs and 29,200 cfs, respectively. The Bay Institute provided flow recommendations for a suite of species, including *E. affinis (*Table 17*).*

Table 16. DFG's Delta Outflow Recommendation to Protect *E. affinis* and *N. mercedis* (DFG Closing Comments)

Species	Parameter	Effect or Mechanism	Timing	Minimum	Maximum	Reference
Zooplankton	Flows	Habitat	February - June	X2 at 75 km	X2 at 64 km	DFG Exhibit 1, p.25-26; Exhibit 2, p.6

Table 17. The Bay Institute's Delta Outflow Recommendations to Protect Zooplankton Species Including *E. affinis*

Species	Mechanism	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eurytemora affinis	Habitat	81-100% (driest years)	14000-21000 cfs		10000-17500 cfs			3000-4200 cfs						
		61-80%	21000-35000 cfs		17500-29000 cfs			4200-5000 cfs						
		41-60%	35200-55000 cfs		29000-42500 cfs			5000-8500 cfs						
		21-40%	55000-87500 cfs		42500-62500 cfs			8500-25000 cfs						
		0-20% (wettest years)	87500-140000 cfs		62500-110000 cfs			25000 - 50000 cfs						

Species-Specific Recommendations

Table 18 shows the State Water Board's determination for Delta outflows needed to protect zooplankton. These recommendations are consistent with those submitted by DFG. (closing comments, p. 7.) The State Water Board concurs with DFG's current science-based conceptual model which concludes that placement of X2 in Suisun Bay represents the best interaction of water quality and landscape for fisheries production given the current estuary geometry. (DFG 2, p. 6.) Maintaining X2 at 75 km and 64 km corresponds to net Delta outflows of approximately 11,400 cfs and 29,200 cfs, respectively. No explicit recommendations concerning zooplankton and inflow or hydrodynamic requirements were identified in the record.

Table 18. Criteria for Delta Outflows to Protect Zooplankton

Effect or Mechanism	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Habitat	All	--	X2[1] – 75 to 64 km (~11400 – 29200 cfs)					--	--	--	--	--	--

4.3 Other Measures

Information in the record for this proceeding broadly supports the five key points submitted by the DEFG of experts (DEFG 1):

1) Environmental flows are more than just volumes of inflows and outflows
2) Recent flow regimes both harm native species and encourage non-native species
3) Flow is a major determinant of habitat and transport
4) Recent Delta environmental flows are insufficient to support native Delta fishes for today's habitats
5) A strong science program and a flexible management regime are essential to improving flow criteria

These key points recognize that although adequate environmental flows are a necessary element to protect public trust resources in the Delta ecosystem, flows alone are not sufficient to provide this protection. These key points and other information in the record warrant a brief summary discussion of other information in the record that should be considered in the development of flow criteria, consistent with the charge of SB1 that "the flow criteria include the volume, quality, and timing of water necessary for the Delta ecosystem. " Based on review of the information in the record this charge is expanded to include specific consideration of:

- Variability, flow paths, and the hydrograph
- Floodplain activation and other habitat improvements
- Water quality and contaminants
- Cold water pool management
- Adaptive management

4.3.1 Variability, Flow Paths, and the Hydrograph

The first of the five key points submitted by the DEFG of experts stated, in part: "There is no one correct flow number. Seasonal, interannual, and spatial variability, to which our native species are adapted, are as important as quantity." Species and biological systems respond to combinations of quantity, timing, duration, frequency and how these inputs vary spatially. (DEFG 1.) Based on their review of the literature in *Habitat Variability and Complexity in the Upper San Francisco Estuary*, Moyle *et al* (2010) find:

> "… unmodified estuaries are highly variable and complex systems, renowned for their high production of fish and other organisms (McClusky and Elliott 2004). The San Francisco Estuary, however, is one of the most highly modified and controlled estuaries in the world (Nichols et al. 1986). As a consequence, the

> estuarine ecosystem has lost much of its former variability and complexity and has recently suffered major declines of many of its fish resources (Sommer et al. 2007).
>
> …the concept of the "natural flow regime" (Poff et al. 1997) is increasingly regarded as an important strategy for establishing flow regimes to benefit native species in regulated rivers (Postel and Richter 2003; Poff et al. 2007; Moyle and Mount 2007). For estuaries worldwide, the degree of environmental variability is regarded as fundamental in regulating biotic assemblages (McLusky and Elliott 2004). Many studies have shown that estuarine biotic assemblages are generally regulated by a combination of somewhat predictable changes (e.g., tidal cycles, seasonal freshwater inflows) and stochastic factors, such as recruitment variability and large-scale episodes of flood or drought (e.g., Thiel and Potter 2001). The persistence and resilience of estuarine assemblages is further decreased by various human alterations, ranging from diking of wetlands, to regulation of inflows, to invasions of alien species (McLusky and Elliott 2004, Peterson 2003).
>
> …a key to returning the estuary to a state that supports more of the desirable organisms (e.g., Chinook salmon, striped bass, delta smelt) is increasing variability in physical habitat, tidal and riverine flows, and water chemistry, especially salinity, over multiple scales of time and space. It is also important that the stationary physical habitat be associated with the right physical-chemical conditions in the water at times when the fish can use the habitat most effectively (Peterson 2003)."

An example of a major change in the natural flow regime of the Delta is demonstrated by the increase in net OMR reverse flows just north of the SWP and CVP pumping facilities. Reverse flows are now a regular occurrence in the Delta channels because Sacramento River water enters on the northern side of the Delta while the two major pumping facilities, the SWP and CVP, are located in the south. This results in a net water movement across the Delta in a north-south direction along a web of channels including OMR instead of the more natural pattern from east to west or from land to sea. Positive net flows, connected flow paths, and salinity gradients are important features of an estuary. Natural net channel flows move water and some biota toward Suisun Bay and maintain downstream directed salinity gradients. Today, Delta gates and diversions can substantially redirect tidal flows creating net flow patterns and salinity and turbidity distributions that did not occur historically. These changes may influence migratory cues for some fishes. These cues are further scrambled by a reverse salinity gradient in the south Delta caused by higher salinity in agricultural runoff. (DEFG 1.)

Per the DEFG's paper, *Habitat Variability and Complexity in the Upper San Francisco Estuary* (Moyle et al., 2010), a more variable Delta has multiple benefits:

> "Achieving a variable, more complex estuary requires establishing seaward gradients in salinity and other water quality variables, diverse habitats throughout the estuary, more floodplain habitat along inflowing rivers, and improved water quality. These goals in turn encourage policies which: (1) establish internal Delta flows that create a tidally-mixed, upstream-downstream gradient (without cross-Delta flows) in water quality; (2) create slough networks with more natural channel

> geometry and less diked rip-rapped channel habitat; (3) improve flows from the Sacramento and San Joaquin rivers; (4) increase tidal marsh habitat, including shallow (1-2 m) subtidal areas, in both fresh and brackish zones of the estuary; (5) create/allow large expanses of low salinity (1-4 ppt) open water habitat in the Delta; (6) create a hydrodynamic regime where salinities in parts of the Delta and Suisun Bay and Marsh range from near-fresh to 8-10 ppt periodically (does not have to be annual) to discourage alien species and favor desirable species; (7) take species-specific actions that reduce abundance of non-native species and increase abundance of desirable species; (8) establish abundant annual floodplain habitat, with additional large areas that flood in less frequent wet years; (9) reduce inflow of agricultural and urban pollutants; and (10) improve the temperature regime in large areas of the estuary so temperatures rarely exceed 20°C during summer and fall months."

Similarly, reliance upon water year classification as a trigger for flow volumes has contributed to reduced flow variability in the estuary. The information received during this proceeding supports the notion that reliance upon water year classification as a trigger for flow volumes is an imperfect means of varying flows. Any individual month or season might have a dramatically different hydrology than the overall hydrology for the year. A critically dry year, for example, can have one or two very wet months, just as a wet year may have several disproportionately dry months. Figure 10 demonstrates how this actually occurs. Unimpaired Delta outflow for the month of June from 1922 through 2003 has historically been highly variable. Many June months that occur in years classified as wet have had much lower flows than June flows in years classified as below normal. The opposite is also true; several June flows in years classified as critically dry are higher than some years classified as above normal. Depending on the direction of this divergence of monthly flows (higher or lower) relative to the water year, reliance upon water year classification can provide less than optimal protection of the ecosystem or more than needed water supply impacts. The figure also shows the actual June flows for various periods of years, demonstrating how much lower actual flows have been than unimpaired flows. The primary reason for the lower historical flows is consumption of water in the watershed. The three periods shown, however, are not directly comparable to the unimpaired flow record because the shorter time frame may have been wetter or drier than the full historical record.

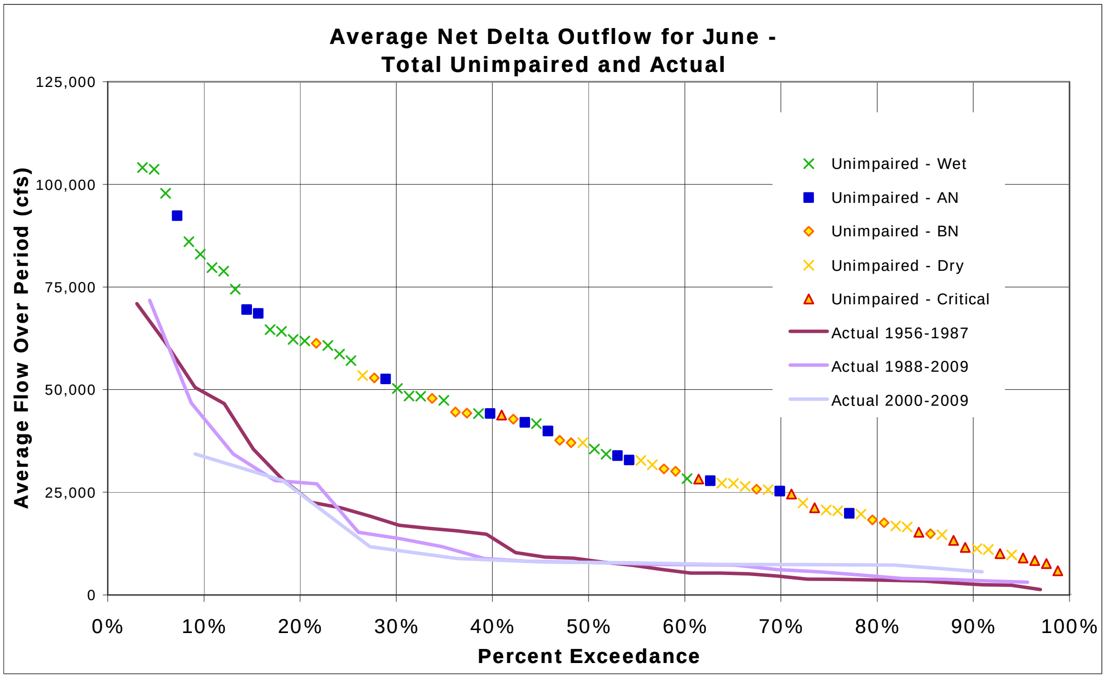


Figure 10. Actual and Unimpaired June Delta Outflow

Proportionality is one of the key attributes of restoring ecosystem functions by mimicking the natural hydrograph in tributaries to the Delta and providing for connectivity. Currently, inflows to the Delta are largely controlled by upstream water withdrawals and releases for water supply, power production, and flood control. As a result, inflows from tributaries frequently do not contribute flow to the Delta in the same proportions as they would have naturally, and to which native fish adapted. There is consensus in contemporary science that improving ecosystem function in the watershed, mainstem rivers, and the Delta is a means to improving productivity of migratory species. (e.g.,Williams 2005; NRC 1996, 2004a, 2004b as cited in NAS 2010, p. 42.) NAS found that, "Watershed actions would be pointless if mainstem passage conditions connecting the tributaries to, and through, the Delta were not made satisfactory." (NAS 2010, p. 42.) "Propst and Gido (2004) support this hypothesis and suggest that manipulating spring discharge to mimic a natural flow regime enhances native fish recruitment (Propst and Gido, 2004 and Marchetti and Moyle, 2001)." (DOI, 1 p. 25.) Specifically, providing pulse flows to mimic the natural hydrograph could diversify ocean entry size and timing for anadromous fishes so that in many years at least some portion of the fish arrive in saltwater during periods favoring rapid growth and survival. (DOI 1, p. 30.) Food production may also be improved by maintaining the attributes of a natural hydrograph (EFG 1, p. 8.) Connectivity between natal streams and the Delta is critical for anadromous species that require sufficient flows to emigrate out of natal streams to the Delta and ocean, and sufficient flows upon returning, including flows necessary to achieve homing fidelity. Specifically, it is necessary for the scent of the river to enter the Bay in order for adult salmonids to find their way back to their natal river. (NMFS 2009, p.407 as cited in EDF 1, p. 48.) Further, insuring adequate flows from all of the tributaries that support native fish is important to maintain genetic diversity and species resilience in the face of catastrophic events.

4.3.2 Floodplain Activation and Other Habitat Improvements

Most floodplains in the Central Valley have been isolated from their rivers by levees. Due to the effects of levees and dams, side channel and floodplain inundating flows have been substantially reduced. At present, besides the Yolo Bypass, the only other Delta region with substantial connectivity to portions of the historical floodplain is the Cosumnes River, a small undammed watershed. (Sommer et al. 2001b.) Floodplains are capable of providing substantial benefits to numerous aquatic, terrestrial, and wetland species. (Sommer et al. 2001b.) Inundation of floodplains facilitates an exchange of organisms, nutrients, sediment, and organic material between the river and floodplain, and provides a medium in which biogeochemical processes and biotic activity (e.g., phytoplankton blooms, zooplankton and invertebrate growth and reproduction) can occur. (AR/NHI 1, p. 22.) This exchange of material can benefit downstream areas. For example, studies suggest phytoplankton, zooplankton, and other organic material transported from the Yolo Bypass enhances the food web of the San Francisco Estuary. (Jassby and Cloern 2000; Mueller-Solger et al. 2002; Sommer et al. 2004.)

Many fishes rear opportunistically on floodplains. (Moyle et al. 2007, as cited in Moyle et al. 2010), and juvenile salmon grow faster and become larger on floodplains than in the main-stem river channels. (Sommer et al. 2001a; Jeffres et al. 2008; DOI 1, p. 27; AR/NHI 1, p. 24.) Splittail require floodplains for spawning (Moyle et al. 2007), with large-scale juvenile recruitment occurring only in years with significant protracted (greater than or equal to 30 days) floodplain inundation, particularly in the Sutter and Yolo bypasses. (Meng and Moyle 1995, Sommer et al. 1997, Feyrer et al. 2006a.) Managing the frequency and duration of floodplain inundation during the winter and spring, followed by complete drainage by the end of the flooding season, could favor splittail and other native fish over non-natives. (Moyle et al. 2007, Grimaldo et al. 2004.) In addition, modeling conducted by Moyle et al. (2004) shows that while splittail are resilient, managing floodplains to promote frequent successful spawning is needed to keep them abundant. Improving management of the Yolo Bypass for fish, increasing floodplain areas along other rivers (e.g., Cosumnes and Mokelumne rivers), and developing floodplain habitat along the lower San Joaquin River, including a bypass in the Delta, represent opportunities to increase the frequency and extent of floodplain inundation. (Moyle et al. 2010.) The BDCP is currently evaluating structural modifications to the Fremont Weir (e.g., notch weir and install operable “inundation gates”), as a means of increasing the interannual frequency and duration of floodplain inundation in the Yolo Bypass. (BDCP 2009.)

The NMFS Opinion stipulates that USBR and DWR, in cooperation with DFG, USFWS, NMFS, and USACE, shall, to the maximum extent of their authorities (excluding condemnation authority), provide significantly increased acreage of seasonal floodplain rearing habitat, with biologically appropriate durations and magnitudes, from December through April, in the lower Sacramento River basin, on a return rate of approximately one to three years, depending on water year type. (NMFS 3, p. 608.) Per this NMFS Opinion, USBR and DWR are to submit a plan to implement this action to NMFS by December 31, 2011. (Id.) This plan is to include an evaluation of options to, among other things, increase inundation of publicly and privately owned suitable acreage within the Yolo Bypass, and modify operations of the Sacramento Weir or Fremont Weir to increase rearing habitat. (Id.)

Moyle et al. (2010) discuss the value of creating more slough networks with natural geometry and less diked, rip-rapped channel habitat, the value of tidal marsh habitat, and low salinity, open water habitat in the Delta:

> "Re-establishing the historical extensive dendritic sloughs and marshes is essential for re-establishing diverse habitats and gradients in salinity, depth and other environmental characteristics important to desirable fish and other organisms (e.g., Brown and May 2008). These shallow drainages are likely to increase overall estuarine productivity if they are near extensive areas of open water, because they can deliver nutrients and organic matter to the more open areas. Dendritic slough networks will develop naturally in Suisun Marsh after large areas become inundated following dike failures and they can be recreated fairly readily in the Cache Slough region by reconnecting existing networks. In the Delta, the present simplified habitat in the channels between islands needs to be made more suitable as habitat for desirable species. Many levees are maintained in a nearly vegetation-free state, providing little opportunity for complex habitat (e.g., marshes and fallen trees) to develop. Much of the low-value channel habitat in the western and central Delta will disappear as islands flood, but remaining levees in submerged areas should be managed to increase habitat complexity (e.g., through planting vegetation), especially in the cooler northern and eastern parts of the Delta.
>
> [Subtidal] habitat has been greatly depleted because marshes in the Delta and throughout the estuary have been diked and drained, mostly for farming and hunting (Figure 3). Unfortunately, most such habitat in shallow water today is dominated by alien fishes, including highly abundant species such as Mississippi silverside which are competitors with and predators on native fishes (Moyle and Bennett 1996; Brown 2003). Such habitat could become more favorable for native fishes with increased variability in water quality, especially salinity. In particular, increasing the amount of tidal and subtidal habitat in Suisun Marsh should favor native fishes, given the natural variability in salinity and temperature that occurs there. The few areas of the marsh with natural tidal channels tend to support the highest diversity of native fishes, as well as more striped bass (Matern et al. 2002; Moyle, unpublished data). With sea level rise, many diked areas of Suisun Marsh currently managed for waterfowl (mainly dabbling ducks and geese) will return to tidal marsh and will likely favor native fishes such as splittail and tule perch (Hysterocarpus traski), as well as (perhaps) migratory fishes such as juvenile Chinook salmon. Experimental (planned) conversions of some of these areas would be desirable for learning how to manage these inevitable changes to optimize habitat for desired fishes.
>
> Open water habitat is most likely to be created by the flooding of subsided islands in the Delta, as well as diked marshland 'islands' in Suisun Marsh (Lund et al. 2007, 2010; Moyle 2008). The depth and hydrodynamics of many of these islands when flooded should prevent establishment of alien aquatic plants while variable salinities in the western Delta should prevent establishment of dense populations of alien clams (Lund et al. 2007).

> Although it is hard to predict the exact nature of these habitats, they are most likely to be better habitat for pelagic fishes than the rock-lined, steep-sided and often submerged vegetation-choked channels that run between islands today (Nobriga et al. 2005). Experiments with controlled flooding of islands should provide information to help to ensure that these changes will favor desired species. Controlled flooding also has the potential to allow for better management of hydrodynamics and other characteristics of flooded islands (through breach location and size) than would be possible with unplanned flooding."

4.3.3 Water Quality and Contaminants

Toxic effects are one of three general factors identified by scientists with the IEP in 2005 as contributing to the decline in pelagic productivity. The life history requirements and water quality sections above identify specific species sensitivities to water quality issues.

Though the information received in this proceeding supports the recommendation that modification to flow through the Delta is a necessary first step in improving the health of the ecosystem, it also supports the recommendation that flow alone is insufficient. The Delta and San Francisco Bay are listed under section 303(d) of the Federal Clean Water Act as impaired for a variety of toxic contaminants that may contribute to reduced population abundance of important fish and invertebrates. The contaminants include organophosphate and pyrethrin pesticides, mercury, selenium and unknown toxicity. In addition, low DO levels periodically develop in the San Joaquin River at the DWSC and in OMR. The low oxygen levels in the DWSC inhibit the upstream migration of adult fall-run Chinook salmon and adversely impact other resident aquatic organisms.

There is concern that a number of non-303(d) listed contaminants, such as ammonia, pharmaceuticals, endocrine disrupting compounds, and blue-green algal blooms could also limit biological productivity and impair beneficial uses. Sources of these contaminants include agricultural, municipal and industrial wastewater, urban storm water discharges, discharges from wetlands, and channel dredging activities. More work is needed to determine their impact on the aquatic community.

Ammonia has emerged as a contaminant of special concern in the Delta. Recent hypotheses are that ammonia is causing toxicity to delta smelt, other local fish, and zooplankton and is reducing primary production rates in the Sacramento River below the SRWTP and in Suisun Bay. A newer hypothesis is that ammonia and nitrogen to phosphorus ratios have altered phytoplankton species composition and these changes have had a detrimental effect on zooplankton and fish population abundance. (Glibert 2010.) More experiments are needed to evaluate the effect of nutrients, including ammonia, on primary production and species composition in the Sacramento River and Delta.

4.3.4 Cold Water Pool Management

As mentioned in the specific flow criteria, the criteria contained in this report should be tempered by the additional need to maintain cold water resources in reservoirs on tributaries to the Delta until improved passage and other measures are taken that would reduce the need for maintaining cold water reserves in reservoirs. As discussed in the Chinook salmon section, salmon have specific temperature tolerances during various portions of their life-cycle. Historically salmonids were able to take advantage of cooler upstream temperatures for parts of their life-cycle to avoid adverse temperature effects. Since construction of the various dams in the Central Valley, access to much of the cooler historic spawning and rearing habitat has been blocked. To mitigate for these impacts, reservoirs must be managed to preserve cold water resources for release during salmonid spawning and rearing periods. As reservoir levels drop, availability of cold water resources also diminishes. Accordingly, it may not be possible to attain all of the identified flow criteria in all years and meet the thermal needs of the various runs of Chinook salmon and other sensitive species. Thorough temperature and water supply modeling analyses should be conducted to adaptively manage any application of these flow criteria to suit real world conditions and to best manage the competing demands for water needed for the protection of public trust resources, especially in the face of future climate change.

Specifically, these criteria should not be construed as contradicting existing and future cold water management requirements that may be needed for the protection of public trust resources, including those for the Sacramento River needed to protect the only remaining population of winter-run Chinook salmon. (see NMFS 3, p. 590-603.)

4.3.5 Adaptive Management

Any environmental flow prescription for native species in the Delta will be imperfect. The problem is too complex, uncertainties are too large, and the situation in the Delta is changing too rapidly in too many ways for any single flow prescription to be correct, or correct for long. (Fleenor et al. 2010.) Some degree of certainty regarding future conditions in the Delta is needed before long term flow criteria can be developed. Since it is unlikely that certainty will be achieved before actions or responses are required by geologic, biological, and legal processes, it might be valuable to provide substantial financial and water reserve resources, along with responsible institutional wherewithal to respond to changes and undertake necessary experiments for more successfully transitioning into the largely unexplored new Delta. (Fleenor et al. 2010.) This confounding need for certainty of operations and water supply at the same time there is uncertainty underlying ecosystem needs, provides good rationale to rely upon adaptive management to address this uncertainty.

The Delta is continually changing. Flow criteria developed for the present Delta ecosystem will become less reflective of ecosystem needs with the passage of time. Accordingly, it is important that flow criteria be adaptive to future changes. Flows, habitat restoration, and measures to address other stressors should be managed adaptively. (AR/NHI Closing Comments.)

Adaptive management is “an iterative process, based on a scientific paradigm that treats management actions as experiments subject to modification, rather than as fixed and final rulings, and uses them to develop an enhanced scientific understanding about whether or not and how the ecosystem responds to specific management actions.” (NRC 1999 as cited in DOI Ex.1.) This notion of treating actions as experiments is key, because information received in this proceeding indicates that the mechanisms underlying the relationship between flows and the health of the Delta ecosystem are, at times, unclear. Adaptive management is the most suitable approach for managing with uncertainty. (DEFG 1.)

Murray and Marmorek (2004) describe an adaptive management approach as:

- exploring alternative ways to meet management objectives
- predicting the outcomes of alternatives based on the current state of knowledge
- implementing one or more of these alternatives
- monitoring to learn about the impacts of management actions
- using the results to update knowledge and adjust management actions

An adaptive approach provides a framework for making good decisions in the face of critical uncertainties, and a formal process for reducing uncertainties so that management performance can be improved over time. (Williams et al. 2007.)

Adaptive management does not postpone action until "enough" is known but acknowledges that time and resources are too short to defer *some* action, particularly actions to address urgent problems. (Lee 1999.) Adaptive management provides a means of informing planning and management decisions in spite of uncertainty. Key point number 5 of the DEFG states: “a strong science program and a flexible management regime are essential to improving flow criteria. (DEFG 1.)

Adaptive management can be used to manage uncertainty in two ways, over two time frames. Over the short-term, adaptive management could allow for a specific response to real time conditions so long as the response is otherwise consistent with the constraints of some overarching regulatory framework. Over the longer term, adaptive management could allow for the more nimble modification of regulatory constraints, so long as these modifications fell within the clearly defined parameters of the overarching regulatory framework.

<u>Short-term Adaptive Management</u>
Per the DEFG’s assessment regarding the role of uncertainty…

> “…despite [our] extensive scientific understanding substantial knowledge gaps remain about the ecosystem's likely response to flows. First, ecosystem processes in a turbid estuary are mostly invisible, and can be inferred only through sampling. Second, monitoring programs only scratch the surface of ecosystem function by estimating numbers of fish and other organisms, whereas the system’s dynamics depend on birth, growth, movement, and death rates which can rarely be monitored. Third, this system is highly variable in space (vertical, cross-channel, along-channel, and larger-scale), time (tidal, seasonal, and interannual), flow, salinity, temperature, physical habitat type, and species composition. Each of the hundreds of species has a different role in the system, and these differences can be subtle but important. As a result, we have little ability to predict how the ecosystem will respond to the numerous anticipated deliberate and uncontrolled changes.” (DEFG 1.)

Flexible management can be designed into a regulatory framework so that any requirements rely upon real time information and real time decisions to guide specific real-time action. A current example of this is the Delta Smelt Working Group that provides information and analyses used to guide real time operation of export facilities so that these facilities can be operated in a manner that conforms with the current NMFS and USFWS opinions. Any such flexible management will need to consider the processes and governance structures required to make sound scienfically-based real-time decisions. The Delta Smelt Working Group is a good example of how scientific assessment of real-time data, including the presence of fish, can better inform the real-time operation of export facilities.

<u>Long-term Adaptive Management</u>
Over the longer term, adaptive management can be used to more nimbly modify regulatory constraints so that fishery and water resource agencies are not locked into prescriptive constraints well past the time that current scientific understanding can support. This longer term adaptive management has bearing on a number of the flow criteria being considered in this report because many of these criteria lack sufficiently robust information to support a specific numeric criterion. Although the functional basis for a beneficial flow may be understood, the basis for a specific numeric criteria may not. Some regulatory flows may therefore need to take the form of an informed experimental manipulation. Such flows would need to be implemented… “as if they were experiments, with explicit conceptual and simulation models, predicting outcomes, and feedback loops so that the course of management and investigation can change as the system develops and knowledge is gained. A talented group of people tasked to integrate, synthesize, and recommend actions based on the data being gathered are essential for making such a system work. Failure to implement an effective adaptive management program will likely lead to a continued failure to learn from the actions, and a lack of responsiveness to changing conditions and increased understanding.” (DEFG 1.)

The Delta Science Program, IEP, and other institutions could be relied upon to evaluate experimental flows and make recommendations to be considered for modifications of such flows.

4.4 Expression of Criteria as a Percentage of Unimpaired Flow

In some cases, participants’ recommendations were expressed as specific flows in specific months, to be applied during specific water year types or with specified probabilities of exceedance. Review of unimpaired hydrology shows there is great variability in the quantity of unimpaired flow during these specified months when categorized by water year type. Reliance upon monthly or seasonal flow prescriptions based on water year type would therefore result in widely ranging relative amounts of unimpaired flow depending upon the specific hydrology of the month or season. Also, the rather coarse division of the hydrograph into five water year types can lead to abrupt step-wise changes in flow requirements. In an attempt to more closely reflect the variation of the natural hydrograph, the State Water Board recommends that, when possible, the flow criteria be expressed as a percentage of unimpaired flow.

To develop criteria in this way, the unimpaired flow rate for a specified time period (e.g. average monthly flow over a range of months) was plotted on an exceedance probability graph (using the Weibull plotting position formula) along with the flow recommendations and desired return frequencies. The unimpaired flow rates were also plotted such that the associated water year type can be identified and their percent exceedance estimated. A percentage of unimpaired flow was selected by trial and error so that the desired flow rate and exceedance frequency was achieved. A separate exceedance plot was produced for each time period being evaluated.

The unimpaired flow estimates used in the development of these flow criteria are based on those developed in the DWR May 2007 document: *"California Central Valley Unimpaired Flow Data" Fourth Edition Draft.* (DWR 2007.) This report contains estimates of the monthly flow for 24 sub-basins in the Central Valley. Each sub-basin uses a separate calculation dependant on conditions specific to that sub-basin, available gauge data, and relationships to other sub-basins. In many cases the methods change over the period of record to incorporate changes to infrastructure within the sub-basins that need to be accounted for. Estimates are provided for 83 water years from 1922 through 2003. A water year begins in October of the previous calendar year through September of the named water year. The following describes the unimpaired flow estimates that are the basis for flow criteria for the Sacramento River at Rio Vista, the San Joaquin River at Vernalis, and Net Delta Outflow.

Sacramento Valley Unimpaired Total Outflow

Estimates of the unimpaired Sacramento Valley outflow were computed as the sum of estimates from 11 sub-basins in the watershed and are understood to represent the flow that would occur on the Sacramento River at approximately Freeport. These 11 sub-basins include the Sacramento Valley Floor, Putah Creek near Winters, Cache Creek above Rumsey, Stony Creek at Black Butte, Sacramento Valley West Side Minor Streams, Sacramento River near Red Bluff, Sacramento Valley East Side Minor Streams, Feather River near Oroville, Yuba River at Smartville, Bear River near Wheatland, and the American River at Fair Oaks.

The unimpaired Sacramento Valley outflow from DWR 2007 is used as the basis for flow criteria on the Sacramento River at Rio Vista, even though it is understood they are more representative of unimpaired flows expected at Freeport. This is a necessary simplification as such estimates do not exist at Rio Vista, but should be adequate for the purpose of these criteria. If future flow requirements are to be established at Rio Vista based on a percentage of unimpaired flow, it is recommended that new estimates of unimpaired flow be developed specific for this location.

San Joaquin Valley Unimpaired Total Outflow

Estimates of the unimpaired San Joaquin Valley outflow were computed as the sum of estimates from nine sub-basins in the watershed and are understood to represent the flow that would occur on the San Joaquin River at Vernalis. These nine sub-basins include the Stanislaus River at Melones Reservoir, San Joaquin Valley Floor, Tuolumne River at Don Pedro Reservoir, Merced River at Exchequer Reservoir, Chowchilla River at Buchanan Reservoir, Fresno River near Daulton, San Joaquin River at Millerton Reservoir, Tulare Lake Basin Outflow, San Joaquin Valley West Side Minor Streams.

Delta Unimpaired Total Outflow

Estimates of unimpaired Net Delta Outflow in DWR 2007 were computed generally as Delta Unimpaired Total Inflow minus unimpaired net use in the Delta, including both lowlands and uplands. Delta Unimpaired Total Inflows was calculated as the sum of the Sacramento Valley and San Joaquin Valley Unimpaired Total Outflows as described above and the East Side Streams Unimpaired Total Outflow. The later consists of four sub-basins including San Joaquin Valley East Side Minor Streams, Cosumnes River at Michigan Bar, Mokelumne River at Pardee Reservoir, and Calaveras River at Jenny Lind. Generally the unimpaired net use in the Delta is an estimate of the consumptive use from riparian and native vegetation (replacing historical irrigated agriculture and urban areas), plus evaporation from water surfaces, minus precipitation, and assumes that existing Delta levees and island remain intact. Unimpaired flow graphs in this report use the unimpaired flow record from 1922 to 2003.

5. Flow Criteria

Two types of criteria are provided in this report: numeric flow criteria, and other, non-numeric, measures that should be considered to complement the numeric criteria. Numeric criteria are subdivided into two categories: category “A” criteria have more and better scientific information, with less uncertainty, to support specific numeric criteria than do Category “B” criteria. Summary numeric criteria are provided for Delta outflow, as well as Sacramento River and San Joaquin River inflows, and Hydrodynamics (Old and Middle River, Inflow-Export Ratios, and Jersey Point flows) in Tables 19 through 22.

In addition to new criteria for Delta outflows, inflows, and hydrodynamics, some of the objectives for the protection of fish and wildlife from the 2006 Bay-Delta Plan are advanced as criteria in this report. While the State Water Board did not specifically reevaluate the methodology and basis for the Bay-Delta Plan objectives, the State Water Board recognizes that these flows provide some level of existing protection for fish and wildlife and, in the absence of more specific information, merit inclusion in these criteria. At the time the Bay-Delta Plan objectives were adopted, they were supported by substantial evidence, including scientific information. While the purpose of this report is to develop flow criteria using best available scientific information, water quality objectives are established taking into account scientific and other factors pursuant to Water Code section 1241.

5.1 Delta Outflows

Following are Delta outflow criteria based on analysis of the species-specific flow criteria and other measures:

1) Net Delta Outflow: 75% of 14-day average unimpaired flow for January through June
2) Fall X2 for September through November
    - Wet years X2 less than 74 km (greater than approximately 12,400 cfs)
    - Above normal years X2 less than 81 km (greater than approximately 7,000 cfs)
3) 2006 Bay-Delta Plan Delta Outflow Objectives for July through December

Delta outflow criteria 1 is a Category A criterion because it is supported by more robust scientific information. Delta outflow criteria 2 and 3 are Category B criteria because there is less scientific information to support specific numeric criteria, but there is enough information to support the conceptual need for flows. Category A and B criteria are both equally important for protection of the public trust resource, but there is more uncertainty about the appropriate volume of flow required to implement Category B criteria. Following is discussion and rationale for these criteria.

The narrative objective of the flow criteria is to halt the population decline and increase populations of native species as well as species of commercial and recreational importance. The need to estimate the magnitude, duration, timing, and quality of Delta outflows necessary to support viable populations of these species is inherent to this objective. McElhany et al. (2000) proposed that four parameters are critical for evaluating population viability: abundance, population growth rate, population spatial structure, and diversity. Delta outflow may affect one, all, or some combination of these parameters for a number of resident and anadromous species. A species-specific analysis of flow needs for a suite of upper estuary species is included in section 4.2.4.

An analysis of generation to generation population abundance versus Delta outflows indicates that the “likelihood” of an increase in the longfin smelt FMWT abundance index in 50% of years corresponded with flow volumes of approximately 9.1 MAF (51,000 cfs) and 6.3 MAF (35,000 cfs) during January through March and March through May, respectively. (TBI/NRDC 2, pp. 17-19.) The provision of sufficient flows to achieve these flow volumes during January through March and March through May in approximately 45% and 47% of years, respectively, is intended to promote increased abundance and improved productivity for longfin smelt and other desirable estuarine species. Based on a comparison of the flows needs identified in section 4.2.4, it appears that winter-spring outflows designed to be protective of longfin smelt would benefit the other upper estuary species evaluated. The DFG recommended that spring outflows extend through June to fully protect a number of estuarine species. (DFG 1, pp. 2-5.) During June, sufficient outflow should be provided to maintain X2 in Suisun Bay (between 75 km and 64 km). (DFG closing comments, p. 7; DFG 2, p. 6.)

The State Water Board recognizes that the target flow volumes of 9.1 MAF (Jan-Mar, 51,000 cfs) and 6.3 MAF (Mar-May, 35,000 cfs) in greater than or equal to approximately 45% and 47% of years, respectively, and the positioning of X2 in Suisun Bay during the month of June are necessary in order to promote increased abundance and improved productivity for longfin smelt and other desirable estuarine species. An approach based on a percentage of unimpaired flows is intended as a means of distributing flows to meet the above-mentioned criteria in a manner that more closely resembles the natural hydrograph. Such an approach also recognizes the importance of preserving the general attributes of the flow regimes to which the native estuarine species are adapted.

Analyses of historic conditions (1921 to 2003), indicates that at 75% of unimpaired flows, average flows of 51,000 cfs occurred between January and March in approximately 35% of years, while average flows of 35,000 cfs happened between March and May in 70% of years. At 75% of unimpaired flow, X2 would be maintained west of Chipps Island more than 90% of the time between January and June (analyses not shown). Rather than advance multiple static flow criteria for the January through March, March through May, and June time periods, the State Water Board determines, as a Category A criterion, that 75% of 14-day average unimpaired flow is needed during the January through June time period to promote increased abundance and improved productivity for longfin smelt and other desirable estuarine species. It is important to note that this criterion is not a precise number; rather it reflects the general timing and magnitude of flows needed to protect public trust resources in the Delta ecosystem. However, this criterion could serve as the basis from which future analysis and adaptive management could proceed.

Given the extensive modifications to the system there may be a need to diverge from the natural hydrograph at certain times of the year to provide more flow than might have actually occurred to compensate for such changes. Fall outflow criteria, intended to improve conditions for Delta smelt by enhancing the quantity and quality of habitat in wet and above normal water years, represent such an instance. As a Category B criterion, the State Water Board determines that sufficient outflow is needed from September through November of wet and above normal water year types to position X2 at less than or equal to 74 km and 81 km, respectively (Fall X2 action). In addition, the Delta Outflow Objectives contained within the Bay-Delta Plan for July through December are advanced as a Category B criterion. The State Water Board does not recommend increasing fall flows beyond those stipulated in the Bay-Delta Plan and Fall X2 action at this time. The quantity and timing of fall outflows necessary to protect public trust resources warrants further evaluation.

Category A: Winter – Spring Net Delta Outflows

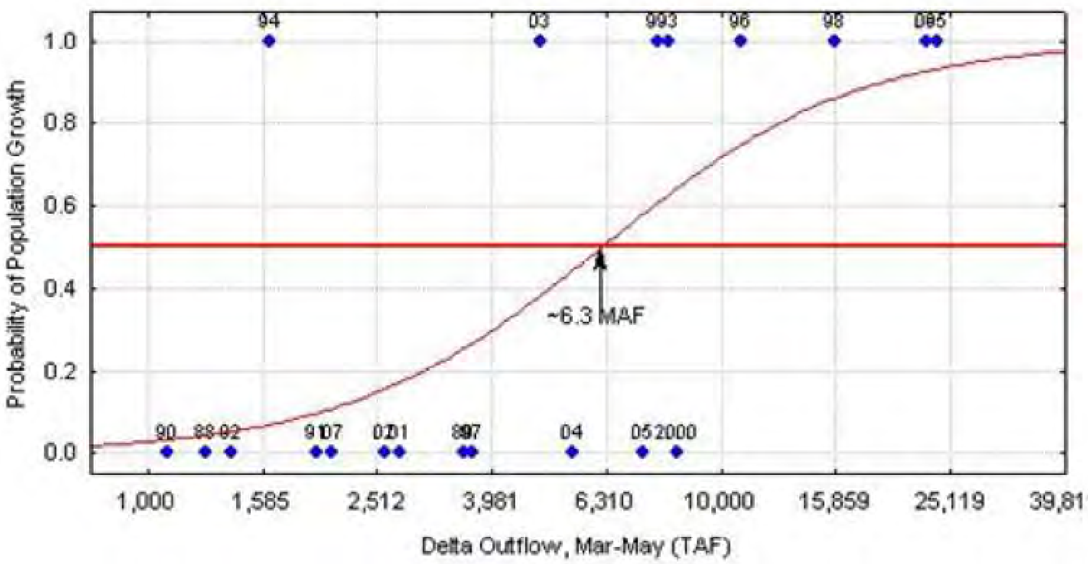
The flow regime is important in determining physical habitat in aquatic ecosystems, which is in turn a major factor in determining biotic composition. (DEFG 1.) Bunn and Arthington (2002) highlight four principles by which the natural flow regime influences aquatic biodiversity: 1) developing channel form, habitat complexity, and patch disturbance, 2) influencing life-history patterns such as fish spawning, recruitment, and migration, 3) maintaining floodplain and longitudinal connectivity, and 4) discouraging non-native species. Altering flow regimes affects aquatic biodiversity and the structure and function of aquatic ecosystems. The risk of ecological change increases with greater flow regime alteration. (Poff and Zimmerman 2010.)

A suite of native, and recreationally or commercially important species were evaluated in an effort to assess the timing, volume, and quality of water necessary to protect public trust resources. Flow criteria were developed for each of the species identified by DFG as those that are priority concern and will benefit the most as a result of improved flow conditions. (DFG closing comments, p. 3.) For Delta outflow, this included longfin smelt, delta smelt, starry flounder, American shad, bay shrimp (*Crangon* sp.), mysid shrimp, and *Eurytemora affinis*. Through this process, data or information pertaining to life history attributes (e.g., timing of migration, spawning, rearing), relationships of species abundance or habitat to Delta outflow, season or time period when flow characteristics are most important, factors influencing and/or limiting populations, and other characteristics were assessed and summarized in the individual species write-ups.

Statistically significant relationships between annual abundance and X2 (or outflow) have been demonstrated for a diverse assemblage of species within the estuary. (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002a; Rosenfield and Baxter 2007; Kimmerer *et al*. 2009.) The causal mechanisms underlying the variation in annual abundance indices of pelagic species in the estuary are poorly understood, but likely vary across species and life stages.

Longfin smelt have the strongest X2-abundance relationship of those species for which such a relationship has been demonstrated. (Kimmerer et al. 2009.) Abundance indices for this species are inversely related to X2 during its winter-spring spawning and early rearing periods. (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002a; Rosenfield and Baxter 2007; Kimmerer et al. 2009.) However, a four-fold decline in the relationship, with no significant change in slope, occurred after 1987, coincident with the introduction and spread of the introduced clam *Corbula amurensis.* (Kimmerer 2002a.) Reduced prey availability due to clam grazing has been identified as a likely mechanism for the decline in the X2-abundance relationship. (Kimmerer 2002a.)

One of the key biological goals of the informational proceeding was to identify the flows needed to increase abundance of native and other desirable species. Logit regression (StatSoft 2010, as cited in TBI/NRDC 2, p.17) was used to address the question: What outflow corresponded to positive longfin smelt population growth 50% of the time in the past? Logit regression is used to find a regression solution when the response variable is binary. For the purpose of this analysis, the generation-over-generation changes in abundance indices were converted to a binary variable (increase = 1 or decrease = 0). The analysis was conducted using FMWT abundance indices for the period extending from 1988 to 2007 (post-*Corbula*). Two periods of the winter-spring seasons (January to March and March to May) were evaluated, as different life stages of longfin smelt are present in the Delta during those periods (spawning adults and larvae/juveniles, respectively) and the mechanisms underlying the flow-abundance relationship may occur and/or vary in some or all of the months during these periods. (TBI/NRDC 2, p. 13.) The results were statistically significant ($p < 0.015$) and revealed that the "likelihood" of an increase in FMWT abundance index in 50% of years corresponded with flows of approximately 9.1 MAF and 6.3 MAF during January through March and March through May, respectively. (Figure 11, TBI/NRDC 2, pp. 17-19.)



Logit regression showing relationship between March through May Delta outflow and generation-over-generation change in abundance of longfin smelt (measured as the difference between annual FMWT abundance indices). Positive changes in the abundance index were scored at "1" and declines were scored as "0". Arrow indicates flows above which growth occurred in more than 50% of years. Point labels indicate year of the FMWT index. (Source: TBI 2, Figure 15.)

Figure 11. Logit Regression Showing Relationship Between March through May Delta Outflow and Generation-Over-Generation Change in Longfin Smelt Abundance

A similar analysis was conducted for bay shrimp (*Crangon* sp.), a species whose flow-abundance relationship did not experience a "step decline" following the invasion of *Corbula.* (Kimmerer 2002a.) Results of the logit analysis indicate that abundance indices for this species increased in about 50% of years when flows during March through May were approximately 5 MAF. (TBI/NRDC 1, p. 17.) Therefore, flows associated with positive changes in the longfin smelt abundance index are anticipated to improve the likelihood of increases in bay shrimp abundance as well.

An analysis of historical longfin smelt flow-abundance relationships that corresponded to recovery targets in the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (USFWS 1996) was also conducted. During the periods of January through March and March through May, cumulative Delta outflows of greater than 9.5 MAF and greater than 6.3 MAF, respectively, historically corresponded to abundance indices equal to or exceeding the recovery targets. (TBI/NRDC 2, p. 14.) These results are based on the intersection of the 1967 to1987 flow-abundance relationship and the recovery target. Use of the 1988 to 2007 flow-abundance relationship predicts lower abundance indices per any given flow, as compared to the historical relationship. Use of the pre-*Corbula* flow-abundance relationship underscores the need to address other stressors that may be affecting longfin smelt abundance concurrently with improved flow conditions. (TBI/NRDC 2, p. 14.) Applying this method and the logit regression produces very similar results.

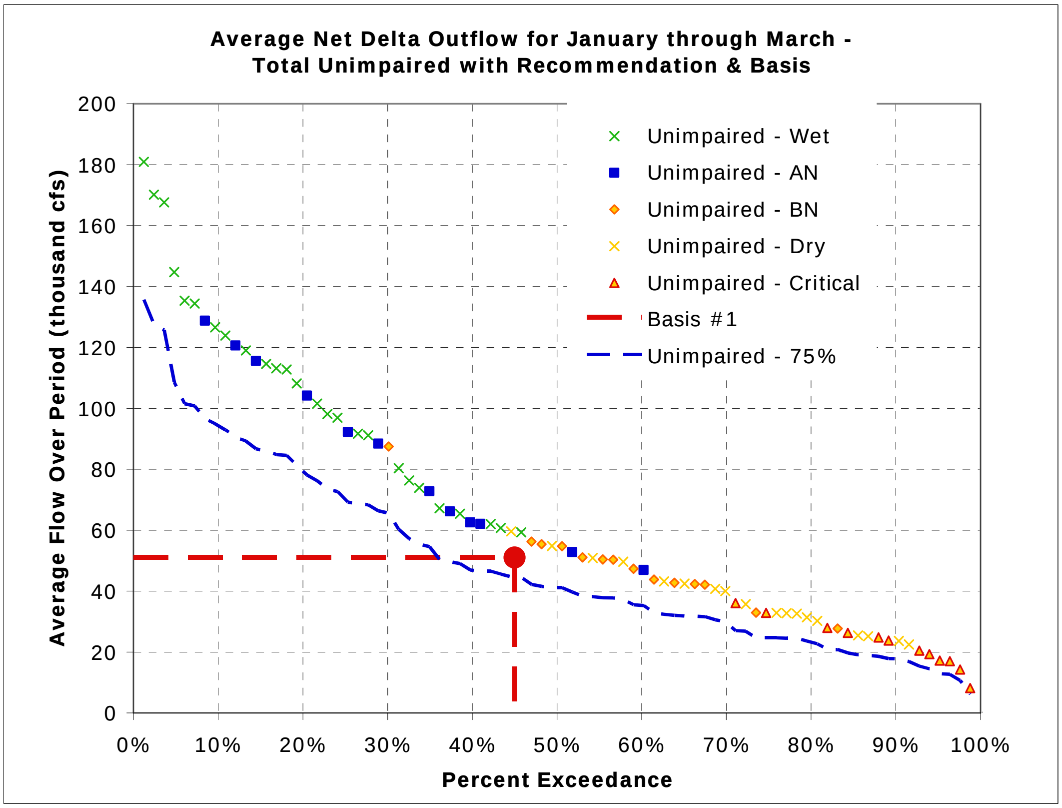
As noted above, the results of the logit analysis indicate that the "likelihood" of an increase in the longfin smelt FMWT abundance index in 50% of years corresponded with flows of approximately 9.1 MAF and 6.3 MAF during January through March and March through May, respectively. (TBI/NRDC 2, pp. 17-19.) Hereafter, these two flow volumes are reported in cubic feet per second, as 51,000 cfs and 35,000 cfs, respectively. Analyses indicate that under historic unimpaired conditions (1921 to 2003) average flows of 51,000 cfs occurred between January and March in approximately 50% of years (Figure 12a), while average flows of 35,000 cfs happened between March and May approximately 85% of the time (Figure 13a). The review of the historic record suggests that it is unrealistic to expect a 100% return frequency for the two magnitudes. A point of reference for determining a more realistic return frequency might be the actual (impaired) flows that occurred from 1956 to 1987. This was a time period when native fish were more abundant than today. Actual average flows between 1957 and 1987 of 51,000 cfs occurred between January and March in approximately 45% of years (Figure 12b). Similarly average flows of 35,000 cfs occurred between March and May 47% of the time (Figure 13b). However, since 2000, average flows of this magnitude only occurred about 27% and 33% of the time, respectively (Figures 12b and 13b). At 75% of unimpaired flow, average flows of 51,000 and 35,000 cfs would happen 35% and 70% of the time, respectively (Figure 12a and Figure 13a). Finally, the DFG has indicated that spring outflows should continue through June to fully protect a number of estuarine species (DFG 1, pp.2-5.)

A fixed 75% of unimpaired flow would extend the flow criteria to other years and distribute flows in a manner that more closely resembles the natural hydrograph. Expression of this criterion as a 14-day running average would better reflect the timing of actual flows (compared with a 30-day running average) while still allowing for a time-step to which reservoirs could be operated. The appropriateness of the 14 day averaging period warrants further evaluation. The unimpaired flows from which the 75% criterion is calculated are monthly values. Estimates of 14-day average unimpaired flows have not been published, but a cursory analysis indicates that they are likely to generate an exceedance curve similar to one generated with monthly values.

The State Water Board therefore determines that the Net Delta Outflow criterion be 75% of the 14-day average unimpaired flow between January and June (Figure 14a, Table

20). Consistent with the DFG recommendation (closing comments, p. 7) that X2 be maintained between 65 and 74 km (Chipps Island and Port Chicago) from January through June, a criterion of 75% of unimpaired flow, would maintain X2 west of Chipps Island more than 90% of the time, between January and June, based on monthly averages (analyses not shown). The return frequency for all months combined is about 98% of the time (Figure 14a). This compares with about a 90% percent return frequency between 2000 and 2009 (Figure 14b).

a)



b)

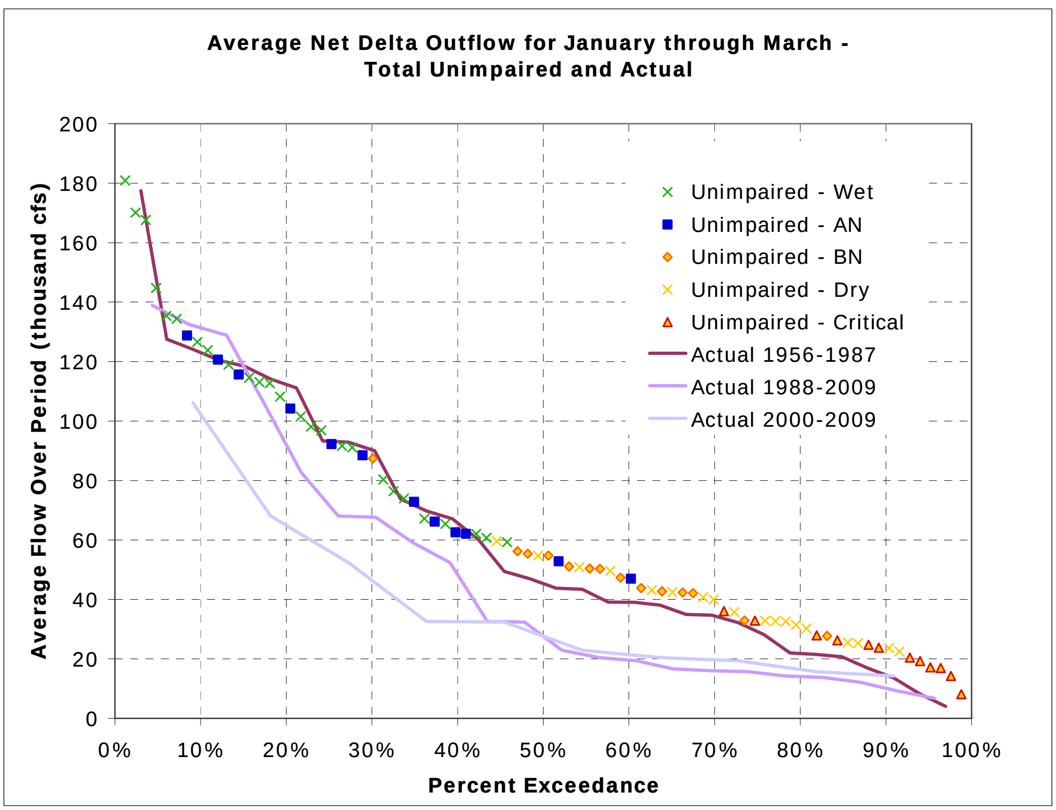
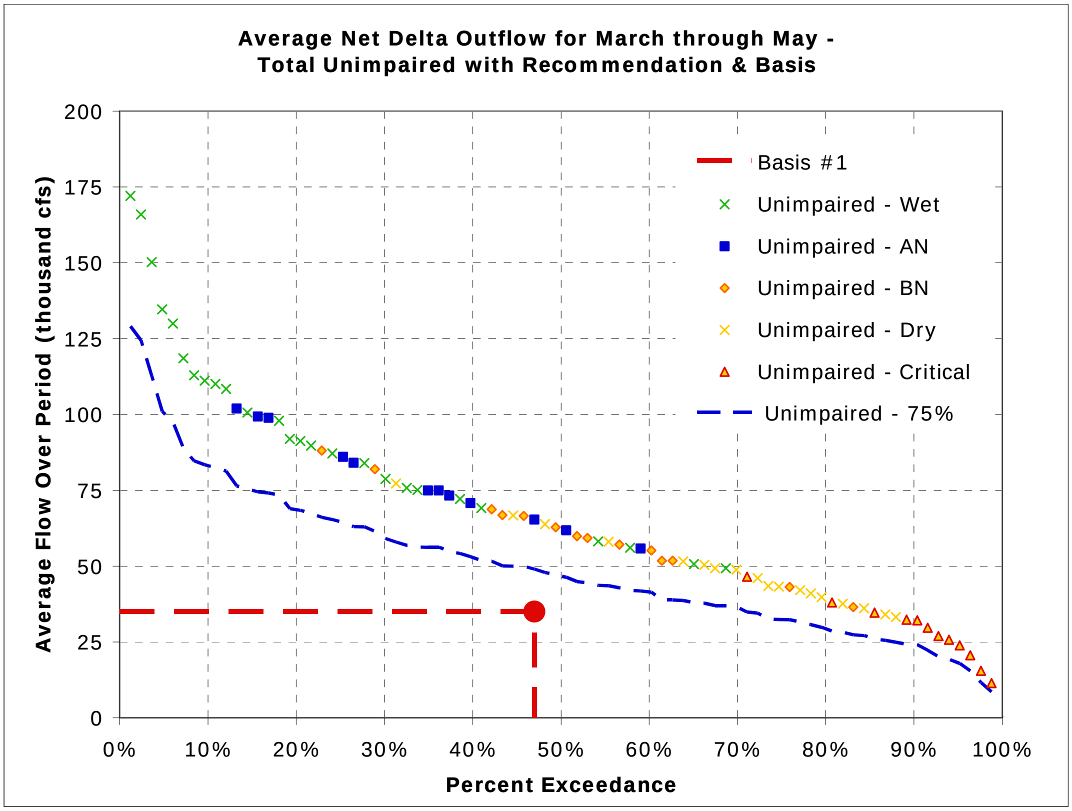


Figure 12. Net Delta Outflow Flow Exceedance Plot - January through March

a)



b)

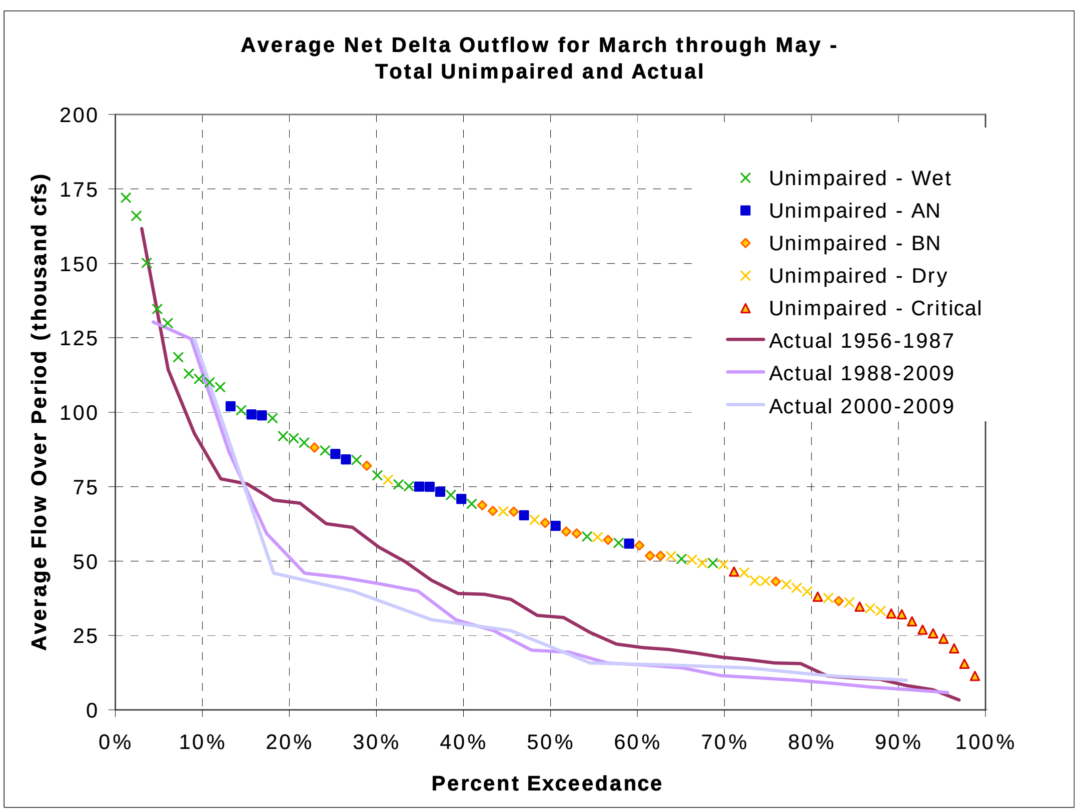
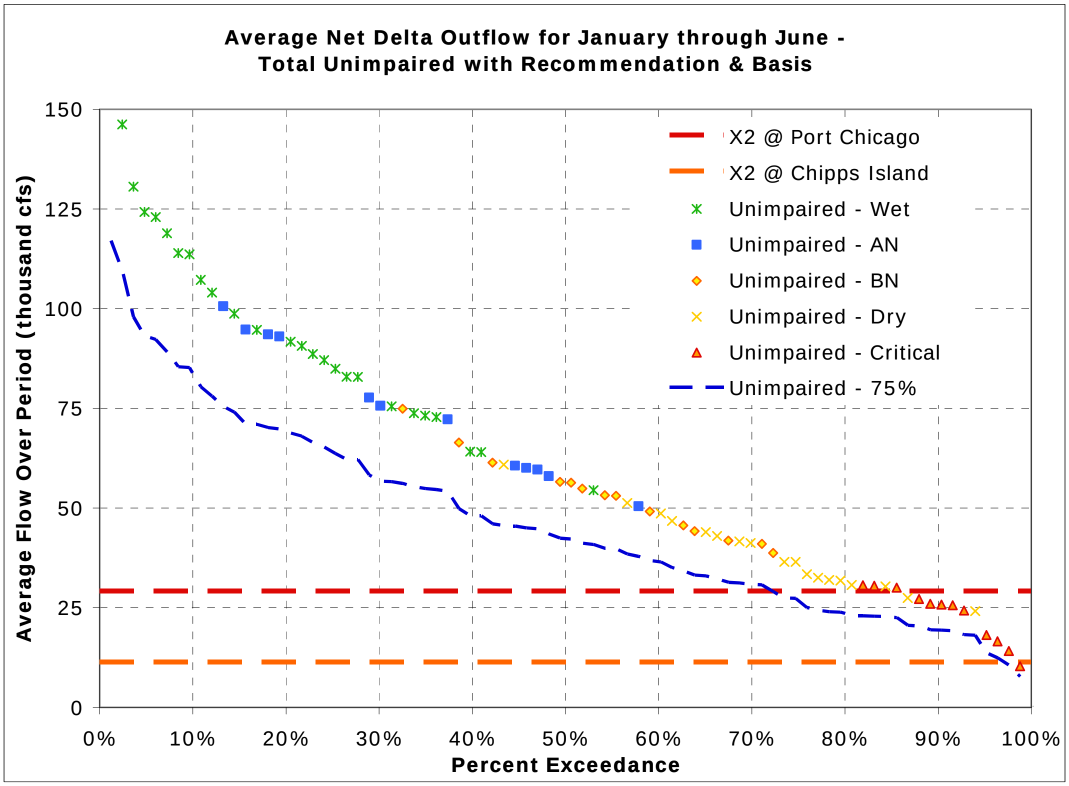


Figure 13. Net Delta Outflow Flow Exceedance Plot - March through May

a)



b)

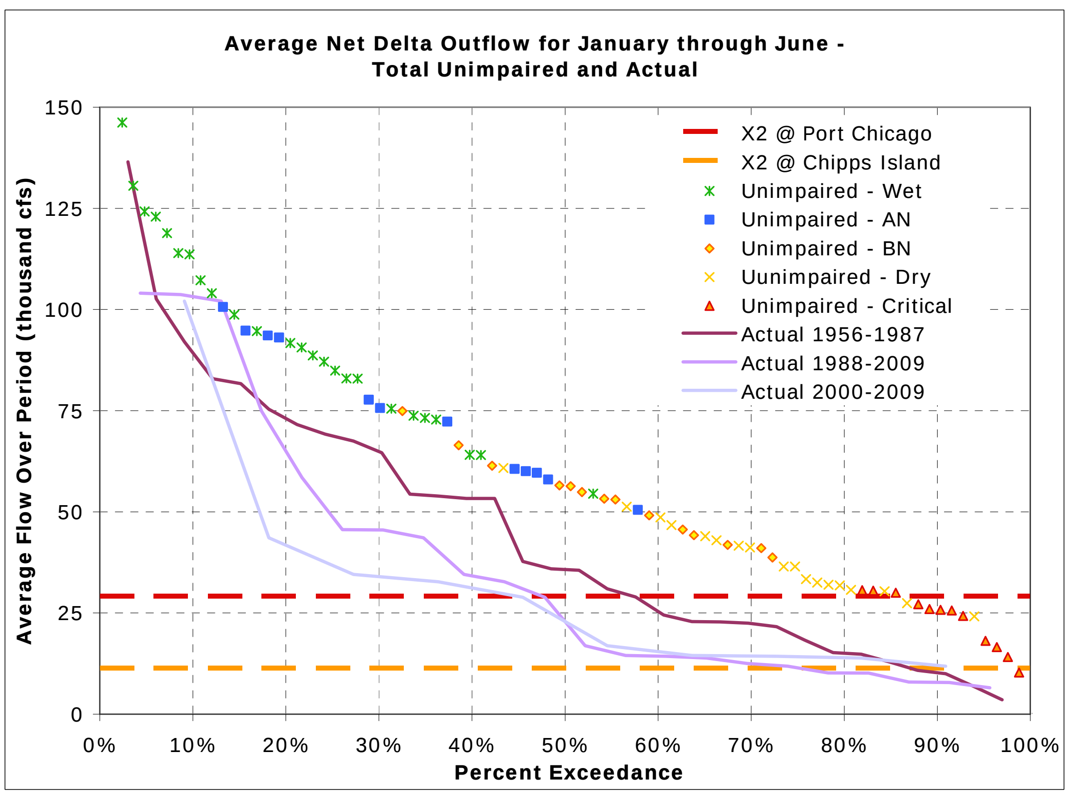


Figure 14. Net Delta Outflow Flow Exceedance Plot - January through June

The net Delta outflow criterion of 75% of unimpaired flows from January through June is anticipated to increase the likelihood of positive population growth for a number of other public trust species, notably those for which abundance-X2 relationships have been demonstrated, including American shad, striped bass, starry flounder, bay shrimp (*Crangon franciscorum*), and *Eurytemora affinis* (spring abundance). For example, the spring (March through May) abundance of *Eurytemora affinis* has been positively related to flow, following the invasion of *Corbula.* (Kimmerer 2002a.) This species represents an important prey item for most small fishes, particularly those with winter and early spring larvae, such as longfin smelt, delta smelt and striped bass. (Lott 1998, Nobriga 2002, Bryant and Arnold 2007, DFG unpublished.) Increases in the abundance of prey species, such as *E. affinis* and bay shrimp, has the potential to improve productivity of the estuarine food web and benefit a number of fishes, especially given that food limitation has been identified as a potential contributing factor in the POD. (Baxter *et al*. 2008.) Additional information concerning the relationship of population abundance to flow for these species is provided in the species life history section of this report.

Delta smelt abundance does not respond to freshwater outflow in a predictable manner similar to that of other numerous estuarine species. (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002a.) However, freshwater outflow during spring (March to June) does affect the distribution of delta smelt larvae by transporting them seaward toward the low salinity zone. (Dege and Brown 2004.) Ideal rearing habitat conditions for this species are believed to be shallow water areas most commonly found in Suisun Bay. (Bennett 2005.) Outflows that locate X2 in Suisun Bay (mean April through July location) produce the highest delta smelt abundance levels; however, low abundances have also been observed under the same conditions, which indicates several mechanisms must be operating. (Jassby et al. 1995; DFG 1, p. 15.) A criterion of 75% of unimpaired flow is expected to place X2 in Suisun Bay from March through June in nearly all years.

The DFG's current science-based conceptual model is that placement of X2 in Suisun Bay represents the best interaction of water quality and landscape for fisheries production given the current estuary geometry. (DFG 2, p. 6.) The DFG (closing comments, p. 7) provided recommended flow criteria for the Delta based on the placement of X2, for January through June (exact period varied by species), for longfin smelt, starry flounder, bay shrimp, zooplankton, and American shad. For each of these species, the DFG (*Id*.) recommends that sufficient outflow be provided to position X2 between 75 km and 64 km. These criteria are generally consistent with spring X2 requirements in the 2006 Bay-Delta Plan, which requires salinity at one compliance point (81 km) not to exceed 2 psu continuously, and at two other compliance points (64 km [Port Chicago] and 75 km [Chipps Island]) not to exceed 2 psu for a set number of days during February through June. Positioning X2 at 75 km and 64 km is equivalent to a 3-day running average Net Delta Outflow Index of 11,400 cfs and 29,200 cfs, respectively. Implementation of the 75% of unimpaired flow criteria would be largely consistent with the intent of the DFG's recommendations by placing X2 between Chipps Island and Port Chicago, or further to the west, in nearly all years during the January through June period.

The step-decline in the abundance-X2 relationship that occurred after 1987 for many of these species in combination with the lack of understanding concerning the causal mechanisms underlying those relationships leads to uncertainty regarding the future response of these species to elevated flows. In addition, a number of major changes to the Delta landscape, including levee failure and island flooding, are likely to occur over the next several decades. (Lund et al. 2007, 2008.) Flow regimes needed to maintain desired environmental conditions will change through time, in response to changes in the geometry of waterways, climate, and other factors. A number of “stressors” are currently being evaluated as potential contributors to the POD, including attributes of physical and chemical fish habitat. (Sommer et al. 2007; Baxter et al. 2008.) Increasing flows, without concurrent improvements to habitat and water quality, would decrease the extent of expected improvements in native species abundances and habitats. (DOI 1, p. 40.) However, the scientific information received during this proceeding supports the conclusion that flow, though not sufficient in and of itself, is necessary to protect public trust resources and that the current flow regime has harmed native species and benefited non-native species. Each of these issues adds further support to the need for a strong adaptive management program.

The specific flow criteria may need to be tempered by the need to maintain water in reservoirs to provide adequate cold water resources to support egg incubation, juvenile rearing, and holding in the Sacramento River, San Joaquin River, and associated tributary basins. It may not be possible to attain the outflow criteria and meet the thermal needs of the various runs of Chinook salmon and other sensitive species in certain years. Water supply modeling and temperature analyses should be conducted to identify conflicting requirements to achieve both outflow and cold water temperature goals.

Category B: Fall X2

Abiotic habitat parameters for delta smelt have been described for both the summer and fall seasons as combinations of salinity, temperature, and turbidity. (Nobriga et al. 2008; Feyrer et al. 2007; Feyrer et al. in review.) During fall, delta smelt typically occur in low salinity rearing habitats located around the confluence of the Sacramento and San Joaquin Rivers. Suitable abiotic habitat for delta smelt during fall has been defined as relatively turbid water (Secchi depths < 1.0 m) with a salinity of approximately 0.6-3.0 psu. (Feyrer et al. 2007.) Long-term trend analysis has shown that environmental quality, as defined by salinity and turbidity, has declined across a broad geographical range, most notably within the south-eastern and western regions of the Delta, leaving a relatively restricted area in the lower Sacramento River and around the confluence of the Sacramento and San Joaquin rivers with the least habitat alteration, compared to the rest of the upper estuary. (Feyrer et al. 2007, DOI 1, p.34.)

The amount of habitat available to delta smelt is controlled by freshwater flow and how that flow affects the position of X2, geographically, in the estuary (Figure 15). (Feyrer et al. in review.) Through the use of a 3D hydrodynamic model, Kimmerer et al. (2009) showed that the extent of delta smelt habitat, as defined by salinity, increases as X2 moves seaward. When X2 is located downstream of the confluence of the Sacramento and San Joaquin rivers, suitable abiotic habitat extends into Suisun and Grizzly bays, resulting in a large increase in the total area of suitable abiotic habitat. (Feyrer et al. in review.) The average position of X2 during fall has moved upstream, resulting in a corresponding reduction in the amount and location of suitable abiotic habitat. (Feyrer et al. 2007; Feyrer et al. in review.)

Average Net Delta Outflow for September, October, and November are presented in Figure 16, Figure 17, and Figure 18. Historically, unimpaired flows in fall were independent of water year type. Interestingly, actual outflow was greater than unimpaired flow between 1956 and 1987. However, fall outflows have fallen since then and since 2000 are almost always less than unimpaired flow. This is consistent with the observations of Feyrer et al. (2007) that fall X2 has moved upstream and this has reduced the amount of available habitat for smelt in fall.

Fall conditions may be very important for delta smelt, since this period of time coincides with the pre-spawning period for adult delta smelt. (Feyrer et al. 2007.) In general, reductions in habitat constrict the range of these fishes, which combined with an altered food web, may affect their health and survival. (Feyrer et al. 2007.) There is a statistically significant stock-recruitment relationship for delta smelt in which pre-adult abundance measured by the FMWT positively affects the abundance of juveniles the following year in the Summer Townet survey. (Bennett 2005; Feyrer et al. 2007, as cited in USFWS 2008.) Incorporating the combined effects of specific conductance and Secchi depth improved the stock-recruitment relationship. (Feyrer et al. 2007.)

Feyrer et al. (In Review) demonstrated that delta smelt are more abundant when a large amount of habitat is available. However, the relationship between habitat area and FMWT abundance is complex and not strong. (NAS 2010.) When the area of highly suitable habitat is low, either high or low FMWT indices can occur (Figure 15). Therefore, delta smelt can be successful in instances where habitat is limited. More important, however, is that the lowest abundances all occurred when the habitat-area index was less than 6,000 ha. (Feyrer et al. in review; NAS 2010.) This potentially suggests that while reduced habitat area may be an important factor associated with the worst population collapses, it is not likely the only cause of the collapse. (NAS 2010.)

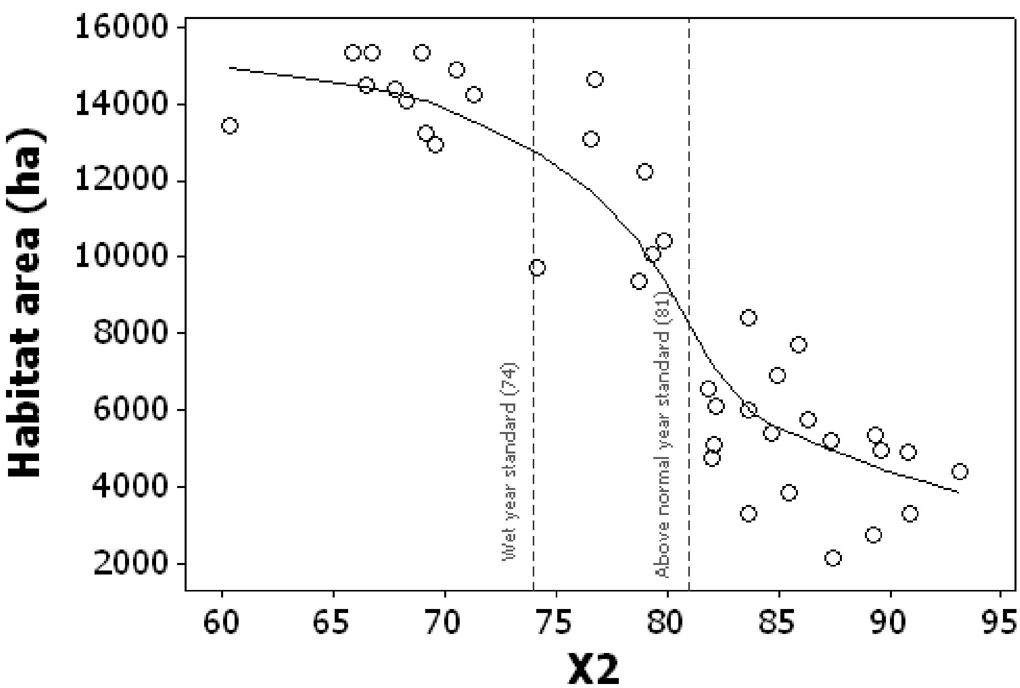
The fall X2 action described in the USFWS Opinion is focused on wet and above normal years because these are the years in which project operations have most significantly affected fall outflows. Actions in these years are more likely to benefit delta smelt. (USFWS 2008.) The action calls for maintaining X2 in the fall of wet years and above-normal years at 74 km and 81 km, respectively. (Figures 14, 15, and 16; USFWS 2008.) In addition to increasing the quality and quantity of habitat for delta smelt, moving X2 westward in the fall may also reduce the risk of entrainment by increasing the geographic and hydrologic distance of delta smelt from the influence of the Project export facilities. (DOI 1, p. 34.)

The NAS (2010) commented on this action in their review of the USFWS Opinion and concluded:

> “The X2 action is conceptually sound in that to the degree that habitat for smelt limits their abundance, the provision of more or better habitat would be helpful. However, the examination of uncertainty in the derivation of the details of this action lacks rigor. The action is based on a series of linked statistical analyses (e.g., the relationship of presence/absence data to environmental variables, the relationship of environmental variables to habitat, the relationship of habitat to X2, the relationship of X2 to smelt abundance), with each step being uncertain. The relationships are correlative with substantial variance being left unexplained at each step. The action also may have high water requirements and may adversely affect salmon and steelhead under some conditions (memorandum from USFWS and NMFS, January 15, 2010). As a result, how specific X2

targets were chosen and their likely beneficial effects need further clarification."

The State Water Board determines that inclusion of the delta smelt fall X2 action as a Category B flow criterion, consistent with requirements stipulated in the USFWS Opinion will likely improve habitat conditions for delta smelt. However, in light of the uncertainty about specific X2 targets and the overall effectiveness of the fall X2 action, the State Water Board recommends this action be implemented within the context of an adaptive management program. The program should include studies designed to clarify the mechanisms underlying the effects of fall habitat on the delta smelt populations, the establishment and peer review of performance measures and performance evaluation related to the action, and a comprehensive review of the outcomes of the action and effectiveness of the adaptive management program. (USFWS 2008.) Absent study results demonstrating the importance of fall X2 to the survival of delta smelt, fall flows beyond those stipulated in the fall X2 action for the protection of delta smelt are not recommended at this time.



Relationship between X2 and habitat area for delta smelt during fall, with standard shown for wet and above normal years. (Source: USFWS 2008, Figure B17).

Figure 15. X2 Versus Habitat Area for Delta Smelt During Fall

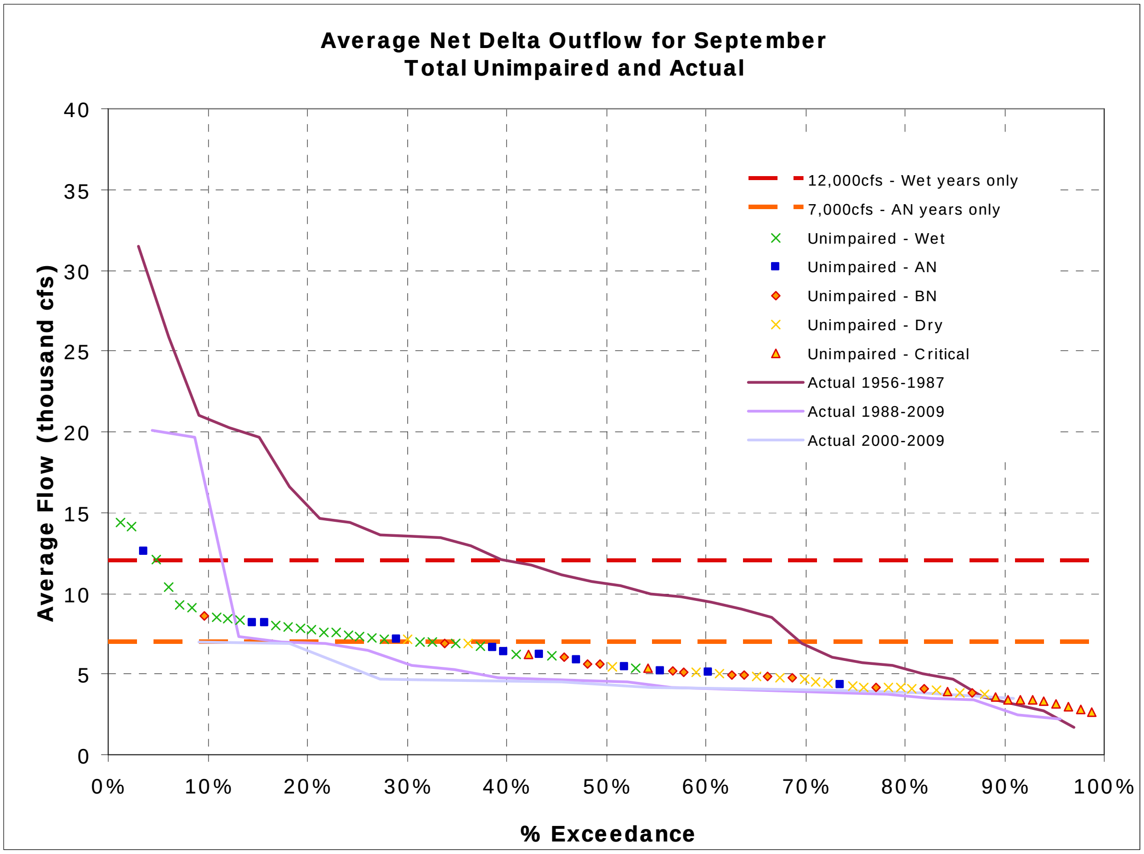


Figure 16. Net Delta Outflow Flow Exceedance Plot - September

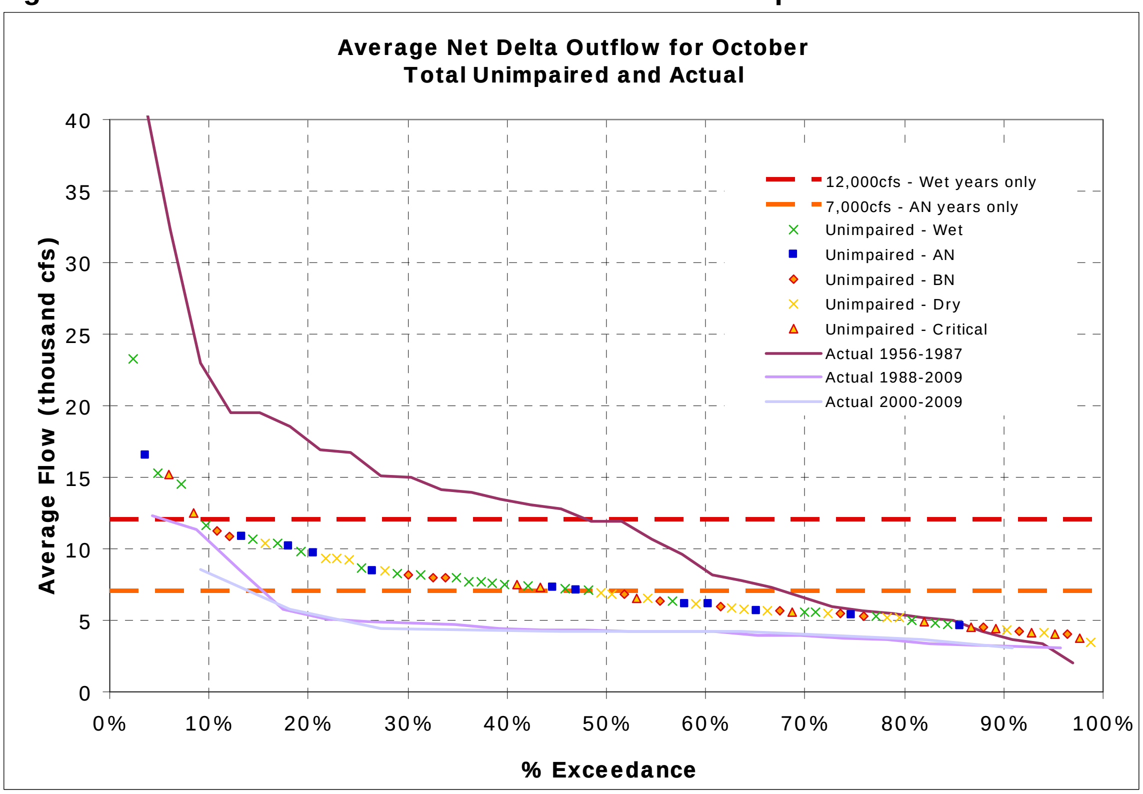


Figure 17. Net Delta Outflow Flow Exceedance Plot - October

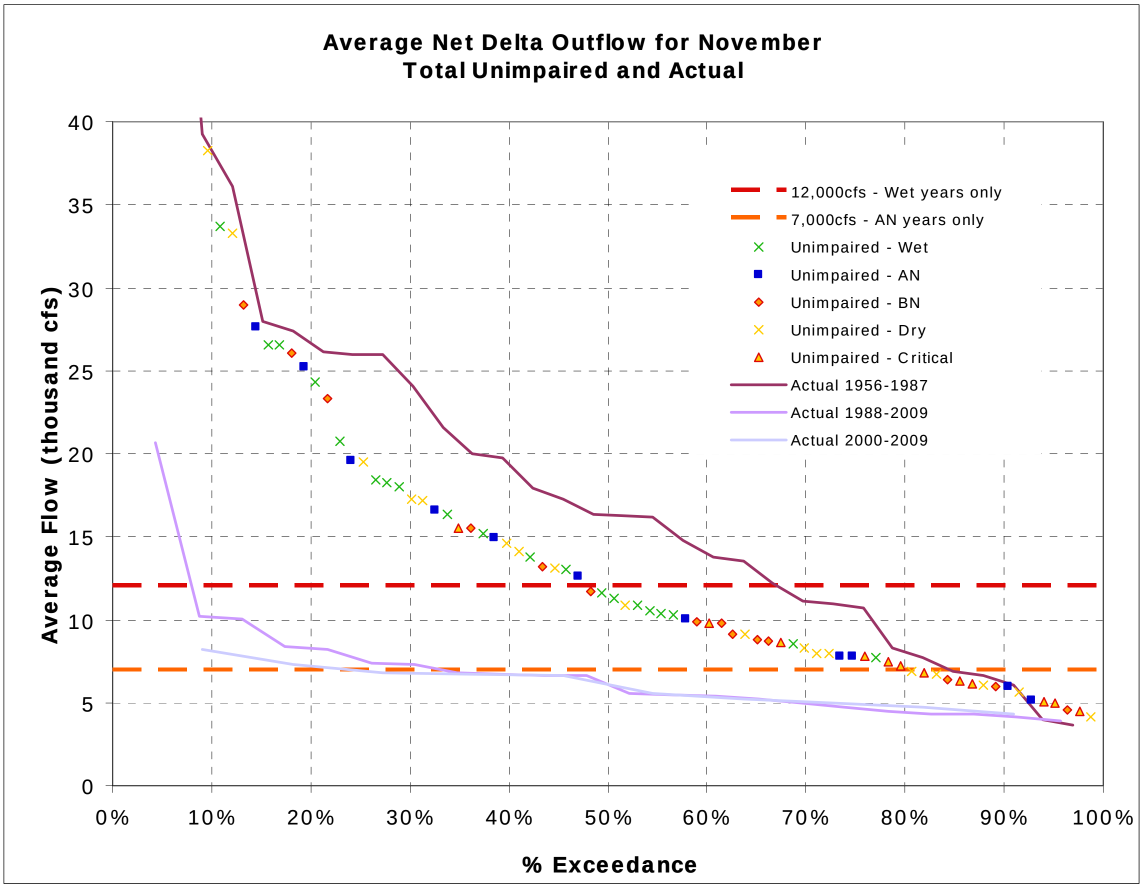


Figure 18. Net Delta Outflow Flow Exceedance Plot - November

The specific Delta outflow criteria may need to be tempered by the need to maintain water in reservoirs to provide adequate cold water and tributary specific flows on tributaries to the Delta. It may not be possible to attain both the flow criteria and meet the thermal and tributary specific flow needs of all of the sensitive species in the Delta Watershed. Water supply modeling and temperature analyses should be conducted to identify conflicting requirements to achieve both flow and cold water temperature goals.

Category B: 2006 Bay-Delta Plan Summer – Fall Delta Outflow

Resident estuarine species, such as delta smelt, require flows sufficient to provide adequate habitat throughout the year. Delta outflow criteria for January through June are discussed above. In addition to providing flows to support resident species, sufficient flows must also be provided in the fall to provide attraction cues and a homing mechanism for returning adult salmon. Criteria for fall salmon attraction flows on the Sacramento and San Joaquin rivers are discussed in Sections 5.2 and 5.3. The 2006 Bay-Delta Plan contains summer – fall Delta outflow water quality objectives for fish and wildlife beneficial uses, which are summarized below in Table 19.

Table 19. 2006 Bay-Delta Plan Delta Outflow Objectives for July through December

Water Year	July	Aug	Sept	Oct	Nov	Dec
Critical	4000	3000	3000	3000	3500	3500
Dry	5000	3500	3000	4000	4500	4500
Below Normal	6500	4000	3000	4000	4500	4500
Above Normal	8000	4000	3000	4000	4500	4500
Wet	8000	4000	3000	4000	4500	4500

Multiple participants submitted testimony concerning the need for additional flows in the fall to benefit delta smelt, striped bass, and other resident species (CSPA 1, p. 7; CWIN 2, p. 29; DOI 1, pp. 46-48; EDF 1, pp. 49-50; TBI/NRDC 2, pp. 27-37), and as a means to potentially control the spread of harmful invasive species (e.g., *Corbula* and toxic algae). (TBI/NRDC 2, pp. 27-37.) The recommendations were based largely on recent research conducted by Feyrer *et al*. (2007 and In Review) and the fall X2 action in the USFWS's Opinion. The Fall X2 action in the USFWS Opinion requires that sufficient outflow be provided in September through November of Above Normal and Wet water year types to position X2 at 81 km and 74 km, respectively. This action was restricted to Above Normal and Wet years because these are the years in which project operations have most significantly affected fall outflows and to limit potential conflicts with cold water pool storage. (USFWS 2008.)

Following its review of the USFWS Opinion, the NAS (2010) noted that:

> "[a]lthough there is evidence that the position of X2 affects the distribution of smelt, the weak statistical relationship between the location of X2 and the size of smelt populations makes the justification for this action difficult to understand… The X2 action is conceptually sound in that to the degree that the amount of habitat available for smelt limits their abundance, the provision of more or better habitat would be helpful… the committee concludes that how specific X2 targets were chosen and their likely beneficial effects need further clarification."

The USFWS Opinion also recognized uncertainty concerning the position of fall X2 and subsequent abundance of delta smelt and requires that the action be implemented with an adaptive management program to provide for learning and improvement of the action over time.

However, some participants provided flow recommendations that called for increased fall outflows during all water year types, as compared to the objectives in the 2006 Bay-Delta Plan, and in certain instances in excess of those required by the USFWS Opinion. Given the need for improved understanding concerning the fall X2 criterion, including the mechanisms underlying the effects of fall habitat on delta smelt populations, determination of specific X2 targets, potential conflicts with cold water pool storage, and the likely effectiveness of the action, the State Water Board is not advancing criteria for increased fall flows in Critical, Dry, and Below Normal water year types beyond those required in the 2006 Bay-Delta Plan and in Above Normal and Wet water year types beyond those stipulated in the fall X2 action (Category B). The quantity and timing of fall outflows necessary to protect public trust resources warrants further evaluation and underscores the need for a well-designed adaptive management program. The potential to use variability in flows during summer and fall months as a means of controlling the distribution and abundance of invasive species should also be evaluated.

5.2 Sacramento River

Following are the Sacramento River inflow criteria based on analysis of the species-specific flow criteria and other measures:

1) Sacramento River Flow at Rio Vista: 75 percent of 14-day average unimpaired flow from April through June to increases juvenile salmon outmigration survival for fall-run Chinook salmon
2) Sacramento River Flow at Rio Vista: 75 percent of 14-day average unimpaired flow from November through March to increases juvenile salmon outmigration survival for other runs of Chinook salmon
3) Sacramento River at Wilkins Slough: Provide pulse flows of 20,000 cfs for 7 days starting in November coincident with fall/early winter storm events; the timing, magnitude, duration, and number of pulses should be determined on an adaptive management basis informed by unimpaired flow conditions and monitoring of juvenile salmon migration to promote juvenile salmon emigration
4) Sacramento River Flow at Freeport: Provide flows of 13,000 to 17,000 cfs in the Sacramento River downstream of confluence with Georgiana Slough when salmon are migrating through the Delta from November through June to increase juvenile salmon outmigration survival by reducing straying into Georgiana Slough and the central Delta
5) Sacramento River at Rio Vista: 2006 Bay-Delta Plan flow objectives for September and October to provide Fall adult Chinook salmon attraction flows

The magnitude, duration, timing, and source of Sacramento River inflows are important to all runs of Chinook salmon migrating through the Bay-Delta and several different aspects of their life history. Inflows are needed to provide appropriate conditions to cue upstream adult migration to the Sacramento River and its tributaries, adult holding, egg incubation, juvenile rearing, emigration from the Sacramento River and its tributaries, and other functions. Sacramento River inflows are important throughout the year to support various life stages of the different Chinook salmon runs inhabiting the Sacramento River. However, given the focus of this proceeding on inflows to the Delta and the importance of the juvenile salmon emigration period, the Sacramento River inflow criteria included in this report focus primarily on flows needed to support emigrating juvenile Chinook salmon from natal streams through the Delta. Following is a brief summary of the Sacramento River inflow criteria that were developed based on the species-specific flow needs analyses for salmon included in section 4.2.3 followed by a detailed discussion.

Available scientific information indicates that average April through June flows of 20,000 to 30,000 cfs on the Sacramento River at Rio Vista represent a flow threshold at which survival of juveniles and subsequent adult abundance is substantially improved for fall-run Chinook salmon. Less information is available for the other runs of Chinook salmon on the Sacramento River. However, outmigration flows needed to protect other races are assumed to be generally the same since factors that affect fall-run survival are generally applicable to other runs with some exceptions. In addition, analyses indicate that providing pulse flows of 20,000 cfs at Wilkins Slough on the Sacramento River beginning in November and extending through the first of the year provides for earlier migration timing and increased survival of juvenile winter, spring, and late-fall run Chinook salmon. In addition, information indicates that flows of 13,000 cfs to 17,000 cfs may be needed on the Sacramento River at Freeport to prevent salmon from migrating through Georgiana Slough and the interior Delta where survival is substantially lower.

Continuity of flows from natal stream through the Delta and flow variability are also important so rather than static April through June threshold flows of 20,000 to 30,000 cfs, the State Water Board determines, as a Category A criterion, that 75% of unimpaired flow is needed to achieve a threshold flow of 25,000 cfs (average of 20,000 and 30,000 cfs) approximately 50% of the time. The same percentage of unimpaired flow for the November through March period is also advanced as a Category B criterion due to the lack of information upon which this criterion was based. In addition, as Category B criteria, the State Water Board determines that shorter pulse flows of 20,000 cfs for 7 days at Wilkins Slough are needed starting in November and extending through the first of the year and flows of 13,000 cfs to 17,000 cfs at Freeport are needed from November through June to provide additional protection for Sacramento River Chinook salmon. The State Water Board also advances the Sacramento River flow objectives from the Bay-Delta Plan during September and October to provide a minimal level of protection during these months pending development of additional information concerning flow needs during this period. All of the Sacramento River flow criteria are not precise; rather they reflect the general timing and magnitude of flows needed to protect public trust resources, but could serve as a reasonable basis from which future analysis and adaptive management could proceed. The criteria also do not consider other Sacramento River flow needs.

Sacramento River Inflow as a Percentage of Unimpaired Flows

It appears to be important to preserve the general attributes of the natural hydrograph to which the various salmon runs adapted over time. Information indicates that Chinook salmon respond to variations in flows and need some continuity of flow between natal streams and the Delta for transport and homing fidelity. As such, the historic practice of developing monthly flow criteria to be met from limited sources may be less than optimal for protecting Chinook salmon runs. At the same time, given the impediments to fish passage into historic spawning and rearing areas, there may also be a need to diverge from the natural hydrograph at certain times of year to provide more flow than might have naturally occurred or less flow such that those flows are available at other times of year to mitigate for passage and habitat issues (e.g. cold water pool management).

Based on the above, the State Water Board developed Sacramento River inflow criteria, intended to mimic the natural hydrograph during the peak emigration period, to protect emigrating juvenile Chinook salmon. While emigration of some runs may occur outside of this period, peak emigration is generally believed to occur between November through June. As such, the criteria are recommended to apply to this time period. To achieve the attributes of a natural hydrograph, the criteria are recommended as a percentage of unimpaired flow on a 14-day average, to be provided generally on a proportional basis from the tributaries to the Sacramento River. The 14-day average is intended to better capture the peaks of actual flows compared to a 30-day average time-step, while still allowing for a time-step at which facilities can be operated. The appropriateness of this time-step for protecting public trust resources should be further evaluated.

Spring Sacramento River Inflows at Rio Vista

The species-specific flow needs analyses for salmon in section 4.2.3 indicates that average April through June flows of 20,000 to 30,000 cfs on the Sacramento River at Rio Vista provide for improved survival and abundance of juvenile fall-run Chinook salmon on the Sacramento River.

Flow exceedance graphs were used to determine the percentage of flow needed to achieve various flows needed to protect Chinook salmon. Analysis of unimpaired flows at Freeport (Figure 19) shows that under historic unimpaired conditions, average April through June flows of 30,000 cfs or more would occur in approximately 60% of years. Flows of 25,000 cfs or more would occur is approximately 72% of years, and flows of 20,000 cfs or more would occur in roughly 85% of years. At 75% of unimpaired flows, average flows of 30,000 cfs would be achieved between April and June in roughly 37% of years, flows of 25,000 cfs would be achieved in roughly 50% of years, and flows of 20,000 cfs would be achieved in approximately 70% of years. At 50% of unimpaired flows, flows of 30,000 cfs would be achieved in approximately 15% of years, flows of 25,000 cfs in roughly 25% of years, and flows of 20,000 cfs in roughly 35% of years. Actual flows of 30,000, 25,000, and 20,000 cfs were met in 26, 32, and 39% of years, respectively between 1986 and 2005. It is important to note, however, that unimpaired flows between 1986 through 2005 are not necessarily representative of the longer term unimpaired flow record. Flow criteria equal to 75% of unimpaired flows during the April through June period, on average, would therefore provide favorable conditions for fall-run juvenile Chinook salmon in at least 50% of years (assuming 25,000 cfs flows). As a result, the State Water Board advances 75% of unimpaired flows on a 14-day average from April through June as a potential means to achieve the 20,000 to 30,000 cfs Sacramento River flow threshold discussed above while maintaining variability and the attributes of the natural hydrograph. This criterion is included as criterion 1) for Sacramento River flows and is a Category A criterion.

The unimpaired estimates from which the 75% criterion is calculated are monthly estimates. Estimates of 14-day unimpaired flow have not been published, but are expected to generate an exceedance curve similar to one generated with monthly estimates. This specific percent of unimpaired flow and the averaging period should be adaptively managed. More information and analyses should be conducted to determine if there are maximum flows above which no, or significantly diminishing, additional biological or geomorphological benefits are obtained. This criterion would allow for flows to vary over time coincident with precipitation events reflecting the natural hydrograph. Climate change, however, and its associated effect on flow patterns will likely change how effective such flows are in protecting Chinook salmon. As such, these flow criteria would need to be adaptively managed in the future to ensure the protection of Chinook salmon.

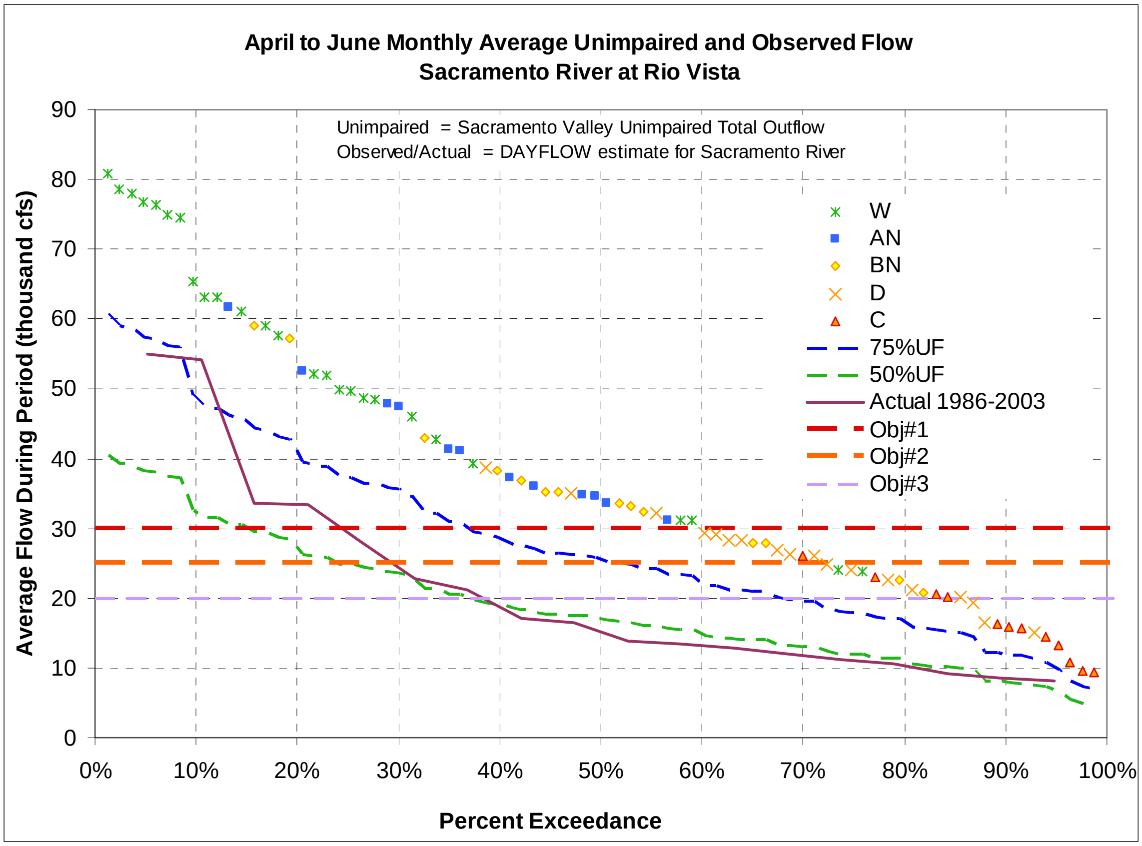


Figure 19. Sacramento River Flow Exceedance Plot - April through June

Fall and Winter Sacramento River Inflows at Rio Vista
Available data and analysis focus primarily on juvenile fall-run Chinook salmon outmigration. Outmigration flows to protect other races and life stages are assumed to be generally the same since factors that affect fall-run survival are generally applicable to other runs, with some exceptions including temperature, which may not be a concern in the winter months. (USFWS 1992, p. 8.) In the absence of sufficient data and analyses regarding flows needed for other Chinook salmon runs, however, the State Water Board advances 75% of unimpaired flows between November and March as an initial criterion from which future analysis and adaptive management could proceed. There is, however, no specific information that indicates that 75% is the correct percent of unimpaired flow. Additional quantitative analyses should be conducted to determine the specific flow needs of winter, spring, and late-fall run Chinook salmon.

Sacramento River Flow at Freeport
Analyses show that Chinook salmon survival is significantly lower for fish migrating through Georgiana Slough. Reverse flows in the vicinity of Georgiana Slough increase the occurrence of salmon migrating through Georgiana Slough. The available data show that flows of 13,000 to 17,000 cfs on the Sacramento River at Freeport provide adequate flow conditions to prevent reverse flows in Georgiana Slough. Flow criteria of 13,000 to 17,000 cfs on the Sacramento River at Freeport when salmon are migrating through the Delta during the November through June period is advanced as a Category B criterion. Additional analyses should be conducted to verify that flows of this magnitude are

needed to achieve the desired outcome of significantly reducing straying of outmigrating juvenile Chinook salmon. These flows are also expected to benefit adult Chinook salmon returning to the Sacramento River basin to spawn during this period. However, additional analyses regarding the relationship of adult Chinook salmon and reverse flows in Georgiana Slough should also be conducted.

Sacramento River Flow at Wilkins Slough

Information discussed in the species-specific flow needs analyses for salmon in section 4.2.3 indicates that significant precipitation in the Sacramento River in the fall facilitates emigration of juvenile Chinook salmon. When this flow is delayed, emigration of salmon is also delayed resulting in reduced survival to the Delta. The available data show that juvenile salmon require flows of 15,000 cfs to 20,000 cfs at Wilkins Slough by November continuing through the first of the year to facilitate emigration. These flows are needed to provide ecological continuity from natal streams to the Delta. Information supports a range of pulse flows of 15,000 cfs to 20,000 cfs at Wilkins Slough to be provided coincident with fall and early winter storm events. This range should be adaptively managed and further evaluated. Absent additional information, flows of 20,000 cfs for seven days are advanced. Such an approach will retain the attributes of the natural hydrograph and provide for ecological continuity. The timing, magnitude, duration, and number of pulses should be determined through adaptive management, informed by unimpaired flow conditions and monitoring of juvenile salmon migration. Additional analyses should be conducted regarding this flow relationship to refine these criteria and inform adaptive management.

Sacramento River at Rio Vista: 2006 Bay-Delta Plan Objectives

The above criteria cover flows on the Sacramento River from the November through June time period. In addition, the Bay-Delta Plan provides minimum flows from September through December. Aside from what is discussed above, there was no new information submitted in the record for this proceeding on fall flows and the Sacramento River fall flow objectives were not specifically reviewed. In the absence of any new information, the State Water Board advances the 2006 Bay Delta Plan Sacramento River inflow objectives for September and October as a Category B criterion. Given that Chinook salmon may also be present in the Sacramento River during July and August, it is likely warranted that some minimal flows be provided during those months as well. However, adequate information on which to base such flows was not readily available for this proceeding. Further, adequate minimal flows during this time period may be provided by temperature and other requirements and reservoir releases for power production and export operations.

The specific Sacramento River flow criteria may need to be tempered by the need to maintain water in reservoirs to provide adequate cold water and tributary specific flows in the Sacramento River basin. It may not be possible to attain both the flow criteria and meet the thermal and tributary specific flow needs of the various runs of Chinook salmon and other sensitive species in the Sacramento River basin. Water supply modeling and temperature analyses should be conducted to identify conflicting requirements to achieve both flow and cold water temperature goals.

5.3 San Joaquin River

Following are the San Joaquin River inflow criteria based on analysis of the species-specific flow criteria and other measures:

1) San Joaquin River at Vernalis: 60%of 14-day average unimpaired flow from February through June
2) San Joaquin River at Vernalis: 10 day minimum pulse of 3,600 cfs in late October
3) San Joaquin River at Vernalis: 2006 Bay-Delta Plan flow objective for October

San Joaquin River inflow criterion 1 and 2 are Category A criteria because they are supported by sufficiently robust scientific information. The 2006 Bay-Delta Plan San Joaquin River inflow objective for October is included as a Category B criterion because it is not clear that eliminating this criterion in lieu of criteria 2 would provide adequate protection to migrating adult Chinook salmon. Following is discussion and rationale for these criteria. Category A and B criteria are both equally important for protection of the public trust resource, but there is more uncertainty about the appropriate volume of flow required to achieve the goals of the Category B criterion. Following is discussion and rationale for these criteria.

As discussed in the Sacramento River inflow section, the magnitude, duration, timing, and source of San Joaquin River inflows are important to Chinook salmon migrating through the Bay-Delta and several different aspects of their life history. Inflows are needed to provide appropriate conditions to cue upstream adult migration to the San Joaquin River and its tributaries, adult holding, egg incubation, juvenile rearing, emigration from the San Joaquin River and its tributaries, and other functions. San Joaquin River inflows are important for much of the year to support various life stages of San Joaquin basin fall-run Chinook salmon (and spring-run when they are reintroduced). However, given the focus of this proceeding on inflows to the Delta and the lack of information received concerning spring-run flow needs on the San Joaquin River, the San Joaquin River inflow criteria included in this report focus on flows needed to support migrating fall-run Chinook salmon from and to natal streams through the Delta. Following is a brief summary of the San Joaquin River inflow criteria that were developed based on the species-specific flow needs analyses for salmon included in section 4.2.3 followed by a detailed discussion.

Available scientific information indicates that average March through June flows of 5,000 cfs on the San Joaquin River at Vernalis represent a flow threshold at which survival of juveniles and subsequent adult abundance is substantially improved for fall-run Chinook salmon and that average flows of 10,000 cfs during this period may provide conditions necessary to achieve doubling of San Joaquin basin fall-run. Both the AFRP and DFG flow recommendations to achieve doubling also seem to support these general levels of flow, though the time periods are somewhat different (AFRP is for February through May and DFG is for March 15 through June 15). Available information also indicates that flows of 3,000 to 3,600 cfs for 10 to 14 days are needed during mid to late October to reduce straying, improve olfactory homing fidelity, and improve gamete viability for San Joaquin basin returning adult Chinook salmon.

Continuity of flows from natal stream through the Delta and flow variability are also important, so rather than advancing static flow criteria for the spring period to support emigration of juvenile San Joaquin basin fall-run Chinook salmon, the State Water Board determines, as a Category A criterion, that 60% of unimpaired flow from February through June is needed in order to achieve a threshold flow of 5,000 cfs or more in most years (over 85% of years) and flows of 10,000 cfs slightly less than half of the time (45% of years). Given that the focus of this proceeding is on protection of public trust resources, the State Water Board determines that the time period for these flows should be extended to cover all three periods supported by the DFG, AFRP, and TBI/NRDC analyses concerning flow needs. In addition, the State Water Board determines, as a Category A criterion, that flows of 3,600 cfs are needed for 10 days in late October. These flows could also be provided in a manner that better reflects the natural hydrograph to coincide with natural storm events. Until additional information is developed, maintaining the October pulse flow called for in the 2006 Bay-Delta Plan is also determined to be a Category B criterion to assure that the existing protection provided during this period is not diminished. All of the San Joaquin River flow criteria are not precise; rather they reflect the general timing and magnitude of flows needed to protect public trust resources, but could serve as a reasonable basis from which future analysis and adaptive management could proceed. The criteria also do not consider other San Joaquin River flow needs.

<u>San Joaquin River Inflows as a Percentage of Unimpaired Flow During the Spring</u>
As discussed in the Sacramento River inflow section, it is important to preserve the general attributes of the natural hydrograph to which the various salmon runs adapted to over time, including variations in flows and continuity of flows. Accordingly, as with the Sacramento River flow criteria, the State Water Board developed flow criteria for San Joaquin River inflows to protect emigrating juvenile Chinook salmon intended to mimic the natural hydrograph during the peak emigration period of February through June. This period may also cover a portion of the rearing period for juveniles as well. As with the Sacramento River flow criteria, to achieve the attributes of a natural hydrograph, the criteria are advanced as a percentage of unimpaired flow on a 14-day average, to be achieved on a proportional basis from the tributaries to the San Joaquin River. The unimpaired estimates from which the 60% criterion is calculated are monthly estimates. Estimates of 14-day unimpaired flow have not been published, but the exceedance curve is likely similar to one generated with monthly estimates. The appropriateness of this time-step and the percentage of unimpaired flows should be further evaluated.

To determine the percentage of unimpaired flow needed to protect Chinook salmon, the State Water Board reviewed flow exceedance information to determine what percentage of flow would be needed to achieve various flows. The analysis in section 4.2.3 indicates that increasing spring flows on the San Joaquin River and its tributaries is needed to protect Chinook salmon in the San Joaquin River basin. The TBI/NRDC analyses of temperatures and population growth indicate that there is a threshold response for fall-run Chinook salmon survival to flows above 5,000 cfs during the spring period and that average flows of 10,000 cfs during this same period may provide adequate flows to achieve doubling. Both the AFRP and DFG modeling analyses also seem to support these flows. However, the time periods for the AFRP recommended flows is from February through May and the time period for the DFG recommended flows is from March 15 through June 15. AFRP, DFG, and TBI/NRDC provide different recommendations for how to distribute flows during the spring period in different years, with increasing flows in increasingly wet years. All are generally consistent with an approach that mimics the natural flow regime to which these fish were adapted. Other analyses speak to the validity of this approach. (Propst and Gido, 2004 and Marchetti and Moyle, 2001, as cited in DOI 1, p. 25.) San Joaquin River flow criteria for the

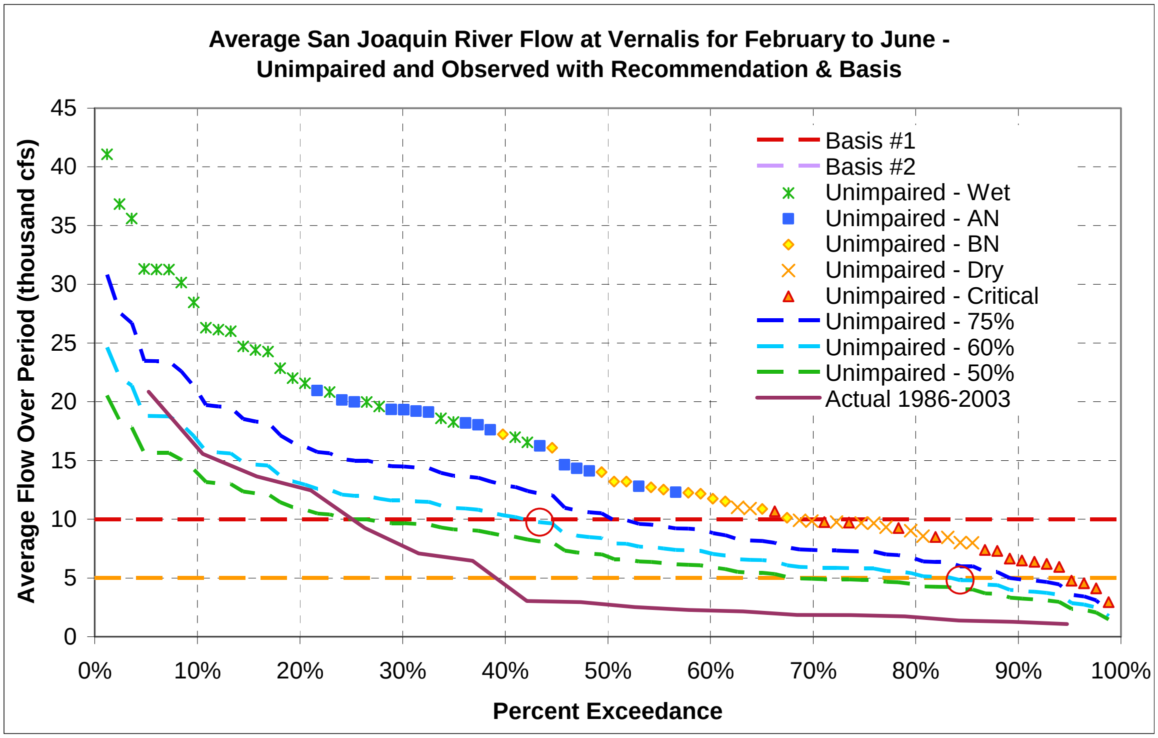
February through June period are determined to be 60% of unimpaired flows. Figure 20b shows that if 60% of unimpaired San Joaquin River flow at Vernalis were provided, average March through June flows would meet or exceed 5,000 cfs in over 85% of years (shown by red circle). An unimpaired flow of 60% during this period would also meet or exceed 10,000 cfs during the March through June time period in approximately 45% of years. The exceedance rates are not significantly different if applied to the February through June period as shown in Figure 20a. Additional information should be developed to determine whether these flows could be lower or higher and still meet the Chinook salmon doubling goal in the long term.

San Joaquin River Fall Flows

In addition to spring flows, fall pulse flows on the San Joaquin River are needed to provide adequate temperature and DO conditions for adult salmon upstream migration, to reduce straying, improve gamete viability, and improve olfactory homing fidelity for San Joaquin basin salmon. Analyses support a range of flows from 3,000 to 3,600 cfs for 10 to 14 days during mid to late October. Absent additional information, the State Water Board determines flow criteria for late fall to be 3,600 cfs for a minimum of 10 days in mid to late October. Providing these flows from the tributaries to the San Joaquin River that support fall-run Chinook salmon appears to be a critical factor to achieve homing fidelity and continuity of flows from the tributaries to the mainstem and Delta. Until additional information is developed regarding the need to maintain the 2006 Bay-Delta Plan October flow objective, these flows supplement and do not replace the 2006 Bay-Delta Plan October flow requirements such that flows do not drop below historic conditions during the remainder of October when the pulse flow criteria would not apply. Additional analyses should be conducted to determine the need to expand the pulse flow time period and modify the criteria to better mimic the natural hydrograph by coinciding pulse flows with natural storm events in order to potentially improve protection by mimicking the natural hydrograph.

Given that salmon and steelhead may be present in the San Joaquin River and its tributaries for all or most of the year (including spring-run in the future) and that the Bay-Delta plan does not currently include any flow requirements from July through September and November through January, additional flow criteria for the remainder of the year may be needed to protect Chinook salmon and their habitat. Specifically, additional criteria for spawning, egg incubation, rearing and riparian vegetation recruitment may be needed. However, adequate information is not available in the record for this proceeding upon which to base such criteria at this time. Additional information, building on the AFRP and other analyses, should be developed to determine needed flows for the remainder of the year.

a)



b)

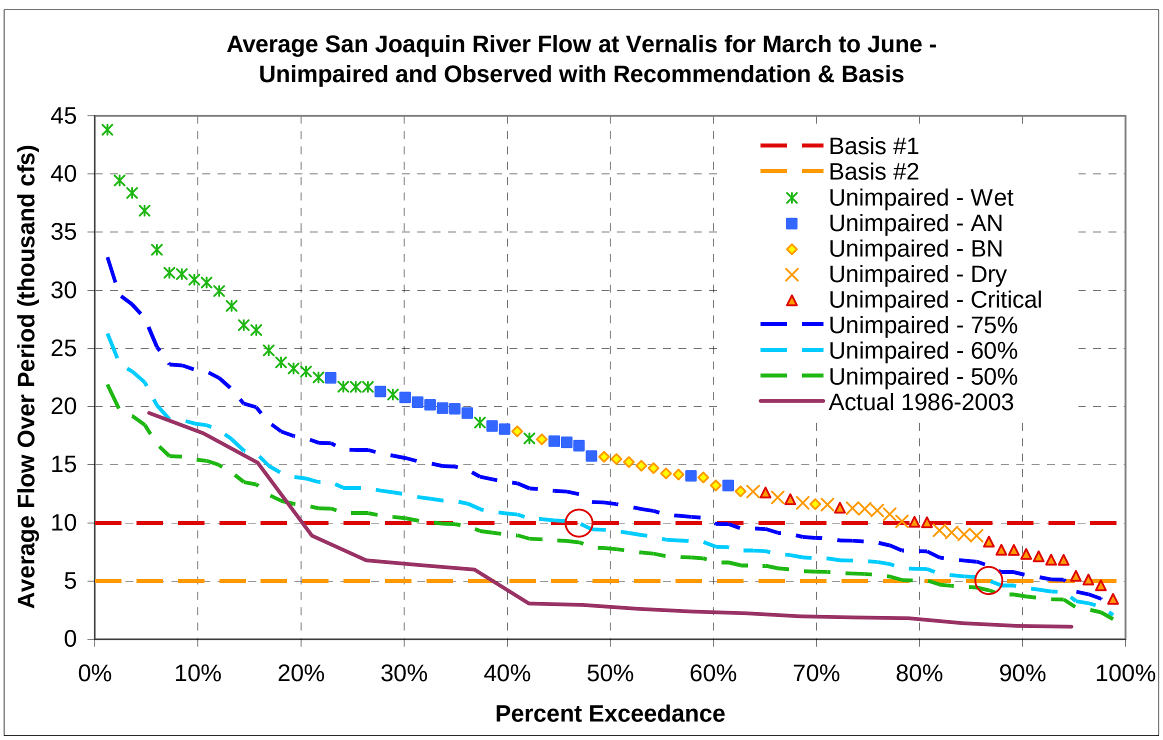


Figure 20. San Joaquin River Flow Exceedance Plot - February through June

The specific San Joaquin River flow criteria may need to be tempered by the need to maintain water in reservoirs to provide adequate cold water and tributary specific flows in the San Joaquin River basin. It may not be possible to attain both the flow criteria and meet the thermal and tributary specific flow needs of steelhead, fall-run Chinook salmon, and other sensitive species in the San Joaquin River basin. Water supply modeling and temperature analyses should be conducted to identify conflicting requirements to achieve both flow and cold water temperature goals.

5.4 Hydrodynamics

The following hydrodynamic related criteria have been developed based on analysis of the species-specific flow criteria and other measures discussed above:

1) San Joaquin River Flow to Export Ratio: Vernalis flows to exports great than .33 during the 10 day San Joaquin River pulse flow in October
2) Old and Middle River Flows: greater than -1,500 cfs in March and June of Critical and Dry water years
3) Old and Middle River Flows: greater than 0 or -1,500 cfs in April and May of Critical and Dry water years, when FMWT index for longfin smelt is less than 500, or greater than 500, respectively
4) Old and Middle River Flows: greater than -5,000 cfs from December through February in all water year types
5) Old and Middle River Flows: greater than -2,500 when salmon smolts are determined to be present in the Delta from November through June
6) San Joaquin River Flow to export Ratio: Vernalis flow to exports greater than 4.0 when juvenile San Joaquin River salmon are migrating in the mainstem San Joaquin River from March through June
7) San Joaquin River at Jersey Point Flows: Positive flows when salmon are present in the Delta from November through June
8) 2006 Bay-Delta Plan Exports to Delta Inflow Limits for the Entire Year

Hydrodynamic criteria 1 is a Category A criterion because it is supported by more robust scientific information. Hydrodynamic criteria 2-7 are Category B criteria because there is less scientific information, with more uncertainty, to support the specific numeric criteria. The 2006 Bay-Delta Plan exports to Delta inflow objective (criteria 8) is offered as a Category B criterion as a minimal level of protection when the other criteria above do not apply. However, the validity of the specific export restrictions included in the 2006 Bay-Delta Plan were not specifically reevaluated. Category A and B criteria are both equally important for protection of the public trust resource, but there is more uncertainty about the appropriate volume of flow required to achieve the goals of the Category B criteria. Following is discussion and rationale for these criteria.

Pelagic Species Criteria

Net OMR reverse flows have increased in both magnitude and frequency with the development of the California water projects (Figure 8) and are having a detrimental effect on biotic resources in the Delta. (Brown et al. 1996.) It is also clear that the negative impact of net OMR reverse flows increases as Sacramento River inflows and net Delta outflow decreases. (Grimaldo et al. 2009; Kimmerer 2008; USFWS 2008; NMFS, 2009.) Net OMR flow restrictions for the protection of longfin and Delta smelt are only recommended for dry and critically dry water years when less Delta outflow may be available (Table 23, criteria 2 and 3). No spring restrictions for the protection of longfin and delta smelt are proposed for other water year types if the higher net Delta outflow criteria are met. If higher outflows are not provided in wetter years, then restrictions on OMR may be needed in these years as well. The State Water Board determines that net OMR flow criteria of greater than -5,000 cfs, from December through February in all water year types, to protect upstream migrating adult smelt are needed. The -5,000 cfs criterion may need to be made more protective if a large portion of the smelt population moves into the central Delta. The additional restrictions would be recommended after consultation with the USFWS (2008) Smelt Working Group. Spring and winter net OMR flow criteria for the protection of longfin and Delta smelt are classified as Category B because, as noted by the NAS (2010),

> "… the data do not permit a confident identification of the threshold [OMR] values to use … and … do not permit a confident assessment of the benefits to the population… As a result, the implementation of this action needs to be accompanied by careful monitoring, adaptive management and additional analyses that permit regular review and adjustment of strategies as knowledge improves…"

Chinook Salmon Criteria

Salmon must migrate through the Delta past the effects of the south Delta export facilities and the associated inhospitable conditions in the central Delta, first as juveniles on their way to the ocean, and later as adults returning to spawn. Exports change the hydrodynamic patterns in the Delta, drawing water across the Delta rather than allowing water to flow out of the Delta in a natural pattern. Over the years, different criteria have been developed to attempt to protect migrating salmon from the adverse hydrodynamic conditions caused by the south Delta export facilities in order to preserve the functional flows needed for migration that could be used to protect public trust resources. Net OMR flows, Jersey Point flows, and Vernalis flow to export ratios are all criteria that can be used to protect migrating salmon. The State Water Board advances a combination of these criteria to protect migrating salmon from export effects.

Increasingly negative net OMR flows have been shown to increase particle entrainment, particularly beginning at flows between -2,500 and -3,500 cfs. While juvenile salmon do not necessarily behave like particles, the particle entrainment estimates are a useful guide until additional information can be developed using evolving acoustic tracking methods and other appropriate techniques. Reduced negative net OMR flows should also provide some level of protection from the indirect reverse flow effects related to fish entering the central Delta where predation and other sources of mortality are higher. Based on the above, the State Water Board determines criteria for net OMR flows should be for greater than -2,500 cfs when salmon are present in the Delta during the peak juvenile outmigration period of November through June, for the protection of Chinook salmon. This is a Category B criterion because there is limited information upon which to base a specific numeric criteria at this time. Such information should be developed to better understand the relationship between salmon survival and net OMR flows to determine more specific criteria that would protect against entrainment and other factors leading to indirect mortality.

Increased reverse flows at Jersey Point have also been shown to decrease survival of salmon smolts migrating through the lower San Joaquin River. However, the precise Jersey Point flow that is necessary to protect migrating salmon is unclear. In addition, it is unclear whether the same functions of such a flow could be better met using different criteria such as net OMR flows or San Joaquin River flow to export ratios. The State Water Board therefore advances positive Jersey Point flows when salmon are present in the Delta during the peak juvenile salmon outmigration period of November through June. Again, this is a Category B criterion because there is limited information upon which to base a specific numeric criteria at this time.

Increased San Joaquin River flow to export ratios appear to improve survival for San Joaquin River salmon, though the exact ratio that is needed to protect public trust resources is not well understood. A San Joaquin River flow to export ratio of greater than 4.0 is recommended as a Category B criterion when San Joaquin River juvenile salmon are outmigrating from the San Joaquin River from March through June. There is, however, sufficient information in the record to support a Category A criterion for exports to be kept to less than 300% of San Joaquin River flows (equal to a San Joaquin River flow to export ratio of more than 0.33) at the same time that the recommended San Joaquin River pulse flows are provided. Additional analyses should be conducted to determine if this time frame should be extended to capture more of the San Joaquin River adult Chinook salmon return period between October and January.

The NAS review concerning OMR restrictions for salmon concluded that:

> "…the strategy of limiting net tidal flows toward the pump facilities is sound, but the support for the specific flows targets is less certain. In the near-term telemetry-based smolt migration and survival studies (e.g, Perry and Skalski, 2009) should be used to improve our understanding of smolt responses to OMR flow levels." (NAS 2010, p. 44.)

Much additional work is needed to better understand the magnitude and timing of the recommended criteria and how net OMR flow criteria should be integrated with other criteria for San Joaquin River flows, San Joaquin River flows to export ratios, Sacramento River flows, and net OMR flow restrictions for the protection of pelagic species. For all of the OMR, Jersey Point, and Vernalis flows to export ratiocriteria, further analysis and consideration is needed to determine: 1) how salmon presence should be measured and the information used to temper the criteria; 2) an appropriate averaging period; and 3) how to adaptively manage to assure that flows are sufficiently, but not overly, protective.

The October San Joaquin River flow to export ratio criteria is a Category A criterion since the basis for this minimum criterion is sufficiently understood to develop a quantitative criteria. Additional analyses should still, however, be conducted to determine if this criteria could be refined to provide better protection for migrating adult San Joaquin River Chinook salmon. All of the other hydrodynamic criteria for the protection of Chinook salmon are Category B criteria.

The San Joaquin River flow to export criterion during the spring is also a Category B criterion due to a lack of certainty regarding the needed protection level. Regarding this issue, the NAS concluded that:

> "…the rationale for increasing San Joaquin River flows has a stronger foundation than the prescribed action of concurrently managing inflows and exports. We further conclude that the implementation of the 6-year steelhead smolt survival study (action IV.2.2) could provide useful insight

> as to the actual effectiveness of the proposed flow management actions as a long-term solution." (NAS 2010, p. 45.)

In addition, based on similar uncertainty regarding needed protection levels and interaction between net OMR flows and San Joaquin River flows to export ratios, the San Joaquin River at Jersey Point criterion is also a Category B criterion. More work is needed to develop a suite of operational tools and an operational strategy for applying those tools to protect public trust resources in the Delta from the adverse hydrodynamic effects of water diversions, channel configurations, reduced flows, and other effects.

2006 Bay-Delta Plan Export Objectives

The 2006 Bay-Delta Plan includes export limitations for the entire year. From February through June exports are limited to 35-45% of Delta inflow. (State Water Board 2006a, pp. 184-187.) From July through January, exports are limited to 65% of Delta inflow. (*Id.)* The export to Delta inflow restrictions are intended to protect the habitat of estuarine-dependent species. (State Water Board 2006b, pp. 46-47.) These export restrictions provide a minimum level of protection for public trust uses and should be maintained to the extent that the other recommended criteria do not override them.

For all of the hydrodynamic criteria, biologically appropriate averaging periods need to be developed. Averaging periods may need to include a two-step approach whereby a shorter averaging period is included that allows for some divergence from the criteria and a longer averaging period is included that does not.

5.5 Other Inflows - Eastside Rivers and Streams

The Cosumnes and Mokelumne rivers, and smaller streams such as the Calaveras River, Bear Creek, Dry Creek, Stockton Diversion Channel, French Camp Slough, Marsh Creek, and Morrison Creek are all tributary to the Delta. Flows should generally be provided from tributaries in proportion to their contribution to unimpaired flow.

5.6 Other Measures

5.6.1 Variability, Flow Paths, and the Hydrograph

Criteria should reflect the frequency, duration, timing, and rate of change of flows, and not just volumes or magnitudes. Accordingly, whenever possible, the criteria specified herein are expressed as a percentage of the unimpaired flow rather than as a single number or range of numbers that vary by water year type. Additional efforts should focus on restoring habitat complexity. Inflows should generally be provided from tributaries to the Delta watershed in proportion to their contribution to unimpaired flow in order to assure connection between Delta flows and upstream tributaries, to the extent that such connections are beneficial to protecting public trust resources. Flows should be at levels that maintain flow paths and positive salinity gradients through the Delta. This concept is reflected in the specific determinations made above. More study is needed to determine to which tributaries such criteria should apply. For example, since the percent of unimpaired flow criteria determined to protect public trust uses for San Joaquin River inflows is at times lower than the criteria determined for Delta outflow, more study is needed to determine the appropriate source of such flows to protect public trust resources. All determined flow criteria must also be tempered by the need to protect health and safety. No flow criteria, for example, should be in excess of flows that would lead to flooding. For all of the flow criteria, there may be a need to reshape the specified flows to better protect public trust resources based on real-time considerations. All of the criteria should be implemented adaptively to allow for such appropriate reshaping to improve biological and geomorphological processes.

Moyle *et al* (2010) concluded, however, that there is a fundamental conflict between restoring variability and maintaining the current Delta:

> "restoring environmental variability in the Delta is fundamentally inconsistent with continuing to move large volumes of water through the Delta for export. The drinking and agricultural water quality requirements of through-Delta exports, and perhaps even some current in-Delta uses, are at odds with the water quality and variability needs of desirable Delta species."

5.6.2 Floodplain Activation and Other Habitat Improvements

Activated floodplains stimulate food web activity and provide spawning and rearing habitat for floodplain adapted fish. The frequency of low-magnitude floods that occurred historically has been reduced, primarily by low water control levees. The record supports the conclusion that topography changes associated with future floodplain restoration will provide improved ecosystem function with less water. Studies and demonstration projects for, and implementation of, floodplain restoration projects should therefore proceed to allow for the possible reduction of flows required to protect public trust resources in the Delta.

<u>Floodplain Flow Determinations for Protection of Salmon and Splittail</u>:
Floodplain and off-channel inundation are required for splittail spawning and appear to be important in protecting Chinook salmon. At the same time, it is also important how and when such inundation occurs. Due to the effects of levees and dams, natural side channel and floodplain inundating flows have been substantially reduced. As a result, modification to weirs and other changes may be needed to substantially improve floodplain inundation conditions on the Sacramento and San Joaquin rivers. Based on the above, the State Water Board determines that an effort be made to provide appropriate additional seasonal floodplain habitat for salmon, splittail, and other species in the Central Valley. The various recommendations the State Water Board received for floodplain inundation are included in Appendix A.1. The State Water Board has no specific flow determinations for floodplain inundation. The State Water Board recommends that BDCP, the Council, and others continue to explore the various issues concerning flood protection, weir modifications, and property rights related to floodplain inundation.

Other future habitat improvements will likely change the response of native fishes to flow and allow flow criteria to be modified. Habitat restoration should proceed to allow for the possible reduction of flows required to protect public trust resources in the Delta. Other future habitat restoration that should be reviewed and implemented include:

- Development of slough networks with natural channel geometry and less diked and rip-rapped channel habitat
- Increased tidal marsh habitat, including shallow (one to two meters) subtidal areas in both fresh and brackish zones of the estuary (in Suisun Marsh, for example)

- Create large expanses of low salinity open water habitat in the Delta

5.6.3 Water Quality and Contaminants

Any set of flow criteria should include the capacity to readily adjust the flows to adapt to changing future conditions and improved understanding. (DEFG 1.) As our understanding of the effect of contaminants on primary production and species composition in the Sacramento River and Delta improves, flow criteria may need to be revisited.

The Central Valley and San Francisco Regional Water Boards should continue developing Total Maximum Daily Loads (TMDLs) for all listed pollutants and adopting programs to implement control actions. Specifically, the Central Valley Regional Board should require additional studies and incorporate discharge limits and other controls into permits, as appropriate, for the control of nutrients, including ammonia.

5.6.4 Coldwater Pool Resources and Instream Flow Needs on Tributaries

The flow criteria contained in this report should be tempered by the need to maintain cold water resources and meet tributary specific flow needs in the Delta watershed. It may not be possible to attain all of the identified flow criteria in all years and meet the tributary flow needs and thermal needs of the various runs of Chinook salmon, steelhead, and other sensitive species. Temperature and water supply modeling analyses should be conducted to identify conflicting requirements to achieve both flow and cold water temperature goals. In addition, these flow determinations do not consider the needs of other non-fish species and terrestrial species which should be considered before any implementation of these criteria.

5.6.5 Adaptive Management

The numeric criteria are all short term criteria that are only appropriate for the current physical system and climate. There is uncertainty in these criteria even for the current physical system and climate, and therefore for the short term. Long term numeric criteria, beyond five years, for example, and assuming a modified physical system, are highly speculative. Only the underlying principles for the proposed numeric criteria and the other measures are advanced as long term determinations.

The information received in this proceeding suggests that the relationships between hydrology, hydrodynamics, water quality, and the abundance of desirable species are often unclear. In preparing for the long term, resources should be directed toward better understanding these relationships. In particular, there is significant uncertainty associated with Category B numeric criteria advcanced in this report. Category B criteria should therefore be high priority candidates for grant funded research.

A strong science program and a flexible management regime are critical to improving flow criteria. The relationship between flow, habitat, and abundance is not well enough understood to recommend flows in the Delta ecosystem without some reliance on adaptive management to better manage these flows. The State Water Board intends to work with the Council, the Delta Science Program, IEP, and others to develop the framework for adaptive management that could be relied upon for the management and regulation of flows in the Delta. The State Water Board will consider supporting and incorporating into its regulations greater reliance upon adaptive management in its flow regulations.

5.7 Summary Determinations

Table 20 through Table 23 provide summary determinations for Delta outflows, Sacramento inflows, San Joaquin River inflows, and hydrodynamics, respectively. Each table shows various numbered criteria, applicable to the shaded range of months. Criteria fall into two categories. Category "A" criteria have more robust scientific information to support specific numeric criteria than do Category "B" criteria. Both categories of criteria are considered equally important for protection of public trust resources in the Delta ecosystem, and are supported by scientific information on function-based species or ecosystem needs. The basis and explanation for each criterion is provided. Each table is appended with the following notes to explain the limitations and constraints of how the criteria should be considered:

- All flows are subject to appropriate ramping rates to avoid ramping impacts to public trust resources
- These flow criteria should be tempered by tributary specific flow needs and the need to manage cold-water resources for the protection of public trust resources
- Criteria for percentages of unimpaired flows apply only up to a specified maximum cap; appropriate maximum flow caps still need to be determined based on public trust needs and to avoid flooding.
- Additional flows may be needed for the protection of public trust resources for periods of time for which no flow criteria have been determined or where Bay-Delta Plan flow objectives are advanced, but adequate information is not available at this time to determine such flows

These criteria are made specifically to achieve the stated goal of halting the population decline and increase populations of native species as well as species of commercial and recreational importance. Additionally, positive changes in the Delta ecosystem resulting from improved flow or flow patterns will benefit humans as well as fish and wildlife, especially when accompanied by large-scale habitat restoration and pollution reduction. (Moyle *et al*, 2010.)

In addition, Table 24 contains a summary of other issues and concepts that should be considered in conjunction with the numeric criteria. These other measures are also based on a synthesis of the best scientific information submitted by participants in the State Water Board's Informational Proceeding. These criteria and other measures, however, must be further qualified as to their limitations. The limitations of this and any other flow prescription are described at the end of the Fleenor *et al*. (2010) "flow prescriptions" report as a "further note of caution":

> "How much water do fish need?" has been a common refrain in Delta water management for many years… it is highly unlikely that any fixed or predetermined prescription will be a "silver bullet". The performance of native and desirable fish populations in the Delta requires much more than fresh water flows. Fish need enough water of appropriate quality over the temporal and spatial extent of habitats to which they adapted their life history strategies. Typically, this requires habitat having a particular range of physical characteristics, appropriate variability, adequate food supply and a diminished set of invasive species. While folks ask "How much water do fish need?" they might well also ask, "How much habitat of different types and locations, suitable water quality,

> improved food supply and fewer invasive species that is maintained by better governance institutions, competent implementation and directed research do fish need?" The answers to these questions are interdependent. We cannot know all of this now, perhaps ever, but we do know things that should help us move in a better direction, especially the urgency for being proactive. We do know that current policies have been disastrous for desirable fish. It took over a century to change the Delta's ecosystem to a less desirable state; it will take many decades to put it back together again with a different physical, biological, economic, and institutional environment."

The State Water Board concurs with this cautionary note and recommends the flow criteria and other conclusions advanced in this report be used to inform the planning efforts for the Delta Plan and BDCP and as a report that can be used to guide needed research by the Delta Science Program and other research institutions.

Table 20. Delta Outflow Summary Criteria

Delta Outflows												
Category A												
Water Year												Criteria
O	N	D	J	F	M	A	M	J	J	A	S	
												1) Net Delta Outflows: 75% of 14-day average unimpaired flow
Category B												
Water Year												Criteria
O	N	D	J	F	M	A	M	J	J	A	S	
												2) Fall X2 a. Wet years: X2 less than 74 km (greater than approximately 12,400 cfs) b. Above normal years: X2 less than 81 km (greater than approximately 7,100 cfs)
												3) Net Delta Outflows: 2006 Bay-Delta Plan Delta Outflow Objectives - applies during critical, dry, and below normal years
Basis for Criteria and Explanation												

1) Promote increased abundance and improved productivity (positive population growth) for longfin smelt and other desirable estuarine species
2) Increase quantity and quality of habitat for delta smelt; fall X2 requirement limited to above normal and wet years to reduce potential conflicts with cold water pool storage, while promoting variability with respect to fall flows and habitat conditions in above normal and wet water year types; expected to result in improved conditions for delta smelt, however, the statistical relationship between fall X2 and abundance is not strong; note 2) above regarding need for improved understanding concerning the fall X2 action also applies
3) Fish and wildlife beneficial use protection

Notes:

- These flow criteria do not consider any balancing of public trust resource protection with public interest needs for water.
- All flows are subject to appropriate ramping rates to avoid ramping impacts to public trust resources.
- These flow criteria should be tempered by tributary specific flow needs and the need to manage cold-water resources for the protection of public trust resources.
- Criteria for percentages of unimpaired flows apply only up to a specified maximum cap; appropriate maximum flow caps still need to be determined based on public trust needs and to avoid flooding.
- Additional flows may be needed for the protection of public trust resources for periods of time for which no flow criteria are recommended or where 2006 Bay-Delta Plan flow objectives are recommended, but adequate information is not available at this time to recommend such flows.

Table 21. Sacramento River Inflow Summary Criteria

Sacramento River Inflows												
Category A												
Water Year												**Criteria**
O	N	D	J	F	M	A	M	J	J	A	S	
						■	■	■				1) Rio Vista: 75% of 14-day average unimpaired flow[1]
Category B												
Water Year												**Criteria**
O	N	D	J	F	M	A	M	J	J	A	S	
	■	■	■	■	■							2) Rio Vista: 75% of 14-day average unimpaired flow to support same functions as #1 for other runs of Chinook salmon
	■	■										3) Wilkins Slough: Provide pulse flows of 20,000 cfs for 7 days starting in November coinciding with storm events producing unimpaired flows at Wilkins Slough above 20,000 cfs until monitoring indicates that majority of smolts have moved downstream[2]
	■	■	■	■	■	■	■	■				4) Freeport: Positive flows in Sacramento River downstream of confluence with Georgiana Slough while juvenile salmon are present (approximately 13,000 to 17,000 cfs)
■											■	5) Rio Vista: 2006 Bay-Delta Plan flow objectives

Basis for Criteria and Explanation, and Notes

1) Increase juvenile salmon outmigration survival and abundance for fall-run Chinook salmon
2) Promote juvenile salmon emigration for other runs of Chinook salmon
3) Increase juvenile salmon outmigration survival by reducing diversion into Georgiana Slough and the central Delta
4) Increases juvenile salmon outmigration survival
5) Fall adult Chinook salmon attraction flows

Notes:

- These flow criteria do not consider any balancing of public trust resource protection with public interest needs for water.
- All flows are subject to appropriate ramping rates to avoid ramping impacts to public trust resources.
- These flow critiera should be tempered by tributary specific flow needs and the need to manage cold-water resources for the protection of public trust resources.
- Criteria for percentages of unimpaired flows apply only up to a specified maximum cap; appropriate maximum flow caps still need to be determined based on public trust needs and to avoid flooding.
- Additional flows may be needed for the protection of public trust resources for periods of time for which no flow criteria are recommended or where 2006 Bay-Delta Plan flow objectives are recommended, but adequate information is not available at this time to recommend such flows.

[1] 75% of unimpaired flow at Freeport applied to Rio Vista

[2] Definition of storm, number of storms, and how to determine when the majority of juveniles have outmigrated needs to be determined.

Table 22. San Joaquin River Inflow Summary Criteria

San Joaquin River Inflows												
Category A												
Water Year												**Criteria**
O	N	D	J	F	M	A	M	J	J	A	S	
				■	■	■	■	■				1) Vernalis: 60% of 14-day average unimpaired flow
■												2) Vernalis: 10 day minimum pulse flow of 3,600 cfs in late October (e.g., October 15 to 26)
Category B												
Water Year												**Criteria**
O	N	D	J	F	M	A	M	J	J	A	S	
■												3) Vernaisl: 2006 Bay-Delta Plan October flows

Basis for Criteria and Explanation, and Notes

1) Increase juvenile Chinook salmon outmigration survival and abundance and provide conditions that will generally produce positive population growth in most years and achieve the doubling goal in more than half of years
2) Minimum adult Chinook salmon attraction flows to decrease straying, increase DO, reduce temperatures, and improve olfactory homing fidelity
3) Adult Chinook salmon attraction flows

Notes:

- These flow criteria do not consider any balancing of public trust resource protection with public interest needs for water.
- All flows are subject to appropriate ramping rates to avoid ramping impacts to public trust resources.
- These flow criteria should be tempered by tributary specific flow needs and the need to manage cold-water resources for the protection of public trust resources.
- Criteria for percentages of unimpaired flows apply only up to a specified maximum cap; appropriate maximum flow caps still need to be determined based on public trust needs and to avoid flooding.
- Additional flows may be needed for the protection of public trust resources for periods of time for which no flow criteria are recommended or where 2006 Bay-Delta Plan flow objectives are recommended, but adequate information is not available at this time to recommend such flows.

Table 23. Hydrodynamics Summary Criteria

Hydrodynamics: Net OMR, Inflow-Export Ratios, and Jersey Point

Category A

O	N	D	J	F	M	A	M	J	J	A	S	Criteria
■												1) San Joaquin River Flow to Export Ratio: Vernalis flows to exports greater than 0.33 during fall pulse flow (e.g., October 15 – 26); complementary action to San Joaquin River inflow critieria #2

Category B

O	N	D	J	F	M	A	M	J	J	A	S	Criteria
					■			■				2) Net OMR Flows: greater than -1,500 cfs in Critical and Dry water years
						■	■					3) Net OMR Flows: greater than 0 or -1,500 cfs in Critical and Dry water years, when FMWT index for longfin smelt is less than 500, or greater than 500, respectively
		■	■	■								4) Net OMR Flows: greater than -5,000 cfs in all water year types
	■	■	■	■	■	■	■	■				5) Net OMR Flows: greater than -2,500 cfs when salmon smolts are determined to be present in the Delta
					■	■	■	■				6) San Joaquin River Flow to Export Ratio: Vernalis flows to exports greater than 4.0 when juvenile San Joaquin River salmon are migrating in mainstem San Joaquin River
	■	■	■	■	■	■	■	■				7) Jersey Point: Positive flows when salmon present in the Delta
■	■	■	■	■	■	■	■	■	■	■	■	8) Exports to Delta Inflows: 2006 Bay-Delta Plan exports to inflows restrictions

Basis for Criteria and Explanation

1) Reduce straying and improve homing fidelity for San Joaquin basin adult salmon
2) Reduce entrainment of larval / juvenile delta smelt, longfin smelt, and provide benefits to other desirable species
3) Same as number 2), but if the previous FMWT index for longfin smelt is less than 500, then OMR must be greater than 0 (to reduce entrainment losses when abundance is low), or greater than -1,500 if the previous FMWT index for longfin smelt is greater than 500
4) Reduce entrainment of adult delta smelt, longfin smelt, and other species; less negative flows may be warranted during periods when significant portions of the adult smelt population migrate into the south or central Delta; thresholds for such flows need to be determined
5) Reduce risk of juvenile salmon entrainment and straying to central Delta at times when juveniles are present in the Delta; will also provide associated benefits for adult migration
6) Improve survival of San Joaquin River juvenile salmon emigrating down the San Joaquin River and improve subsequent escapement 2.5 years later
7) Increase survival of outmigrating smolts, decrease diversion of smolts into central Delta where survival is low, and provide attraction flows for adult returns
8) Protection of estuarine dependent species

(cont.)

Notes:

- These flow criteria do not consider any balancing of public trust resource protection with public interest needs for water.
- All flows are subject to appropriate ramping rates to avoid ramping impacts to public trust resources.
- These flow critieria should be tempered by tributary specific flow needs and the need to manage cold-water resources for the protection of public trust resources.
- Criteria for percentages of unimpaired flows apply only up to a specified maximum cap; appropriate maximum flow caps still need to be determined based on public trust needs and to avoid flooding.
- Additional flows may be needed for the protection of public trust resources for periods of time for which no flow criteria are recommended or where 2006 Bay-Delta Plan flow objectives are recommended, but adequate information is not available at this time to recommend such flows.

Table 24. Other Summary Determinations

Variability and the Natural Hydrograph:

- Criteria should reflect the frequency, duration, timing, and rate of change of flows, and not just volumes or magnitudes. Accordingly, whenever possible, the criteria specified above are expressed as a percentage of the unimpaired hydrograph.
- Inflows should generally be provided from tributaries to the Delta watershed in proportion to their contribution to unimpaired flow unless otherwise indicated. This concept is reflected in the specific criteria above.

Floodplain Activation and Other Habitat Improvements:

- Studies and demonstration projects for, and implementation of, floodplain restoration, improved connectivity and passage, and other habitat improvements should proceed to provide additional protection of public trust uses and potentially allow for the reduction of flows otherwise needed to protect public trust resources in the Delta.

Water Quality and Contaminants:

- The Central Valley and San Francisco Regional Water Boards should continue developing TMDLs for all listed pollutants and adopting programs to implement control actions.
- The Central Valley Regional Board should require additional studies and incorporate discharge limits and other controls into permits, as appropriate, for the control of nutrients and ammonia.

Coldwater Pool Resources and Instream Flow Needs on Tributaries:

- Temperature and water supply modeling and analyses should be conducted to identify conflicting requirements to achieve both flow and cold water temperature goals.

Adaptive Management:

- A strong science program and a flexible management regime are critical to improving flow criteria. The State Water Board should work with the Council, the Delta Science Program, IEP, and others to develop the framework for adaptive management that could be relied upon for the management and regulation of Delta flows.
- The numeric criteria in this report are all short term criteria that are only appropriate for the current physical system and climate; actual flows should be informed by adaptive management
- Only the underlying principles for the numeric criteria and these other measures are advanced as long termcriteria.

6. References

Exhibits Cited

American Rivers (AR), Natural Heritage Institute (NHI). Exhibit 1. Testimony of John R. Cain, Dr. Jeff Opperman, and Dr. Mark Tompkins on Sacramento and San Joaquin Flows, Floodplains, Other Stressors, and Adaptive Management.

California Department of Fish and Game (DFG). Exhibit 1. Effects of Delta Inflow and Outflow on Several Native, Recreational, and Commercial Species.

California Department of Fish and Game (DFG). Exhibit 2. Development of an Estuarine Fish Habitat Suitability Indicator Based on Delta Outflow and Other Factors.

California Department of Fish and Game (DFG). Exhibit 3. Flows Needed in the Delta to Restore Anadromous Salmonid Passage from the San Joaquin River at Vernalis to Chipps Island.

California Department of Fish and Game (DFG). Exhibit 4. Effects of Water Temperature on Anadromous Salmonids in the San Joaquin River Basin.

California Sportfishing Protection Alliance (CSPA). Exhibit 1. Testimony of Bill Jennings.

California Sportfishing Protection Alliance (CSPA). Exhibit 7. Testimony of Carl Mesick, Statement Of Key Issues On The Volume, Quality, And Timing Of Delta Outflows Necessary For The Delta Ecosystem to Protect Public Trust Resources With Particular Reference To Fall-Run Chinook Salmon In The San Joaquin River Basin.

California Sportfishing Protection Alliance (CSPA). Exhibit 14. The High Risk of Extinction for the Natural Fall-Run Chinook Salmon Population in the Lower Tuolumne River due to Insufficient Instream Flow Releases. Carl Mesick, Ph.D. Energy and Instream Flow Branch U.S. Fish and Wildlife Service.

California Water Impact Network (CWIN). Exhibit 2. Testimony of Tim Stroshane.

Delta Environmental Flows Group (DEFG). Exhibit 1. Key Points on Delta Environmental Flows for the State Water Resources Control Board.

Delta Environmental Flows Group (DEFG). Exhibit 2. Changing ecosystems: a brief ecological history of the Delta.

Environmental Defense Fund (EDF). Exhibit 1. A Focal Species and Ecosystem Functions Approach for Developing Public Trust Flows in the Sacramento and San Joaquin River Delta. Testimony prepared by Stillwater Sciences.

National Marine Fisheries Service (NMFS). Exhibit 3. NMFS OCAP Biological Opinion & Appendices (June 2009)

National Marine Fisheries Service (NMFS). Exhibit 5. Public Draft Recovery Plan for Central Valley Salmon and Steelhead & Appendices (October 2009).

National Marine Fisheries Service (NMFS). Exhibit 7. Residence of Winter-Run Chinook Salmon in the Sacramento-San Joaquin Delta: The role of Sacramento River hydrology in driving juvenile abundance and migration patterns in the Delta.

National Marine Fisheries Service (NMFS). Written Summary.

Pacific Coast Federation of Fishermen's Associations (PCFFA). Exhibit 2. Testimony of William M. Kier. San Francisco Bay-Delta estuary water quality and flow criteria necessary to protect Sacramento River fall-fun chinook salmon.

State and Federal Water Contractors (SFWC). Exhibit 1. Written Testimony: The Information Proceeding to Develop Flow Criteria for the Delta Ecosystem. Submitted on behalf of the San Luis and Delta Mendota Water Authority, State Water Contractors, Westland Water District, Santa Clara Valley Water District, Kern County Water Agency, and Metropolitan Water District of Southern California.

The Bay Institute (TBI) and Natural Resources Defense Council (NRDC). Exhibit 1. Written Testimony of Jonathan Rosenfield, Ph.D., Christina Swanson, Ph.D., John Cain, and Carson Cox Regarding General Analytical Framework.

The Bay Institute (TBI) and Natural Resources Defense Council (NRDC). Exhibit 2 – Written Testimony of Jonathan Rosenfield, Ph.D. and Christina Swanson, Ph.D. Regarding Flow Criteria for the Delta Necessary to Protect Public Trust Resources: Delta Outflows.

The Bay Institute (TBI) and Natural Resources Defense Council (NRDC). Exhibit 3. Written Testimony of Christina Swanson, Ph.D., John Cain, Jeff Opperman, Ph.D., and Mark Tompkins, Ph.D. Regarding Delta Inflows.

The Bay Institute (TBI) and Natural Resources Defense Council (NRDC). Exhibit 4. Written Testimony of Christina Swanson, Ph.D. Regarding Delta Hydrodynamics.

United States Department of the Interior (DOI). Exhibit 1. Comments regarding the California State Water Resources Control Board notice of public informational proceeding to develop Delta flow criteria for the Delta ecosystem necessary to protect public trust resources.

Closing Comments Cited

American Rivers (AR), Natural Heritage Institute (NHI). Closing Comments.

California Department of Fish and Game (DFG). Closing Comments.

California Sportfishing Protection Alliance (CSPA). Closing Comments.

California Water Impact Network (CWIN). Closing Comments.

Contra Costa Water District (CCWD). Closing Comments.

Department of Water Resources (DWR). Closing Comments.

Environmental Defense Fund (EDF). Closing Comments.

The Bay Institute (TBI) and Natural Resources Defense Council (NRDC). Closing Comments.

State and Federal Water Contractors (SFWC). Closing Comments.

Literature Cited

Anadromous Fish Restoration Program (AFRP). 2005. Recommended streamflow schedules to meet the AFRP doubling goal in the San Joaquin River Basin. 27 September 2005.

Baxter, R.D. 1999. Pleuronectiformes. Pages 369-442 In J. Orsi, editor. Report on the 1980-1995 fish, shrimp and crab sampling in the San Francisco Estuary. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Technical Report 63.

Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Sommer and K. Souza. 2008. Pelagic organism decline progress report: 2007 synthesis of results. Interagency Ecological Program for the San Francisco Estuary. http://www/science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2007_synthesis_report_031408.pdf

Baxter, R. M. Nobriga, S. Slater and R. Fujimura. 2009. Effects Analysis. State Water Project Effects on Longfin Smelt. California Department of Fish and Game, Sacramento, CA.

Bay Delta Conservation Plan (BDCP). 2009. Working Draft Conservation Strategy, Chapter 3. 27 July 2009.

Bennett, W.A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science [Internet]:3(2). http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art1

Brandes, P.L. and J S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: R.L. Brown, editor, Contributions to the biology of Central Valley salmonids. Volume 2. California Department of Fish and Game Fish Bulletin 179:39-136.

Brown, L.R. 2003. Will tidal wetland restoration enhance populations of native fishes? San Francisco Estuary and Watershed Science 1, Article 2. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2

Brown, L.R and J.T. May. 2006. Variation in spring nearshore resident fish species composition and life histories in the Lower Sacramento-San Joaquin watershed and Delta. San Francisco Estuary and Watershed Science 4. Article 1. http://escholarship.org/uc/item/09j597dn?query=Brown,%20L.R.

Brown, L. R., and D. Michniuk. 2007. Littoral fish assemblages of the alien-dominated Sacramento-San Joaquin Delta, California, 1980-1983 and 2001-2003. Estuaries and Coasts 30:186-200.

Brown, L.R., W. Kimmerer, and R. Brown. 2008. Managing water to protect fish: a review of California's Environmental Water Account, 2001-2005. Environmental Management DOI 10.1007/s00267-008-9213-4 http://www.springerlink.com/content/u4022223x2181287/fulltext.pdf

Bunn, S.E. and A.H. Arthington. 2002. Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity. Environmental Management 30(4):492-507.

CALFED Bay-Delta Program. 2000. Strategic plan for ecosystem restoration. Sacramento, CA.

California Department of Fish and Game (DFG). 1987. Requirements of American Shad (*Alosa sapidissima*) in the Sacramento-San Joaquin River System. Exhibit 23, Entered by the DFG for the State Water Resources Control Board 1987 Water Quality/Water Rights Proceeding on the San Francisco Bay/Sacramento-San Joaquin Delta.

California Department of Fish and Game (DFG). 1987b. Long-term trends in zooplankton distribution and abundance in the Sacramento-San Joaquin Estuary. Exhibit 28, Entered by DFG for the State Water Resources Control Board 1987 Water Quality and Water Rights Proceedings on the San Francisco Bay and Sacramento-San Joaquin Delta.

California Department of Fish and Game (DFG). 1992. Estuary dependent species. Exhibit 6, Entered by the DFG for the State Water Resources Control Board 1992 Water Quality/Water Rights Proceedings on the San Francisco Bay/Sacramento-San Joaquin Delta.

California Department of Fish and Game (DFG). 1998. A status review of the spring run Chinook salmon in the Sacramento River drainage. Report to the Fish and Game Commission. Candidate species status report 98-1. Sacramento, California. June. 394 pp.

California Department of Fish and Game (DFG). 2009. California Endangered Species Act Incidental Take Permit No. 2081-2009-001-03, Department of Water Resources, California State Water Project Delta Facilities and Operations.

California Department of Fish and Game (DFG). 2010. State and Federally Listed Endangered and Threatened Animals of California. January 2010. Biogeographic Data Branch, California Natural Diversity Database.

Central Valley Regional Water Quality Control Board. 2009. The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board, Central Valley Region, The Sacramento River Basin and The San Joaquin River Basin, Fourth Edition. Revised September 2009 (with Approved Amendments).

Daniels, R.A., and P.B. Moyle. 1983. Life history of the Sacramento splittail (Cyprinidae: *Pogonichthys macrolepidotus*) in the Sacramento–San Joaquin estuary. Fishery Bulletin 81:647–654.

Dege, M., and L.R. Brown. 2004. Effect of outflow on spring and summertime distribution of larval and juvenile fishes in the upper San Francisco Estuary. Pages 49–65 In F. Feyrer, L.R. Brown, R.L. Brown, and J.J. Orsi, eds. Early life history of fishes in the San Francisco estuary and watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Delta Smelt Working Group (DSWG). 2006. Meeting Notes dated September 26, 2006. http://www.fws.gov/sacramento/es/documents/ds_working_group/DSWG_Minutes_26Sep06.pdf

Department of Water Resources (DWR). 2006. California Central Valley Unimpaired Flow Data, Fourth Edition, Bay-Delta Office, California Department of Water Resources, Sacramento, CA.

Department of Water Resources (DWR). 2007. Sacramento-San Joaquin Delta Overview. State of California. See http://baydeltaoffice.water.ca.gov/sdb/tbp/deltaoverview/index.cfm

Dettman, D.H., D.W. Kelley, and W.T. Mitchell. 1987. The influence of flow on Central Valley salmon. Prepared for the California Department of Water Resources. Revised July 1987. (Available from D.W. Kelley and Associates, 8955 Langs Hill Rd., P.O. Box 634, Newcastle, CA 95658).

Dugdale, R.C., F.P. Wilkerson, V.E. Hogue, and A. Marchi. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay, Estuarine Coastal and Shelf Science 73:17-29.

Emmett, R.L., S.A. Hinton, S.L. Stone, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries Volume II: species life history summaries. NOAA/NOS Strategic Environmental Assessments Division, 8, Rockville, MD. 329 pp.

Feyrer, F. 2004. Ecological segregation of native and alien larval fish assemblages in the southern Sacramento-San Joaquin Delta. Pages 67-80 in F. Feyrer, L.R. Brown, R.L. Brown, and J.J. Orsi, editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Feyrer, F. and M.P. Healey. 2003. Fish community structure and environmental correlates in the highly altered southern Sacramento-San Joaquin Delta. Environmental Biology of Fishes 66(2):123-132.

Feyrer, F., B. Herbold, S.A. Matern, and P.B. Moyle. 2003. Dietary shifts in a stressed fish assemblage: Consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes 67(3):277-288.

Feyrer, F., T. Sommer, and R.D. Baxter. 2005. Spatial-temporal distribution and habitat associations of age-0 splittail in the lower San Francisco watershed. Copeia 2005(1):159-168.

Feyrer, F., T. Sommer, and W. Harrell. 2006a. Managing floodplain inundation for native fish: production dyanmics of age-0 splittail (*Pogonichtys macrolepidotus*) in California's Yolo Bypass. Hydrobiologia 573:213-226.

Feyrer, F.T., T. Sommer and W. Harrell. 2006b. Importance of flood dynamics versus intrinsic physical habitat in structuring fish communities: Evidence from two adjacent engineered floodplains on the Sacramento River, California. North American Journal of Fisheries Management 26(2):408-417.

Feyrer, F, M.L. Nobriga, T.R. Sommer. 2007. Multi-decadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal of Fisheries and Aquatic Sciences 64:723-734.

Feyrer, F., T. Sommer, and J. Hobbs. 2007a. Living in a dynamic environment: variability in life history traits of age-0 splittail in tributaries of San Francisco Bay. Transactions American Fisheries Society 136:1393-1405.

Feyrer, F., K. Newman, M.L. Nobriga, and T.R.Sommer. In review. Modeling the effects of future freshwater flow on the abiotic habitat of an imperiled estuarine fish. Manuscript submitted to Estuaries and Coasts.

Fleenor, W., W. Bennett, P. Moyle, and J. Lund. 2010. On developing prescriptions for freshwater flows to sustain desirable fishes in the Sacramento-San Joaquin Delta. Submitted to the State Water Resources Control Board regarding flow criteria for the Delta necessary to protect public trust resources. 43 pp.

Foe, C., A. Ballard, and S. Fong. 2010. Nutrient concentrations and biological effects in the Sacramento-San Joaquin Delta, Draft Report. Central Valley Regional Water Quality Control Board.

Glibert, P.M. 2010. Long-term changes in nutrient loading and stoichiometry and their relationships with changes in the food web and dominant pelagic fish species in the San Francisco Estuary, California. Pre-publication copy. Reviews in Fisheries Science.

Grimaldo, L.F., T. Sommer. N. Van Ark, G. Jones, E. Holland, P.B. Moyle, and B. Herbold. 2009. Factors affecting fish entrainment into massive water diversions in a tidal freshwater estuary: can fish losses be managed? North American Journal of Fisheries Management 29:1253–1270.

Hallock, R.J., W.F. Van Woert, and L. Shapovalov. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout (*Salmo gairdnerii gairdnerii*) in the Sacramento River system. California Department of Fish and Game. Fish Bulletin No. 14. 74 pp.

Harrell, W.C., and T.R. Sommer. 2003. Patterns of Adult Fish Use on California's Yolo Bypass Floodplain. California riparian systems: Processes and floodplain management, ecology, and restoration. Pages 88-93 in P.M. Faber, editor of 2001 Riparian Habitat and Floodplains Conference Proceedings, Riparian Habitat Joint Venture, Sacramento, California.

Hatfield, S. 1985. Seasonal and interannual variation in distribution and population abundance of the shrimp *Crangon franciscorum* in San Francisco Bay. Hydrobiologia 129:199–210.

Haugen, C.W. 1992. Starry flounder. Pages 103-104 In W. S. Leet, C. D. Dewees, and C. W. Haugen, eds. California's living marine resources and their utilization. Sea Grant Extension Program, UCSGEP-92-12. Department of Wildlife and Fisheries Biology, University of California, Davis, California.

Healey, M.C. 1991. Life history of Chinook salmon (*Oncorhynchus tshawytscha*). In C. Groot and L. Margolis, editors, Pacific Salmon Life Histories, pages 396-445 [check. Another reference said Pages 313-393]. University of British Columbia Press, Vancouver, British Columbia. 564 pp.

Hennessy, A. 2009. Zooplankton monitoring 2008. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter 22(2):10-16.

Hieb, K. 1999. Caridean Shrimp. In: J. Orsi, editor, Report on the 1980-1995 fish, shrimp, and crab sampling in the San Francisco Estuary, California. IEP Technical Report 63, 501 pp.

Hughes, R.M., J.N. Rinne, and B. Calamusso. 2005. Historical changes in large river fish assemblages of the Americas: a synthesis. American Fisheries Society Symposium 45:603-612.

Jassby, A.D., W.J. Kimmerer, S.G. Monismith, C. Armor, J.E. Cloern, T.M. Powell, J.R. Schubel, and T.J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5(1):272-289.

Jassby, A.D., and J.E. Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Freshwater and Marine Ecosystems 10:323-352.

Jassby, A.D. 2008. Phytoplankton in the Upper San Francisco Estuary: Recent biomass trends, their causes and their trophic significance. San Francisco Estuary and Watershed Science. 6(1):Article 2.

Jeffres, C. A., J.J. Opperman, and P.B. Moyle. 2008. Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. Environmental Biology of Fishes 83:449-458.

Karpov, K.A., D.P. Albin, and W.H. Van Buskirk. 1995. The marine recreational fishery in northern and central California: A historical comparison (1958-86), status of stocks (1980-86) and effects of changes in the California current. California Department of Fish and Game, Fish Bulletin. 176 pp.

Kimmerer, W.J. 2002a. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Marine Ecology Progress Series 243:39-55.

Kimmerer, W.J. 2002b. Physical, biological and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25:1275-1290.

Kimmerer, W.J. 2004. Open water processes of the San Francisco Estuary: from physical forcing to biological processes. San Francisco Estuary and Watershed Science [Internet] 2(1) http://repositories.cdlib.org/jmie/sfews/vol2/iss1/art1

Kimmerer, W.J. 2008. Losses of Sacramento River Chinook salmon and Delta smelt (*Hypomesus transpacificus*) to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 6(2):Article 2.

Kimmerer, W. and M. Nobriga. 2008. Investigating particle transport and fate in the Sacramento-San Joaquin Delta using a Particle Tracking Model. San Francisco Estuary and Watershed Science 6(1):Article 4.

Kimmerer, W.J., E.S. Gross, and M.L. MacWilliams. 2009. Is the response of estuarine neckton to freshwater flow in the San Francisco Estuary explained by variation in habitat volume? Estuaries and Coasts 32:375-389.

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 P.D. Cross and D.L. Williams, editors, Proceedings of the National Symposium on Freshwater Inflow to Estuaries, pp. 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, pp. 393-411. Academic Press, New York, New York.

Kjelson, M.A., and P.L. Brandes. 1989. The use of smolt survival estimates to quantify the effects of habitat changes on salmonid stocks in the Sacramento-San Joaquin rivers, California. Pages 100-115 in Levings, C.D., L.B. Holtby, and M.A. Henderson. (ed.) Proceedings of the National Workshop on Effects of Habitat alteration on salmonid Stocks. Can. Spec. Publ. Fish. Aquat. Sci. 105:100-115.

Lee, K.N. 1999. Appraising Adaptive Management. Conservation Ecology 3(2):3. http://www.consecol.org/vol3/iss2/art3.

Lott, J. 1998. Feeding habits of juvenile and adult delta smelt from the Sacramento-San Joaquin River Estuary. Interagency Ecological Program Newsletter 11(1):14-19.

Lund, J., E. Hanak, W. Fleenor, R. Howitt, J. Mount, and P. Moyle. 2007. Envisioning futures for the Sacramento-San Joaquin Delta, Public Policy Institute of California, San Francisco, CA. 284 pp.

Lund, J., E. Hanak, W. Fleenor, W. Bennett, R. Howitt, J. Mount, and P. Moyle. 2008. Comparing Futures for the Sacramento-San Joaquin Delta, Public Policy Institute of California, San Francisco, CA. 184 pp.

Lund, J., E. Hanak, W. Fleenor, W. Bennett, R. Howitt, J. Mount, and P. Moyle. 2010. Comparing Futures for the Sacramento-San Joaquin Delta. University of California Press, Berkeley, CA. 256 pp.

MacFarlane, B.R. and E.C. Norton. 2002. Physiological ecology of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) at the southern end of their distribution, the San Francisco Estuary and Gulf of the Farallones, California. Fisheries Bulletin 100:244-257.

Mager, R.C. 1996. Gametogenesis, Reproduction and Artificial Propogation of Delta Smelt, *Hypomesus transpacificus*. [Dissertation] Davis: University of California, Davis. 115 pp.

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 pp.

Matern, S.A., P.B. Moyle and L.C. Pierce. 2002. Native and alien fishes in a California estuarine marsh: twenty-one years of changing assemblages. Transactions of the American Fisheries Society 131:797-816.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42. 156 pp.

McEwan, D. and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game. Sacramento, California. 234 pp.

Meng, L., P.B. Moyle, and B. Herbold. 1994. Changes in abundance and distribution of native and introduced fishes of Suisun Marsh. Transactions of the American Fisheries Society 123:498-507.

Meng, L., and P.B. Moyle. 1995. Status of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society 124:538-549.

Mesick, C. 2009. The high risk of extinction for the natural fall-run chinook salmon population in the lower Tuolumne River due to insufficient instream flow releases. U.S. Fish and Wildlife Service, Energy and Instream Flow Branch, Sacramento, CA. 4 September 2009. Exhibit No. FWS-50.

Miller, D.J., and R.N. Lea. 1972. Guide to the coastal marine fishes of California, volume 157.

Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Wildlife and Fisheries Biology Department, University of California, Davis. Prepared for The Resources Agency, California Department of Fish and Game, Rancho Cordova.

Moyle, P.B. 2002. Inland Fishes of California, 2nd Edition. University of California Press, Berkeley, California. 502 pp.

Moyle, P.B., R.D. Baxter, T. Sommer, T.C. Foin, and S.A. Matern. 2004. Biology and population dynamics of Sacramento splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: A review. San Francisco Estuary and Watershed Science 2(2): Article 3.

Moyle, P.B., P.K. Crain, and K. Whitener. 2007. Patterns in the use of a restored California floodplain by native and alien fishes. San Francisco Estuary and Watershed Science 5(3), 1-27. http://repositories.cdlib.org/jmie/sfews/vol5/iss3/art1

Moyle, P.B. 2008. The future of fish in response to large-scale change in the San Francisco Estuary, California. Pages 357-374 in K.D. McLaughlin, editor. Mitigating impacts of natural hazards on fishery ecosystems. American Fisheries Society, Symposium 64, Bethesda, Maryland.

Moyle, P. B. and W.A. Bennett. 2008. The future of the Delta ecosystem and its fish. Technical Appendix D. Comparing Futures for the Sacramento-San Joaquin Delta. Public Policy Institute of California. San Francisco, CA., 1-38.

Moyle, P.B., W.A. Bennet, W.E. Fleenor, and J.R. Lund. 2010. Habitat variability and complexity in the Upper San Francisco Estuary. Working Paper, Delta Solutions, Center for Watershed Sciences, University of California, Davis.

Müller-Solger, A., A.D. Jassby, and D.C. Müller-Navarra. 2002. Nutritional quality of food resources for zooplankton (Daphnia) in a tidal freshwater system (Sacramento-San Joaquin River Delta). Limnol Oceanogr 47(5):1468-1476.

Murray, C. and D.R. Marmorek. 2004. Adaptive management: A science-based approach to managing ecosystems in the face of uncertainty. In: N.W.P. Munro, T.B. Herman, K. Beazley and P. Dearden (eds.). Making Ecosystem-based Management Work: Proceedings of the Fifth International Conference on Science and Management of Protected Areas, Victoria, BC, May, 2003. Science and Management of Protected Areas Association, Wolfville, Nova Scotia. http://www.essa.com/downloads/AM_paper_Fifth_International_SAMPAA_Conference.pdf

National Academy of Sciences. 2010. A scientific assessment of alternatives for reducing water management effects on threatened and endangered fishes in the California's Bay Delta. Committee on Sustainable Water and Environmental Management in the California Bay-Delta. The National Academies Press; National Research Council, Washington, D.C. http://www.nap.edu/catalog/12881.html

National Marine Fisheries Service (NMFS). 1994. Status of Sacramento River Winter-run Chinook Salmon, Final Rule. Federal Register 59(2):440-450.

National Marine Fisheries Service (NMFS). 1998. Threatened Status for Two ESUs of Steelhead in Washington, Oregon, and California, Final Rule. Federal Register 63(53):13347-13371.

National Marine Fisheries Service (NMFS). 1999. Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California, Final Rule. Federal Register 64(179):50394-50415.

National Marine Fisheries Service (NMFS). 2004. Establishment of Species of Concern List, Addition of Species to Species of Concern List, Description of Factors for Identifying Species of Concern, and Revision of Candidate Species List Under the Endangered Species Act. Federal Register 69(73):19975-19979.

National Marine Fisheries Service (NMFS). 2005. Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs, Final Rule. Federal Register 70(123):37160-37204.

National Marine Fisheries Service (NMFS). 2006a. Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead, Final Rule. Federal Register 71(3):834-862.

National Marine Fisheries Service (NMFS). 2006b. Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon, Final Rule. Federal Register 71(67):17757-17766.

National Marine Fisheries Service (NMFS). 2009. Public draft recovery plan for the evolutionarily significant units of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon and the distinct population segment of Central Valley steelhead. Sacramento Protected Resources Division. http://swr.nmfs.noaa.gov/recovery/cent_val/Public_Draft_Recovery_Plan.pdf

Newman, K.B. 2003. Modelling paired release-recovery data in the presence of survival and capture heterogeneity with application to marked juvenile salmon. Statistical Modelling 3:157-177.

Nobriga, M.L., F. Feyrer, R.D. Baxter, and M. Chotowski. 2005. Fish community ecology in an altered river delta: spatial patterns in species composition, life history strategies, and biomass. Estuaries 28:776-785.

Nobriga, M.L., F. Feyrer, and R.D. Baxter. 2006. Aspects of Sacramento pikeminnow biology in nearhsore habitats of the Sacramento-San Joaquin Delta, California. Western North American Naturalist 66:106-114.

Nobriga, M.L., T.R. Sommer, F. Feyrer, and K. Fleming. 2008. Long-term trends in summertime habitat suitability for delta smelt (*Hypomesus transpacificus*). San Francisco Estuary and Watershed Science 6:1–13.

Orcutt, H.G. 1950. The life history of the starry flounder, *Platichthys stellatus* (Pallas). Fish Bulletin 78:64 pp.

Perry, R.W. and J.R. Skalski. 2008. Migration and survival of juvenile Chinook salmon through the Sacramento-San Joaquin River Delta during the winter of 2006-2007. Report prepared for the U.S. Fish and Wildlife Service. September 2008. 32 pp.

Perry, R.W. and J.R. Skalski. 2009. Survival and migration route probabilities of juvenile chinook salmon in the Sacramento-San Joaquin River Delta during the winter of 2007-2008. Report prepared for the U.S. Fish and Wildlife Service. 15 July 2009. 54 pp.

Poff, N.L. and J.K.H. Zimmerman. 2010. Ecological responses to altered flow regimes: a literature review to inform environmental flows science and management. Freshwater Biology 55:194-20.

Reilly, P., K. Walters, and D. Richardson. 2001. Bay Shrimp. pp. 439-442 and 453, In W.S. Leet, C.M. Dewees, R. Klingbeil, and E.J. Larson, eds. California's Living Marine Resources: A Status Report, California Department of Fish and Game, 593 pp.

Ribeiro, F., P.K. Crain, and P.B. Moyle. 2004. Variation in Condition Factor and Growth in Young-of-Year Fishes in Floodplain and Riverine Habitats of the Cosumnes River, California. Hydrobiologia 527:7-84.

Rosenfield, J.A. and R.D. Baxter. 2007. Population dynamics and distribution patters of longfin smelt in the San Francisco Estuary. Transactions of the American Fisheries Society 136:1577-1592.

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

San Joaquin River Group Authority (SJRGA). 2007. 2006 Annual Technical Report: On implementation and monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January. 137 pp.

San Joaquin River Group Authority (SJRGA). 2008. 2007 Annual Technical Report: On implementation and monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. Prepared for the California Water Resources Control Board incompliance with D-1641. 128 pp.

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. Baxter, and B. Herbold. 1997. Resilience of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society 126:961-976.

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

Sommer, T., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001b. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26:6–16.

Sommer, T.R., W.C. Harrell, A. Mueller-Solger, B. Tom, and W. Kimmerer. 2004. Effects of flow variation on channel and floodplain biota and habitats of the Sacramento River, California, USA. Aquatic Conservation: Marine and Freshwater Ecosystems 14:247-261.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32:270–277.

Sommer, T., K. Reece, F. Mejia, and M. Nobriga. 2009. Delta smelt life history contingents: a possible upstream rearing strategy. IEP Newsletter 22(1):11-13.

State Water Resources Control Board. 1999. Final Environmental Impact Report for Implementation of the 1995 Bay/Delta Water Quality Control Plan. http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/eirs/eir1999/index.shtml

State Water Resources Control Board. 2006a. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. http://www.waterrights.ca.gov/baydelta/docs/2006_plan_final.pdf

State Water Resources Control Board. 2006b. Plan Amendment Report, Appendix 1 to the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/wq_control_plans/2006wqcp/docs/2006_app1_final.pdf

State Water Resources Control Board. 2008. Strategic Workplan for Activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. http://www.waterrights.ca.gov/baydelta/docs/strategic_plan/baydelta_workplan_final.pdf

Stevens, D.E. and L.W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin river system. North American Journal of Fisheries Management 3:425-437.

U.S. Environmental Protection Agency. 1999. 1999 Update of Ambient Water Quality Criteria for Ammonia. EPA 822-R-99-014.http://www.epa.gov/waterscience/criteria/ammonia/99update.pdf

U.S. Fish and Wildlife Service (USFWS). 1987. Exhibit 31: The Needs of Chinook Salmon, *Oncorhyncus tshawytscha*, in the Sacramento-San Joaquin Estuary. Entered by the U.S. Fish and Wildlife Service for the State Water Resources Control Board, 1987

Water Quality/Water Rights Proceeding on the San Francisco Bay/Sacramento-San Joaquin Delta.

U.S. Fish and Wildlife Service (USFWS). 1992. Expert testimony of United States Fish and Wildlife Service on chinook salmon technical information for State Water Resources Control Board Water Rights phase of the Bay/Delta Estuary Proceedings, 6 July 1992. WRINT-USFWS-7.

U.S. Fish and Wildlife Service (USFWS). 1993. Determination of Threatened Status for the Delta Smelt, Final Rule. Federal Register 58(42):12854-12864.

U.S. Fish and Wildlife Service (USFWS). 1995b. Working Paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 3. May 9, 1995. Prepared for the U.S. Fish and Wildlife Services under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.

U.S. Fish and Wildlife Service (USFWS). 1996. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service (USFWS). 2008. Biological opinion on coordinated operations of the central valley project and state water project. http://www.fws.gov/sacramento/es/documents/swp-cvp_ops_bo_12-5_final_ocr.pdf.

U.S. Fish and Wildlife Service (USFWS). 2009. 12-Month Finding on a Petition to List the San Francisco Bay-Delta Population of the Longfin Smelt (*Spirinchus thaleichthys*) as Endangered. Federal Register 74(67):16169-16175.

U.S. Fish and Wildlife Service (USFWS). 2010. 12-Month Finding on a Petition to Reclassify the Delta Smelt from Threatened to Endangered Throughout Its Range. Federal Register 75(66):17667-17680.

Vogel, D.A. 2004. Juvenile Chinook salmon radio-telemetry studies in the northern and central Sacramento-San Joaquin Delta, 2002-2003. Report to the National Fish and Wildlife Foundation, Southwest Region. January. 44 pp.

Vogel, D.A. 2008. Pilot study to evaluate acoustic-tagged juvenile Chinook salmon smolt migration in the Northern Sacramento-San Joaquin Delta 2006-2007. Report prepared for the California Department of Water Resources, Bay/Delta Office. Natural Resource Scientists, Inc. March. 43 pp.

Wang, J. 1986. Fishes of the Sacramento-San Joaquin Estuary and adjacent waters, California: a guide to the early life stages. Interagency Ecological Studies Program Technical Report 9. Sacramento, California.

Wang, J.C.S. 2007. Spawning, early life stages, and early life histories of the Osmerids found in the Sacramento-San Joaquin Delta of California. Tracy Fish Facilities Studies California Volume 38. U.S. Bureau of Reclamation, Mid-Pacific Region.

Werner, I. L. Deanovic, M. Stillway, and D. Markiewicz 2008. The effects of wastewater treatment effluent associated contaminants on delta smelt. Final report to the State Water Resources Control Board. 60 pp.

Werner, I., L. Deanovic, M. Stillway, and D. Markiewicz. 2009. Acute Toxicity of Ammonia/um and Wastewater Treatment Effluent-Associated Contaminants on Delta Smelt, Final Report. 3 April 2009.

Wilkerson, F.P., R.C. Dugdale, V.E. Hogue, and A. Marchi. 2006. Phytoplankton Blooms and Nitrogen Productivity in the San Francisco Bay. Estuaries and Coasts. 29(3):401-416.

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2007. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2007. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

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. Pages 71-176 in Brown, R.L. (ed.), Contributions to the biology of Central Valley salmonids. (Fish Bulletin 179 v.1). Sacramento, CA. California Deptartment of Fish and Game.

7. Appendices

Appendix A: Summary of Participant Recommendations

Appendix A, Table 1. Delta outflow recommendations summary table (cfs unless otherwise noted).

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Note
Unimpaired Flow 1956-2003	C	16092	23292	31045	29103	27552	15301	5974	3880	4096	8167	8372	12531	
	D	24670	37460	52907	45810	39512	18994	6801	4759	5180	7221	16635	19339	
	BN	32402	63985	52056	53471	49644	25325	9091	5683	6004	7027	12842	16911	
	AN	88051	99722	86990	69589	78076	50019	18214	7932	7862	8162	13980	26763	
	W	113261	114512	103250	92975	96911	68197	27987	11354	8717	11804	30357	77204	
Historical Flow 1956-2003	C / D	14117	17916	17597	9193	7367	4504	3952	3334	4285	6896	9663	12734	87
	BN	27274	48832	32673	14991	10100	4336	3952	5025	7798	12116	15192	18996	
	AN	61801	70133	70404	32283	27876	13444	7172	5985	7865	6766	10940	17093	
	W	94930	111565	87497	67642	46530	29897	14279	10588	15545	13385	23024	60061	
D1641	C	4500 ([1])	7100 - 29200 ([2])					4000	3000	3000	3000	3500		1, 2
	D	4500	7100 - 29200					5000	3500	3000	4000	4500		
	BN	4500	7100 - 29200					6500	4000	3000	4000	4500		
	AN	4500	7100 - 29200					8000	4000	3000	4000	4500		
	W	4500	7100 - 29200					8000	4000	3000	4000	4500		
Draft D1630	All				6700									3
	C					3300	3100	2900						4
	D					4300	3600	3200						
	BN					11400	9500	6500						
	AN					14000	10700	7700						
	W					14000	14000	10000						
	W		10000											5
	BN & AN	12000												6
	All	6600 (if > flow not required by other standards)												7
TBI / NRDC / AR / NHI / EDF	81-100% (driest years)	14000 - 21000			10000 - 17500		3000 - 4200			5750 - 7500				8
	61-80%	21000 - 35000			17500 - 29000		4200 - 5000			7500 - 9000				
	41-60%	35200 - 55000			29000 - 42500		5000 - 8500			9700 - 12400				
	21-40%	55000 - 87500			42500 - 62500		8500 - 25000			12400 - 16100				
	0-20% (wettest years)	87500 - 140000			62500 - 110000		25000 - 50000			16100 - 19000				
CSPA / C-WIN	C	4100	9100		6700				4100					9
	D	9200	23500		10800				9200					
	BN	12100	41000		14400				12100					
	AN	14600	90800		23000				14600					
	W	29000	91800		43000				29000					
EDF / Stillwater (monthly average)	C	11500	26800	26800	17500	17500	7500	4800	4800	4800	6500	5300	7500	10, 11, 12
	D	11500	26800	26800	17500	17500	7500	4800	4800	4800	6500	5300	7500	
	BN	26800	26800	26800	26800	26800	11500	7500	7500	7500	7500	7500	11500	
	AN	26800	26800	26800	26800	26800	11500	11500	11500	11500	11500	11500	17500	
	W	26800	26800	26800	26800	26800	17500	17500	17500	17500	17500	17500	26800	
EDF / Stillwater (peak flows)	C	11500	26800	26800	17500	17500	7500	4800	4800	4800	6500	5300	7500	13
	D	11500	26800	26800	17500	17500	7500	4800	4800	4800	6500	5300	7500	
	BN	26800	90800 ([14])	90800 ([15])	26800	26800	11500	7500	7500	7500	7500	7500	11500	14, 15
	AN	26800	105600 ([16])	105600 ([17])	26800	26800	11500	11500	11500	11500	11500	11500	17500	16, 17
	W	26800	105600 ([18])	105600 ([19])	26800	26800	17500	17500	17500	17500	17500	17500	26800	18, 19
USFWS - OCAP Bio Op	AN									X2 ≤ 81 km (approx. 7000)		X2 ≤ 81 km		20
	W									X2 ≤ 74 km (approx. 12400)		X2 ≤ 74 km		

Appendix A, Table 1. Delta outflow recommendations summary table - con't. (p. 2 of 2)

<table>
<tr><th></th><th>Water Year</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sept</th><th>Oct</th><th>Nov</th><th>Dec</th><th>Source / Note</th></tr>
<tr><td colspan="15"></td></tr>
<tr><td>CDFG</td><td>All</td><td colspan="6">Recommendation in X2 format: 64 - 75 km (approx. 29200 - 11400 cfs)</td><td colspan="6"></td><td>21</td></tr>
<tr><td colspan="15"></td></tr>
<tr><td>DWR / SFWC</td><td>All</td><td colspan="12">Recommendation to maintain requirements stipulated in D-1641</td><td>22</td></tr>
<tr><td colspan="15"></td></tr>
<tr><td colspan="15">The following is from Fleenor et al. 2010 (Preliminary Draft) - Functional flow approach with exports occurring via a peripheral canal, tunnel, or other alternative form of conveyance.</td></tr>
<tr><td>Delta Solutions Group</td><td>5 of 10 yrs</td><td colspan="2"></td><td colspan="3">48000</td><td colspan="7"></td><td>23</td></tr>
</table>

Appendix A, Table 2. Sacramento River inflow recommendations (cfs unless noted otherwise).

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Note
D1641	C									3000		3500		
	D									3000	4000	4500		
	BN									3000	4000	4500		
	AN									3000	4000	4500		
	W									3000	4000	4500		
Draft D1630	All				≥18000									24
	All					≥13000 (14-day running average) and ≥9000 (min mean daily flow)								25
	C	1500	2500	2000				1000	1000	1500				26
	D	1500	2500	2500				1000	1000	1500				
	BN	2500	2500	3000				2000	1000	2500				
	AN	2500	2500	3000				2000	1000	2500				
	W	2500	3000	5000				3000	1000	5000				
CDFG	All		6000 (base flows)											27
	All				20000 - 30000 (pulse flows @ Rio Vista)									
C-WIN / CSPA	All		6000 (minimum base flows, measured @ Rio Vista)											28
	All				30000 (Freeport to Chipps Island)									29
PCFFA	All				25000 (Hood to Chipps Island)									30
USFWS					The catch of juvenile salmon at Chipps Island between April and June is correlated to flow at Rio Vista. The highest abundance leaving the Delta has been observed when flows at Rio Vista between April and June averaged above 20000 cfs..."									31
AR / NHI	All	Sac Riv at Bend Bridge - Pulse flows continuously exceed 8000, periodically exceed 12000, for a duration exceeding 2 weeks										See Jan - May		32
	All	Sac Riv at Wilkins Slough and Freeport - Pulse flows of 15000 at Wilkins Slough, and up to 20000 at Freeport, should occur for a duration of 7 days or longer. There should be at least 5 such events in dry years and more in wet years											See Jan - May	33
TBI / NRDC / AR / NHI	C (0-20 percentile)			27500 for 15 cont days										34
	D (20-40 percentile)			27500 for 30 cont days										
	BN			30000 for 60 cont days										
	AN			32500 for 90 continous days										
	W			35000 for 120 continuous days										
NMFS	AN & W		≥ 17700 (at Grimes RM125)											35
	AN & W		≥ 31100 (at Verona RM80)											
	All	Provide pulse flows ≥ 20000 cfs, measured at Freeport periodically during winter-run emigration season to facilitate outmigration past Chipps Island (ie, Dec-Apr)											See Jan-Apr	36

Appendix A, Table 2. Sacramento River inflow recommendations - con't. (p. 2 of 2)

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Note
EDF / Stillwater	C	3500			10000			Determined based on Delta outflows ([38])			3000 - 3500 ([39])		3500	37, 38, 39
	D	4500			10000						3000 - 4500		4500	
	BN	4500			10000						3000 - 4500		4500	
		64000 (pulse flow, 21 consecutive days)												
	AN	4500			10000						3000 - 4500		4500	
		64000 (pulse flow, 35 consecutive days)												
	W	4500			10000						3000 - 4500		4500	
		64000 (pulse flow, 49 consecutive days)												
DWR / SFWC	All	Recommendation to maintain requirements stipulated in D-1641												22
The following is from Fleenor et al. 2010 (Preliminary Draft) - Functional flow approach with exports occurring via a peripheral canal, tunnel, or other alternative form of conveyance.														
Delta Solutions Group	6 of 10 yrs	10000									10000			40
	6 of 10 yrs			25000										
	1 of 10 yrs	70000												41
	8 of 10 yrs		Yolo Bypass 2500 (Sac Riv ~45750)											42
	6 of 10 yrs			Yolo Bypass 4000 (pulse) (Sac Riv ~ 50150)										

Appendix A, Table 3. San Joaquin River inflow recommendations summary table (cfs unless noted otherwise).

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Note
D1641	C		710 or 1140 (43)		3110 or 3540 (44)	710 or 1140 (43)					1000 (45)			43, 44, 45
	D		1420 or 2280		4020 or 4880	1420 or 2280					1000			
	BN		1420 or 2280		4620 or 5480	1420 or 2280					1000			
	AN		2130 or 3420		5730 or 7020	2130 or 3420					1000			
	W		2130 or 3420		7330 or 8620	2130 or 3420					1000			
Draft D1630	C				2000 (46)						≥2000 (47)			46, 47
	D				4000						≥2000			
	BN				6000						≥2000			
	AN				8000						≥2000			
	W				10000						≥2000			
CDFG	C			1500 (Base)	5500 (Pulse) (4/15-5/15) (Total 7000)									48
	D			2125 (Base)	4875 (Pulse) (4/11-5/20) (Total 7000)									
	BN			2258 (Base)	6242 (Pulse) (4/6-5/25) (Total 8500)									
	AN			4339 (Base)	5661 (Pulse) (4/1-5/30) (Total 10000)									
	W			6315 (Base)	8685 (Pulse) (3/27-6/4) (Total 15000)									
C-WIN / CSPA	C		13400	4500	6700 / 8900	1200					5400			49
	D		13400 (2 days)	4500	6700 / 8900	1200					5400			
	BN		13400 (16 days), 26800 (2 days)	4500	6700 / 8900	11200 / 1200					5400			
	AN		13400 (13 days), 26800 (5 days)	4500	6700 / 8900	11200 / 1200					5400			
	W		13400 (17 days), 26800 (5 days)	13400		14900					5400			
TBI / NRDC	100% of years (all yrs)	2000			5000		2000							50
	80% (D yrs)	2000			5000 / 10000	7000 / 5000	2000							
	60% (BN yrs)	2000			20000 / 10000	7000 / 5000	2000							
	40% (AN yrs)	2000		5000	20000	7000	2000							
	20% (W yrs)	2000		5000	20000	7000	2000							

Appendix A, Table 3. San Joaquin River inflow recommendations summary table - con't. (p. 2 of 3)

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Note
AR / NHI	100% of years (all yrs)			3000; 4000	5000	5000	2000							51
	80% (D yrs)			3000; 4000	5000; 10000	7000; 5000	2000							
	60% (BN yrs)			3000; 5000	20000; 10000	7000; 5000	2000							
	40% (AN yrs)			3000; 5000	20000	7000	2000							
	20% (W yrs)			3000; 5000	20000	20000; 7000	7000; 2000							
	All			Flows of approx. 10000 cfs should occur at Vernalis for ≥5 days. There should be at least 2 such events in dry years, and more in wetter years.										
EDF / Stillwater	All									> 1800 in DWSC	> 1800 in DWSC			52
	All			Discuss USFWS (1995) and D-1641, no clear recommendation (55)			Determined based on Delta outflows (38)				3500 (10-14 days) (54)	FERC (53)		38, 53, 54, 55
	C & D	1000 (positive flows at Jersey Pt)	1000 (positive flows at Jersey Pt)										See Jan-Feb	56
	BN & AN	2000 (positive flows at Jersey Pt)	2000 (positive flows at Jersey Pt)										See Jan-Feb	
	W	3000 (positive flows at Jersey Pt)	3000 (positive flows at Jersey Pt)										See Jan-Feb	
	AN	14800 (pulse flow, ≥ 21 consecutive days)												57
	W	14800 (pulse flow, ≥ 35 consecutive days)												
USFWS			"...the Board should consider the Vernalis flows contained in USFWS (2005) [AFRP] and DFG's San Joaquin Escapement Model as a starting point for establishing flow for the protection of salmon and steelhead migrating from the San Joaquin basin"											58
AFRP (salmon doubling)	C		1744	2832	4912	5665								59
	D		1784	3146	5883	7787								
	BN		1809	3481	6721	9912								
	AN		2581	5162	8151	13732								
	W		4433	8866	10487	17369								
AFRP (53% Increase in Salmon Production)	C		1250	1665	2888	3331								60
	D		1350	1850	3459	4579								
	BN		1450	1933	3733	5505								
	AN		1638	2703	4266	7194								
	W		2333	4667	5520	9142								
NMFS OCAP Bio Op					Interim Operations in 2010-2011, min flows at Vernalis ranging from 1500 - 6000 based on New Melones Index									61
		In addition, USBR/DWR shall seek supplemental agreement with SJRGA as soon as possible to achieve the min flows listed below at Vernalis												
	C				1500	1500								
	D				3000	3000								
	BN				4500	4500								
	AN				6000	6000								
	W				6000	6000								

Appendix A, Table 3. San Joaquin River inflow recommendations summary table - con't. (p. 3 of 3)

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Note
NMFS	AN & W		≥ 14000 (at Vernalis)											62
	AN & W		≥ 7000 (at Newman)											
DWR / SFWC	All	Recommendation to maintain requirements stipulated in D-1641												22
The following is from Fleenor et al. 2010 (Preliminary Draft) - Functional flow approach with exports occurring via a peripheral canal, tunnel, or other alternative form of conveyance.														
Delta Solutions Group	C		2000		5000	2000								63
	D		2000		7000		2000							
	BN		2000		10000		2000							
	AN		2000		15000			2000						
	W		2000		20000			2000						

Appendix A, Table 4. Old and Middle River flow, export restriction, San Joaquin River flows at Jersey Point (e.g., QWEST) recommendations summary table (cfs unless noted otherwise).

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Note
D1641	All	See Jul-Dec	Export/Inflow Ratio: 35% of Delta Inflow ([64])					Export/Inflow Ratio: 65% of Delta Inflow						64
	All				Export Limit: > of 1500 or 100% of 3-day avg. Vernalis flow									65
Draft D1630	All	QWEST > -2000	No reverse flow for all year types on a 14-day running average in the Western Delta (QWEST > 0 cfs, as calculated in Dayflow)					QWEST > -1000	QWEST > -2000					66
	C & D				14-day running average combined export rate for Tracy, Banks, and Contra Costa pumping plants shall be ≤ 4000 cfs									
	BN, AN, W				14-day running average combined export rate for Tracy, Banks, and Contra Costa pumping plants shall be ≤ 6000 cfs									
CSPA / C-WIN	All			Combined Export Rates = 0										67
	All			2000 cfs daily flow in Old and Middle Rivers										68
	C	1000 (positive 14-day mean flows at SJ Riv at Jersey Pt)									See Jan-June			
	D	1500 (positive 14-day mean flows at SJ Riv at Jersey Pt)									See Jan-June			
	BN	2000 (positive 14-day mean flows at SJ Riv at Jersey Pt)									See Jan-June			69
	AN	2500 (positive 14-day mean flows at SJ Riv at Jersey Pt)									See Jan-June			
	W	3000 (positive 14-day mean flows at SJ Riv at Jersey Pt)									See Jan-June			
TBI / NRDC		Sac Salmonids, Delta Smelt, Longfin Smelt*		Sac & SJR Salmonids, D. Smelt, L. Smelt*	Sac & SJR Salmonids, D. Smelt, L. Smelt (C & D yrs)		Sac & SJR Salmonids, D. Smelt				Sac Basin Salmon		Sac Salmon, D. Smelt	70
	C	-1500 or >0*	-1500 or >0*	-1500 or >0*	>0	>0	-1500				-2000	-2000	-1500	
	D	-1500 or >0*	-1500 or >0*	>0	>0	>0	-1500				-2000	-2000	-1500	
	BN	-1500 or >0*	-1500 or >0*	>0	>0	>0	-1500				-2000	-2000	-1500	
	AN	-1500 or >0*	-1500 or >0*	>0	>0	>0	-1500				-2000	-2000	-1500	
	W	-1500 or >0*	-1500 or >0*	>0	>0	>0	-1500				-2000	-2000	-1500	
AFRP	C / D	1000 (net seaward flows at Jersey Pt)									See Jan-June			
	BN / AN	2000 (net seaward flows at Jersey Pt)									See Jan-June			71
	W	3000 (net seaward flows at Jersey Pt)									See Jan-June			
NMFS - OCAP Bio Op	All	Limit negative flows to -2000 to -5000 cfs in Old and Middle Rivers, depending on the presence of salmonids (see decision tree upon which the negative flow objective w/in the range shall be determined)												72
	All				Export restrictions based on Vernalis flow: <6000 cfs = 1500 cfs export limit 6000-21750 cfs = 4:1 (Vernalis flow:export ratio) >21750 = Unrestricted									

Appendix A, Table 4. Old and Middle River flow, export restriction, San Joaquin River flows at Jersey Point (e.g., QWEST) recommendations summary table - con't. (p. 2 of 2)

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Note
USFWS	All	Board should develop reverse flow criteria that would maintain Old and Middle River flow positive during key months (Jan - Jun)												73
USFWS	All	"...the AFRP Working Paper (USFWS, 1995) Restoration Action #3 calls for maintaining positive QWEST flows, or an equivalent measure of net seaward flows at Jersey Point... Higher flow at Jersey Point has been provided during the VAMP period (mid-April to mid-May) with the adoption of VAMP flows and exports. We encourage the Board to retain or expand this type of action to assure the contribution of downstream flow from the San Joaquin Basin to Delta outflow..."									See Jan - June			74
USFWS - OCAP Bio Op	All	Action 1: -2000 cfs for 14 days once turbidity or salvage trigger has been met. Action 2: range btw -1250 and -5000 cfs ([75])			Range between -1250 and -5000 ([76])								See Jan-Mar	75, 76
CDFG Longfin Smelt Incidental Take Permit	All	Condition 5.1 (Dec - Feb): >-5000 ([77]) Condition 5.2 (Jan - June): OMR flow between -1250 and -5000 cfs ([78])											Condition 5.1 (Dec-Feb)	77, 78
DWR / SFWC	All	Recommendation to maintain requirements stipulated in D-1641												22

Appendix A, Table 5. Floodplain inundation flow recommendations summary table.

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Note
CDFG	AN & W	≥ 30 day floodplain inundation												79
EDF / Stillwater	BN AN W	64000 (pulse flow, 21 consecutive days) 64000 (pulse flow, 35 consecutive days) 64000 (pulse flow, 49 consecutive days)												37 Sacr Riv - Yolo Byp
TBI / NRDC / AR / NHI	C (0-20 percentile)			27500 for 15 cont days										34 Sac Riv - Yolo Byp
	D (20-40 percentile)			27500 for 30 cont days										
	BN		30000 for 60 cont days											
	AN		32500 for 90 continous days											
	W	35000 for 120 continuous days												
AR / NHI	All	Sac Riv at Bend Bridge - Pulse flows continuously exceed 8000, periodically exceed 12000, for a duration exceeding 2 weeks										See Jan - May		32
USFWS	6 of 10 yrs	"The Board should consider the importance of more frequent floodplain inundation (especially Yolo Bypass flows) when determining the Delta outflows..."												80
NMFS - OCAP Bio Op	All	"...Reclamation and DWR shall, to the maximum extent of their authorities, provide significantly increased acreage of seasonal floodplain rearing habitat, with biologically appropriate durations and magnitudes, from December through April, in the lower Sacramento River basin, on a return rate of approximately one to three years, depending on water year type."											See Jan-Apr	81
NMFS - Recovery Plan	All	"Enhance the Yolo Bypass by re-configuring Fremont and Sacramento weirs to: ... and (6) create annual spring inundation of at least 8000 cfs to fully activate the Yolo Bypass floodplain."												82
Delta Solutions Group	8 of 10 yrs		Yolo Bypass 2500 (Sac Riv ~ 45750)											42
	6 of 10 yrs			Yolo Bypass 4000 (pulse) (Sac Riv ~ 50150)										
San Joaquin River														
EDF / Stillwater	AN W	14800 (pulse flow, ≥ 21 consecutive days) 14800 (pulse flow, ≥ 35 consecutive days)												57
See TBI / NRDC and AR / NHI SJ River Inflow recommendations, flows >20000 cfs to trigger floodplain inundation														

Appendix A, Table 6. Delta Cross Channel closures summary table.

	Water Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Source / Notes
D-1641		see Nov	Gates Closed			Close for 14 days ([83])						Nov-Jan - gates may be closed for up to total of 45 days		83
Draft D-1630	All	Closed if daily DOI >12000	Operated based on results of real-time monitoring											84
CSPA / C-WIN	All		Gates Closed											85
	All		Acoustic Barrier at head of Georgiana Slough at Sacramento River											
NMFS - OCAP Bio Op	All	Dec 15 - Jan 31 Gates closed	Gates Closed per D1641			Gates closed up to 14 days per D1641					Gates closed if fish are present		Gates closed except for experim ents/wa ter quality / Dec 15 Jan 31 Gates closed	86

Appendix A, Table 7. Notes for Tables 1 through 6.

No.	Entity	Type	Notes (excerpts from source documents)
1	D1641	Outflow	All water year types - Increase to 6000 if the Dec 8RI is > than 800 TAF
2	D1641	Outflow	Habitat Protection Flows, minimum Delta outflow calculated from a series of rules that are described in Tables 3 and 4 of D1641
3	Draft D1630	Outflow	Striped Bass, Antioch spawning - Delta outflow index, Sac Riv at Chipps Island, average for the period not less than value shown (cfs).
4	Draft D1630	Outflow	Striped Bass, general - Delta outflow index, Sac River at Chipps Island - average for period not less than value shown (cfs), May period = May 6-31
5	Draft D1630	Outflow	Suisun Marsh - Delta outflow index at Sac River at Chipps Island - average of daily DOI for each month, not less than value shown (cfs)
6	Draft D1630	Outflow	Suisun Marsh - Delta outlflow index, Sac River at Chipps Island - minimum daily DOI for 60 consecutive days in the period
7	Draft D1630	Outflow	Suisun Marsh - Delta outflow index, Sac River at Chipps Island - average of daily DOI for each month, not less than value shown, in cfs: applies whenever storage is at or above minimum level in flood control reservation envelope at two of the following - Shasta Reservoir, Oroville Reservoir, and CVP storage on the American River
8	TBI et al	Outflow	Water year categories represent exceedance frequencies for the 8-river index, they are not equivalent to the DWR "water year types" (which account for storage and other conditions). TBI_Exhibit 2 (Outlfow). References for correlation btw winter-spring outlfow and abundance of numerous species on p.3. Winter-spring Delta outflow criteria approximate the frequence distribution of outflow levels, i.e., the relationship btw outflow and the 8 River Index, for the 1956-1987 period. Winter and spring outlfow recommendations to benefit public trust uses of pelagic species (as represented by abundance and productivity of longfin smelt, Crangon shrimp, and starry flounder and spatial distribution of longfin smelt) (see TBI Exhibit 2, pp 21-25). Two methods were used to develop outflow criteria: an analysis of historical flow-abundance relationships that corresponded to recovery targets for longfin smelt abundance (Native Fishes Recovery Plan, USFWS 1995), and an analysis of population growth response to outflows in order to identify outflows that produced population growth more than 50% of the time. Applying these
8 cont	TBI et al	Outflow	two methods produces very similar results regarding desirable outflow levels. Break in summary table at mid-Mar is artificial, original table included Mar under both Winter and Spring, so for simplicity, it was split at 15 Mar. Fall outflows (TBI Exhibit 2, p. 35, Table 1 and Fig 27) - analyzed emerging statistical evidence of relationship btw outlfow and abundance and distribution of delta smelt and striped bass (Feyrer et al 2007; Feyrer et al In Review; DSWG notes, Aug 21, 2006), in order to develop recommendations. Recommendations occassionaly exceed unimpaired outflow in limited cases (would require reservoir releases in fall independent of antecedent conditions).

Appendix A, Table 7. Notes for Tables 1 through 6.

No.	Entity	Type	Notes (excerpts from source documents)
9	CSPA / C-WIN	Outflow	Net Delta Outflow, as a 14-day running average - Source WRINT-DFG Exh 8 (1992). Feb-Mar - flows correspond to Table 8 (p.23), Alternative C (Estuarine species - target mean monthly flows based on data from DWR's 1995 Level of Development + 50% increase). Orig. recommendations by month, C-WIN/CSPA took average of Feb and Mar, and reported as such. Apr-July - flows correspond to Table 2 (p16), Alternative C (mean Delta outflows required to maintain populations of 1.7 million adult striped bass). Aug-Jan - based on Alt C (discussed above), in combination with flow recommendations developed by C-WIN for Jan. DFG identified flows for all months except Jan, C-WIN developed a method for Jan flows from DayFlow information (C-WIN extracted monthly average Delta outflows from DayFlow, sorted them, and then allocated them to water years based on unimpaired runoff data from the California Data Exchange Center. The medians of the water year types were then used as January flows in developing our optimal conditions recommendations for mean Delta outflows in the August 1 through January 31 period).
10	EDF / Stillwater	Outflow	Stillwater Focal Species Approach - Source - EDF closing comments (Table 1), Supporting Info - EDF Exhibit 1 (Winter [Dec-Feb] outflows - p.52-53). A primary objective was to provide enough Delta outflow to maintain X2 westward of 65 km, w/ variations to allow eastward excursion of X2 as far as 80 km in drier water year types. Proximate function is to increasethe westward extent of fresh water into Suisun and San Francisco bays to more closely approximate historical conditions. "This will serve to increase the availability of food resources to larval fish species in late winter as well as improve access to low salinity habitat in the shallows of Grizzly and Honker bays (Feyrer et al 2009)." Flows also designed to limit the eastward distribution and density of overbite clam. "...low salinity may inhibit spawning and subsequent adult recruitment, thereby reducing grazing pressures on phytoplankton and the pelagic food web. Improvements in food resources to the western Delta will serve to increase populations of Delta smelt, striped bass, and other pelagic species that are currently in decline."
11	EDF / Stillwater	Outflow	Stillwater Focal Species Approach - Source - EDF closing comments (Table 1), Supporting Info - EDF Exhibit 1 (Spring [Mar-May] Outlfows - p.55-56). Spring flows primarily based on delta outflows needed to maintain X2 in locations that are beneficial to delta pelagic fish populations as well as the provision of floodplain inundation in the Yolo Bypass during March Primary objective was to provide enough Delta outflow to maintain X2 westward of 65 km, w/ variations to allow eastward excursion of X2 as far as 70 km in drier water year types. References in justification: Feyrer et al. In Revision, Bennett et al 2005. Herbold 1994, Hobbs et al 2004, Bennett et al. 2008, and others). Secondary goal is to provide sufficient flows to maintain inundated season floodplain habitat in Yolo Bypass and lower SJ Riv for varying periods in March based on water year type. These floodplain inundation flows should be coordinated with flows in late winter to provide prolonged periods of inundation.
12	EDF / Stillwater	Outflow	Stillwater Focal Species Approach - Source - EDF closing comments (Table 1), Supporting Info - EDF Exhibit 1 (Fall [Sept-Nov] - pp.49-50; Summer - pp.57-58) Summer (Jun-Aug) and Fall flows based primarily on Delta outflows needed to maintain X2 in the shallow-water habitats of Suisun Bay. Secondary objective for Fall outflows from the Delta were to provide attraction flows for upstream-migrating salmonids and to maintain adequate DO concentrations for fall-run chinook salmon within the lower SJ River system. Summer and Fall - in some months and water year types, depending on water year type and month, the projected monthly outflows are higher than the unimpaired and/or current flow ranges. Thus some modification of upstream reservoir release schedules may be required to meet these flows. Fall - references in justification - Feyrer et al 2007; Feyrer et al In revision; Bennet et al 2002; Jassby et al 1995; and others

Appendix A, Table 7. Notes for Tables 1 through 6.

No.	Entity	Type	Notes (excerpts from source documents)
13	EDF / Stillwater	Outflow	EDF_Closing Comments (Table 1) - Peak flows required to provide floodplain inundation are assumed to be concurrent between the Sac and SJ River basins as well as the east side tributaries. However, the duration of the peak flows varies by water year (see notes 69-74)
14	EDF / Stillwater	Outflow	EDF_Closing Comments (Table 1) - Includes 14 days of floodplain inundation flow of 64000 cfs in the Sac River
15	EDF / Stillwater	Outflow	EDF_Closing Comments (Table 1) - Includes 7 days of floodplain inundation flow of 64000 cfs in the Sac River
16	EDF / Stillwater	Outflow	EDF_Closing Comments (Table 1) - Includes 21 days of floodplain inundation flow of 64000 cfs in the Sac River and 14 days of floodplain inundation flow of 14800 cfs in the SJ River
17	EDF / Stillwater	Outflow	EDF_Closing Comments (Table 1) - Includes 14 days of floodplain inundation flow of 64000 cfs in the Sac River and 7 days of floodplain inundation flow of 14800 cfs in the SJ River.
18	EDF / Stillwater	Outflow	EDF_Closing Comments (Table 1) - Includes 28 days of floodplain inundation flow of 64000 cfs in the Sac River and 21 days of floodplain inundation flow if 14800 cfs in the SJ River
19	EDF / Stillwater	Outflow	EDF_Closing Comments (Table 1) - Includes 21 days of floodplain inundation flow of 64000 cfs in the Sac River and 14 days of floodplain inundation flow of 14800 cfs in the SJ River
20	USFWS	Outflow	Delta smelt biological opinion (RPA concerning Fall X2 requirements [pp. 282-283] - improve fall habitat [quality and quantity] for DS) (references USFWS 2008, Feyrer et al 2007, Feyrer et al in revision) - Sept-Oct in years when the preceeding precipitation and runoff period was wet or above normal, as defined by the Sacramento Basin 40-30-30 Index, USBR and DWR shall provide sufficient Delta outflow to maintain monthly average X2 no greater than 74 km and 81 km in Wet and Above Normal yrs, respectively. During any November when the preceding water yr was W or AN, as defined by Sac Basin 40-30-30 index, all inflow into the CVP/SWP reservoirs in the Sac Basin shall be added to reservoir releases in Nov to provide additional increment of outflow from Delta to augment Delta outflow up to the fall X2 of 74 km and 81 km for W and AN water yrs, respectively. In the event there is an increase in storage during any Nov this action applies, the increase in reservoir storage shall be released in December to augment the Dec outflow requirements in SWRCB D-1641.
21	CDFG	Outflow	Outflow recommendations from closing comments. Originally provided as X2 recommendations - Source - DFG Exhibit 1 and Exhibit 2 - Consolidates recommendations for American Shad, Longfin Smelt, Starry Flounder, Bay Shrimp, Zooplankton (consistent with D1641 requirements to maintain X2 at one of two compliance points in Suisun Bay [64 km or 75 km] from Feb-June). Longfin smelt = Jan - June; Starry flounder, Bay shrimp, zooplankton = Feb - Jun; and American Shad = April - June.
22	DWR / SFWC	Outflow, SJ Riv Inflow, Sac Riv Inflow, OMR	DWR_closing comments, in response to request for a table identifing recommended flows, DWR submitted summary of D-1641 objectives.

Appendix A, Table 7. Notes for Tables 1 through 6.

No.	Entity	Type	Notes (excerpts from source documents)
23	UCDavis - Delta Solutions Group	Outflow	Functional Flow 5a - Delta Smelt flows, 48000 cfs, from March through May (5 out of 10 years, every other year). Maintain freshwater to low salinity habitat in the northeastern Delta to Napa River, facilitating a broad spatial and temporal range in spawning and rearing habitat (Bennett 2005, Hobbs et al 2005). Flow recommendation not based on water year type, but rather number of years out of 10. Based on exports through an alternative form of conveyance (e.g., peripheral canal or tunnel).
24	Draft D1630	Sac River Inflow	Function = Chinook salmon. Sac River at Freeport. Average flow at Freeport >18000 cfs for a 14-day continuous period corresponding to release of salmon smolts from Coleman Nat Fish Hatchery. Anticipate to occur in late April or early May. If no fish are released from the hatchery, the Executive Director shall determine the appropriate timing of this pulse flow with advice from CDFG.
25	Draft D1630	Sac River Inflow	Function = striped bass, general; Sac River at Freeport - 14-day running average at Freeport >13000 cfs for a 42-day continuous period, with minimum mean daily flow >9000 cfs. Requirement initiated when real-time monitoring indicates the presence of striped bass eggs and larvae in Sac River below Colusa. This period should begin in late April or early May in most years.
26	Draft D1630	Sac River Inflow	Function = chinook salmon. Sac River at Rio Vista - 14-day running average of minimum daily flow.
27	CDFG	Sac River Inflow	Chinook salmon, smolt outmigration. (1) Feb - Oct base flows. Source - DFG Exhibit 14 (WRINT-DFG-8, p.11). (2) Apr - Jun pulse flows. Source - DFG Exhibit 1, page 1, 6, and USFWS Exhibit 31 (Kjelson).
28	CSPA	Sac River Inflow	CSPA Closing Comments. Source - CDFG_1992_WRINT-DFG-Exhibit #8, p.11. Minimum base flow, measured at Rio Vista. 14-day average flow.
29	CSPA / C-WIN	Sac River Inflow	Sacramento River from Freeport to Chipps Island - Pulse flows - flows needed to sustain viable migration corridor for optimal smolt passage and survival. Source - USFWS Exhibit 31 (Kjelson)
30	PCFFA	Sac River Inflow	Function = salmonid juvenile outmigration. PCFFA closing comments, Source - USFWS Exhibit 31 (Kjelson). Kjelson and Brandes research - found that flows of 20000 to 30000 cfs yield the greatest survival of juvenile salmon during out-migration from Sac River to San Francisco Bay (PCFFA recommends splitting the difference and setting standard at 25000 cfs). Set from Hood to Chipps Island.
31	USFWS	Sac River Inflow	USFWS testimony concerning scientific information used to determine flow criteria. Source: U.S. Department Of the Interior - Comments Regarding the California State Water Resources Control Board's Notice of Public Informational Proceeding to Develop Delta Flow Criteria for the Delta Ecosystem Necessary to Protect Public Trust Resources, Sections II and III, pages 25, 54, and 57. "The catch of juvenile salmon at Chipps Island between April and June is correlated to flow at Rio Vista (USFWS, 1987; Brandes and McLain, 2001; Brandes et al., 2006). The highest abundance leaving the Delta has been observed when flows at Rio Vista between April and June averaged above 20,000 cfs which is also the level where we have observed maximum survival in the past (USFWS, 1987)" (p.25).

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No.	Entity	Type	Notes (excerpts from source documents)
32	AR / NHI	Sac River Inflow	AR_NHI_Exh1 (testimony of Cain, Opperman, and Tompkins) and AR_NHI_closing comments. Purpose - interconnect side channels with main channel, contribute to foodweb productivity and rearing habitat for salmon. Inundated off-channel habitat such as high flow channels can also provide rearing habitat for salmon (Peterson and Reid 1984), but regulated spring flows are generally insufficient to inundate these habitats for prolonged periods (30-60 days), A recent study of these habitats in the Sac River determined that a large proportion of secondary channels between Red Bluff and Colusa become fully connected to the river at flows above 12000 cfs (Kondolf 2007). (from AR_NHI_Exh1 p.28)
33	AR / NHI	Sac River Inflow	AR_NHI_Exh1 (Testimony of Cain, Opperman, and Tompkins) and AR_NHI_closing comments - aid migration of winter-run chinook, in later months aid migration of spring and fall-run. Recent analyses indicate that the onset of emigration of winter-run fish to the Delta at Knights Landing is triggered by flow pulses of 15000 cfs at Wilkins Slough, and emigration from the Sac River to Chipps Island follows pulse flows of 20000 cfs at Freeport (del Rosario 2009). Previous studies found that smolt survival increased with increasing Sac River flow at Rio Vista, with maximum survival observed at or above about 20000 and 30000 cfs (USFWS 1987, Exhibit 31). Despite uncertainty about the exact magnitude of flow necessary to initiate substantial bank erosion, there is growing evidence that flows between 20000 and 25000 cfs will erode some banks while flows above 50000 to 60000 cfs are likely to cause widespread bank erosion (Stillwater 2007).
34	TBI / NRDC / AR / NHI	Sac River Inflow	TBI_Exh3 (Inflows - Table 3), TBI_closing comments (Table 3), AR/NHI_Exh1 (Testimony of Cain, Opperman, and Tompkins), AR/NHI closing comments - Table 3. Flows recommended for floodplain inundation (Sutter and Yolo Bypasses) - salmonid rearing, splittail spawning and early rearing. Flows measured at Verona. Flow magnitudes assume structural modifications to the weir to allow inundation at lower flow rates than is currently possible. Reservoir releases should be timed to coincide with and extend duration of high flows that occur naturally on less regulated rivers and creeks. The duration target is fixed for each year type, but actual timing of inundation should vary across the optimal window depending on hydrology and to maintain life history diversity.
35	NMFS	Sac River Inflow	NMFS_Exh9 (from ARFP 1995), Sturgeon (Grn and Wht) - adult migration to spawning and downstream larval transport
36	NMFS	Sac River Inflow	Public Draft Recovery Plan for Central Valley Salmon and Steelhead (October 2009). NMFS_Exhibit_5. Section 6.1.1 Recovery Action Narrative, Action 1.5.9, p.158.
37	EDF / Stillwater	Sac River Inflow	Source: EDF_Exh1 (Stillwater Sciences - Focal Species Approach). Spring flows - Establishing base flows of at least 10000 cfs in the Sac Riv in spring would improve transport of eggs and larval striped bass and other young anadromous fish and to reduce egg settling and mortality at low flows (USFWS 2001, EDF_Exh1, p.53). Proximate function of Delta inflows is to maintain net transport of passively swimming fishes (juv salmonids, larval delta smelt, and striped bass) and nutrients towards Suisun and San Francisco bays (USFWS 2008). Goal of winter and spring floodplain activation flows (managed pulse flows of approx 64000 cfs at Verona) is to maintain inundated seasonal floodplain habitat conditions in much of Yolo Bypass during January and April for a minimum of 21, 35, and 49 days in Below Normal, Above Normal, and Wet water year types, respectively. The NMFS (2009) draft recovery plan for Sac winter-run chinook, CV spring-run chinook, and CV steelhead ESUs calls for an annual spring flow of 8000 cfs (approx 64000 cfs at Verona) above the initial spill level "to fully activate the Yolo Bypass floodplain." For the

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No.	Entity	Type	Notes (excerpts from source documents)
37 cont	EDF / Stillwater	Sac River Inflow	purposes of this assessment, Stillwater allocated the Delta inflows for floodplain inundation to February and March. Summer Delta inflows to be determined by Delta outflows. Fall Inflows - Maintenance of D1641 flow standards in necessary to provide attraction flows for Chinook salmon, although these levels would potentially need to be increased to provide adequate Delta outflows. Winter Inflows - Winter flows primarily designed to provide upstream migration passage for salmonids and striped bass during Dec and Jan, as well as to inundate floodplains such as Yolo Bypass for benefit of rearing juv salmonids and other floodplain associated species (p.50-51). See Spring for discussion of goal of combined winter-spring floodplain activation flows.
38	EDF / Stillwater	Sac Riv Inflow / SJ Riv Inflow	Inflows determined based on Delta outflows (EDF_Exh1 - Stillwater Focal Species)
39	EDF / Stillwater	Sac River Inflow	These levels may need to be increased to provide adequate Delta outflows (EDF_Exh1 - Stillwater Focal Species)
40	UCDavis - Delta Solutions Group	Sac River Inflow	Functional Flow 2a - Sac River adult salmon - 10000 cfs to to occur from Oct - June during 6 out of 10 years (references Newman and Rice 2002, Williams 2006, Harrell et al. 2009, USFWS Exhibit 31 1987, Kjelson and Brandes 1989). Functional Flow 2b - Sac River juvenile salmon migration - 25000 cfs from Mar - June during 6 out of 10 years (references Newman and Rice 2002, Williams 2006, Harrell et al. 2009, USFWS Exhibit 31 1987, Kjelson and Brandes 1989). Flows not based on water year type, but rather number of years out of ten.
41	UCDavis - Delta Solutions Group	Sac River Inflow	Functional Flow 2c - Sacr River adult sturgeon flows - 70000 cfs to occur between Jan and May during 1 out of 10 years (flows for salmon -2a, 2b, and 1a,1b) (Kohlhorst et al 1991 [flow rate], Harrell and Sommer 2003 [passage problems at Fremont Weir]). Flows not based on water year type, but rather number of years out of ten.
42	UCDavis - Delta Solutions Group	Sac River Inflow	Functional Flow 1a - yolo bypass inundation - salmon and splittail (area inundated based on recommended flows BDCP draft rpt 2008) (other references related to flow and corresponding extent of habitat in Yolo Bypass Moyle et al. 2004, Sommer et al. 2004, Harrell and Sommer 2003, Harrell et al. 2009). Functional Flow 1b - yolo bypass pulse - salmon and splittail (area inundated based on recommended flows BDCP draft rpt 2008) (other references related to flow and corresponding extent of habitat in Yolo Bypass Moyle et al. 2004, Sommer et al. 2004, Harrell and Sommer 2003, Harrell et al. 2009). Functional Flows 1a and 1b require flows at Freeport of approx. 45750 and 50150 cfs, respectively, based on regressions of historical data.
43	D1641	SJ River Inflow	Base Vernalis minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 20% below the objective). Take the higher objective if X2 is required to be west of Chipps Island
44	D1641	SJ River Inflow	Pulse Vernalis minimum monthly average flow rate in cfs. Take the higher objective if X2 is required to be west of Chipps Island
45	D1641	SJ River Inflow	Pulse - up to an additional 28 TAF pulse/attraction flow to bring flows up to a monthly average of 2000 cfs except for a critical year following a critical year. Time period based on real-time monitoring and determined by CalFed Op's group

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No.	Entity	Type	Notes (excerpts from source documents)
46	Draft D1630	SJ River Inflow	SJ River at Vernalis. Function = chinook salmon. Minimum daily flow, in cfs, for 21-day continuous period. Start date depends on beginning of chinook salmon smolt out-migration from SJ basin. During this time, water right holders on Mokelumne and Calaveras rivers shall bypass all inflows for 5 consecutive days. Daily mean combined pumping at Tracy, Banks, and Contra Costa pumping plants shall be $\leq$1500 cfs. All pumping restrictions are to be split equally between CVP and SWP. Total annual maximum of 150 TAF for the two salmon flows (these and fall attraction flows) from the SJ Basin reservoirs
47	Draft D1630	SJ River Inflow	SJ River at Vernalis. Function = chinook salmon. Minimum daily flow, for 14-day continuous period. Start date depends upon beginning of chinook salmon adult spawning migration. Attraction flow shall be provided only if water is avaiable from the 150 TAF alloted for the two salmon flows. During this time, water right holders on Mokelumne and Calaveras rivers shall bypass all inflows for 5 consecutive days.
48	CDFG	SJ River Inflow	Source: SJR Salmon Model V.1.6 (CDFG 2009), DFG Exhibit 3 (Flows needed in the Delta to restore anadromous salmonid passage from the SJ River at Vernalis to Chipps Island) - Table 10 - South Delta (Vernalis) flows needed to double smolt production at Chipps Island (by water year type), and CDFG closing comments. Flows to support smolt outmigration.
49	CSPA / C-WIN	SJ River Inflow	CSPA and C-WIN Closing Comments - CSPA Table 2. Based on WRINT-DFG Exhibit 8 (1992) and C. Mesick 2010 (C-Win Exh 19). Pulse flows in all years to attract adult spawning salmonids, Oct 20-29, SJR at Vernalis. To the tributary flows (each measured at their confluence with SJ Riv mainstem (see Mesick 2010), C-WIN / CSPA added in a flow of the SJ Riv below Millerton Lake reflecting that river's fair share unimpaired flow, as well as accretions and other inflows. Combined valley flows at Vernalis assumes tributaries (Mer, Stan, Tuol) are 67.06% of total SJ River flow at Vernalis. Spring - pulse flows for temperature regulation, migration cues, habitat inundation. Oct - pulse flows to attract adult salmonids.
50	TBI / NRDC	SJ River Inflow	TBI Exhibit 3 - Delta Inflows (Table 1, p.28), TBI / NRDC closing comments (Table 3b). Flows >5000 cfs to maintain minimum temperature ($\leq$ 65F) for migrating salmonids in April and May. Flows >20000 to trigger floodplain inundation. Year-round flows should exceed 2000 cfs to alleviate potential for DO problems in DWSC.
51	AR / NHI	SJ River Inflow	AR_NHI_Exh1 (testimony of Cain, Opperman, and Tompkins) and AR_NHI_closing comments (Table 2). SJ River flows to benefit salmon rearing habitat and smolt out-migration (increase flow velocities and turbidity), with focus on temperature (maintain temp at or below 65F) and floodplain inundation. Criteria recommended to be in addition to those stipulated in D1641.
52	EDF / Stillwater	SJ River Inflow	EDF / Stillwater Exh 1 (focal species approach, pp.47-49). Based upon investigations for the SJ River DO TMDL, minimum instream flows at the Stockton DWSC should be maintained in excess of 1,800 cfs during Sept and Oct of each year. Low DO in the lower SJ River has been found to impede upstream salmon migration (NMFS 2009, p.74). Studies by Hallock (1970) indicate that low DO at Stockton delay upmigration and straying rates.
53	EDF / Stillwater	SJ River Inflow	EDF / Stillwater Exh 1 (focal species approach, pp.47-49). Flows during November should correspond to current minimum Federal Energy Regulatory Commission (FERC) spawning flow requirements from the Stanislaus, Tuolumne, Merced, and upper San Joaquin rivers.

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No.	Entity	Type	Notes (excerpts from source documents)
54	EDF / Stillwater	SJ River Inflow	EDF / Stillwater Exh 1 (focal species approach, pp.47-49). Salmonid spawning attraction flows in excess if 3500 cfs at Vernalis should be provided for 10-14 days during October, using coordinated releases from the SJ River and tributaries. For remainder of fall, Delta inflows would be determined by the minimum instream flow requirements of the SJ River basin and east side tributaries. Upstream flow levels would likely be increased to meet the Delta outflow recommendations.
55	EDF / Stillwater	SJ River Inflow	EDF / Stillwater Exh 1 (focal species approach, pp.54). "Although USFWS (1995) previously recommended spring Delta inflows ranging from 4,050 cfs to 15,750 cfs at Vernalis based upon of regression models of Chinook salmon smolt survival. The current D-1641 flow minimums range from 3,110 cfs to 8,620 cfs (Table 1-5), depending upon water year type, have never been fully implemented. In addition to baseline flows, for the benefit of rearing Chinook salmon and other native fishes, floodplain activation flows should be provided..."
56	EDF / Stillwater	SJ River Inflow	EDF / Stillwater Exh 1 (focal species approach, pp.51-52). Winter Inflows - Minimum flows at Vernalis and the eastside tributaries should be coordinated to maintain net seaward flows at Jersey Point of 1000 cfs in Critical and Dry years, 2000 cfs in Below and Above Normal years, and 3000 cfs in Wet years (USFWS 1995 3-Xe-19). Net seaward flows for benefit of outmigrating juvenile salmon.
57	EDF / Stillwater	SJ River Inflow	EDF / Stillwater Exh 1 (focal species approach, pp.54-55). For the benefit of rearing chinook salmon and other native fishes, floodplain activation flows should be provided of 14800 cfs in the lower SJ River in Above Normal and Wet water year types. A series of pulse flows instead of a single extended high flow event might also be used to achieve the desired target of continuous days of inundated floodplain. Goal for combined winter and spring floodplain activation flows is to maintain inundated seasonal floodplain habitat conditions (or the potential for such conditions in sites where floodplain restoration actions may be undertaken in the future) in the lower SJ River during Jan through Apr for a minimum of 21 and 35 consecutive days in Above Normal and Wet water year types, respectively. For the purposes of this assessment, Stillwater allocated the Delta inflows for floodplain inundation to February and March. Also discusses inundation of Cosumnes River floodplain.
58	USFWS	SJ River Inflow	USFWS testimony concerning scientific information used to determine flow criteria. Source: U.S. Department Of the Interior - Comments Regarding the California State Water Resources Control Board's Notice of Public Informational Proceeding to Develop Delta Flow Criteria for the Delta Ecosystem Necessary to Protect Public Trust Resources, Sections II and III, pages 56-57 and 25. Quote in table from p.56-57. "The Anadromous Fish Restoration Program has developed estimates of flow levels needed at Vernalis to achieve a 53% increase (page 9) and a doubling (page 10) in predicted Chinook salmon production for the basin (USFWS, 2005). These Vernalis flow criteria vary by water year type and by month between February and May. We recommend these flows as starting point for establishing minimum and maximum volume of flow for increasing juvenile salmon and steelhead survival in the San Joaquin basin." (p.25).
59	AFRP	SJ River Inflow	Anadromous Fish Restoration Program (ARFP). Recommended streamflow schedules to meet the AFRP Doubling Goal in the San Joaquin River Basin (USFWS, 27 Sept 2005). Salmon doubling - total average flow (Stanislaus, Tuolumne, Merced) that would be expected to double the total predicted Chinook salmon production for the basin.

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No.	Entity	Type	Notes (excerpts from source documents)
60	AFRP	SJ River Inflow	Anadromous Fish Restoration Program (ARFP) - Recommended streamflow schedules to meet the AFRP Doubling Goal in the San Joaquin River Basin (USFWS, 27 Sept 2005). Total average flow (Stanislaus, Tuolumne, Merced) that would be expected to achieve a 53% increase in total predicted Chinook salmon production for the basin.
61	NMFS	SJ River Inflow	NMFS OCAP Bio Opinion, Action IV.2.1 (pp.641-644) San Joaquin River Inflow to Export Ratio - both interim (2010-2011) and long-term (beginning in 2012) requirements are stipulated. Interim flows are based on maintaining a minimum status quo for SJ River basin salmonid populations. Long term flow schedules for the SJ River are expected to result from SWRCB proceedings on SJ River flows. Export limitations and flows are also described on pp. 642-644
62	NMFS	SJ River Inflow	NMFS_Exh9 (from AFRP 1995) - Sturgeon (Green and White), mean monthly flows - ensure suitable conditions for sturgeon to migrate and spawn and for progeny to survive.
63	UCDavis - Delta Solutions Group	SJ River Inflow	Functional Flows 3a - transport juvenile salmon (references USFWS Exhibit 31, 1987; Newman and Rice 2002; Williams 2006) - wet years - 20000 cfs, Apr-Jun (2 out of 10 years); AN years - 15000 cfs, April - Jun 15 (4 out of 10 years); BN years - 10000 cfs, Apr-May (6 out of 10 years); Dry years - 7000 cfs, Apr-May 15 (8 out of 10 years); and Critical years - 5000 cfs, Apr (10 out of 10 years). Functional Flows 3c - adult salmon recruitment (reference USFWS Exhibit 31, 1987) - 2000 cfs year round (10 out of 10 years) (flows were not experienced in unimpaired conditions, but likely result from the disturbed conditions). Functional Flows 3b - Improve DO conditions in DWSC (2000 cfs, July-Oct, all years) (Lehman et al 2004, Jassby and VanNieuwenhuyse 2005).
64	D1641	OMR	Export/Inflow ratio - the maximum percent Delta inflow diverted for Feb may vary depending on the Jan 8RI (see D1641)
65	D1641	OMR	SWP/CVP Export Limit - All water year types, Apr 15 - May 15, the greater of 1500 cfs or 100% of 3-day avg. Vernalis flow. Maximum 3-day average of combined export rate (cfs), which includes Tracy Pumping Plant and Clifton Court Forebay Inflow less Byron-Bethany pumping. The time period may need to be adjusted to coincide with fish migration. Maximum export rate may be varied by CalFed Ops Group.
66	Draft D1630	OMR	Reverse flow restrictions for all year types are relaxed when combined CVP and SWP exports are < 2000 cfs. Export pumping restriction is relaxed for all year types when Delta outflow > 50000 cfs, except for the export pumping restriction during the SJ River pulse period. July 1 - Jan 31 - 14-day running average flow (as calculated in DAYFLOW), these restrictions do not apply whenever the EC at the Mallard Slough monitoring station is < 3 mmhos/cm. QWEST standards in 1630 discussed in DOI submittal, p.53, section concerning reverse flows.
67	CSPA / C-WIN	OMR	CSPA closing comments, C-WIN closing comments, CSPA_Exh1_Jennings. Combined export rates would be 0 cfs in all years from March 16 through June 30. Prevent entrainment and keep migration corridors open to maximize salmon juvenile and smolt survival. Facilitate SJ River salmonid migration down Old River.
68	CSPA / C-WIN	OMR	CSPA and C-WIN closing comments - flow direction, entrainment protection and provision of migration corridors

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No.	Entity	Type	Notes (excerpts from source documents)
69	CSPA / C-WIN	OMR	SJ River at Jersey Point flow recommendations (positive 14-day mean flows). Source: CSPA_exh1_Jennings_test; CDFG_1992_WRINT-DFG-Exhibit #8, Alt C (p.11, flows at Jersey Pt from Apr 1 through June 30, salmon); AFRP Working Paper, 1995, p. 3-Xe-19 (salmon). Function maintain positive flow for salmonid smolt outmigration and protect Delta smelt, originally two separate recommendations. DS - Feb 1 - Jun 30, Salmon - Oct 1 - Jun 30, only difference between flow recommendations where overlap occurred was DS in AN years = 2500 cfs, salmon in AN years = 2000. For this table, recommendations merged and 2500 cfs used for AN years (+DFG Exh 8 recommends 2500 cfs in AN years)
70	TBI / NRDC	OMR	TBI/NRDC closing comments (Table 4). The hydrodynamic recommendations expressed as Vernalis flow and/or export to inflow ratios in TBI/NRDC Exh4 (Delta Hydrodynamics, p.30) were converted to OMR flows, using the San Joaquin flow recommendations as described in TBI/NRDC Exh 3 (Delta Inflows), for inclusion in Table 4. Note: recommended OMR flows assume SJ River flows recommended in TBI Exhibit 3 are also implemented. (*) - when the previous longin smelt FMWT index <500, OMR flows in Jan-Mar are >0. This corrects a typographical error in the table on p.30 of TBI Exhibit 4
71	AFRP	OMR	Anadromous Fish Restoration Program (ARFP) (Working Paper on Restoration Needs, Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California, Volume 3, 1995, p. 3-Xe-19). Action 3 - Maintain positive QWEST flows, or an equivalent measure of net seaward flows at Jersey Point, of 1000 cfs in Critical and Dry years, 2000 cfs in below- and above normal years, and 3000 cfs in wet years from Oct 1 through June 30. Objective - Increase survival of smolts migrating down the mainstem rivers, decrease the number of smolts diverted into the central Delta, increase the survival of smolts diverted into the central Delta, and provide attraction flows for San Joaquin Basin adults (Oct - Dec).
72	NMFS	OMR	NMFS OCAP Bio Opinion, Action IV.2.3 - Old and Middle River Flow Management (pp. 648-652). See action triggers on pp. 648-650. Actions will be taken in coordination with USFWS RPA for Delta Smelt and State-listed longfin smelt 2081 incidental take permit. During the Jan 1 - Jun 15 period, the most restrictive export reduction shall be implemented.
73	USFWS	OMR	USFWS testimony concerning scientific information used to determine flow criteria. Source: U.S. Department Of the Interior - Comments Regarding the California State Water Resources Control Board's Notice of Public Informational Proceeding to Develop Delta Flow Criteria for the Delta Ecosystem Necessary to Protect Public Trust Resources, Sections II and III, pages 50, 53, and 24-25 (references USFWS 1992; AFRP Working Paper p.3-Xe-19, USFWS 2005, Restoration Action #3; D-1630, pp44-47). "Based on the scientific information we reviewed, the Board should develop reverse flow criteria that would maintain the Old and Middle river flow positive during key months (January through June) of the year to protect important public trust resources in the Delta" (p.53).

Appendix A, Table 7. Notes for Tables 1 through 6.

No.	Entity	Type	Notes (excerpts from source documents)
74	USFWS	OMR	USFWS testimony concerning scientific information used to determine flow criteria. Source: U.S. Department Of the Interior - Comments Regarding the California State Water Resources Control Board's Notice of Public Informational Proceeding to Develop Delta Flow Criteria for the Delta Ecosystem Necessary to Protect Public Trust Resources, Sections II and III, pages 24,25, and 53. "In a previous Board exhibit (USFWS, 1992), we showed a positive relationship between temperature corrected juvenile survival indices and flow at Jersey Point for marked fish released at Jersey Point (QWEST) (USFWS, 1992, p.21). In addition, the AFRP Working Paper (USFWS, 1995) Restoration Action #3 calls for maintaining positive QWEST flows, or an equivalent measure of net seaward flows at Jersey Point, of 1000 cfs in critical and dry years, 2000 cfs in below- and above-normal years, and 3000 cfs in wet years from Oct 1 through June 30. Higher flow at Jersey Point has been provided during the VAMP period (mid-April to mid-May) with the adoption of VAMP flows and exports. We encourage the Board to retain or expand this
74 cont	USFWS	OMR	type of action to assure the contribution of downstream flow from the San Joaquin Basin to Delta outflow for the protection of juvenile and adult salmonids migrating from the San Joaquin basin."
75	USFWS	OMR	USFWS OCAP Bio Opinion - RPA re: OMR flows. Component 1 - Adults (Dec - Mar) - Action 1 (protect upmigrating delta smelt) - once turbidity or salvage trigger has been met, -2000 cfs OMR for 14 days to reduce flows towards the pumps. Action 2 (protect delta smelt after migration prior to spawning) - OMR range between -1250 and -5000 cfs determined using adaptive process until spawning detected. pp.280-282
76	USFWS	OMR	USFWS OCAP Bio Opinion - RPA re: OMR flows. Component 2 - Larvae/Juveniles - action starts once temperatures hit 12 degrees C at three delta monitoring stations or when spent female is caught. OMR range between -1250 and -5000 cfs determined using adaptive process. OMR flows continue until June 30 or when Delta water temperatures reach 25 degrees C, whichever comes first. pp. 280-282
77	CDFG	OMR	Longfin Smelt Incidental Take Permit (2009), p. 9-10, Condition 5.1. This Condition is not likely to occur in many years. To protect adult longfin smelt migration and spawning during December through February period, the Smelt Working Group (SWG) or DFG SWG personnel staff shall provide OMR flow advice to the Water Operations Management Team (WOMT) and to Director of DFG weekly. The SWG will provide the advice when either: 1) the cumulative salvage index (defined as the total longfin smelt salvage at the CVP and SWP in the December through February period divided by the immediately previous FMWT longfin smelt annual abundance index) exceeds five (5); or 2) when a review of all abundance and distribution survey data and other pertinent biological factors that influence the entrainment risk of adult longfin smelt indicate OMR flow advise is warranted. Permittee shall ensure the OMR flow requirement is met by maintaining the OMR flow 14-day running average is no more negative than -5000 cfs and the initial 5-day running average is not more negative than -6250 cfs. During any time OMR flow restrictions for
77 cont	CDFG	OMR	the FWS's 2008 Biological Opinion for delta smelt are being implemented, this condition (5.1) shall not result in additional OMR flow requirements for protection of adult longfin smelt. Once spawning has been detected in the system, this Condition terminates and 5.2 begins. Condition 5.1 is not required or would cease if previously required when river flows are 1) > 55000 cfs in the Sac River at Rio Vista; or 2) > 8000 cfs in the SJ River at Vernalis. If flows go below 40000 cfs in the Sac River at Rio Vista or 5000 cfs in the SJ River at Vernalis, the OMR flow in Condition 5.1 shall resume if triggered previously. Review of survey data and other pertinent biological factors that influence the entrainment risk of adult longfin smelt may result in a recommendation to relax or cease an OMR flow requirement.

Appendix A, Table 7. Notes for Tables 1 through 6.

No.	Entity	Type	Notes (excerpts from source documents)
78	CDFG	OMR	Longfin Smelt Incidental Take Permit (2009), p. 10-11, Condition 5.2. To protect larval and juvenile longfin smelt during Jan-June period, the SWG or DFG SWG personnel shall provide OMR flow advice to the WOMT and the DFG Director weekly. The OMR flow advice shall be an OMR flow between -1250 and -5000 cfs and be based on review of survey data, including all of the distributional and abundance data, and other pertinent biological factors that influence the entrainment risk of larval and juvenile longfin smelt. When a single Smelt Larval Survey (SLS) or 20 mm Survey sampling period results in: 1) longfin smelt larvae or juveniles found in 8 or more of the 12 SLS or 20mm stations in the central and south Delta (Stations 809, 812, 901, 910, 912, 918, 919) or, 2) catch per tow exceeds 15 longfin smelt larvae or juveniles in 4 or more of the 12 survey stations listed above, OMR flow advice shall be warranted. Permittee shall ensure the OMR flow requirement is met by maintaining the OMR flow 14-day running average no more negative than the required OMR flow and the 5-day running average is within 25% of the
78 cont	CDFG	OMR	required OMR. This Conditions OMR flow requirement is likely to vary throughout Jan through June. Based on prior analysis, DFG has identified three likely scenarios that illustrate the typical entrainment risk level and protective measures for larval smelt over the period: High Entrainment Risk Period: Jan - Mar OMR range from -1250 to -5000 cfs; Medium Entrainment Risk Period: April and May OMR range from -2000 to -5000 cfs, and Low Entrainment Risk Period: June OMR -5000 cfs. When river flows are: 1) greater than 55000 cfs in the Sac River at Rio Vista; or 2) greater than 8000 cfs in the SJ River at Vernalis, the Condition would not trigger or would be relaxed if triggered previously. Should flows go below 40000 cfs in Sac River at Rio Vista or 5000 cfs in the SJ River at Vernalis, the Condition shall resume if triggered previously. In addition to river flows, the SWG or DFG SWG personnel review of all abundance and distribution survey data and other pertinent biological factors that influence the entrainment risk of longfin smelt may result in a recommendation by DFG to WOMT to relax or cease an OMR flow requirement.
79	CDFG	Floodplain	DFG_Closing: DFG Exhibit 1, Page 13. Sacramento Splittail - floodplain inundation (habitat) - incubation, early rearing, egg and larval habitat and survival
80	USFWS	Floodplain	USFWS testimony concerning scientific information used to determine flow criteria. Source: U.S. Department Of the Interior - Comments Regarding the California State Water Resources Control Board's Notice of Public Informational Proceeding to Develop Delta Flow Criteria for the Delta Ecosystem Necessary to Protect Public Trust Resources, Sections II and III, pages 28 and 54. "The Board should consider the importance of more frequent floodplain inundation (especially Yolo Bypass flows) when determining the Delta outflows needed to restore the Delta ecosystem pursuant to the Board’s public trust responsibilities" (p.28). "The Yolo Bypass floods via the Fremont Weir when flows on the Sacramento River exceed approximately 70,000 cfs, which it currently does in about 60% of years (Feyrer, et al. 2006). Flows on the Sacramento River should therefore exceed 70,000 cfs in at least six out of ten years. Recent historical floodplain inundation events are shown in Figure 4 (Sommer et al., 2001)" (p.54).

Appendix A, Table 7. Notes for Tables 1 through 6.

No.	Entity	Type	Notes (excerpts from source documents)
81	NMFS	Floodplain	NMFS OCAP Bio Opinion, Action I.6.1 - Restoration of Floodplain Rearing Habitat. p.608. " Objective: To restore floodplain rearing habitat for juvenile winter-run, spring-run, and CV steelhead in the lower Sacramento River basin. This objective may be achieved at the Yolo Bypass, and/or through actions in other suitable areas of the lower Sacramento River. Action: In cooperation with CDFG, USFWS, NMFS, and Corps, Reclamation and DWR shall, to the maximum extent of their authorities, provide significantly increased acreage of seasonal floodplain rearing habitat, with biologically appropriate durations and magnitudes, from December through April, in the lower Sacramento River basin, on a return rate of approximately one to three years, depending on water year type. In the event this action conflicts with Shasta Operations Actions I.2.1 to I.2.3., the Shasta Operations Actions shall prevail." By December 31, 2011, Reclamation and DWR shall submit to NMFS a plan to implement this action.
82	NMFS	Floodplain	NMFS - Public Draft Recovery Plan for the ESUs of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the DPS of Central Valley Steelhead (October 2009), Section 1.5.5, p.157. "Enhance the Yolo Bypass by re-configuring Fremont and Sacramento weirs to: (1) all for fish passage through Fremont Weir for multiple species; (2) enhance lower Putah Creek floodplain habitat; (3) improve fish passage along the toe drain/Lisbon weir; (4) enhance floodplain habitat along the toe drain; and (5) eliminate stranding events;and (6) create annual spring inundation of at least 8000 cfs to fully activate the Yolo Bypass floodplain."
83	D1641	DCC	For the May 21 - June 15 period, close the Delta Cross Channel gates for a total of 14 days per CALFED Ops Group. During the period the DCC gates may close 4 consecutive days each week, excluding weekends
84	Draft D1630	DCC	When monitoring indicates that significant numbers of salmon smolts or striped bass eggs and larvae are present or suspected to be present, the Executive Director (ED) or his designee shall order USBR to close the gates. The ED, with advice from other agencies, will develop specific monitoring and density criteria for closing and opening the gates.
85	CSPA / C-WIN	DCC	CSPA_Exh1_Jennings, C-WIN closing comments. Source CDFG_1992_WRINT-DFG-Exhibit #8, Alt C (p10). Function: reduce entrainment of Sacramento salmon smolts into the interior Delta
86	NMFS	DCC	NMFS OCAP Bio Opinion, Action Suite IV.1 (pp. 631-640)
87	EDF / Stillwater	Ouflow	EDF_Closing Comments (Table 1) - Mean Historical Delta Outflow Volumes (TAF) for 1956-2003 by month and water year type. Historical and unimpaired flow values are based on Water Years 1956-2003 using California Central Valley Unimpaired Flow Data, 4th ed. (CDWR 2007). In instances where there was a difference between Dry and Critically Dry years, the value for Critically Dry years was selected. Originally reported as volume (TAF). Conversion calculated as follows: (TAF/month)(1000 AF/TAF)(43560 ft3/AF)(month/X days)(day/86400 sec)

Appendix B: Enacting Legislation

California Water Code, Division 35 (Sacramento-San Joaquin Delta Reform Act of 2009), Part 2 (Early Actions), Section 85086

(a) The board shall establish an effective system of Delta watershed diversion data collection and public reporting by December 31, 2010.

(b) It is the intent of the Legislature to establish an accelerated process to determine instream flow needs of the Delta for the purposes of facilitating the planning decisions that are required to achieve the objectives of the Delta Plan.

(c)

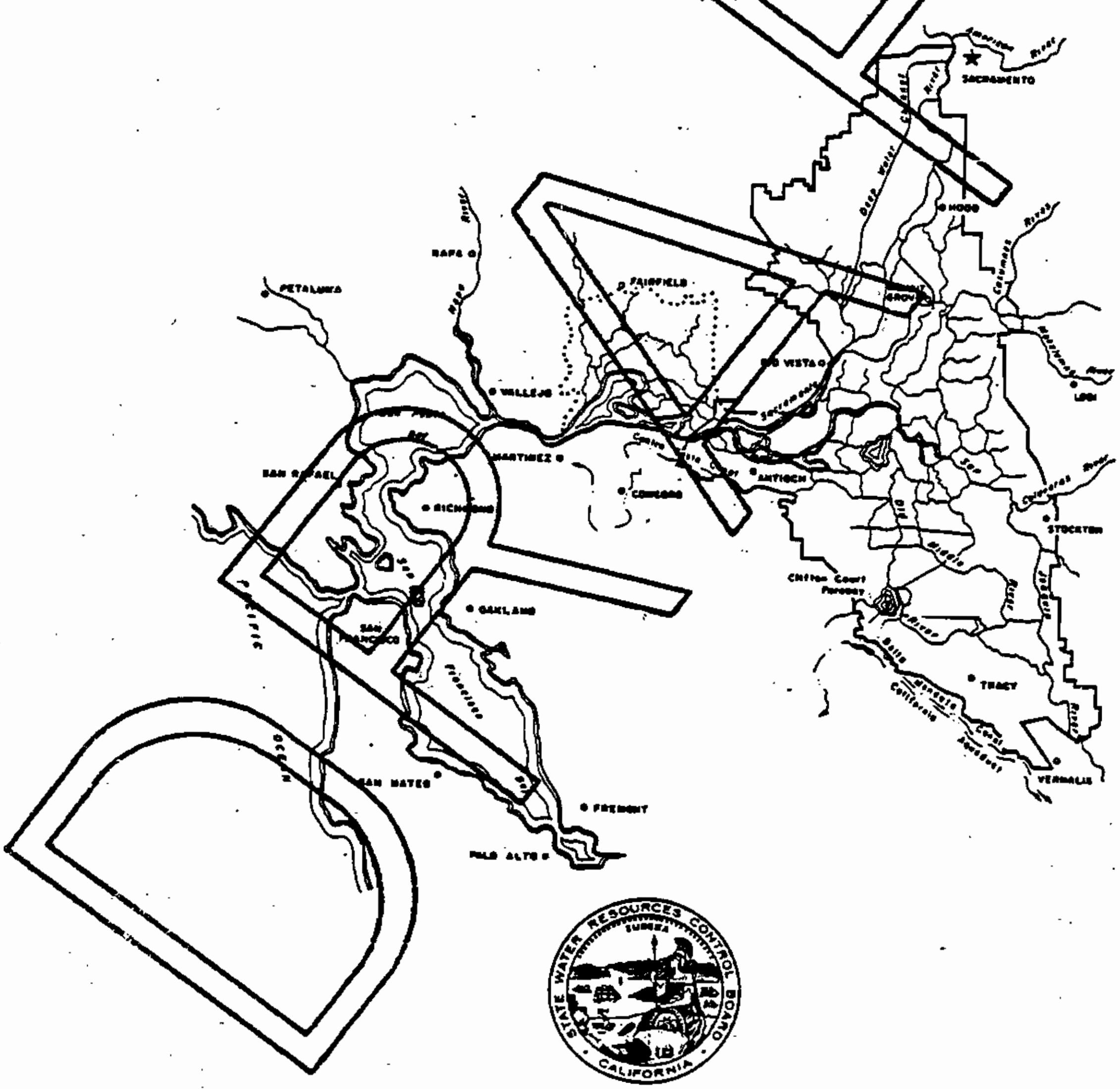
> (1) For the purpose of informing planning decisions for the Delta Plan and the Bay Delta Conservation Plan, the board shall, pursuant to its public trust obligations, develop new flow criteria for the Delta ecosystem necessary to protect public trust resources. In carrying out this section, the board shall review existing water quality objectives and use the best available scientific information. The flow criteria for the Delta ecosystem shall include the volume, quality, and timing of water necessary for the Delta ecosystem under different conditions. The flow criteria shall be developed in a public process by the board within nine months of the enactment of this division. The public process shall be in the form of an informational proceeding conducted pursuant to Article 3 (commencing with Section 649) of Chapter 1.5 of Division 3 of Title 23 of the California Code of Regulations, and shall provide an opportunity for all interested persons to participate. The flow criteria shall not be considered predecisional with regard to any subsequent board consideration of a permit, including any permit in connection with a final BDCP.
>
> (2) Any order approving a change in the point of diversion of the State Water Project or the federal Central Valley Project from the southern Delta to a point on the Sacramento River shall include appropriate Delta flow criteria and shall be informed by the analysis conducted pursuant to this section. The flow criteria shall be subject to modification over time based on a science-based adaptive management program that integrates scientific and monitoring results, including the contribution of habitat and other conservation measures, into ongoing Delta water management.
>
> (3) Nothing in this section amends or otherwise affects the application of the board's authority under Part 2 (commencing with Section 1200) of Division 2 to include terms and conditions in permits that in its judgment will best develop, conserve, and utilize in the public interest the water sought to be appropriated.

(d) The board shall enter into an agreement with the State Water Project contractors and the federal Central Valley Project contractors, who rely on water exported from the Sacramento River watershed, or a joint powers authority comprised of those contractors, for reimbursement of the costs of the analysis conducted pursuant to this section.

(e) The board shall submit its flow criteria determinations pursuant to this section to the council for its information within 30 days of completing the determinations.

Water Quality Control Plan for Salinity

SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA ESTUARY



OCTOBER 1988

STATE WATER RESOURCES CONTROL BOARD

PREFACE

This draft document was prepared by technical staff of the State Water Resources Control Board (State Board) and is subject to the Board's review. The wording of this Plan is presented in a format for Board adoption, rather than being phrased as a staff recommendation to the Board. This Plan does not reflect a position by the Board. Board members have worked with staff in reviewing the contents of the Plan. However, the Board's decision will be based upon the public's comments on this Plan as presented in Phase II as well as the evidence already given in Phase I of the hearing.

Tim Stroshane
November 1988

CITING INFORMATION

When citing evidence in the hearing record, the following conventions have been adopted:

Information derived from the transcript:

```
T,XIX,123:09-125:20
| |   |       |
| |   |       └── ending page and line number (can be same
| |   |           as the starting page) - may be omitted
| |   |           if a single line reference is used
| |   └── beginning page and line number
| └── volume number
└── identifying abbreviation of the information source
    (T = Hearing Transcript)
```

Information derived from an exhibit:

```
SWRCB,25,45
 |    |  |
 |    |  └── page number, table number, graph number
 |    └── exhibit number
 └── identifying abbreviation of the information
     source (see Appendix C, Abbreviations)
```

When citing references outside of the hearing record, the following conventions have been adopted:

Information derived from published documents,
(a) in the text of the Plan:

```
Denton, R.A.,1985
        |    |
        |    └── year of publication
        └── author's name or agency abbreviation
```

(b) at the end of the appropriate Plan Chapter:

```
Denton, R.A., Currents in Suisun Bay, January 1985, pg. 4.
        |             |                     |          |
        |             |                     |          └── page no.
        |             |                     └── publication date
        |             └── title of document cited
        └── author's name or agency abbreviation
```

CITING INFORMATION (Continued)

Information derived from Phase I closing briefs,
(a) in the text of the Plan:

```
RIC,Brief,8
 |    |   |
 |    |   └────────── page number
 |    └──────────── "Brief"
 └────────── identifying abbreviation of the information source
```

(b) at the end of the appropriate Plan Chapter:

Brief of the Rice Industry Committee on Pollutants in the Bay-Delta Estuary, pg. 8.

For a complete list of the abbreviations for information sources, citations and symbols used in this document, see Appendix C.

Appendix D is a Glossary of Terms.

WATER QUALITY CONTROL PLAN FOR SALINITY
SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA ESTUARY

CONTENTS

Chapters (continued)

Chapters (continued)

Chapters (continued)

FIGURES

Figures (continued)

Figures (continued)

Figures (continued)

TABLES

Tables (continued)

Tables (continued)

Tables (continued)

1.0 EXECUTIVE SUMMARY

1.1 Background

The San Francisco Bay and Sacramento-San Joaquin Delta Estuary (Bay-Delta Estuary) includes the Sacramento-San Joaquin Delta (Delta), Suisun Marsh and San Francisco Bay. The Delta is composed of about 738,000 acres, of which 48,000 acres are water surface area; Suisun Marsh comprises approximately 85,000 acres of marshland and waterways. San Francisco Bay includes around 300,000 acres of water surface area. The Delta and Suisun Marsh are located where California's two major river systems, the Sacramento and San Joaquinrivers, converge to flow westward where they meet seawater in the San Francisco Bay. The Bay-Delta Estuary is one of the largest, most important estuarine systems for fish and waterfowl production in the United States. The Delta is also one of the state's most fertile and important agricultural regions and is the location of a major industrial corridor in the vicinity of Antioch.

The watershed of the Bay-Delta Estuary provides about two-thirds of all the water used in California, including 40 percent of the state's drinking water. Two major water distribution systems export supplies from the Delta to areas of use: the State Water Project (SWP) operated by the California Department of Water Resources (DWR), and the Central Valley Project (CVP) operated by the U.S. Bureau of Reclamation (USBR). Numerous other water development projects also alter the river inflows into the Bay-Delta Estuary.

Salinity and flow objectives protect the beneficial uses of water in the Delta and Suisun Marsh. Existing objectives affect operations of the SWP and the CVP. New flow and salinity objectives for the entire Bay-Delta Estuary affecting the SWP, the CVP and other water diverters in the Bay-Delta watershed are being considered by the State Water Resources Control Board (State Board).

1.2 Hearing Process

In 1987 the State Board began a three-phase hearing process to receive and examine evidence on beneficial uses and water quality issues for the possible revision of existing water quality objectives in the Bay-Delta Estuary. The Water Quality Control Plan for Salinity for the San Francisco Bay and Sacramento-San Joaquin Delta Estuary (Plan), one of two documents prepared after the first hearing phase, addresses salinity levels and flow regimes necessary to protect the beneficial uses of Bay-Delta water. The second document, a Pollutant Policy Document (PPD), addresses other pollutants affecting beneficial uses of Bay-Delta water. This latter document will give guidance to the two Regional Water Quality Control Boards which have regulatory responsibility within the Bay-Delta Estuary. Both documents are being circulated for public review. Public comments from that review will be received during Phase II of the hearing process currently scheduled to begin in January 1989. Once these documents have been evaluated and revised by the State Board, they will be adopted. During Phase III, the State Board will conduct a water right hearing to consider implementation of the Plan by the appropriate water right holders.

1.3 Purpose and Current Context of the Plan

The draft Plan has been prepared by State Board staff after careful review and evaluation of the evidence presented during Phase I of the hearing. The Plan includes a description of a series of alternatives and recommendations for the flow and salinity levels needed to protect beneficial uses in the Bay-Delta Estuary; it is prepared under the authority of Water Code Section 13170.

1.4 Structure of the Plan

The draft Plan reflects the process by which the competing beneficial uses of Bay-Delta waters are balanced to provide reasonable protection for each beneficial use.

1.4.1 Chapter 1 -- Executive Summary

The Executive Summary serves as the first chapter of the Plan.

1.4.2 Chapter 2 -- Scope of the Plan

The Plan contains recommended flow and salinity objectives, as well as a program of implementation which will provide reasonable protection for beneficial uses of Bay-Delta Estuary water. In determining these levels of protection, all uses of water originating from and transferred into the Bay and Delta hydrologic basins are considered. The flow and salinity objectives for the Bay-Delta Estuary contained in this Plan supercede any conflicting objectives contained in the current Water Quality Control Plans of the San Francisco Bay and Central Valley Regional Water Quality Control Boards and other State Board plans.

- Board Authority

  The State Board is responsible for formulating and adopting state policy for water quality control. Under its water right authorities, the State Board can condition rights for the diversion and use of water. The Board has continuing authority over all water rights to prevent waste and unreasonable use of water and to protect public trust uses. The Board also has authority under the Water Code to impose specific terms and conditions on new permits to protect the public interest, prior water rights, recreation, fish and wildlife, and other interests.

  Recent court decisions, specifically, the Racannelli or Delta Water Cases Decision,[1/] have directed the State Board to take a global perspective of water resources in developing water quality objectives. The State Board's duty in its water quality role is to provide reasonable protection for beneficial uses, considering all demands made on the water.

1/ United States v. State Water Resources Control Board (1986) 182 Cal.App.3d 82, 227 Cal.Rptr 161.

The State Board's water quality function is related to but not coincident with protection of water rights. Water quality objectives are not to be limited to what the State Board can enforce under its water right authority. The court recognized, however, that an implementing program may be a lengthy and complex process that requires significant time intervals and action by entities over which the State Board has little or no control.

The contents of each Chapter are briefly described in Chapter 2 along with the geographic limits for the water quality objectives set in the Plan. The PPD is also identified as establishing state policy for pollutant regulation in the waters of the Bay-Delta Estuary.

1.4.3 Chapter 3 -- Basin Description

The Bay-Delta Estuary and its adjacent areas described in the Plan include the Delta; the Delta's tributary areas of the Sacramento River, the Central Sierra and the San Joaquin River basins; and the San Francisco Bay and itshydrologic basin. This chapter provides information on the physical description, hydrology, and unimpaired and current flow conditions for each of these areas.

- Water Year Classification

Under the Delta Plan adopted in 1978, water quality objectives were set for different water year classifications. Those classifications were wet, above normal, below normal, dry, and critically dry and were based on the four rivers of the Sacramento Basin. In this Plan the classification is still used (see Figure 1), but in addition, a separate water year classification has been established for the San Joaquin River Basin. The San Joaquin River Basin classification (see Figure 2) is based on the following four tributaries: the Stanislaus, Tuolumne, Merced, and San Joaquin rivers. An 82-year period, 1906 through 1987, is used to determine the classification boundaries for both river basins, instead of the 50-year period, 1922 through 1971, used in the 1978 Delta Plan. The current water year and the "year following critical year" designations are based on the April through July runoff, and apply to all objectives, not just those for fish and wildlife.

The San Joaquin River Basin water year classification is used for water quality objectives in the southern Delta and for the export objectives.

1.4.4 Chapter 4 -- Beneficial Uses

A clear understanding of each beneficial use builds a foundation for weighing and balancing appropriate levels of protection discussed in succeeding chapters. Beneficial uses include domestic, municipal, agricultural and industrial supply; recreation; esthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources. In summarizing issues addressed during Phase I of the Bay-Delta hearing, this chapter discusses what beneficial uses are, their flow requirements and their salt tolerances.

1.4.5 Chapter 5 -- Optimal Levels of Protection

The levels of flow and salinity considered to be optimal for the protection of each beneficial use without regard to others are presented in this chapter. Three alternatives for each beneficial use are discussed: (1) the no action alternative; (2) advocated levels of protection; and (3) the optimal level of protection.

1. The no action alternative is the existing level of flow and salinity protection for the beneficial use being discussed. This level complies with federal regulations protecting existing uses.

2. Advocated levels of protection are those recommended by the participants in Phase I of the hearing. Testimony or exhibits that recommend flow and salinity levels to protect a specific beneficial use are summarized.

3. The optimal level can be the same as one or both of the previous two if they provide optimal protection; it can also be a separate level based upon an independent evaluation of available data. In any case, the optimal level provides the ideal condition for a specific beneficial use and the background against which all alternatives developed in Chapter 7 can be measured.

1.4.6 Chapter 6 -- Reasonable Demands for Consumptive Use of Bay-Delta Waters

water ethic

This chapter offers a California water ethic (discussed subsequently) along with assumptions on water use that are consistent with this ethic. In order to preserve and distribute California's limited water resources equitably, there is a distinct need for a high degree of conservation, reclamation and conjunctive use of water.

simply not enough water to all B-uses

Since some beneficial uses have competing needs, an examination of optimal levels shows that full protection of all beneficial uses in all water years is impossible. There simply is not enough water. Also, protection of some uses can conflict with the needs of others. Some accommodation has to occur. An analysis of the reasonable consumptive needs for Bay-Delta water in areas upstream, within, and exported from the Estuary reveals that water can be managed differently to meet existing and reasonable future needs.

Water users offered projections of water needs to the year 2010. In these projections, some water savings were assumed. However, a more rigorous application of the California water ethic indicates that greater savings can be realized. Further, this chapter evaluates the ability to increase April through July Sacramento and San Joaquin river flows through the conjunctive use of surface and ground water and the changing of reservoir operations. The objectives in Chapter 7 are founded on the foregoing assumptions.

Estimates of agricultural water conservation savings are based on a more efficient, yet achievable, water application and reuse program.

The assumed water saving methods apply to all municipal and industrial needs, including upstream areas tributary to the Estuary, in-basin areas, downstream areas, and export areas. Estimates of savings are based on an agressive water conservation and reclamation program.

1.4.7 Chapter 7 -- The Development of Reasonable Alternative Water Quality Control Objectives

Reasonable water quality and instream flow needs for beneficial uses in the Estuary are discussed. These water quantity and water quality needs are compared in six sets of alternatives; the water supply impacts are summarized for three components: Sacramento and San Joaquin river inflows and Delta exports. To achieve equitable global balancing of protection for beneficial uses, the reasonable water quality and flow needs of the Estuary are weighed against the appropriateness of achieving those flows. Alternative five (5) is recommended (see Recommendation Section below).

1.4.8 Program of Implementation

Programs that reflect the need for the long range California water ethic are highlighted. They include water conservation and reclamation. The Plan anticipates that water projects other than the CVP and SWP will be modified as needed to protect beneficial uses in the Estuary. Additional water facilities such as ground water and offstream storage facilities are encouraged. The Central Valley Regional Water Quality Control Board is requested to adopt a salt load reduction policy. Various monitoring programs and legislative proposals are also suggested.

1.5 Concerns

During Phase I of the hearing, evidence was introduced about the need foradequate protection of water quality for agricultural, municipal, industrial and biological uses in the Estuary. The data show a prolonged decline in the natural salmon population and Delta fish as they related to water project operations (see Figure 3). The need for water to reduce salinity levels and for sufficient flows to protect the resources in the Estuary was presented. Considering the certainty of California's population and economic growth, representatives from several areas of the state testified that large amounts of additional water would be needed in the future.

Several witnesses testified about the availability of water. The evidence shows a greater need for water than the available supply. A broad balancing of that evidence has been made in recommending flow and salinity objectives.

In the balancing process, it should be recognized that biological resources have declined and are not experiencing the same degree of protection as other beneficial uses. Past balancing to protect biological resources has not been as effective as projected according to present evidence. This decline has beentaken into consideration in the balancing process.

1.6 California Water Ethic

All Californians must practice conservation, reclamation and conjunctive surface and ground water use in order to share responsibility for the reasonable use of water appropriately.

California's ground and surface waters are a precious, but limited resource. Water rights allow only the reasonable use of this resource. Water is vital to homes, industry, agriculture and public trust values. Supplies vary substantially from year to year. In the past, dams were built to control flooding and provide supplies during prolonged dry periods. Today, additional actions to promote the conservation, control and maximum utilization of water are required (Water Code Section 13000). All Californians must become involved in the reasonable use of water.

The California water ethic includes the coordination of several programs, each applicable in varying degrees to every region of the state. Best management practices related to the use of water are needed in all areas of the state. Careful water use decreases pollutant loadings as well as water demands.

The water ethic assumes:

- Conservation -- Municipal and industrial water users (residential, industrial and commercial) will be metered. With appropriate plumbing, leak detection, and landscaping techniques, per capita water use will be significantly reduced. Also, there are substantial opportunities for water savings by commercial and industrial water users. All agricultural users will use water as efficiently as feasible, particularly those who contribute drainage flows to salt sinks where reuse is impractical.

- Reclamation -- Where feasible, water reclamation and recycling consistent with state laws shall be required to reduce the demand on existing potable water supplies. Water reclamation includes the enhanced treatment of wastewater for reuse, the conversion of saline water to freshwater, and the treatment of ground water to a sufficient level to allow subsequent beneficial use.

- Conjunctive Use -- Ground water storage basins will be effectively utilized in conjunction with distribution of surface water.

- Sharing Responsibility -- Adequate flows for beneficial uses in the Estuary are the responsibility of all water users in the Bay-Delta watershed. In the past this obligation has been imposed largely on the CVP and SWP.

- Physical Facilities -- To better manage California's water resources, physical facilities are encouraged.

- Pollution Control -- Maximum practical pollution control at the source takes precedence over releases of freshwater for flushing flows.

1.7 Principles Guiding the Development of Water Quality Objectives

The following principles will assist in the conservation and equitable distribution of California's limited water resources. These principles are founded upon the foregoing water ethic, a careful review of the Phase I hearing evidence, an understanding of the Board's authority, and the appellate court's direction. Further, these principles also provide reasonable protection to each of the beneficial uses of the waters of the Bay-Delta Estuary under Water Code Section 13241.

- Municipal and industrial water users should receive salinity protection of at least the secondary public health standard of 250 mg/l chloride.

- Delta agricultural users should receive water quality that fully protects their needs assuming that they are employing best management practices and to the extent that such quality was available under unimpaired conditions with present day channel configurations (see Cal. Const., Art X, Sec.2).

- Aquatic life in the Estuary should receive the salinity and flows at an appropriate historic level. The appropriate historic level is established during the balancing process as subsequently explained. (See Water Code Section 1243; Public Resources Code Section 21000, et seq.; State Board Resolution 68-16).

- The formation of trihalomethane compounds from Delta waters cannot reasonably be resolved through the establishment of flow and salinity objectives.

- At this time, the use of Delta outflow solely to flush pollutants, other than ocean derived salts, out of the Estuary is not reasonable. The need for such flows may be considered in the future after all reasonable source control methods have been implemented and only if it is found to be in the public interest.

- Increasing Delta inflows and decreasing Delta exports in the spring (which among other things will reduce reverse flows in the Old and Middle rivers) offers the best chance to obtain balanced protection of all beneficial uses dependent upon Bay-Delta water supplies. The Department of Water Resources should continue to investigate the potential for protecting beneficial uses and more efficient use of water through development of physical facilities.

The foregoing principles were used as assumptions in developing the water quality objectives contained in this Plan.

1.8 Recommendations

The Plan develops new water quality objectives for each beneficial use in the Estuary. The water quality objectives are shown in Table 1 and a summary of these objectives is presented below. Control stations for the objectives are depicted in the accompanying map (See Appendix D).

1. Municipal and industrial intakes are provided water quality protection for the secondary public health standard of 250 mg/l chloride. Actual water quality during most of the year will be considerably better than this due to the "umbrella" protection provided by other objectives.

   The 150 mg/l chloride objective at the Rock Slough intake of the Contra Costa Water District is deleted. The beneficial uses of water will be reasonably protected at 250 mg/l chloride. The users from this intake could relocate their intake, construct local reservoirs to capture winter time flows for blending in the summer, and take other actions to improve their water quality consistent with local desires for such quality and local economics.

2. Agricultural users in the Delta are provided water quality that fully protects their needs assuming that they are employing best management practices and to the extent such water quality was available under unimpaired flow with existing channel configurations. Evidence presented during the hearing indicates that the farmers on the Delta's organic soils can achieve full crop yields with saltier water than previously believed. The new objectives reflect these data.

   Agricultural pursuits on southern Delta mineral soils need better water quality than currently exists. The Plan will improve water quality so that these users are better protected.

3. Aquatic life in the Estuary has suffered losses in the recent past. The best data are for only two fish species--salmon and striped bass. Abundance of those species is affected by inflows into and exports from the Estuary, especially during the April through July period. The objectives for the Sacramento River salmon populations are established to attain the 1930-87 average monthly April through June flows (for each year type) which have been shown to be important to salmon. This represents all the data available for interior Delta stations important for salmon protection. The level of protection prescribed for the Sacramento River system was found to be unattainable on the San Joaquin River system without an unreasonable impact on upstream consumptive uses. An achievable and reasonable level of protection was the attainment of average flows that have existed since the current physical configuration of the Delta (1953-87). Also, minimum flows to protect striped bass

recommended by the State Department of Fish and Game (DFG) and supported by the U. S. Fish and Wildlife Service are incorporated in the recommended objectives. Export limits during the April through July period are made equivalent to the levels that existed before the decline of young fish survival in the Delta (1953-1967), but only to the extent that such reductions are needed to reduce the magnitude of reverse flows in Old and Middle rivers.

These levels reflect the average monthly exports that occurred during April through July for each year type in the period 1953-1967. One may note under Delta Fishery Export Limits in Table 1 that export limits for dry and critical years exceed those allowed in more water plentiful year types. The resilience of the fishery resource demonstrated in the past illustrates that the resource can withstand greater impacts of the magnitude shown for a short period of time (dry and critical years) and still recover.

These new objectives better protect aquatic resources than the previous objectives.

4. Suisun Marsh is provided protection generally consistent with the Four-Agency Agreement signed by the Suisun Resource Conservation District, DFG, State Department of Water Resources, and the U. S. Bureau of Reclamation. The only difference is that in water deficient years, year types are determined by using the median year runoff forecasts instead of the lower 20 percent forecasts as used in the agreement. This provides better protection than the Four-Agency Agreement. The Board is requesting DFG's advice during Phase II on the effects of the agreement on endangered species within tidal marshes in the Suisun Bay area.

5. San Francisco Bay was discussed extensively during the Board's Phase I hearing. Information presented showed an insufficient connection between physical changes in the Bay due to inflows and the beneficial uses in the Bay. The evidence presented was judged insufficient as a basis for water quality objectives. The Board will require that further studies be performed to address these concerns and that such concerns will be addressed in the consideration of the water right permits of any large unconstructed water storage projects.

6. Analyses of the reasonable consumptive water needs of areas receiving exported water from the Delta indicates that the needs through the year 2010 can be met without increasing current annual exports. This assumes the California water ethic set forth previously is implemented. In Phase III the Board should consider the following in order to best conserve and utilize Bay-Delta waters:

   a. The combined export quantity per water year from the USBR Tracy Pumping Plant and the SWP Banks Pumping Plant be limited, except that in wet and above normal years water above that required to meet objectives in the Bay-Delta Estuary may be pumped for conjunctive ground water storage and offstream surface storage; and

b. The amount of water pumped per water year at the SWP Edmonston Pumping Plant for use in the southern California portion of the SWP service area be limited, except that: (1) an increase above that amount equal to the quantity of water conserved through increased agricultural efficiency in the San Joaquin Valley would be allowed; and (2) in wet and above normal years water above that required to meet objectives in the Bay-Delta Estuary may be pumped for conjunctive ground water storage and offstream surface storage; and

c. Agricultural users who contribute drainage flows to salt sinks should achieve a high but reasonably attainable water use efficiency.

1.9 Implementation

Many of the recommendations contained in this water quality control plan will be attained through the Board's water right authority. During Phase III of the Bay-Delta hearing process, the Board will determine which water users will share in the responsibility of attaining the water quality objectives specified in the Plan and in achieving other provisions of the Plan. Implementation of all objectives is scheduled to occur over the next six years. A detailed time frame for implementing this Plan will be determined after the specific water users have been identified.

1.10 Water Supply Impacts

Alternative 5 best achieves the balanced levels of protection of beneficial uses described in the foregoing section. The impacts are depicted in Figures 4 and 5.

Two bases of comparison were used to develop an impact analysis. Impacts that could result from the objectives specified in the recommended alternative were compared to: (1) those of the 1978 Delta Water Quality Control Plan (currently in place) using a 1922-78 hydrologic cycle and a projected 1990 level of development as presented by DWR (Figure 4); and (2) actual values using the recent hydrologic period of 1972-87 (Figure 5). Two different analyses of impacts were performed to provide the public with an assessment of the effects of Alternative 5 objectives on planned water diversions in the near future and on historical conditions experienced in the recent past. Note that in the latter analysis, the 1983 water year data were disregarded because that year was the wettest year of record and tended to skew the average.

In both instances, the average impacts were analyzed on an annual basis and during the April through July period. The period April through July is particularly significant. Although the top bar graph in both figures depicts average impacts over the period of record, impacts for each year type (i.e., wet, above normal, etc.) were assessed to determine if the objectives were attainable and reasonable. A more detailed analysis of impacts is sought during the Phase II hearings.

1. The top bar graph of both figures reveals that there will be no change in average annual flows nor in the 1985-level of exports. Exports in 1985 are the highest to date, and 16 percent higher than the average amount of water exported since D-1485 standards went into effect in 1978. While Delta inflows from the Sacramento and San Joaquin rivers to meet the recommended Plan objectives increase over those required to meet the 1978 Plan objectives and increase over recent historic levels, annual flows do not. However, as shown in the bottom bar graphs, April through July flows do change. Our analysis shows that the reduction in flows during that period can be fully offset during other months of the year. This assumes partial utilization of existing water reserves on the Sacramento River system, conjunctive use of ground and surface waters in the San Joaquin River Basin, greater utilization of offstream storage south of the Delta, and a rescheduling of exports from the spring to winter months.

2. With regard to Figure 4, total Delta outflow in April through July to protect the Estuary will result in an increase over the long-term hydrologic period of 1922-78 of about 1,560 thousand acre-feet (TAF). If compared to recent historic information (Figure 5), the increase amounts to 1,080 TAF. The increase in April through July Delta outflow is achieved through an increase in river inflows into the Delta (Sacramento River -- 360 TAF and San Joaquin River -- 530 TAF; total of 890 TAF) and a decrease in water exported from the Delta (670 TAF). Correspondingly, Figure 5 illustrates that a total increase in river inflow of 880 TAF is needed with a decrease in exports, on the average, of 200 TAF.

   As stated previously, in order to meet the objectives of the recommended alternative and the additional water required, two major actions will be needed. First, a portion of the water reserves in the Sacramento and San Joaquin basins will be required for Estuary protection. According to DWR Bulletin 160-87, the Sacramento Basin currently has a 588 TAF reserve and the San Joaquin has a 157 TAF reserve. These reserves are projected to decrease to 549 and 128 TAF respectively by the year 2010. Second, conjunctive use of surface water and ground water supplies plus a different mode of operation of reservoirs may be needed to make up for water not available in the April through July period. On the San Joaquin River system, for instance, an analysis indicates that such programs could increase flows in the river during the April through July period from at least 170 TAF in critical years to almost 700 TAF in wet years. This change in operations would affect less than five percent of the combined ground water/surface water storage in the Basin.

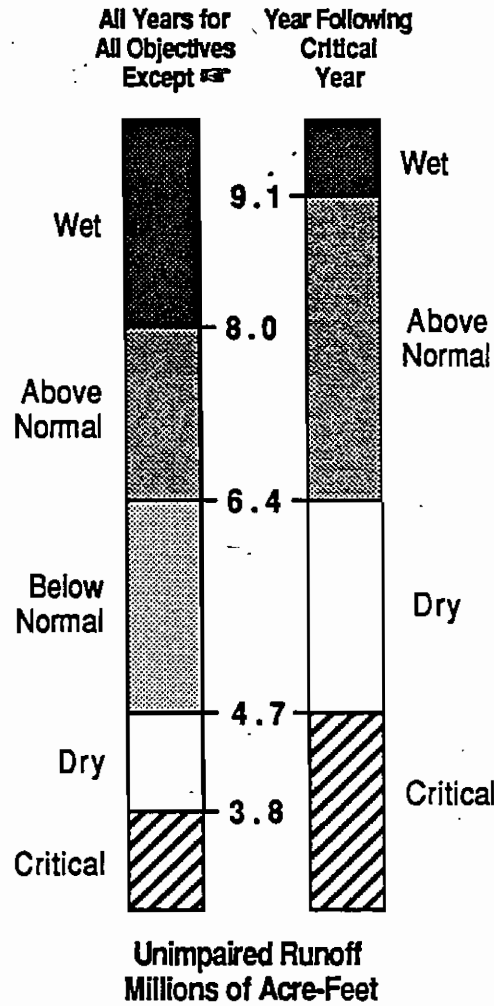
3. April through July exports from the Delta, projected from the 1990 operations study would be reduced by about 670 TAF under the recommended alternative Plan. A slightly greater reduction (about 680 TAF) would occur if the recommended Plan is compared to the recent high export values of 1985. On the other hand, if comparing to recent historic data, the reduction in exports would amount to 200 TAF on the average, or 540 TAF if compared to the 1985 level of exports. In either case, as demonstrated in the operations study, the capability to recover this deficit exists in the other seasons of the year, albeit a change in export operations would be required.

FIGURE 1
SACRAMENTO RIVER BASIN
APRIL THROUGH JULY HYDROLOGIC CLASSIFICATION

The Sacramento River Basin April through July hydrologic classification shall be determined by the forecast of Sacramento Valley unimpaired runoff for the year's April through July period as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of the classification shall be based on the April through July hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the April through July period.

CLASSIFICATION	UNIMPAIRED RUNOFF MILLIONS OF ACRE-FEET
Wet	Equal to or greater than 8.0 (except equal to or greater than 9.1 in an April through July period following a critical year).
Above Normal	Greater than 6.4 and less than 8.0 (except greater than 6.4 and less than 9.1 in an April through July period following a critical year).
Below Normal	Equal to or less than 6.4 and greater than 4.7 (except in an April through July period following a critical year).
Dry	Equal to or less than 4.7 and greater than 3.8 (except equal to or less than 6.4 and greater than 4.7 in an April through July period following a critical year).
Critical	Equal to or less than 3.8 (except equal to or less than 4.7 in an April through July period following a critical year).

APRIL THROUGH JULY CLASSIFICATION *



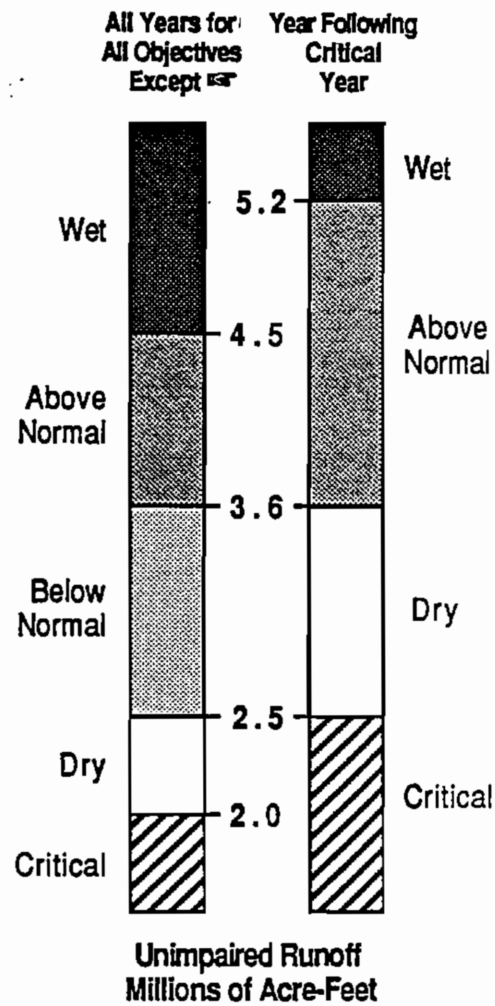
* The April through July classification for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year's April through July classification is available.

FIGURE 2
SAN JOAQUIN RIVER BASIN
APRIL THROUGH JULY HYDROLOGIC CLASSIFICATION

The San Joaquin River Basin April through July hydrologic classification shall be determined by the forecast of San Joaquin Valley unimpaired runoff for the year's April through July period as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake. Preliminary determinations of the classification shall be based on the April through July hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the April through July period.

CLASSIFICATION	UNIMPAIRED RUNOFF MILLIONS OF ACRE-FEET
Wet	Equal to or greater than 4.5 (except equal to or greater than 5.2 in an April through July period following a critical year).
Above Normal	Greater than 3.6 and less than 4.5 (except greater than 3.6 and less than 5.2 in an April through July period following a critical year).
Below Normal	Equal to or less than 3.6 and greater than 2.5 (except in an April through July period following a critical year).
Dry	Equal to or less than 2.5 and greater than 2.0 (except equal to or less than 3.6 and greater than 2.5 in an April through July period following a critical year).
Critical	Equal to or less than 2.0 (except equal to or less than 2.5 in an April through July period following a critical year).

APRIL THROUGH JULY CLASSIFICATION *



* The April through July classification for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year's April through July classification is available.

FIGURE 3

STRIPED BASS INDEX, SACRAMENTO/SAN JOAQUIN NATURAL SALMON POPULATION AND TOTAL DELTA EXPORTS

SBI: 1959 - 1988, EXCEPT 1966; POPULATION: SR 1953 - 1984, SJR 1953 - 1984; EXPORTS: AVERAGE APRIL - JULY EXPORTS, 1953 - 1987

(5 Year Running Average)

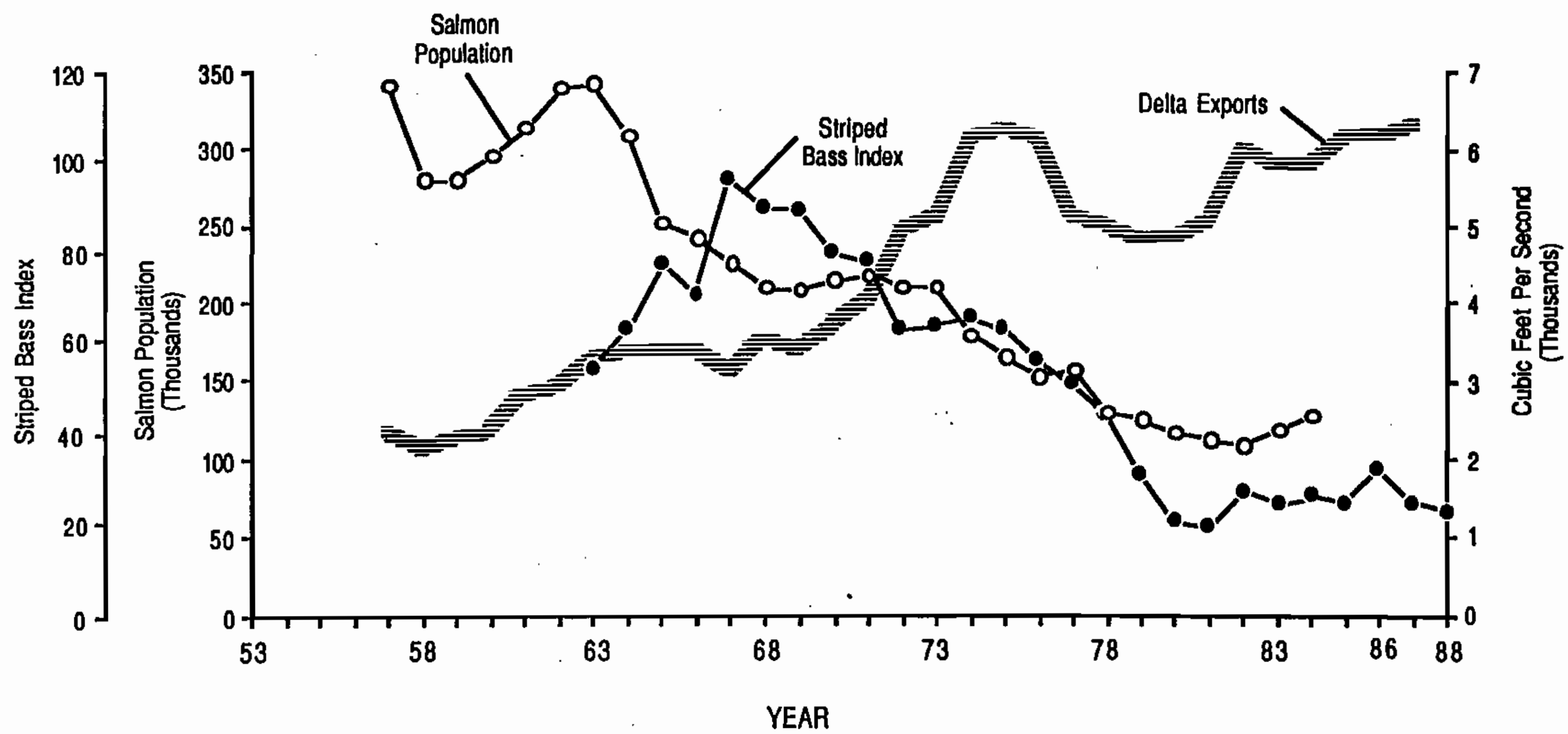


FIGURE 4

RECOMMENDED PLAN WATER SUPPLY IMPACTS

1922–78 HYDROLOGY UNDER THE PRESENT LEVEL–OF–DEVELOPMENT

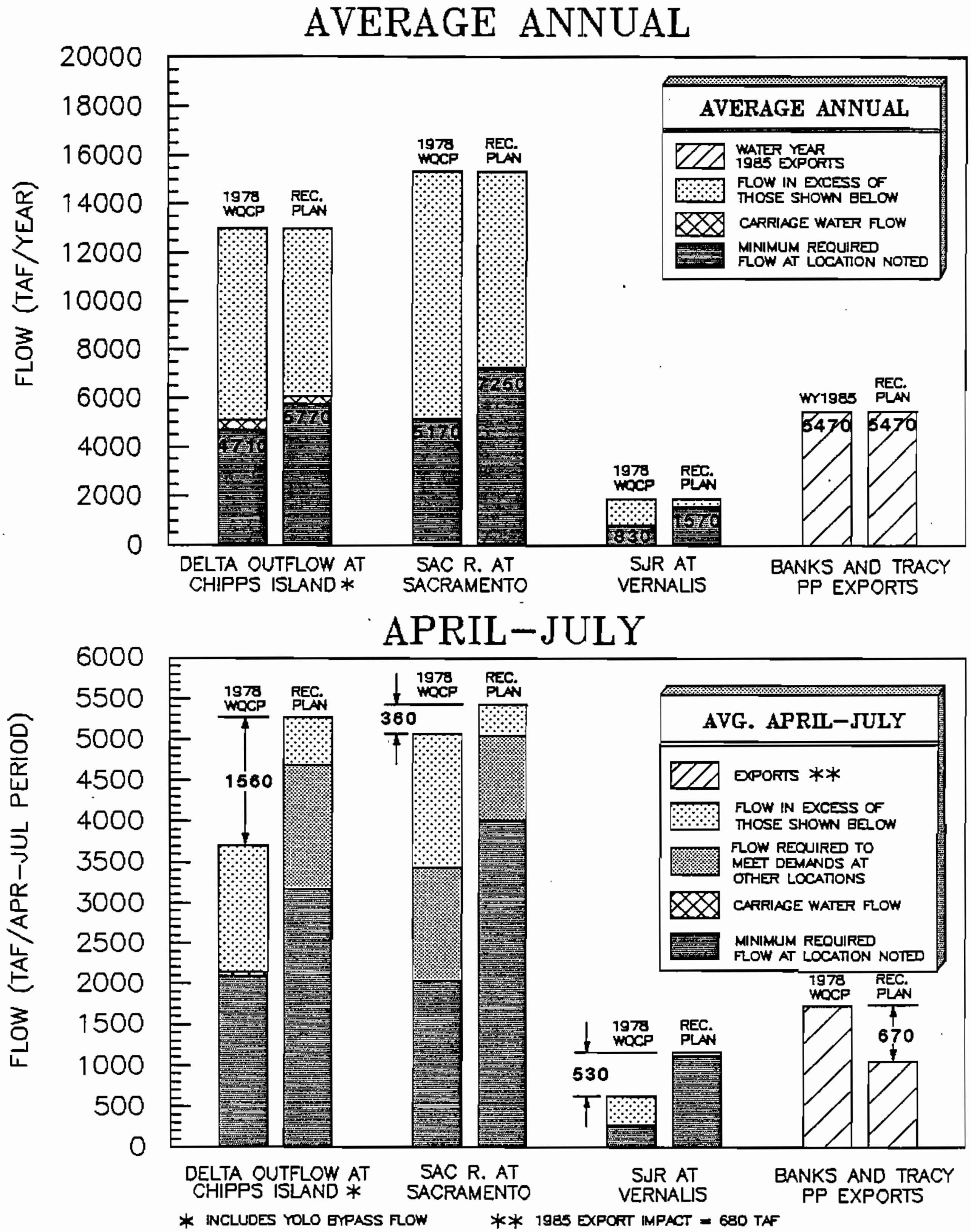
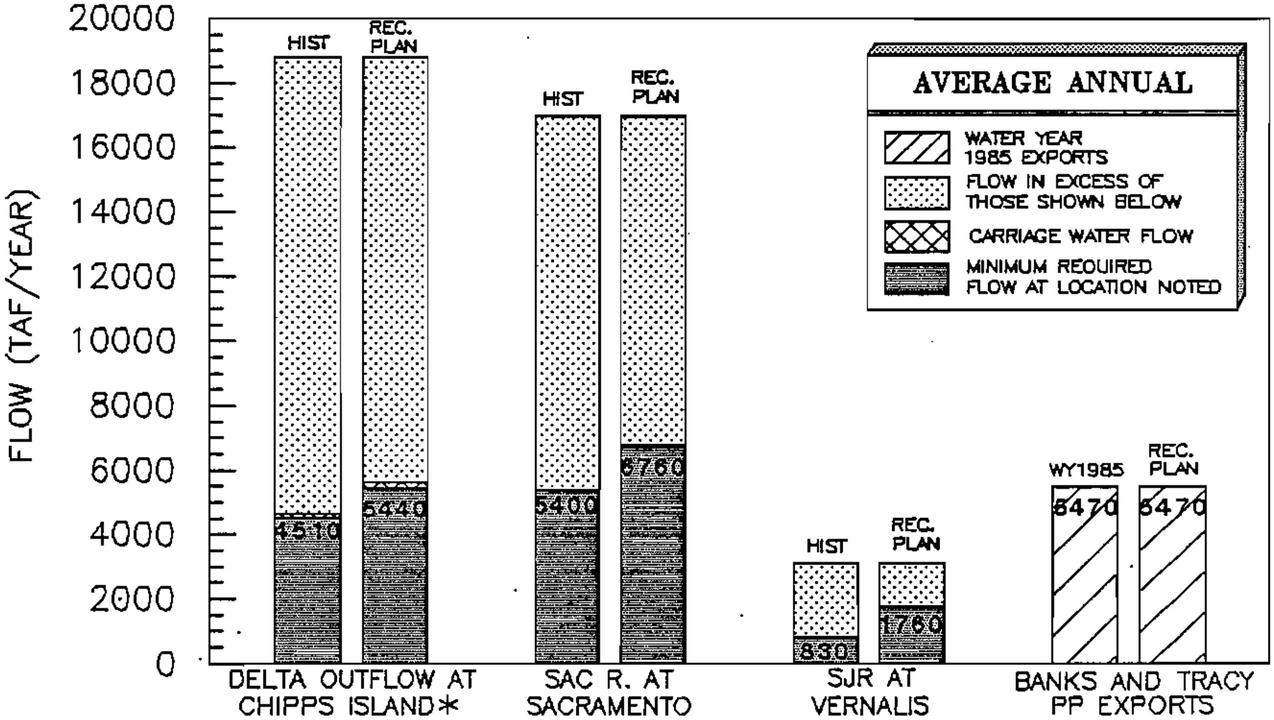


FIGURE 5

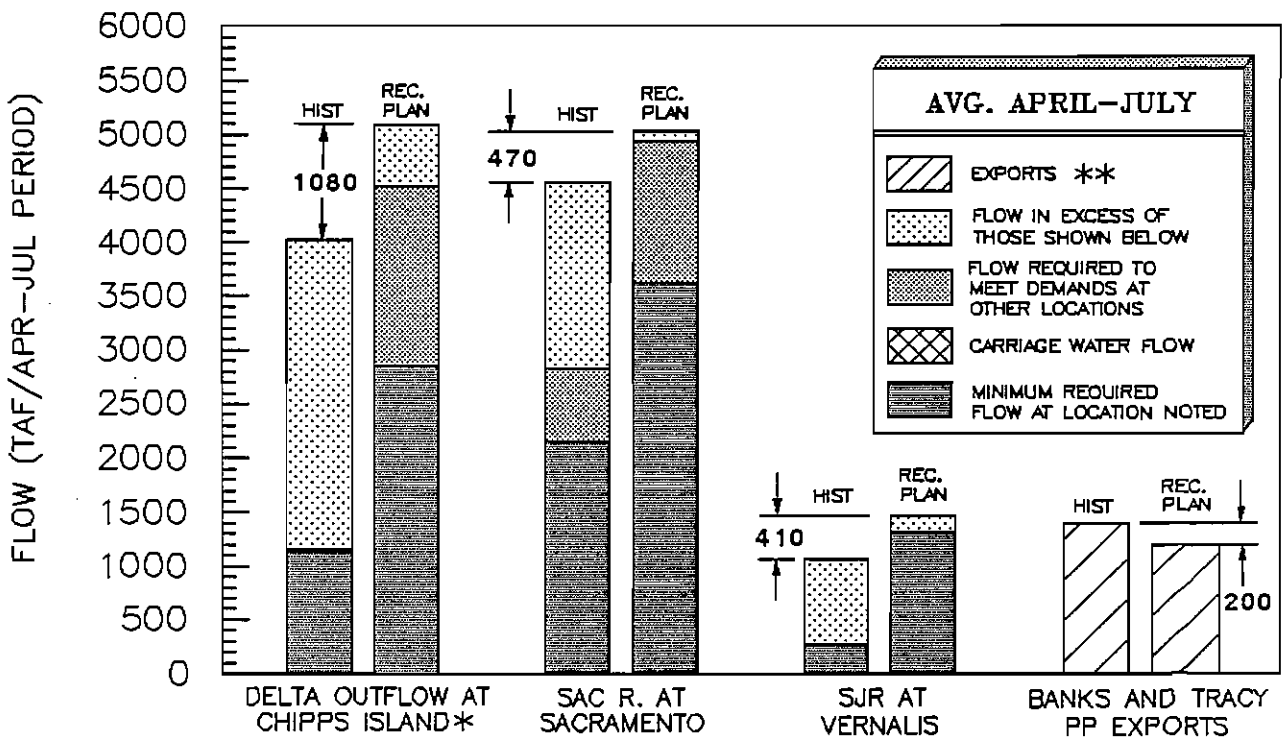
RECOMMENDED PLAN WATER SUPPLY IMPACTS

1972–1987 (W/O 1983) HISTORIC HYDROLOGY

AVERAGE ANNUAL



APRIL–JULY



* INCLUDES YOLO BYPASS FLOW   ** 1985 EXPORT IMPACT = 540 TAF

TABLE 1

RECOMMENDED WATER QUALITY OBJECTIVES

Beneficial Use Protected and Location		Sampling Site #	Parameter	Description	Year Type (Sacramento, unless * shows San Joaquin)	Dates	Values or Limits
MUNICIPAL and INDUSTRIAL							Cl-
City of Vallejo Intake (Footnote 1)		C19 (Footnote 2)	Chloride	Maximum Mean Daily Chloride, mg/l	All		250
Contra Costa Canal at Pumping Plant #1 (Footnote 3)		C5	"	"	"		"
Clifton Court Forebay Intake at West Canal		C9	"	"	All*		"
Delta Mendota Canal at Tracy Pumping Plant		DMC1	"	"	All*		"
North Bay Aqueduct at Barker Slough		NBA1	"	"	All		"
AGRICULTURE						Dates	EC
Western Delta Irrigation	Emmaton Jersey Pt.	D22 D15	Electrical Conductivity	Maximum 14-Day Running Average of Mean Daily EC, mmho/cm	All except Critical	4/1-8/15	1.5
					Critical	4/1-7/31 8/1-8/15	1.5 3.0
Interior Delta Irrigation	Cache Slough at Junction Pt. San Andreas Landing Terminous	CS1 C4 C13	Electrical Conductivity	Maximum 14-Day Running Average of Mean Daily EC, mmho/cm	All	4/1-8/15	1.5
South Delta Irrigation	Vernalis Brandt Bridge Tracy Road Br. Mossdale Howard Road Br. at Middle R. Old R. at Middle R.	C10 C6 P12 C7 HRM1 C8	Electrical Conductivity	Maximum 14-Day Running Average of Mean Daily EC, mmho/cm	All*	4/1-8/31 9/1-3/31	0.7 1.0
Delta Salinity Leaching	Emmaton Jersey Pt. Cache Slough San Andreas Landing Terminous	D22 D15 CS1 C4 C13	Electrical Conductivity	Winter pond leaching Maximum Monthly Ave. of Mean Daily EC, mmho/cm	All	12/1-2/28	1.7

See last page of table for Footnotes

TABLE 1 cont'd

RECOMMENDED WATER QUALITY OBJECTIVES

Beneficial Use Protected and Location		Sampling Site #	Parameter	Description	Year Type (Sacramento, unless * shows San Joaquin)	Dates	Values or Limits				
FISH and WILDLIFE							EC	Dates	EC		
Suisun Marsh Wildlife Habitat Interim objectives (Footnote 4)	Chipps Is.	D10	Electrical Conductivity	4-Agency Agreement Interim objective 28-day mean EC, mmhos/cm at Chipps Island	Wet	10/1-12/31	12.5	1/1-5/31	12.5		
					Ab. Normal	"	12.5	"	12.5		
					Bl. Normal	"	12.5	"	12.5		
					Dry (deficiency)	"	12.5 (15.6)	"	12.5		
					Critical(deficiency)	"	12.5 (15.6)	"	12.5		
Suisun Marsh Wildlife Habitat Interim objectives (Footnote 4)		D10	Delta Outflow Index (DOI) (Footnote 5)	4-Agency Agreement Interim objective Min mean mo. DOI with 2 of 3 reservoir flood env's encroached	All	All Year		Flow in CFS 6,600			
Suisun Marsh Wildlife Habitat Interim objectives (Footnote 4)		D10	Delta Outflow Index	4-Agency Agreement Interim objective Min 14-day mean DOI for 60 consec.days	Wet	2/1-5/31		10,000			
					Ab. Normal	1/1-4/30		12,000			
					Bl. Normal	"		12,000			
Suisun Marsh Wildlife Habitat Normal objectives		See Below	Control Sta. Electrical Conductivity	4-Agency Agreement Normal objective at station Mean mo. high tide EC, mmhos/cm	All (except in deficiency period)	Dates	EC	Deficiency Period EC			
Sacto. R. at Collinsville Road (C-2)						10/1-31	19.0	19.0			
Montezuma Slough at National Steel (S-64)						11/1-30	16.5	16.5			
Montezuma Slough near Beldon Landing (S-49)						12/1-31	15.5	15.6			
Suisun Slough 300 ft S. of Volanti Slough (S-42)						1/1-31	12.5	15.6			
Goodyear Sl. S. of proposed Goodyear Sl. Control Structure (proposed S-75)						2/1-28	8.0	15.6			
Cordelia Slough at Cordelia-Goodyear Ditch (proposed S-97)						3/1-31	8.0	15.6			
Chadbourne Slough at Chadbourne Rd.(proposed S-21)						4/1-30	11.0	14.0			
Goodyear Slough at Morrow Island Clubhouse (S-35)(Footnote 7)						5/1-31	11.0	12.5			
Cordelia Slough, 500 ft W. of Southern Pacific crossing at Cygnus (S-33)(Footnote 7)								(Footnote 6)			
						Flow in CFS 1/1-31	2/1-3/15	3/16-31	7/1-31	8/1-31	9/1-12/31
Sacramento Salmon Migration of Fall Run Adults	Rio Vista Bridge	D24	Flow	30-day Running Average of Mean Daily Flow,CFS	Wet	2,500	3,000	5,000	3,000	1,000	5,000
					Ab. Normal	2,500	2,000	3,000	2,000	1,000	2,500
					Bl. Normal	2,500	2,000	3,000	2,000	1,000	2,500
					Dry	1,500	1,000	2,000	1,000	1,000	1,500
					Critical	1,500	1,000	2,000	1,000	1,000	1,500
						4/1-30	5/1-31	6/1-30			
Outmigration of Smolts	Rio Vista Bridge	D24	Flow (Footnote 9)	Historic 1930-87 flows in CFS	Wet	22,500	22,000	18,500			
					Ab. Normal	22,500	21,000	10,500			
					Bl. Normal	16,500	14,500	7,500			
					Dry	12,500	10,000	6,500			
					Critical	8,500	5,000	2,500			
Salmon Fry Survival	Walnut Grove		Delta Cross Channel	Operation of gates	All when Delta Outflow Index over 12,000 CFS (Footnote 5)	1/1-3/31 closed					
San Joaquin Salmon Outmigration of Juveniles	Vernalis	C10	Flow (Footnote 9)	Historic 1953-87 flows in CFS	Wet *	14,000	13,500	11,000			
					Ab. Normal *	5,000	5,000	5,000			
					Bl. Normal *	2,500	3,500	3,000			
					Dry *	1,500	1,500	1,000			
					Critical *	1,000	1,000	500			
Migration of Fall Run Adult Salmon	Stockton to Turner Cut		Dissolved Oxygen	Minimum dissolved oxygen (DO) in mg/L	All*	Dates 7/1-11/30		DO 6.0			

See last page of table for Footnotes

TABLE 1 cont'd

RECOMMENDED WATER QUALITY OBJECTIVES

Beneficial Use Protected and Location		Sampling Site #	Parameter	Description	Year Type (Sacramento, unless * shows San Joaquin)	Dates	Values or Limits
FISH and WILDLIFE							
Delta Fishery Striped bass spawning	Prisoners Pt.	D29	Mean Daily Electrical Conductivity	Average for period not to exceed EC in mmhos/cm	All	4/1-5/5	EC 0.55
	Chipps Island	D10	Delta Outflow Index (DOI)	Average of the daily DOI, for the period, not less than	All	4/1-14	Flow in CFS 6,700
	Antioch Waterworks Intake on the San Joaquin River	D12 (near)	Electrical Conductivity	Average of the mean daily EC, mmhos/cm for the period, not more than	All	4/15-5/5	EC 1.5
	Antioch Waterworks	D12 (near)	Electrical Conductivity (Relaxation provision - replaces the above Antioch and Chipps Island objectives whenever the CVP and SWP impose deficiencies in firm supplies (Footnote 8)	Average of mean daily EC for the period, not more than the values corresponding to the deficiencies taken (linear interpolation to be used to determine values between those shown)	All - whenever the SWP and CVP impose deficiencies in firm supplies (Footnote 8)	Total Annual Imposed Deficiency (TAF)	4/1-5/5 EC

Total Annual Imposed Deficiency (TAF)	4/1-5/5 EC
none	1.5
500	1.9
1,000	2.5
1,500	3.4
2,000	4.4
3,000	10.3
4,000 or more	25.2

Delta Fisheries Egg and larvae survival — Chipps Is. — D10 — Mean Delta Outflow for Period (Footnote 9) — DFG and USF&WS outflow recommendations in CFS

Year Type	Dates/Flow in CFS 5/1-31	6/1-10	6/11-17	6/18-7/31
Wet	30,000	30,000	20,000	10,000
Ab. Normal	25,000	25,000	17,500	10,000
Bl. Normal	22,000	22,000	16,000	10,000
Dry	12,000	12,000	10,000	8,000
Critical	3,300	3,300	3,100	2,900

Delta Fishery Export limit (Footnote 10) — Banks, Tracy, Contra Costa Delta Pumping Plants — Mean export for period (Footnote 11) — Historic 1953-67 exports from Delta, except wet years, in CFS (Footnote 12)

Year Type	4/1-30	5/1-31	6/1-30	7/1-15	7/15-31
Wet *	8,300	7,500	5,300	3,300	9,200
Ab. Normal *	2,000	2,900	3,700	4,200	9,200
Bl. Normal *	2,000	2,000	2,900	3,300	9,200
Dry *	3,000	3,300	4,000	4,600	9,200
Critical *	2,800	2,800	3,000	4,300	9,200

Delta Fishery Flow control — Walnut Grove — Delta Cross Channel — Operation of Channel gates

Year Type	4/1-30	5/1-31	6/1-30	7/1-31
Wet	closed	closed	closed	open
Ab. Normal	closed	closed	c/ow	open
Bl. Normal	closed	closed	c/ow	open
Dry	closed	c/ow	open	open
Critical	open	c/ow	open	open

c/ow = gates closed, open weekends

See last page of table for Footnotes

TABLE 1 cont'd

RECOMMENDED WATER QUALITY OBJECTIVES

Footnotes

Footnote 1: Only used as a control station if City of Vallejo is taking water from this source in lieu of from North Bay Aqueduct.

Footnote 2: Sampling site numbers remain the same as in D-1485 for same sites. New sites are temporarily designated by their initials and a number.

Footnote 3: This objective will remain in effect until Contra Costa Water District moves its intake to Clifton Court Forebay. See accompanying map.

Footnote 4: Interim objective, superseded when parties agree facilities work. Water year types developed by State Board need no relaxation for subnormal snowmelt.

Footnote 5: DOI = Flows at Freeport + Vernalis - Channel Depletions + Byron Bethany Irrig. Dist. Diversions - Exports. All in CFS.

Footnote 6: Deficiency Period as defined in 4-Agency Agreement, except year type forecast shall be based on prediction of normal runoff instead of lowest 20 percentile of predicted runoff.

Footnote 7: Suisun Marsh control stations proposed to be replaced if objectives cannot be met with new facilities. New location and additional facilities to be developed and objectives are to be met with additional Delta outflows until facilities are adequate.

Footnote 8: Firm supplies of the USBR shall be any water the USBR is legally obligated to deliver under any CVP contract of 10 years or more duration, excluding the Friant Division of the CVP, subject only to dry and critical year deficiencies. Firm supplies of DWR shall be any water DWR would have delivered under Table A entitlements of water supply contracts and under prior right settlements had deficiencies not been imposed in that dry or critical year.

Footnote 9: Daily minimum to be not less than 80% of objective.

Footnote 10: Appropriate operating requirements to protect fish at the J. E. Skinner Fish Protective Facility and the CVP Tracy Fish Protective Facility should be presented to the State Board for incorporation in objectives during Phase III of these Bay-Delta Hearings.

Footnote 11: Daily maximum not to exceed 120% of objective.

Footnote 12: Exports above the values shown are permitted provided that positive downstream flows are maintained with a combined flow rate in Old and Middle rivers of at least 500 CFS.

2.0 SCOPE OF THE PLAN

2.1 Introduction

On July 7, 1987 the State Water Resources Control Board (State Board), pursuant to commitments in its 1978 Water Right Decision 1485 (D-1485) and Water Quality Control Plan (Delta Plan) for the Sacramento-San Joaquin Delta and Suisun Marsh, opened a public proceeding to receive evidence on beneficial uses and water quality issues for the San Francisco Bay and Sacramento-San Joaquin Delta Estuary (Estuary). Differing procedurally from that held for D-1485, the current hearing is to be conducted in three separate phases. To complete the first phase, this Water Quality Control Plan for Salinity for the San Francisco Bay and Sacramento-San Joaquin Delta Estuary (Plan) as well as a separate Pollutant Policy Document (PPD) have been prepared and are being distributed for review. After public comment, the Plan will be revised where necessary and adopted in the second phase, and will be considered for possible water right determinations in the third.

The scope of the Phase I proceedings covered:

- the beneficial uses being made of water flowing into, within, and from the Bay-Delta Estuary;
- the levels of protection, in terms of flow and salinity, which should be afforded these beneficial uses;
- reasonable consumptive uses made of Bay-Delta waters;
- the effects of pollutants on beneficial uses of Bay-Delta Estuary waters; and
- implementation measures to achieve the levels of protection afforded the beneficial uses.

2.2 Purpose of the Plan

This Plan establishes, where reliable data exist, numerical flow and salinity objectives[1/] as well as a program of implementation for the beneficial uses of Bay-Delta Estuary waters. In the 1978 Water Quality Control Plan and D-1485, the State Board set flow and salinity standards to protect only the Delta and Suisun Marsh against the effects of the SWP and the CVP (see Appendix A). This Plan takes a broader view in

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1/ For this Plan, "objectives" means the concept of enforceable numerical limits on water quality characteristics established to protect beneficial uses. The term is used in this Plan as it is used in the California Water Code, and not in the commonly understood sense of 'goals' or non-binding 'guidelines'. "Water quality objectives" in conjunction with an implementation schedule are the equivalent of EPA's "water quality standards".

"objectives" defined

setting water quality objectives. The entire Bay and Delta as well as waters that flow into and out of the Bay-Delta Estuary are considered when developing reasonable levels of protection for all beneficial uses. The flow and salinity objectives for the Bay-Delta Estuary contained in this Plan supersede any conflicting objectives contained in the current Water Quality Control Plans (Basin Plans) of the San Francisco Bay and Central Valley Regional Water Quality Control Boards, Regions 2 and 5, respectively.

A separate Pollutant Policy Document (PPD) prepared by the State Board addresses in detail the effects of pollutants on beneficial uses in the Bay-Delta Estuary; it contains water quality objectives to be used by Regions 2 and 5 as guidance when they update their Basin Plans (see 2.5).

Both the Plan and the PPD will be subjects of the Phase II hearing, during which the public will have the opportunity to comment on both before they are finalized and formally adopted by the State Board.

2.3 Authority for Regulation of Water Quality in the Bay-Delta Estuary

The State Board is responsible for formulating and adopting state policy for water quality control (Water Code {WC} Section 13140). The Water Code states that activities and factors which may affect the quality of waters of the state "...shall be regulated to attain the highest water quality which is reasonable considering all demands being made and to be made on those waters and the total values involved..."(WC Section 13000). Through the basin planning process, the State and Regional Boards formulate and adopt Basin Plans specifying water quality objectives to ensure reasonable protection for designated beneficial uses of water (WC Sections 13170, 13240). The federal Clean Water Act (Section 303(e)) also requires states to have a continuing planning process which contains water quality standards subject to review and approval by the Environmental Protection Agency (EPA).

Under its water right authorities, the State Board ensures the reasonable protection of beneficial uses of water by placing conditions on permits and licenses for the diversion and use of waters of the state (WC Sections 1253,1257,1258). The State Board has continuing authority over all water rights to:

- Prevent waste, unreasonable use, method of use, or unreasonable method of diversion of water;[1/] and to
- Protect public trust uses of water.[2/]

The State Board also has authority under the Water Code to impose specific terms and conditions on new permits to protect the public interest, prior water rights, recreation, fish and wildlife, and other interests.

1/ California Constitution Article X, Section 2; Imperial Irrigation District v. State Water Resources Control Board (1986) 183 Cal.App.3d 1160, 231 Cal.Rptr. 283; Water Code Sections 100,275,1050.

2/ National Audubon Society v. Superior Court (1983) 33 Cal.3d 419,189 Cal.Rptr. 346.

The Board may in addition reserve jurisdiction under Water Code Section 1394 to amend permits in anticipation of new information. For this reason, and "...recogniz(ing) the uncertainty associated with proposed project facilities to be constructed and the need for additional information on the Bay-Delta ecosystem," the Board limited the Delta Plan in 1978 to current and near term conditions in the Delta (Delta Plan, p. I-10). The Board stated it would review the 1978 Water Quality Control Plan in about ten years. This commitment as well as recent court decisions have called for the current hearing and have expanded the scope of its proceedings.

Specifically, in 1986, the State Court of Appeal, First District, issued a decision,[1/] also known as the Racannelli or Delta Water Cases decision, addressing legal challenges to D-1485 and the Delta Plan. This decision directed the State Board to take a global perspective of water resources in developing water quality objectives: the State Board's duty in its water quality role is to provide reasonable protection for beneficial uses, considering all demands made on the water. The State Board's water quality function should not be equated with protection of existing water rights. Additionally, water quality objectives should not be limited to what the State Board can enforce under its water right authority. The decision recognized, however, that an implementing program may be a lengthy and complex process that requires significant time intervals and action by entities over which the State Board has little or no control.

Both the State Board's authority and the court's recent decision have guided the reassessment developed in this Plan.

2.4 Geographic Limits

The geographic limits for the water quality objectives set in the Plan include:

2.4.1 San Francisco Bay

San Francisco Bay (Bay), with its approximately 300,000 acres of water surface area, is located at the mouth of the Sacramento-San Joaquin Delta, the outlet for the Sacramento and San Joaquin rivers. These rivers drain about forty percent of the state. The Bay is composed of four primary embayments which are: (1) the south Bay, stretching from the Oakland Bay Bridge on the north to Mountain View on the southern edge; (2) the central Bay, the area between the Richmond-San Rafael Bay Bridge and the Oakland Bay Bridge; (3) the San Pablo Bay to the north, encompassing the area from the Richmond-San Rafael Bay Bridge on the south side to the Petaluma River on the north and the Carquinez Strait on the east; and (4) the area between the entrance to the Carquinez Strait and Chipps Island, encompassing the Carquinez Strait, Suisun Bay, Grizzly Bay, and Honker Bay.

[1/] United States v. State Water Resources Control Board (1986) 182 Cal.App.3d 82, 227 Cal.Rptr. 161

2.4.2 Sacramento-San Joaquin Delta

The Delta, as defined in Water Code Section 12220, is roughly a triangular 738,000-acre area extending from Chipps Island near Pittsburg on the west to Sacramento on the north and to the Vernalis gaging station on the San Joaquin River in the south. Also included within the Delta boundary are the Harvey O. Banks Pumping Plant and the Tracy Pumping Plant, SWP and CVP facilities. Although water from the Delta is diverted for use in central and southern California, the water quality objectives for export uses are set at the pumping plants in the Delta. (The Tulare Lake Basin is not being considered tributary to the Estuary.)

2.4.3 Suisun Marsh

The 85,000-acre Suisun Marsh, located in southern Solano County south of the cities of Fairfield and Suisun City, is bordered on the south by Suisun Bay, Honker Bay, and the confluence of the Sacramento and San Joaquin Rivers; on the west by State Highway 21 running from Benecia to Cordelia; on the north by Cordelia Road to the city of Suisun; and on the east from Denverton along Shiloh Road to Collinsville.

2.5 Pollutants in the Bay-Delta Estuary

The information on pollutants received in Phase I of the hearing has been used in this Plan only to differentiate, where possible, the effects of flow and salinity on beneficial uses from those of pollutants. As noted, a separate Pollutant Policy Document (PPD) establishes state policy for pollutant regulation in the waters of the Bay-Delta Estuary, and will be used by Regions 2 and 5 in updating portions of their Basin Plans.

The PPD also identifies and characterizes pollutants with the greatest potential biological significance in the Bay-Delta Estuary. Point, nonpoint and riverine sources of pollutants presented during the hearing are discussed as well as the effects of these pollutants on public health and biological resources. The PPD recommends that water quality objectives be adopted for certain identified priority pollutants. Where information is insufficient to set water quality objectives, an approach is established for developing such objectives. Other related issues that the Regional Boards requested the State Board to resolve, such as dredging spoils, trihalomethanes, cumulative pesticide loads and database evaluation, are also addressed.

2.6 California Environmental Quality Act (CEQA)

Pursuant to Section 15251(g) Title 14, California Code of Regulations (C.C.R.), the State Board's Water Quality Control (Basin) Planning Program is a "certified program" by the Secretary for Resources. As a certified program it is exempt from the requirements of preparing Environmental Impact Reports (EIR). However, the Program remains subject to other provisions in CEQA, such as the policy of avoiding significant adverse effects on the environment when feasible.

The Draft Water Quality Control Plan "globally balances" the competing uses of Bay-Delta waters and provides reasonable protection to each use. It identifies alternatives and mitigation measures to avoid or reduce any significant or potentially significant effects thatthis Plan might have on the environment. Therefore, this Plan meets the requirements of a substitute for an EIR as set forth in 14 C.C.R. Section 15252.

3.0 BASIN DESCRIPTION

3.1 Introduction

The Estuary and adjacent areas described in this Plan include:

- o The Delta (Figure 3.1-1);
- o The Delta's tributary areas, that is, the Sacramento River, the Central Sierra, the San Joaquin River basins[1/] (Figure 3.1-2); and
- o The San Francisco Bay and hydrologic Basin (Figure 3.1-3).

Together, the Estuary and tributary basins provide about two-thirds of all the water used in California, including 40 percent of the state's drinking water.

This chapter outlines the hydrologic conditions of the Estuary by providing a detailed description of each area's:

1. Physical Description--the geographical and legal dimensions;
2. Hydrology--the characteristics and nature of water movement;
3. Unimpaired Flow Conditions--the maximum amount of flow available in existent channels without consideration of diversions or storage (3.1.1); and
4. Current Flow Conditions--the water flow conditions as they now exist, or, where appropriate, as they have been affected by the Delta Plan (3.1.2).

3.1.1 Unimpaired Flow Conditions

Unimpaired flow conditions within the Estuary are the estimated amounts of water that would be available if there were no upstream impoundments or diversions of runoff but current upstream and Delta channel configurations existed (SWRCB,3,8). Unimpaired conditions could also be defined as the present day conditions if all storage and diversion were to cease on a short-term basis (T,II,114:2-15). "Natural" or "true natural flow" conditions, on the other hand, are defined as those existing in the late 1700's at the time of the first Spanish exploration of California (SWC,276,3). Unlike natural flow, it is assumed for unimpaired flow conditions that: (1) the present levees, bypasses and channel configuration are in place; (2) the natural flood basins and their marshes are drained; and (3) that only those riparian forests and tule marshes that currently exist are consuming water (SWC,262,6A2-21). Unimpaired flow conditions as well as current flow conditions are measured over a given period of time--the water year (see Section 3.1.3).

[1/] The Tulare Lake Basin (Basin 5D), although part of the Central Valley, is not considered to be tributary to the Delta.

FIGURE 3.1.-1 Boundary of the Bay-Delta Estuary and locations of diversion points (from: SWRCB, 3, 5)

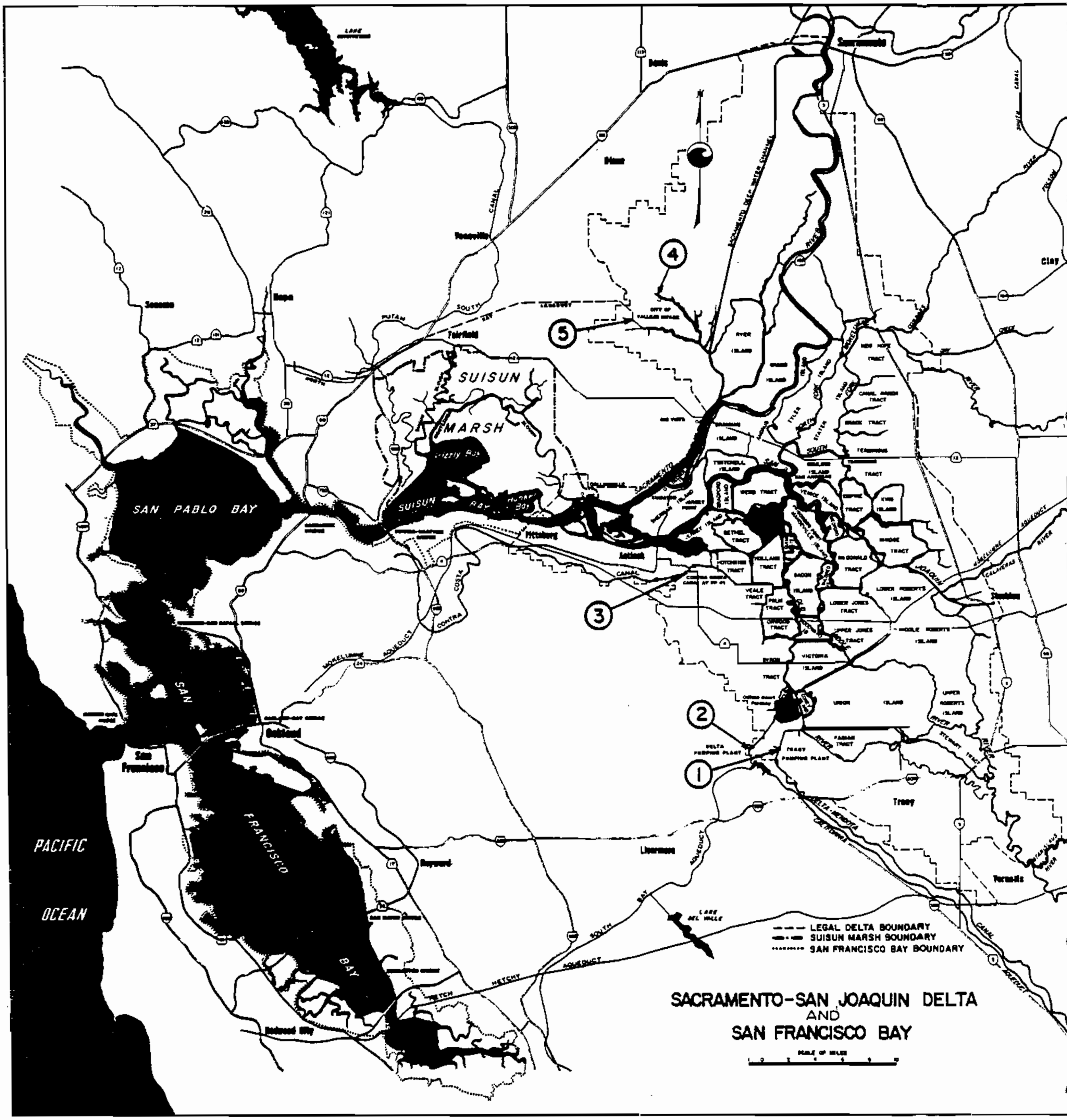
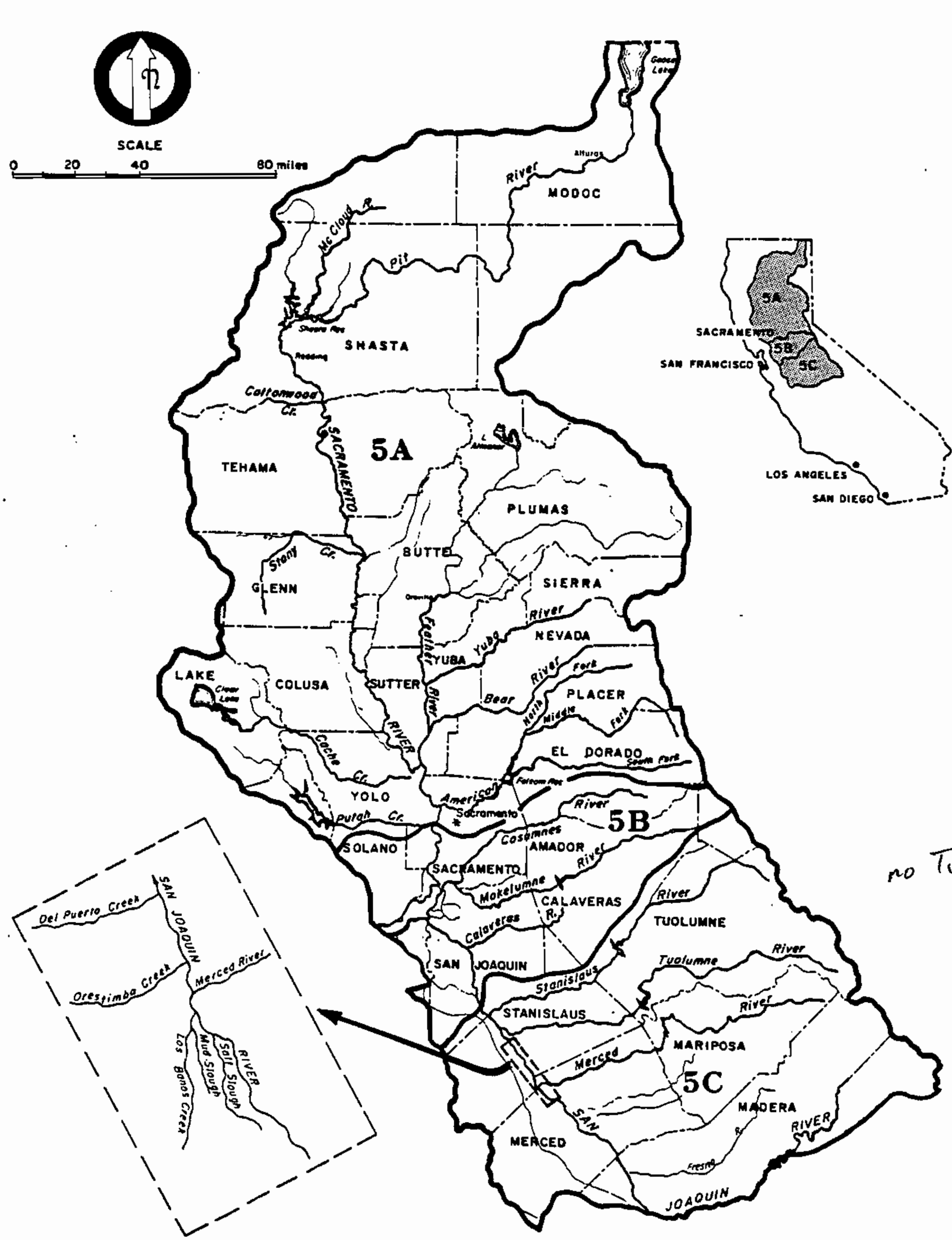


FIGURE 3.1-2 Boundaries of the Sacramento River (5A), Central Sierra and Delta (5B), and San Joaquin (5C) basins
(From: RWQCB 5, 1975)



no Tulare Lake Basin

FIGURE 3.1-3 Boundary of the San Francisco Bay Basin
(From: SWRCB, 3, 12)

3.1.2 Current Flow Conditions

Current flow conditions are those estimated by DWR's 1990 level of development operations study which uses the unimpaired basin inflows for the hydrologic period 1922-1978 and modifies these based on reservoir operations and consumptive demands reflective of current conditions (1990). The operations study is run to meet the existing 1978 Delta Plan and D-1485 water quality objectives. Upstream storage releases, diversions and exports also depend, to some degree, on conditions established by the Delta Plan. To the extent, for example, that specified minimum outflows from the Delta are mandated by the Delta Plan and D-1485, the Sacramento River Basin is directly affected by the upstream storage releases that provide the required outflow amounts. The San Francisco Bay is likewise directly affected by Delta outflows not directly regulated even though its waters are. In discussing 'current flow conditions', it will therefore be necessary to describe the extent to which the Delta Plan influences water amounts available from storage releases and diversions in the Estuary.

At the end of this section a table comparing unimpaired flow and current flow conditions by water year type provides a summary of the actual amounts of water available in each basin.

3.1.3 Water Year Types

3.1.3.1 Classifying Water Years for a Basin

Water year (WY) classifications provide estimates of the amount of water in a basin that is available from precipitation and snowmelt runoff to meet the needs of beneficial uses. Most often, the classification means a water year of 12 months, but it can refer to a shorter period. The wetter classifications indicate the high probability that enough water will be available to meet the needs of all beneficial uses. Drier classifications indicate that, for at least part of the time, the demand could be greater than the natural supply of water needed to support beneficial uses fully.

3.1.3.2 1978 Delta Plan Water Year Classifications

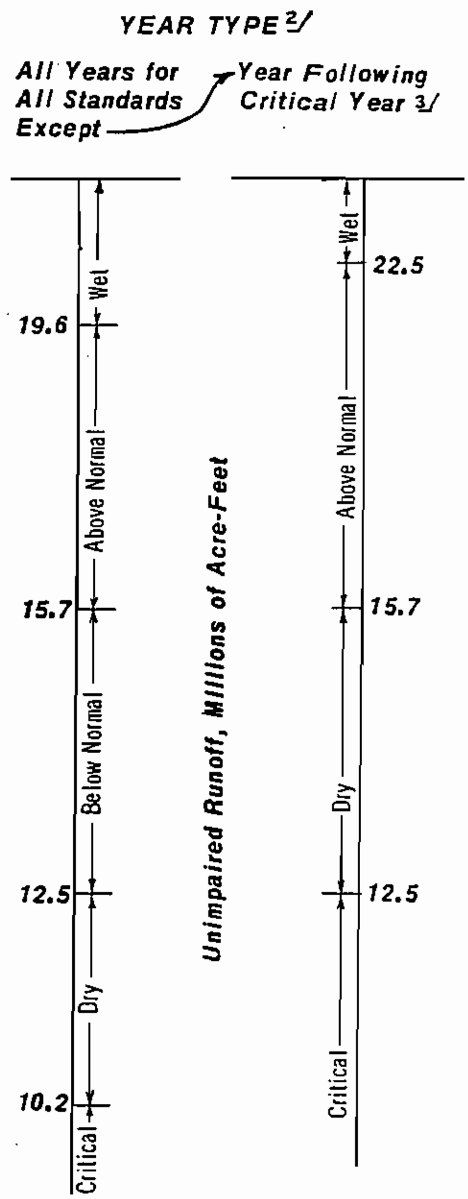
- Four River Index

The current hydrologic classification established by D-1485 is divided into five water year types: wet, above normal, below normal, dry, and critically dry (Figure 3.1.3.2-1) (SWRCB,13,III-10). This system is based on the "Four River Index"—the annual unimpaired runoff to the Sacramento Valley from its four principal tributaries, the Sacramento, Feather, Yuba, and American rivers.

FIGURE 3.1.3.2-1 Water Quality Control Plan Hydrologic Classification

Year classification shall be determined by the forecast of Sacramento Valley unimpaired runoff for the current water year *(October 1 of the preceding calendar year through September 30 of the current calendar year)* as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

YEAR TYPE	*RUNOFF, MILLIONS OF ACRE-FEET*
Wet [1]	equal to or greater than 19.6 (except equal to or greater than 22.5 in a year following a critical year). [3]
Above Normal [1]	greater than 15.7 and less than 19.6 (except greater than 15.7 and less than 22.5 in a year following a critical year). [3]
Below Normal [1]	equal to or less than 15.7 and greater than 12.5 (except in a year following a critical year). [3]
Dry	equal to or less than 12.5 and greater than 10.2 (except equal to or less than 15.7 and greater than 12.5 in a year following a critical year). [3]
Critical	equal to or less than 10.2 (except equal to or less than 12.5 in a year following a critical year). [3]



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[1] *Any otherwise wet, above normal, or below normal year may be designated a subnormal snowmelt year whenever the forecast of April through July unimpaired runoff reported in the May issue of Bulletin 120 is less than 5.9 million acre-feet.*

[2] *The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.*

[3] *"Year following critical year" classification does not apply to Agricultural, Municipal and Industrial standards.*

This classification defines normal inflow, or the boundary between a below normal and an above normal water year, as the logarithmic mean of the Sacramento Basins Four River Index for the period of 1922 through 1971. The logarithmic mean is also the 50th percentile value. Half the years exceed this value and half the years are less than this value. In other words, there is a 50 percent chance that flows will exceed 15.7 million acre feet (MAF), the logarithmtic mean for the Sacramento Basin. The boundary between an above normal year and a wet year was set at the 70 percent probability, 19.7 MAF. In years following a critical year the 80 percent value, or 22.5 MAF, was used. The classifications of dry and critically dry years were developed by identifying the Four River Index values which had a potential for water supply shortages or critical water supply shortages. As a result of an analysis by DWR, it was determined that for the Four River Index the appropriate definition of dry and critically dry years should be 12.5 and 10.2 MAF, respectively (DWR, Exhibit 1).

3.1.3.3 Revised Water Year Types: An Index for Each Basin

The current hydrologic classification system does not provide an adequate indication of the quantity of water available in the Delta. The current water year measurements apply only to the Sacramento River Basin; the San Joaquin Basin needs to be included. The timing of seasonal flow also should be addressed. Two different water years, for instance, can have the same annual runoff; however, the runoff can come from separate seasons, that is, from winter flow or spring snowmelt. Planning for water supplies should account for these and other conditions.

In addressing these problems, the Department of Water Resources has suggested a revised hydrologic classification which forecasts unimpaired runoff during the period of April through July to determine the runoff classification for any particular year (T,I,99:13-20). South Delta Water Agency (SDWA) has also developed a separate classification for the San Joaquin River Basin (SDWA,4, 23-25).

The State Board has taken these and other recommendations and developed two new classification systems, one for each Basin (Figures 3.1.3.3-1 and 3.1.3.3-2)[1/]. The new classifications include the following:

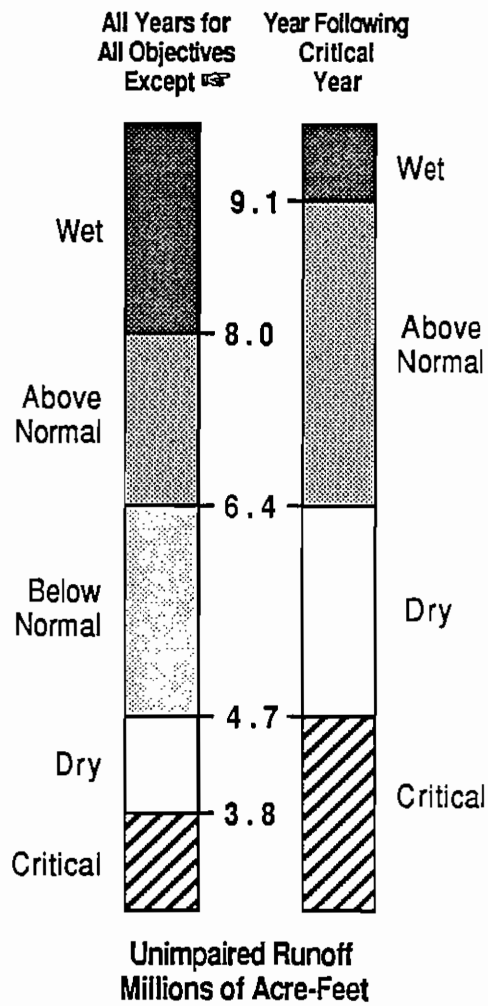
1/ The water year type designations for the Sacramento and San Joaquin River basins were developed by first determining the frequency an estimated unimpaired flow level occurred during April through July for the years 1906 through 1987 (Figure 3.1.3.3-3). Then, using the same percentage of occurrence as the Delta Plan, the water year types (i.e., wet, above normal, below normal, dry and critical for average years and for years following critical years) were classified for both basins.

FIGURE 3.1.3.3-1
SACRAMENTO RIVER BASIN
APRIL THROUGH JULY HYDROLOGIC CLASSIFICATION

The Sacramento River Basin April through July hydrologic classification shall be determined by the forecast of Sacramento Valley unimpaired runoff for the year's April through July period as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of the classification shall be based on the April through July hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the April through July period.

CLASSIFICATION	UNIMPAIRED RUNOFF MILLIONS OF ACRE-FEET
Wet	Equal to or greater than 8.0 (except equal to or greater than 9.1 in an April through July period following a critical year).
Above Normal	Greater than 6.4 and less than 8.0 (except greater than 6.4 and less than 9.1 in an April through July period following a critical year).
Below Normal	Equal to or less than 6.4 and greater than 4.7 (except in an April through July period following a critical year).
Dry	Equal to or less than 4.7 and greater than 3.8 (except equal to or less than 6.4 and greater than 4.7 in an April through July period following a critical year).
Critical	Equal to or less than 3.8 (except equal to or less than 4.7 in an April through July period following a critical year).

APRIL THROUGH JULY CLASSIFICATION *



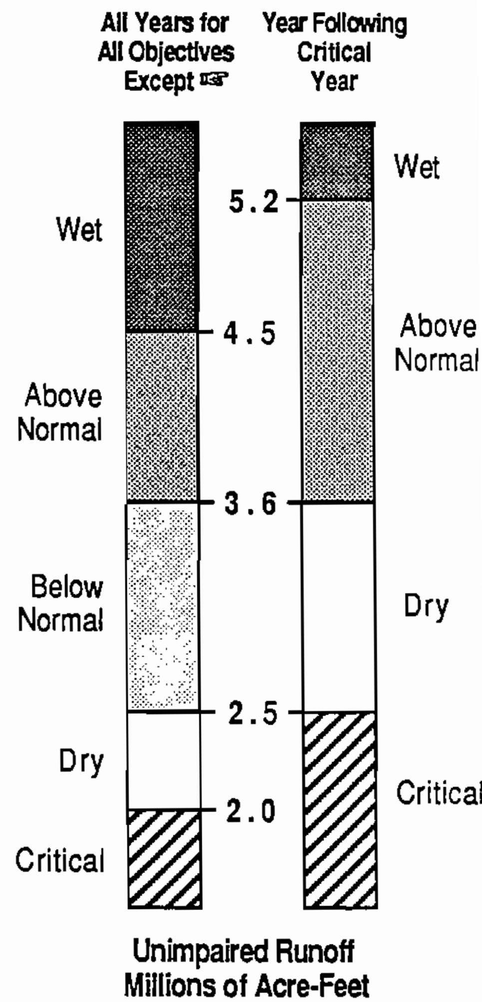
* The April through July classification for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year's April through July classification is available.

FIGURE 3.1.3.3-2
SAN JOAQUIN RIVER BASIN
APRIL THROUGH JULY HYDROLOGIC CLASSIFICATION

The San Joaquin River Basin April through July hydrologic classification shall be determined by the forecast of San Joaquin Valley unimpaired runoff for the year's April through July period as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake. Preliminary determinations of the classification shall be based on the April through July hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the April through July period.

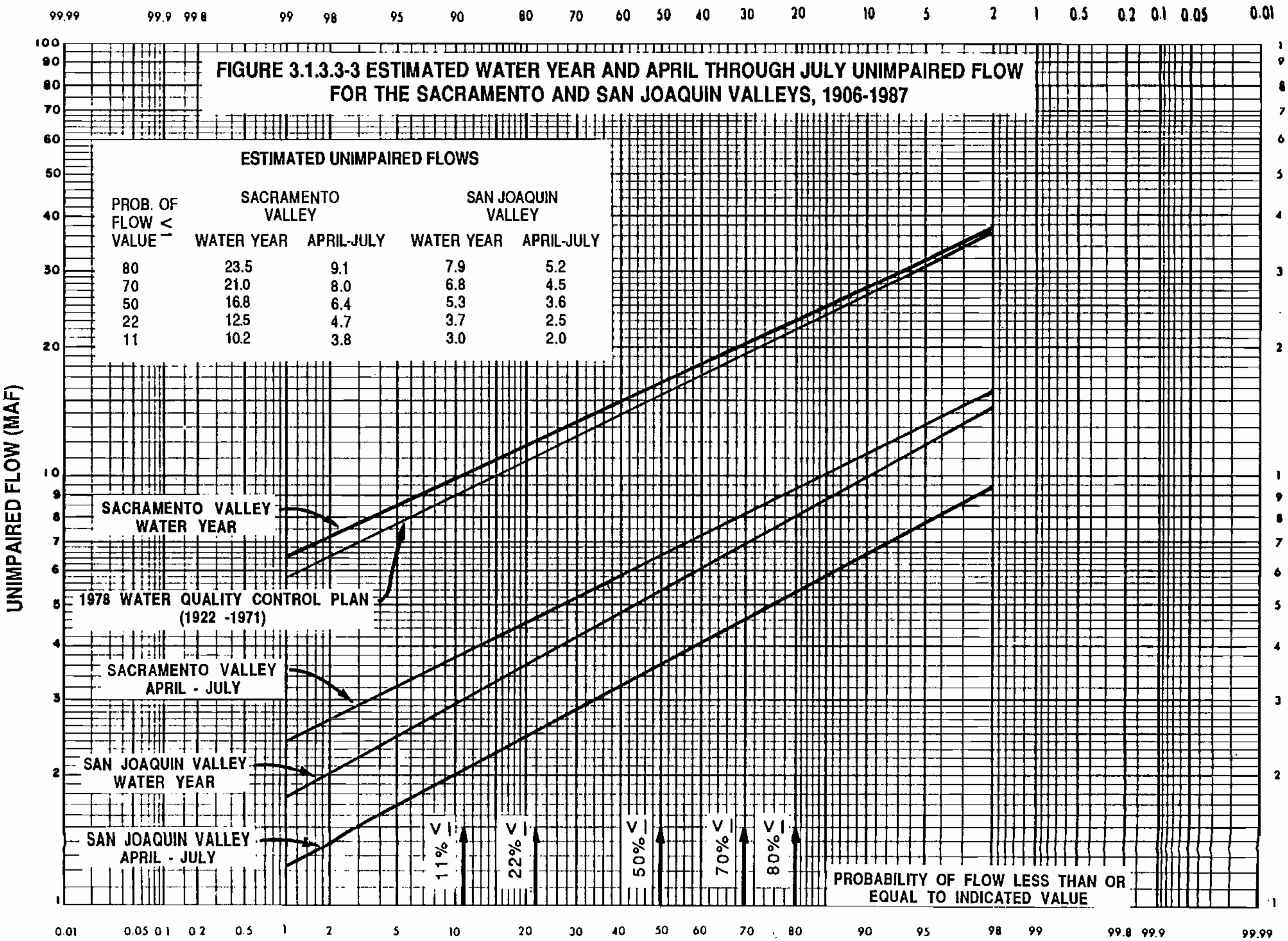
CLASSIFICATION	UNIMPAIRED RUNOFF MILLIONS OF ACRE-FEET
Wet	Equal to or greater than 4.5 (except equal to or greater than 5.2 in an April through July period following a critical year).
Above Normal	Greater than 3.6 and less than 4.5 (except greater than 3.6 and less than 5.2 in an April through July period following a critical year).
Below Normal	Equal to or less than 3.6 and greater than 2.5 (except in an April through July period following a critical year).
Dry	Equal to or less than 2.5 and greater than 2.0 (except equal to or less than 3.6 and greater than 2.5 in an April through July period following a critical year).
Critical	Equal to or less than 2.0 (except equal to or less than 2.5 in an April through July period following a critical year).

APRIL THROUGH JULY CLASSIFICATION *



* The April through July classification for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year's April through July classification is available.

FIGURE 3.1.3.3-3 ESTIMATED WATER YEAR AND APRIL THROUGH JULY UNIMPAIRED FLOW FOR THE SACRAMENTO AND SAN JOAQUIN VALLEYS, 1906-1987



ESTIMATED UNIMPAIRED FLOWS

PROB. OF FLOW ≤ VALUE	SACRAMENTO VALLEY		SAN JOAQUIN VALLEY	
	WATER YEAR	APRIL-JULY	WATER YEAR	APRIL-JULY
80	23.5	9.1	7.9	5.2
70	21.0	8.0	6.8	4.5
50	16.8	6.4	5.3	3.6
22	12.5	4.7	3.7	2.5
11	10.2	3.8	3.0	2.0

- The Sacramento Basin index incorporates its four principal tributaries--the Sacramento, Feather, Yuba, and the American Rivers.

- A separate classification system developed for the San Joaquin River Basin incorporates its four principal tributaries--the Stanislaus, Tuolumne, Merced, and San Joaquin rivers.

- The San Joaquin River Basin water year classification is used for water quality objectives in the southern Delta and for export objectives.

- An 82 year period, 1906 through 1987, is used to determine the classification boundaries for both river basins, instead of the 50 year period 1922 through 1971.

- The April through July unimpaired flows determine runoff classification systems for both the Sacramento and San Joaquin river systems. The subnormal snowmelt designation has been eliminated.

- The "year following critical year" designation is based on the previous year's April through July classification.

- The "year following critical year" designation applies to all objectives, not just those for fish and wildlife.

These revisions add information to, but do not greatly change, the conditions of hydrologic classification used in the 1978 Delta Plan.

3.1.3.4 Differences in Classification

Three possible classifications for the Sacramento and the San Joaquin River basins have been considered (see Tables 3.1.3.4-1 through -3):

1. The 1978 Delta Plan classification which is based on an entire water year, but only for the period of hydrologic record of 1922 through 1971.

2. A revised classification which is also based on an entire water year, but for the expanded period of 1906 through 1987.

3. The proposed classification which is based on the months of April to July, but also for the expanded period of 1906 through 1987.

There are only minor differences between the three. When, for example, the classification is expanded to include the period of 1906 to 1987, some relatively small changes in percentage of occurrence result (Table 3.1.3.4-3).

TABLE 3.1.3.4-1

SACRAMENTO RIVER BASIN FOUR RIVER INDEX AND HYDROLOGIC CLASSIFICATIONS *

WATER YEAR	WATER YEAR UNIMPAIRED RUNOFF (TAF)	WATER YEAR PERCENT OF LOG MEAN	WATER YEAR CLASSI-FICATION	APRIL THROUGH JULY UNIMPAIRED RUNOFF (TAF)	APRIL THROUGH JULY PERCENT OF LOG MEAN	APRIL-JULY CLASSI-FICATION	D-1485 ** D-1485 CLASSI-FICATION
1906	26709	159%	W	12924	202%	W	W
1907	33705	201%	W	13450	210%	W	W
1908	14773	88%	BN	5605	88%	BN	BN/SS
1909	30681	183%	W	8985	140%	W	W
1910	20122	120%	AN	6116	96%	BN	W
1911	26384	157%	W	13119	205%	W	W
1912	11410	68%	D	5646	88%	BN	D
1913	12847	76%	BN	6287	98%	BN	BN
1914	27812	166%	W	10077	157%	W	W
1915	23860	142%	W	11416	178%	W	W
1916	24143	144%	W	8886	139%	W	W
1917	17261	103%	AN	9138	143%	W	AN
1918	10997	65%	D	4888	76%	BN	D
1919	15657	93%	BN	6775	106%	AN	BN
1920	9200	55%	C	4910	77%	BN	C
1921	23801	142%	W	7523	118%	AN	W
1922	17982	107%	AN	10568	165%	W	AN
1923	13209	79%	BN	6271	98%	BN	BN
1924	5737	34%	C	1936	30%	C	C
1925	15994	95%	D	6511	102%	AN	AN
1926	11766	70%	D	4791	75%	BN	D
1927	23835	142%	W	8750	137%	W	W
1928	16763	100%	BN	5860	92%	BN	AN/SS
1929	8403	50%	C	3836	60%	D	C
1930	13516	80%	D	4652	73%	D	BN/D
1931	6095	36%	C	2088	33%	C	C
1932	13118	78%	D	6238	97%	D	BN/D
1933	8939	53%	C	4665	73%	D	C
1934	8631	51%	C	2452	38%	C	C
1935	16590	99%	D	9692	151%	W	AN
1936	17350	103%	AN	6407	100%	AN	AN
1937	13335	79%	BN	7238	113%	AN	BN
1938	31828	189%	W	12935	202%	W	W
1939	8183	49%	C	3039	47%	C	C
1940	22434	134%	AN	6927	108%	AN	W/AN
1941	27080	161%	W	9770	153%	W	W
1942	25237	150%	W	9931	155%	W	W
1943	21124	126%	W	6897	108%	AN	W
1944	10433	62%	D	4934	77%	BN	D
1945	15063	90%	BN	5919	92%	BN	BN
1946	17619	105%	AN	5971	93%	BN	AN
1947	10383	62%	D	3827	60%	D	D
1948	15752	94%	BN	9545	149%	W	AN

TABLE 3,1,3,4-1 (continued)

SACRAMENTO RIVER BASIN FOUR RIVER INDEX AND HYDROLOGIC CLASSIFICATIONS *

	WATER YEAR			APRIL THROUGH JULY			D-1485 **
WATER YEAR	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	WATER YEAR CLASSIFICATION	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	APRIL-JULY CLASSIFICATION	D-1485 CLASSIFICATION
1949	11969	71%	D	5587	87%	BN	D
1950	14442	86%	BN	6720	105%	AN	BN
1951	22945	137%	W	5418	85%	BN	W/SS
1952	28600	170%	W	13676	214%	W	W
1953	20086	120%	AN	8260	129%	W	W
1954	17427	104%	AN	6813	106%	AN	AN
1955	10986	65%	D	5067	79%	BN	D
1956	29890	178%	W	8604	134%	W	W
1957	14888	89%	BN	6294	98%	BN	BN
1958	29711	177%	W	12241	191%	W	W
1959	12055	72%	D	3837	60%	D	D
1960	13059	78%	BN	4651	73%	D	BN/SS
1961	11976	71%	D	4388	69%	D	D
1962	15116	90%	BN	6234	97%	BN	BN
1963	22993	137%	W	10091	158%	W	W
1964	10917	65%	D	4374	68%	D	D
1965	25665	153%	W	8134	127%	W	W
1966	12955	77%	BN	4836	76%	BN	BN/SS
1967	24060	143%	W	11016	172%	W	W
1968	13639	81%	BN	4114	64%	D	BN/SS
1969	26839	160%	W	10628	166%	W	W
1970	24060	143%	W	4356	68%	D	W/SS
1971	22775	136%	W	8914	139%	W	W
1972	13421	80%	BN	4991	78%	BN	BN/SS
1973	20029	119%	AN	6371	100%	BN	W
1974	32554	194%	W	9769	153%	W	W
1975	19227	114%	AN	8960	140%	W	AN
1976	8184	49%	C	2720	43%	C	C
1977	5105	30%	C	1925	30%	C	C
1978	23826	142%	W	8077	126%	AN	W
1979	12435	74%	D	5658	88%	BN	D
1980	22339	133%	W	6000	94%	BN	W
1981	11140	66%	D	3653	57%	C	D
1982	33338	198%	W	11745	184%	W	W
1983	37798	225%	W	13705	214%	W	W
1984	22352	133%	W	5518	86%	BN	W/SS
1985	11045	66%	D	4005	63%	D	D
1986	25735	153%	W	5358	84%	BN	W/SS
1987	9193	55%	C	2778	43%	C	C

* W - Wet; AN - Above Normal; BN - Below Normal; D - Dry; C - Critically Dry; SS - Subnormal Snowmelt

** In some cases a year will have a dual classification - one classification for fish and wildlife standards and the next wetter classification for agricultural and municipal and industrial standards

TABLE 3.1.3.4-2

SAN JOAQUIN RIVER BASIN FOUR RIVER INDEX AND HYDROLOGIC CLASSIFICATIONS *

	WATER YEAR			APRIL THROUGH JULY			D-1485 **
WATER YEAR	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	WATER YEAR CLASSI-FICATION	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	APRIL-JULY CLASSI-FICATION	D-1485 CLASSI-FICATION
1906	12427	234%	W	9238	257%	W	W
1907	11825	223%	W	7606	211%	W	W
1908	3327	63%	D	2167	60%	D	BN/SS
1909	8972	169%	W	5906	164%	W	W
1910	6645	125%	AN	3622	101%	AN	W
1911	11481	217%	W	7522	209%	W	W
1912	3211	61%	D	2572	71%	BN	D
1913	2995	57%	C	2340	65%	D	BN
1914	8691	164%	W	5672	158%	W	W
1915	6406	121%	AN	4949	137%	W	W
1916	8382	158%	W	5497	153%	W	W
1917	6663	126%	AN	4837	134%	W	AN
1918	4589	87%	BN	3397	94%	BN	D
1919	4097	77%	BN	2987	83%	BN	BN
1920	4096	77%	BN	3289	91%	BN	C
1921	5900	111%	AN	3840	107%	AN	W
1922	7677	145%	W	5996	167%	W	AN
1923	5512	104%	AN	3954	110%	AN	BN
1924	1500	28%	C	1034	29%	C	C
1925	5506	104%	AN	3926	109%	AN	AN
1926	3488	66%	D	2560	71%	BN	D
1927	6501	123%	AN	4564	127%	W	W
1928	4367	82%	BN	2639	73%	BN	AN/SS
1929	2844	54%	C	2292	64%	D	C
1930	3252	61%	C	2437	68%	D	BN/D
1931	1660	31%	C	1178	33%	C	C
1932	6630	125%	AN	4686	130%	AN	BN/D
1933	3341	63%	D	2767	77%	BN	C
1934	2286	43%	C	1259	35%	C	C
1935	6410	121%	AN	5025	140%	AN	AN
1936	6487	122%	AN	4379	122%	AN	AN
1937	6527	123%	AN	4655	129%	W	BN
1938	11268	213%	W	7358	204%	W	W
1939	2905	55%	C	1831	51%	C	C
1940	6589	124%	AN	4047	112%	AN	W/AN
1941	7932	150%	W	5515	153%	W	W
1942	7382	139%	W	5282	147%	W	W
1943	7266	137%	W	4273	119%	AN	W
1944	3919	74%	BN	2973	83%	BN	D
1945	6599	125%	AN	4371	121%	AN	BN
1946	5729	108%	AN	3645	101%	AN	AN
1947	3418	64%	D	2116	59%	D	D
1948	4210	79%	BN	3583	100%	BN	AN

TABLE 3.1.3.4-2 (continued)

SAN JOAQUIN RIVER BASIN FOUR RIVER INDEX AND HYDROLOGIC CLASSIFICATIONS *

	WATER YEAR			APRIL THROUGH JULY			D-1485 **
WATER YEAR	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	WATER YEAR CLASSIFICATION	UNIMPAIRED RUNOFF (TAF)	PERCENT OF LOG MEAN	APRIL-JULY CLASSIFICATION	D-1485 CLASSIFICATION
1949	3793	72%	BN	3113	86%	BN	D
1950	4652	88%	BN	3571	99%	BN	BN
1951	7251	137%	W	2829	79%	BN	W/SS
1952	9305	176%	W	6834	190%	W	W
1953	4354	82%	BN	3184	88%	BN	W
1954	4300	81%	BN	3161	88%	BN	AN
1955	3500	66%	D	2666	74%	BN	D
1956	9669	182%	W	5291	147%	W	W
1957	4288	81%	BN	3187	89%	BN	BN
1958	8356	158%	W	6396	178%	W	W
1959	2980	56%	C	1853	51%	C	D
1960	2958	56%	C	2072	58%	C	BN/SS
1961	2095	40%	C	1497	42%	C	D
1962	5612	106%	AN	4245	118%	AN	BN
1963	6237	118%	AN	4369	121%	AN	W
1964	3143	59%	D	2144	60%	D	D
1965	8120	153%	W	4549	126%	W	W
1966	3978	75%	BN	2422	67%	D	BN/SS
1967	9985	188%	W	7095	197%	W	W
1968	2935	55%	C	1850	51%	C	BN/SS
1969	12292	232%	W	8140	226%	W	W
1970	5613	106%	AN	2956	82%	BN	W/SS
1971	4907	93%	BN	3228	90%	BN	W
1972	3577	67%	D	2209	61%	D	BN/SS
1973	6475	122%	AN	4487	125%	AN	W
1974	7127	134%	W	4537	126%	W	W
1975	6156	116%	AN	4647	129%	W	AN
1976	1942	37%	C	1050	29%	C	C
1977	1016	19%	C	782	22%	C	C
1978	9425	178%	W	6363	177%	W	W
1979	5982	113%	AN	3991	111%	AN	D
1980	9453	178%	W	5389	150%	W	W
1981	3089	58%	D	2203	61%	D	D
1982	11259	212%	W	6951	193%	W	W
1983	14828	280%	W	8625	240%	W	W
1984	6843	129%	W	3479	97%	BN	W/SS
1985	3540	67%	D	2379	66%	D	D
1986	9293	175%	W	4584	127%	W	W/SS
1987	2029	38%	C	1453	40%	C	C

* W - Wet; AN - Above Normal; BN - Below Normal; D - Dry; C - Critically Dry; SS - Subnormal Snowmelt

** In some cases a year will have a dual classification - one classification for fish and wildlife standards and the next wetter classification for agricultural and municipal and industrial standards

This table is significant for historical reasons

TABLE 3.1.3.4-3
DECISION 1485 WATER YEAR CLASSIFICATION
FOR THE SACRAMENTO RIVER BASIN:
NUMBER AND PERCENTAGE OF OCCURENCES

	Hydrologic Period			
	1922 to 1971[1/]		1906 to 1987	
Classification	No. of Years	Frequency of Occurrence	No. of Years	Percentage of Occurrence
Wet	16	32%	33	40%
Above Normal	9	18%	11	13%
Below Normal	9	18%	13	16%
Dry	10	20%	15	18%
Critical	6	12%	10	12%
TOTAL	50	100%	82	100%

[1/] Time period used in The Delta Plan to develop the original water year classification system.

Likewise, when the entire water year classification (1906 to 1987) is compared with the April through July classification for both the Sacramento and San Joaquin River basins, small changes in the percentage of occurrence also result (Tables 3.1.3.4-4 & -5). A comparison of the D-1485 classification with the April through July classification for the Sacramento River Basin over the 1906-87 period gives a difference in 35 years. In 18 of the 82 years, however, the April to July classification is wetter and in 17 years the classification is drier--a net real difference of one.

Finally, comparing the April to July classification for the San Joaquin River with the same classification for the Sacramento River, there is a difference in 31 years. In 15 of the 82 years, the San Joaquin classification is wetter, in 16 years drier--again, a net real difference of one. Where differences do exist between classifications and between basins, they are mainly due to the timing and magnitude of runoff as well as the boundaries of water year types.

Finally, when the classifications proposed in the Plan are compared with those in the Delta Plan, the total numbers of years in the extreme classifications, wet and critical, are reduced while the other, middle ranges are increased for both Basins (Table 3.1.3.4-6).

Why aren't these the same?

TABLE 3.1.3.4-4
WATER YEAR AND APRIL THROUGH JULY CLASSIFICATION:
FREQUENCIES OF OCCURRENCE
FOR THE SACRAMENTO RIVER BASIN

Probably because it's not the D-1485 scheme

Classification	Classification System: Water Year — No. of Years	Water Year — Frequency of Occurrence	April-July — No. of Years[1/]	April-July — Frequency of Occurrence
Wet	30	37%	28	34%
Above Normal	10	12%	10	12%
Below Normal	15	18%	24	29%
Dry	17	21%	12	15%
Critical	10	12%	8	10%
TOTAL	82	100%	82	100%

1/ Year following critical year classification not included.

TABLE 3.1.3.4-5
WATER YEAR AND APRIL THROUGH JULY CLASSIFICATION:
FREQUENCIES OF OCCURRENCE
FOR THE SAN JOAQUIN RIVER BASIN

Classification	Classification System: Water Year — No. of Years	Water Year — Frequency of Occurrence	April-July — No. of Years	April-July — Frequency of Occurrence
Wet	25	31%	27	33%
Above Normal	20	24%	15	18%
Below Normal	13	16%	19	23%
Dry	10	12%	10	12%
Critical	14	17	11	14
TOTAL	82	100%	82	100%

3.2 Sacramento River Basin

3.2.1 Physical Description

The Sacramento River Basin, Basin 5A in Figure 3.1-2, includes the westerly drainage of the Sierra Nevada and the Cascade ranges, the easterly drainage of the Coast Range, and the valley floor. The Basin covers about 26,500 square miles (16,960,000 acres) and extends from the Goose Lake Basin at the Oregon border to the American River Basin (RWQCB 5, 1975). The Basin includes the watersheds of the following major tributaries: McCloud, Pit, Feather, Yuba, Bear, and American rivers, and Cottonwood, Stony, Cache, and Putah creeks. In years of normal runoff, the Sacramento River Basin contributes about 70 percent of the total runoff to the Estuary (SWRCB,3,3).

TABLE 3.1.3.4-6

PROPOSED AND 1978 WQCP HYDROLOGIC CLASSIFICATIONS

NUMBER AND FREQUENCIES OF OCCURRENCE
(1906 THROUGH 1987)

SACRAMENTO RIVER BASIN

PROPOSED SALINITY CONTROL PLAN

April—July Classification	No. of Years	Frequency of Occurrence
Wet	28	34%
Above Normal	10	12%
Below Normal	24	29%
Dry	12	15%
Critical	8	10%
TOTAL	82	100%

1978 WATER QUALITY CONTROL PLAN *

Water Year Classification	No. of Years	Frequency of Occurrence
Wet	33	40%
Above Normal	11	13%
Below Normal	13	16%
Dry	15	18%
Critical	10	12%
TOTAL	82	100%

SAN JOAQUIN RIVER BASIN

PROPOSED SALINITY CONTROL PLAN

April—July Classification	No. of Years	Frequency of Occurrence
Wet	27	33%
Above Normal	15	18%
Below Normal	19	23%
Dry	10	12%
Critical	11	14%
TOTAL	82	100%

1978 WATER QUALITY CONTROL PLAN *

Water Year Classification	No. of Years	Frequency of Occurrence
Wet		
Above Normal		
Below Normal	SAME AS ABOVE	
Dry		
Critical		
TOTAL		

goes along w/ the perception of wide variability in California's climate.

* NOT INCLUDING SUB-NORMAL SNOWMELT CLASSIFICATION

The Sacramento Valley floor ranges from 30 to 45 miles wide in the central and southern parts, but narrows to five miles at its northern end; it slopes southward from about 300 feet above sea level at the north end near Red Bluff to sea level at Suisun Bay. The crestline of the Sierra Nevada generally ranges from 8,000 to 10,000 feet, while the crestline of the Coast Range extends from 2,000 to 8,000 feet. Due to the large snowpack at higher elevations in the Basin, the greatest volume of streamflow above the reservoirs occurs during snowmelt in the spring and early summer.

3.2.2 Hydrology

The Sacramento River Basin receives water transfers from other basins via the following projects:

Trinity River, Sly Park, Little Truckee Ditch, and Echo Lake Conduit.

The Basin exports water to other basins via the following projects:

Putah South Canal, Folsom South Canal, Tule Lake Diversion, North Fork Ditch, and Folsom Lake Diversion.

These and the amounts of other interbasin transfers are shown in Figure 3.2.2-1 (DWR,19). The basin boundaries in this figure differ somewhat from the boundaries defined in this Plan; however, it provides a good illustration of the magnitude of interbasin water transfers from the Sacramento River Basin to other areas in California.

3.2.3 Unimpaired Flow Conditions

The Sacramento River Basin inflow to the Delta comes from four major river systems—the Sacramento, Feather, Yuba, and American. The unimpaired flows from these river systems, often referred to as the Sacramento River Basin Four Rivers Index, represent approximately 47, 25, 13, and 15 percent, respectively, of the total flow from the Sacramento River Basin that make up this index. Figure 3.2.3-1 shows the average unimpaired and measured flows over the period of 1922 to 1978 ('1990 level' is the estimated flow for any year given current, or 1990, storage capacities, diversions and exports).

3.2.4 Current Flow Conditions

Delta inflow from the Sacramento River Basin comes from two major sources, the Sacramento River near Sacramento and the Yolo Bypass just west of Sacramento. The current annual flows, i.e., those estimated by DWR's 1990 level operations study, in the Sacramento River near Sacramento for 1922 through 1987 are also shown in Figure 3.2.3-1. In this time period, current flows are expected to decrease below unimpaired flows in wetter years due to upstream diversions and reservoir storage. Dry and critical year flows remain about the same principally due to river flow requirements needed to meet water quality objectives and export demands (Table 3.2.4-1).

FIGURE 3.2.2-1 Interbasin water transfers for a 1980 level of development `and the annual amounts in AF/YR (from: DWR, 19)

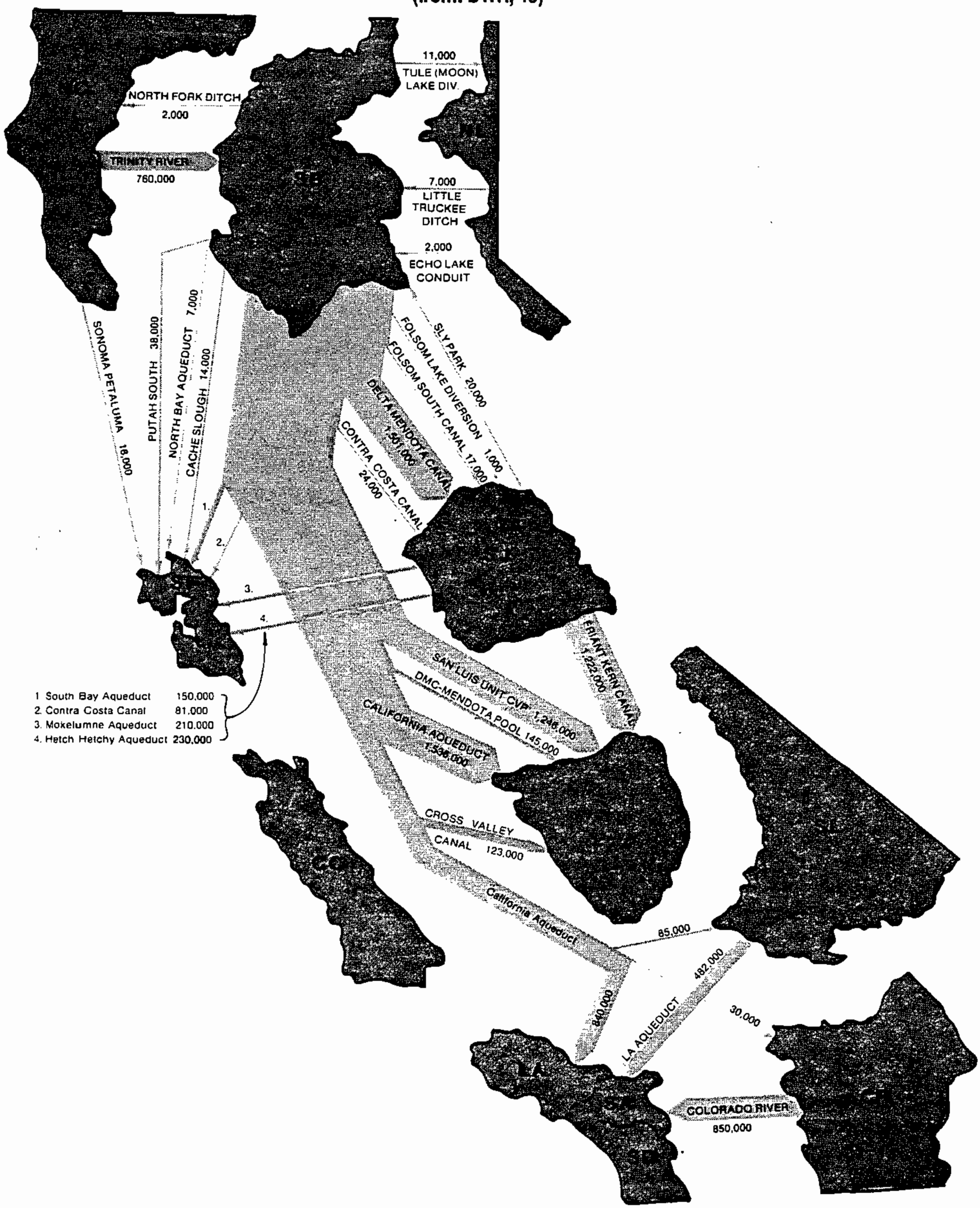


FIGURE 3.2.3–1

SACRAMENTO VALLEY AVERAGE MONTHLY FLOW

1922 THROUGH 1978

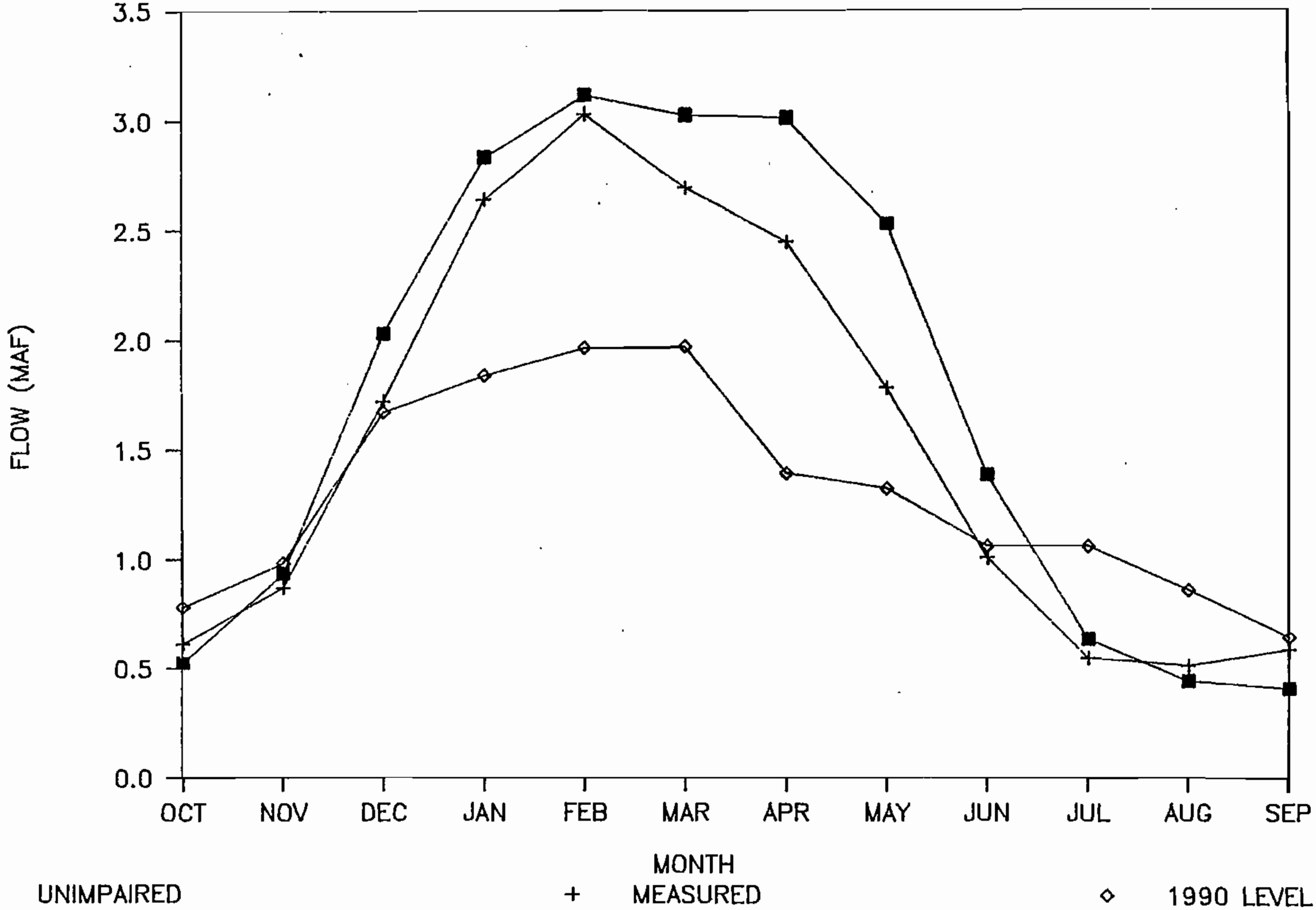


TABLE 3.2.4-1
SACRAMENTO RIVER BASIN:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS
BY WATER YEAR TYPE[1/]

Water Year Type[2/]	Unimpaired Flow (TAF)[3/] Low	High	Current Flow[4/] (TAF) (The Delta Plan Requirements) Low	High
Wet	24,456	40,639	19,711	36,003
Above Normal	18,284	23,673	12,682	20,698
Below Normal	15,063	18,061	8,923	15,768
Dry	12,014	14,231	10,597	14,089
Critical	5,557	10,103	7,092	10,737

1/ Using 1922 through 1978 hydrology.
2/ Using the wetter classification in dual classification years.
3/ Thousands of acre-feet.
4/ From DWR 1990 Level-of-Development Study.

During high flow periods (greater than 30,000 cfs), the Sacramento River overflows into the Yolo Bypass.

3.3 CENTRAL SIERRA BASIN

3.3.1 Physical Description

Basin 5B in Figure 3.1-2 is referred to as the Central Sierra Basin (SWRCB,3,4). This Basin includes the Delta and the watersheds of the Cosumnes, Mokelumne, and Calaveras rivers. Excluding the Delta, this Basin encompasses about 3,800 square miles (2,432,000 acres) of valley, foothills, and Sierra Nevada. In years of normal runoff, Basin 5B contributes about five percent of the total runoff to the Estuary (SWRCB,3,3).

3.3.2 Hydrology

The Central Sierra Basin inflow to the Delta comes from two river systems, the Mokelumne and Cosumnes, sometimes called the "Eastside Streams." The Basin also receives water from the Sacramento River Basin via the Folsom South Canal and the Folsom Lake Diversion. Water is exported from the Central Sierra Basin via the following projects:

Mokelumne Aqueduct, South Bay Aqueduct[1/], and Sly Park.

1/ The South Bay Aqueduct diverts water just outside the legal boundaries of the Delta.

3.3.3 Unimpaired Flow Conditions

The Central Sierra Basin contributes about five percent of the average annual unimpaired inflow to the Delta. When unimpaired flows are reduced to current flow conditions, the percentage of the Central Sierra Basin's inflow to the Estuary remains five percent (see 3.3.4).

3.3.4 Current Flow Conditions

As of 1987, about 242,000 acre-feet of water or about one-third of the average annual Mokelumne River flow were diverted into the Mokelumne Aqueduct for use in the east San Francisco Bay area (EBMUD,1,9). Table 3.3.4-1 compares the amounts of water available in the Central Sierra Basin under unimpaired and current flow conditions.

The Delta Plan does not contain any flow or salinity standards at the Delta inflow points of the Central Sierra Basin.

TABLE 3.3.4-1
CENTRAL SIERRA BASIN:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS
BY WATER YEAR TYPE 1/

	Unimpaired Flow (TAF) 3/		Current Flow 4/	
Water Year Type 2/	Low	High	Low	High
Wet	1,176	3,329	669	2,534
Above Normal	954	2,343	358	1,377
Below Normal	722	1,940	319	1,092
Dry	361	1,030	240	505
Critical	162	593	163	366

1/ Using 1922 through 1978 hydrology. Individual water years measured as percentages of the Sacramento Basin's Four River Index have been used, resulting in some overlap of flow amounts for different water year types.
2/ Using the wetter classification in dual classification years.
3/ Thousands of acre-feet.
4/ From DWR 1990 Level-of-Development Operation Study; this Basin has no D-1485 requirements.

3.4 San Joaquin River Basin

3.4.1 Physical Description

The San Joaquin River Basin, Basin 5C in Figure 3.1-2, encompasses over 11,000 square miles (7,040,000 acres) between the crest of the Sierra Nevada Range and the crest of the Coast Range, and stretches southward from the Delta to the drainage divide between the San Joaquin and Kings rivers. The valley floor in the Basin measures about 50 miles wide by 100 miles long, and slopes from an elevation of about 250 feet at the southern end to near sea level at the northern end (RWQCB 5, 1975). In years of normal runoff, the San Joaquin River Basin now contributes about 15 percent of the total measured runoff to the Estuary (SWRCB,3,3).

The Kings River historically flowed into Fresno Slough and into the San Joaquin River. Due to upstream controls and diversions, this occurs now about once every three years (DWR,26,33). Due to this discontinuity, the Kings River is now considered to be part of the Tulare Lake Basin, Basin 5D, and not part of the San Joaquin River Basin.

3.4.2 Hydrology

The major tributaries in Basin 5C are the San Joaquin, Merced, Tuolumne, and Stanislaus rivers which originate in the Sierra Nevada. Peak streamflows above the reservoirs generally occur later in spring than the Sacramento Basin because the San Joaquin Basin mountain ranges are generally higher than those in the Sacramento Basin. Smaller tributaries, consisting of runoff from the Coast Range and/or argricultural drainage, include the following:

Salt and Mud sloughs, and Panoche, Little Panoche, Los Banos, Orestimba, and Del Puerto creeks.

Water is imported into the San Joaquin River Basin from the Delta via the Delta-Mendota Canal (DMC) of the CVP. Water is exported from the Basin via the following projects (see Figure 3.2.2-1):

Friant-Kern Canal (CVP), Hetch Hetchy Aqueduct, and San Felipe Unit (CVP).

About 77,000 acres in the San Joaquin River Basin have subsurface agricultural drainage systems which discharge to the San Joaquin River, primarily via Mud and Salt sloughs (EDF,11,I-1). During the irrigation season and occasionally following the flushing of agricultural drainage water from duck clubs in January and February, agricultural drainage makes up a significant portion of San Joaquin River flows and constituent loads (EDF,11,V-36--V-44,V-46&V-47). The San Joaquin River contains considerably higher concentrations of several constituents (including nitrates, selenium, arsenic, nickel and manganese) than the Sacramento River (AHI,302,219,231).

3.4.3 Unimpaired Flow Conditions

The unimpaired and measured annual flow of the four major rivers in the San Joaquin River Basin are shown in Figure 3.4.3-1 for WYs 1922 to 1978.

The completion of the Friant and Delta-Mendota Canal units of the CVP around 1950 altered the natural state of the San Joaquin River. A comparison of the pre-1950 and the post-1950 unimpaired versus measured flow relationship is shown in Figure 3.4.3-2 (EDF,11,II-30). The two regression lines in the figure are significantly different, indicating that the total amount of flow measured at Vernalis (the entry point of the San Joaquin River to the Delta) has decreased since 1950 (see 3.4.4).

FIGURE 3.4.3–1

SAN JOAQUIN VALLEY AVERAGE MONTHLY FLOW

1922 THROUGH 1978

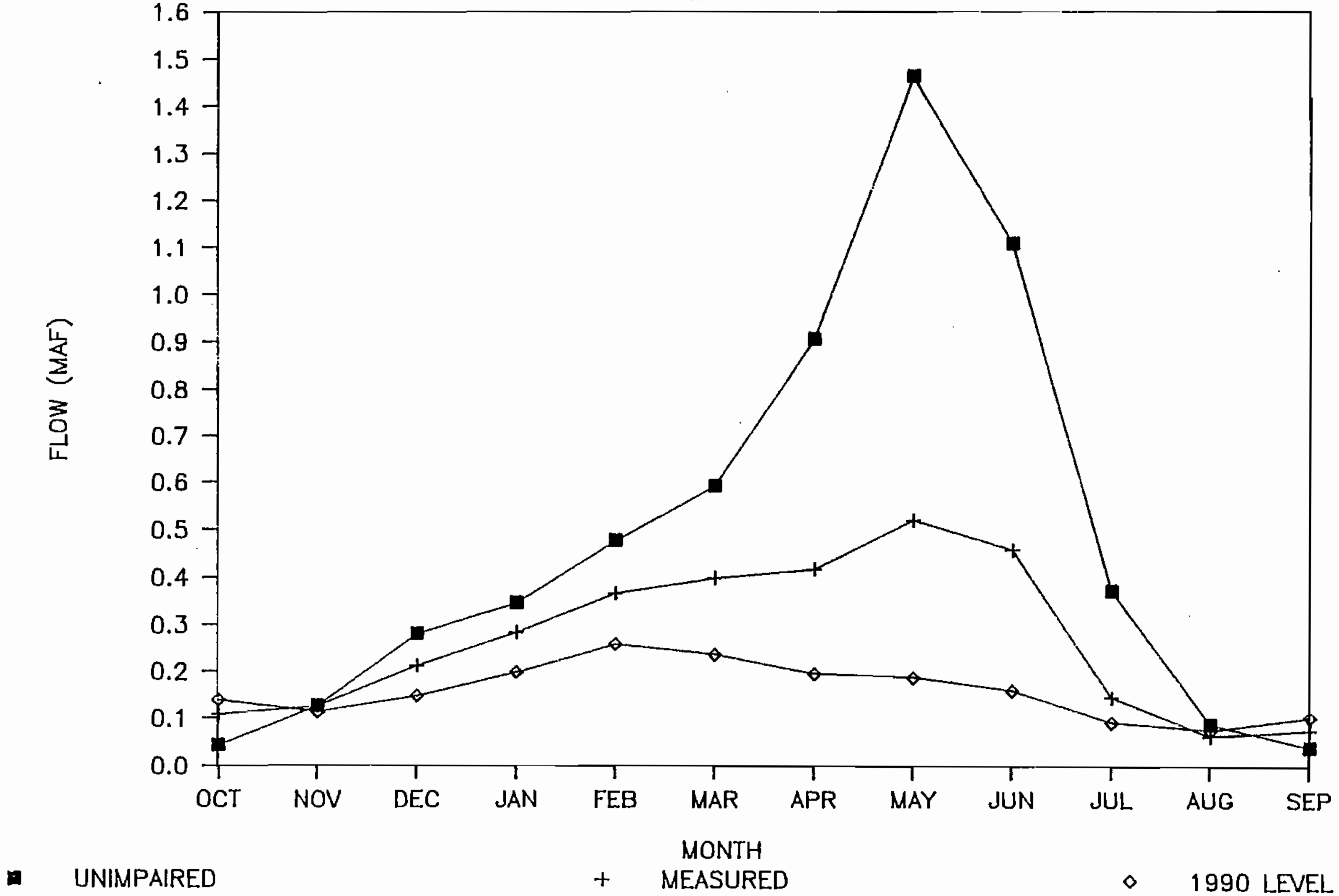
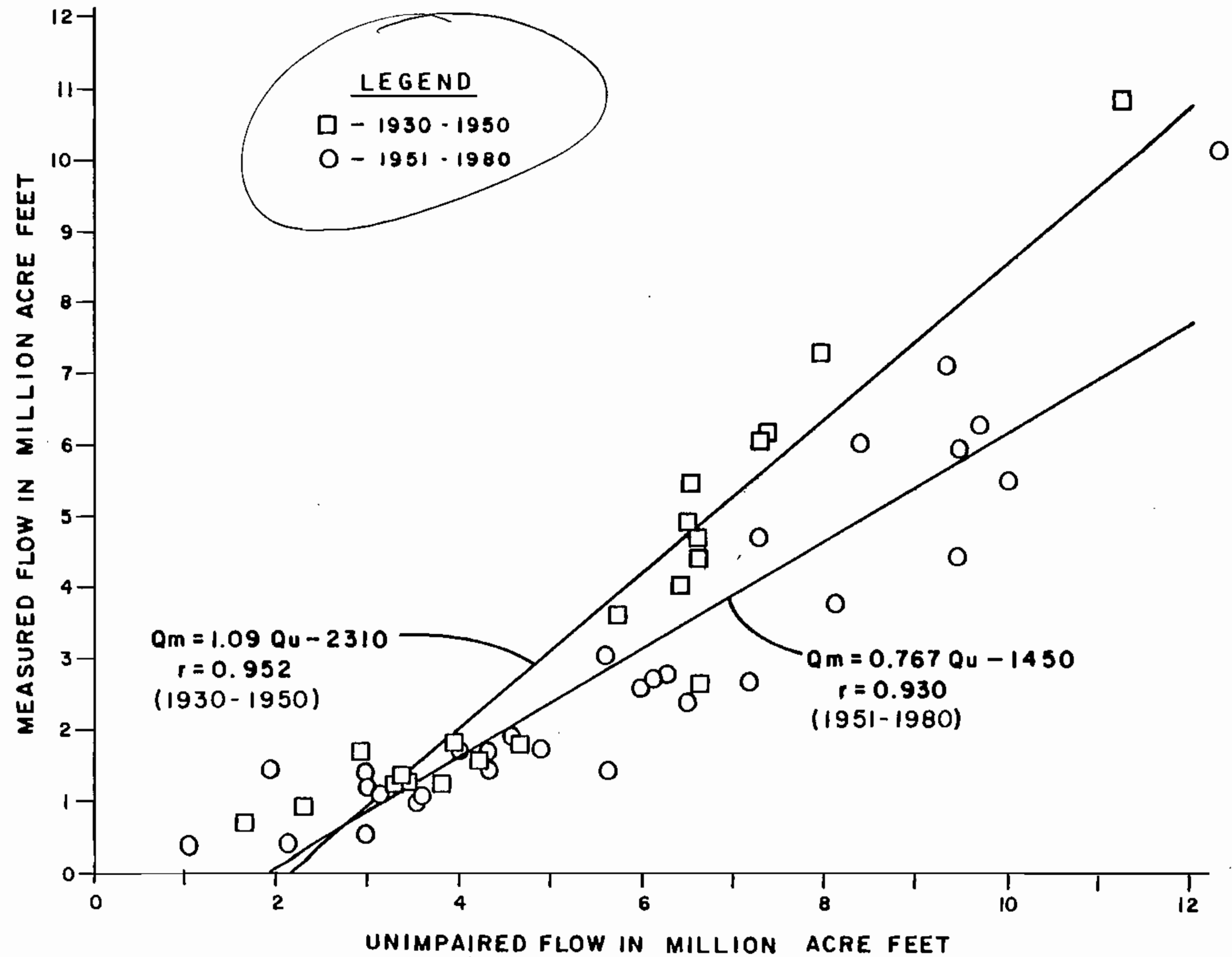


FIGURE 3.4.3-2 Unimpaired flows versus measured flows for the San Joaquin Basin



3.4.4 Current Flow Conditions

The annual measured flows in the San Joaquin River near Vernalis for WYs 1921 to 85 are also plotted in Figure 3.4.3-1 for comparison (flow data are not available for the 1906 to 20 and 1986 to 87 time periods). With the exception of the extremely wet WY 1983, the annual measured flows are less than the unimpaired flows[1/].

The main reason for the differences between annual unimpaired and measured flows is the consumptive water use by valley agriculture during the irrigation season, generally from April through September. Reservoirs on the four major rivers in the San Joaquin River Basin have also altered the timing of measured flows in relation to the unimpaired flows above the reservoirs, and have raised flows in September and October above unimpaired levels.

The current water quality objective set by The Delta Plan for the San Joaquin River Basin is a monthly mean of 500 ppm TDS for the San Joaquin River near Vernalis (RWQCB 5, 1975). For the period of 1975 through 1987, the 500 ppm TDS objective was met in all but two critically dry water years, 1976 and 1977, as well as the beginning of Water Year 1978. However, this 12-year period was dominated by wet years--six wet, two above normal, two dry, and two critical. Table 3.4.4-1 compares the amounts of water available in the San Joaquin River Basin under unimpaired and current flow conditions.

Figure 3.4.4-1, plotting annual salinity as TDS in the San Joaquin River near Vernalis for 1930-80 (Data from Orlob,1982), shows that salinity concentrations have increased since 1930. The salt load has also increased since 1985, according to Dr. G. T. Orlob's analysis of USBR data measured at Vernalis (Orlob,1988), probably because of the bypassing of agricultural drainage around the Grassland Water District directly to the San Joaquin River.

3.5 The Delta

3.5.1 Physical Description

The Delta is a roughly triangular area of approximately about 1,150 square miles (738,000 acres) extending from Chipps Island near Pittsburg on the west to Sacramento on the north and to the Vernalis gaging station on the south (see Figure 3.1-1) (California Water Code Section 12220). This area includes those waterways above the confluence of the Sacramento and San Joaquin rivers which are influenced by tidal action, and about 800 square miles (512,000 acres) of agricultural lands which derive their water supply from these waterways. The total surface area of these waterways is over 75 square miles (48,000 acres) with an aggregate navigable length of about 550 miles. Major tributaries to the Delta, besides the Sacramento and San Joaquin rivers, include the Cosumnes, Mokelumne, and Calaveras rivers, Dry Creek, and the Yolo Bypass.

1/ In WY 1983, flows from the Tulare Lake Basin contributed over two million acre-feet to the San Joaquin River flows near Vernalis, but were not included in the unimpaired flow of the four major rivers (DWR,26,33).

FIGURE 3.4.4.-1 Salinity, Flow and Salt Load in the San Joaquin River near Vernalis (5 year running Averages)
(adapted from Orlob, 1982 data)

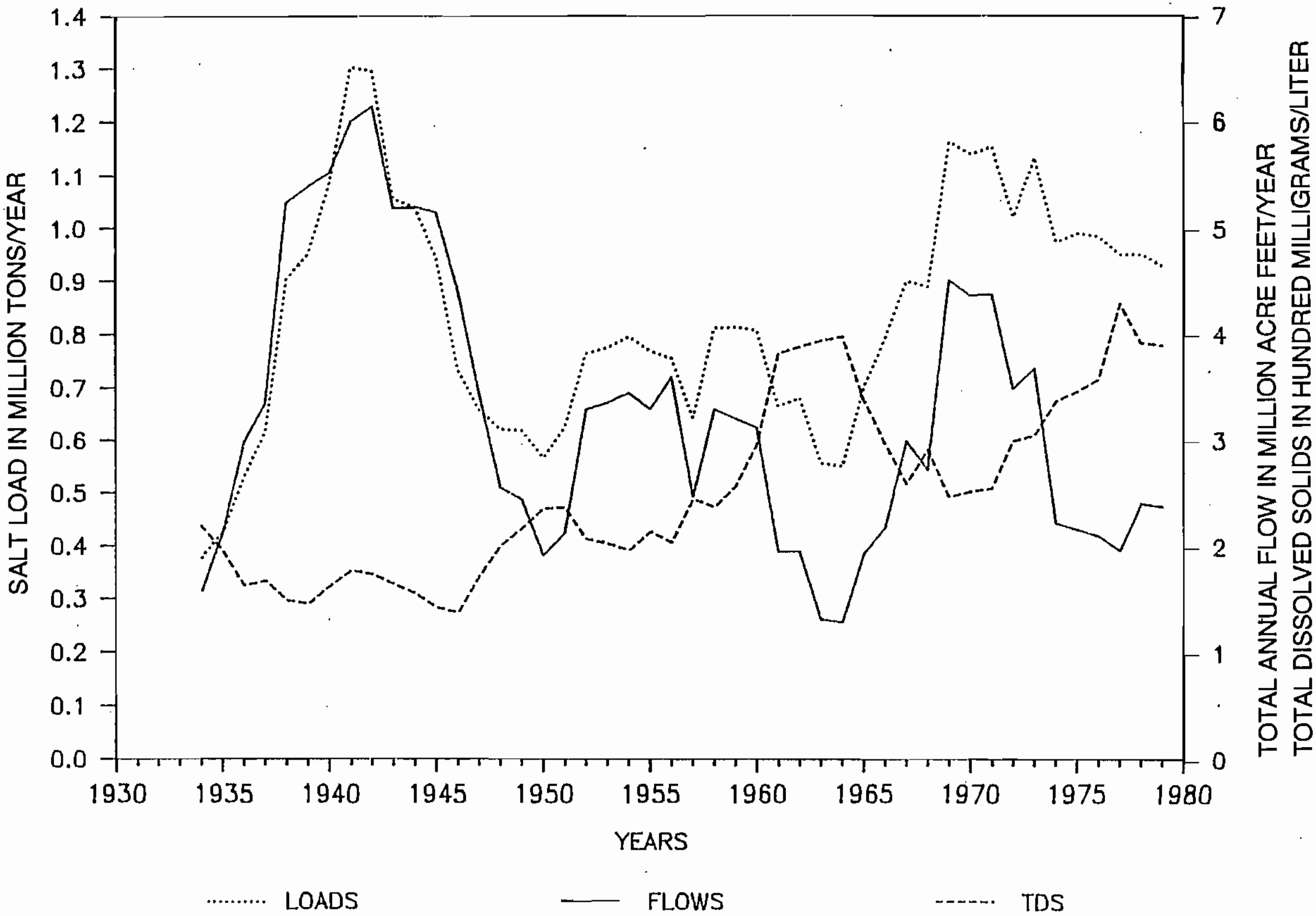


Table 3.4.4-1
SAN JOAQUIN RIVER BASIN:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS
BY WATER YEAR TYPE[1/]

	Unimpaired Flow (TAF)[2/]		Current Flow (The Delta Plan Requirements)	
Water Year Type	Low	High	Low	High
Wet	4,522	15,020	1,124	6,571
Above Normal	4,339	8,703	945	2,901
Below Normal	3,017	7,530	926	2,488
Dry	2,132	4,128	957	1,598
Critical	1,026	3,436	850	1,596

1/ Assuming 1922 through 1978 hydrology. Individual water years measured as percentages of the Sacramento Basin's Four River Index (see Chapter 4) have been used, resulting in some overlap of flow amounts for different water year types.

2/ Thousands of acre-feet.

Water is exported from the Delta at four major locations (identified by number on Figure 3.1-1):

Tracy Pumping Plant (1), Clifton Court Intake (2), Contra Costa Canal at Pumping Plant No. 1 (3), and the City of Vallejo intake at Cache Slough (4). The North Bay Aqueduct intake at Barker Slough (5) has recently replaced the City of Vallejo's intake (DWR,707,50).

3.5.2 Hydrology

3.5.2.1 Background

In its original condition, the Delta was a vast, flat marsh traversed by an ever changing network of channels and sloughs that divided the area into islands (SWC,262,A2-15). "During the flood season, the Delta became a great inland lake; when the floodwater receded, the network of sloughs and channels reappeared throughout the marsh" (DWR,707,67). In the 1860's reclamation began on low-lying areas, and local landowners undertook cooperative levee construction to allow the lands to be farmed. By the 1920's about 45,000 acres were completely reclaimed and in agricultural production (SWRCB,13,III-4); and "{m}any miles of entirely new channels had been dredged, and farmlands, small communities, highways and utilities were protected--often tenuously--by 1,100 miles of levees, many of them built on peat soils" (DWR,707,67).

The export of water directly from the Delta first took place in 1940 with the completion of the Contra Costa Canal, a unit of the CVP. In 1951, water supplying the Delta-Mendota Canal began to be exported at the CVP's Tracy Pumping Plant (DWR,707,67). In the same year the Delta Cross Channel and control gates were constructed near Walnut Grove to allow a more efficient transfer of water to the Tracy pumps (SWRCB,13,III-6). With the commencement of operation of the State Water Project's (SWP) Harvey O. Banks Pumping Plant in 1967, Delta exports were again increased. By 1975 the combined deliveries of waters exported by both the CVP and SWP totaled 4.8 million acre-feet per year--totals projected to reach 6.6 million acre-feet per year by the year 2000 (USBR,2,27).

3.5.2.2 Water Flow

- Inflow

Freshwater flow into the Delta comes primarily from the Sacramento and San Joaquin rivers, with small additional amounts contributed by the Mokelumne and Cosumnes rivers (SWRCB,13,III-7). Under present conditions, these river systems contributed 85, 10, and 5 percent, respectively, of the average annual Delta inflow during the water years 1922 to 1978 (DWR, 1987, from DWR 1990 'Level of Development Operation Model Output').

- In-channel Flow

  Flows in the Delta channels themselves result from a combination of Delta inflows, Delta agricultural use, export diversions, and the counteracting force of the tides from the Pacific Ocean through the San Francisco Bay. Many times when freshwater inflows are low, flows can change direction and move back upstream on incoming tides. The distance of the upstream movement, and the extent of saline intrusion, can vary depending on the quantities of water flowing in and the opposing force of tidal action (SWRCB,14,II-1). The total flow, however, is normally downstream, out of the Delta (SWRCB,13,III-11).

- Outflow

  The total outflow from the Delta is a combination of unimpaired runoff, Delta channel depletions, exports and upstream developments, which either reduce unimpaired runoff or change its time of occurrence.

  Delta outflow is highly seasonal and is characterized by large winter inflows from rainfall runoff generated by Pacific storms, and small, relatively steady inflows during the dry summers from reservoir releases. Delta outflow commonly exceeds 35,000 cfs from December through April, whereas it is usually less than 14,000 cfs from July through October (USGS,10,6).

3.5.2.3 Flow Measurement

Tidal movement, Delta channel depletions, and Delta exports (see 3.5.2.4) are not directly measured at present due to the complex effects of tidal fluctuation and flow patterns (SWRCB,14,IV-7). However, an estimate of net Delta outflow is important for purposes of water quality control and water resource management (SWRCB,13,III-16). The net Delta outflow at Chipps Island is usually estimated by performing a water balance at the boundary of the Delta, using Chipps Island as the western limit. The water balance involves adding the total Delta inflow and Delta precipitation runoff, then subtracting Delta channel depletions and exports (DWR,47,2).

DWR has estimated daily Delta outflow at Chipps Island for water years 1956 through 1985 using the flow accounting model, DAYFLOW. DAYFLOW is also used to estimate interior Delta flow at specified locations. (DWR,47) Figure 3.5.2.3-1 gives the means and standard deviations of Delta outflows computed by DAYFLOW for water years 1956 through 1985 (USGS,10,6).

Another commonly used estimate of Delta outflow, especially for the daily operation of the CVP and SWP, is the Delta Outflow Index (DOI). The DOI is similar to the DAYFLOW Delta outflow but does not include the smaller peripheral streams entering the Delta, such as the Mokelumne and Calaveras rivers, or the flows through the Yolo Bypass. Because of these differences, the DOI is considered to be less accurate than the DAYFLOW Delta outflow estimate (USBR,111,16).

FIGURE 3.5.2.3-1
(FROM USGS EXHIBIT 10, PAGE 6)

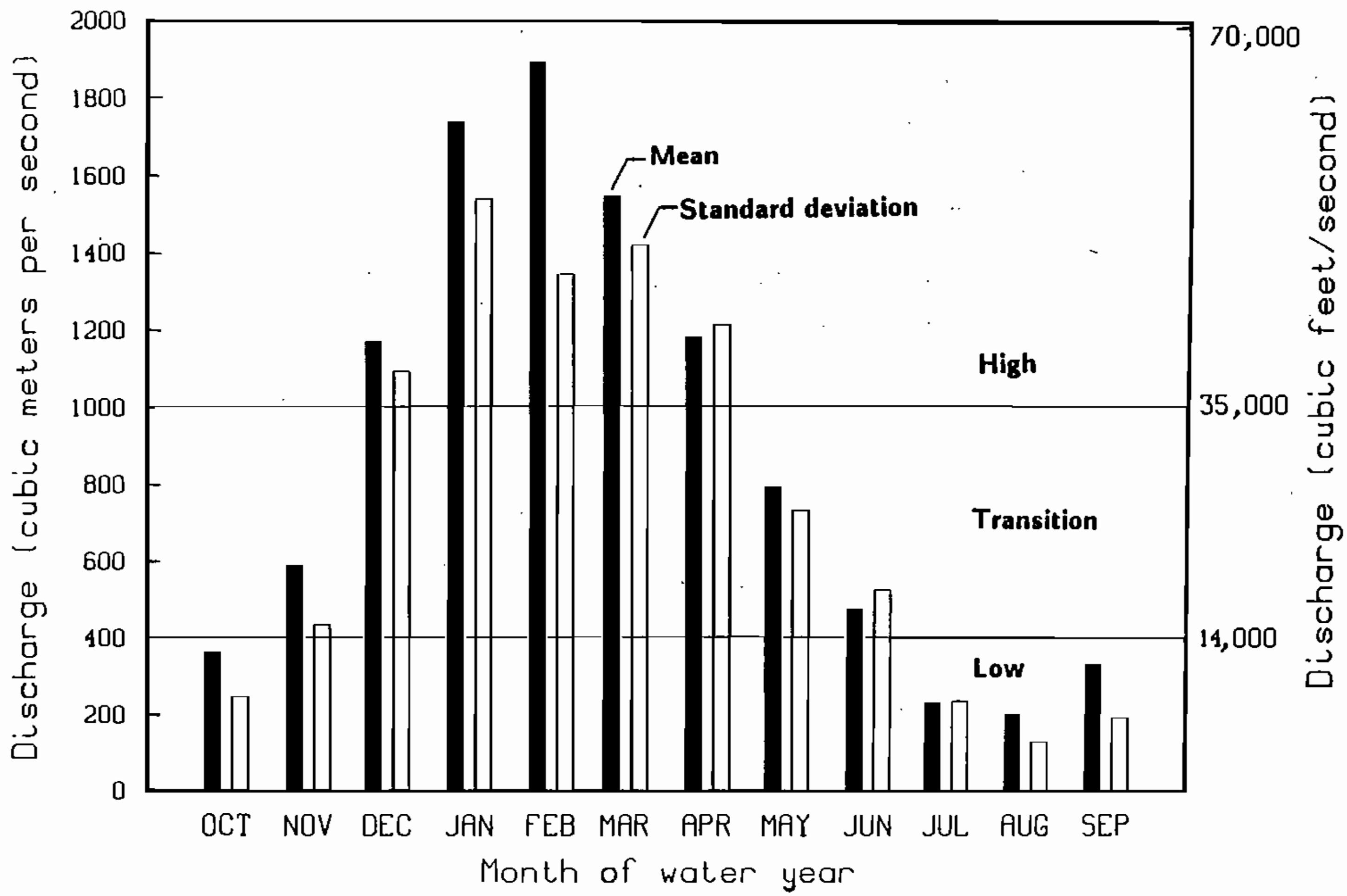


FIGURE 3.5.2.3-1 --**Means and standard deviations of net monthly discharges of the Sacramento-San Joaquin Delta into San Francisco Bay at Chipps Island, 1956-85 from estimates of the State of California (1986). Also shown are arbitrary divisions of the months into high (>1,000 m^3/s [35,000 ft^3/s]), transition (400-1,000 m^3/s [14,000-35,000 ft^3/s]), and low (<400 m^3/s [14,000 ft^3/s]) delta discharges.**

3.5.2.4 Channel Depletion, Exports and Reverse Flow

One of the critical factors in determining Delta outflow is Delta channel depletion, that is, "...the diversions of Delta channel waters via pumps, siphons, and subsurface seepage into the Delta uplands and lowlands for consumptive use by agriculture and native plants" (DWR,36,3-4)[1/]. The Delta channel depletions (not including precipitation) range from approximately 34 TAF inJanuary to 278 TAF in July (DWR,1988,Operation Study). Currently, over 1,600 diversion locations have been identified within the Delta (T,II,189:17). The location of agricultural irrigation diversion and drainage return points are shown in Figures 3.5.2.4-1 (DWR,49,1) and 3.5.2.4-2 (DWR,64,1).

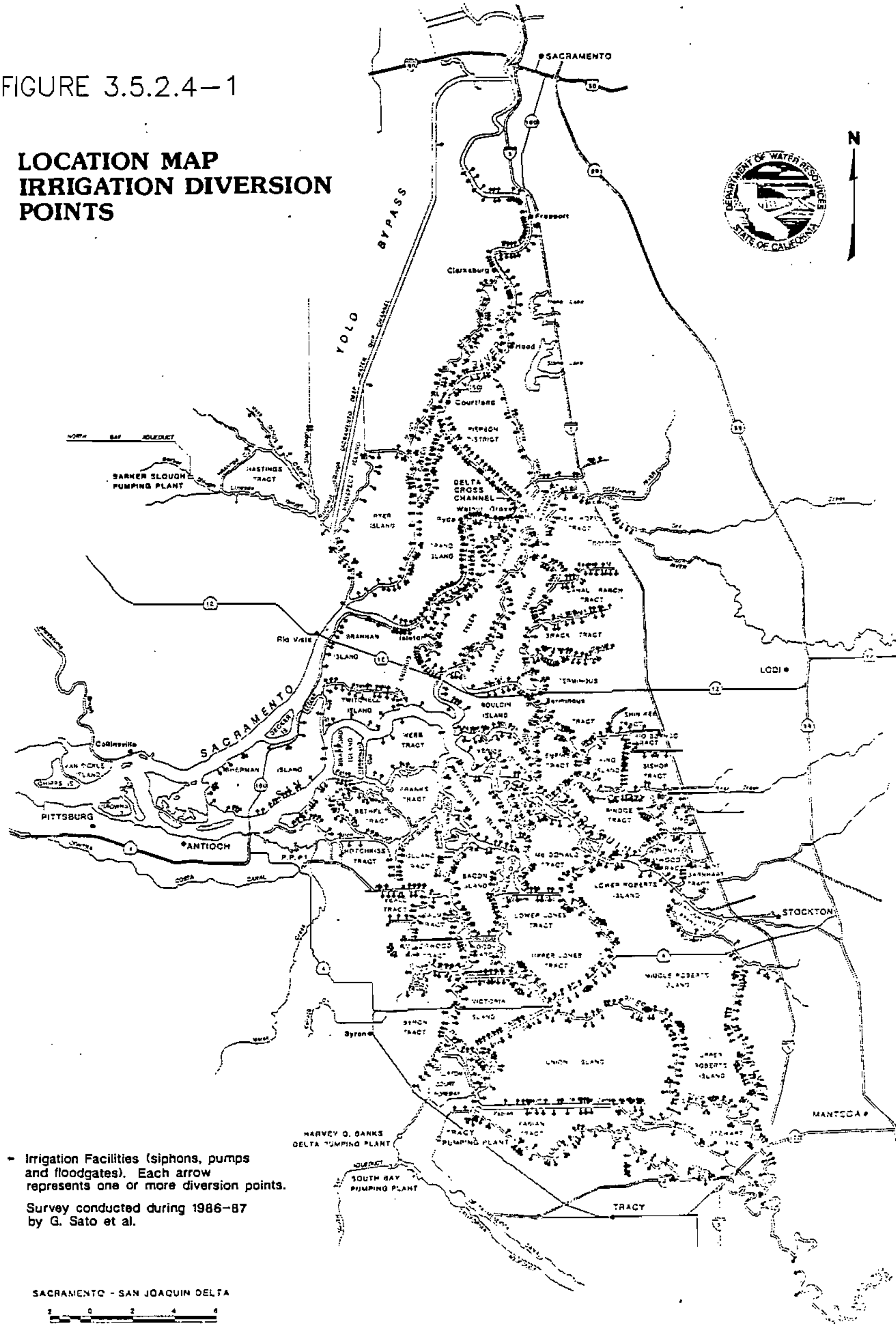
According to DWR, water supplies for export by the CVP and SWP are obtained from surplus Delta flows, and from upstream reservoir releases during low Delta inflow. Upstream reservoir releases from the Sacramento River Basin enter the Delta via the Sacramento River and then flow by various routes to the pumps in the southern Delta. Some of these releases are drawn to the CVP and SWP pumps through interior Delta channels facilitated in part by the CVP's Delta Cross Channel at Walnut Grove (DWR,707,69).

When export rates are high, the net flow of water can flow in an upstream direction and move toward the export pumps (SWRCB,13,III-II). This is known as reverse flows. During periods of high Delta inflow and high export, there is some reverse flow, but enough water is available from the San Joaquin River, eastern Delta tributaries (Central Sierra Basin) and from water transported out of the Sacramento River via the Delta Cross Channel to meet export demands (Figure 3.5.2.4-3). When there are high exports, low San Joaquin River inflows and high Delta consumptive uses, however, the normal water path changes, causing a reversal of flows around the lower (western) end of Sherman Island where the Sacramento River and the San Joaquin River meet (SWRCB,13,III-23) (Figure 3.5.2.4-4). As water travels around Sherman Island, it mixes with saltier ocean water entering as tidal inflow and is drawn upstream into the San Joaquin River and other channels that feed the CVP and SWP pumping plants (DWR,707,69). Figures 3.5.2.4-5 through 3.5.2.4-7 show other typical Delta flow patterns (DWR,51a-e).

1/ The consumptive use values used by the USBR and DWR to operate the CVP and SWP were fixed in the Federal-State Memorandum of Agreement dated April 9, 1969. The consumptive use values were based on: (1) a 1955 Delta land use survey; (2) estimates of consumptive use by identified crops; (3) changes in soil moisture; and (4) estimates of leaching requirements (SWRCB,13,III-16). Although the consumptive use values are adjusted seasonally, they are not adjusted between years; error can thereby be introduced into the Delta outflow calculations (USBR,111,16).

FIGURE 3.5.2.4-1

LOCATION MAP IRRIGATION DIVERSION POINTS

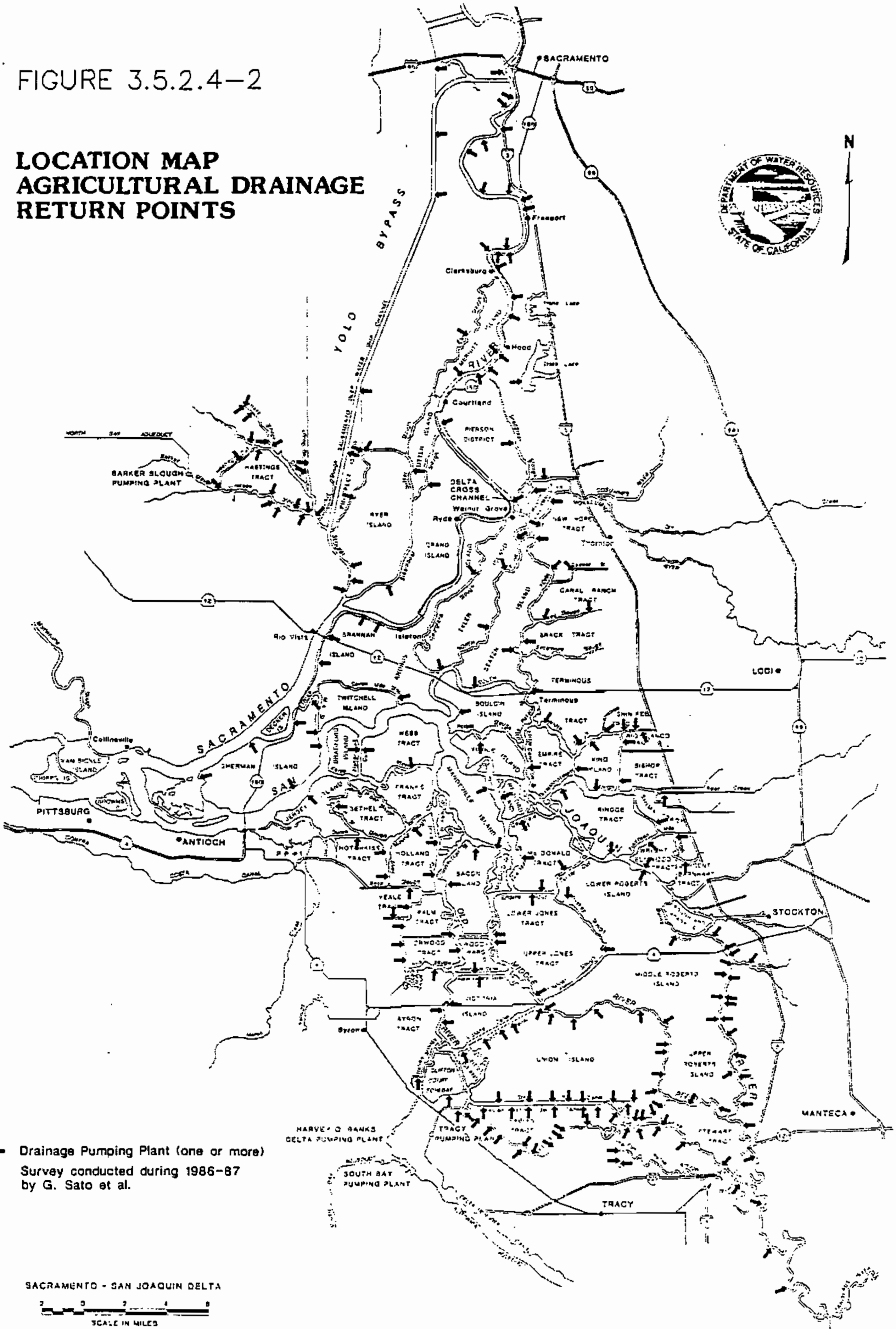


- Irrigation Facilities (siphons, pumps and floodgates). Each arrow represents one or more diversion points.

Survey conducted during 1986–87 by G. Sato et al.

FIGURE 3.5.2.4-2

LOCATION MAP
AGRICULTURAL DRAINAGE
RETURN POINTS



← Drainage Pumping Plant (one or more)

Survey conducted during 1986-87 by G. Sato et al.

SACRAMENTO - SAN JOAQUIN DELTA

SCALE IN MILES

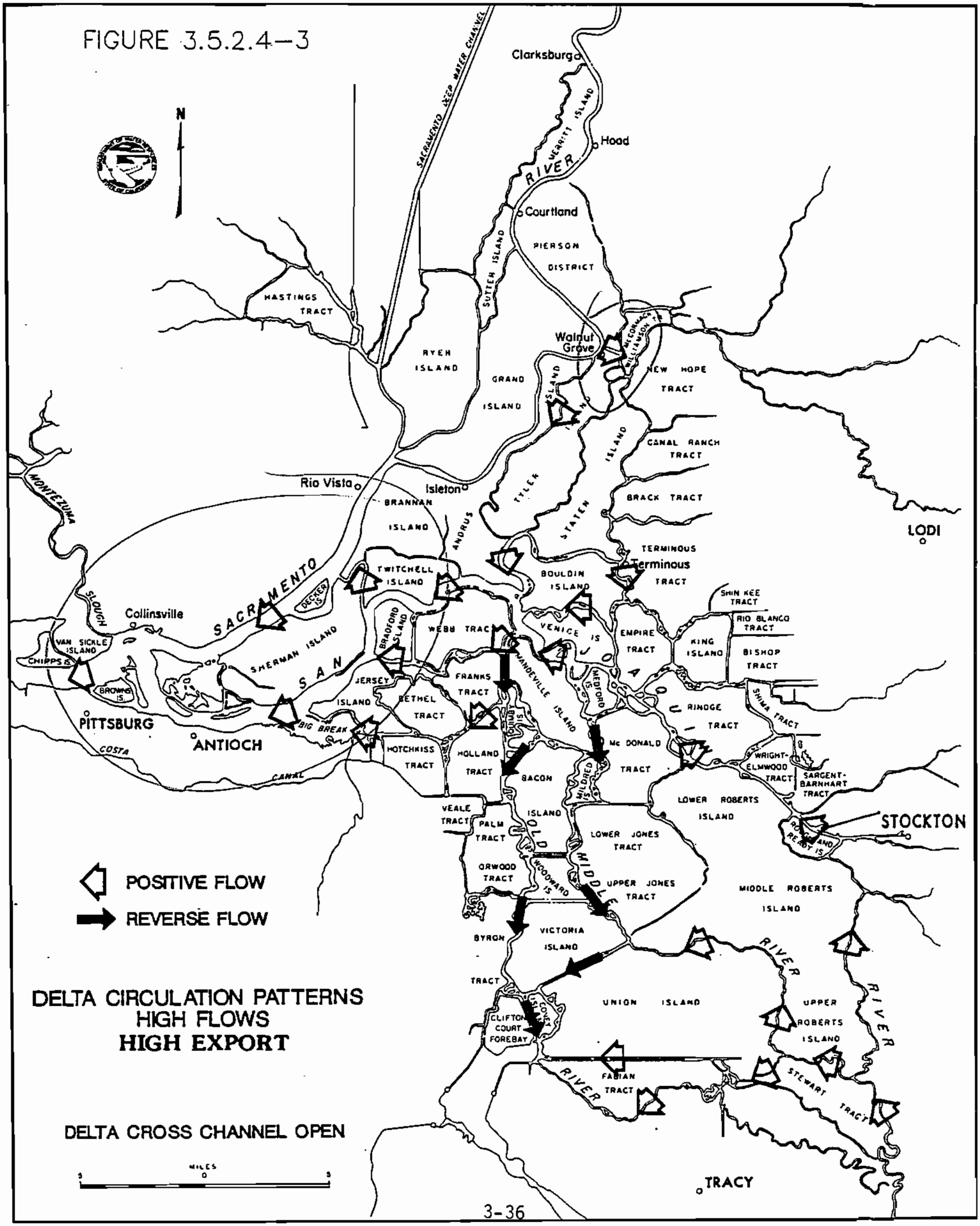


FIGURE 3.5.2.4-3
N
Clarksburg
Hood
MERRITT ISLAND
RIVER
SACRAMENTO DEEP WATER CHANNEL
Courtland
PIERSON DISTRICT
SUTTER ISLAND
HASTINGS TRACT
RYER ISLAND
GRAND ISLAND
Walnut Grove
McCORMACK WILLIAMSON TR.
NEW HOPE TRACT
CANAL RANCH TRACT
TYLER ISLAND
STATEN ISLAND
BRACK TRACT
MONTEZUMA
Rio Vista
Isleton
BRANNAN ISLAND
ANDRUS
LODI
TERMINOUS TRACT
Terminous
TWITCHELL ISLAND
BOULDIN ISLAND
SACRAMENTO
DECKER IS.
SLOUGH
Collinsville
SHERMAN ISLAND
BRADFORD ISLAND
WEBB TRACT
VENICE IS
SHIN KEE TRACT
RIO BLANCO TRACT
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
VAN SICKLE ISLAND
CHIPPS IS.
BROWNS IS.
SAN
JERSEY ISLAND
FRANKS TRACT
MANDEVILLE ISLAND
MEDFORD IS
JOAQUIN
RINDGE TRACT
SHIMA TRACT
PITTSBURG
ANTIOCH
BIG BREAK
BETHEL TRACT
COSTA CANAL
HOTCHKISS TRACT
HOLLAND TRACT
McDONALD TRACT
MILDRED IS
WRIGHT-ELMWOOD TRACT
SARGENT-BARNHART TRACT
BACON ISLAND
LOWER ROBERTS ISLAND
STOCKTON
ROUGH AND READY IS.
VEALE TRACT
PALM TRACT
OLD
LOWER JONES TRACT
MIDDLE
ORWOOD TRACT
WOODWARD IS
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
POSITIVE FLOW
REVERSE FLOW
BYRON TRACT
VICTORIA ISLAND
RIVER
DELTA CIRCULATION PATTERNS
HIGH FLOWS
HIGH EXPORT
CLIFTON COURT FOREBAY
CONEY ISLAND
UNION ISLAND
UPPER ROBERTS ISLAND
FABIAN TRACT
STEWART TRACT
DELTA CROSS CHANNEL OPEN
MILES
5 0 5
TRACY

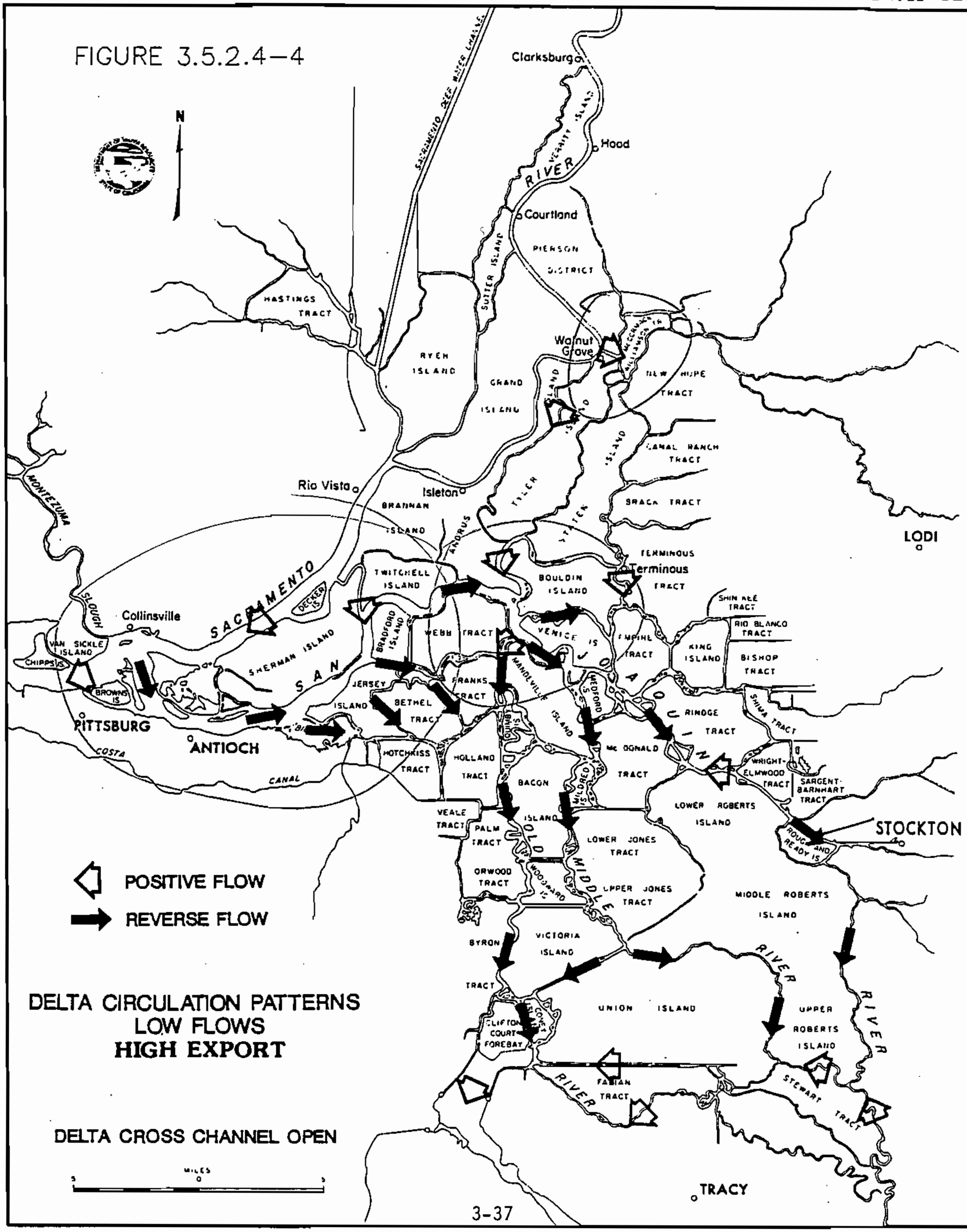
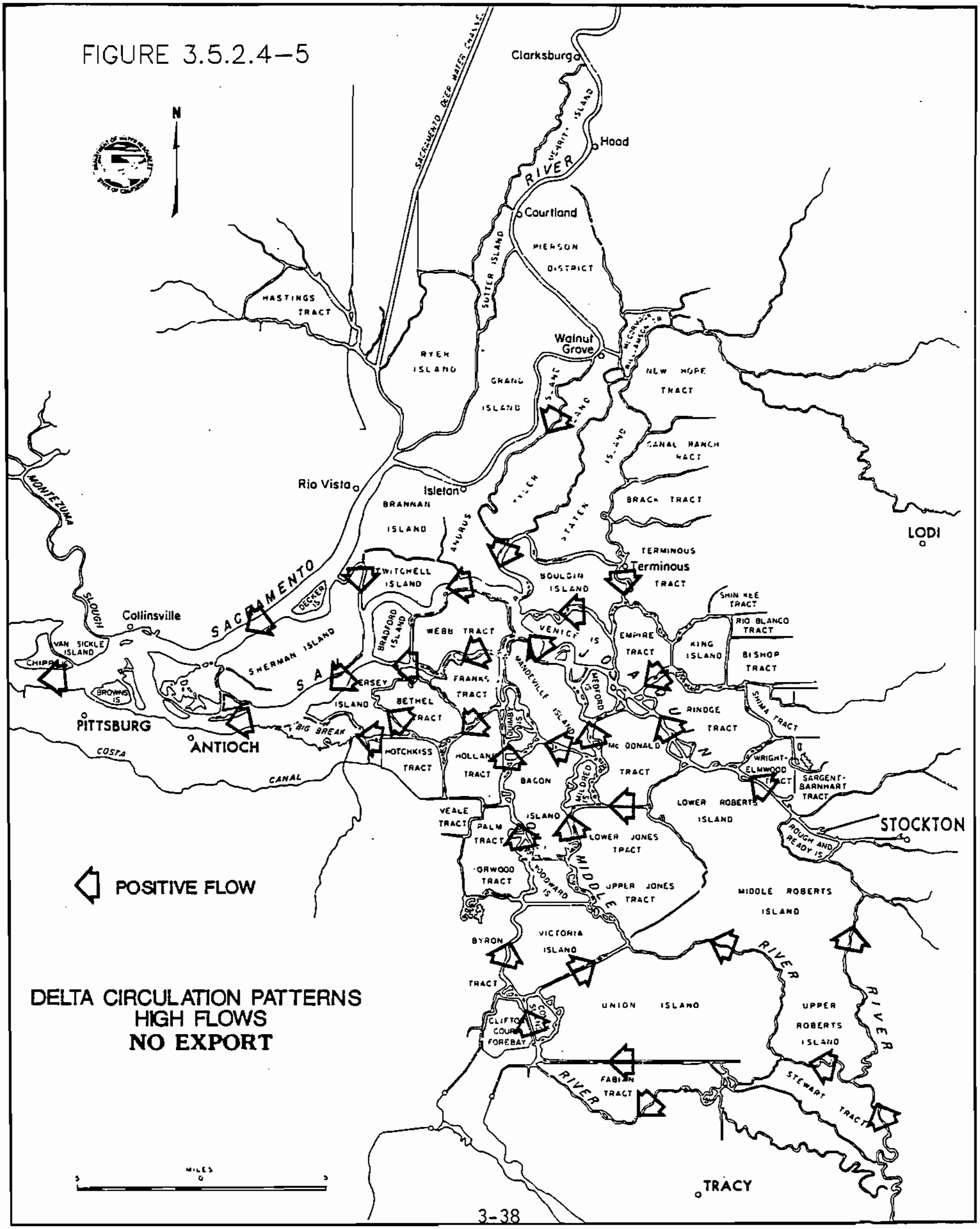


FIGURE 3.5.2.4-4
N
Clarksburg
Hood
RIVER
Courtland
PIERSON DISTRICT
SUTTER ISLAND
HASTINGS TRACT
RYER ISLAND
GRAND ISLAND
Walnut Grove
NEW HOPE TRACT
CANAL RANCH TRACT
BRACK TRACT
Rio Vista
Isleton
BRANNAN ISLAND
ANDRUS
TYLER
LODI
TERMINOUS
Terminous
TRACT
BOULDIN ISLAND
TWITCHELL ISLAND
SACRAMENTO
DECKER IS
MONTEZUMA
SLOUGH
Collinsville
VAN SICKLE ISLAND
CHIPPS IS
BROWNS IS
SHERMAN ISLAND
SAN
JOAQUIN
BRADFORD ISLAND
WEBB TRACT
VENICE IS
EMPIRE TRACT
KING ISLAND
SHIN KEE TRACT
RIO BLANCO TRACT
BISHOP TRACT
JERSEY ISLAND
BETHEL TRACT
FRANKS TRACT
MANDEVILLE ISLAND
MEDFORD IS
RINDGE TRACT
SHIMA TRACT
PITTSBURG
ANTIOCH
COSTA
CANAL
HOTCHKISS TRACT
HOLLAND TRACT
BACON ISLAND
Mc DONALD TRACT
WRIGHT-ELMWOOD TRACT
SARGENT-BARNHART TRACT
LOWER ROBERTS ISLAND
STOCKTON
ROUGH AND READY IS
VEALE TRACT
PALM TRACT
OLD
LOWER JONES TRACT
ORWOOD TRACT
WOODWARD IS
MIDDLE
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
POSITIVE FLOW
REVERSE FLOW
BYRON TRACT
VICTORIA ISLAND
RIVER
UNION ISLAND
UPPER ROBERTS ISLAND
RIVER
CLIFTON COURT FOREBAY
FABIAN TRACT
RIVER
STEWART TRACT
DELTA CIRCULATION PATTERNS
LOW FLOWS
HIGH EXPORT
DELTA CROSS CHANNEL OPEN
MILES
5
0
5
TRACY

FIGURE 3.5.2.4-5



DELTA CIRCULATION PATTERNS
HIGH FLOWS
NO EXPORT

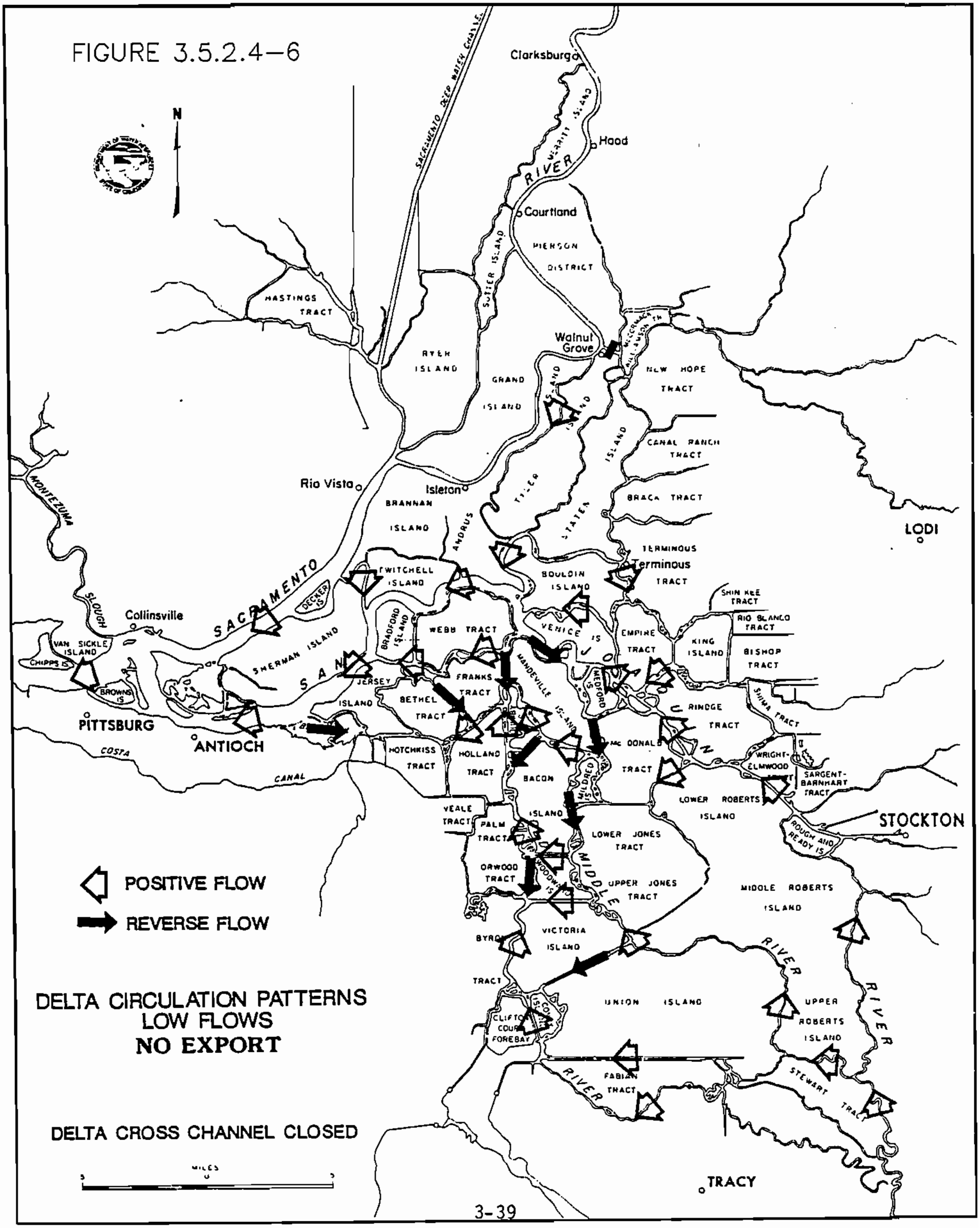
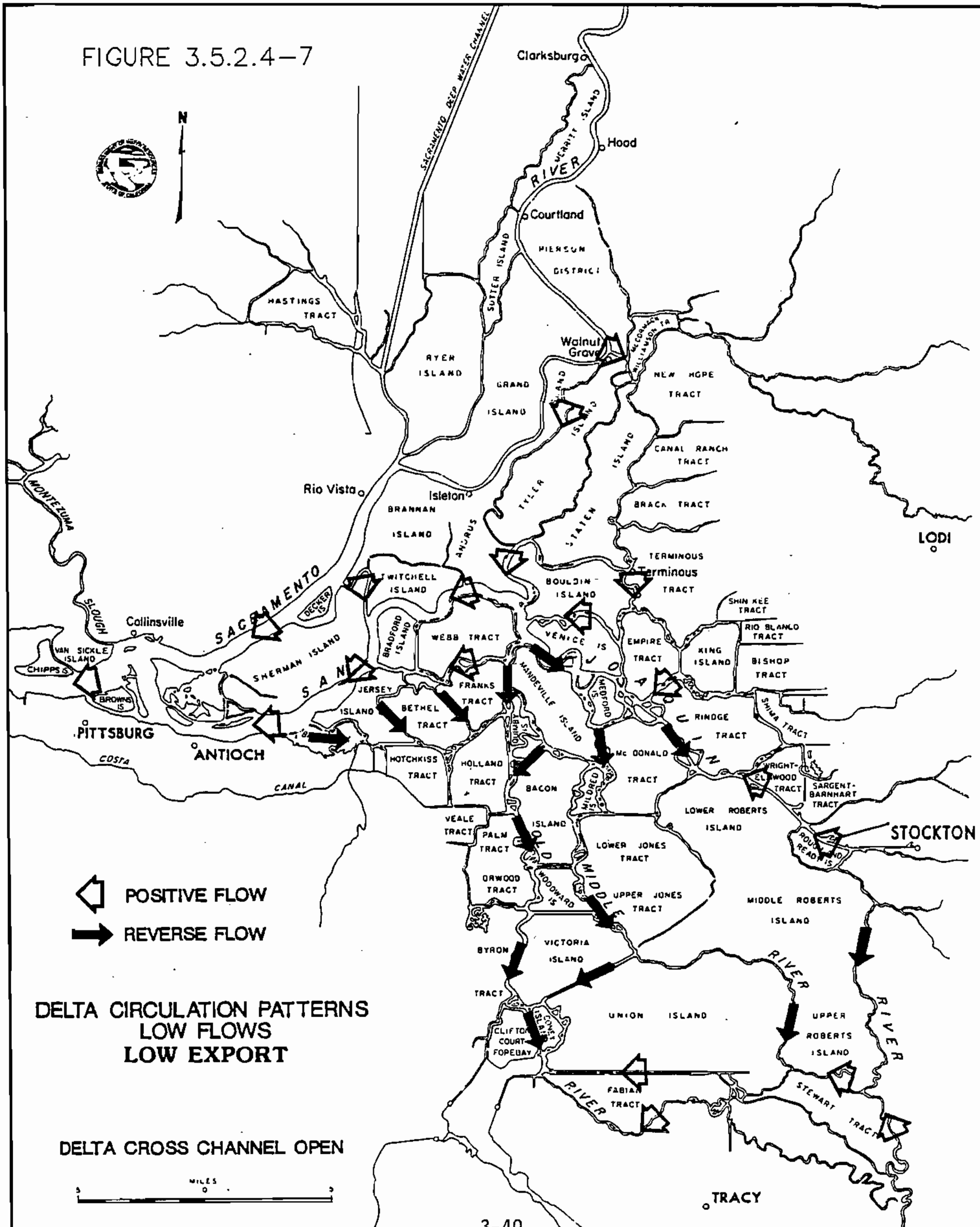


FIGURE 3.5.2.4-6
N
Clarksburg
Hood
RIVER
Courtland
PIERSON DISTRICT
SUTTER ISLAND
HASTINGS TRACT
RYER ISLAND
GRAND ISLAND
Walnut Grove
NEW HOPE TRACT
CANAL RANCH TRACT
BRACK TRACT
Rio Vista
Isleton
BRANNAN ISLAND
ANDRUS
TYLER
STATEN
ISLAND
MONTEZUMA
SLOUGH
LODI
TERMINOUS
Terminous
TRACT
TWITCHELL ISLAND
DECKER IS
BOULDIN ISLAND
SHIN KEE TRACT
Collinsville
SACRAMENTO
BRADFORD ISLAND
WEBB TRACT
VENICE IS
EMPIRE TRACT
RIO BLANCO TRACT
KING ISLAND
BISHOP TRACT
VAN SICKLE ISLAND
CHIPPS IS
SHERMAN ISLAND
SAN
JOAQUIN
BROWNS IS
JERSEY ISLAND
FRANKS TRACT
MANDEVILLE ISLAND
MEDFORD IS
RINDGE TRACT
SHIMA TRACT
PITTSBURG
ANTIOCH
BETHEL TRACT
COSTA
CANAL
HOTCHKISS TRACT
HOLLAND TRACT
BACON ISLAND
Mc DONALD TRACT
WRIGHT-ELMWOOD TRACT
SARGENT-BARNHART TRACT
MILDRED IS
LOWER ROBERTS ISLAND
STOCKTON
VEALE TRACT
PALM TRACT
ROUGH AND READY IS
LOWER JONES TRACT
ORWOOD TRACT
WOODWARD IS
MIDDLE
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
POSITIVE FLOW
REVERSE FLOW
BYRON
TRACT
VICTORIA ISLAND
RIVER
DELTA CIRCULATION PATTERNS
LOW FLOWS
NO EXPORT
UNION ISLAND
UPPER ROBERTS ISLAND
CLIFTON COURT FOREBAY
COY IS
FABIAN TRACT
STEWART TRACT
RIVER
DELTA CROSS CHANNEL CLOSED
MILES
TRACY



DELTA CIRCULATION PATTERNS
LOW FLOWS
LOW EXPORT

DELTA CROSS CHANNEL OPEN

3.5.2.5 Salinity and Flow

Salinity is one of the major water quality factors affecting beneficial uses of Delta water supplies. Figure 3.5.2.5-1 shows that, as Delta outflows decrease, salinity increases[1/] (DWR,58,1). Changes in Delta outflow during low flow periods have greater effects on salinity than similar changes during high flow periods.

Upstream storage facilities, in-basin depletions and Delta exports, have reduced winter and spring Delta outflows. Releases from upstream storage facilities, on the other hand, have increased summer and fall Delta outflows (SWRCB,14, II-1). These changes in flows have correspondingly changed the extent of salinity intrusion into the Delta. Figure 3.5.2.5-2 shows the maximum annual salinity intrusion into the Delta for the period 1920 through 1977 (DWR,60). Flow modifications due to storage facilities since the 1940's have generally kept salinity intrusion, as indicated by the 1000 ppm chloride line in the Delta, at a point further west, or downstream, than had been the case before that period.

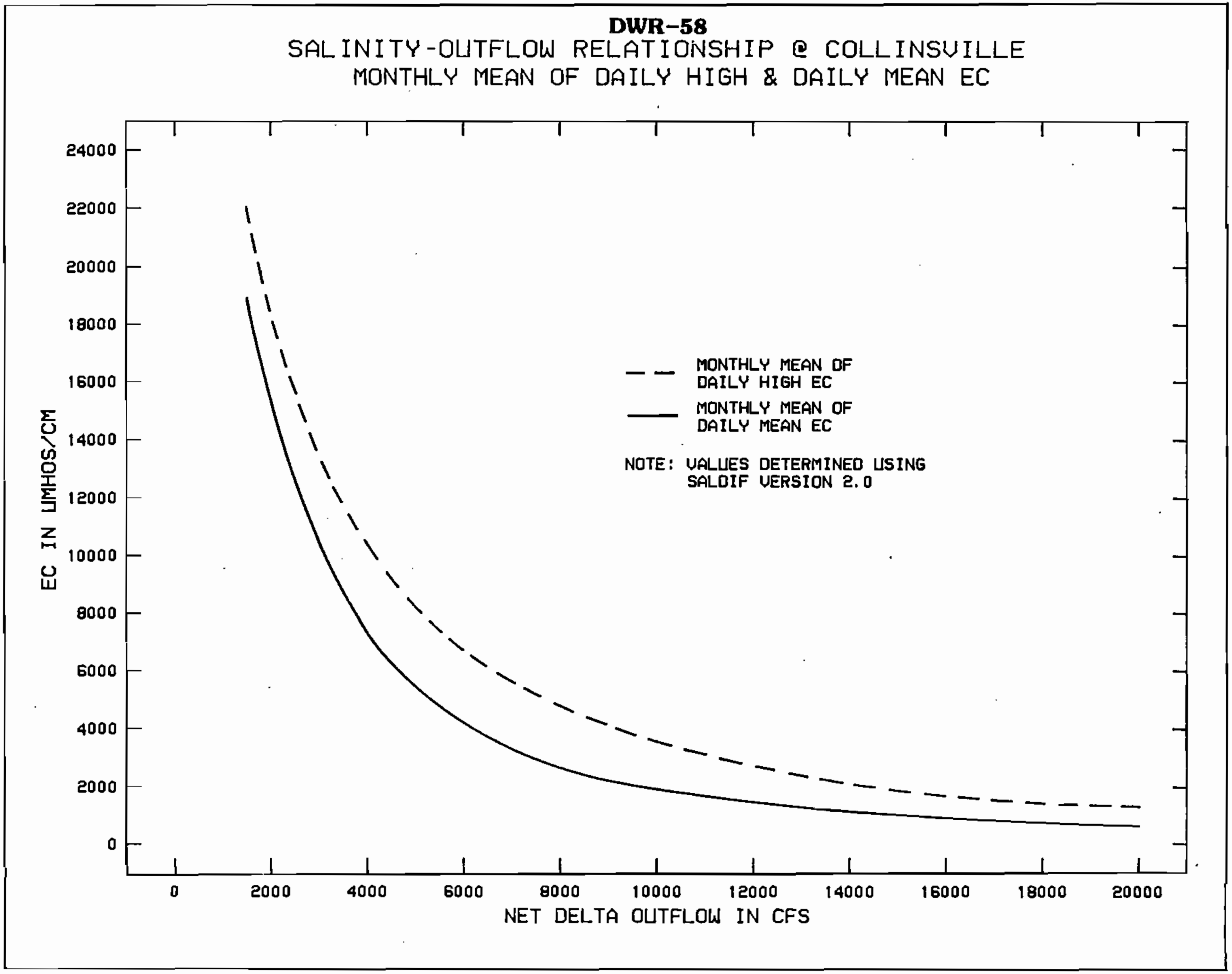
3.5.3 Unimpaired Flow Conditions

The State Water Contractors (SWC) estimated the average monthly Delta outflow under natural flow conditions (Case A & B) and compared these to DWR's estimated unimpaired and 1990 level of development outflows (Figure 3.5.3-1) (DWR,30,26;SWC,353,1). Compared to DWR's unimpaired flow, the Delta outflow that the SWC estimated to be natural is smaller due to the consumptive use by vegetation of natural marshes and riparian areas, and also due to the absence of existing man-made levees. David R. Dawdy also estimated the average monthly Delta outflow under natural flow conditions and arrived at values somewhat higher than the SWC estimate (DAWDY,3,5). The difference between these estimates results mainly from different estimates of tule acreage, which in turn causes different amounts of consumptive use via plant evapotranspiration. DWR's estimate of unimpaired Delta outflow (DWR,36,3) differs from the SWRCB's estimate (SWRCB,3,M-2) primarily due to different estimates of Delta consumptive use under unimpaired conditions.

This Plan uses the unimpaired Delta inflows developed by both SWRCB and DWR to estimate unimpaired flows and salinities within the Estuary (SWRCB,3-5).

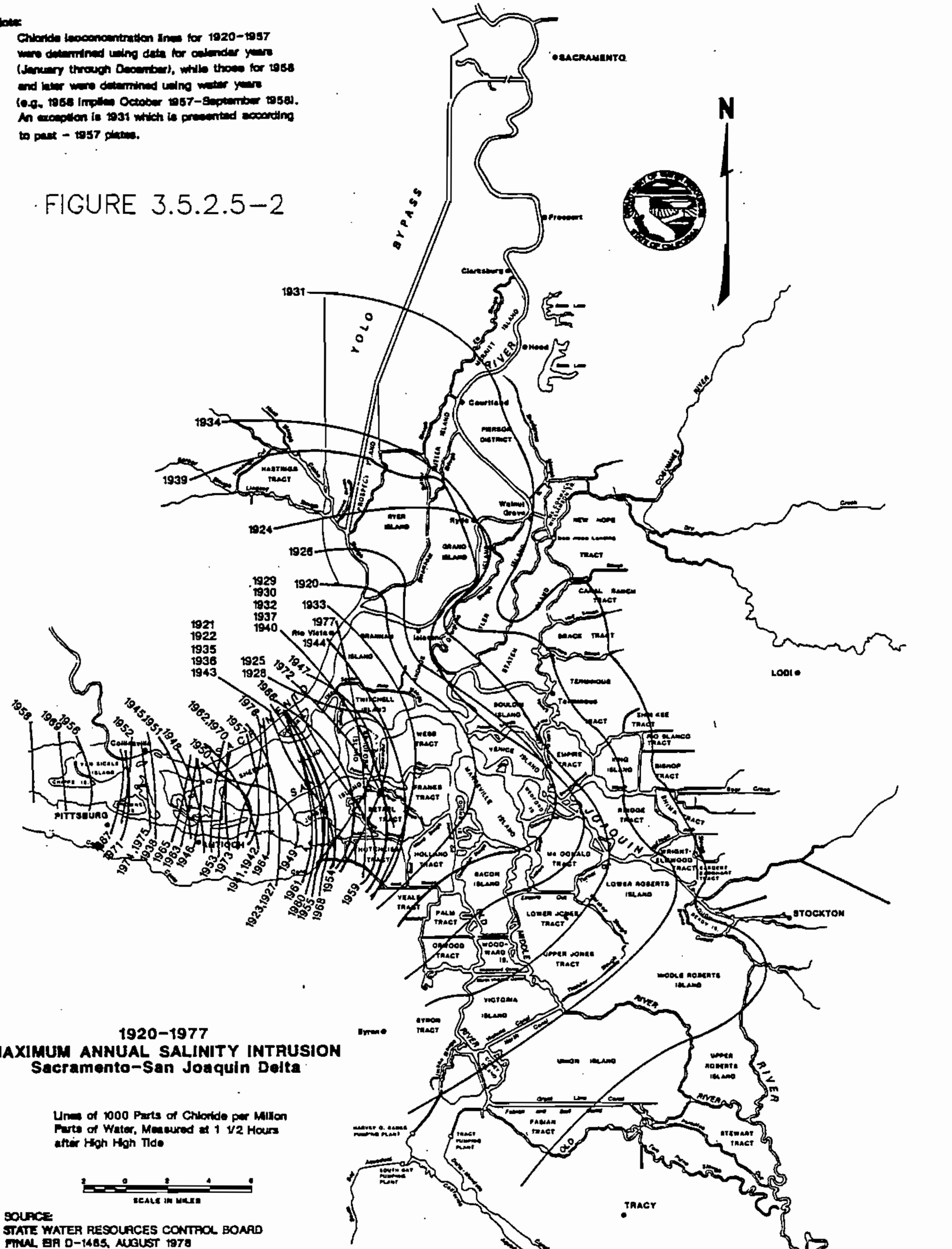
1/ In terms of EC at Collinsville in the western Delta. Historically, the salinity of waterways in the Delta has been expressed in chloride (Cl) or total dissolved solids (TDS) concentrations, and, more recently, in electrical conductivity (EC). However, sometimes it is necessary to convert one unit of salinity to another. Consequently, DWR has developed "Unit Conversion Equations" which are used to convert any one of the parameters to any of the others at various locations in the Delta using specific formulas for geographic location and water year type (DWR,61,1).

FIGURE 3.5.2.5-1



Note:
Chloride isoconcentration lines for 1920–1957 were determined using data for calendar years (January through December), while those for 1958 and later were determined using water years (e.g., 1958 implies October 1957–September 1958). An exception is 1931 which is presented according to past – 1957 plates.

FIGURE 3.5.2.5–2



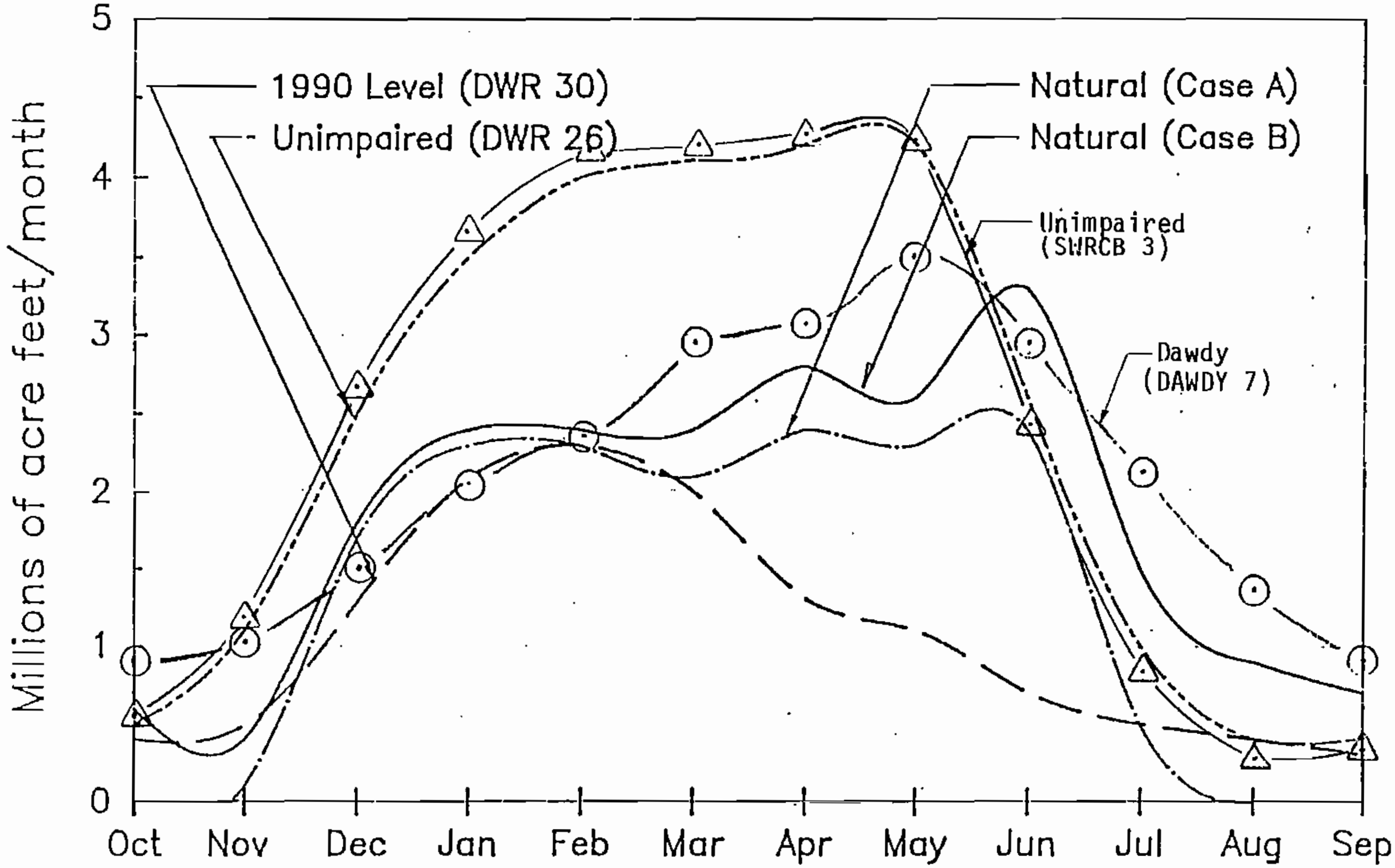
1920–1977
MAXIMUM ANNUAL SALINITY INTRUSION
Sacramento–San Joaquin Delta

Lines of 1000 Parts of Chloride per Million Parts of Water, Measured at 1 1/2 Hours after High High Tide

SOURCE:
STATE WATER RESOURCES CONTROL BOARD
FINAL EIR D–1485, AUGUST 1978

FIGURE 3.5.3-1

Average Monthly Delta Outflow



(From SWC 353)

	DWR Unimpaired	SWRCB Unimpaired	SWC Natural	DAWDY Natural	DWR 1990 L.O.D.
ANNUAL FLOW (MAF/YR)	28	28	16-22	25	14

3.5.4 Current Flow Conditions

The Delta Plan currently requires the CVP and SWP to meet specified flow and salinity standards within the Delta and Suisun Marsh (SWRCB,15,5). Figures 3.5.4-1 through -3, and Table 3.5.4-1 compare unimpaired Delta outflows with minimum outflow requirements set by the Delta Plan objectives (DWR,1986,1). DWR has established (Table 3.5.4-2) the minimum outflow requirements to meet The Delta Plan objectives (DWR,1986,1). In some months such as August, Delta Plan flow requirements can actually be above the unimpaired amounts available(Figure 3.5.4-1).

TABLE 3.5.4-1
TOTAL ANNUAL DELTA OUTFLOWS:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS
BY WATER YEAR TYPE 1/

	Unimpaired Flow (TAF) 2/		Current Flow 3/	
Water Year Type	Low	High	Low	High
Wet	29,441	56,686	16,034	34,715
Above Normal	22,997	32,368	6,554	16,145
Below Normal	18,428	26,110	4,684	11,021
Dry	15,334	18,133	4,785	8,707
Critical	5,793	13,279	3,273	4,848

1/ Assuming 1922 through 1978 hydrology.
2/ Thousands of acre-feet.
3/ Delta Plan requirements.

3.6 San Francisco Bay and Basin – includes Suisun Marsh

3.6.1 Physical Description: San Francisco Bay

The boundary of San Francisco Bay (SWRCB,3,3) extends from the Golden Gate Bridge on the west to the Delta on the east and includes:areas subject to tidal action up to mean high tide, areas 100 feet landward of the mean high tide shoreline, saltponds, and managed wetlands.

This definition includes the entire Suisun Marsh as part of San Francisco Bay. Suisun Marsh, as defined by Section 29101 of the Public Resources Code, includes the waterways north of Suisun, Grizzly, and Honker bays which are subject to tidal action and the adjacent lands whose management is dependent on tidal action of these waters. This definition generally follows the San Francisco Bay Conservation and Development Commission (BCDC) boundary as defined in Government Code Sections 66610 and 66611.

TABLE 3.5.4-2

ESTIMATED DELTA OUTFLOW REQUIREMENTS OF THE 1978 DELTA PLAN

Time Period	Delta Outflow Requirements in cfs (acre-feet)									
	Wet		Above Normal		Below Normal		Dry		Critical	
	Lower Requirements	Upper Requirements	Lower Requirements	Upper Requirements	Lower Requirements	Upper Requirements	Lower Requirements	Upper Requirements	Lower Requirements	Upper Requirements
January	4,500[2] (276,700)	6,600[1] (405,800)	4,500[2] (276,700)	6,600[1] (405,800)	4,500[2] (276,700)	6,600[1] (405,800)	4,500[2] (276,700)	6,600[1] (405,800)	4,500[2] (276,700)	6,600[1] (405,800)
February	10,000 (555,400)	10,000 (555,400)	4,500[2] (249,900)	12,000 (666,500)	4,500[2] (249,900)	12,000 (666,500)	4,500[2] (249,900)	6,600[1] (366,600)	4,500[2] (249,900)	6,600[1] (366,600)
March 1-17	10,000 (337,200)	10,000 (337,200)	4,500[2] (151,700)	12,000 (404,600)	4,500[2] (151,700)	12,000 (404,600)	4,500[2] (151,700)	6,600[1] (222,500)	4,500[2] (151,700)	6,600[1] (222,500)
March 18-31	10,000 (277,700)	10,000 (277,700)	4,500[2] (125,000)	12,000 (333,200)	4,500[2] (125,000)	12,000 (333,200)	4,500[2] (125,000)	6,600[1] (183,300)	4,500[2] (125,000)	6,600[1] (183,300)
April	10,000 (595,000)	10,000 (595,000)	7,600 (452,200)	7,600 (452,200)	7,600 (452,200)	7,600 (452,200)	7,600 (452,200)	7,600 (452,200)	4,500[3] (267,800)	6,700[3] (398,700)
May 1-5	10,000 (99,200)	10,000 (99,200)	7,600 (75,400)	7,600 (75,400)	7,600 (75,400)	7,600 (75,400)	7,600 (75,400)	7,600 (75,400)	4,500[3] (44,600)	6,700[3] (66,400)
May 6-31	7,600 (391,900)	14,000[4] (722,000)	7,600 (391,900)	14,000[4] (722,000)	7,600 (391,900)	11,400[4] (587,900)	7,600 (391,900)	7,600 (391,900)	3,900 (201,100)	3,900 (201,100)
June 1-15	7,600 (226,100)	14,000[4] (416,500)	7,600 (226,100)	10,700[4] (318,400)	7,600 (226,100)	9,500[4] (282,600)	7,600 (226,100)	7,600 (226,100)	3,900 (116,000)	3,900 (116,000)
June 16-20	7,600 (75,400)	14,000[4] (138,800)	7,600 (75,400)	10,700[4] (106,100)	7,600 (75,400)	9,500[4] (94,200)	4,700 (46,600)	4,700 (46,600)	3,900 (38,700)	3,900 (38,700)
June 21-30	7,600 (150,700)	14,000[4] (227,700)	7,500 (150,700)	10,700[4] (212,200)	5,400 (107,100)	9,500[4] (188,400)	4,700 (93,200)	4,700 (93,200)	3,900 (77,400)	3,900 (77,400)
July	7,600 (467,300)	10,000[4] (614,900)	6,700 (412,000)	7,700[4] (473,500)	5,400 (332,000)	6,500[4] (399,700)	4,700 (289,000)	4,700 (289,000)	3,900 (239,800)	3,900 (239,800)
August 1-15	7,600 (226,100)	7,600 (226,100)	6,700 (199,300)	6,700 (199,300)	5,400 (160,700)	5,400 (160,700)	4,700 (139,800)	4,700 (139,800)	3,900 (116,000)	3,900 (116,000)
August 16-31	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)	2,500 (79,300)
September	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)	2,500 (148,800)
October	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	3,500[5] (215,200)	4,500 (276,700)	3,500[5] (215,200)	4,500 (276,700)
November	4,500 (267,800)	4,500 (267,800)	4,500 (267,800)	4,500 (267,800)	4,500 (267,800)	4,500 (267,800)	3,500[5] (208,300)	4,500 (267,800)	3,500[5] (208,300)	4,500 (267,800)
December	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	4,500 (276,700)	3,500[5] (215,200)	4,500 (276,700)	3,500[5] (215,200)	4,500 (276,700)
Total in 1000s acre-feet	4,728	5,666	3,836	5,418	3,673	5,100	3,384	3,942	2,772	3,482

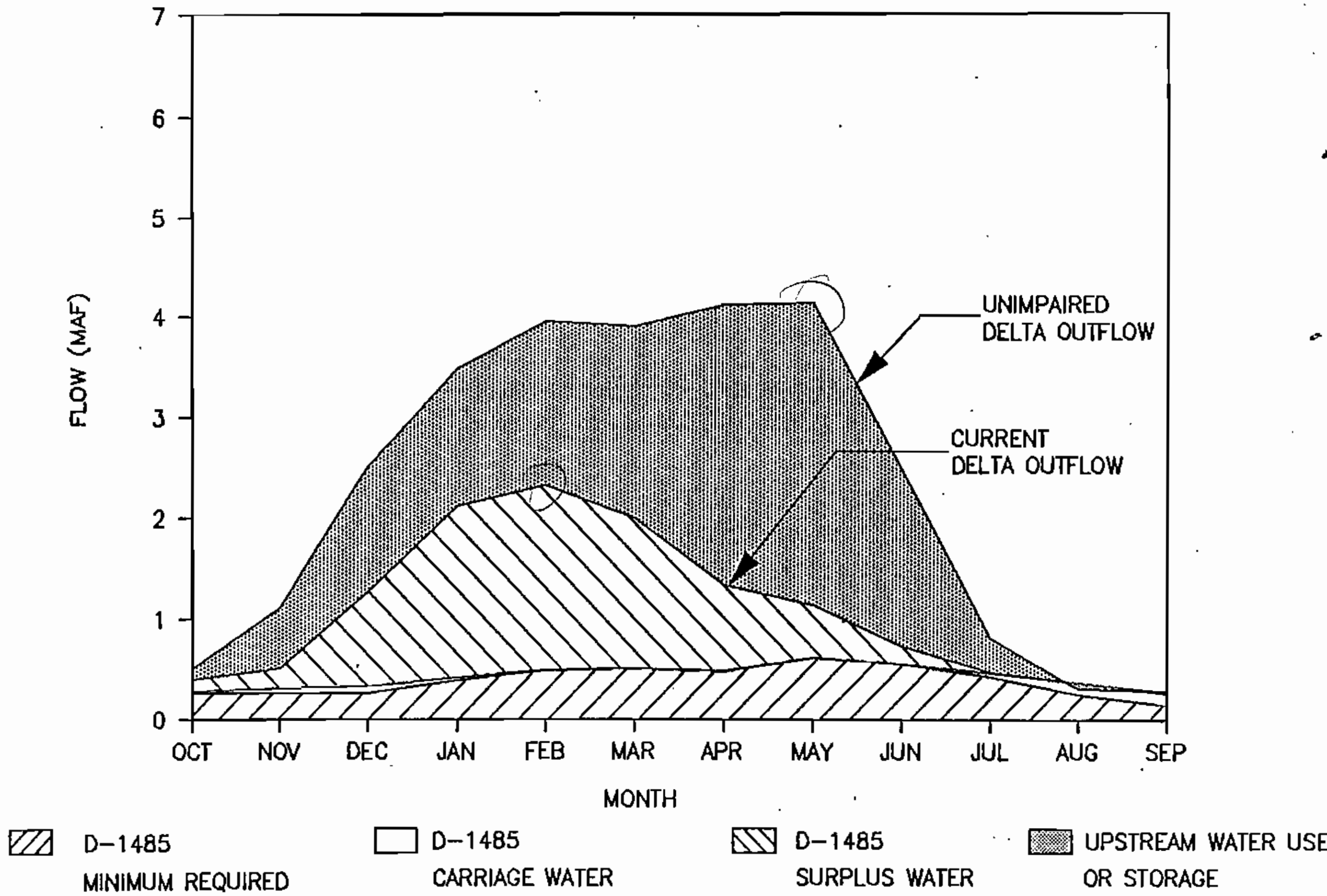
1 When the storages at any two of Shasta, Oroville and Folsom Reservoirs are encroached in their flood control reservation.
2 If storages are encroached (see No. 1) then 6,600.
3 If SWP and CVP users are taking deficiencies in firm supplies then 4,500 cfs for critical year.
4 If subnormal snowmelt then use lower limit.
5 When project users (CVP and SWP) are taking deficiencies, otherwise 4,500 cfs.

Department of Water Resources
Division of Operations and Maintenance
March 1986

FIGURE 3.5.4-1

CURRENT AND UNIMPAIRED DELTA OUTFLOW

USING 1922-1978 MONTHLY AVERAGE HYDROLOGY



- Unimpaired Flow hydrograph peaks in May
- Current Delta Outflow peaks in February!

FIGURE 3.5.4–2

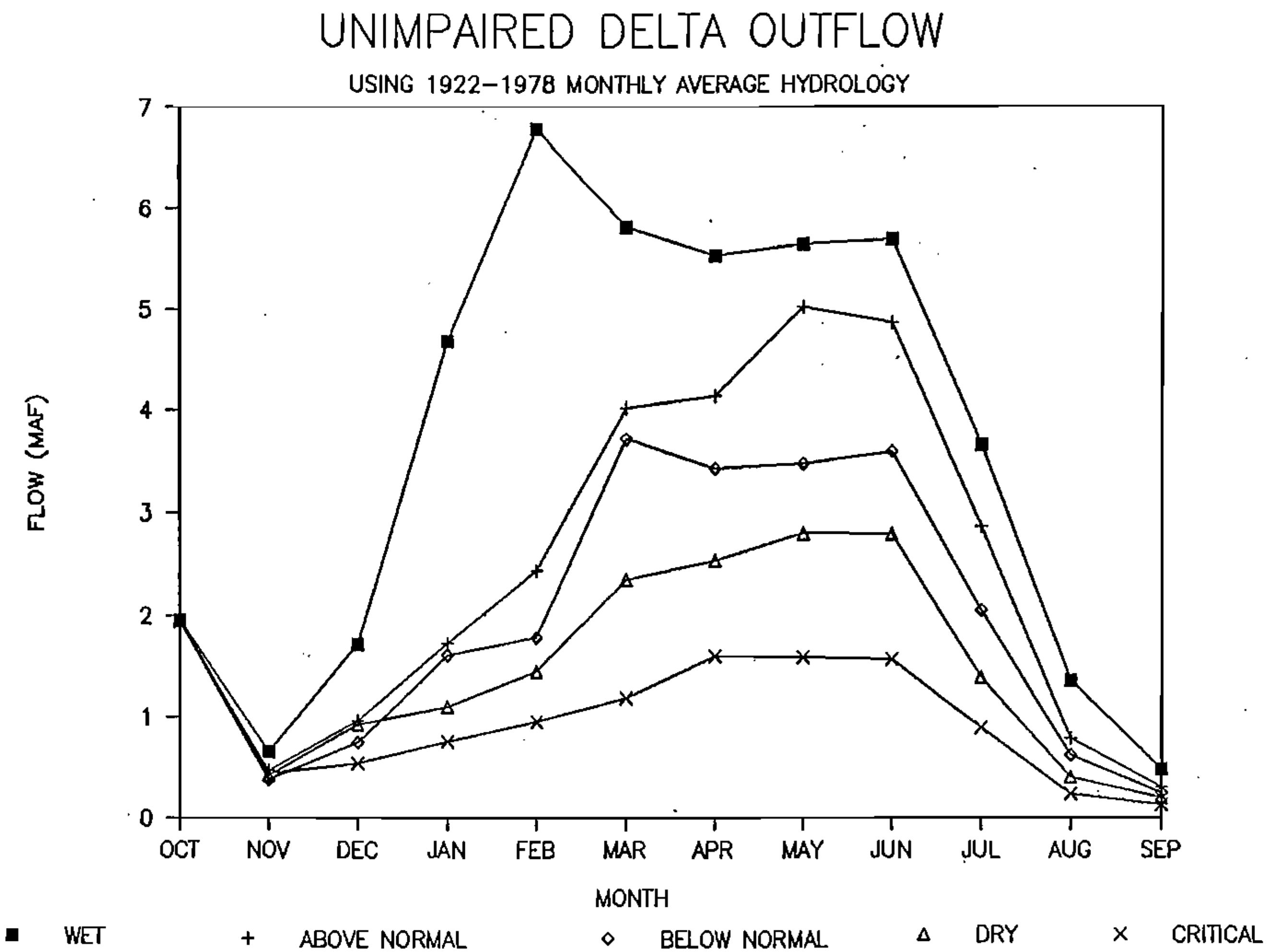
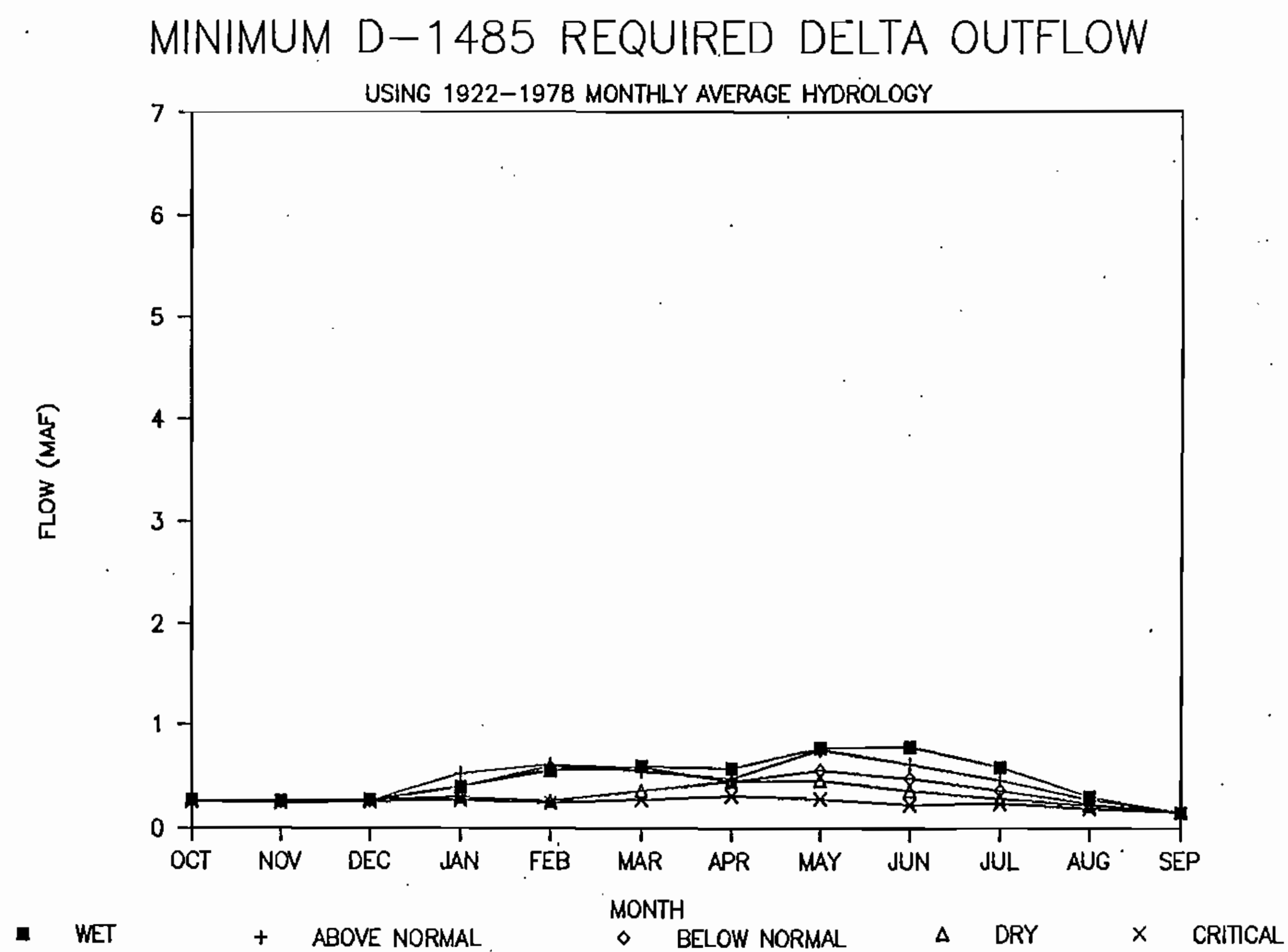

UNIMPAIRED DELTA OUTFLOW
USING 1922–1978 MONTHLY AVERAGE HYDROLOGY
FLOW (MAF)
7
6
5
4
3
2
1
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
MONTH
WET
ABOVE NORMAL
BELOW NORMAL
DRY
CRITICAL

FIGURE 3.5.4-3


MINIMUM D-1485 REQUIRED DELTA OUTFLOW
USING 1922-1978 MONTHLY AVERAGE HYDROLOGY
FLOW (MAF)
0
1
2
3
4
5
6
7
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
MONTH
WET
ABOVE NORMAL
BELOW NORMAL
DRY
CRITICAL

San Francisco Bay consists of about 805 square miles (515,000 acres) (BCDC,1982) including: 420 square miles (269,000 acres) of open water, 125 square miles (80,000 acres) of tidal marshes; 110 square miles (70,000 acres) of Suisun Marsh; 80 square miles (51,000 acres) of diked historic baylands, 70 square miles (45,000 acres) of saltponds and other managed wetlands.

3.6.2 Physical Description: San Francisco Bay Basin

The San Francisco Bay Basin, Figure 3.1-3, is the area contributing runoff to the Bay. This discription differs somewhat from the Basin Plan boundary of Region 2 (RWQCB,2,1975) which includes the entire San Francisco Bay Basin as well as coastal area from Dillon Beach to San Gregorio. The total area of the Basin is about 3,870 square miles, or 2,477,000 acres (SWRCB,3,Appendix F). The major streams contributing to local runoff to the Bay are Napa, Petaluma, and Guadalupe rivers, and Alameda, Coyote, Sonoma and Walnut creeks. Water is imported to the Basin via the following water projects (see Figure 3.1-3):

water imports to SF Bay Basin

Mokelumne Aqueduct, Hetch Hetchy Aqueduct, South Bay Aqueduct, Contra Costa Canal, Putah South Canal, Sonoma Petaluma Aqueducts, North Bay Aqueduct (begun in 1988), and City of Vallejo intake at Cache Slough (ended when the North Bay Aqueduct began operation).

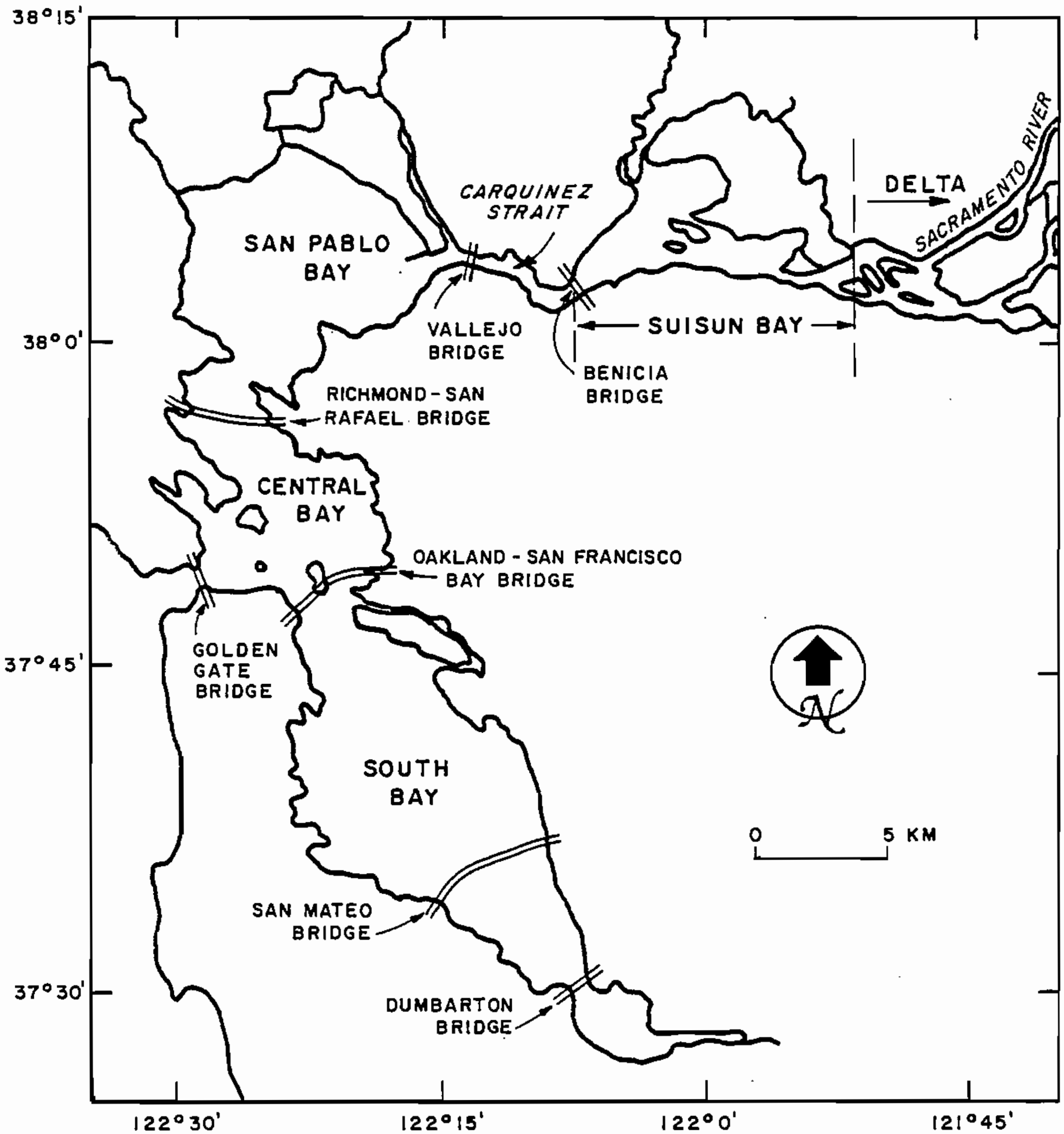
In years of normal runoff, the San Francisco Bay Basin contributes about ten percent of the total runoff to the Estuary (SWRCB,3,3). From 1970 to 1982, rainfall discharge averaged about 57 percent of the total runoff from the Bay Basin, with the rest being municipal and industrial discharges (SWRCB,3, Appendix R and 35).

3.6.3 Hydrology: San Francisco Bay

San Francisco Bay, excluding the Delta, but including saturated mudflats, has a total water surface area of approximately 300,000 acres or 470 square miles at mean lower low water (MLLW). The area, mean depth and volume of the subregions of the Bay are summarized in Table 3.6.2.1-1 (Cheng and Garner, 1984). The locations of the Bay's subregions are shown in Figure 3.6.2.1-1.

San Francisco Bay is unique among American estuaries in having two arms or reaches, the northern reach including San Pablo and Suisun bays, and the southern reach extending from the Oakland-Bay Bridge to Mountain View. The northern reach receives discharge from the Sacramento-San Joaquin Delta, approximately 90 percent of the freshwater inflow to San Francisco Bay. The southern reach receives only local runoff and is considered a tributary estuary. Between the two reaches is the central Bay bounded by the Richmond-San Rafael, Oakland-Bay, and Golden Gate bridges. The central Bay is deeper either of the two reaches, is more ocean-like in character and provides most of the inflow to the South Bay (SWRCB,431,18-19).

FIGURE 3.6.2.1-1 Location map of San Francisco Bay showing the four sub-regions and the Sacramento-San Joaquin Delta.
(Source: Denton and Hunt, 1986)



- Freshwater Inflow

  Excluding water from the Delta, freshwater inflows come into the Bay primarily via the Napa and Petaluma rivers which provide local drainage to the northern part of San Pablo Bay; via Walnut Creek and Suisun Slough which enter Suisun Bay; Pinole and Novato creeks which enter the San Pablo Bay; and San Lorenzo, Matadero and Coyote creeks which enter the south Bay. In addition, there are many municipal and industrial wastewater treatment plants and combined sewer overflows that contribute to inflows (SWRCB,3,11-16). Because these freshwater inflows into the Bay are small compared to Delta outflow, they are often ignored in calculations of total inflow to the Bay. In the southern portion of the south Bay, all tributary streams have intermittent, local runoff (excluding effluent) (BISF,6, 56-59).

- Tidal Exchange

  Immense flows are exchanged between the bay and the ocean on tidal currents driven by the gravitational attraction between the earth, the sun and moon. Their exact size is not known (USGS,3 updated,5), but tidal flows entering San Francisco Bay at the Golden Gate Bridge have been estimated to average greater than 2.5 million cfs (BISF,6,51). Because of complex circulation eddies outside the entrance to the Bay, only a portion of the water flooding in from the ocean is "new" water, i.e., water which has not entered the Bay for at least several tidal cycles (Denton and Hunt, 1986).

  - Central Bay

    Flood tides first entering the central Bay pass on either side of Alcatraz Island, through Raccoon Strait between the Tiburon Peninsula and Angel Island; tides then flow northwards through San Pablo Strait into San Pablo Bay and southwards beneath the Oakland-Bay Bridge into south Bay (Figure 3.6.2.1-2).

  - San Pablo Bay

    The main tidal flows in San Pablo Bay pass along a natural channel between San Pablo Strait, across the shallow Pinole Shoal and through Carquinez Strait to the east (Figure 3.6.2. 1-3). The maximum depth in the two straits is about 83 feet, decreasing to about 20-25 feet over Pinole Shoal. A 600 foot wide shipping channel, dredged to a depth of 35 feet, across the shallow Pinole Shoal provides shipping access to the Mare Island Naval Shipyard and the ports of Sacramento and Stockton. The areas north and south of the shipping channel are very shallow; one half of the area of San Pablo Bay, for example, has a depth of less than six feet.

Table 3.6.2.1-1
BATHYMETRIC DATA FOR SAN FRANCISCO BAY
(Adapted from Cheng and Gardner, 1984)

Region	Surface Area at MLLW[1/] (sq mi)	Mean Depth[2/] (ft)	Mean Volume (AF)
Central Bay	103	35	2,307,000
San Pablo Bay	105	9	605,000
Carquinez Strait	12	29	223,000
Suisun Bay[3/]	36	14	323,000
South Bay	214	11	1,507,000
San Francisco Bay	470	17	4,965,000

1/ Excluding the Delta but including saturated mudflats
2/ These depths do not agree with those of Section 3.6.1 because of the inclusion of saturated mudflats.

FIGURE 3.6.2.1-2 Map of the Central Bay and the region immediately outside Golden Gate. The dotted line shows the 60 ft depth contour and the dashed line is the 18 ft contour. (Source: Denton and Hunt, 1986)

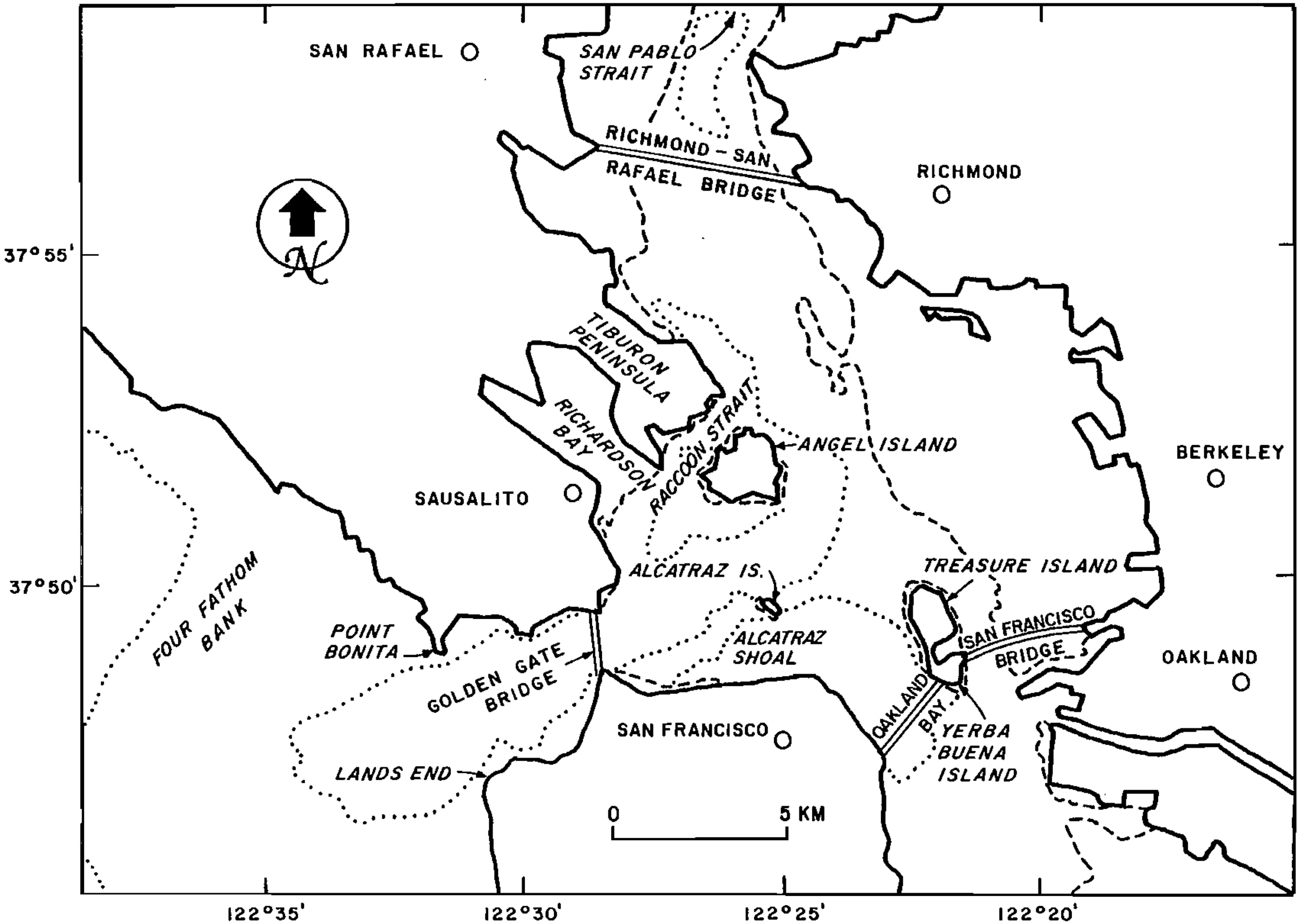
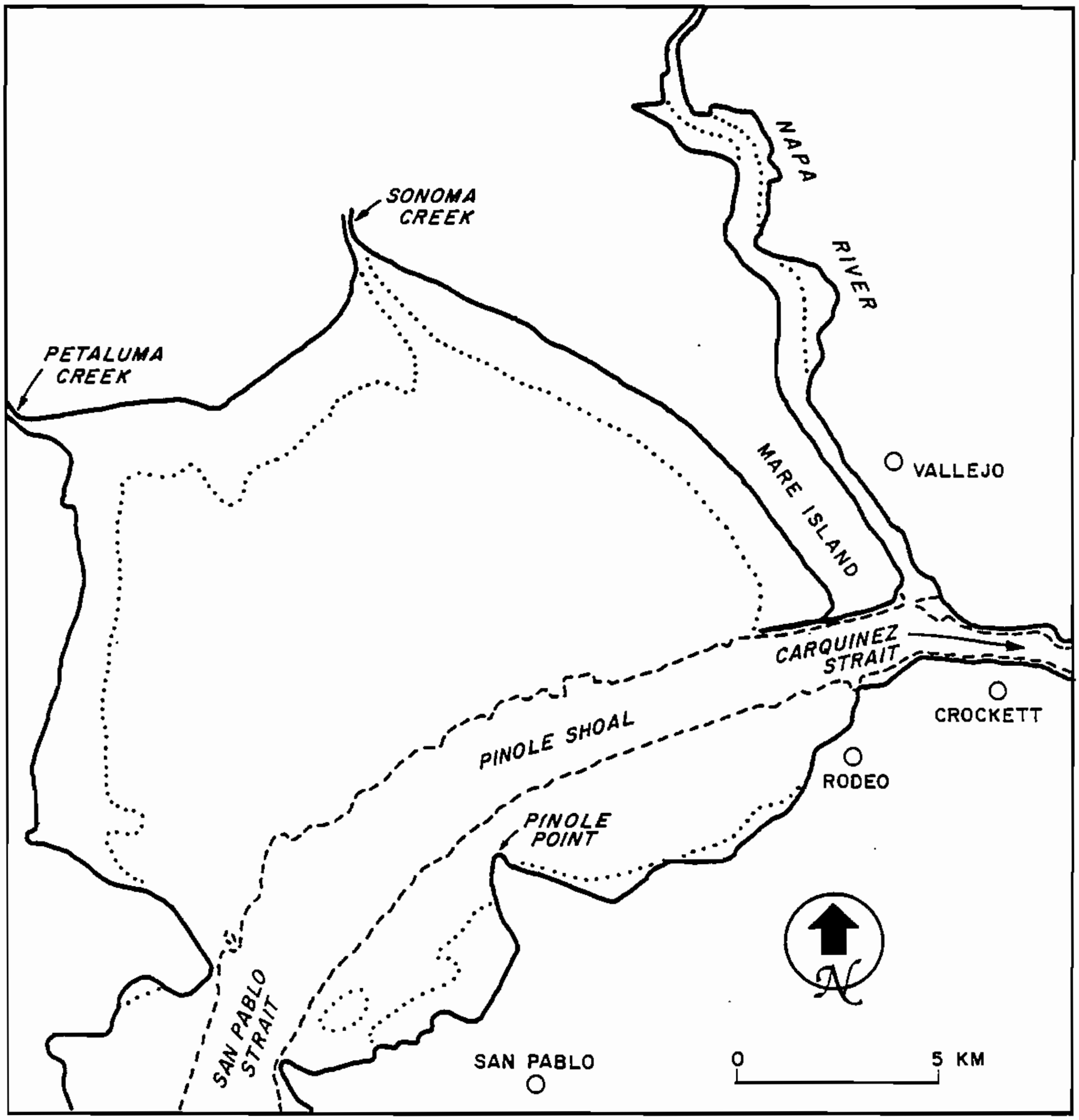


FIGURE 3.6.2.1-3 Map of San Pablo Bay. The 18 ft (5.5) depth contour is plotted as a dashed line and indicates the location of the main channel. The dotted line shows the extent of the mudflats around the bay.
(Source: Denton and Hunt, 1986



- Suisun Bay and Marsh

Having the smallest surface area of the four embayments, Suisun Bay is situated in the northeastern reach of San Francisco Bay between the cities of Benicia and Antioch (Figure 3.6.2.1-4). The entire Suisun Bay and Marsh area, including two subbays, Grizzly and Honker, consists of 84,190 acres, of which about 26,880 acres are bays and sloughs. The remaining 57,310 acres are diked and managed wetlands. (Approximately 45,710 acres of managed wetlands are privately owned and used primarily for duck hunting; 10,490 acres are owned by the State of California as a waterfowl management area, wildlife refuge and public recreation area; and 1,110 acres are controlled by the U.S. Navy {SWRCB,1978}).

null zone in Suisun Bay

The main tidal flows are along a few well-defined channels separated by islands and shallow gravel banks. During most periods of outflow from the Delta, Suisun Bay is the location of the estuary's 'null zone' (defined as the region in a partially or well-mixed estuary where the residual bottom currents are effectively zero). Upstream of this area there is a net downstream, or seaward, residual velocity along the bottom caused by river inflow. Seaward of the null zone, gravitational circulation produces a transport, for the most part toward land, of denser more saline water along the bottom. The null zone is significant because it is the theoretical upstream boundary of the entrapment zone, the area in the estuary where suspended materials, including biota, accumulate (USBR,112,407). Figure 3.6.2.1-5, a diagram of estuarine circulation for a partially mixed estuary such as Suisun Bay, illustrates the relationships between flows, salinities, and the null and entrapment zones (CCCWA/EDF,1,56).

The salinity of water within Suisun Bay varies seasonally with the freshwater outflow from the Delta. Salinities of the water in Montezuma Slough are lower than in Suisun Bay itself for a longer period of time each year because Slough lies further upstream and receives freshwater inflow from the Sacramento River and other tributary channels first. For the most part, low salinity water stays in the Suisun Marsh channels later in the spring and in early summer, but higher salinity water remains later in the fall before the Marsh channels are flushed by increasing Delta outflows (SWRCB,1978).

By most definitions, Suisun Bay includes Suisun Marsh, located to the north of the main body of the Bay. The Marsh was a natural brackish water marsh prior to widespread reclamation for agricultural purposes in the early 1900's. However, because the agricultural developments were largely unsuccessful in the 1930's, the reclaimed marsh lands were gradually converted to private duck clubs and state Wildlife Management Areas.

FIGURE 3.6.2.1-4 Map of Suisun Bay. The dashed line shows the 18 ft (5.5) depth contour.
(Source: Denton and Hunt, 1986)

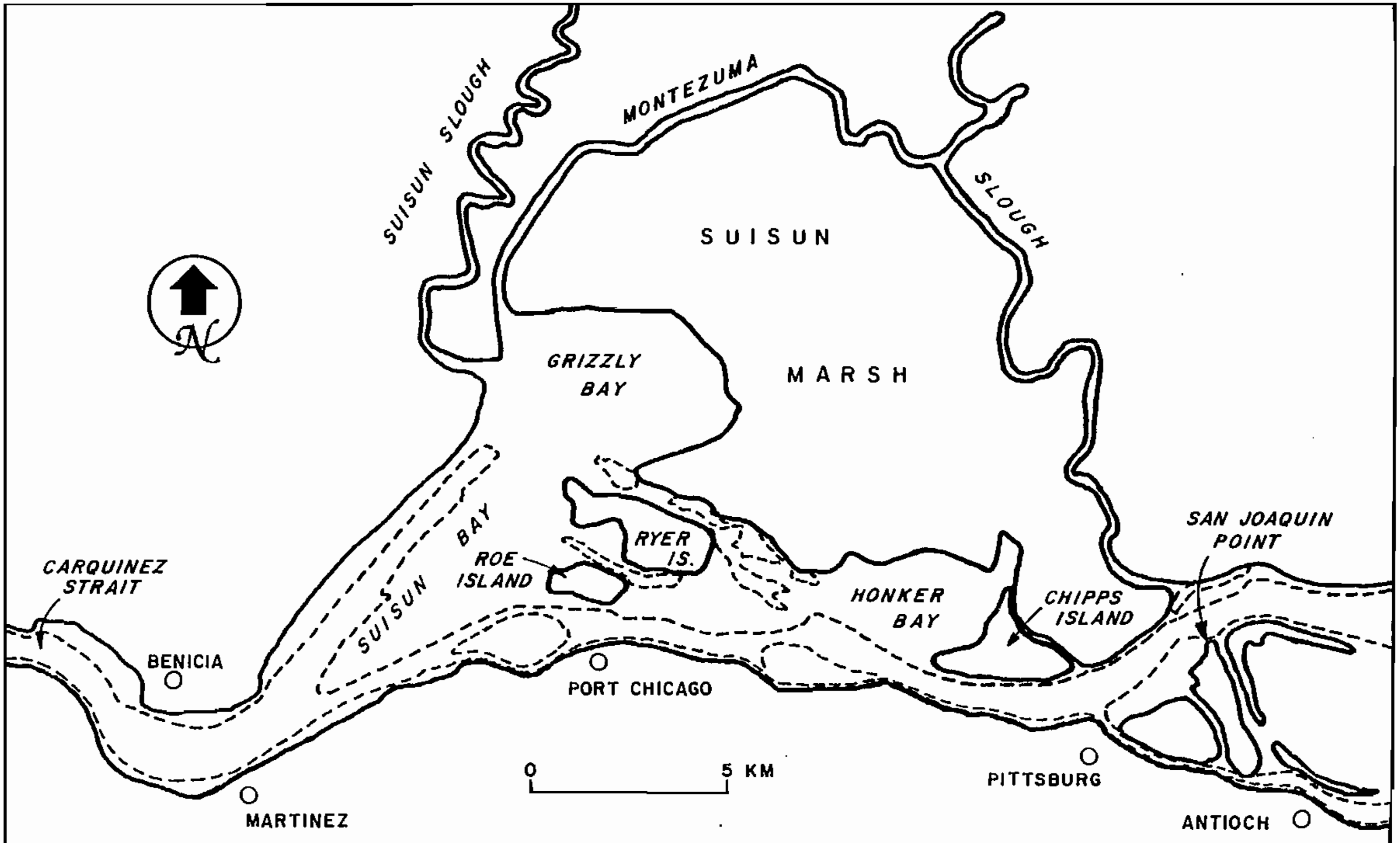
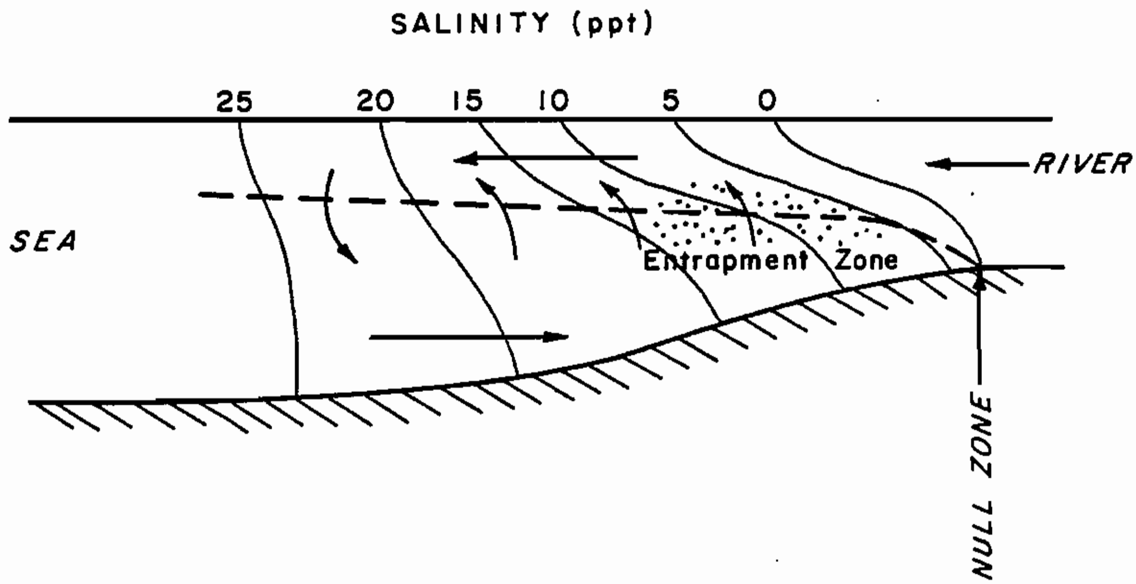


FIGURE 3.6.2.1-5 Diagram of Estuarine Circulation for a Partially Mixed Estuary
(Source: CCCWA/EDF, 1, Figure 12)



- South Bay

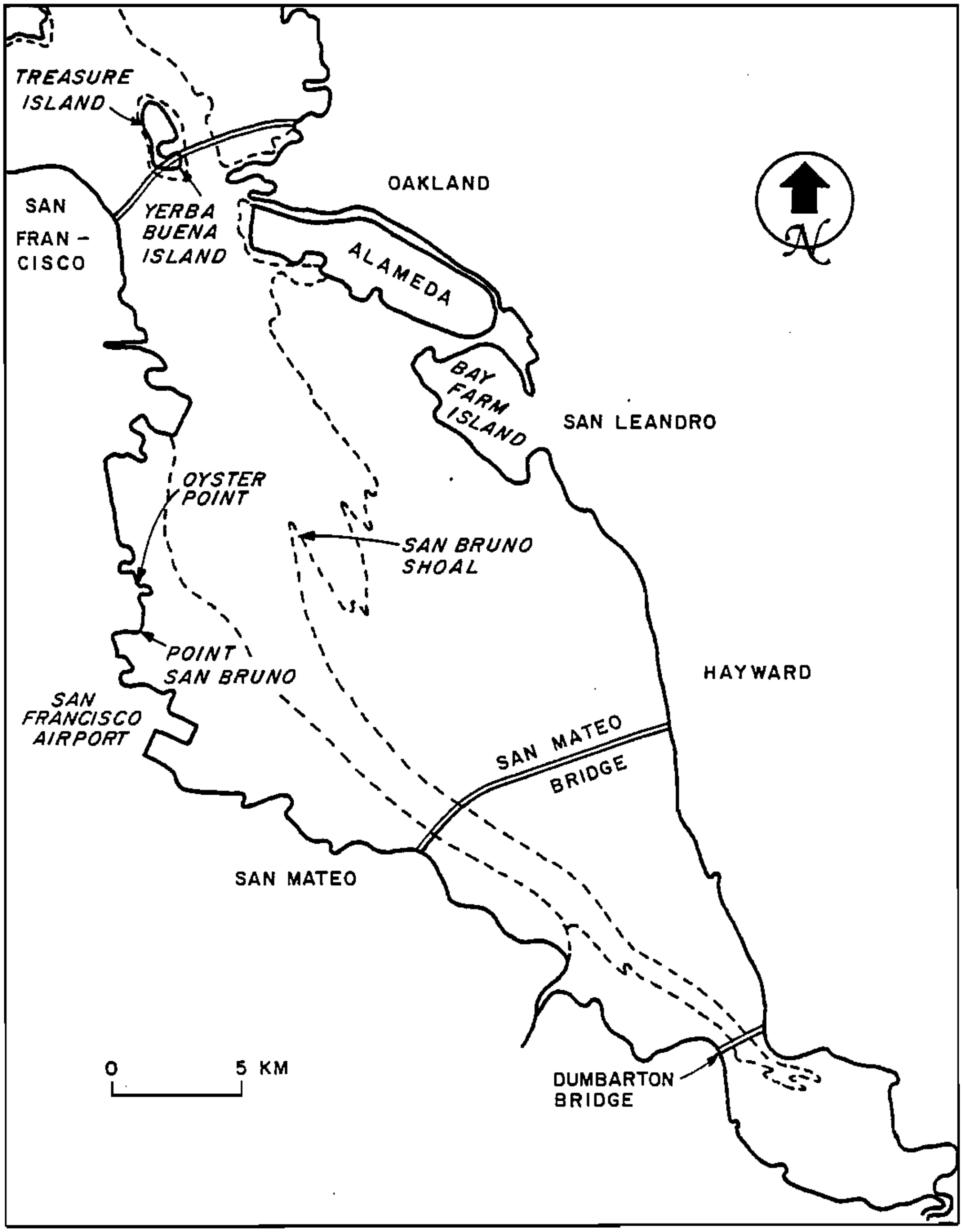
  The entrance to the south Bay from the central Bay is separated by Treasure and Yerba Buena islands into two passages, one to the east that is 30 to 35 feet deep and one to the west that is 70 feet deep at the Oakland-San Francisco Bay Bridge (Figure 3.6.2.1-6). Because the south Bay receives only minor amounts of local freshwater inflows, it is essentially a tidal lagoon. Tidal currents in south Bay are greatest along the main channel on the western side of the Bay. In the south Bay, evidence suggests three distinct mixing zones exist between: (1) the Oakland-San Francisco Bay Bridge and San Bruno Shoal, a relatively shallow area with water depths of about 11 to 26 feet between Bay Farm Island and Oyster Point; (2) San Bruno Shoal and the San Mateo Bridge; and (3) the area south of the San Mateo Bridge. A 500 foot wide, 29 feet deep navigation channel is maintained across the San Bruno Shoal. The salinity of the south Bay remains close to the level of the ocean (33 to 35 parts per thousand) throughout most of the year, except during periods of high Delta outflow. During particularly hot, dry periods when evaporation rates are high, the south Bay can act as a negative estuary where salinity levels actually increase in the southern extremities (Denton and Hunt, 1986).

  Currents differ in the south Bay according to Delta outflows. From analyses of current data for summer wind conditions and low Delta discharges, the USGS has concluded that net currents in south Bay north of San Bruno Shoal are southward along the eastern side and northward along the western side of the Bay (USGS,3 updated,25). During the season of high Delta outflows,a lens of fresher water can form on the surface of the northern reach of San Francisco Bay. This lens of fresher water eventually spreads southwards into the central and south Bays over more saline water that is flowing toward the ocean. This process, which provides the major source of freshwater for the South Bay, is known as gravitational overturn (Denton and Hunt, 1986). The significant density difference between the two flows acts to inhibit vertical mixing. When Delta outflow subsides, reintrusion of ocean water raises the salinities in central Bay above those in south Bay, and the direction of circulation reverses; that is, surface waters again flow seaward (USGS,3 updated,26).

3.6.4 Hydrology: San Francisco Bay Basin

In the San Francisco Bay Basin, most precipitation comes as rainfall that flows directly to the Bay, with some loss due to infiltration, evapotranspiration, and storage in natural impoundments. The timing and volume of inflows to the Bay from local runoff, for the most part, follow closely after precipitation in the Bay Basin.

FIGURE 3.6.2.1-6 Map of the South Bay. The dashed line shows the 18 ft. depth contour. (Source: Denton and Hunt, 1986)



3.6.5 Unimpaired Flow Conditions: San Francisco Bay

Throughout this section, the San Francisco Bay and San Francisco Bay Basin are described separately. Before this section, both a river and its basin are considered together, as integral parts of an area's total description. This is not the case with the Bay and its Basin. Whereas the San Francisco Bay Basin may be compared with other basins, the San Francisco Bay (the equivalent of this Basin's river) cannot be meaningfully compared with any river in the Estuary. There have been no sizeable impoundments or diversions of San Francisco Bay waters. Unimpaired inflows to the Bay from the San Francisco Bay Basin are small when compared to the volume of tidal exchange (see Table 3.6.3.2-1, Figures 3.6.3.2-1 and -2). Existent tidal and seasonal flows from the Pacific Ocean, the Delta and the San Francisco Bay Basin therefore constitute the closest estimate of unimpaired flow conditions for the Bay.

3.6.6 Unimpaired Flow Conditions: San Francisco Bay Basin

The unimpaired runoff for separate hydrologic areas in the Bay Basin was simulated by SWRCB for the period of water years 1921 through 1978 (SWRCB,3,Appendix F). Unimpaired flow to the Bay Basin includes local inflows but does not include inflow from the Delta. Table 3.6.3.2-1 includes estimated monthly and annual runoff values for the years 1921 through 1978 (SWRCB,3,17 {revised 11/5/87}).

Figure 3.6.3.2-1 shows that average unimpaired Bay Basin local runoff is small, about 3.3 percent of average unimpaired Delta inflow to the Bay (SWRCB,3). When tidal exchanges are compared, local runoff becomes insignificant (DWR,662,1) (Figure 3.6.3.2-2). However, local inflow may have an effect on subregions within the Bay, such as the Suisun Marsh, the marshes around Cuttings Wharf west of Vallejo, and the Petaluma Creek discharge area.

3.6.7 Current Flow Conditions: San Francisco Bay

The considerations in 3.6.3.1 are also valid for current flow conditions in the Bay, with some exceptions. Upstream storage and regulated releases required by the Delta Plan, for instance, have provided higher levels of inflow from the Delta in the summer months of dry and critically dry years. Significant amounts of effluent from industrial and municipal sources are discharged into the Bay, but the total effects of these additional flows are not known.

3.6.8 Current Flow Conditions: San Francisco Bay Basin

A variety of factors—upstream reservoirs, the change in land use patterns from native vegetation to agricultural vegetation, impermeable surfaces such as concrete or asphalt, and the effects of ground water pumping--have altered the effects of Bay Basin local runoff. For example, the extensive expansion of

TABLE
3.6.3.2-1

SAN FRANCISCO BAY BASIN LOCAL INFLOW STUDY - UNIMPAIRED FLOW CONDITIONS
TOTAL MONTHLY LOCAL RUNOFF INTO SAN FRANCISCO BAY
SUMMATION OF MONTHLY LOCAL RUNOFF FROM FSA'S 90 - 96 (TAF)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	AVERAGE MONTHLY	YEARLY TOTAL
21	2.4	14.9	356.7	378.1	127.7	68.1	83.8	20.2	8.0	2.7	2.8	0.9	88.8	1066.1
22	1.6	22.5	188.8	199.3	82.5	232.5	66.0	19.4	7.6	3.9	3.6	1.4	69.1	829.1
23	1.4	17.1	288.3	355.0	137.7	82.1	80.0	17.2	6.7	2.3	2.4	2.2	82.8	993.2
24	3.4	7.6	10.3	13.4	14.3	27.7	9.9	4.3	0.9	0.1	0.1	0.1	7.7	92.0
1925	5.4	228.0	241.8	375.4	124.8	401.1	195.9	25.6	10.1	5.3	3.0	2.7	134.9	1619.0
26	1.5	8.4	83.2	86.7	267.0	241.2	45.0	14.7	4.8	2.2	0.9	0.9	63.0	756.5
27	1.7	7.5	259.2	427.5	169.9	172.0	79.4	27.2	10.1	4.5	2.2	1.7	96.9	1163.0
28	2.5	2.8	82.5	83.4	210.7	197.2	36.6	15.5	5.6	2.8	1.2	0.9	53.5	641.8
29	1.1	1.9	5.1	88.8	42.8	78.3	27.1	11.9	2.0	0.5	0.3	0.5	21.8	261.2
1930	0.3	5.4	151.9	91.4	77.7	78.4	15.4	7.0	2.5	0.8	0.2	0.2	35.9	431.3
31	1.0	6.0	21.2	104.8	24.9	100.9	39.7	11.8	2.6	0.5	0.3	0.3	26.8	322.0
32	1.3	1.1	287.9	192.9	115.0	56.8	27.2	12.0	5.2	2.3	0.9	0.5	58.6	703.2
33	0.8	9.5	36.2	27.0	96.5	94.1	30.9	7.4	4.2	1.3	1.0	1.6	25.9	310.6
34	1.0	19.2	28.5	38.0	80.9	83.1	28.2	7.0	3.4	0.7	0.5	0.7	24.3	291.2
1935	2.0	32.4	128.5	499.6	152.0	173.2	62.3	21.4	8.7	4.2	2.0	1.5	90.7	1087.9
36	0.9	18.5	285.5	368.4	89.8	56.5	63.7	15.4	5.3	2.2	1.2	1.0	75.7	908.5
37	1.8	9.5	133.8	202.2	257.9	259.1	62.7	17.1	6.0	2.6	1.1	1.1	79.6	954.9
38	6.0	1.6	508.5	631.4	584.6	160.4	83.8	28.4	8.8	3.6	1.7	1.3	168.3	2020.0
39	9.5	13.9	18.8	18.4	24.0	23.4	23.5	7.7	2.5	0.1	0.0	0.6	11.9	142.5
1940	0.4	5.5	25.0	304.1	704.4	431.0	140.5	24.7	11.1	4.7	2.6	1.6	138.0	1655.6
41	0.9	4.8	387.8	718.7	572.4	366.1	416.9	56.2	16.4	7.3	5.0	4.0	213.0	2556.5
42	1.6	27.3	326.1	400.2	639.0	200.0	209.3	44.4	15.1	7.0	3.4	2.0	156.3	1875.6
43	1.9	19.0	111.5	464.8	167.0	140.9	41.2	19.7	8.2	4.2	1.9	1.0	81.8	981.4
44	0.8	5.7	14.9	28.2	183.2	212.2	26.7	14.2	7.2	2.6	1.2	0.5	41.5	497.6
1945	2.1	30.7	86.2	69.3	294.0	136.0	42.7	17.3	7.3	4.1	2.2	1.8	57.8	693.7
46	3.4	30.5	315.9	134.0	64.0	37.2	29.8	10.6	5.1	2.0	1.2	1.6	52.9	635.3
47	0.4	9.9	32.6	8.4	87.5	99.6	32.9	7.5	3.4	0.8	0.5	0.2	23.6	283.5
48	2.7	4.3	5.7	54.2	14.7	83.9	192.9	49.9	13.0	3.4	1.5	0.7	35.6	427.0
49	0.2	4.8	19.5	17.6	37.8	126.0	11.5	4.1	1.0	0.6	0.4	0.2	18.6	223.7
1950	1.9	1.8	2.3	117.8	215.7	55.1	30.0	10.1	3.9	0.9	0.6	0.3	36.7	440.5
51	1.9	113.4	407.7	376.0	219.1	172.2	41.4	23.6	8.1	3.9	2.0	1.4	114.3	1371.5
52	7.1	16.5	348.0	822.0	300.4	208.9	114.7	28.9	10.7	4.7	2.0	1.3	162.2	1946.1
53	1.2	2.6	333.9	438.0	43.8	82.4	40.2	25.1	9.1	3.2	1.6	1.1	81.7	980.2
54	0.9	3.4	4.7	114.9	135.5	93.0	75.3	10.6	3.3	1.0	0.6	1.6	37.3	447.7
1955	0.5	24.7	64.0	103.8	55.5	31.6	46.4	19.4	4.9	1.1	0.3	0.1	29.4	352.3
56	0.0	0.6	713.5	647.8	460.3	83.5	29.2	19.1	5.5	3.1	1.0	0.6	163.6	1963.4
57	5.5	5.4	4.9	26.7	195.1	118.7	33.6	61.8	13.1	2.3	0.7	0.5	39.0	468.4
58	13.7	8.9	54.4	276.0	910.2	424.0	570.9	35.1	14.6	5.6	2.2	1.2	193.1	2316.8
59	0.9	1.6	2.7	69.6	230.3	35.1	12.6	4.6	0.8	0.1	0.0	1.3	30.0	359.6
1960	0.3	0.4	1.4	16.6	222.5	85.8	18.0	6.5	1.8	0.4	0.1	0.2	29.5	354.1
61	0.4	6.8	22.5	64.9	128.4	99.3	34.7	11.5	3.3	0.5	0.3	0.4	31.1	373.0
62	0.1	3.1	19.2	17.6	312.3	149.3	18.7	6.2	1.7	0.6	0.4	0.1	44.1	529.4
63	234.5	13.5	111.9	364.3	411.4	171.6	369.3	54.2	16.7	5.7	3.8	2.3	146.6	1759.1
64	2.7	59.9	15.0	146.3	24.8	18.2	8.3	4.3	2.0	0.4	0.3	0.3	23.5	282.4
1965	1.0	20.0	420.6	453.8	51.0	31.0	112.6	20.6	7.6	3.1	3.2	1.3	93.8	1125.9
66	0.8	20.4	58.1	226.0	94.8	31.8	13.9	6.1	2.1	0.8	0.4	0.5	38.0	455.7
67	2.1	56.2	299.9	651.6	158.5	294.1	423.5	76.9	34.0	8.2	3.6	3.2	184.3	2211.8
68	1.5	2.5	17.2	150.8	141.9	119.7	20.5	6.8	2.1	0.7	0.9	0.8	38.9	466.4
69	1.4	4.6	126.9	648.9	544.1	174.0	51.5	16.8	8.0	3.1	3.0	2.5	132.1	1585.0
1970	3.5	3.2	170.6	712.7	119.2	101.3	15.3	7.4	4.1	2.3	1.4	1.1	95.2	1142.1
71	2.5	89.2	433.9	176.4	32.7	85.6	32.5	12.9	6.5	2.7	1.6	1.3	73.2	878.8
72	0.8	3.7	42.8	40.3	68.2	27.8	15.7	6.9	2.9	1.3	0.7	1.3	17.7	212.4
73	10.2	90.9	100.1	851.1	645.3	287.4	57.5	20.6	8.1	4.1	1.9	2.1	173.3	2079.3
74	8.1	247.2	251.3	368.2	104.7	450.4	223.1	29.2	11.9	6.7	4.1	3.6	142.4	1708.5
1975	5.1	4.1	11.9	16.5	270.6	339.5	80.0	20.7	7.3	4.0	2.0	1.7	63.6	763.4
76	10.8	14.1	12.0	12.2	13.7	21.9	21.6	7.0	2.4	0.1	0.1	0.5	9.7	116.2
77	2.1	7.1	10.3	16.9	17.0	31.8	7.8	4.3	0.8	0.1	0.0	0.0	8.2	98.5
78	0.3	33.7	133.9	863.9	470.9	391.7	117.6	35.8	12.0	4.7	2.7	3.1	172.6	2071.0
AVE	6.6	24.7	140.7	265.1	207.6	150.4	83.6	19.5	7.0	2.7	1.5	1.2	76.6	918.7

(SWRCB 3,27 Revised)

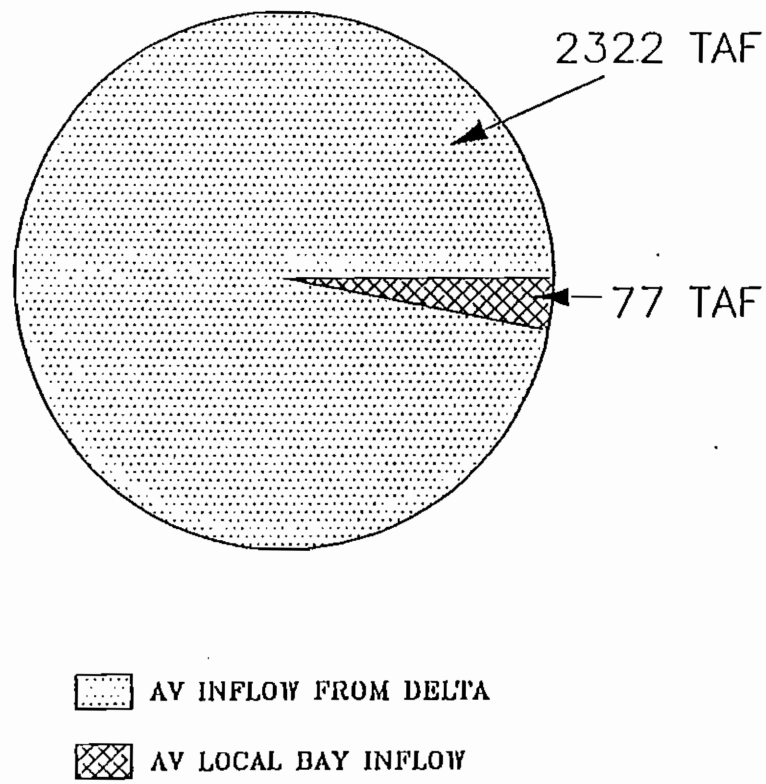
REVISED: 10-26-87

FIGURE 3.6.3.2-1

AVERAGE INFLOW FROM THE DELTA

COMPARED WITH

AVERAGE LOCAL BAY INFLOW

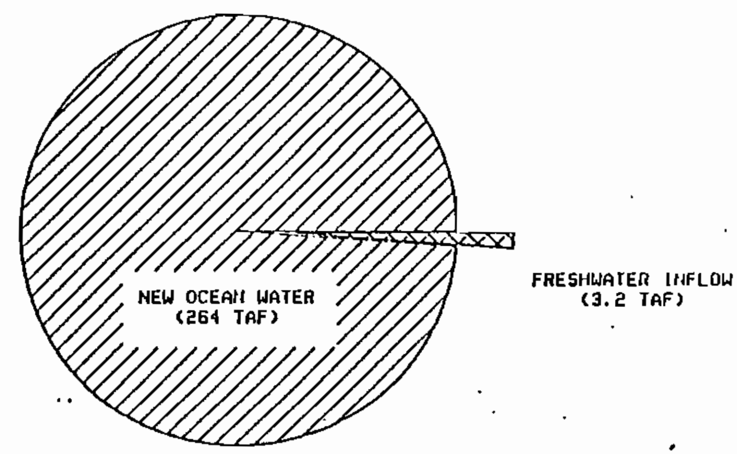


(From SWRCB, 3)

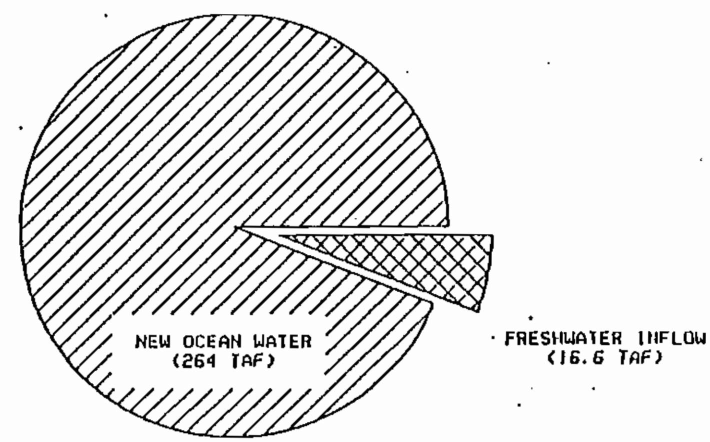
FIGURE 3.6.3.2-2

GOLDEN GATE TIDAL EXCHANGE VOLUME COMPARED WITH FRESHWATER INFLOW DURING A FLOOD TIDE WITH A 24% TIDAL EXCHANGE RATIO

SUMMER CONDITIONS (6,200 cfs FRESHWATER INFLOW)



WINTER CONDITIONS (32,300 cfs FRESHWATER INFLOW)



(DWR, 662)

streets, parking lots and drainage conduits have caused less rainfall to reach ground water and subsequently greater amounts to flow directly into the Bay. Wastewater treatment plant discharges and water imports into the Bay Basin have also changed the locations and greatly increased the quantity of local inflows to the Bay.

DWR developed a local runoff survey for separate Bay Basin hydrologic areas (Table 3.6.4.2-1) and a summary of wastewater discharge for the period of water years 1970 through 1982 (Table 3.6.4.2-2)(SWRCB,3,Appendix R). Listing the monthly, and yearly runoff totals, the tables indicate that effluent discharge can be as much as 70 percent less than local runoff (WY 81-82) and as much as 25 percent more (WY 76-77). Table 3.6.4.2-3 compares unimpaired and current flow conditions in the San Francisco Bay Basin.

TABLE 3.6.4.2-3
SAN FRANCISCO BAY BASIN:
UNIMPAIRED FLOW AND CURRENT FLOW CONDITIONS BY WATER YEAR TYPE[1]

	Unimpaired Flow (TAF)		Current Flow	
Water Year Type	Low	High	Low	High
Wet	427.0	2556.5	157.2	301.3
Above Normal	440.5	2071.0	194.9[2]	
Below Normal	212.4	1079.3	112.3	231.6
Dry	261.2	1142.1	191.0[3]	
Critical	92.0	322	84.1	126.8

1/ Individual water years measured as percentages of the Sacramento Basin's Four River Index (see Chapter 4) have been used, resulting in some overlap of flow amounts for different water year types. Flows do not include inflows from the Delta.

2/ Only one reference point, Water Year 1969-70.

3/ Only one reference point, Water Year 1977-78

TABLE 3.6.4.2-1
SAN FRANCISCO BAY AREA LOCAL RUNOFF

(SUM OF DRAINAGE STUDY AREAS (DSA) 90 ---> 96) LESS (SUM OF DSAs 90 ---> 96) EFFLUENT DISCHARGE (ED) (TAF)

WTR YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	AVG MO
6970	51	46	187	724	145	161	55	48	43	43	42	39	1584	132
7071	44	130	385	148	61	106	65	50	42	42	42	40	1155	96
7172	40	45	85	65	77	52	50	44	41	42	42	42	627	52
7273	64	132	100	595	506	264	85	63	55	47	45	44	2000	167
7374	52	225	229	322	112	387	247	63	50	49	45	43	1824	152
7475	46	44	58	59	277	347	104	55	44	43	43	41	1161	97
7576	52	43	44	41	44	50	43	39	37	38	40	38	509	42
7677	40	41	44	42	32	42	32	34	31	33	33	33	438	36
7778	32	63	113	517	294	301	130	53	42	41	41	40	1665	139
7879	41	46	43	187	225	124	66	50	40	40	40	39	942	78
7980	51	57	139	406	627	189	83	55	44	44	44	41	1780	148
8081	45	42	65	159	73	130	56	47	43	43	42	41	786	66
8182	51	171	370	584	330	385	659	73	54	49	46	47	2821	235
MO AVG	47	83	143	296	216	195	129	52	44	43	42	41	1330	111

(SUM OF DSAs 90 ---> 96) LESS (SUM OF DSAs 90 ---> 96) ED (CFS)

WTR YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	AVG MO
6970	825	767	3035	11777	2614	2619	917	777	726	698	687	661	26102	2175
7071	711	2183	6257	2403	1102	1730	1093	809	710	688	686	665	19038	1587
7172	656	761	1388	1050	1338	847	844	715	690	687	685	713	10374	864
7273	1038	2215	1629	9683	9105	4300	1421	1026	919	757	732	746	33570	2798
7374	841	3782	3725	5238	2010	6293	4144	1032	835	801	737	722	30157	2513
7475	747	744	941	961	4989	5645	1748	900	744	700	691	683	19493	1624
7576	843	719	712	666	765	819	729	633	624	615	650	643	8417	701
7677	655	682	718	686	584	681	544	554	529	531	532	554	7252	604
7778	528	1051	1841	8402	5292	4890	2178	857	706	670	661	664	27739	2312
7879	661	778	699	3037	4057	2023	1102	816	676	658	650	650	15806	1317
7980	822	963	2266	6596	10895	3073	1398	895	743	719	712	692	29774	2481
8081	726	709	1053	2586	1311	2114	941	763	729	695	688	694	13010	1084
8182	835	2882	6024	9489	5934	6268	11080	1190	906	799	752	789	46949	3912
MO AVG	760	1403	2330	4813	3846	3177	2165	844	734	694	682	683	22129	1844

(SWCRB,3,APPENDIX R,pg. 17)

TABLE 3.6.4.2-2

SAN FRANCISCO BAY AREA LOCAL RUNOFF

EFFLUENT DISCHARGE (ED) FOR DRAINAGE STUDY AREA (DSA) 90 ---> 96 (MGD)

WTR YEAR	90 & 91	92 N	92 S	92	93	94	95	96	TOTAL	AVG MO
6970	93.0	28.2	79.6	107.8	33.5	120.9	51.2	116.4	630.6	52.6
7071	93.0	29.2	84.3	113.5	30.1	109.0	51.6	124.1	634.8	52.9
7172	89.2	30.2	82.7	112.9	29.6	114.5	52.0	135.3	646.4	53.9
7273	91.8	31.9	88.0	119.9	29.6	136.0	52.0	141.3	690.5	57.5
7374	89.5	28.7	83.7	112.4	26.9	129.9	47.6	140.0	658.7	54.9
7475	87.1	27.0	83.7	110.7	26.4	112.2	48.9	147.7	643.7	53.6
7576	66.6	24.0	73.4	97.4	24.8	104.5	42.4	147.4	580.5	48.4
7677	60.3	22.1	63.2	85.3	24.7	95.8	36.1	126.3	513.8	42.8
7778	68.1	25.3	68.5	93.8	27.0	110.6	41.8	162.5	597.6	49.8
7879	76.6	30.5	71.7	102.2	27.2	103.7	46.4	158.9	617.2	51.4
7980	79.0	34.7	75.2	109.9	27.7	116.2	45.0	163.8	651.5	54.3
8081	76.2	33.9	71.0	104.9	36.3	117.7	59.3	150.7	650.0	54.2
8182	98.5	39.1	81.5	120.6	42.9	140.8	30.4	154.6	708.4	59.0
AREA AVG	82.2	29.6	77.4	107.0	29.7	116.3	46.5	143.8	632.6	52.7

ED FOR DSAs 90 ---> 96 (CFS)

WTR YEAR	90 & 91	92 N	92 S	92	93	94	95	96	TOTAL	AVG MO
6970	144.2	43.7	123.4	167.1	51.9	187.4	79.4	180.4	977.4	81.5
7071	144.2	45.3	130.7	175.9	46.7	169.0	80.0	192.4	983.9	82.0
7172	138.3	46.8	128.2	175.0	45.9	177.5	80.6	209.7	1001.9	83.5
7273	142.3	49.4	136.4	185.8	45.9	210.8	80.6	219.0	1070.3	89.2
7374	138.7	44.5	129.7	174.2	41.7	201.3	73.8	217.0	1021.0	85.1
7475	135.0	41.9	129.7	171.6	40.9	173.9	75.8	228.9	997.7	83.1
7576	103.2	37.2	113.8	151.0	38.4	162.0	65.7	228.5	899.8	75.0
7677	93.5	34.3	98.0	132.2	38.3	148.5	56.0	195.8	796.4	66.4
7778	105.6	39.2	106.2	145.4	41.9	171.4	64.8	251.9	926.3	77.2
7879	118.7	47.3	111.1	158.4	42.2	160.7	71.9	246.3	956.7	79.7
7980	122.5	53.8	116.6	170.3	42.9	180.1	69.8	253.9	1009.8	84.2
8081	118.1	52.5	110.1	162.6	56.3	182.4	91.9	233.6	1007.5	84.0
8182	152.7	60.6	126.3	186.9	66.5	218.2	47.1	239.6	1098.0	91.5
AREA AVG	127.4	45.9	120.0	165.9	46.1	180.3	72.1	222.8	980.5	81.7

ED FOR DSAs 90 ---> 96 (TAF)

WTR YEAR	90 & 91	92 N	92 S	92	93	94	95	96	TOTAL	AVG MO
6970	104.4	31.7	89.3	121.0	37.6	135.7	57.5	130.6	707.8	59.0
7071	104.4	32.8	94.6	127.4	33.8	122.3	57.9	139.3	712.5	59.4
7172	99.8	33.8	92.6	126.4	33.1	128.1	58.2	151.4	723.4	60.3
7273	103.0	35.8	98.8	134.6	33.2	152.6	58.4	158.6	775.0	64.6
7374	100.5	32.2	93.9	126.2	30.2	145.8	53.4	157.1	739.3	61.6
7475	97.8	30.3	93.9	124.2	29.6	125.9	54.9	165.8	722.5	60.2
7576	74.5	26.9	82.1	109.0	27.8	116.9	47.5	165.0	649.7	54.1
7677	67.7	24.8	70.9	95.7	27.7	107.5	40.5	141.8	576.7	48.1
7778	76.4	28.4	76.9	105.3	30.3	124.1	46.9	182.4	670.7	55.9
7879	86.0	34.2	80.5	114.7	30.5	116.4	52.1	178.3	692.7	57.7
7980	88.4	38.8	84.2	123.0	31.0	130.0	50.4	183.3	729.1	60.8
8081	85.5	38.0	79.7	117.7	40.7	132.1	66.6	169.1	729.5	60.8
8182	110.6	43.9	91.5	135.4	48.1	158.0	34.1	173.5	795.1	66.3
AREA AVG	92.2	33.2	86.8	120.0	33.4	130.4	52.2	161.3	709.5	59.1

(SWCRB,3,Appendix R,pg. 14)

References for Chapter 3.0

- BCDC.1982. Diked Historic Baylands of San Francisco Bay. Findings, Policies, and Maps. Adopted October 21, 1982.

- RWQCB 2.1975. Water Quality Control Plan Report, San Francisco Bay Basin (2). Part II, April 1975.

- RWQCB 5.1975. Water Quality Control Plan Report, Sacramento River Basin (5A), Sacramento-San Joaquin Delta Basin (5B), San Joaquin Basin (5C). Volume II. 1906 through 1920--DWR Division of Planning Statewide Planning Branch, 4/14/80; 1921 through 1978--DWR Exhibit 7, except as stated below;

  1969 through 1983 Sacramento River near Red Bluff--DWR California Data Exchange Center, 1/15/88; 1984 through 1987--DWR California Data Exchange Center, 1/15/88

- Cheng, T.T., and Gardner, J.W., Tides, Tidal and Residual Currents in San Francisco Bay, 1979-1980, ~~UGSG~~ USGS Water Resources Investigation Report 84-4339, February 1984.

- Denton, R.A., and Hunt, J.R., Currents in San Francisco Bay--Final Report, SWRCB Publication No. 86-7wr, March 1986.

- SWRCB, Final Environmental Impact Report for the Water Quality Control Plan and Water Right Decision, Sacramento-San Joaquin Delta and Suisun Marsh, August 1978.

- Orlob, G.T. 1982. "Without Project" Water Quality. Memorandum from Dr. G.T. Orlob of G.T. Orlob and Associates to Diverters, South Delta Water Agency on February 10, 1982.

4.0 BENEFICIAL USES OF BAY-DELTA ESTUARY WATER

4.1 Introduction

"'Beneficial uses' of the waters of the state that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; esthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves" (Porter-Cologne Water Quality Control Act, Water Code Section 13050(f)).

The establishment of beneficial uses of waters of the state is the first task of water quality control planning. Only after beneficial uses have been properly identified can appropriate water quality objectives and other control policies be established. A clear understanding of the service each beneficial use provides to the citizens of California also builds a foundation for weighing and balancing the levels of protection needed. In summarizing issues addressed during Phase I of the Bay-Delta hearing, this chapter discusses the beneficial uses, their water requirements, their salt tolerance, and, when available, their economic value.

4.2 Estuary Water for Municipal and Domestic Supply Purposes

Municipal and Domestic Supply (MUN) includes established uses in community or military water systems as well as domestic uses from private systems (RWQCB,1975). Common domestic uses of water include those for sanitation, direct consumption, food preparation, landscape watering, among others (RWQCB, 1975). Common municipal uses of water include those for light commercial businesses, restaurants, parks, etc. The two MUN needs are continuous and require a dependable water supply (SWC,3,1). It is state policy that domestic use is the highest use of water (Water Code {WC} Section 106).

Delta surface waters are used to supply MUN needs in both northern and southern California. The quality of these waters, and therefore MUN supplies, depends on complex flow and salinity relationships within the Estuary. When Delta outflow is insufficient to move the salinity gradient west of Chipps Island, there is a potential for ocean salinity to be drawn into the Delta's interior if reverse flows also occur (see 3.5.2.4). Saline waters may subsequently degrade supplies taken through the intakes of the Contra Costa Canal and Clifton Court (DWR,51D).

Locations of historic MUN use remain much the same, although there has been a change in the season and length of time that acceptable water occurs. Historically, to mitigate adverse salinity conditions prior to the existence of the state and federal projects, municipalities would fill storage reservoirs, "...when the water in the (San Joaquin River) was fresh to provide a supply to meet the demands during the period of saline invasion..." (DWR,1931). Prior to 1920, in the western Delta the MUN water source for Antioch became "...unfit for domestic consumption during part of the late summer or early fall months of most years and certainly during dry years as far back as the (eighteen) sixties and seventies." (DWR,1931). By 1920 Antioch had a significant decrease in the period of availability of municipal water supply from the San Joaquin River. Generally, as upstream development increased, the position of the salinity gradient moved upstream. In most areas in the Delta, operations of the federal and state water projects reversed this degradation by providing additional, sustained amounts of water during the summer months and prolonged dry periods (T,XIII,151:5-21;DWR, 84-87).

Present and projected MUN water use of Delta surface water is presented in Table 4.2-1. Delta cities that rely on this water are Antioch, Pittsburg, Tracy and Oakley. Pittsburg and Oakley obtain water supplies from Rock Slough via the Contra Costa Canal; Tracy obtains its supply from Old River via the Delta-Mendota Canal. Antioch diverts part of its water supply directly from the San Joaquin River and obtains part from the Contra Costa Canal. Sacramento maintains a standby diversion facility on the Sacramento River in the Upper Delta, but normally diverts from two other facilities on the American and Sacramento rivers upstream of the Delta. The cities of Stockton, Tracy, Rio Vista, and other Delta communities rely to various degrees on ground water for MUN water supplies (SWRCB,1978).

TABLE 4.2-1
MAJOR MUNICIPAL WATER DEMANDS

	Current 1986 Population	Current 1986 Water Demands (AF)
City of Tracy	25,300 1/	7,822 2/
Antioch	40,734 3/	9,073 4/ (1985)
Pittsburg	53,125 3/	7,729 4/ (1985)
Oakley County W.D.	8,436 3/	2,128 4/ (1985)
	Year 2000 Population	Year 2000 Water Demands (AF)
City of Tracy	33,000 1/ (1990)	10,400 2/ (1990)
Antioch	78,900 5/	14,338 4/
Pittsburg	59,100 5/	12,994 4/
Oakley County W.D.	N/A	5,153 4/

1/ City of Tracy (CT), Exhibit No. 2
2/ CT, Exhibit No.3
3/ Contra Costa Water District (CCWD), Exhibit No. 7
4/ CCWD, Exhibit No. 25
5/ CCWD, Exhibit No. 24

4.3 Industrial Beneficial Uses

4.3.1 Industrial Use Comprises Three Separate Beneficial Uses:

- Industrial Service Supply (IND) "includes uses which do not depend primarily on water quality such as mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization".

- Industrial Process Supply (PROC) "includes process water supply and all uses related to the manufacturing of products".

- Hydroelectric Power Generation (POW) "is that supply used for hydropower generation" (RWQCB,5,1975).

Very little information on Bay-Delta industrial use was presented in Phase I of the hearing. Two Bay-Delta industries, Fibreboard and Shell Oil Company, presented testimony, but no exhibits. Contra Costa Water District (CCWD) and DWR presented exhibits and testimony, but of a limited scope. SWRCB presented the "Environmental Impact Report for the Water Quality Control Plan and Water Right Decision, Sacramento-San Joaquin Delta and Suisun Marsh" (D-1485 EIR). This document was prepared for the D-1485 hearings and contains more extensive, but possibly out-of-date information on Bay-Delta industrial use.

Water use in 1975 of 11 major industries using at least 50,000 gallons per day is summarized in Table 4.3-1. Water delivered from the Contra Costa Canal to major industrial water users in the Delta totaled 22,733 acre-feet in 1985 and 15,519 acre-feet in 1986 (CCWD,26).

4.3.2 Antioch-Pittsburg Area

Most of the industries that depend upon Bay-Delta surface waters are in the Antioch-Pittsburg area. These industries depend almost exclusively for their water supplies on three possible sources:

- Water pumped by the industries directly from the San Joaquin River or New York Slough.

- Untreated water purchased from CCWD and conveyed from Rock Slough via the Contra Costa Canal or, in the Pittsburg area, pumped from Mallard Slough at the District's pumping plant.

- Treated water purchased from municipal purveyors who obtain their water from the Contra Costa Canal or, in the case of Antioch, from either Contra Costa Canal or a San Joaquin River diversion.

The Pacific Gas and Electric Company (PG&E) powerplants at both Antioch and Pittsburg use large quantities of water for once-through cooling. These uses are not affected substantially by salinity changes. PG&E did not provide information concerning Bay-Delta industrial water use in Phase I of the hearing, nor did they participate in the D-1485 hearing.

Table 4.3-1
Industrial Water Use Summary - 1975
(acre-feet per year)

Industrial Water User	Location	Product	Water Use	Water Source: Offshore Diversions	Ground Water	Costa Canal	Municipal Supply	Total
Crown Zellerbach Antioch (Now Gaylord Containers Inc.)	Antioch	Pulp and Paper Products	Boiler	(230)*		(90)	(40)	360
			Cooling	(620)				620
			Process	(11,000)				11,000
			Total	11,850	0	90	40	11,980
								17,422 (1986) a/
E.I DuPont	Oakley	Pigments, Petrochemicals, Fluorocarbons	Boiler				420	420
			Cooling				240	240
			Process				1,420	1,420
			Total	0	0	0	2,080	2,080
Fibreboard	Antioch	Pulp and Paper Products	Boiler		(780)	(230)		1,010
			Cooling	(1,770)				1,770
			Process	(14,020)		(320)		14,340
			Total	15,790	780	550	0	17,120
				13,783 (1986) b/				
Hickmott Canning	Antioch	Tomato Products	Boiler					
			Cooling				560	560
			Process				560	560
			Total	0	0	0	1,120	1,120
Kaiser Gypsum	Antioch	Wallboard	Boiler				(75)	75
			Cooling				(75)	75
			Process	0	0	0	150	150
			Total					
PG&E	Antioch	Electric Power	Boiler					
			Cooling	1,106,000				1,106,000
			Process					
			Total	1,106,000	0	0	0	1,106,000
Collier Carbon and Chemical	Pittsburg	Ammonium Phosphate Fertilizers	Boiler					
			Cooling	25		25		50
			Process			60		60
			Total	25	0	85	0	110
Dow Chemical	Pittsburg	Commercial Chemicals	Boiler			(1,300)		1,300
			Cooling	(1,310)				1,310
			Process	(1,110)		(200)		1,310
			Total	2,420	0	1,500	0	3,920
Johns-Manville	Pittsburg	Roofing Paper	Boiler				40	40
			Cooling	190				190
			Process	150			100	250
			Total	340	0	0	140	480
PG&E	Pittsburg	Electric	Boiler					
			Cooling	708,000				708,000
			Process					
			Total	708,000	0	0	0	708,000
U.S. Steel	Pittsburg	Steel Products	Boiler					
			Cooling			(10,000)		10,000
			Process				(1,500)	1,500
			Total	0	0	10,000	1,500	11,500

a) *DWR*,204
b) Ibid.
*Note: Parentheses indicate assumed breakdown of water use where industry could not furnish these data.
Source: Environmental Impact Report for the Water Quality Control Plan, August 1978 and Water Decision, Sacto-SanJoaquin Delta & Suisun Marsh, pg. III-149.

4.3.3 Other Industries

Shell
Heinz

Other Bay-Delta industries located outside the Antioch-Pittsburg area include: Shell Oil Company in Martinez which obtains most of its water supply from the Contra Costa Canal (T,IX,41:11-14); and three industries near Tracy, H. J. Heinz Company, Laprino Cheese and Laura Scudders, which obtain their water supply from the DMC or local ground water supplies (T,IX,11:4-12;T,IX,21:21-25).

Gaylord Container

Gaylord Containers Corporation recycles wastepaper at a mill on the south shore of the San Joaquin River. In 1975, approximately 12.5 million gallons per day (MGD) of water pumped directly from the San Joaquin River or purchased from CCWD were required for processing and cooling in the manufacture of several grades of paper that are converted into corrugated boxes, paper towels, etc.

Because canned goods can corrode when left in contact with linerboard of corrugated boxes containing more than 500 ppm sodium chloride, process water for the manufacture of boxes is kept below 150 ppm chloride (T,VI,92:25-93:6).

Lou-Pacific

Fibreboard Louisiana-Pacific, a large kraft paper mill located on the south shore of the San Joaquin River approximately five miles east of Antioch, produces linerboard, corrugating medium, and fiber board from wood chips (hearing for D-1485,RT,Vol.XVII,p.135). Unlike the nearby Gaylord Container Mill, Fibreboard's predominant raw material is pulp produced from wood chips. Fibreboard presented the only evidence supporting the need for process water with not more than 150 ppm chloride for the production of linerboard (T,IV,92:25-93:6;T,IX75:23,81:23). A witness for Contra Costa Water District, however, stated that a standard of 250 ppm chloride year-round would be adequate (T,VII,97:22,25).

Fibreboard

Fibreboard has two main sources of water, direct pumping from the San Joaquin River and CCWD. When the chlorinity in the San Joaquin River supply is higher than 150 ppm, a partial supply of water is purchased from CCWD; when the chlorinity level reaches 250 ppm, the entire supply is taken from the Contra Costa Canal (T,IX,77:23-78:6). A third, relatively minor source is ground water from two wells that provide between 500,000 and 800,000 gallons per day.

Dow

Dow Chemical Company did not present information on current water requirements during the hearing, but information was introduced in the D-1485 EIR. The Dow Chemical plant, located on New York Slough between the cities of Antioch and Pittsburg, diverts from New York Slough for cooling and process waters (hearing for D-1485, citing Decision 1379, RT Vol. XXXI, pp. 3292-3371; Dow Exhibit 502). An alternate water supply from the Contra Costa Canal was available for "critical water use" when the offshore supply exceeded a chloride concentration of 160 ppm.

U.S. Steel presented testimony in 1970 regarding water use at its steel processing facilities located on the south shore of New York Slough between Pittsburg and Antioch (hearing for D-1485, pg. III-160). Water was diverted from New York Slough for cooling uses and, seasonally, for process water in the Wire Mill. Contra Costa Canal water was used for process water in the Sheet and Tin Mill, the Morgan Rod Mill, the Pipe Mill, and for boiler feed water supply (hearing preceding D-1485; hearing preceding Decision 1379, RT, Vol. XXX, pp. 3175-3246). Table 4.3-1 shows that in 1975 U.S. Steel used 11,500 acre-feet of water from the Contra Costa Canal and city supplies.

Johns-Manville Products Corporation presented testimony in 1970 concerning water use at its plant located on New York Slough in the City of Pittsburg (hearing for D-1485, citing Decision 1379, RT Vol. 28, pp. 3098-3140). New York Slough provided the entire water supply until chlorinity limits were reached, at which point an alternate supply purchased from the City of Pittsburg was then used for the boiler feed water and paper mill (see Table 4.3-1).

Shell Oil Company operates an oil refinery on the south bank of Suisun Bay near Martinez, next to the Benicia Bridge. Though no water is incorporated directly in the refineries products, water is important in the refining process. Large quantities are used for cooling, steam generation, pumps and compressors, and to heat refining processes (T,IX,42:15-19). The refinery's main products are approximately five million gallons per day of gasoline, jet and diesel fuel (T,IX,41:22-25). The facility has 850 company employees and 300 contract employees, with a current annual company payroll of $38 million, and an annual contract payroll of $18 million (T,IX,42:3-5).

Shell Oil Company's source of water supply is the Contra Costa Canal terminating in Martinez. Annual water consumption in 1986 was approximately 10,000 acre-feet, with an average consumption rate of approximately 6,200 gallons per minute (gpm) and a peak consumption rate of approximately 9,060 gpm. Of the average use rate of 6,200 gpm, about 2,500 gpm is used for preparing boiler feed water, and 3,000 gpm for cooling water. The balance is used for pad and equipment washdown, landscape irrigation and other miscellaneous uses (T,IX,42:20-25;T,IX,43:1-10). Shell Oil Company's major concern is the reliability of their water supply (T,IX,46:12-13).

4.4 Estuary Agriculture Beneficial Uses

4.4.1 Delta Agriculture

About three-quarters of the Delta land area (515,000 acres) is farmed with water from the channels and sloughs adjacent to each individual island in the Delta (DWR,304). There is not a water supply problem in the agricultural waters affected by tidal actions. Most channels in the Delta have sufficient volume to supply agricultural water needs even at low tidal stages. However, water levels in some isolated channels in the southern Delta are affected by drawdown caused by the state and federal pumping plants (T,XIII,230:17-233:10).

Soils in the Delta fall generally into two categories, organic and mineral. Farmed organic soils constitute 68 percent of the total cropped area and mineral soils the remaining 32 percent. Organic soils are usually found in the Delta lowlands, that is, the land area below an elevation of +5 feet mean sea level. Delta uplands are those areas above +5 feet mean sea level. Mineral soils are found in both the Delta lowlands and uplands.

4.4.1.1 Delta Organic Soils - below +5' mean sea level

The Delta organic soils were formed through the biochemical breakdown of marsh plants and grasses that existed prior to the development of the present levee system. The amount of organic soils in the Delta is constantly being reduced because of continuing decomposition and oxidation from both natural processes and farm practices. As a result, the lowland Delta islands are sinking at the rate of one to three inches per year and the actual acreage of the organic soils is also being reduced (T,LV,82:20-25).

The high permeability of organic soils and their low surface elevation compared to surrounding waterways produces high ground water table conditions. The high ground water table, along with problems associated with uneven decomposition and settlement of organic soils,makes subirrigation the primary method of water application for crop production. Subirrigation is the delivery of water to plant roots by capillary action from the underlying saturated soil strata. This form of irrigation, however, must be tied to a winter leaching program to remove salts accumulated in the root zone. In the organic, sub-irrigated soils, the salts are brought into the soil column from beneath the plant roots. The shallow water table prevents downward leaching of these salts after the irrigation has been completed. To lower the high level of ground water and provide adequate drainage, water must be pumped from beneath the soil profile of the lowlying Delta islands and discharged into the adjoining waterways.

high water table → subirrigation

water must be removed from soil in Delta organics via pumping

4.4.1.2 Delta Mineral Soils - above +5' mean sea level

Delta mineral soils were formed through deposition of sands and minerals eroded from the Sierra Nevada by various streams tributary to the Delta. These soils are generally found in the Delta uplands. Since subirrigation is not practicable in the mineral soils, water is applied to the soil surface, usually through furrow, sprinkler, or flood irrigation. Leaching of the soils is also required along with occasional changes in cropping patterns. Unlike subirrigation of organic soils, in the mineral, surface-irrigated soils, the salts are brought into the soil column from above with the irrigation water. Excess salts are then removed at the end of the irrigation season by applying irrigation water to flush the salt into the lower ground water table. Some leaching may also be accomplished with winter rainfall.

4.4.1.3 Crop Production

Crop production information was presented by DWR for the Delta lowlands and uplands (DWR,304). Corn was the predominant crop grown in the Delta during the period 1977-84, accounting for 25.8 percent of the total acreage (Table 4.4.1.3-1). Grain is grown on an additional 21.5 percent of the acreage, followed by tomatoes, alfalfa and mixed pasture; other crops such as sugar beets, deciduous trees and safflower account for the majority of the remainder. Crops and livestock production in the Delta has a gross sale value of approximately $500 million (Table 4.4.1.3-2), with field and truck crops making up 57 percent of that total.

TABLE 4.4.1.3-2
ECONOMIC VALUE OF DELTA CROPS AND LIVESTOCK

Agricultural Category	Gross Value Delta Area Lowland	Upland ($ Million)	Total
Field Crops	100.4	67.2	167.6
Truck Crops	76.9	34.6	111.5
Tree Fruit, Nut & Vine	25.1	18.2	43.2
Seed & Nursery	7.9	1.8	9.7
Livestock	9.9	144.5	154.5
TOTAL	$220.2	$266.3	$486.5

4.4.1.4 Salinity Tolerance

A major question to be addressed in setting salinity standards for agriculture is, "What is the salt tolerance of the crops grown in the Delta?" Several parties presented information on this topic (DWR,327,328; CCWD,50; SDWA,105,109,117; SWRCB,22,23,26). Table 4.4.1.4-1 presents selected information concerning salt threshold and yield levels for sensitive and moderately sensitive crops (DWR 328). The salt threshold for a particular crop is the level below which no loss in yield is experienced due to soil salt conditions.

TABLE 4.4.1.3-1
1977 to 1984 CROP ACREAGES AND PERCENTAGES*
FOR THE SACRAMENTO-SAN JOAQUIN DELTA
FROM DWR 304

Crop	Lowlands & Uplands		Lowlands		Uplands	
	ac.	%	ac.	%	ac.	%
Field Corn	132,770	25.8	107,480	30.6	25,290	15.6
Grain	110,900	21.5	81,960	23.4	28,940	17.8
Tomatoes	43,100	8.4	25,370	7.2	17,730	10.9
Alfalfa	39,770	7.7	24,350	6.9	15,420	9.5
Mixed Pasture	36,020	7.0	17,730	5.0	18,290	11.3
Sugar Beets	27,650	5.4	15,240	4.3	12,410	7.6
Deciduous	25,960	5.0	9,240	2.6	16,720	10.3
Safflower	23,530	4.6	21,060	6.0	2,470	1.5
Asparagus	23,400	4.5	21,840	6.2	1,560	1.0
Beans	17,580	3.4	4,690	1.3	12,890	7.9
Sunflower	6,630	1.3	6,050	1.7	580	0.4
Vineyard	4,870	1.0	4,150	1.2	720	0.5
Sorghum	4,580	0.9	3,600	1.0	980	0.6
Cole Crops	4,140	0.8	3,610	1.0	530	0.3
Melons	2,430	0.5	250	0.1	2,180	1.4
Sudan	2,180	0.4	710	0.2	1,470	0.9
Potatoes	2,160	0.4	2,160	0.6	0	0.0
Rice	1,810	0.4	480	0.1	1,330	0.8
Native Pasture	1,130	0.2	140	0.0	990	0.6
Misc. Truck	1,120	0.2	750	0.2	370	0.2
Lettuce	1,110	0.2	0	0.0	1,110	0.7
Onions	590	0.1	370	0.1	220	0.1
Misc. Field	510	0.1	460	0.1	50	0.0
Clover	450	0.1	440	0.1	10	0.0
Carrots	300	0.1	300	0.1	0	0.0
Peppers	250	0.0	50	0.0	200	0.1
Nursery	60	0.0	0	0.0	60	0.0
TOTAL	515,000	100.0	352,480	100.0	162,520	100.0

*Percentages computed by State Board staff

TABLE 4.4.1.4-1
DELTA SERVICE AREA
CROP SALT SENSITIVITY
(DWR,328)

Crop	Salt Sensitivity (Crop Salt Sensitivity) Threshold ECe[1/] ds/m	Loss in Yield per Unit Increase in ECe Beyond Threshold
Sensitive Crops		
Beans	1.0	19%
Onions	1.2	16%
Moderately Sensitive Crops		
Fruits & Nuts		
Almonds	1.5	19%
Apricots	1.6	24%
Peaches	1.7	21%
Grapes	1.5	9.%
Corn	1.7[2/]	12%
Corn (subirrigated, organic soil)	(2.1)	
Potatoes		
Miscellaneous		
Truck Crops		
Carrots	1.0	14%
Lettuce	1.3	13%
Cabbage	1.8	9.7%
Broccoli	2.8	9.2%
Alfalfa	2.0	7.3%
Tomatoes	2.5	9.9%
Sudan	2.8	4.3%
Rice	3.0	12%

1/ ECe means Electrical Conductance of the soil saturation extract, reported as deci Siemens per meter (ds/m).

2/ This tolerance of corn shown is for corn grown on a mineral soil using conventional methods of surface irrigation (furrow or sprinklers). The Delta corn trials (reported by Hoffman, et al., 1983) indicate a corn tolerance a little higher for corn grown on the Delta peat under subirrigation. It is reported to be ECe=2.1 ds/m, or 23% higher. This is probably due to the higher water content of the peat. The usual tolerance (for mineral soils) can be multiplied by a factor of 1.23 to obtain tolerance of similar crops grown on subirrigated soils.

4.4.2 Bay Agriculture

Very little information was presented in the hearing sessions on agriculture, as a beneficial use, outside of the legal limits of the Delta but within the boundary of San Francisco Bay. Contra Costa Water District presented records showing crop production for their district (CCWD,48) (Table 4.4.2-1).

TABLE 4.4.2-1--CROPS PRODUCED IN CONTRA COSTA WATER DISTRICT, 1986

Crop	Acres
Corn	10
Alfalfa	20
Irrigated Pasture	30
Other miscellaneous field crops	60
Apricots	10
Grapes*	500
Almonds*	700
Walnuts	10

* Not irrigated in 1986

4.5 Estuary Fishery Habitat Beneficial Uses

The fishery resources of the Estuary depend on its complex ecosystem for a variety of purposes during different life stages and in different seasons and water year types. The Estuary provides habitat for close to 150 fish species and a vast aquatic food web of invertebrates, including shellfish and crustacean, and planktonic organisms. The fishery provides valuable resources for many other terrestrial and aquatic wildlife species as well.

The relationship of fishery habitat requirements to water quality has been documented for relatively few species. Studies normally focus on important commercial and recreational species such as Bay shrimp, Dungeness crab, Chinook salmon, striped bass, and American shad, among others. There is still a great deal of debate about the relationship between water quality and quantity and the changes in fishery resources even for the well studied species.

Beneficial uses of the Estuary's fishery comprise four major categories in the current Water Quality Control Plans (Basin Plans) for the San Francisco and Central Valley Regional Water Quality Control Boards, Regions 2 and 5, respectively. These are:

- Freshwater Habitat -- which provides habitat to sustain aquatic resources for cold water (COLD) and warm water (WARM) species.
- Fish Migration (MIGR) -- which provides a migration route and temporary aquatic environment for anadromous and other fish species. This beneficial use is also subdivided for warm and cold water species.
- Fish Spawning (SPWN) -- which provides a high quality aquatic habitat suitable for fish spawning.

- Preservation of Rare and Endangered Species (RARE) -- which provides an aquatic habitat necessary, at least in part, for the survival of certain species established as being rare and endangered.

The following sections 4.5.1--4.5.2.3 summarize available information on the fishery beneficial uses of the Estuary, including invertebrates. There are two major subdivisions: Section 4.5.1 discusses fishery habitat beneficial uses for species mostly using freshwater habitat; Section 4.5.2 discusses those which mostly use estuarine habitat. The information presented in this chapter will be used in Chapters 5 and 7 to determine what levels of protection are optimal and reasonable for the fishery habitat in the Bay-Delta Estuary.

4.5.1 Delta Habitat

This section considers the habitat for species that primarily use the freshwater of the Delta. Suisun Bay and the other lower estuarine areas (San Pablo, San Francisco and South bays) are discussed in Section 4.5.2..

4.5.1.1 Phytoplankton and Zooplankton

The importance of phytoplankton and zooplankton (including the opossum shrimp, Neomysis mercedis) as the basis for the food chain of fish and larger invertebrates was discussed at length in Phase I of hearing record (see, for example, DFG,28,14; T,XXXIX,15:16-19,28:13-29:14,70:19-71:8;T,XLI,52:19-53:5,59:1-4). The young of striped bass and other game fish, and all life stages of forage fish, feed on zooplankton and Neomysis (DFG,28,1), which in turn feed on smaller zooplankton and phytoplankton (DFG,28,1-4). Phytoplankton abundance is itself dependent on light, flow, salinity and nutrients. The complex interactions of these components are discussed in the hearing record.

While phytoplankton and zooplankton in the Delta food chain are undoubtedly important, the evidence presented is not sufficiently definitive to develop specific objectives for the protection of phytoplankton or zooplankton. A variety of factors have led to this conclusion:

- Changes in the Delta

  There have been extensive changes in recent years in the Delta area, the effects of which are poorly understood. These changes include: (1) the introduction of the Asian copepod, Sinocalanus doerrii, and its apparent displacement of the native copepod, Eurytemora affinis from the central Delta area (DFG,28,25-28); (2) changes in phytoplankton bloom patterns in the Delta, with the appearance of dense blooms of the chain diatom, Melosira (DFG,28,14-19); (3) changes in Delta outflow, salinity and rate of exports (DFG,20,22-25); and (4) increases in releases of water from New Melones Reservoir for interim improvement of southern Delta water quality (T,XV,21:1-9).

- Limitations on Data and Analysis

  Limited available data precluded critical analyses needed to evaluate potential flow and salinity objectives to protect these beneficial uses. For example, almost no data were presented from the 1960's, prior to the operation of the SWP; thus the effects of increased export operations could not be analyzed. Data presented by DFG (Exhibit 28) tended to lump data into pre-drought (1969-1975) and post-drought (1978-1985) periods, even though they noted that some of the changes discussed in the post-drought period began to occur prior to the 1976-1977 drought (DFG,28,16,31). In addition, much of the data was presented as March-November averages, which tended to prohibit interpretation of the data during critical periods of the year, such as the spring spawning period for striped bass. Data averaged in this way reduced the usefulness of the evidence for the purpose of setting objectives.

- Absence of Definitive Relationships

  Limits on data collection design and data interpretation prevented development of definitive relationships among data sets. For example, USBR testified that the phytoplankton data they collected were not used to make connections with other parts of the food chain (T,LXII,109:7-18). The DFG presentations on the relationship between chlorophyll a levels and abundance of various zooplankton used the March-November average abundance levels for both factors (DFG,28,61-74). However, in most years, blooms occur for only a small portion of this nine-month period. Therefore, the effects of blooms on zooplankton abundance, an important concept in much of the discussion, is lost because the long-term average chlorophyll a is at background or non-bloom levels (<10 ug/l). Seasonal and geographic differences are also obscured because only one data point is presented for each year.

  For these reasons, no objectives are proposed specifically for the protection of phytoplankton or zooplankton in the Delta. It is anticipated, however, that the objectives proposed for the protection of other beneficial uses may provide substantial protection for these aquatic resources as well.

  Should additional evidence indicate that these aquatic resources are not being protected, and the evidence is sufficiently definitive to propose objectives, this issue may be reexamined at a later date.

4.5.1.2 Chinook Salmon

- Races and Migration

Chinook, or king salmon, Onchorhynchus tshawytscha, is a native, coldwater, anadromous species of major commercial and recreational importance in California. The total annual sport and commercial harvest of chinook salmon produced in the Central Valley since 1957 averages over 400,000 fish. The estuarine gill net fishery for salmon was outlawed in 1957. Since then the ocean commercial troll harvest of Central Valley salmon has averaged about 324,000 fish, approximately 57 percent of all Chinook harvested in California. The ocean recreational catch has averaged close to 60,000 fish and the inland sport harvest is estimated to be about 35,000 fish (USFWS,31,103,176-179;DWR,56,57-59).

Adult Chinook salmon migrate through the Estuary from the ocean to spawning areas in the upper Sacramento-San Joaquin River basins. Four races, all believed to be genetically distinct (USFWS,31,109), spawn in the upper Sacramento Basin (USFWS,29,4). Each race is named for the time of year when the upstream migration (run) occurs. There are fall, late-fall, winter and spring runs. Because the spawning runs of the four races overlap in the upper Sacramento River, all life stages may be found in all months (see Figure 4.5.1.2-1). The occurrence of four races of Chinook salmon in a single river basin is unique in the United States (T,XXXV,16:24-17:1).

The fall race, comprising 90 percent of all Chinook spawning in the Central Valley, migrates upstream from about late July through December (USFWS,29,5). Smaller populations of late-fall, winter, and spring run fish spawn in the upper Sacramento River (see Figure 4.5.1.2-2). The winter run was formerly the second largest but today is the smallest (T,XXXV,22:6-14); it is now under consideration as a candidate for endangered species status. The Sacramento River and its tributaries produce 80 percent of all Central Valley Chinook salmon (USFWS,31,1) with almost 20 percent contributed by the San Joaquin River Basin in some years (DFG,15,Appendix 1).

Prior to the closure of Friant dam on the San Joaquin River, there was a spring run in the upper river (DFG,15,8). Today, only the fall run spawns in the Merced, Tuolumne and Stanislaus rivers (DFG,15,4). There are also small runs in the Mokelumne and Cosumnes Rivers (SWRCB,435,35).

FIGURE 4.5.1.2-1 Timing of life history stages for the four races of Chinook salmon in the Sacramento River Basin (after USFWS, 29, 5, Figure 2)

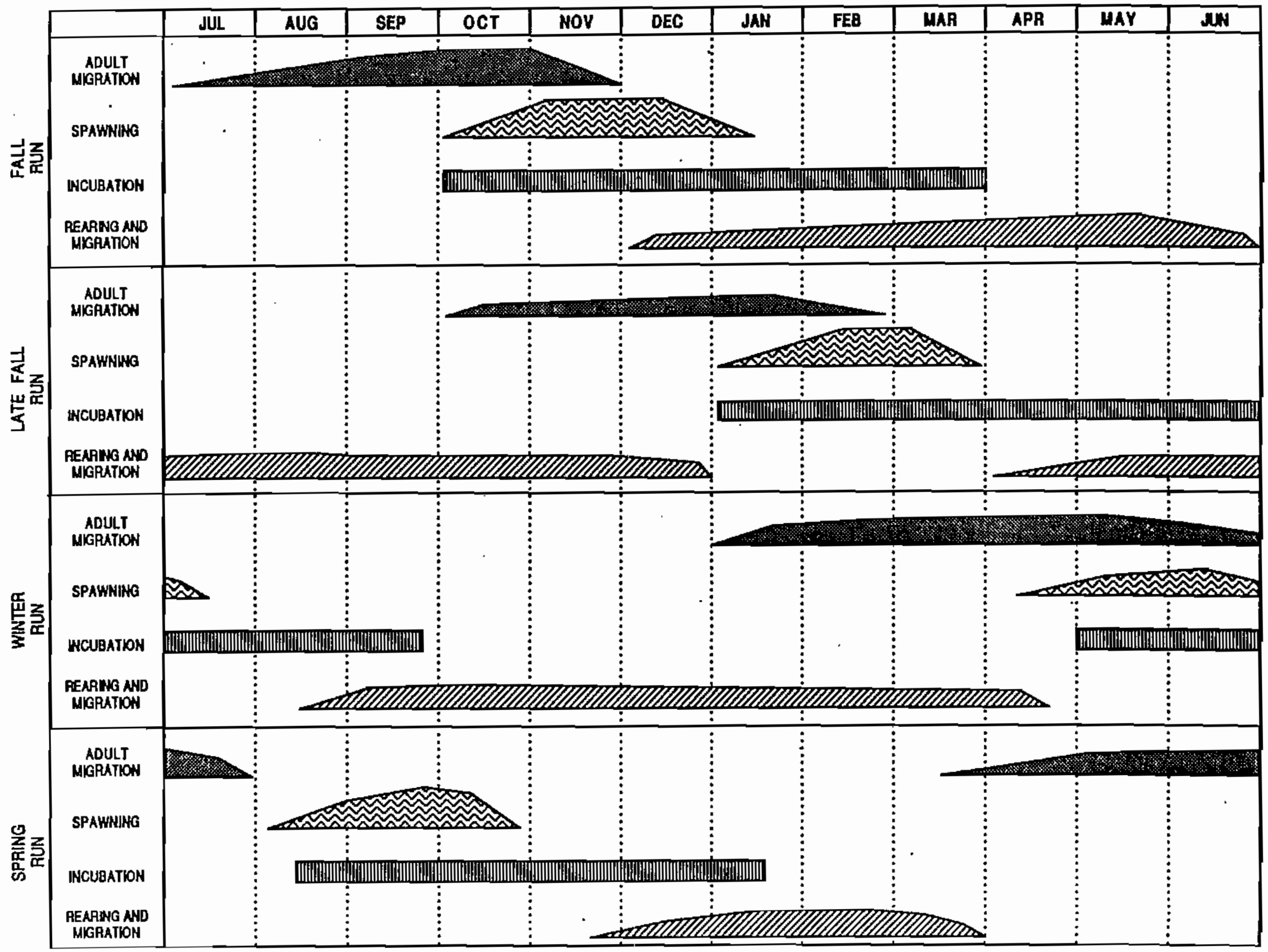
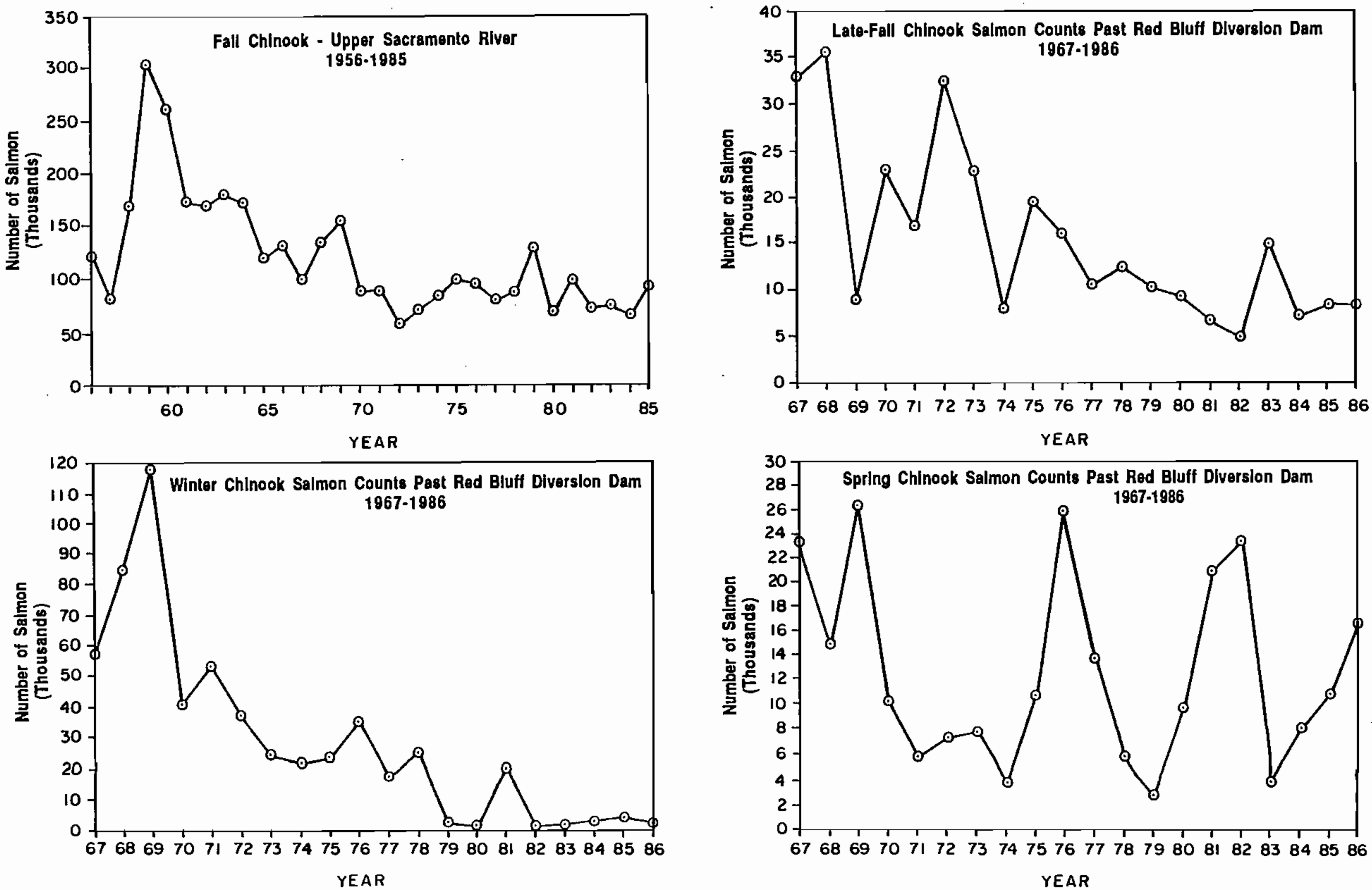


FIGURE 4.5.1. 2-2 Spawning escapement of the four races of Chinook salmon in the Upper Sacramento River Basin
(after USFWS, 29, 7-10, Figures 3-6)



- Development and Migration

The developmental stages and habitat requirements for each stage are generally the same for the four races of Chinook salmon in the Central Valley. However, the different life stages use different locations and require different habitat conditions as they develop within the Sacramento-San Joaquin River basins. The water quality and habitat requirements of each life stage, their location and duration are shown in Table 4.5.1.2-1.

Chinook salmon are a cold water species. Water temperatures below 60°F are required for spawning and the survival and growth of eggs and fry (USFWS,29,4; USFWS,31,4;T,XXXV,43:6-8). The virulence of many diseases affecting Chinook salmon is reduced when temperatures are below 60°F (USFWS,29,23). Juvenile emigrants (smolts) can tolerate water temperatures somewhat higher than 60°F but above about 65°F a variety of stress effects occur (DWR,562,3; DWR,563,1-3; USFWS,31,4; DFG,15,23-27). At temperatures of about 68°F or more, smolts are highly stressed (DFG,15,25-26); 76°F is lethal (USFWS,31,42).

Most naturally spawning Chinook salmon typically return to the stream where they hatched (home stream) at three years of age (DFG,15,18) (two and one-half years after their smolt migrating) or more. During the upstream migration, adults depend on sensing the chemical composition of the water for olfactory cues acquired during their juvenile emigration. Downstream flows of home stream water are necessary for successful spawning migration. If these flows are inadequate or have been diverted, migration delays can occur (USFWS, 31,94).

Adults follow the salinity gradient to the western Delta. Peak numbers of adult migrants, from the fall, late fall, and winter runs move through the Estuary from October to February (USFWS, 31, 93). However, because the spawning runs overlap, adults can be found in the Estuary during the entire year. In the western Delta, stocks from the two major river basins diverge. Most of the San Joaquin River fish follow the mainstem of the San Joaquin River into the tributaries although some use Old and Middle rivers (USFWS, 31, 93). Most Sacramento River Basin Chinook are thought to use the mainstem, though some travel through the Central Delta via the lower forks of the Mokelumne River (USFWS 31, 93).

Spawning, incubation and early rearing take place primarily upstream of the Delta. However, some fry also rear also takes place in the Estuary. While rearing, young salmon feed for about two months or more on a diet of aquatic and terrestrial insects and zooplankton (USFWS,29,4;USFWS,31,14; SWRCB,450,5-4). Peak fry abundance occurs in the Delta in February and March (USFWS,31,7). As they grow and move into the Estuary, _Neomysis_ (opossum shrimp), _Corophium_ (an amphipod) and _Crangon_ (Bay shrimp) become important prey items (SWRCB,433,113).

Table 4.5.1.2-1--Chinook Salmon Environmental Requirements and Life History Stages

Life Stage	Location	Duration (race)	Flow	Water Quality	Other
Adult Migration	Pacific Ocean Bay-Delta to upstream	July-Dec (fall) Oct-Mar (late fall) Jan-June (winter) mid Mar-Aug (spring)	Adequate flow of home stream water to locate spawning grounds and cover redds	Temperature <68°F Dissolved oxygen >5mg/l marine to freshwater	
Spawning	Upper reaches of all major rivers and streams in Sacramento-San Joaquin River Basins below dams	Oct-mid Jan (fall) Jan-Apr (late fall) Apr-mid July (winter) Aug-Nov (spring)	Stable flow without extreme fluctuations sufficient to cover and aerate redds	Temperature <56°F Dissolved oxygen > 7mg/l freshwater	Clean gravel substrate with good circulation through redd
Incubation (Egg-Alevin)	Spawning grounds (see above)	Oct-Apr (fall) Jan-Jul (late fall) May-Oct (winter) mid Aug-mid Jan (spring)	same as above	same as above	
Rearing (Fry-Juvenile)	Upstream, Delta, and upper estuary	Dec-Mar (fall) Apr-Aug (late fall) mid Aug-Nov (winter) late Nov-Jan (spring)	Stable flow to prevent stranding Can tolerate greater flows and velocities as they mature and move into deeper water	Temperature optimum=54°F freshwater	Diet of aquatic and terrestrial insects, crustaceans
Smolt Migration	Bay-Delta Estuary to Pacific Ocean	Apr-June (fall) Aug-Jan (late fall) Nov-late Apr (winter) Feb-Apr (spring)	Tolerates higher flows typical of spring snow melt or rainy season. Helps move smolt downstream	Temperature <68°F Dissolved oxygen >5mg/l estuarine to marine	Diet of Neomysis Crangon, Corophium, and aquatic and terrestrial insects

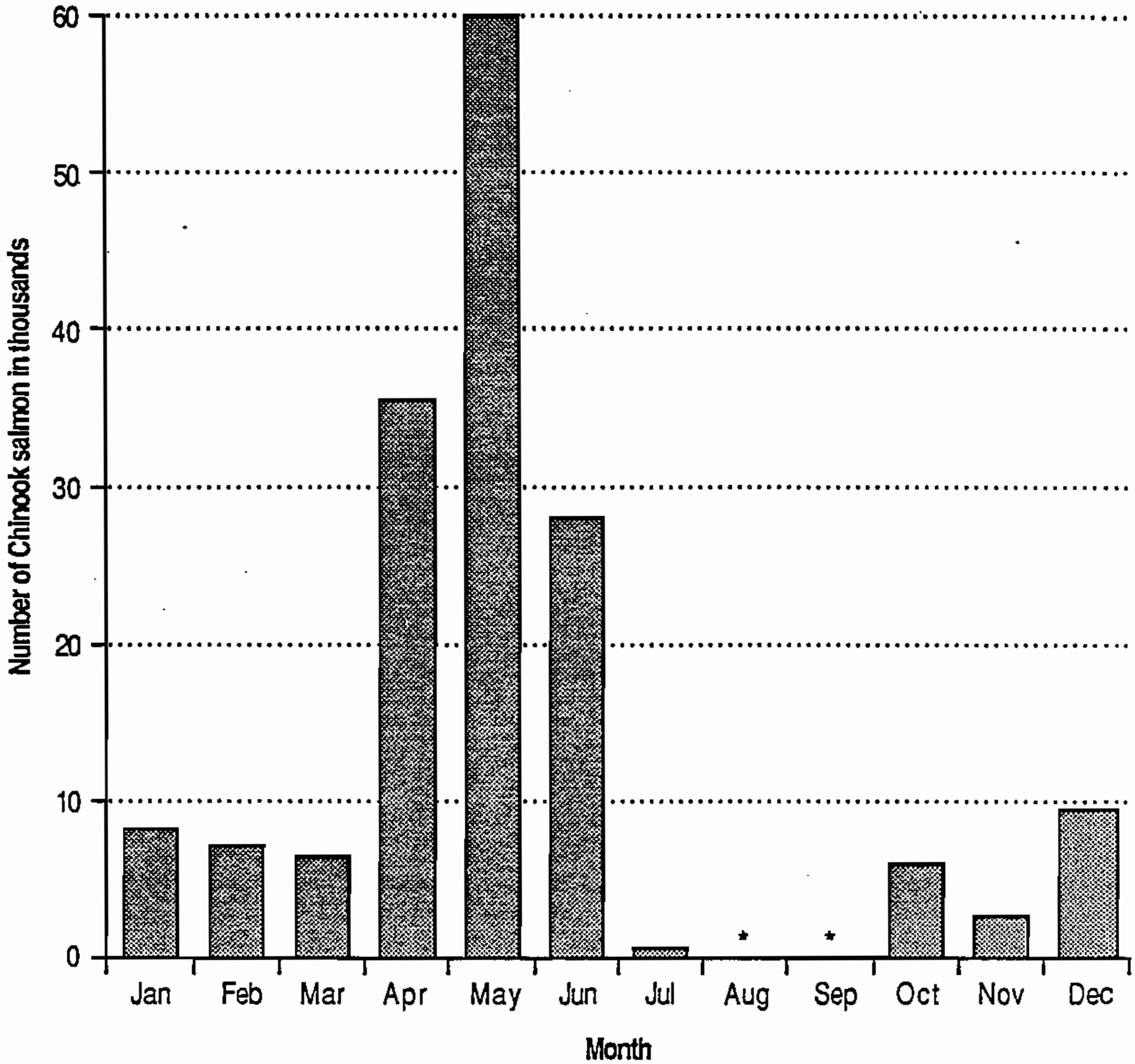
Salmon smolts migrate downstream through the Delta in all but the summer months when water temperatures reach lethal levels (USFWS,31,17-19). Including naturally produced fish and hatchery reared salmon released in or above the Delta (USFWS,31,27), the annual fall smolt run that passed Chipps Island between 1978 and 1985 was estimated to range from 10 to 50 million fish (USFWS,31,25). On the average, it takes an individual fall run smolt three weeks to emigrate from the upper Sacramento to the ocean, one week to reach the Delta and about two weeks to pass through the Delta and Bay (USFWS,31,32). Smolt emigration through the Delta usually peaks in May (Figure 4.5.1.2-3) (USFWS,31,22). However, smolts from different tributaries leave their natal streams and move into the Delta at different times and there are year to year variations in the timing of emigration (USFWS,31,23). The fall run emigration from April through June (USFWS,31,17) coincides with historical flow increases caused by snow melt (DWR,561,6). San Joaquin River Basin fall run smolts emigrate somewhat earlier during this period than Sacramento River Basin smolts (USFWS,31,23). The increase in Delta smolt abundance observed in October and November is probably the late fall race or yearling, fall run salmon. The winter or spring run emigrates from January through March. Peak abundance of salmon salvaged at the state's Delta pumping plant confirm this seasonal pattern of young salmon abundance in the Delta (see Figure 4.5.1.2-3).

- Survival and Abundance

Smolts migrate downstream to the ocean where they mature for two or more years. Recoveries of adults in the ocean, tagged as smolts and released in Suisun Bay, indicate that only about two percent survive. Thus, 10 to 50 million smolts would produce 200,000 to 1,000,000 fish available to the ocean fishery (USFWS,31,27). The number of fish escaping harvest and mortality and returning to the spawning grounds each year is known as annual escapement. Survival from eggs to returning adults in a stable population was reported to average 0.04 percent (DWR,561,3). No detailed evidence was presented regarding overall survival rates for Sacramento-San Joaquin Basin Chinook salmon.

The USFWS estimated that the abundance of naturally produced Chinook salmon has decreased by over 50 percent since the DFG began recording Central Valley escapement in the early 1950's when the population averaged over 400,000 fish (see Figure 4.5.1.2-4) (USFWS,31,1). From about 1955 until 1965, Sacramento Basin Chinook salmon escapement averaged above 250,000 fish. However, according to calculations by the DWR, over the last 20 years the total number of naturally produced adult salmon has declined to around 100,000 fish while escapement of hatchery reared fish has increased to about 90,000 fish (see Figure 4.5.1.2-4)(DWR,559,74). Escapement of nonhatchery salmon of all runs except the spring run have shown a consistent downward trend (see

FIGURE 4.5.1.2-3 Mean monthly salvage of Chinook salmon at the State Water Project fish protective facility, 1968 - 1986 (from DFG, 17, Appendix , Table 4)



* about 100 fish

FIGURE 4.5.1.2-4 Total Sacramento Basin fall run spawning Chinook salmon. Light bars are estimates of natural production, dark bars are estimates of production from Feather and American River hatcheries. Production from Coleman National hatchery is not included. (after DWR, 559,78, Figure VI-1)

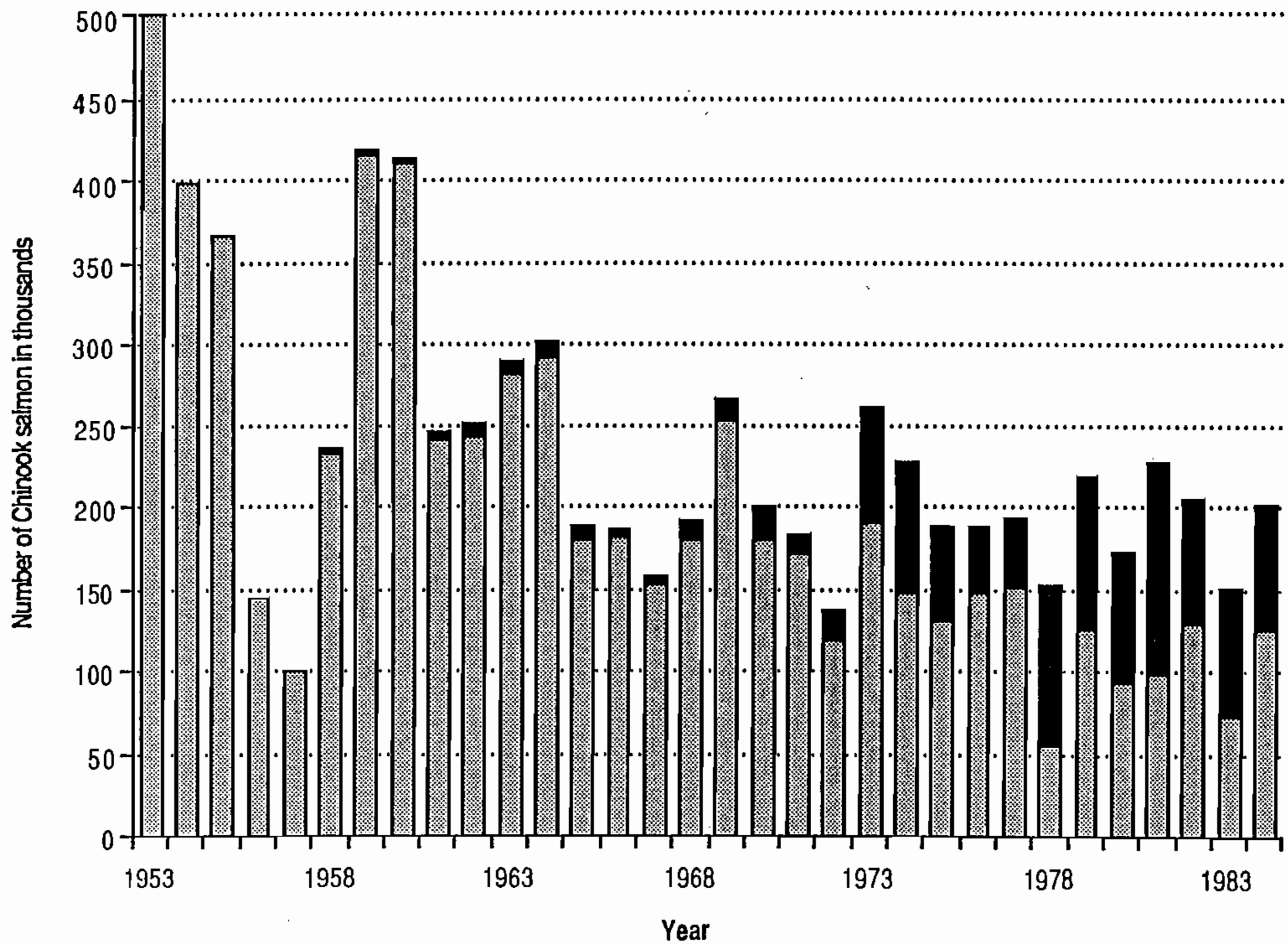


Figure 4.5.1.2-2). Upstream factors identified as contributing to the decline in natural salmon production include loss of habitat from construction and operation of dams and diversions (T,XXXV,25:20-23;DFG,15,8;T,XXXV,33:7-37:12). Stressful to lethal water temperatures, reduced or fluctuating flows, and harmful concentrations of toxins are also factors (USFWS,29;DWR,561)

Annual Sacramento Basin escapement and commercial ocean harvest have become relatively stable in the last 20 years due to the practice of taking immature Chinook salmon from the Feather and American River hatcheries and releasing them below the Delta (DWR,559,47-74; USFWS,31,2). Survival of these fish is six to eight times better than naturally or hatchery produced fish emigrating from upstream of the Delta (T,XXXVII,153: 2-154:1;T,XXXVII,161:22-162:1).

DWR's consultant reported that the Feather and American River hatcheries support. A significant proportion of spawning runs and the commercial catch (T,XXXVII,151:13-18, 14:1-14;T,XXXVI,140-10-21). Between 1978 and 1984, it has been estimated that hatcheries contributed an average of 87 and 78 percent to the American and Feather River runs, respectively (T,XXXVII,153:2-17), at least 16 percent or more to the upper Sacramento run, and an undetermined number to the Yuba River run (USFWS,29,12;T,XXXVII,152:6-22). DWR's consultant calculated that between 1978 and 1984 the Feather and American river hatcheries produced about 48 percent of total Sacramento Basin escapement and 44 percent of the ocean harvest of Central Valley Chinook salmon (T,XXXVII,151:22-152:5). This has enabled the commercial harvest of Central Valley Chinook to be maintained at around 350,000 to 450,000 fish and the catch to escapement ratio (harvest fraction) to double (T,XXXVIII,257:14-22) (see Figures 4.5.1.2-5 and 4.5.1.2-6).

San Joaquin Basin stocks, where the hatchery contribution to escapement is less than five percent (USFWS,31,107), still fluctuate widely (see Figure 4.5.1.2-7). Maximum adult escapement to the San Joaquin Basin appears to be correlated with high spring flow conditions two and one-half years earlier when young fish were produced and emigrating downstream (DFG,15,34-44;USFWS,31,64-66T,XXXVI,160:1-161:6). San Joaquin Basin escapement of 40,000 or more spawners is typical when spring outflows two and one-half years earlier are high (USFWS,31,65).

- Factors Contributing to Delta Survival

Delta conditions during smolt emigration have been identified as a major factor affecting salmon smolt survival and consequent adult escapement of hatchery and naturally produced Chinook (T,XXXVI,139:17-22). The primary changes identified by the USFWS, DFG and others to improve smolt survival in the Delta were: (1) higher spring flows, (2)

FIGURE 4.5.1.2-5 Estimated ocean harvest fraction for California Chinook salmon (illustrates the relative proportion of salmon harvested commercially to spawning escapement in the Central Valley) (T,XXXVIII, 251: 20-25 and 257: 19-22)
(adapted from DWR, 570)

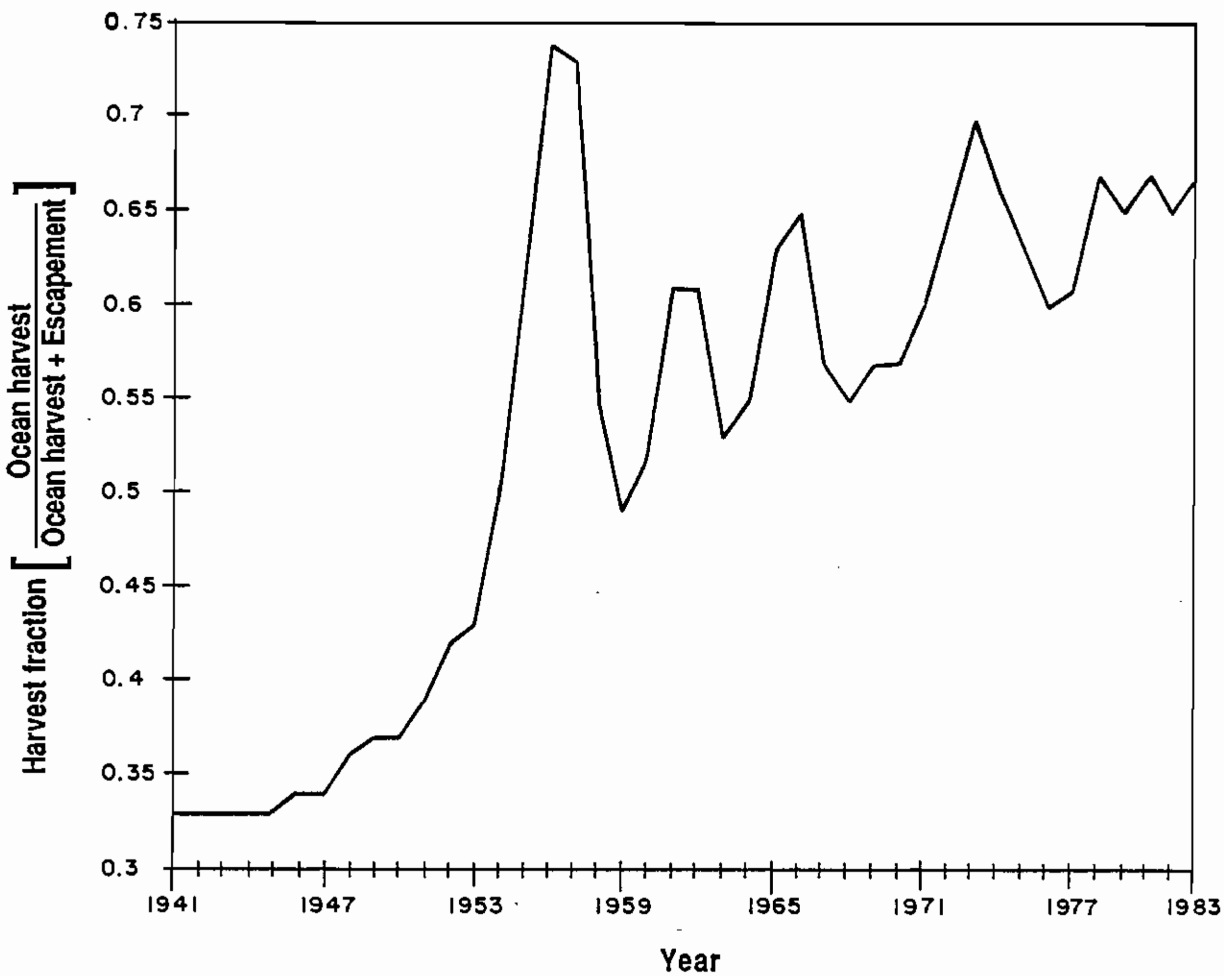


FIGURE 4.5.1.2-6 Estimates of annual ocean harvest of Central Valley Chinook salmon (after DWR, 561, 2, Figure III-3)

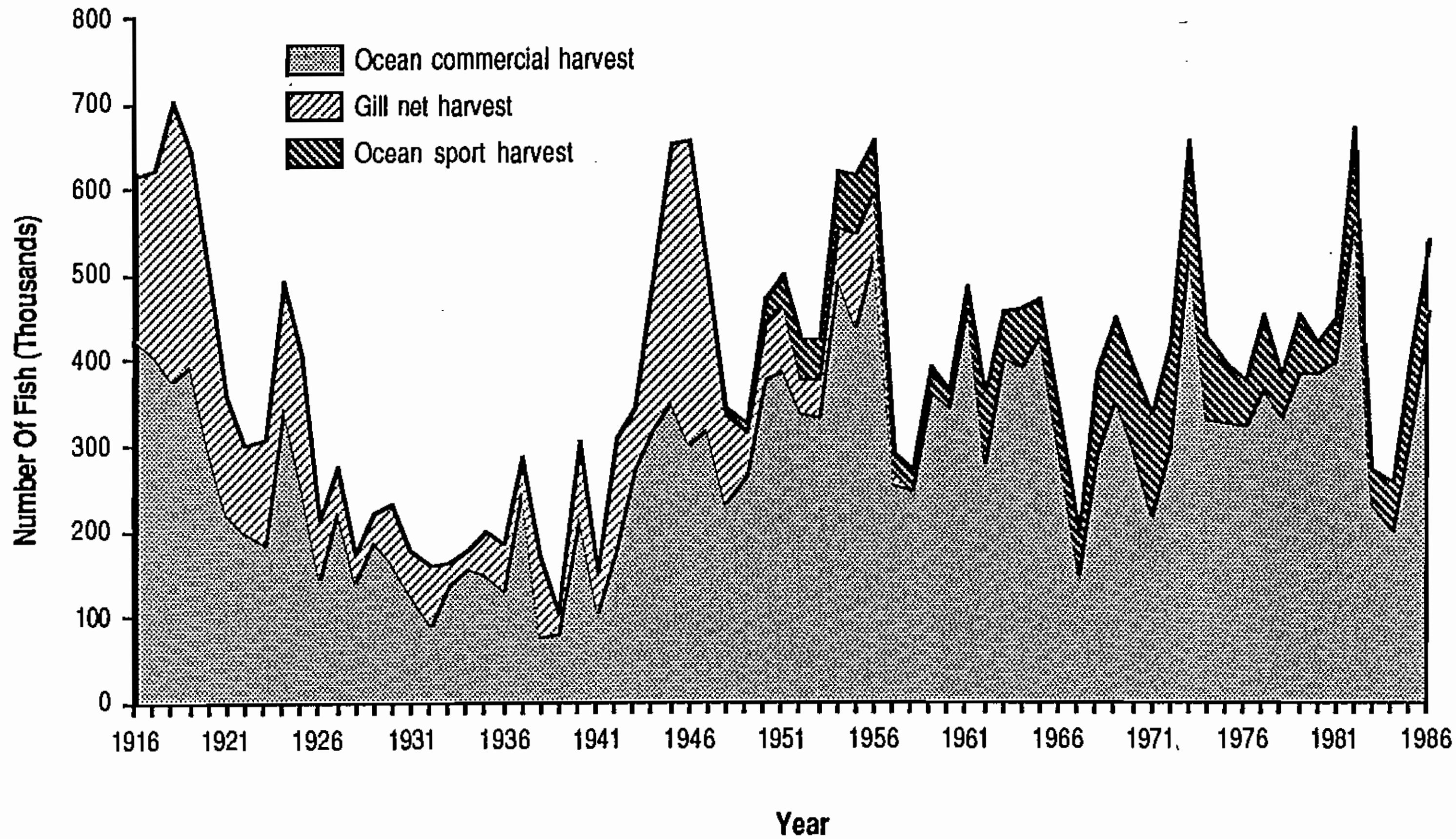
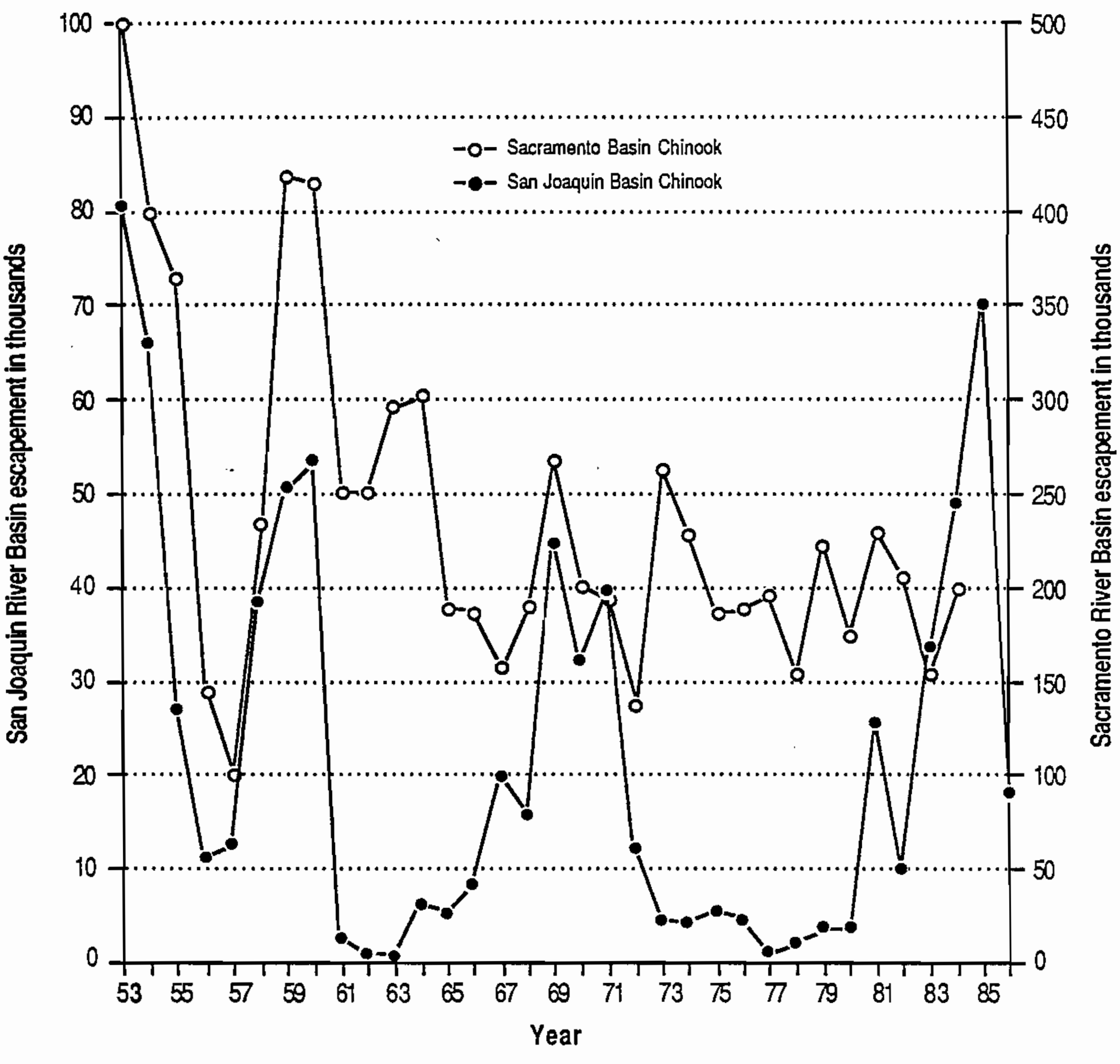


FIGURE 4.5.1.2-7 Comparison of total spawning escapement of Sacramento and San Joaquin River Basin Chinook salmon, 1953 - 1986 (from DFG, 15, Appendix 1)



temperatures below the stressful level of about 66 to 68°F, (3) "overcoming" the adverse impacts of water diversion that transport Sacramento Basin fish through the Delta Cross Channel, and (4) reverse flows in the lower San Joaquin that transport San Joaquin Basin fish away from their normal migration routes to CVP and SWP export pumps. (T,XXXVI,156:21-23; USFWS,31,62).

- Salmon Harvest and Economic Value

Table 4.5.1.2-2 shows the average estimated ocean commercial and sport catch of Central Valley Chinook salmon in California and an estimate of the proportion supported by hatchery production (DWR,559,45). The estimated 1977-1986 California commercial harvest of Chinook salmon from the Central Valley averaged well over 300,000 fish per year (USFWS,31,177,Appendix 32), representing almost 60 percent of the total ocean catch of Chinook salmon in California during this period. The five year average price per salmon purchased "off the boat" was estimated to be $26 in 1987. The average commercial catch for 1982-1986 was about 315,500 fish (USFWS,31,177), which translates to an average annual value of about $8.2 million per year for the commercial fishery. The ocean sport harvest averages about 60,000 fish per year (see Figure 4.5.1.2-6). It is estimated that $72 per day is spent for about 100,000 days of ocean recreational fishing, primarily party boat rentals, for an estimated annual value of $7.2 million (Thomson and Hupert, 1987). USFWS presented an estimate for the inland sport harvest of Chinook salmon of 35,000 fish (USFWS,31,103). However, Meyer Resources (1985) reported the inland catch to be ten percent of the ocean catch (BISF,40,15), or about 6,000 fish. At a catch rate of 0.2 fish per day represents a range of about 1,200 (for 6,000 fish) to 175,000 (for 35,000 fish) angler days each year. Based on cost estimates for shore fishing ($31 per day) to boat rental (about $48/day) the estimated annual value of the inland recreational Chinook fishery ranges from $37,300 to $57,500 for the lower catch estimate to $5.4 to $8.4 million for the upper catch estimate. The value of Central Valley Chinook salmon harvested in California's inland and coastal waters is estimated to range from a minimum of approximately $15.8 million to a maximum of approximately $23.8 million (see Table 4.5.1.2-3).

4.5.1.3. Striped Bass

Striped bass, <u>Morone saxatilis</u>, were successfully introduced into the Estuary at Martinez with the planting of about 140 fish from the Navesink River, New Jersey, on June 18, 1879. A second planting of 300 fish occurred in 1882 (BISF,58,2). The stock expanded quickly and before 1890 supported a commercial fishery that was terminated in 1935 due to a population decline (BISF,47,27). While important recreational fishery continues to the present, recent declines have caused concern.

Table 4.5.1.2-2. Estimated Average Annual Harvest of Chinook Salmon and the Hatchery Contribution to the Catch of Central Valley Salmon

Year	Ocean Commercial Catch 1/ (1)	Commercial Catch of Central Valley Chinook 1/ (2)	Percent of Ocean Catch from Central Valley Chinook (2/1) (3)
1952-1970	558,282	320,982	57
1971-1977	564,796	309,402	55
1978-1986	560,711	333,160	59

Year	Sport + Commercial Catch of Central Valley Chinook (2+4) (5)	Ocean Commercial + Sport Catch of Hatchery Chinook 3/ (6)	Percent Hatchery Chinook in Central Valley Catch (6/5) (7)
1952-1970	373,139	7,407	2.0
1971-1977	401,010	88,603	22.1
1978-1986	397,026	141,291	35.6

1/ from DWR,561,57, Appendix A-3
2/from DWR,561,58-60, Appendix A-4
3/from DWR,559,44-45, Table III-4. The period of time covers 1957-1970 for the American River hatchery alone. Subsequent years include the Feather River hatchery production through 1984. Contributions by other Central Valley hatcheries were not determined.

Table 4.5.1.2-3--Estimated Dollar Value of Chinook Salmon caught in California

Commercial Fishery (million $)	Sport Fishery[1/] (million $)		Total (million $)
	Inland	Ocean	
	.373-.575	7.2	15.8-16.0
8.2	5.4-8.4		20.8-23.8

[1/] Estimates of the size of the inland fishery vary widely from 6,000-35,000 fish. Therefore the estimated dollar value was calculated for both these estimates.

- Migration and Spawning

The striped bass is an anadromous fish. Most of its adult life is spent in San Francisco Bay and adjacent ocean areas (T,XLI,67:1-7). In the fall the adults migrate upstream and spend the winter in Suisun Bay and the western Delta. In spring the adults move farther upstream to spawn in the Sacramento River between Sacramento and Colusa and in the western and central Delta portion of the San Joaquin River between Antioch and Venice Island (T,XLI,67:1-16). The Delta spawning area is delimited by ocean salinity downstream and by land-derived salinity in excess of 0.550 mmhos/cm EC upstream, typically around Venice Island (T,XLI,68:11-20). Temperature is also important for spawning, with initiation of spawning typically occurring as water temperatures increase to above 61° F (SWC,203,13;SWRCB,450,24-1). Spawning typically occurs in the Delta from late April through May and in the Sacramento River from mid-May to mid-June (T,XLI,67:22-25). About one-half to two-thirds of the eggs that are spawned are produced in the Sacramento River, with the remainder in the Delta (T,XLI,67:20-22).

About 3 mm in diameter, striped bass eggs drift with the currents and hatch in two to three days (T,XLI,69:11-13). The larvae first feed on the remainder of their yolk sacs and oil droplets and continue to drift until they are about six mm in length when they start feeding (BISF,47,35) on zooplankton (copepods and cladocerans). They soon consume larger organisms, especially the opossum shrimp, Neomysis mercedis, which remains the dominant food organism through the first two years of life before the bass shift to larger food, including Bay shrimp and forage fish (T,XLI,70:1-8).

The majority of bass larvae tend to concentrate in the entrapment zone in Suisun Bay and the western Delta, although in very high flow years the larvae may be dispersed farther down the Estuary (T,XLI,69:15-24). The lower San Joaquin River appears to be a less desirable nursery area than in former years. Higher larval mortalities here appear to be the cause for the decline of the Delta portion of the Striped Bass Index (SBI)(T,XLIII,30:17-23;31:11-15).

Striped bass represent a substantial resource throughout the Estuary, upstream on the Sacramento River, in coastal waters and in export canals and reservoirs (see Sections 4.9.3 and 4.9.5). In the years 1983 to 1985, sales of striped bass stamps (required by law for fishing) have averaged over 560,000 per year (NOAA,1986). Annual recreational catches of striped bass (excluding reservoirs and aqueducts) vary from 100,000 to 400,000 fish (T,XLI,70:17-18) taken mainly from private boats or along the shoreline. Charter boats take 10-15 percent of the catch (T,XLI,70:25-71:17). Apart from the fishery, striped bass are also valuable in the food chain of the Estuary. Their eggs and small larvae also serve as food for other fish and invertebrates. Being principal predators in the river and estuarine food chains, larger bass contribute to the control of the size of forage fish populations.

Extensive, multi-year studies of the striped bass population have all indicated a substantial decline in the population since the 1950's (SWC,203,16-19; DFG,25,8-10,28-30,39-41). Estimates of adult population size have declined from about three million in the early 1960's to less than one million fish currently (T,XLI,72:3-7;SWRCB,500,1). The current two-fish, 18-inch minimum length bag limit was established in 1982 in response to this decline, and the striped bass stamp was instituted to provide additional funds for research on this fish. A variety of theories have been proposed to explain the reasons for the decline (see Chapter 5).

4.5.1.4 American Shad

American shad, Alosa sapidissima, is a warm water, anadromous fish species. Shad were introduced to the Delta from the east coast in the late 1800's and within ten years a commercial gill net fishery developed. Over one million pounds (lbs) per year were regularly harvested. It is estimated (at an average weight of three lbs per fish) that this represented a catch of about two million shad, with a total population of two to three times this number (DFG,23,16). By the late 1940's the fishery declined, and by 1957 commercial fishing of shad ended when gill netting was prohibited to protect other fisheries (DFG,23,1; SWRCB,405).

A popular shad sport fishery exists in the Sacramento, San Joaquin, American, Feather, and Yuba rivers and in the Delta. Surveys in the late 1970's indicate that between 35,000 and 55,000 angler days were spent in catching about 79,000 to 140,000 shad (DFG,23,1-2). Estimates from a 1976-1977 survey indicate a population of about three million shad (T,XXXIX,13:11-12;DFG,23,15). No specific data on the value of the shad fishery is available. However, if shore fishing expenditures average about $31 per angler day (Thomson and Huppert, 1987), the total annual value ranges from $2.4 to $4.3 million.

The life history stages and habitat requirements of American shad are shown in Table 4.5.1.4-1. Adult shad spend three to five years in the ocean before they reach maturity (SWRCB,450,3-3) and enter the lower Estuary in the fall; they migrate through the Delta from about March through May to upstream spawning grounds (T,XXXIX,13:23-24), actively feeding on copepods and cladocerans, as well as Neomysis and Corophium (DFG,23,12; SWRCB,433,100). Peak adult numbers occur in the upper Delta in May (DFG,23,5) at water temperatures ranging from about 57° to 75°F (DFG,23,4).

Historically, spawning occurred through the tidal fresh water reaches of the San Joaquin and Sacramento rivers and upstream (T,XXXIX,14:5-7) from about May through July. Today, the lower San Joaquin River no longer supports significant spawning activity because of poor water quality as well as low and reverse flows during the spawning season (T,XXXIX,14:23-24;SWRCB,450,3-3). Spawning occurs from May to June in the north Delta, the Sacramento River above Hood up to the Red Bluff diversion dam, and the major tributaries of the Sacramento River (DFG,23,2-4; SWRCB,450,3-3; DFG,13,21; SWRCB,405,41).

Table 4.5.1.4-1--American Shad Environmental Requirements and Life History Stages (from DFG,23;DFG,13;SWRCB,405;SWRCB,433)

Life Stage	Location	Period	Flow	Water Quality	Other
Adult Migration	from Pacific Ocean through Bay-Delta to upstream freshwater tributaries	March-May	low flows reduce size of run in tributaries	temperature 57-75° F	diet is _Neomysis_ and other zooplankton
Spawning	upper Sacramento River to Red Bluff Diversion Dam and major tributaries, North Delta, Mokelumne and Old River. Formerly San Joaquin R.	April-early July	higher flows increase numbers spawning in tributaries	63-75° F optimum = 60-70° F	spawn over sand or gravel
Egg Incubation	lower Sacramento R. below Colusa, Feather and American Rivers, Delta	May-July	higher flows carry more eggs into Delta		
Rearing	same as above	June-Sept	more juveniles produced when flows are higher		feed on terrestrial insects, zooplankton
Juvenile Emigration	Delta-Estuary to Bay or Pacific Ocean	late June-December			diet is _Neomysis_, _Corophium_, larval fish, copepods

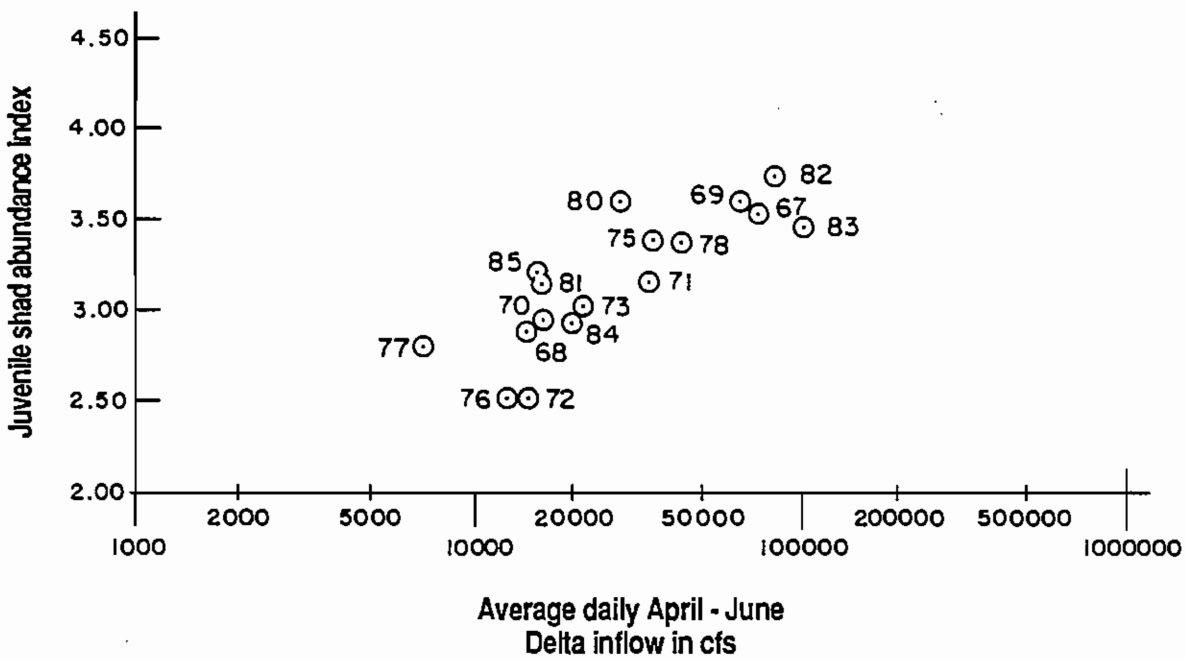
Shad spawn where there is a current, over gravel or sand at water temperatures of about 60°F to 75°F (DFG,13,21; DFG,23,3). The distribution and abundance of spawners is influenced by flow. When spring tributary flows are low, the bulk of the run spawns in the main stem of the Sacramento River while spawning in the tributaries decreases (T,XXXIX,14:12-14:22;DFG,13,22). Many shad die after spawning although some do survive to spawn again. It is believed these fish return to the tributary where they initially spawned (DFG,23,8).

After shad spawn, the fertilized eggs sink and drift with the current until hatching about 4-6 days later (SWRCB,405,41). When river flows are high, more shad eggs are carried further downstream and the importance of the Delta as rearing habitat increases (T,XXXIX,15:13-15). The major shad nursery areas are located in the Feather River below the mouth of the Yuba River, the lower American River, the Sacramento River from Colusa to Sacramento, and the north Delta (DFG,23,8;T,XXXIX,15:3-15:6). Shad nursery habitat is mostly upstream from striped bass nursery habitat (T,XXXIX,49:1-49:3) and overlaps with Chinook salmon rearing areas. In rearing areas upstream from the Delta, young shad concentrate near the water surface, feeding on terrestrial insects that drop into the water from riparian vegetation (SWRCB,433,101). From about June through August in the Delta, young shad feed on zooplankton before emigrating as juveniles during September to December (DFG,23,11; SWRCB,450, 3-3). Most shad emigrate by the end of their first year (DFG,23,10). However, some may remain in San Francisco, San Pablo, and Suisun bays and Suisun Marsh for a second year or not emigrate to the ocean at all (DFG,23,10-11). According to DFG relatively few yearling shad use the Suisun Marsh (T,XXXIX,46:1-5).

When Delta inflows are greater during the spawning and rearing seasons, shad production increases (Figure 4.5.1.4-1) (DFG,23,17). Higher flows during the spring to early summer may improve shad abundance by: (1) providing more spawning and rearing habitat with a consequent reduction in competition for food; (2) dispersing eggs and larvae over a larger area which also decreases competition; and (3) reducing the proportion of river flow diverted to the export pumps, thereby reducing the number of young shad entrained (T,XXXIX,16:2-17:16).

Millions of young shad, both those spawned in the Delta and migrants from the Sacramento River that have been transported through the Delta Cross Channel, are entrained by the CVP and SWP export pumps (DFG,23,20-21;TXXXIX;17:6-24). Fifty percent or more of the shad collected at the CVP and SWP fish protection facilities die during fish salvage operations (T,XXXIX,17:11-16-18:4;DFG,23,22). Numerous unscreened Delta agricultural diversions also contribute to the mortality of young shad (T,XXXIX,17:4-10). Water diversions during the spawning and rearing season may also reduce shad production by decreasing the abundance of their primary food, zooplankton (T,XXXIX,18:6-18).

FIGURE 4.5.1.4-1 Relationship between average daily April-June inflow to the Delta and fall abundance of juvenile American shad, 1967-1985 (except 1974 and 1979) (from DFG, 23, 19).



4.5.1.5 Other Resident and Anadromous Fish

There are over 30 species of resident, warmwater fishes in the Estuary (DFG,24,2), more than half of which were introduced. Most resident fish are members of one of three families: Centrachidae, sunfish; Cyprinidae, minnows; and Ictaluridae, catfish.

- Background

These families support popular recreational fisheries in the Delta. White catfish, Ictalurus catus, are the most commonly caught resident fish, followed by largemouth bass, Micropterus salmoides, and then other sunfish. Sunfish, catfish and largemouth bass are the second, third, and fourth most commonly caught gamefish statewide (DFG,24,5). Non-game resident fish are important components in the estuarine food web both as predators and prey (DFG, 24,6). An important introduced forage species, the threadfin shad, Dorosoma petenense, is consumed by striped bass, largemouth bass and other sunfish (SWRCB,450,3-10).

Relatively little is known about specific flow and water quality requirements of resident fishes of the Estuary (DFG,24,5). The results of a 1980 to 1983 survey by DFG were broadly descriptive but the habitat conditions controlling resident species populations could not be determined (DFG,24,41). Many of the native species were so rarely collected that they could not be statistically analyzed (DFG,24,2). Table 4.5.1.5-1 lists the resident species of the Estuary. Table 4.5.1.5-2 summarizes the regional water quality trends as measured during the DFG survey.

According to DFG, native species were generally associated with the "better water quality" of the northern and western Delta (DFG,24,41), but this could not be confirmed from the information presented. Species abundance and diversity was second highest in the northern Delta compared to the other regions (DFG,24,16). The abundance of several species—the native Sacramento sucker, Catostomas occidentalis; prickly sculpin, Cottus asper; tule perch, Hysterocarpus traski; Sacramento squawfish, Ptychocheilus grandis; and splittail, Pognichthys marolepidotus—was greatest where electrical conductivity (EC) was lowest, mainly in the northern and western Delta (DFG,24,19). However, it is known that the splittail, tule perch and prickly sculpin tolerate brackish conditions. It is therefore possible that other factors may be responsible for their distribution (DFG,24,21-22). The highest abundance and diversity of resident fish was observed in the eastern Delta (DFG,24,18) where introduced species predominated in the sluggish deadend sloughs (see Table 4.5.1.5-2).

According to DFG, Delta water temperatures are within the tolerance range of resident species (DFG,24,39). Warm water fish can tolerate temperatures as high as 86°F. Several native minnows are associated with the cooler temperatures

Table 4.5.1.5-1--Fishes of the Delta (from DFG 24 and SWRCB,450)

Cyprinidae - Minnows

Carassius, auratus, goldfish (I)* +

Cyprinus, carpio, common carp (I) +

Lavinia, exilicauda, hitch (N) +

Mylopharadon, conocephalus, hardhead (N) +

Notemigonus, crysoleucas, golden shiner (I) +

Orthodon, microlepidotus, Sacramento blackfish (N) +

Pimephales, promelas, fathead minnow (I)

Pogonichthys, macrolepidotus, splittail (N) + 2/

Ptychocheilus, grandis, Sacramento squawfish (N) +

Ictaluridae - Catfish

Ictalurus, catus, white catfish (I) +

Ictalurus, melas, black bullhead (I) +

Ictalurus, nebulosus, brown bullhead (I) +

Ictalurus, punctatus, channel catfish (I) +

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* I=introduced, N=native + indicates species collected in DFG's 1980-1983 electrofishing survey

1/ Species of special concern being considered for endangered species status

Table 4.5.1.5-1--contd.

Centrarchidae - Sunfish

Lepomis, cyanellus, green sunfish (I) +

Lepomis, gibbosus, pumpkinseed (I) +

Lepomis, gulosus, warmouth (I) +

Lepomis, macrochirus, bluegill (I) +

Lepomis, microlophus, redear sunfish (I) +

Micropterus, dolomieui, smallmouth bass (I) +

Micropterus, punctulatus, spotted bass (I) +

Micropterus, salmoides, largemouth bass (I) +

Pomoxis, annularis, white crappie (I) +

Pomoxis,-nigromaculatus, black crappie (I) +

Others

Catostomus, occidentalis, Sacramento sucker (N) +

Hysterocarpus, traski, tule perch (N) +

Menidia, beryllina, inland silversides (I) +

Table 4.5.1.5-1--condt.

Dorosoma, petenense, threadfin shad (I) +

Percina, macrolepida, bigscale logperch (I) +

Morone, saxatilis, striped bass (I) +

Alosa, sapidissima, American shad (I) +

Acanthogobius, flavimanus, yellowfin goby (I) +

Cottus, asper, prickly sculpin (N) +

Leptocottus, armatus Pacific staghorn sculpin (N) +

Oncorhynchus, tshawytscha, chinook salmon (N) +

Salmo gairdneri, gairdneri, steelhead (N) +

Gambusia, affinis, mosquitofish (I) +

Gastrosteus, aculeatus, three spine stickleback (N) +

Lampetra, tridentata, Pacific lamprey (N) +

Lampetra, ayresi, river lamprey (N)

Mugil, cephalus, striped mullet +

Hypomesus, transpacificus, Delta smelt (N) + 1/

Spirinchus, thaleichthys, longfin smelt (N) +

Platichthys, stellatus, starry flounder (N) +

Acipenser, transmontanus, white sturgeon (N)

Acipenser, medirostris, green sturgeon (N)

Table 4.5.1.5-2--Annual Average Water Quality Trends in the Delta (from DFG,24,15)

Delta Region	Water Temperature (°F)	Electrical Conductivity (mmho)	Dissolved Oxygen (ppm)	Transparency (cm)
Eastern	63.1	212	8.8	50.5
Northern	61.5	197	9.7	61.4
Western	61.7	353	9.6	46.6
Central	62.1	316	9.0	55.3
Southern	62.8	460	9.0	44.0

more typical of the northern and western Delta (DFG,24,39), (see Table 4.5.1.5-2). Except in localized areas, dissolved oxygen (DO) concentrations at or below the lethal level of 3 ppm were not observed (DFG,24,40-41). The DFG study concluded that resident fish abundance could not be correlated with Delta water temperatures or DO levels (DFG,24,39).

- Sunfish

Sunfish were most abundant in the eastern Delta in habitats with slow currents such as deadend sloughs, oxbows, and sheltered channels and embayments (DFG,24,29); with abundant riparian and/or aquatic vegetation (DFG,24,41-42); and with an abundance of zooplankton (DFG,24,22-23). Sunfish are carnivorous and eat everything from zooplankton to young-of-the-year striped bass (DFG,24,3;SWRCB, 433,145-152). They spawn in shallow water during the spring and summer when water temperatures range from 57° to 75°F (DFG,24,3). Aquatic vegetation is used as cover by all life stages (DFG,24,34).

The only native sunfish, the Sacramento perch, Archoplites interruptus, has disappeared from the Delta, probably due to competition with introduced species and habitat destruction (DFG,24,22). This species was once very widespread and abundant in the waters of the Central Valley floor but is now found only in artificial impoundments where it has been introduced (SWRCB,433,17).

- Minnows

Three species of introduced minnows--the carp, Cyprinus carpio; the goldfish, Carassius auratus; and the golden shiner, Notemigonus crysoleucus--have come to dominate the five species of native minnows (see Table 4.5.1.5-1)(DFG,24,4). The introduced minnows are abundant in the slow water of sloughs and sheltered channels, particularly in the eastern Delta (DFG,24,29).

In an earlier study (SWRCB,433,154), the introduced goldfish and carp, as well as the native Sacramento blackfish, Orthodon microlepidotus and Sacramento hitch, Lavinia exilicauda, were most numerous in the southern Delta at Mossdale on the San Joaquin River, and were also associated with high concentrations of dissolved solids, an indication of elevated salinity typical of areas receiving agricultural drainage. In the present study, goldfish, carp, and Sacramento blackfish were associated with higher salinity habitats in the Delta (DFG,24,28).

The native minnows have diverse feeding habits. The splittail eats Neomysis in the Estuary and amphipods and clams in the Delta (SWRCB,407,53); blackfish feed on phytoplankton and organic detritus; the hitch, zooplankton, and the squawfish, other fish (SWRCB,407,53). The introduced minnows eat small insects, zooplankton and plant material (SWRCB,450,10-4,10-6,10-15).

- Catfish

Of the four species of introduced catfish (see Table 4.5.1. 5-1), the white catfish, by far the most numerous (DFG,24,4) supports a significant recreational fishery. In the southern Delta where EC and turbidity were greater, white catfish were the most numerous resident fish species (DFG,24,28). The breeding behavior of all four species is similar, spawning in the spring and summer when water temperatures reach or exceed 70°F (SWRCB,405,22-27). They are omnivorous (DFG,24,4), but the amphipod, Corophium, was found to be their primary food (SWRCB, 433,131-143). According to the DFG survey, white and channel catfish, Ictalurus punctatus, are abundant in the turbid riverine and open slough habitats of the south Delta where EC rises as agricultural runoff increases during the summer.

- Other Anadromous Species

Several other native, anadromous fish use the Delta as a migration corridor and nursery habitat. They are the green sturgeon, Acipenser medirostris; the white sturgeon, Acipenser transmontanus; and the steelhead rainbow trout, Salmo gairdneri gairdneri. Other than information presented in SWRCB exhibits, no testimony or recommendations were made in Phase I of the hearing regarding these species' use of the Delta.

Little is known about either the white or green sturgeon. Adults of both species migrate through the Bay-Delta to upstream spawning areas (SWRCB,405,38). White sturgeon migrate from the late winter through early spring. Most spawning occurs between February and May (SWRCB,407,46) in the Sacramento River upstream of its confluence with the Feather River. Larvae are present from late February to early June. Following spawning, adults return to the Bay and Delta where they remain, feeding on benthic invertebrates, Bay shrimp and herring. Green sturgeon are believed to spend more time offshore, traveling up and down the coast (SWRCB,430,452-453). Juvenile sturgeon live year round in the Delta, eating American shad, Corophium, Neomysis, and other species of benthic invertebrates and shrimp (SWRCB,433,120-122).

An intense commercial sturgeon fishery existed in the 1800's. It was closed in 1901 after the catch plummeted. The fishery reopened in 1910, was closed in 1917, and only reopened for recreational purposes in 1954 (SWRCB,430,453). Angling is popular in the Sacramento River up to Colusa, the Delta (SWRCB,405,35-36), and the bays. Sturgeon are taken in San Francisco Bay where they congregate to feed during the herring runs (SWRCB,430,454). Party boats reportedly harvested 2,400 sturgeon in 1967. There is no information on the recent magnitude of the recreational fishery.

Adult steelhead migrate upstream from the ocean during the spring through fall. Spawning occurs from December through April in tributaries above the Delta. Like salmon, steelhead return home to their natal stream; unlike salmon, not all adults die after spawning. Steelhead are known to have spawned up to four or more times (SWRCB,405,60; SWRCB,450, 5-7). There are several seasonal runs of steelhead migrating through the Delta (SWRCB,405,59-60;SWRCB,450,5-6). The size of the recreational fishery for steelhead adults and juveniles is unknown.

Juvenile steelhead rear in freshwater habitats for one to three years (DFG,13,21). Because they require flows to maintain adequate habitat during this period and much of their original upstream habitat is no longer available, natural steelhead populations have declined (SWRCB,407,48). Hatcheries in the upper Sacramento, Feather, American, and Mokelumne rivers now produce many of the steelhead occurring in the Bay-Delta (SWRCB,450,5-7;SWRCB,407,48). During their downstream migration through the Bay-Delta Estuary in the spring (April-May) and fall, juvenile steelhead feed on Corophium, terrestrial and aquatic insects, crustaceans, and fish (SWRCB,433,113; SWRCB,450,5-7).

- Species of Concern

The splittail is one of two species of special concern because its distribution is restricted to the Bay-Delta Estuary and it has recently declined in abundance (USFWS,35,1). The other, the Delta smelt, Hypomesus transpacificus, once abundant in Suisun Marsh and the Delta, has undergone a precipitious decline since the early 1970's (USFWS,35,20). Both fish have been recommended as candidate species by the USFWS to be studied to determine whether they should be added to the federal endangered and threatened list (USFWS,35,11).[1/]

Resident fish are subject to entrainment by the SWP and CVP Delta pumping plants. Between 1978 and 1985 an average of 330,000 white catfish and 810,000 threadfin shad were entrained annually at the SWP, with the highest numbers during the summer (DFG,24,35-36). Species inhabiting open

1/ Listing refers to a process established under state and federal Endangered Species Acts by which native species are identified. Those listed are determined to be in immediate jeopardy of extinction ("Endangered") or to be present in such small numbers throughout their range that they may become endangered if their present environment worsens (rare plant or threatened species) (California Fish and Game Code Sections 1901, 2062, 2067 and 2068; 16 USC.Section 1531, et seq.)

water or more riverine habitats are thought by DFG to be more vulnerable to diversion and entrainment than fish inhabiting dead end sloughs and other backwater areas. However, since the size of resident fish populations is unknown, it cannot be determined what effect losses caused by water diversions may have (DFG,24,36).

The information on resident freshwater species and other anadromous fish presented in the Phase I hearing was mostly descriptive. No quantitative data were presented on the relationship between population abundance and distribution and flow or salinity regimes. In the absence of such information no water quality objectives can be developed. Therefore, there will be no further discussion of these species in the following chapters of this report.

4.5.2 Bay Habitat

Suisun, San Pablo, San Francisco and south San Francisco (south) bays and consider here. Since, for this Plan, Suisun Bay is considered to be part of the Bay, it is included here for purposes of discussion (see Section 4.5.1.1).

4.5.2.1 Phytoplankton and Zooplankton

As in the freshwater portions of the Estuary (Section 4.5.1.1), phytoplankton and zooplankton form important parts of the food chain in the more saline portions of the Estuary. Extensive testimony was presented concerning three major issues. The first is the need for Delta outflows to position the entrapment zone in Suisun Bay in particular locations, and to stimulate growth of phytoplankton and zooplankton (including the opposum shrimp) to provide food for young striped bass and other fish species. As noted in the discussion of the Delta (Section 4.5.1.1), there have been numerous changes in the Bay in recent years. A second factor is the periodic intrusion of freshwater or estuarine benthic organisms into Suisun Bay under different outflow conditions (T,LXII,58:22-59:11;68:3-16), and their possible impacts on phytoplankton abundance. A third is the recently reported introduction of a new species of benthic bivalve (Potamocorbula amurensis, Family Corbulidae) which further complicates attempts to understand the biology of Suisun Bay.

Some Phase I hearing participants proposed objectives to maximize phytoplankton production, locate the entrapment zone in particular positions, and prevent intrusion of marine benthos into Suisun Bay (see, for example, CCCWA/EDF Exhibits 1 and 2). However, much of the evidence was challenged by other participants (see, for example, USBR rebuttal, T,LXII,65:18-75:9).

In the absence of definitive date to draw on, these positions cannot be resolved. However, it would appear that proposed Delta outflow objectives to protect other beneficial uses, especially outmigration of striped bass larvae and salmon smolt, are generally consistent with those outflows volumes required for protection of certain Suisun Bay aquatic resources. Some of the proposed objectives are also contradictory. Proposing, for instance, an objective to protect one food chain for striped bass, namely by stopping the intrusion of benthic organisms, has an immediate negative impact on the food chain of demersal (bottom-feeding) fish such as sturgeon. No evidence was presented that established there would not be negative impacts on these fish.

The second issue was the proposal to provide sufficient freshwater inflow to develop an entrapment zone in San Pablo Bay similar to that seen in Suisun Bay. The benefit of this second entrapment zone was intended to be additional production of phytoplankton, a concept proposed by witnesses for CCCWA/EDF based on their interpretation of USGS, USBR and other data. They presented evidence to suggest that, at Delta outflows of 10,000 to 20,000 cfs, an entrapment zone forms in Suisun Bay and an apparent second entrapment zone (or at least an area with "stratified flow...with a strong horizontal salinity gradient") forms in San Pablo Bay (CCCWA/EDF,3,23). This position was challenged by USBR in their rebuttal testimony and exhibits (T,LXII,75:10-87:12).

The evidence for the presence of a second entrapment zone is not conclusive. In addition, no compelling evidence was presented to demonstrate a benefit to populations of fish or invertebrates if such an entrapment zone did develop in San Pablo Bay.

The third major issue concerned the merits of setting objectives to cause a stratification of the South Bay by introduction of freshwater inflow, either by month-long periods of high winter or spring outflow or by short periods of large storage releases at specified times (i.e., pulse flows). It was proposed that these flows would enhance phytoplankton production in the South Bay (CCCWA/EDF,4). USGS testified that they have observed a correlation in South Bay among freshwater inflow, density stratification, and rapid development of phytoplankton blooms (T,LI,179:2-23). Their research also showed that the clam, Macoma balthica, tended to show increases in growth rates consistent with availability of microalgae, including phytoplankton (T,LI,181:20-182:15). These and other data were used as the basis for the CCCWA/EDF proposal. However, it was noted that the clams responded not just to increases in phytoplankton, but also to increases of periphyton, microalgae growing in the sediment (T,LI,238:1-22). In addition, these phytoplankton blooms have not been shown to have effects on zooplankton abundance. There is also no evidence to conclude that increases in zooplankton or benthos are likely to yield increases in fish populations in the South Bay. USGS noted that in other estuaries a relationship between phytoplankton production and fisheries production had been demonstrated, but to their knowledge, no such relationship has been demonstrated for San Francisco Bay (T,LI,180:9-181:11; 192:10-17).

Like that for the Delta, the evidence presented is not sufficiently definitive to develop specific objectives for the protection of phytoplankton and zooplankton in Suisun, San Pablo, San Francisco and South bays. It is anticipated that freshwater inflow resulting from flows to protect beneficial uses in these areas or upstream may also provide protection for estuarine phytoplankton and zooplankton. Should additional evidence indicate that these aquatic resources are not being protected, and the evidence is sufficiently definitive to propose objectives, this issue may be reexamined at a later date.

4.5.2.2 Benthic Invertebrates

"The 'benthos' is the community of invertebrate animals (worms, clams, shrimp, etc.) living on the bottom of aquatic environments. These animals consume organic matter that grows on, or settles to the bottom and in turn become food for fish and other consumers including humans" (TIBCEN,23,65). Benthic invertebrates in the Estuary tolerate a range of salinities; some prefer different flows and salinities at different life stages (DFG,59,14). There are species requiring only freshwater, species requiring a combination of salt and freshwater, and those surviving only in saltwater. For example, some species such as the commercially valuable starry flounder (Platichthys stellatus) prefer fresher water during early life stages and as juveniles are found in the upper reaches of the estuary, whereas adults prefer higher salinities and occupy the Bay (DFG,59,22). Adult shrimp occupy bottom areas in their preferred habitat, while shrimp larvae are found in less saline surface layers. These behavioral differences, combined with the effects of the two-layered flow in the Bay (see 3.6.2.1) result in different distributional patterns of young and old shrimp (USBR,110,15). For example, Crangon shrimp breed in the Bay, produce planktonic larvae which may be carried into the ocean near shore by surface water, drop down as benthic post-larvae and reenter the estuary carried by gravitational circulation (DFG,59,23). Gravitational circulation also strongly affects the distribution of bottom-dwelling species like speckled sanddab and English sole larvae (DFG,59,24).

The following benthic organisms found in the Estuary are part of the food chain which support popular sport or commercial fisheries and wintering waterfowl:

- mollusks, including clams (Macoma balthica, Mya arenaria, Tapes japonica, Gemma gemma, Corbicula spp.), mussels (Ischadium demissum, Mytilus edulis), oysters (Ostrea lurida), and snails (Nassarius obsoletus);

- arthropods, including amphipods (Corophium, spp. Grandidierella japonica, Ampelisca milleri), shrimp (Crangon spp.), and crabs (Cancer spp.); and

- worms (Limnodrilus spp., Boccardia ligerica, Streblospio benedicti) (Markmann, 1986).

There is a pronounced "faunal break" west of Suisun Bay, where freshwater and brackish water species give way to salt-tolerant species found in San Pablo Bay (DFG,59,12).

Densities of benthic organisms are highly variable in the Estuary. At any location their survival and growth can be affected by factors such as predation, disease, parasites, currents which carry them away, salinity regime and broodstock population size (DFG,60,57). Density estimates[1/] as high as 910 to 1153 grams per square meter (g/m^2) are reported in South Bay channels, to as low as 4 to 17 g/m^2 in the channels of San Pablo Bay; Suisun Bay has benthic invertebrate biomass ranging from 25 to 34 g/m^2 in channel substrates and from 6 to 30 g/m^2 in shoal areas (CCCWA/EDG,10,T2). The number of organisms varies much more than the biomass, with a few large animals sometimes equalling the biomass of many smaller ones. At the Carquinez Strait, this biomass was made up of about 160,000 and 40,000 organisms/m^2 in June and October of 1976; 25,000 organisms/m^2 in March of 1977; but by less than 1,000 organisms/m^2 in October 1977 and in 1978 (Markmann,1986,F8-F11). Organism numbers per m^2 at all stations were low in 1978; numbers appeared to recover to about 40,000 organisms/m^2 in the western Delta (Station D4) in 1979 and 1981, although Carquinez Strait stations were no longer sampled (Markmann, 1986, F8-F11). The brief peak in organism numbers in 1976 and 1977 during a major drought was due in part to an invasion of Suisun Bay by the filter-feeding clam, Mya arenaria, which replaced the usual deposit-feeding fauna (CCCWA/EDF,7,383).

The benthic grazing hypothesis was formed to explain the high numbers of these (e.g., Mya arenaria) more saline tolerant filter feeders (a ten-fold increase when compared to non-drought conditions) and the low phytoplankton and zooplankton populations during the 1976-1977 drought (CCWA,EDF,7,385). In Suisun Bay, the benthic salt-tolerant, filter-feeders apparently become large enough and sufficiently abundant to be capable of filtering the entire volume of the Suisun Bay in a day. With this amount of feeding, it is hypothesized that benthic filter-feeders consumed virtually all phytoplankton and nutrient material in the water column. The pelagic (open-water) food web, which is also based on phytoplankton, was therefore replaced by the benthic food web (CCCWA/EDF,7,386). However, it appears that marine benthic organisms which do invade during dry periods will be virtually wiped out during years of high flow. In the same way,

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1/ Abundance or density of benthic organisms measured by biomass per square meter freshwater filter-feeding organisms will be eliminated during drought. Under unimpaired rainfall and runoff conditions, the Suisun Bay normally receives enough fluctuation in salinity to prevent either marine or freshwater filter-feeding benthic organisms from surviving for more than a few months (SWRCB,105). This fluctuation in conditions provides a habitat which is uniquely suited to an open-water food web based on phytoplankton and zooplankton.

One of the consequences of water project operations under D-1485 is that salinity fluctuations in the Estuary are reduced under most flow conditions (SWRCB,102,A-K;SWRCB,103,A-C). Variability of habitat in the bays and estuaries normally increases the number of species (DFG,59,9-10). Under the more stable conditions of salinity which result from operations under D-1485, a reduction in habitat and species diversity can be expected. At present, with existing storage facilities and diversion capability operated according to D-1485, there are still a large number of pulses of freshwater outflow during above normal and wet years (LIII,199:13-17;DWR,654;DWR,655). DFG concluded that reductions in either annual outflows or pulse flow levels could result in more intraspecific competition and reduce recruitment into the adult population, but that more field observation than the six years of field sampling to date should be used to test whether their conclusion was correct (DFG,59,30).

Because substantial variation in freshwater outflow from the Delta will continue to occur with existing water project operations, and because of the lack of testimony or evidence linking the abundance of other fish and wildlife to the benthic organisms, no objectives are proposed specifically to control or enhance the benthic community. If data become available that relate freshwater outflow to changes in the benthos and other aquatic communities of organisms, may be reviewed.

4.5.2.3 Fish

Studies of San Francisco Bay fish required by the 1978 Delta Plan (T,LI,249:10-24) were initiated by DFG in January 1980 (T,LI,251:20-24) to "document the importance of flow to Bay resources...and determine...the ecological benefits of unregulated outflows and salinity gradients established by them". (DFG,59,29).

In reporting that "{s}port fishing is the most popular recreational activity in the San Francisco Bay and Delta area," DFG estimated that 4.4 million recreation days were used in this activity, with a much larger, as yet undeveloped potential demand existing (DFG,59,10). Striped bass, Chinook salmon, and halibut are the most popular species caught in the Bay; other sport species include brown rockfish, surf perch, lingcod, jacksmelt, topsmelt, white croaker, shark, ray and skate.

The commercial harvest of finfish in the Bay has been limited by legislation (T,LII,19:3-20), with only herring and anchovy being taken commercially today(DFG,59,11). The herring fishery is primarily for roe which is exported to Japan. English sole, which use the San Francisco Bay as a nursery, are an important offshore commercial species. Anchovy are harvested primarily for bait. DFG estimated the commercial harvest of herring roe and shrimp from San Francisco Bay landings to have a value of $11.6 million per year (H.Chadwick,pers.comm.,12/28/87).

DFG was unable to establish any relationship between freshwater outflow and the size of commercial catches because of significant problems with the data base, among which were: (1) inconsistent catch reports; (2) a commercial fishery with changing equipment, methods and territory; (3) catch reporting methods which make it difficult to determine catch location; (4) the species fished as well as the size of the catch being determined primarily by the market place rather than species abundance; and (5) life history information not being known for most commercially harvested species (DFG,60,318).

In Phase I of the hearing, DFG presented much new descriptive information about the effects of flow on individual fish species and the abundance and distribution of their life stages in the Bay. This is a necessary first step in describing the beneficial use of Bay fish. However, the information needed to establish numerical flow or salinity objectives for the protection of Bay finfish resources downstream of the entrapment zone was not presented. (Delta outflows needed to protect anadromous fish and/or the entrapment zone are discussed in Section 5.3.4.3). Numerical objectives cannot be set without considerable additional study (T,LII,25:17-24;T,LII,38:8-14;T,LII,45:12-24;T,LII,67:13-17;T,LII,74:6-13).

Patterns of Bay fish abundance and distribution, and their relationship to freshwater outflow were highly variable and were influenced by offshore as well as upstream processes. Studies from other estuaries confirm what the DFG studies indicated, that "{i}n some cases, the same flow changes favor some organisms, while negatively impacting others" (DFG,61,73). Also, "{t}here may be some level of [inflow] reduction that causes serious impacts in each system but certainly that level varies among systems and...species." (DFG,61,77). DFG postulated that the extreme variability of Bay conditions is normal and contributes to the productivity of the system (T,LII,4:13-25). Among the reasons for the diversity of responses observed by DFG are: (1) a constantly shifting community of fish species; (2) the hydrologic and biologic environment of the Bay not being isolated from oceanic influences; and (3) the very limited historical database on Bay finfish.

DFG collected 122 fish species and about 1,642,000 individual fish, including larvae, during a six-year study, from January 1980 through December 1985 (DFG,59). Most species were so rare they were not analyzed further. Bottom (demersal) habitats supported a more abundant, diverse fish community than open water (pelagic) or nearshore areas (DFG,59,6). Table 4.5.2.3-1 identifies the predominant species in each of these areas.

DFG analyzed the abundance of the 69 most common species in relation to DWR's water year classification system. During the study period there were four wet years (1980, 1982, 1983, and 1984) and two dry years (1981 and 1985) with a wide range of freshwater outflows (DFG,60,3)(see Figure 4.5.2.3-1). The abundance of 61 percent (42 species) showed no consistent change with water year type, 29 percent (20 species) increased in wet years and 10 percent (7 species) increased in dry years (DFG,59,19-20). This method of analysis produced only a very general idea of species' response to outflow since DFG did not relate fish numbers to monthly flows (T,LII,37:11-12).

Thirteen species occurred in numbers sufficient to warrant more detailed analysis (DFG,60) (see summaries in Tables 4.5.2.3-2 and 4.5.2.3-3). Of these, twelve were native species and one was introduced. All of the predominant species use the Bay during their life cycle (see Table 4.5.2.3-2)(DFG,59,10). Many of the species which are prey for other fish or birds are permanent residents of the Bay, including gobies, topsmelt, and Pacific staghorn sculpin. The Bay also provides nursery and rearing habitat for species which are harvested commercially and recreationally (see Table 4.5.2.3-2). For example, the English sole and starry flounder spawn off shore but their eggs or young are carried by gravational circulation into the Bay where they mature. Adults of other commercially important species such as Pacific herring and northern anchovy actively move into and spawn in the Bay where their young also mature (DFG,59,10).

DFG also examined fish abundance relative to salinities ranging from 0 to 35 ppt salinity. Nine species preferred more saline areas, among them Pacific herring, English sole, several gobies and northern anchovy. Four species, yellowfin goby, Pacific staghorn sculpin, longfin smelt, and starry flounder, tolerate a broader range of saline conditions (DFG,59,7-10;DFG,60,121,210, 280-283). Salinity preference appears to change with age in some species; for example, young starry flounder and Bay gobies prefer fresher water while older fish prefer more saline environments (DFG,59,22). The distribution of different life stages may change with shifts in salinity. For example, during wet years, juvenile English sole do not use San Pablo Bay but in dry years when salinity is higher they do (DFG,59,22). When marine waters penetrate upstream, marine fish species follow. During the drought (1976-77), freshwater species moved out of Suisun Marsh and marine species moved in (DFG,61,46).

No uniform response to Delta outflow was evident among the 13 most abundant species (DFG,59,13-28). DFG reported that some species or life stages increased in abundance and/or expanded their distribution during increased freshwater outflows while others did not (see Table 4.5.2.3-3). No consistent

Table 4.5.2.3-1 Most Common Bay Fin Fish Collected from Demersal, Pelagic, and Nearshore Areas by DFG,1980-1986 (from DFG,59,6)

SHORE HABITAT	PELAGIC HABITAT	DEMERSAL HABITAT
Atherinops affinis topsmelt	Engraulis mordax Northern anchovy	Spirinchus thaleichthys longfin smelt
Clupea harengus pallasi Pacific herring	Sprinchus thaleichthys longfin smelt	Engraulis mordax Northern anchovy
Engraulis mordax Northern anchovy	Clupea harengus pallasi Pacific herring	Morone saxatilis striped bass
Atherinopsis californiensis jacksmelt	Morone saxatilis striped bass	Cymatogaster aggregata shiner perch
Morone saxatilis striped bass		Parophrys vetulus English sole
Leptocottus armatus Pacific staghorn sculpin		Genyonemus lineatus white croaker
Menidia beryllina inland silversides		Leptocottus armatus Pacific staghorn sculpin
Clevelandia ios arrow goby		Leptocottus lepidus Bay goby
Cymatogaster aggregata shiner perch		Citharichthys stigmaeus speckled sanddab
Micrometrus minimus dwarf perch		Acanthogobius flavimanus yellow fin goby
Acanthogobius flavimanus yellow fin goby		Platichthys stellatus starry flounder
		Clupea harengus pallasi Pacific herring

FIGURE 4.5.2.3.-1 Average monthly outflow at Chipps Island, 1980-1985
(DFG, 60, 3)

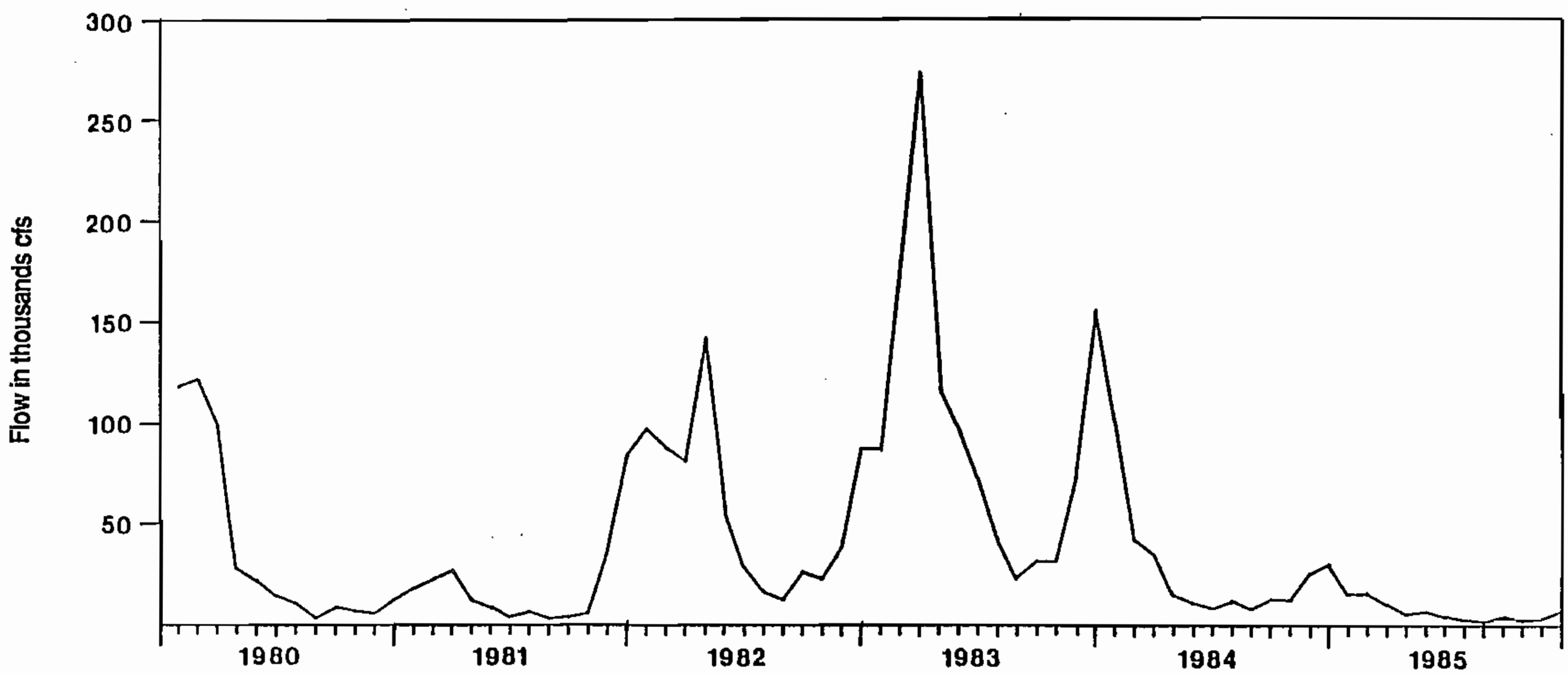


TABLE 4.5.2.3-2 Life history and descriptive information for the most abundant species of fish collected. (DFG, 59)

Species	Species origin	Species type	Life history			Center of population	Importance of species	Preferred habitat	Use of bay	Life stage major food source	
			Spawning time	Spawning location	Nursery area					Adult	Juvenile
Pacific herring	N	M	Fall-Winter	Bay	SSFB-SPB	Ocean	Commercial Forage	Pelagic	Spawning Nursery	P	P
Longfin smelt	N	E	Winter	Rivers	SPB	SPB	Forage	Pelagic	Nursery Residence	P	P
Pac. staghorn sculpin	N	E	Winter	Bay	Bay	CSFB-SPB	Forage	Demersal	Residence	F, B	B
Starry flounder	N	E	Winter	Ocean	SB-Delta	Ocean-Bay	Commercial Recreation	Demersal	Nursery Residence	B	B
Speckled sanddab	N	M	All Year	Ocean	Ocean-CSFB	Ocean	Forage	Demersal	Nursery Residence	B	B
English sole	N	M	Winter	Ocean	Ocean-Bay	Ocean	Commercial	Demersal	Nursery	B	B
California tonguefish	N	M	Summer - Fall	Ocean	Ocean-CSFB	Ocean	Forage	Demersal	Nursery	B	B
Yellowfin goby	I	E	Winter	Bay	SB-Delta	SPB-SB	Forage Commercial	Demersal	Residence	B	B
Arrow goby	N	M	Spring - Summer	Bay	SSFB-SPB	SSFB-SPB	Forage	Demersal	Residence	B	B
Bay goby	N	M	Summer - Fall	Bay	SSFB-SPB	CSFB	Forage	Demersal	Residence	B	B
Topsmelt	N	M	Summer	Bay	SSFB-CSFB	SSFB	Forage	Littoral / Pelagic	Residence	B	B
Jacksmelt	N	M	Spring - Summer	Bay - Ocean	SSFB-CSFB	Ocean	Recreation Forage	Pelagic	Spawning Nursery	F	P
Northern anchovy	N	M	Spring - Summer	Ocean	Ocean	Ocean	Commercial Forage	Pelagic	Spawning Nursery	P	P

N = native, I = introduced, E = estuarine, M = marine, SSFB = South San Francisco Bay, CSFB = Central San Francisco Bay, SPB = San Pablo Bay, SB = Suisun Bay, P = plankton, B = benthos, F = fish

TABLE 4.5.2.3-3 Relationship between freshwater outflow and abundance and distribution of various life stages of the most abudant fish. (DFG, 59)

SPECIES	LIFE STAGE	ABUDANCE CHANGES WITH INCREASING DELTA OUTFLOW				IN BAY DISTRIBUTION CHANGES WITH INCREASING DELTA OUTFLOW			
		Winter	Spring	Summer	Fall	Expand	Decrease	Shift	No change
Longfin smelt	larval					x			
	juvenile	+	+			x			
	adult					x			
Pacific herring	larval								x
	juvenile						x		
	adult						x		
Northern anchovy	larval								x
	juvenile						x		
	adult						x		
Pac. staghorn sculpin	larval	-					x		
	juvenile								x
	adult			+		x			
Starry flounder	juvenile		+	+		x			
	adult								
English sole	larval	+				x			
	juvenile		-				x		
Speckled sanddab	juvenile		+	+					x
	adult		+	+					x
California tonguefish	juvenile			+		x			
	adult		+	+		x			
Yellowfin goby	larval	-					x		
	juvenile					x			
	adult		+	+					x
Arrow goby	larval								
	juvenile								x
	adult								x
Bay goby	larval			-	-		x		
	juvenile	+	+						x
	adult	+	+						x
Topsmelt	larval						x		
	juvenile								x
	adult						x		
Jacksmelt	larval								x
	juvenile								x
	adult								x

relationship was observed between fish abundance and pulse flows (DFG,60,293). Monthly sampling was inadequate to determine the effects of short-term pulses (DFG,60,308). Freshwater pulses temporarily affected fish distribution, more widely dispersing estuarine species of the upper water column. The distribution of demersal species was less affected by pulse flows (DFG,60,296).

According to DFG, the juveniles of estuarine species (see Table 4.5.2.3-2) as well as the juveniles and adults of several flatfish species were generally more abundant during wetter conditions (DFG,59,15). Fish abundance appeared to be mostly associated with increases in Delta outflow for specific life stages of seven species during the spring or summer and three species during the winter (see Table 4.5.2.3-3). Increasing Delta outflows associated with increased abundance or distribution for a particular species in one season or life stage were often reversed in another period or life stage. For example, the abundance of larval English sole in the Bay increased during years of high Delta outflow and their range was broader; in contrast, the range of juvenile sole was limited to Central Bay in wetter years and expanded in drier years (DFG,60,248-251). Some life stages exhibited no detectable distributional shift with higher Delta outflows (DFG,59,16-17). The effect of increasing outflow had to be interpreted with respect to each species' life history because the location of a particular life stage influenced its response to changing hydrodynamics.

Winter-spring Delta outflows may play an important, but as yet poorly understood, role in the productivity and biological diversity of the Bay. Peak flow events and gravitational currents may transport nutrients into the Bay and disperse immature fish to estuarine nursery habitat species which DFG reported showed a positive response when Delta outflows increased (DFG,60) include Bay shrimp, several gobies, starry flounder, Pacific staghorn sculpin, longfin smelt, and English sole.

Future studies of Bay fish are needed to identify critical food chain relationships and the flow and water quality requirements of key species. Studies should concentrate on selected species within the Bay community identified as indicators of community viability and productivity.

Although the evidence presented by DFG in the Phase I hearing adds to knowledge of Bay fish, no specific salinity or outflow regimes were identified as being necessary to protect Bay fishery resources. From the available information, it would be premature to do so at this time. However, it should be noted that the Bay fish community appears well adapted to current variations in outflow and salinity and that potential future appropriations that reduce this variability may reduce the productivity of Bay fish and/or their adaptability. Unless it is determined that objectives proposed for the protection of other beneficial uses provide inadequate protection for Bay finfish, no specific objectives will be set for this beneficial use.

4.5.3 Ocean Habitat

Testimony concerning outflows from San Francisco Bay described two main effects on ocean habitat. The first is that the plume of freshwater in the Gulf of the Farallones provides for an abundant amount of marine life and thus serves as a concentrated feeding habitat for fish, marine mammals and birds (T,LIV,152:22-153:1). Two bird species which particularly use this plume area are the Brandt's cormorant and the common murre (T,LIV,154:3-13). The second effect of San Francisco Bay outflow is related to the movement of organisms, especially the larvae and juveniles of finfish and shellfish, into the Bay (T,LI,267:23-268:4). In certain cases, such as for bay shrimp, movement of larvae out of the Bay into the Gulf of the Farallones and their return later in the year is facilitated by higher Bay outflows (T,LI,272:6-19). In some circumstances, pulse flows, and their timing, were shown to be important in the determination of abundance of larvae (T,LI,289:5-25). The larvae or adults of English sole, Dungeness crab, Pacific herring and northern anchovy are transported back into the Bay on the bottom current inflows generated by the lighter, less saline freshwater flowing out of the Bay (see gravitational circulation; 3.6.2.1, south Bay) (T,LI,292:15-25).

The testimony presented general relationships between Bay outflow and the abundance of various species. However, there was no quantification of the relationship between specific levels of outflow and the effects on these species. Testimony from PRBO indicated that studies have not yet been done to relate the size of the plume to the volume of freshwater flowing from San Francisco Bay (T,LIV,155:15-156:6). No relationship has been established between the amount of freshwater outflow and the productivity of the plume (T,LIV,169:18-20;). Likewise, DFG has not yet been able to quantify the relationship between flows and their effects on various species (T,LI,300:5-8). No recommendations were given for any particular volume or timing of San Francisco Bay outflows, nor for any periodicity or volume of pulse flows to provide protection for beneficial uses in the ocean habitat. Any ocean outflows must be viewed in the context of the effects of water flows in the Estuary as a whole. As DFG pointed out, it is not appropriate to attempt to compartmentalize these effects for the ocean alone (T,LI,293:7-17;T,LIII,49:4-13).

Because of the lack of quantifiable data, and the absence of specific recommendations for flows to protect beneficial uses in the ocean habitat, no specific recommendations for flow or salinity will be made for the ocean habitat. If quantitative data become available that relate Bay outflow to ocean habitat, and if a determination can be made that objectives for the Estuary provide inadequate protection for the ocean habitat, this issue may be reviewed again.

4.6 Estuary Wildlife Habitat Beneficial Use

4.6.1 Delta

In the Delta there are 600,000 acres of agricultural land on the leveed islands and uplands, of which 515,000 acres are cultivated; about 7,000 acres are riparian woodland and scrub/shrub vegetation; 7,000 acres are freshwater marsh; 50,000 acres, water surface; 42,000 acres, grasslands and uplands; and about 32,000 acres of the Delta are urban—for a total of 706,000 acres (DFG,6,1). Freshwater marsh and riparian growth provide the habitats which support the greatest diversity of plant and animal species (DFG,6,4). The agricultural areas have supported from 450,000 to 600,000 migratory waterfowl during the winter, with thousands of shorebirds and wading birds making use of the shallows of seasonally flooded fields (DFG,6,4).

Over 230 species of birds and 43 species of mammals occur in the Delta (DFG,6,1). There are also 15 reptile species and eight amphibians reported or thought to occur in the Delta (Delta Wildlife Habitat Protection and Restoration Plan; DFG, USFWS, 1986). Many of these animals are so uncommon they have been identified on official lists of rare, threatened or endangered species by wildlife agencies. Seven bird species are listed by either the state or federal government as threatened or endangered. Two more bird species are candidates for federal listing (DFG,6,3;USFWS,19,20,21). The giant garter snake is a state-listed threatened species as well as a candidate for federal listing as either threatened or endangered (DFG,6,3; USFWS,22). Two mammals, the riparian brush rabbit and the riparian woodrat are candidates for federal listing as threatened or endangered; three invertebrates also are federally listed as threatened or endangered and thirteen plants are listed by federal and/or state agencies as rare, threatened or endangered (DFG,6,3).

In the Delta, wildlife habitat and wildlife are dependent upon water quality and flow in the channels and upon cropping patterns on the cultivated land. Migratory waterfowl in particular use spilled and unharvested corn and other grain crops, especially when Delta islands are allowed to be ponded or flooded for leaching purposes (DFG,6,4). The quality of water available in Delta channels can affect waterfowl and migratory bird use, as they are influenced by the crops planted and leaching frequencies. Fewer grain crops and less frequent flooding would reduce use by waterfowl such as Aleutian Canada geese, tule white-fronted geese, tricolored blackbirds, as wellas sandhill cranes which now depend on wet or flooded pasture and cultivated grains (DFG,6,4 and 7). The peregrine falcon may also be affected by changed waterfowl abundance because of the importance of waterfowl in their diet (USFWS,17,2).

Swainson's hawk, black rail, yellow-billed cuckoo, riparian brush rabbit, riparian woodrat and giant garter snake are species which would be affected by changes in water quality and flow to the degree that such changes lead to contamination of, or a reduction in, the natural habitat of the Delta (T,XXX,5:23-25). Vegetation changes which reduce the acreage of freshwater marsh and riparian forest or scrub/shrub would also have an adverse effect.

4.6.2 Suisun Marsh

Suisun Marsh, with an area of 116,000 acres, is the largest contiguous brackish water marsh in the United States (T,XXX,12;DFG,5,1). The major habitat types are managed marsh, subject to controlled inundation and drainage (generally for the enhancement of waterfowl habitat), and tidal marsh influenced by the water regime in the channels. There are also substantial areas of habitat consisting mostly of annual grasses and weedy growth, cropland and open ground. Between 54,000 acres (T,XXX,110:4-5) and 57,000 acres (DFG,5,3) are marshland, of which approximately 10,000 acres are tidal marsh (T,XXX,49:21,110:5). Estimates differ in regard to what proportion of the marsh acreage is managed and what is tidally influenced, depending on the definitions used and the areas examined. By all estimates the large majority (80 to 90 percent) of marshland is managed for plant species considered beneficial to wintering waterfowl (DFG,5,6).

The principal waterfowl species using Suisun Marsh in winter are pintail, mallard, shoveler, widgeon and green-winged teal; mallard, gadwall, and cinnamon teal breed here. The plants which are preferred food items for wintering waterfowl are alkali bulrush, brass buttons, and fat-hen (DFG,5,9). During the remainder of the year, invertebrates are important food for pre-nesting females and broods of ducklings (DFG,5,13).

Besides waterfowl, several state or federally listed animals and plants exist in the Marsh. Animals include salt marsh harvest mice, clapper rail, and black rail; plants include Mason's lilaeopsis, Suisun aster, Delta tule pea, and salt marsh bird's beak. These animals and plants are likely to be affected by changes in flow and salinity in the Marsh (T,XXX,68:24,136:3-25;BAAC,4). Increased salinity in tidally influenced channels will cause an increased physiological stress on plants, resulting in decreased reproduction and productivity, eventually leading to changes in the plant and dependent community (CNPS,1,5-8). Water quality standards lower than present levels, i.e., higher TDS levels (T,XXIX,210:9-12), will increase plant stress, decrease photosynthetic productivity of marsh plants, kill salt-sensitive species, retard growth of new plants, and reduce plant species diversity (CNPS,1,10).

4.6.3 Other Tidal Marshes

San Francisco Bay's tidal marshes, ranging from fresh to salt habitats, include 53 square miles of tidal marsh, 15 square miles of diked marsh and 55 square miles of diked ponds (DFG,7,1). Major areas of tidal wetland occur on the northeast shore of San Pablo Bay, specifically Tubbs Island, Napa and Petaluma Marsh. Diked marshes, ponds and mudflats are extensive in the south Bay (DFG,7,1).

Bay area wetlands and aquatic habitats support over half of the Pacific Flyway's wintering population of such waterfowl as canvasback ducks and are very important for scaup, scoters and redhead ducks. A variety of species of wildlife listed as threatened or endangered by state or federal wildlife agencies depend on Bay habitats for all or part of the year. Salt marsh harvest mice, California clapper rail, black rail, California brown pelican, and California least tern are listed (DFG,7,13). In Bay marshes, salt marsh bird's beak and Mason's lilaeopsis, are listed by the state as rare plants. Both plants are dependent on brackish or salt marsh conditions (T,XXX,70:19-23;T,XXX,76:5-22) and occur near the upper reaches of the Bay.

Aquatic habitat and aquatic invertebrates are important in their contribution to the food supply of higher forms of Bay wildlife. One of the most important food items for canvasback ducks is the clam Macoma balthica and two other molluscs, Mya arenaria and Musculus senhousia are also extensively eaten. These molluscs are also food for clapper rail, as are a variety of other invertebrates (DFG,7,9).

Although many Bay tidal marshes are relatively isolated from Delta outflow and salinity, the nearby Bay waters are affected by stratification, gravitational circulation, and flushing induced by outflow. To the degree that mollusc and fish species and aquatic habitat productivity changes in the Bay, the value of the adjacent marshes and beaches for sensitive wildlife, such as rails, terns, and pelicans, may change (DFG,7,10-12).

4.7 Estuary Recreation Beneficial Use

The waters of the Estuary are used for a variety of contact and non-contact forms of recreation, among them, swimming, boating, fishing, hunting, water skiing, and houseboating. The waters are also used for competitive events, marine parades and emerging activities, such as boardsailing and jetskiing (EBRPD,1-33). There are also a variety of water-oriented, non-contact activities such as sightseeing, whale-watching, bird watching and beachcombing, all of which depend on the esthetics or visual quality of the Estuary's waters to some degree (EBRPD,1-33).

4.7.1 Sacramento-San Joaquin Delta and Tributaries

Evidence was provided which projected user days and economic values for freshwater recreation in the Delta as compared to similar types of recreation at storage and export reservoirs and facilities (SWC,65,24). Freshwater-oriented recreation in the Delta was estimated to be 8.3 million user days in 1977-78, although this number includes some activities which do not depend entirely on the Delta's waters. Brackish water, ocean and estuary activities were not included in the total (SWC,66,5). Testimony and evidence were also provided which indicated that recreation visits to Estuary shoreline park facilities have been growing rapidly compared to the projections used by SWC, i.e., 122 percent in two years vs. 0.8 percent/year (EBRPD,24,T.1). Millions of user days and daily values of $20 or more for water use are calculated for recreational use of Estuary water (BISF,38,T4). Flow and salinity objectives which affect those uses, either in the area of origin or in the export area, will have an economic effect, but no testimony or evidence addressed quantitative effects of particular objectives on recreational uses. An extrapolation of old studies of Delta recreation has generated estimates in the range of 13 million recreation days annually (PICYA,2,51). Testimony by SWC suggested that these estimates were high and should be reduced to 6.95 million. However, no current information, based on recreation use studies, during this decade is available (T,LV,137:13-16).

There is also little evidence of the degree to which the Estuary's water recreation would be affected by flow or salinity. Submittals by SWC argued that recreation in the Delta depends on the surface acreage and has little or no relationship to changes in flow of freshwater (SWC,66,14). On the other hand, there was no evidence given as to the impacts of salinity on corrosion, growth of fouling organisms which might grow on boats moored in the Delta, or the costs of piling replacement if marine boring organisms penetrated further into the Delta as a result of higher salinity or more prolonged intrusion of marine water into the Delta.

4.7.2 Suisun Marsh and Carquinez Straits Area

Some evidence was submitted on the recreational use of the Suisun Marsh or Carquinez Straits area of the Bay-Delta Estuary. BAAC submitted evidence inferring that bird watching goes on in the Suisun Marsh (BAAC,20;26;27). From evidence submitted by EBRPD, estimated recreation at its Contra Costa shoreline facilities (Antioch and Martinez shoreline) has increased rapidly from 1981 to 1987, growing from 84,000 visitors to 287,000 visitors, or about 340 percent in six years (EBRPD,34,T1). Although there is little evidence linking the quantity of recreation in this reach to flow and salinity of the water, both BAAC and EBRPD expressed concern that visitors to these recreational areas would experience losses of the value they place on wildlife and fish resources which might be harmed if flow decreased and salinity increased (T,XXX,45:12-23;T,LV,184:15-25,185:1-2).

The rate of growth of recreational use in EBRPD units with water quality problems, Point Isabel and San Leandro Bay, increased from 71,000 to 487,000 users between 1981 and 1987, an increase of over 680 percent (EBRPD,34,T1). This occurred despite serious heavy metal contamination at these beaches. In comparison, the rate of growth at the nearby, unpolluted Hayward and Miller-Knox shorelines has moved from 21,000 users to 196,000, an increase of 930 percent in the same time. Without specific information on the features which prompt users to attend the various park units, or the measurement method by which use estimates were made, it is probably unrealistic to use these figures to show that visitation and recreational use would be harmed by changes in water flow or salinity. Moreover, it is noteworthy that users did not avoid contaminated sites, and it does not seem reasonable to suppose that a moderate change (of one or two parts per thousand) in salinity would substantially change future recreational use. This might not be true if the change were such as to convert a freshwater beach to saltwater; however, no data are in the record on this subject.

4.7.3 San Francisco Bay and Adjacent Ocean

The Basin Plan for Region 2, the San Francisco Bay Basin, identifies most of the same forms of recreation as the Delta. Recreational uses are also identified for the Pacific Ocean and the San Francisco Bay system and all other surface waters (RWQCB,2.1975). Water-oriented recreation in the San Francisco Bay area was estimated to total over 127 million user days (BISF,38,T3).

Evidence was presented that outflow to the Bay and Pacific Ocean and resultant salinity changes may affect recreation, but quantification was not made available. The Basin 2 Plan specifies a salinity standard in ocean waters requiring no significant variation beyond present natural background levels. A significant variation is "defined as any level of water quality which has an adverse and unreasonable effect on beneficial water uses or causes nuisance" (RWQCB 2,1975,3-3). Several participants presented testimony to the effect that past flow and salinity changes have impaired recreational beneficial uses, and that future flow and salinity changes could impair them further (BISF,38,40,41,46; EBRPD,34). Other parties submitted testimony and evidence which proposed that ecosystem changes in flow or salinity would also adversely affect recreational uses (BAAC,4;BCDC,1;BISF,50,51; PRBO,2;TIBCEN,1,2).

4.8 Other Beneficial Uses

4.8.1 Navigation

Navigation in the Estuary includes both commercial and recreational activities. There are seven major ports in the Estuary (San Francisco, Oakland, Alameda, Redwood City, Richmond, Stockton, and Sacramento), serving more than 5,000 ships annually (NOAA,1986,89); there arealso numerous oil transfer terminals located between Richmond and Suisun Bay. In 1984, imports at the Estuary's seven major ports were worth $10,419,000, while exports were worth $6,295,000 (NOAA,1986). Six million tons of cargo have been transported annually in Stockton and Sacramento deep-water ship channels (DWR,1987,60). In 1985 there were 143,646 recreational boats registered in the nine counties surrounding San Francisco Bay (NOAA,1986,74), and about 82,000 pleasure boats are registered in the Delta area (DWR,1987,60). These Delta area boaters are served by more than 8,500 berths, 119 docks and 27 launching facilities (DWR,1987,60).

Navigation is enhanced by a network of deepwater channels to the major ports. Extensive dredging is required to maintain these channels; in 1985, for example, nearly 8.6 million cubic yards of material were dredged in the Estuary at a cost of more than $17 million (NOAA,1986,97).

These channels have two major effects on the Estuary. The deeper channels allow increased salt water intrusion into the Estuary (T,LVI,176:9-178:8;DWR,709,1-2). This increased salinity may have impacts on other beneficial uses such as recreational boating which

Export

would see greater maintenance costs from hull fouling, corrosion of propellers and structures, and related problems (T,LV,158:1-7). The second effect is the impact of dredging and dredge spoils disposal on water quality (see, for example, T,XLVIII,71:20-102:9). This impact will be discussed in the Pollutant Policy Document.

On the other hand, water quality constraints to protect other beneficial uses may affect navigation. Objectives set for salinity and flow may, for example, influence the costs of maintaining or increasing the depths of existing channels (DFG & USFWS,1980,2-15). Closure of the Delta Cross Channel gates also prohibits recreational boaters from using the Cross Channel as a shortcut between the Sacramento and Mokelumne rivers.

Navigational requirements also have direct effects on the Sacramento River. The 5,000 cfs minimum at Wilkins Slough, just below Tisdale Wier, that the CVP is required to provide (T,I,43:15-21), sustains a minimum flow in the Sacramento River in the absence of other regulations.

The SWP and CVP export pumps currently operate under U.S. Army Corps of Engineers (COE) criteria. Maximum flow rates for Clifton Court Forebay are stipulated for various times of the year (DWR,708,10). Operations deviating from these criteria, such as additional export with the four new SWP pumps now under construction, will require a new permit from the COE (DWR,1982,7).

4.8.2 Dilution of Pollutants

Freshwater flows to dilute pollutant burdens in the Estuary and upstream was the subject of considerable testimony, much of which concerned "flushing flows" to reduce pollutant burdens in south San Francisco Bay. Burdens here tend to be higher because of limited exchange of water between South Bay and the ocean in the absence of substantial freshwater inflows to drive the exchange.

Evidence received on pollutants will be used by Regional Boards 2 and 5 to update their basin plans. The State Board will provide guidance to the Regional Boards in the development of pertinent provisions of these plans and will review and approve Regional Board updates. During the final phase of the hearing, the Board will evaluate whether the source control of pollutants proposed by the Regional Boards is sufficient to protect beneficial uses in the Estuary. The need for dilution or flushing flows through water right amendments may be considered only after all reasonable source control methods have been implemented.

4.9 Uses of Water Exported From the Bay-Delta Estuary

The following sections address water use in the areas of export, that is, the areas defined for purposes of this Plan as being outside the legal boundary of and receive water diverted from the Bay-Delta Estuary.

4.9.1 Municipal and Industrial Uses

The majority of California's population lives in semi-arid areas where population and industrial expansion have exceeded the ability of many communities to meet their water needs with local sources.

Local as well as distant communities have seen the Estuary's waters as a means to meet their needs. Municipal and Industrial (M&I) water exports to local areas outside the Estuary began in 1929 when EBMUD initiated the first export of Delta supplies by diverting Mokelumne River water through its Mokelumne Aqueduct to Alameda and Contra Costa counties. In 1934 San Francisco began diverting water from the Tuolumne River through the Hetch Hetchy Project for use in San Francisco, San Mateo, and Alameda Counties. In 1940 the Contra Costa Canal (CCC), the first unit of the CVP, was completed and began supplying water to the Antioch-Pittsburg area. The City of Vallejo began importing Delta surface water from Cache Slough in 1953. USBR began diverting Putah Creek water via the Putah South Canal to Fairfield and Benicia in 1957. In 1965 the South Bay Aqueduct of the SWP began exporting an interim supply of Delta water from the Delta-Mendota Canal (DMC) to Alameda and Santa Clara Counties. The North Bay Aqueduct Phase II facilities of the SWP divert Delta waters from Barker Slough tributary to Lindsey and Cache sloughs, and connect with the Phase I facilities just west of Cordelia. Water will be delivered to Solano and Napa counties (DWR,207,1-7).

The first non-local, statewide exports began in 1968 when the federal Central Valley Project began exporting water to the municipalities of Coalinga, Huron and Avenal through the DMC and San Luis Canal (DWR,204,1). In 1971 the SWP's California Aqueduct began exporting water to southern California through the Edmondston Pumping Plant over the Tehachapi Mountains (DWR,207,1-7).

CVP statewide M&I deliveries are approximately 430,000 AF/yr with a projected delivery in the year 2010 of 1,033,116 AF/yr (Table 4.9.1-1)(USBR,1987). In 1985, SWP statewide M&I deliveries were approximately 1,008,000 AF/yr (Table 4.9.1-2)(DWR,461,1). No estimate of SWP projected deliveries to southern California was presented. Table 4.9.1-3 lists state and federal water transfer facilities and the areas each serve.

Population and economic projections indicate growing M&I water demands. The Department of Finance has estimated that the state population will increase from 27,000,000 people in 1986 to 36,280,000 people in 2010 (DOF,1987). Of this, the population of the six most populated counties in southern California--Ventura, Los Angeles, Orange, Riverside, San Bernardino, and San Diego--are expected to increase from a 1986 level of 15,290,000 people to 20,220,000 in 2010 (SWC,6,7).

Table 4.9.1-1

Municipal and Industrial Water Contracts
Central Valley Project
(acre-feet)

SACRAMENTO VALLEY AND AMERICAN RIVER SERVICE AREAS c/

Contracting Entity	Contract Maximum a/	1986 Deliveries b/	Projected 2010
Bella Vista WD d/	7,000	2,060	7,000
City of Folsom d/	22,000	15,042	22,000
City of Redding d/	21,000	10,424	21,000
City/Redding(Buckeye)	6,140	2,320	6,140
City/Redding(Buckeye)	40	40	0
City of Roseville	32,000	11,591	32,000
City/Sacramento(AmRv) d/	326,000	71,331	227,500
City/Sacramento(SacRv) d	above	18,896	above
Clear Creek CSD	10,300	1,346	6,400
County of Colusa	40	40	40
Diamond International	510	0	510
Diamond International d/	425	425	425
East Bay MUD	150,000	0	20,000
East Yolo CSD	9,290	0	8,860
El Dorado ID	2,875	3,006	2,875
El Dorado ID	7,500	1,540	7,500
Elk Creek CSD d/	100	96	100
Folsom Prison d/	4,000	1,432	4,000
Foresthill PUD	2,500	1,084	2,500
G.W. Williams	130	0	130
Keswick SD	500	140	300
Lake CA (Rio Alto)	200	200	200
Louisiana Pacific d/	25	26	25
Mather AFB (temporary)	350	271	350
Mountain Gate	350	457	350
Napa Co. FCWCD	7,500	3,167	1,500 e/
Parks & Recreation d/	5,000	15	15
Placer Co. Water Ag. d/	150,000	4,921	75,000
Riverview Golf Club d/	280	280	280
San Juan Suburban WD	5,600	7,840	5,600
San Juan Suburban WD d/	33,000	23,100	33,000
Shasta County WA	5,000	162	2,800
Shasta CSD	1,000	602	1,000
Shasta Dam PUD	3,227	1,573	3,227
So. Cal. Water Co. d/	10,000	1,612	10,000
Sacramento MUD	7,500	3,167	1,500
Summit City PUD	1,170	300	1,170
U.S. Forest Service	10	10	10
Total Sacramento and American River	1,006,462	238,839	629,407

SAN JOAQUIN VALLEY SERVICE AREAS

Contracting Entity	Contract Maximum a/	1986 Deliveries b/	Projected 2010
Arvin Edison WSD	500	0	500
Arvin Edison (Cross Val.)	500	0	500
Broadview WD	20	23	20
City of Avenal	3,500	1,257	3,500
City of Coalinga	10,000	6,000	10,000
City of Fresno	60,000	45,000	60,000
City of Huron	3,000	828	3,000
City of Lindsay	2,500	2,021	2,500
City of Orange Cove	1,400	422	1,400
City of Tracy	10,000	5,734	10,000
Contra Costa WD	195,000	124,386	195,000
County of Madera	200	30	200
County of Tulare	1,345	1	1,345
Fresno County WW#18	150	59	150
Musco Olive Prod. (temp)	--	0	--
Pacheco WD	80	12	80
Panoche WD (DMC)	37	18	37
Panoche WD (SLC)	63	23	63
San Benito WD	8,250	0	6,680
Santa Clara WD	128,700	0	117,200
San Luis WD (DMC)	140	109	140
San Luis WD (SLC)	440	387	440
State of Calif.	10	10	10
Stockton-East WD	10,000	0	8,000
Tracy Golf Club-CA (temp)	--	451	--
Westlands WD	10,000	5,917	10,000
Total San Joaquin	418,779	192,690	403,709
Total Sacramento and San Joaquin	1,425,239	431,529	1,033,116

a/ Quantity is a contract maximum or is projected M&I use within a combination M&I/agricultural water service contract.
b/ Deliveries may include water transferred from other contractors or purchased under provisions of the contract and may therefore be higher than contract maximum.
c/ Includes Solano FCWCD and Napa Co. FCWCD of Solano Project.
d/ Contract includes water rights; no payment is made to the United States for water rights water.
e/ *Present use includes City of Napa which will cease when North Bay Aqueduct completed.*

Source: USBR, Factsheet: "Exhibits and Testimony before SWRCB, Bay-Delta Hearing, 1987", 1987.

Table 4.9.1-2

SWP WATER DELIVERIES FOR AGRICULTURE, MUNICIPAL AND INDUSTRIAL USES, RECREATION USE AT SWP FACILITIES AND HYDROELECTRIC ENERGY, 1962 to 1985.

	Water Delivered (Acre-Feet)								
	Entitlement Water			Other Deliveries					
Year	Municipal & Industrial Use	Agricultural Use	Total	Municipal & Industrial Use	Agricultural Use	Other Water a/	Total Delivery	Recreation Supported (Recreation Days) b/	Hydro-Electric Energy Generated (megawatt-hours) c/
1962						18,289	18,289	[illegible]	
1963						22,456	22,456	[illegible]	
1964						32,507	32,507	[illegible]	
1965						44,105	44,105	[illegible]	
1966						67,928	67,928	[illegible]	
1967	5,747	5,791	11,538	0	0	53,605	65,143	[illegible]	
1968	46,472	125,237	171,709	10,000	111,534	14,777	308,020	[illegible]	[illegible]
1969	34,434	158,586	193,020	0	72,397	18,829	284,246	[illegible]	[illegible]
1970	47,996	185,997	233,993	0	133,024	38,080	405,097	[illegible]	[illegible]
1971	85,286	272,054	357,340	2,400	293,619	44,127	697,486	[illegible]	[illegible]
1972	181,066	430,735	611,801	22,205	401,759	73,127	1,108,892	[illegible]	[illegible]
1973	293,824	400,564	694,388	3,161	293,255	43,666	1,034,470	[illegible]	[illegible]
1974	418,521	455,556	874,077	4,753	412,923	48,342	1,340,095	[illegible]	[illegible]
1975	641,621	582,369	1,223,990	21,043	601,859	67,170	1,914,062	[illegible]	[illegible]
1976	818,588	554,414	1,373,002	32,488	547,622	116,962	2,070,074	[illegible]	[illegible]
1977	280,919	293,236	574,155	0	0	390,176	964,331	[illegible]	[illegible]
1978	742,385	710,314	1,452,699	3,566	13,348	122,916	1,592,529	[illegible]	[illegible]
1979	690,659	969,237	1,659,896	66,081	582,308	189,396	2,497,681	[illegible]	[illegible]
1980	730,545	799,204	1,529,749	19,722	384,835	48,590	1,982,896	[illegible]	[illegible]
1981	1,057,273	852,289	1,909,562	12,000	896,428	283,849	3,101,839	[illegible]	[illegible]
1982	928,721 e/	821,303	1,750,024	0	215,873	155,820 e/	2,121,717	[illegible]	[illegible]
1983	483,499	701,370	1,184,869	0	13,019	188,596	1,386,484	[illegible]	[illegible]
1984	723,468 f/	865,043	865,043	3,663	259,254	387,505 f/	2,238,933	[illegible]	[illegible]
1985	998,138	1,002,915	2,001,053	9,638	292,372	414,566	2,717,629	[illegible]	[illegible]
Total d/	9,209,162	10,186,214	19,395,376	210,720	5,525,429	2,885,384	28,016,909	76,889,600	54,187,000

a/ Includes preconsolidation repayment water, emergency relief water, exchange water, regulated delivery of local supply, non-SWP water delivered to Napa County FC&WCD through SWP facilities, conveyance of CVP water (including Decision 1485 water), recreation water, and demonstration ground water fill withdrawal.
b/ A recreation day is the visit of one person to a recreation area for any part of one day.
c/ Includes SWP share of generation from Hyatt-Thermalito, San Luis, Devil Canyon, Warne, and Castaic Powerplants.
d/ In addition, SWP dams have prevented millions of dollars worth of flood damage.
e/ Revised and corrected from, Bulletin 132-85 to reflect 557 acre-feet of 1978 exchange water (MWDSC Basin) changed from other water to municipal and industrial use entitlement water.
f/ Revised and corrected from, Bulletin 132-85 to reflect 126 acre-feet of 1982 exchange water (MWDSC Basin) changed from other water to municipal and industrial use entitlement water.

(DWR,461)

TABLE 4.9.1-3
DELTA DRINKING WATER DIVERSIONS
AND AREAS SERVED 1/

Diversion Point	Area Served
State	
North Bay Aqueduct (Cache Slough)	Solano-Napa County Fairfield Vacaville Vallejo Benicia Napa American Canyon
South Bay Aqueduct (Clifton Court)	Livermore Valley Alameda CWD Santa Clara Valley WD
California Aqueduct	Avenal Coalinga Kern County WA Antelope Valley MWDSC San Diego CWA Crestline-Lake Arrowhead San Bernardino Valley Palm Springs Indio
Federal	
Contra Costa Canal (Clifton Court)	Concord Oakley Pittsburg Antioch Martinez Pleasant Hill Walnut Creek
Delta-Mendota Canal (Old River)	Tracy Huron Dos Palos

1/ SWC,76,6

The expected additional M&I demand for Bay-Delta water supply is a result both of the loss or degradation of alternative water supplies and of increases in population (SWC,4,6). Supreme Court decisions on the Colorado River have reduced MWD's supply of water by 692,000 AF/yr(SWC,3,2). Ground water pollution and overdraft have restricted the use of some ground water basins (SWC,3,9). Studies performed by DWR indicate a shortage of 1.4 MAF between existing dependable supplies and projected needs in southern California by 2010 (SWC,3,2; DWR,707,43)[1].

In the future the SWP and the CVP plan to expand deliveries to new areas and to areas experiencing increased need. SWP is studying a Coastal Branch which will supply water to Santa Barbara and San Luis Obispo counties, and an East Branch enlargement which will increase deliveries to the eastern part of the Metropolitan Water District's service area. CVP is studying an extended San Felipe Branch which will supply water to Monterey and Santa Cruz counties, as well as an American River Aqueduct which will increase deliveries to EBMUD's service area in the Bay Area. SWP is also planning transfer and storage facilities that will increase its water distribution capabilities at these locations: the Kern Water Bank, Los Banos Grandes Reservoir, the South Delta, and North Delta Facilities and additional pumps at the Delta Pumping Plant (DWR,707,42-53).

1/ One of the assumptions of this study was that the maximum salinity level allowable at Clifton Court would be set at 100 ppm chlorides, a project goal. The SWRCB objective for export use at this location is 250 ppm chlorides. Using information from DWR studies, SWRCB staff estimated that the additional volume of water needed to meet the 100 ppm chloride level project goal at Clifton Court can be as much as 200,000 acre-feet per year.

4.9.2 Agriculture

The CVP and SWP export water from the Estuary to support many farming and ranching operations (RWQCB 5, 1975). The main area of agricultural use of export waters is the San Joaquin Valley; three of its counties, Fresno, Kern, and Tulare, ranked first, second, and third in the nation in gross cash receipts from annual farm marketing in 1982 (CVAWU,41). The SWP exports water for agricultural use primarily in the Tulare Lake Basin, with smaller amounts exported to other areas. The CVP exports water for agricultural use as shown in Table 4.9.2-1.

TABLE 4.9.2-1
CVP EXPORT AREAS

Export Area	CVP Unit
San Joaquin Basin	Delta Mendota Canal San Luis Mendota Pool
Tulare Lake Basin	San Luis Cross Valley Canal
Contra Costa County	Contra Costa Canal

The recently completed San Felipe Unit of the CVP will soon make deliveries to Santa Clara and San Benito counties.

By 1970 the entitlement of agricultural contracts (including exchange contractors[1/]) to CVP export waters totaled over two million AF/yr (CVPWA,10-1). With the addition of the Cross Valley Canal Unit and expansion of the San Luis Unit, the 1980 total was almost 2 1/2 million AF/yr (CVPWA,10-1).

During the 1985 Water Year, the various units of the CVP exported a total of about 2,750,000 acre-feet of water to serve 1,220,000 acres (Table 4.9.2-2).

1/ Exchange contractors formerly diverted from the San Joaquin River, but exchanged their diversion rights for a contract that granted more consistent water supplies from the DMC. The maximum contractual entitlement of these users is 840,000 AF/yr (USBR,1987).

TABLE 4.9.2-2
AGRICULTURAL WATER EXPORTS AND SERVICE AREAS
BY CVP UNIT FOR THE 1985 WATER YEAR

CVP Unit	Water Exported (AF)	Area Served (ac)
Delta Mendota Canal (including exchange contractors)	1,050,000 (CVPWA,11;USBR, 1984;USBR,1985)	356,000 (T,XXVI,186:6-8,11-17)
San Luis	1,545,000 (CVPWA,11)	698,000 (T,XXVI,186a:24)
Mendota Pool	94,000 (CVPWA,11)	42,000 (T,XXVI,187:14)
Cross Valley Canal	64,000 (CVPWA,11(b)-3)	125,000 (CVPWA,11(b)-3)
Contra Costa Canal	895 (T,XXVI,185:16-21)	---
TOTAL	2,754,000	1,221,000

Although the recently completed San Felipe Unit began making deliveries in mid-1987, two contracts have been executed for a total of 68,600 AF/yr (T,XXVI,194:2-8). The projected water use by the existing CVP contractors is not expected to differ substantially from this 1985 Water Year level (T,XXVI,208:6-8). However, additional CVP supplies are needed to help solve ground water overdraft (T,XXVI, 209:6-13).

The SWP exports water for agricultural use via the California Aqueduct to Oak Flat WD in the San Joaquin Basin, to the Tulare Lake Basin and to southern California, and via the South Bay Aqueduct to Santa Clara and Alameda counties. The magnitude of SWP deliveries to the 13 southern California contractors for agricultural use was not identified in the hearing record. The annual SWP exports for agricultural use (excluding southern California) increased from about 237,000 AF in 1968 to about 1.3 million AF in 1985 (DWR,461). The future need for exported SWP water for agriculture should not change substantially from this 1985 amount (DWR,707,11). However, Kern County needs an additional 300,000 AF/yr to help solve its ground water overdraft problem (SWC,412,5).

SWP export process

The main change in agricultural production in the San Joaquin Valley since 1955 has been the increased acreage devoted to the production of vegetables, fruits and nuts (CVAWU,26). The acreage of vegetables increased from about 250,000 acres in 1955 to almost 400,000 in 1985. The acreage devoted to the production of fruits and nuts increased from about 550,000 acres in 1955 to about 1,300,000 acres in 1985 (CVAWU,26). The acreages of field crops and seeds in the San Joaquin Valley have remained relatively stable since 1955. Overall, the acreage devoted to these four major commodity groups (vegetables, fruits and nuts, field crops, and seeds) in the San Joaquin Valley has increased only about 25 percent from 1955 to 1985, from about 3.7 million acres to about 4.6 million acres (CVAWU,26).

In 1985, the CVP units listed in Table 4.9.2-2 delivered over 2.7 million AF of water to over 1.2 million acres in the export areas of the San Joaquin Valley to produce crops with a gross value of about $1.2 billion (CVPWA,12;EDF,11,G-148) (Table 4.9.2-3).

TABLE 4.9.2-3
MAJOR CROPS GROWN IN THE CVP EXPORT AREA
BY ACREAGE AND GROSS CASH VALUE

Crop	Acreage[1/] (thousands of acres)	Gross Cash Value[1/] (millions of dollars)
Cotton	450	360
Alfalfa	100	70
Wheat	90	22
Tomatoes	80	130
Melons	50	130
Barley	40	6
Almonds	30	NA[2/]
Table Grapes	NA[2/]	80
Apricots	NA[2/]	60
Lettuce	NA[2/]	60
TOTAL	1,221	1,200

1/ CVPWA,12;EDF,11,G-148
2/ Not available

In 1985, the SWP delivered over 1.3 million AF of water to about 445,000 acres in the export agricultural areas of the San Joaquin Valley to produce crops with a gross value of about $431 million (DWR,489h)(Table 4.9.2-4).

TABLE 4.9.2-4
MAJOR CROPS GROWN IN THE SWP EXPORT AREA
BY ACREAGE AND GROSS CASH VALUE

Crop	Acreage[1/] (thousands of acres)	Gross Cash Value[1/] (millions of dollars)
Cotton	210	154
Alfalfa	40	27
Almonds	35	26
Wheat	30	9
Pistachios	18	28
Wine grapes	18	13
Table Grapes	6	28
Oranges	4	19
Carrots	5	18
Other	79	109
TOTAL	445	431

1/ DWR,489h

Since water usage and acreage for livestock, poultry, and dairy production were not identified in the hearing record by CVP or SWP export areas, an accurate account of the effect of export water on the market values of these products cannot be given. In addition, project export areas often use supplemental water supplies from ground water and local sources; only a part of the value of agricultural production in the export area can therefore be directly attributed to project exports. Only an indirect indication can be made from the fact that the market value of livestock, poultry and dairy products for the entire San Joaquin Valley in 1982 was over half the value of all crops (CVAWU,28):

	1950	1969	1982
Crops	$455 million	$933 million	$4,039 million
Livestock, Poultry, Dairy	$199 million	$751 million	$2,053 million

The hearing record does not indicate any present or anticipated future problem of adequate water quality for agricultural production in the export areas. However, three main problems have affected and will continue to affect the agricultural uses in the export areas: (1) drainage; (2) ground water overdraft; and (3) urbanization. The drainage problems on the west side of the San Joaquin Valley have been well documented. The water quality problems associated with drainage disposal threatens agricultural production in many parts of the export areas, e.g., Westlands WD and entities draining to Grassland WD (EDF,11,I-2 and I-3). The amount of land with drainage problems will increase in the export area. The use of evaporation ponds for drainage disposal removes agricultural lands from production, especially in the Tulare Lake Basin; ground water overdraft causes lowered water tables and land subsidence and in turn causes higher pumping costs or increased demand for export water; subsidence creates problems of soil compaction and unlevel fields. The overdraft problem is particularly widespread in the Tulare Lake Basin. Encroaching urbanization continues to remove agricultural land from production in the export area.

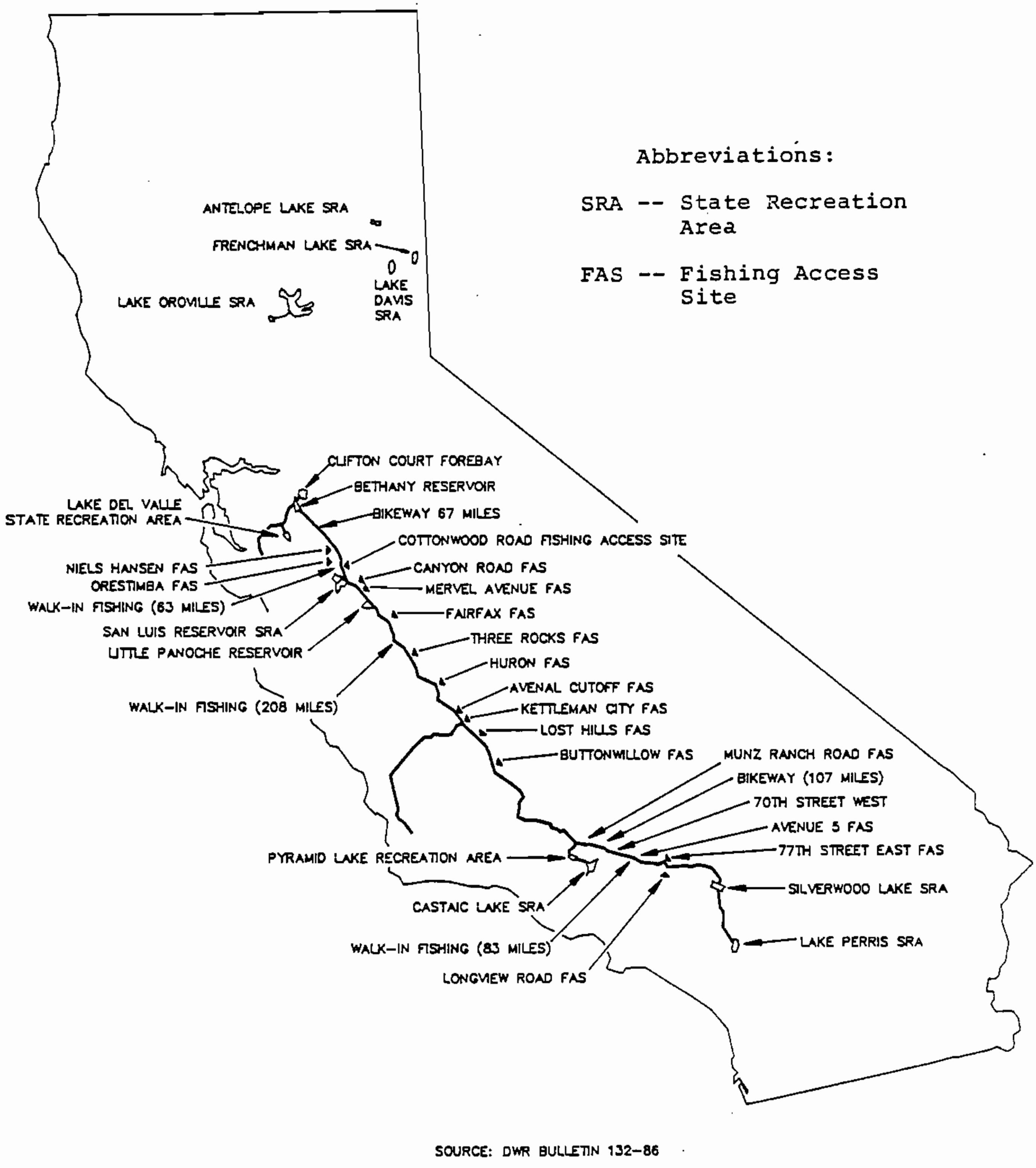
4.9.3 Fishery Habitat

Export fishery habitat consists primarily of the reservoirs and conveyance channels used for movement and storage of Bay-Delta water south of the Delta. In all cases this habitat may be classified as warm water fishery habitat. The major facilities discussed here and in Section 4.9.5 (Export Recreation) are:

- San Joaquin Valley and San Francisco Bay Area

  Delta-Mendota Canal, San Luis Canal, Edmund G. Brown California Aqueduct, Lake Del Valle, Bethany Reservoir, San Luis Reservoir (and O'Neill Forebay), and Los Banos Reservoir.

FIGURE 4.9.3-1 State Water Project Recreation Developments (from: SWC, 65, 6)



SOURCE: DWR BULLETIN 132-86

- o Southern California

  West Branch California Aqueduct, East Branch California Aqueduct, Pyramid Lake, Castaic Lake, Silverwood Lake, and Lake Perris (SWC,65,6).

Recreational access at all SWP facilities is shown in Figure 4.9.3-1 (SWC,65,6). Expansion of this habitat will not occur unless additional facilities are built (e.g., Los Banos Grandes Reservoir) (DWR,707).

Some of the eggs and larvae of some fish entrained into the export pumps survive and develop in the aqueducts and some of the reservoirs such as Bethany Reservoir and San Luis Reservoir (and O'Neill Forebay) (SWC,65,45). The hearing record is unclear whether these populations are self-sustaining or are maintained by additional entrainment. In other reservoirs, the majority of fish are planted for recreational fishing (SWC,65,47) (see Section 4.9.5). (It was inferred from SWC,65,47 that DFG plants the fish in these reservoirs, but no direct evidence was presented.) No information was presented on which species are planted, or what percent of total statewide fish planting is dedicated to SWP facilities.

The aqueducts tend to provide a relatively stable habitat for fish because the export water quality is maintained for municipal and industrial standards, and because water depth in the aqueducts does not change. In some reservoirs such as San Luis, however, the habitat may change significantly due to either seasonal variation in temperature or drawdown to meet water demands. The San Luis Reservoir recreational storage objective for Labor Day is 6,900 acres of surface area, or approximately half the surface area of the full reservoir (DWR,708,14). However, this converts to an 83 percent reduction in storage and, therefore, in fishery habitat. Other reservoirs, especially the terminal SWP reservoirs in southern California, are operated to retain more stable water levels because of the level of recreational activity on them (T,39,122:2-9); DWR presented the specific operating criteria (DWR,708.)

4.9.4 Export Wildlife Use

Water exported from the Sacramento-San Joaquin watershed provides some wetland, aquatic, and riparian habitat wherever it is delivered. Examples of important wildlife uses may be found in a number of export areas (SWRCB,14,III-9). Water in SWP reservoirs and in wildlife areas in southern California provides aquatic habitat where there might formerly have been none or replaces wetland habitat which was damaged or destroyed by earlier urbanization or water development. Substantial waterfowl habitat for example is maintained with DMC water in the Grassland Water District, an area that formerly received water from San Joaquin River overflows and agricultural return flows which ceased when Friant Dam began operations (EDF,11,II-3). The quality of exported water generally meets the water quality needs of wildlife in the export areas, although supplies are unreliable (DFG,2,A-8). Attempts to develop more wildlife habitat by using agricultural drainage water have led to toxicity problems (EDF,11,II-11).

4.9.5 Export Recreation

The aqueducts and reservoirs in the SWP[1/] are used for recreation in both central and southern California. Fishing and bicycle riding are the main activities along the aqueducts, and numerous fishing access points are available along them (SWC,65,6)(see Figure 4.9.3-1). The reservoirs are used for a wide variety of water-contact and non-water-contact activities, including fishing, swimming, boating, waterskiing, camping, picnicking and bird watching (SWC,65,5). About five million visitors used the SWP facilities south of the Delta in 1985 and they spent an estimated $95 million to travel to and use these sites (SWC,65,7,14).More than one million game fish were stocked in 1985 (SWC,65,7) to support recreational fishing activity in the four southern California SWP reservoirs. No evidence was presented on alternative sites for freshwater recreation in southern California.

The water quality requirements for salinity and other constituents of SWP and CVP water to protect municipal and industrial uses also protect recreational uses. The aqueducts are usually full, and the southern California reservoirs are operated to minimize impacts on recreation during the peak recreation seasons (T,XXXIX, 122:2-9) primarily by limiting drawdown rates (DWR,708,15-18).

1/ Discussion is limited to recreational activities directly related to export facilities of the SWP. No information was provided on recreation at CVP export facilities other than those used jointly by the CVP and SWP, which are included in the SWP descriptions. These facilities are listed in Section 4.9.3 (Export Fishery Habitat).

References for Chapter 4

- Regional Water Quality Control Board #5, Water Quality Control Plan Report 5B, Volume I, 1975, pg. I-2-2.
- Department of Water Resources Bulletin 166-3 "Urban Water Use in California", October 1983, pgs. 1-25.
- Department of Water Resources, Bulletin 27 "Variation and Control of Salinity in the Sacramento-San Joaquin Delta and Upper San Francisco Bay", 1931, pgs. 21 and 47.
- State Water Resources Control Board, "Environmental Impact Report for the Water Quality Control Plan and Water Right Decision, Sacramento-San Joaquin Delta and Suisun Marsh", August 1978, pgs. 142,143.
- National Oceanic and Atmospheric Admininstration. 1986. Marine Environmental Assessment, San Francisco Bay, 1985 Annual Summary, 122 pp.
- Department of Water Resources. 1987. Sacramento-San Joaquin Delta Atlas.
- California Department of Fish and Game, and U.S. Fish and Wildlife Service. 1980. Sacramento-San Joaquin Delta Wildlife Habitat Protection & Restoration Plan.
- Department of Water Resources. 1982. Draft Environmental Impact Report. Proposed Additional Pumping Units. Harvey O. Banks Delta Pumping Plant.
- Regional Water Quality Control Board #4, Water Quality Plan Report 4B, Volume I, 19075, pg I-2-2.
- USBR, Factsheet: "Exhibits and Testimony before SWRCB, Bay-Delta Hearing, 1987", 1987.
- Department of Finance, Report 86-E-2, January 1987.
- RWQCB 5. 1975. Water Quality Control Plan Report, Sacramento River Basin (5A); Sacramento-San Joaquin Delta Basin (5B), San Joaquin Basin (5C). Volume I.
- USBR. 1952. Report of Operations. Table 14. December, 1952.
- USBR. 1984. Report of Operations. Table 28. December, 1984.
- USBR. 1985. Report of Operations. Table 28. December, 1985.
- USBR. 1987. Fact Sheet, USBR Exhibits and Testimony before SWRCB, Bay-Delta Hearings.

5.0 OPTIMAL LEVELS OF PROTECTION FOR BENEFICIAL USES OF BAY-DELTA ESTUARY WATER

5.1 INTRODUCTION

The levels of flow and salinity considered to be optimal for the protection of beneficial uses are presented in this chapter. The levels needed for protection are developed solely for the beneficial use being addressed; other beneficial uses are not considered. Three levels are addressed: (1) the no action alternative; (2) The advocated level(s); and (3) the optimal level of protection.

1. The no action alternative is considered to provide the minimum level of flow and salinity protection for the beneficial use being discussed. It is the level of protection currently existing at any particular site as a result of the Delta Plan, and the level considered to be in compliance with federal regulations protecting existing uses (40 CFR Section 131.3(e)and(f)[1/]. Those standards affecting South Delta Water Agency (SDWA) were held in abeyance, at their request, awaiting the results of negotiation among them, Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR). Therefore, the existing 500 mg/l TDS standards for Vernalis contained in the New Melones water right permit is considered the "no action" value for this chapter. This standard would be in effect for this area if no further action occurred. Though water quality standards for San Francisco Bay were not explicitly addressed in the Delta Plan, the effects on the Bay were indirectly determined from Delta inflows regulated by the Delta Plan.

2. Advocated level(s) of protection are those recommended by witnesses during Phase I of the hearing. Testimony or exhibits that recommended flow and/or salinity levels to protect a specific beneficial use are summarized. (They are not given in any priority or ranking.)

3. The optimal level of protection can be considered the maximum level of protection possible for a beneficial use. This protection level is identified for a particular site when appropriate, and when data are available. The level can be the same as the two previous levels, if either provides optimal protection; or it can be a separate level based upon an independent evaluation of available data. The optimal level of protection will be used as a point of comparison for developing globally balanced objectives in chapter 6 and 7.

1/ The level of protection necessary to maintain the beneficial uses actually attained on or after November 28, 1975 level of protection. The level is mandated to the State Board by EPA regulations (40 CFR 131.12) and is considered to be the minimum protection which may be afforded a beneficial use.

5.2 Hydrologic Considerations

Flow and salinity at any particular location in the Delta is dependent upon Delta inflows, agricultural drainage return flows, consumptive uses, exports, and the placement of the Delta Cross-Channel gates. The major factors affecting the overall Delta flow and salinity are the magnitude and relative distribution of the Sacramento and San Joaquin river's inflows, since they are the major sources of water for the Delta. In the southern Delta, the flow and salinity is almost exclusively influenced by inflow and salt loading from the San Joaquin River due to its proximity to Vernalis. The internal Delta, on the other hand, is influenced to some degree by both river systems, especially when Delta exports are high. For the purpose of considering river effects on the beneficial uses discussed in this chapter, all of the Estuary locations were considered to be part of the hydrologic classification of the Sacramento River system except the following locations which were considered to receive water from the San Joaquin River system: San Joaquin River at Vernalis; San Joaquin River at Mossdale; San Joaquin River at the former location of Brandt Bridge; the bifurcation of Old and Middle River; Middle River at Howard Road Bridge; and Old River at Tracy Road Bridge.

5.3 DETERMINING THE OPTIMAL LEVEL OF PROTECTION FOR BENEFICIAL USES

5.3.1 Municipal and Industrial

5.3.1.1 No Action Alternative

Municipal and Industrial (M&I) use is currently protected by standards developed in the Delta Plan. These standards, listed in Table 5.3.1.1-1, cover both M&I categories of beneficial uses. The level of protection considered adequate to protect municipal uses was determined by the Delta Plan to be 250 mg/L chlorides. This level was not based on a primary health requirement, but on a secondary aesthetic requirement, set by the Department of Health Services (DHS).

The level set for the protection of industrial uses was determined to be 150 mg/L chlorides. This standard, intended to protect the historical water supply of two paper manufacturing industries provided a salinity necessary to maintain industry products.

5.3.1.2 Advocated Levels of Protection

The participating organizations making M&I recommendations have recommended that the Delta Plan be retained in total or in part to protect M&I use (DWR,280;T,LIX,189:1-7;T,VI,125:4-15). Modifications to the Delta Plan M&I standards were recommended by DWR, USBR, SWC, and CCWD. DWR and USBR are unified in their recommended modifications. SWC's recommended modifications fall within the recommendations made by DWR and USBR. The participants' recommendations are:

Table 5.3.1.1-1--Decision 1485
Water Quality Standards
For the Sacramento-San Joaquin Delta and Suisun Marsh[1/]

Beneficial Use Protected and Location	Parameter	Description	Year Type[2/]	Values
MUNICIPAL AND INDUSTRIAL				
Contra Costa Canal Intake at Pumping Plant No.1	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250
Contra Costa Canal Intake at Pumping Plant No. 1 or Antioch Water Works Intake on San Joaquin River	Chloride	Maximum Mean Daily 150 mg/l Chloride for at least the number of days shown during the Calendar Year. Must be provided in intervals of not less than two weeks duration. (% of year shown in parenthesis)		Number of Days Each Calendar Year Less than 150 mg/l Chloride
			Wet	240 (66%)
			Ab. Normal	190 (52%)
			Bl. Normal	175 (48%)
			Dry	165 (45%)
			Critical	155 (42%)
City of Vallejo Intake at Cache Slough	Chloride	Maxium Mean Daily Cl^- in mg/l	All	250
Clifton Court Forebay Intake	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250
Delta Mendota Canal	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250

1/ All values for surface zone measurements. All mean daily values are based on at least hourly measurements. All dates are inclusive.

2/ The year for the preceding Water Year will remain in effect until the initial forecast of unimpaired runoff for the current Water Year is available.

- DWR, USBR, and SWC (where noted by reference)

  - Eliminate the 250 mg/l maximum mean daily chloride quality standard at Cache Slough. The City of Vallejo will divert water from the newly finished North Bay Aqueduct; the Cache Slough diversion point will only be used as a secondary M&I supply source (DWR,280).

  - Add a quality objective at the North Bay Aqueduct intake at Barker Slough. The recommended objective would be set at a maximum mean daily chloride level of 250 mg/l for all water year types. Barker Slough is an M&I diversion point for Napa, Vallejo, and Sonoma counties (DWR,280).

  - Eliminate the 150 mg/l chloride quality standard at both the Antioch Water Works Intake on the San Joaquin River and the Contra Costa Canal Intake at Rock Slough. This standard is set to protect industrial uses in the Antioch-Pittsburg area. The recommendation to eliminate this standard is based on the evidence indicating that diversion of water for industry of this quality at Antioch is not reasonable when considering the Delta outflow required to maintain it (DWR,280;T,LIX,149:12-20).

  - Add a quality objective at Old River near Rock Slough. The recommended objective would be set at a maximum mean daily chloride level of 250 mg/l for all water year types. This recommendation is based on the conclusion that an objective at Old River near Rock Slough will help in determining an "allocation of responsibility" for meeting the standard at the Contra Costa Canal Intake (DWR,280;T,VI,97:8-19;T,LIX,213:8-214,8).

- CCWD

  - Add a quality objective at the site of the future intake to the Kellogg/Los Vaqueros Reservoir. The location of the intake has not yet been determined. The recommended objective would be set at a maximum chloride level of 50 mg/l for the months of April through June (T,VII,57:13-19; T,VII,118:16-120,9).

5.3.1.3 Optimal Level of Protection

Retain the Delta Plan standards to protect M&I beneficial uses with the following changes:

o Retain the 250 mg/l maximum mean daily standard at Cache Slough as discussed in 5.3.1.2, under the condition that it would only be in effect when water is being diverted from there for M&I uses.

o Add a 250 mg/l maximum mean daily chloride objective at Barker Slough as discussed in 5.3.1.2. This objective will provide protection for M&I uses at this new point of diversion.

- Add a 250 mg/l maximum mean daily chloride objective, to become effective when the proposed facility begins operation, at the future intake to the proposed Kellogg/Los Vaqueros Reservoir. The objective will provide reasonable protection to the M&I uses supplied by the proposed facility.

- Retain the 150 mg/l maximum mean daily chloride objective at the Contra Costa Canal intake/Antioch water works intake. Extend the period of time that this objective is met to the full year. Industrial water quality within the Delta is protected in the Delta Plan by this standard. The amount of time this standard is in effect varies according to year type. Optimally, this objective would be met for the full year and is proposed as such under the optimal levels of protection.

The advocated addition of a 250 mg/l chloride objective at Old River near Rock Slough has been determined to be inappropriate. The current standard at the Contra Costa Canal Intake provides full protection for M&I diversions at that location. The advocated objective, located a distance away from the current point of diversion; does not represent the salinity at the point of diversion; it therefore does not protect the M&I beneficial uses served by the Contra Costa Canal as well as they are by the current standard. Also, the basis for the recommendation, i.e., that it would allow a "...later allocation of responsibilities..." for meeting the standard at the Contra Costa Canal does not justify the addition of a new standard.

The CCWD's proposal to add a 50 mg/l chloride objective at the intake of the proposed Kellogg/Los Vaqueros Reservoir should be rejected because the hearing evidence and testimony presented on M&I beneficial use needs do not justify it. The water quality standard for MUN use is 250 mg/l chlorides, which is a taste rather than a health consideration. Industries outside of the Delta, many of which are supplied from a diversion point other than the Contra Costa Canal, have not submitted evidence showing a need for water quality better than 250 mg/l chlorides. Based on this information, a level of protection better than 250 mg/l is not justified.

Table 5.3.1.3-1 is a list of averaged monthly salinities for each water year type. The source data are mean monthly hourly salinities over a tidal cycle simulated for an unimpaired condition over the Water Years 1922 through 1978. The data show that at no time do these average values exceed the 250 ppm chloride standard set forth in the Delta Plan. Table 5.3.1.3-2 lists the locations and optimal levels protection for M&I uses.

TABLE 5.3.1.3-1
UNIMPAIRED FLOW MEAN SALINITY
(mg/l chlorides)

WATER YEAR INDEX	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CLIFTON COURT												
CRITICAL	190	154	119	77	64	102	137	154	146	176	199	196
DRY	145	105	80	56	40	52	107	144	160	163	195	182
B. NORMAL	114	85	63	45	29	44	91	130	158	189	162	127
A. NORMAL	100	53	45	32	21	34	74	114	139	182	200	167
WET	74	63	52	36	21	22	50	99	140	193	176	99
TRACY PUMPING PLANT												
CRITICAL	190	182	160	136	109	93	99	127	152	138	162	183
DRY	151	143	129	108	88	72	73	100	131	135	156	158
B. NORMAL	161	142	123	101	80	65	62	81	113	133	164	171
A. NORMAL	148	116	91	75	60	50	48	62	96	144	166	166
WET	124	93	72	58	47	39	37	47	75	142	169	166
CONTRA COSTA CANAL												
CRITICAL	142	146	157	132	84	74	100	101	146	119	137	145
DRY	131	137	130	93	56	50	66	90	92	135	139	133
B. NORMAL	60	59	57	48	33	30	39	54	55	56	58	59
A. NORMAL	69	68	66	49	29	26	36	52	54	71	71	71
WET	107	103	100	86	44	26	41	65	95	104	109	108
CACHE SLOUGH												
CRITICAL	16	16	16	16	17	18	20	21	22	19	18	17
DRY	16	16	16	16	16	17	18	19	19	20	19	16
B. NORMAL	18	18	18	18	18	18	20	21	22	21	19	18
A. NORMAL	18	18	18	18	18	18	19	21	22	22	20	19
WET	19	19	19	19	20	20	20	22	22	23	21	20
LINDSEY SLOUGH (BARKER SLOUGH)												
CRITICAL	16	16	16	16	16	17	17	19	23	17	16	16
DRY	16	16	16	16	16	16	17	17	17	18	17	16
B. NORMAL	18	18	18	18	18	18	19	19	19	19	18	18
A. NORMAL	18	18	18	18	18	18	19	19	19	19	19	18
WET	20	20	20	20	20	20	20	20	20	21	20	20

TABLE 5.3.1.3-2
OPTIMAL LEVEL OF PROTECTION FOR
MUNICIPAL AND INDUSTRIAL USES

Beneficial Use Protected and Location	Parameter	Description	Year Type	Values
MUNICIPAL				
Contra Costa Canal Intake[1/] at Pumping Plant #1	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
Clifton Court Forebay Intake at West Canal	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
Delta Mendota Canal at Tracy Pumping Plant	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
North Bay Aqueduct at Barker Slough	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
City of Vallejo Intake[2/] at Cache Slough	Chloride	Maximum Mean Daily Chloride in mg/l	All	250
INDUSTRIAL				
Contra Costa Canal Intake at Pumping Plant #1	Chloride	Maximum Mean Daily Chloride in mg/l	All	150
or				
Antioch Water Works Intake on San Joaquin River				

1/ This objective will remain in effect until Contra Costa Water District moves its intake to Clifton Court Forebay.

2/ Only used as a control station if City of Vallejo is taking water from this source.

5.3.2 (not used)

5.3.3 Agriculture

5.3.3.1 No Action Alternative

- Western Delta

In the Delta Plan, the 0.45 millimhos/centimeter (mmhos/cm) electrical conductivity (EC) agricultural standards set for applied water in the western Delta were based upon the corn criterion which provided 100 percent corn yield in this region's subirrigated organic soil. These standards were relaxed in all water year types except wet years at Emmaton and Jersey Point, and in the above normal year at Jersey Point. The amount of relaxation was based on time weighted average of water quality over the period April 1 to August 15 for conditions that would exist without Central Valley Project (CVP) and the State Water Project (SWP) conditions (Without Project conditions). Adjustment of the standards for water year type was justified based on the water quality that would have occurred in the absence of the projects for such deliveries. Table 5.3.3.1-1 lists the numerical standards set for western Delta agriculture.

TABLE 5.3.3.1-1
WATER QUALITY STANDARDS FOR WESTERN DELTA AGRICULTURE[1/]

Location	Parameter	Description	Year Type[2/]	Values: 0.45 EC April 1 to Date Shown	Values: EC from Date Shown[3/] to August 15
Emmaton on the Sacramento River	EC	Max. 14-day Running Avg. of Mean Daily EC in mmhos/cm	Wet	August 15	—
			Ab. Norm	July 1	0.63
			Bl. Norm	June 20	1.14
			Dry	June 15	1.67
			Critical	--	2.78
Jersey Point on the San Joaquin River	EC	Max. 14-day Running Avg. of Mean Daily EC in mmhos/cm	Wet	August 15	—
			Ab. Norm	August 15	--
			Bl. Norm	June 20	0.74
			Dry	June 15	1.35
			Critical	--	2.20

1/ Water Quality Control Plan, August 1978
2/ The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.
3/ When no data are shown EC limit continues from April 1.

- Interior Delta

The Delta Plan agricultural water quality standards for the interior Delta were set using the same corn criterion as in the western Delta. However, under Without Project conditions, water quality in the interior Delta during the irrigation season was better than in the western Delta. Therefore, water year type relaxations for the interior Delta were not as severe. Table 5.3.3.1-2 lists the interior Delta water quality standards set in the Delta Planhearing process.

TABLE 5.3.3.1-2
WATER QUALITY STANDARDS FOR INTERIOR DELTA AGRICULTURE[1/]

Location	Parameter	Description	Year Type[2/]	Values: 0.45 EC April 1 to Date Shown	Values: EC from Date Shown[3/] to August 15
Terminous on the Mokelumne River	EC	Max. 14-day Running Avg. of Mean Daily EC in mmhos/cm	Wet	August 15	--
			Ab. Norm	August 15	--
			Bl. Norm	August 15	--
			Dry	August 15	--
			Critical	--	0.54
San Andreas Landing on the San Joaquin River	EC	Max. 14-day Running Avg. of Mean Daily EC in mmhos/cm	Wet	August 15	--
			Ab. Norm	August 15	--
			Bl. Norm	August 15	--
			Dry	June 25	0.58
			Critical	--	0.87

1/ Water Quality Control Plan, August 1978.
2/ The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.
3/ When no data are shown EC limit continues from April 1.

- Southern Delta

Water quality standards for the southern Delta in the Delta Plan were based on University of California guidelines for the quality requirements of two of the most predominant salt sensitive crops grown in the southern Delta, beans and alfalfa. They recommended an applied water quality for beans of 0.7 mmhos/cm EC from April through August, and 1.0 mmhos/cm EC for alfalfa the remainder of the year (WQCP,8/79; VI-18,19).

The standards were not implemented pending completion of New Melones Reservoir and an agreement among the South Delta Water Agency, the Department of Water Resources, and the Bureau of Reclamation to complete suitable circulation and water supply facilities. Upon completion of New Melones Reservoir in 1981, a 500 mg/l total dissolved solids (TDS) (770 mmhos/cm EC) standard at Vernalis came into effect. In the Delta Plan the Board stated that, if by January 1, 1980 facilities and water supplies were not in place, the Board would take appropriate enforcement action to prevent encroachment on riparian rights in the southern Delta. At South Delta Water Agency's request, this enforcement action was postponed awaiting results of continuing negotiations among the three agencies. For the purposes of the no action alternative these standards will be considered to have been in place. Table 5.3.3.1-3 lists the southern Delta water quality standards used as the no-action alternative objectives.

TABLE 5.3.3.1-3
WATER QUALITY STANDARDS FOR SOUTHERN DELTA AGRICULTURE[1/]

Location	Parameter	Description	Year Type	Values	
Vernalis near the San Joaquin River	TDS	Max. 30-day Running Avg. of Mean Daily TDS in mg/l	All[2/]	500	
				April 1 to August 31	September 1 to March 31
Tracy Road Bridge on Old River	EC	Max. 30-day Running Avg. of Mean Daily EC in mmhos/cm	All[3/]	0.7	1.0
Old River near Middle River					
Brandt Bridge on San Joaquin River					
Vernalis near the San Joaquin River					

1/ Water Quality Control Plan, August 1978
2/ After New Melones Reservoir becomes operational and until the standards below become effective.
3/ To become effective only upon the completion of suitable circulation and water supply facilities.

5.3.3.2 Advocated Levels of Protection

Central Delta Water Agency (CDWA):

- Water Quality Objectives

  The agricultural water quality objectives for the Delta should be set at a minimum water quality of 0.45 mmhos/cm EC year round except for adjustments in the drier months of drier years. The objective should not require a "leaching regimen" more rigorous than "winter flooding" or "fall sub-irrigation" more frequently than once in three years (CDWA,Brief,26-27). Delta leaching practices were defined in Section 4.4.1 of this Plan.

- Monitoring Locations

  The CDWA requests that monitoring stations be established at Old River near Holland Tract or Rancho Del Rio and on Turner Cut near McDonald Island Bridge, in addition to those previously established by the Delta Plan at Emmaton, Jersey Point, San Andreas Landing and Terminous (CDWA,Brief,27).

- Water Level Objectives

  CDWA stated that, "Water level objectives need to be established to prevent the operations of export diversions from depleting local channel volumes beyond the point that agricultural pumps and siphons are not adequately supplied" (CDWA,Brief, 27-28). No specific method of implementing this was recommended.

Central Valley Project Water Users Association (CVPWA):

- Water Quality Objectives

  Objectives should be established at 1.5 mmhoS/cm EC for the April 1 through August 15 period at Emmaton and Jersey Point. This objective should be adjusted to 3.0 mmhos/cm EC in critical Water Years (CVPWA,Brief,49). No objectives need be established for the areas of the Delta covered by contracts with the Department of Water Resources. DWR currently meets the Delta Plan standards in contracts with ECCID and NDWA (CVPWA,Brief,49).

- South Delta

  Meeting the existing 500 mg/l TDS standard at Vernalis must be the responsibility of all water right holders on the San Joaquin system (CVPWA,Brief,49).

Contra Costa County Water Agency (CCCWA):

- Water Quality Objectives

  The CCCWA recommends that the minimum water quality standard necessary to achieve a 100 percent yield of corn be set at 0.45 mmhos/cm EC for organic soils in the Delta (CCWA,Brief,17).

Delta Tributaries Agency Committee (DTAC):

- Water Quality Objectives

  DTAC recommends relaxation of the Delta Plan agricultural standard in the Central Delta, to the range of 1.5 to 2.5 deciSiemens/meter in all but critical years (One deciSiemen/meter is approximately equal to one mmho/cm EC). No objectives were suggested for critical years (DTAC,Brief,6).

- Leaching Objectives

  Water quality standards should be carefully established "to provide fall leaching water at the levels needed to leach a necessary minimum amount of salt from the crop root zone of Delta soils, but such leaching standard should be related to the quantity of water available for such leaching" (DTAC,BNIF,6-7).

- Southern Delta Objectives:

  DTAC recommends that the Board impose a short timetable for completion of the negotiations between SDWA, DWR, and USBR. Pending completion of such an agreement, the Board should require elimination of reverse flows in the San Joaquin River which are attributable to export pumping, and continuance of Delta plan standards (DTAC,Brief,6-7).

Department of Water Resources (DWR):

- Water Quality Objectives

  "Water quality objectives for the western and central Delta should be based upon the results and information derived from the Corn Study" (DWR,Brief,28). No specific numerical water quality criteria were recommended.

- Leaching Objectives

  An objective for post-harvest subirrigation leaching should be provided for a ten-day period between November 1 and December 20 at the Emmaton and Jersey Point stations. This objective should be in effect only when the upstream October 1 storage conditions are at or above the normal operating level which DWR defines as 11 million acre-feet for the following major Sacramento River system reservoirs: Shasta, Whiskey Town, Black Butte, Frenchman, Antelope, Grizzley Valley, Oroville, Almanor, New Bullards Bar, Engelbright, Folsom, Berryessa, and Trinity. Furthermore, a winter ponding objective should be provided at the Junction Point and San Andreas Landing stations for the months December through February (DWR,Brief,29-30).

- Monitoring Locations

  DWR recommends that specific Delta agricultural objectives for the irrigation season should be adopted for the following locations: (1) Sacramento River at Emmaton; (2) San Joaquin River at Jersey Point; (3) Mokelumne River at Terminous; (4) San Joaquin River at San Andreas Landing; and (5) Cache Slough near Junction Point (DWR,Brief, 30-31). Furthermore, the water quality objective at Emmaton should be eliminated when overland water supply facilities are developed for Sherman Island (DWR,Brief,32). The objective would be moved to the intake of the overland facilities.

- Southern Delta Objectives

  Negotiations should be completed among the DWR, USBR, SDWA to provide permanent solutions to the problems of local water level, water quality and circulation in the southern Delta (DWR,Brief,32).

North Delta Water Agency (NDWA) and East Contra Costa Irrigation District (ECCID):

- Water Quality Objectives

  NDWA and ECCID recommend that no change be made in Delta agricultural water objectives which would impair the contractual rights and obligations embodied in the contracts among NDWA, ECCID, and DWR (NDWA,Brief,2). These standards are outlined in summaries of testimony for ECCID and NDWA.

South Delta Water Agency (SDWA):

- Water Flow and Quality Objectives (Without Facilities)

  SWDA advocated two sets of recommendations. The first are recommendations with no south Delta facilities (SDWA,115, 1-2). The second are recommendations with south Delta facilities (SWDA,116,1-2). SDWA recommends that water quality at any monitoring points should not exceed an average of 400 mg/l TDS for the period March 1 through September 30 and must not exceed 400 mg/l TDS on a seven-day running average during March through June 30 and 500 mg/l TDS seven-day running average between July 1 and October 31. A TDS of 550 mg/l would be the maximum permissible seven-day running average between November 1 and February 28 (T,XV,31:15-31:23).

The minimum flow at Vernalis should comply with the following schedule to maintain the above water quality (the following figures relate to SDWA channel depletion, with a 500 cfs 5-day running average minimum flow. They do not include a flushing flow.):

October	696 cfs
November	583
December	500
January	500
February	500
March	600
April	900
May	900
June	1000
July	1300
August	1204
September	847

- Water Level Objectives (Without Facilities)

  Water levels at low tide should not be less than zero mean sea level at any point north of Vernalis at any time. Export pump drawdown must not contribute to violations of this objective (SDWA,115,1).

- Monitoring Locations (Without Facilities)

  SDWA proposes monitoring for water levels and water quality in the San Joaquin River near Vernalis, Mossdale, the bifurcation of Middle River and Old River, Middle River at Howard Road Bridge, San Joaquin River at, or near, the former location of Brandt Bridge, Old River at Tracy Boulevard, Old River at Westside Irrigation District intake; and water level only at the south end of Tom Paine Slough. The water flow should continue to be monitored in the San Joaquin River at Vernalis (SDWA,115,1).

- Water Flow and Quality Objectives (With Facilities)

  "Water quality required at the inflow points would be specified as a function of net daily inflow rate and of channel depletion by months for the channel reaches receiving water from each inflow point. The values would be initially determined by mathematical modeling of the system to give water quality equivalent to the no barrier standards" (SDWA,116,2).

  "The required net daily inflow rates at each inflow point would be in accordance with a monthly schedule sufficient to maintain the required undirectional net daily flow in each channel reach" (SDWA,116,2).

- Monitoring Locations (With Facilities)

  "Water levels would be monitored at Vernalis, on Old River at Middle Howard Road Bridge, on the San Joaquin River near Paradise Cut, on Old River at Tracy Boulevard, on Grantline Canal at Tracy Boulevard, and at Clifton Court" (SDWA,116,1).

  "Water quality would be monitored at Vernalis, on the downstream (intake) side of each barrier, at the former location of Brandt Bridge on the San Joaquin River north of Old River and Tracy Boulevard. On Grantline Canal, flow would be measured at Vernalis and through each barrier" (SDWA,116,172).

- Water Level Objectives (With Facilities)

  "Water level restraints at the monitoring points would be the same as for the no-barrier case except for an additional required level to be determined on the San Joaquin River south of Paradise Cut. Water level maintenance could also be assisted by seasonally functional flow restrictions in Grantline Canal and in the San Joaquin River Channel near Paradise Cut (SDWA,116,2).

State Water Contractors (SWC):

- Water Quality Objectives

  The SWC recommend changing existing standards to reflect the results of the corn study. Specific recommendations are 1.5 mmhos/cm EC from April 1 through August 15 for all water year types, and 3.0 mmhos/cm EC during critical years (SWC,Brief,I-43).

- Monitoring Locations

  The measuring station at Emmaton in the Sacramento River should be relocated to Three Mile Slough upon completion of overland water supply facilities to serve Sherman Island (SWC,Brief,I-43).

Bureau of Reclamation with Support from the U.S. Department of Interior:

- Water Quality Objectives

  The USBR presented testimony on the leaching requirements of the five most salt sensitive crops grown in the Delta uplands. These were beans, fruit and nuts, vineyards, corn and alfalfa (USBR,10 & A&B). From these leaching requirements, average irrigation season water quality objectives of 600 mg/l TDS in a normal year and 800 mg/l TDS in a dry year were developed for Delta agriculture (T,XV,139:15-139:21). The USBR, however, did not formalize these into recommendations (T,XV,140:3-140:9).

5.3.3.3 Optimal Level of Protection

Western and Interior Delta:

- Water Quality

  - Irrigation Water Quality

Field corn, the most widely grown crop in the Delta, is grown on greater than 21 percent of the total Delta land area including greater than 26 percent of the Delta lowlands (DWR,304). The optimal level of protection for the western and interior Delta will be based on the protection of corn as it is the predominant crop and among the most salt sensitive crops grown in the area.

The results of the corn study show that, with reasonable farm management practices, an irrigation water EC of 1.5 mmhos/cm will provide 100 percent corn crop yields in Delta organic soils that are subirrigated. An irrigation water salinity of up to 2.0 mmhos/cm EC would provide the same protection for corn on Delta mineral soils. In general, the quality level of 1.5 mmhos/cm EC is met under unimpaired flow conditions at all stations in all year types during the irrigation period of April 1 through August 15. Based on the need and the availability of this quality of water during unimpaired flow conditions, 1.5 mmhos/cm EC is proposed as the optimal level of protection. From information given in Phase I, it has been determined that, even with the adoption of these optimal objectives, Delta farmers will on occasion need to monitor field soil salinity conditions and provide effective leaching to bring the soil salinity to below the threshold value of 3.7 mmhos/cm EC (discussed below) before the start of each irrigation season. Results of the corn study also show that irrigation water salinity may be increased to as much as 6.0 mmhos/cm EC after the end of July without loss in crop yield for that irrigation season. The method or irrigation did not influence the salt tolerance relationship of corn but required increased leaching (SWRCB,22-24).

  - On-Farm

Should the foregoing water quality objectives for irrigation water be adopted, then leaching to remove excess salt buildup will be required. Removal of salt from the crop root zone through leaching will be required when root zone salinity exceeds 3.7 mmhos/cm EC.

- Water Quality Objectives for Leaching

  DWR's proposal for a winter ponding objective is appropriate. DWR did not propose a particular level of water quality, but did propose that it be in the form of maximum monthly EC. To protect the Western Delta, this objective should be provided at the Western and interior Delta monitoring agricultural locations for December through February. A maximum monthly EC objective of 1.7 mmhos/cm is recommended for this purpose. This objective is sufficient to provide for the leaching needs throughout the Delta.

- Water Levels

  Insufficient information was presented on the negative impacts of water levels and possible solutions to set objectives in the western and interior Delta.

- Location of Objectives

  Water quality objectives for the western and interior Delta should be established at the following locations: Emmaton on the Sacramento River, Jersey Point on the San Joaquin River, Terminous on the Mokelumne River, San Andreas Landing on the San Joaquin River, and Cache Slough near Junction Point.

Southern Delta:

- Water Quality

  Beans, the most widely grown salt sensitive crop in the southern Delta, were chosen as a target crop for purposes of setting objectives. By setting objectives for this crop, the less salt sensitive crops would also be fully protected. Water quality standards were developed in the Plan for the southern Delta based on bean growth (Table 5.3.3.1-3). As New Melones Reservoir is now operational, the 500 TDS objective at Vernalis is not recommended. The remaining standards, along with a change in the description from a 30-day to a 14-day running average, should provide an optimal level of protection for the southern Delta.

- Water Levels

  The issue of protection from low water levels was raised in Phase I of the hearing. Maintaining adequate water levels in the southern Delta can be accomplished through increased flow releases through regulating export pumping, or through channel modifications. It is believed that structural alternatives combined with dredging and regulating export pumping operations are feasible water level solutions and that no flow objective be set for water levels in the southern Delta.

- Flows

  As discussed previously, SDWA requested a schedule of flows for protection of southern Delta agriculture, in addition to minimum water quality standards. Since water quality objectives that will sufficiently protect the crops grown in the southern Delta are being recommended, there is no need for an additional requirement for flows.

- Location for Setting Objectives

  The agricultural water quality objectives in the southern Delta should be set at the San Joaquin River near Vernalis and near Mossdale; at the bifurcation of Old and Middle rivers; in Middle River at Howard Road Bridge; in Old River at Tracy Road Bridge; and in the San Joaquin River at the former location of Brandt Bridge.

Bay Agriculture:

Insufficient information was presented in the hearings to set objectives for agriculture in the Bay region.

5.3.3.4 Consideration of Water Availability

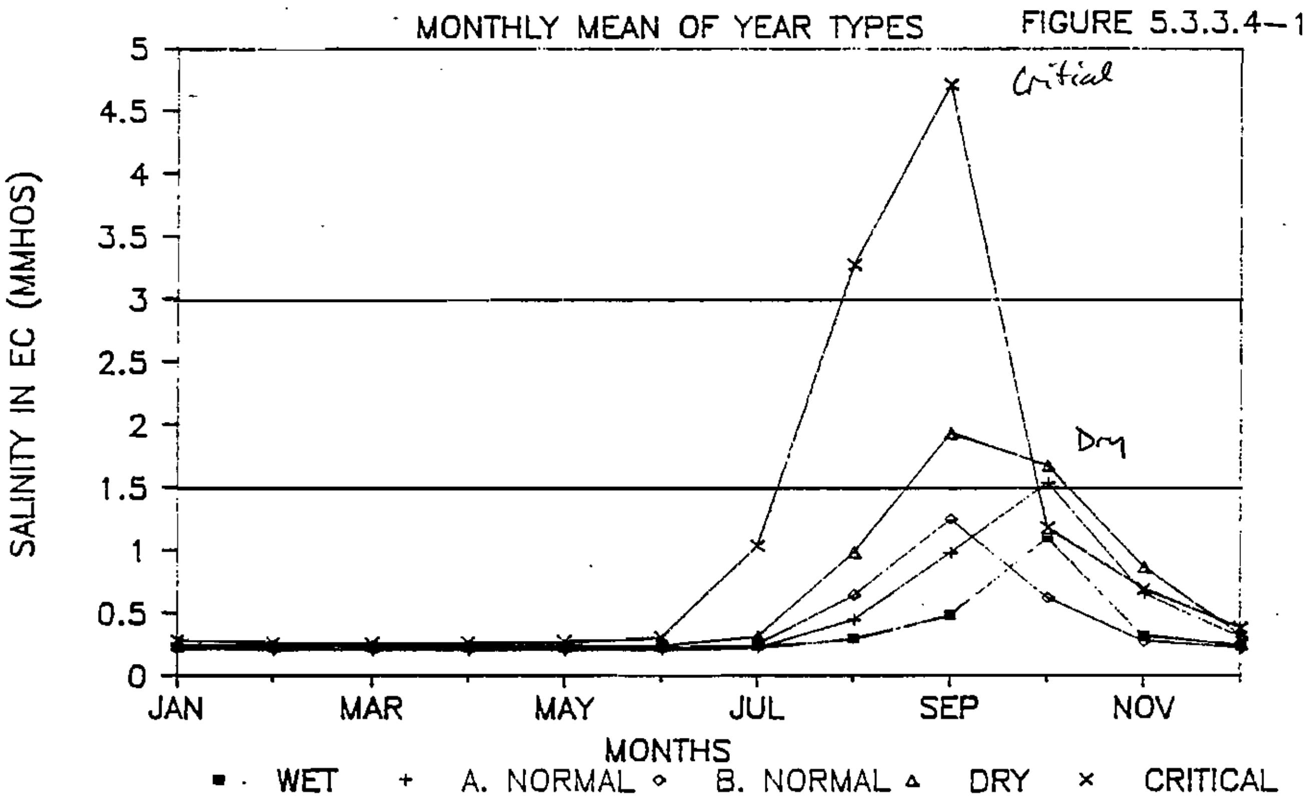
- Western and Interior Delta

  Figures 5.3.3.4-1 through 5 show the optimal objectives for the western and interior Delta superimposed over unimpaired water quality conditions for an average water year type at selected locations in the western and interior Delta. For the five stations in the western and interior Delta, the 1.5 mmhos/cm EC objective is exceeded at Emmaton only in dry and critical years and at Jersey Point only in critical years.

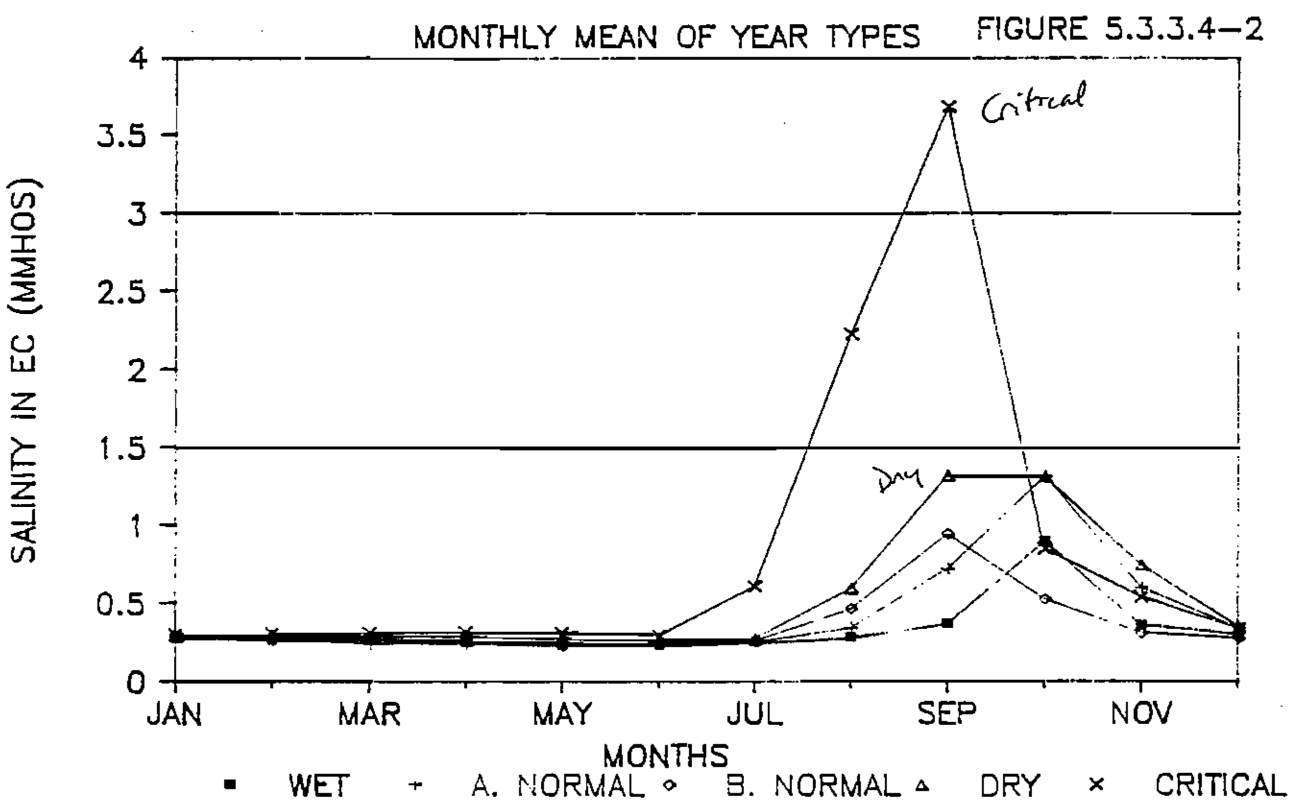
- South Delta

  Figures 5.3.3.4-6 through 11 show the optimal objectives for the southern Delta superimposed over average water year type of unimpaired water quality conditions for selected locations in the southern Delta. All stations in the southern Delta are below the objective of 0.7 mmhos/cm EC through the month of June in all year types. In all cases, July, only the critical years exceed the 0.7 mmhos/cm EC objective. In August through November for most year types, unimpaired water qualities are above the 0.7 mmhos/cm EC objective.

SACRAMENTO RIVER AT EMMATON

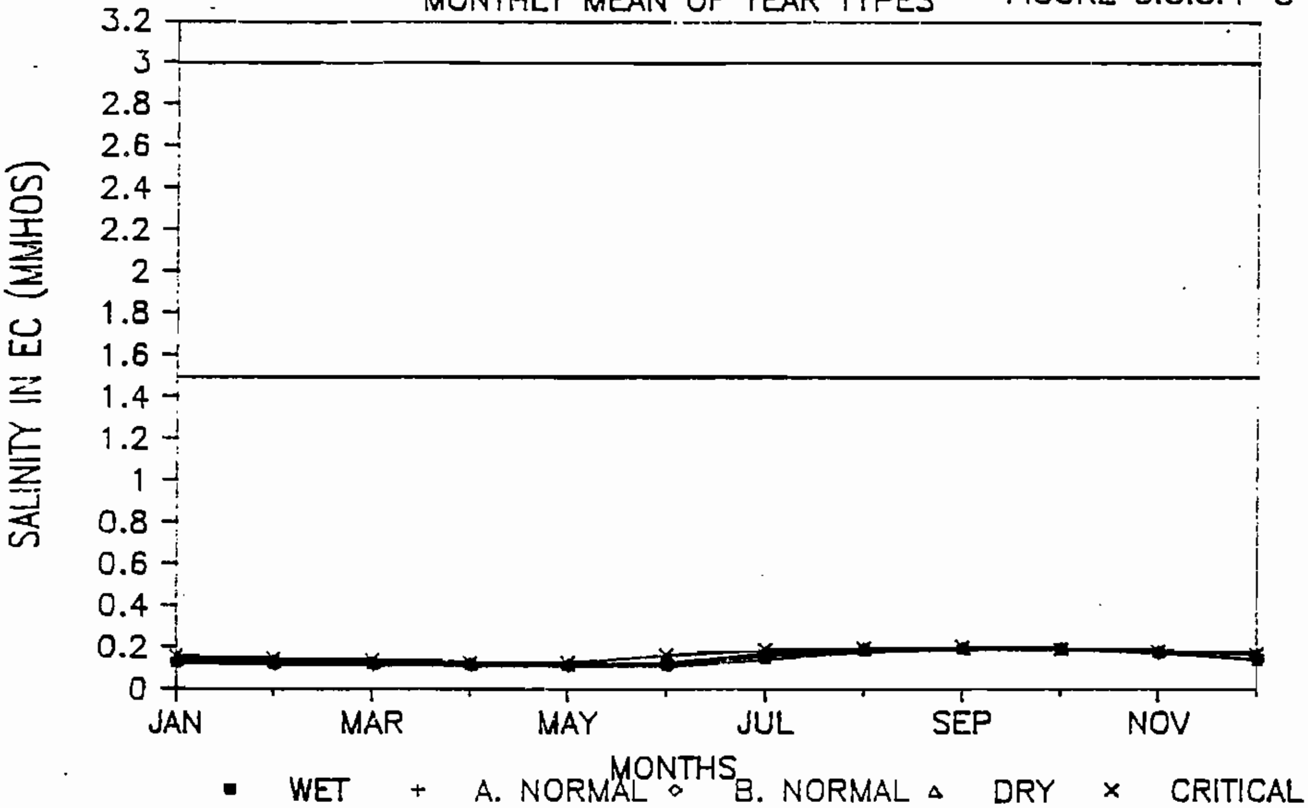


SAN JOAQUIN RIVER AT JERSEY POINT



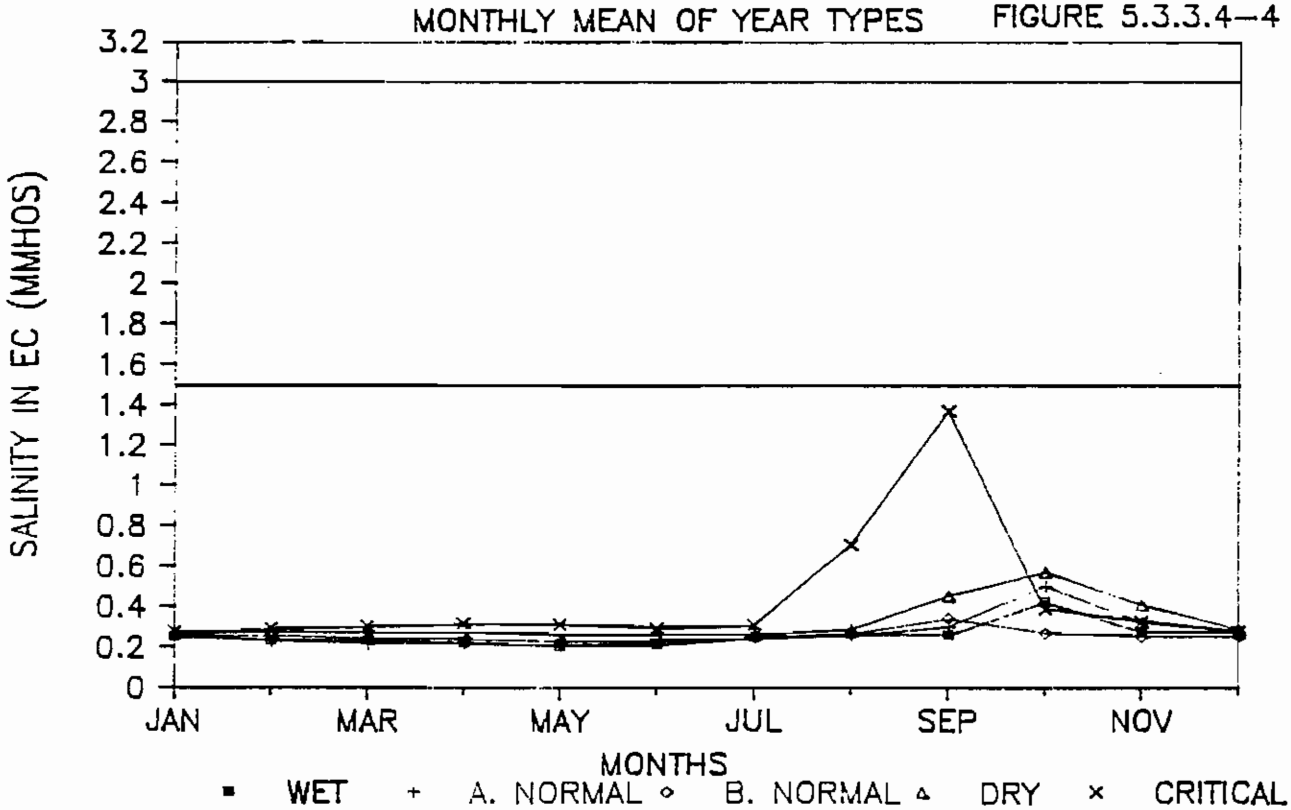
MOKELUMNE RIVER AT TERMINOUS

MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4-3



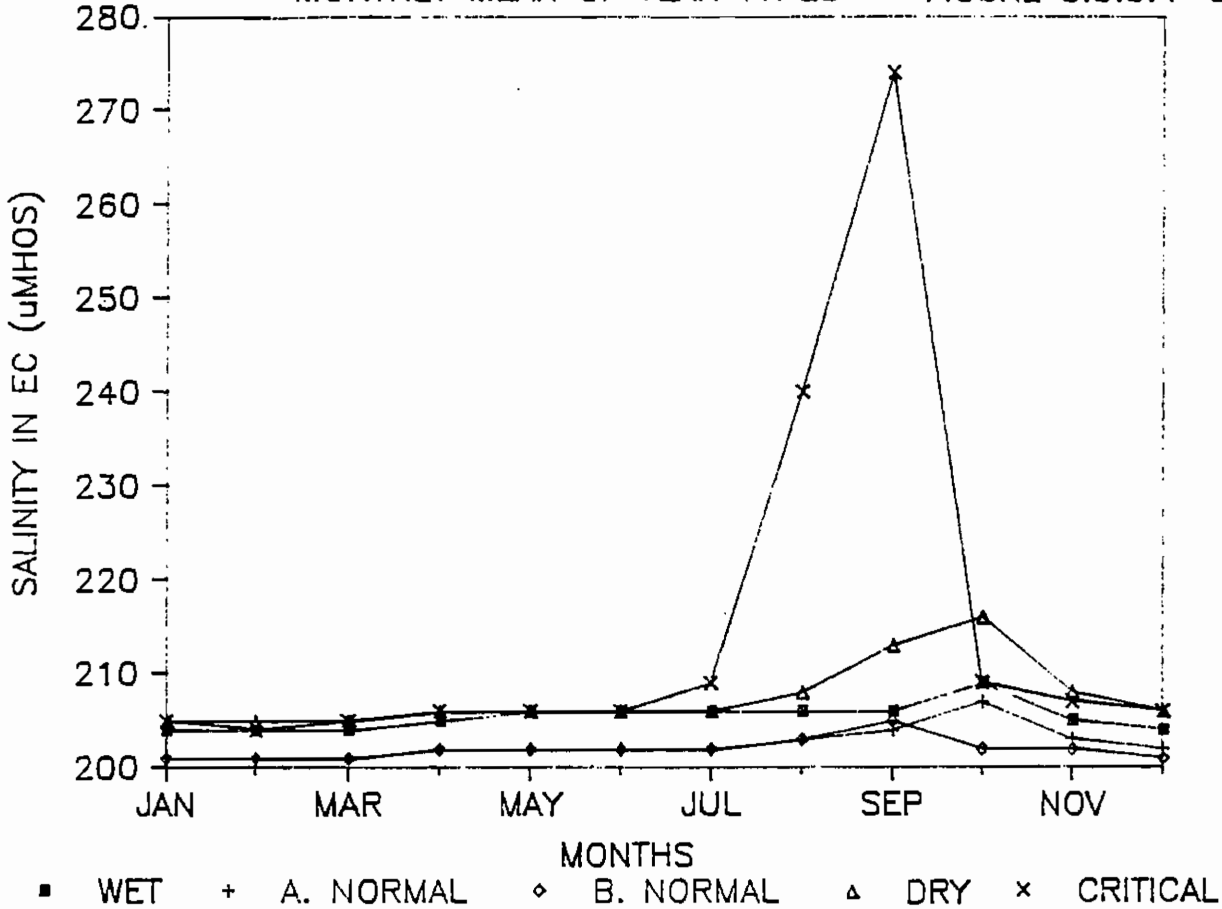
SAN JOAQUIN RIVER AT SAN ANDREAS

MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4-4



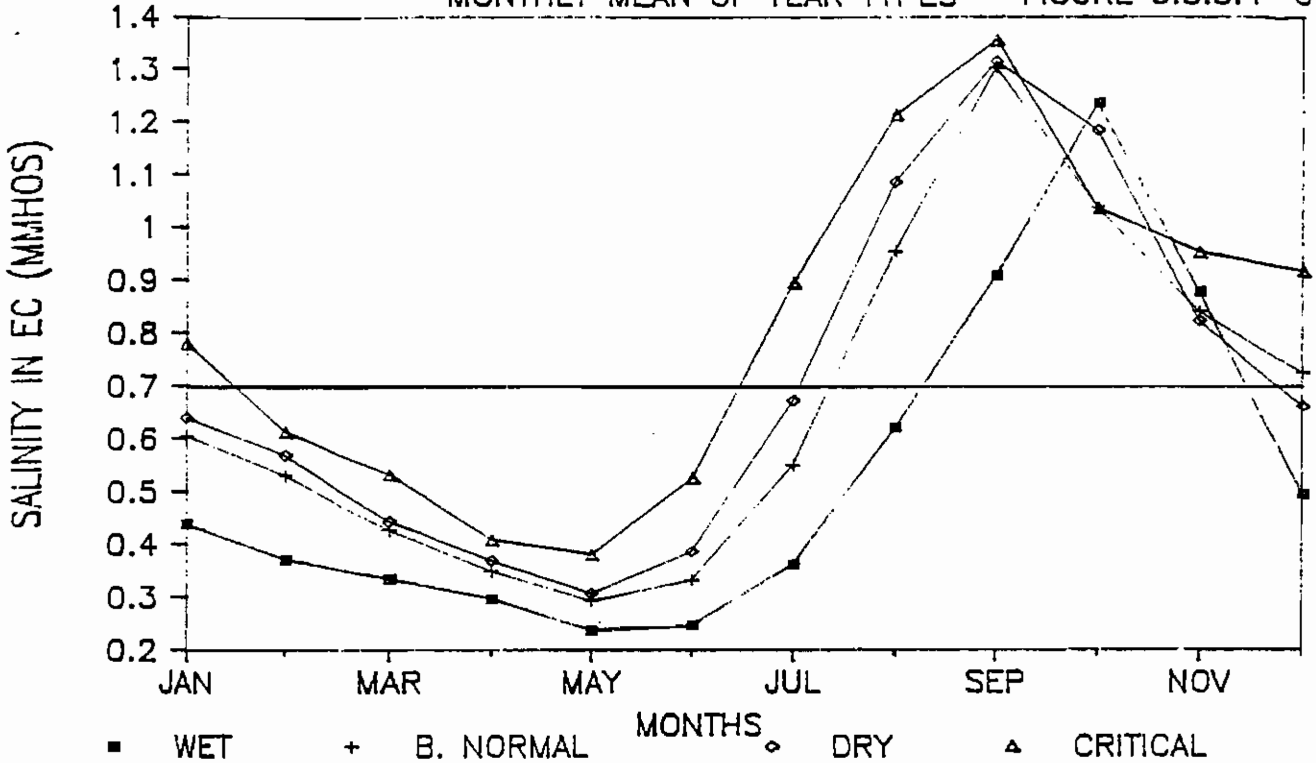
CACHE SLOUGH NEAR JUNCTION POINT

MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4-5



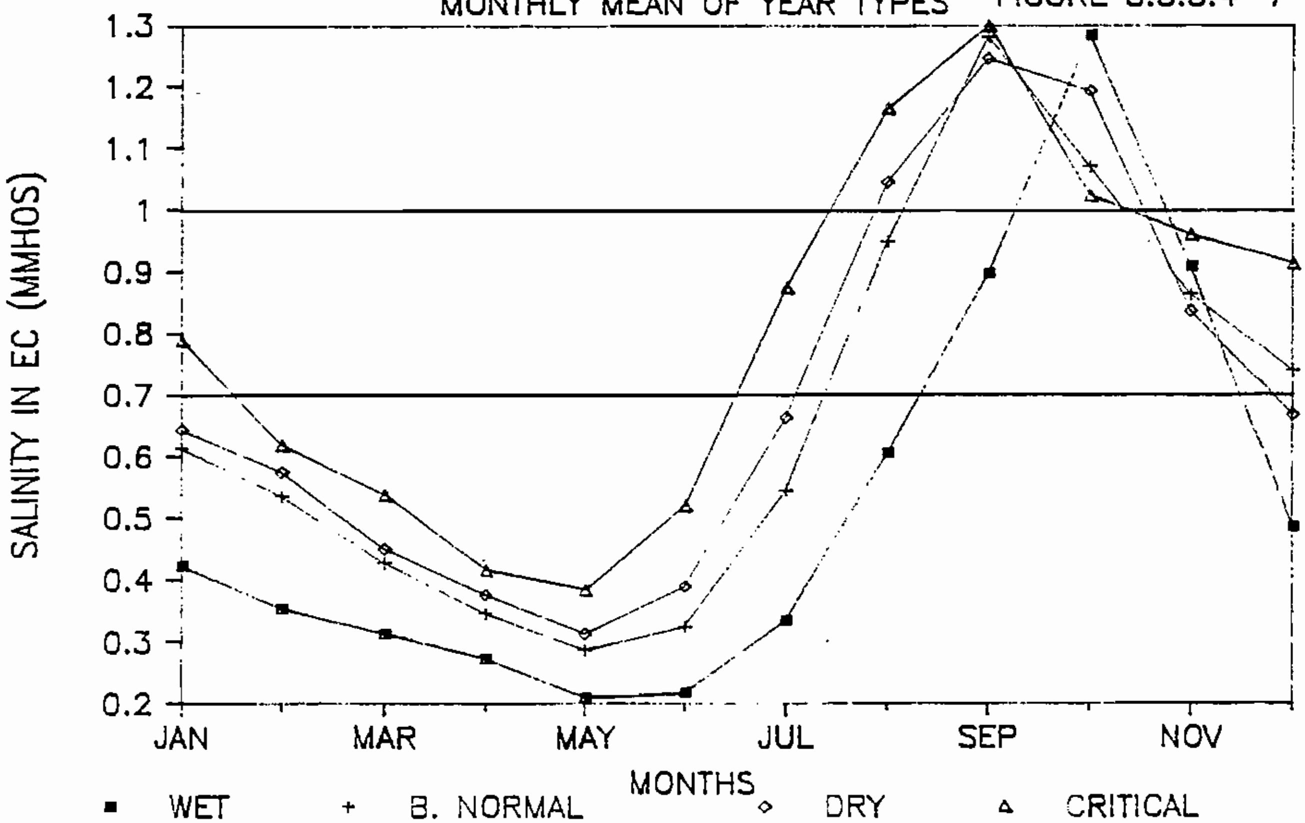
SAN JOAQUIN RIVER AT VERNALIS

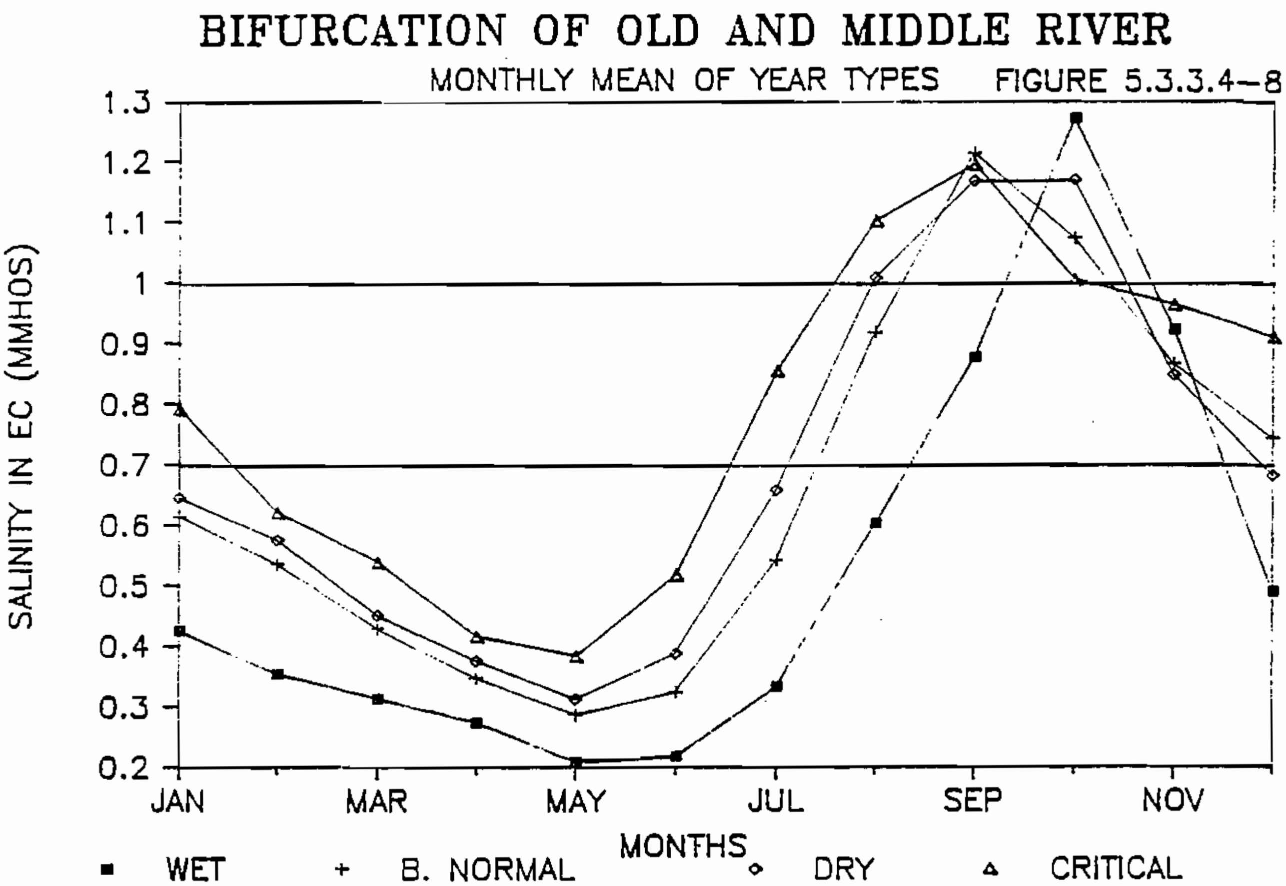
MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4–6

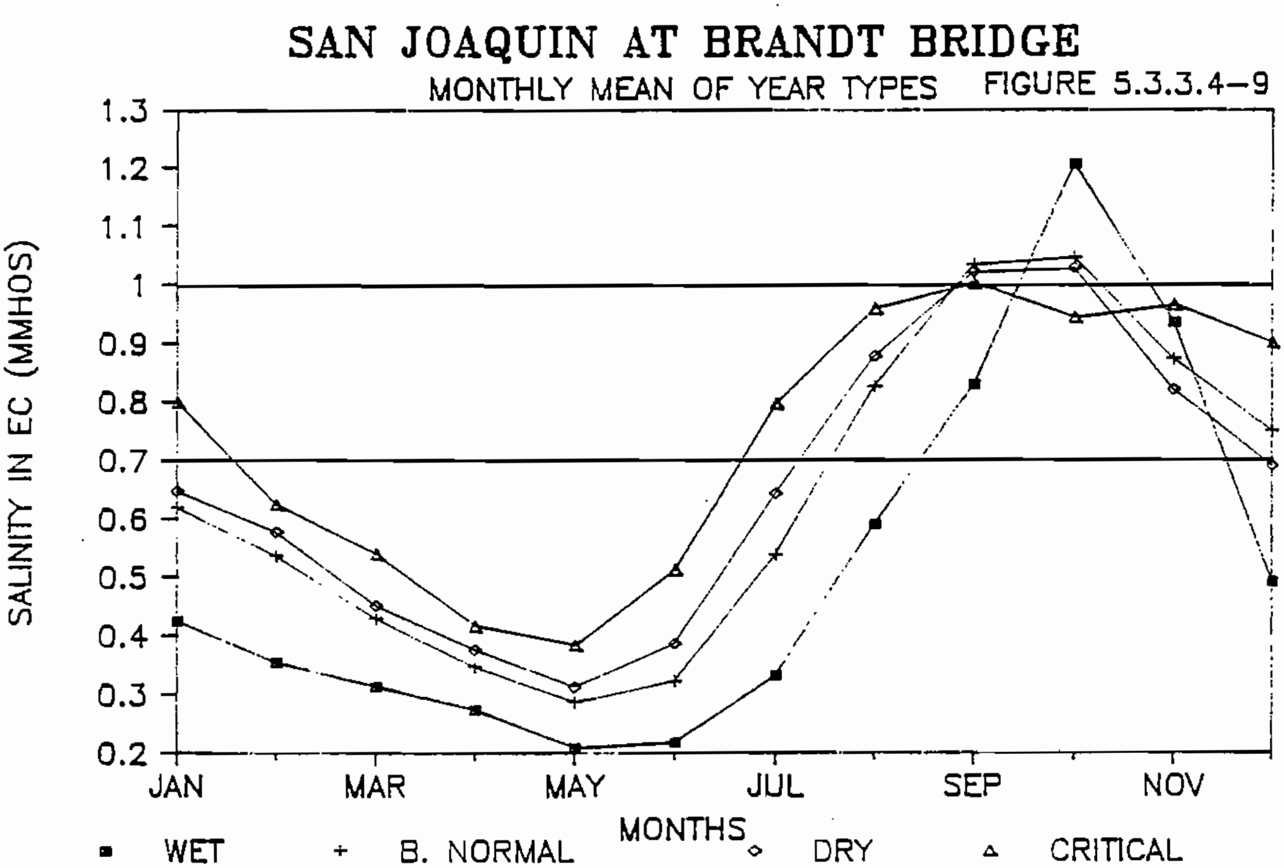


SAN JOAQUIN RIVER AT MOSSDALE

MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4–7




BIFURCATION OF OLD AND MIDDLE RIVER
MONTHLY MEAN OF YEAR TYPES
FIGURE 5.3.3.4-8
SALINITY IN EC (MMHOS)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
JAN
MAR
MAY
JUL
SEP
NOV
MONTHS
WET
B. NORMAL
DRY
CRITICAL


SAN JOAQUIN AT BRANDT BRIDGE
MONTHLY MEAN OF YEAR TYPES
FIGURE 5.3.3.4-9
SALINITY IN EC (MMHOS)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
JAN
MAR
MAY
JUL
SEP
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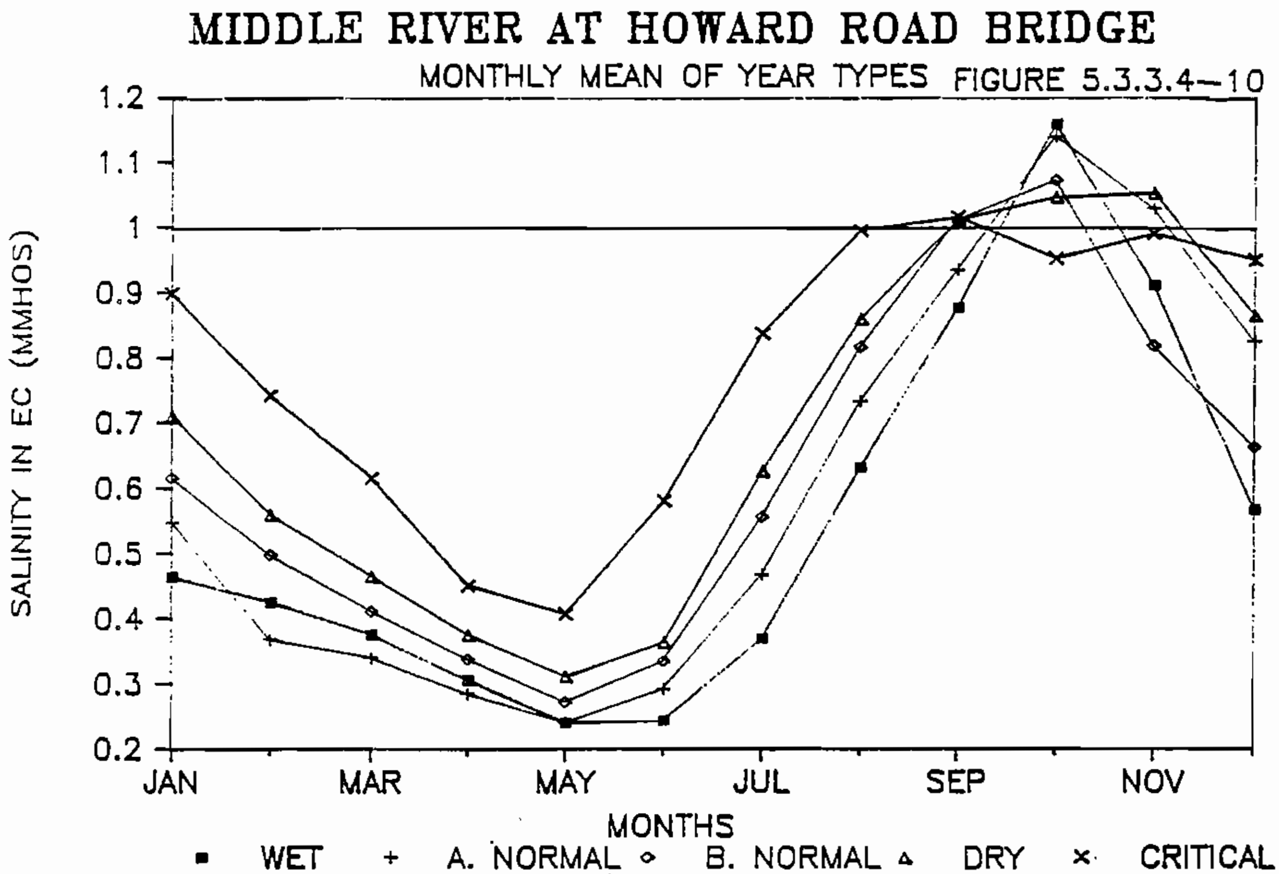
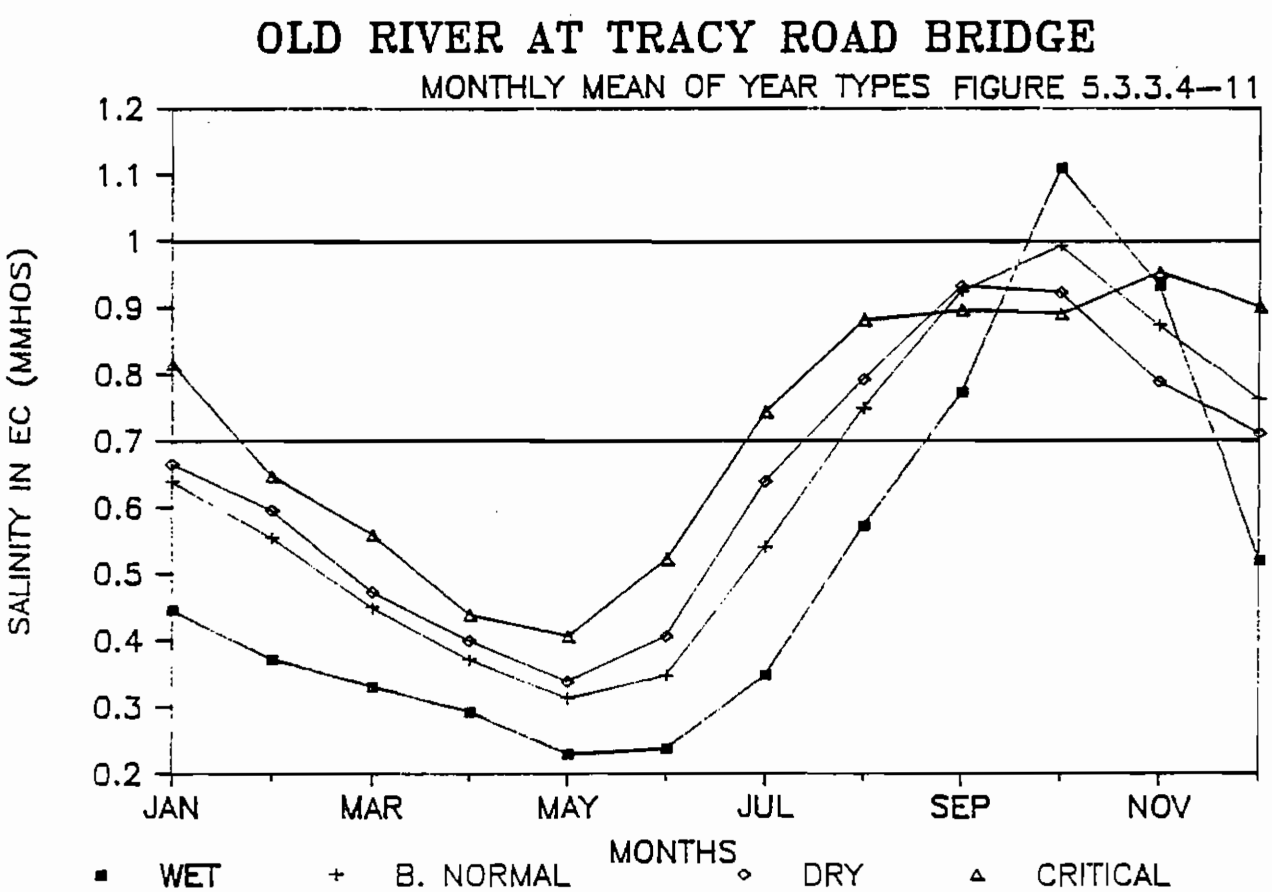
MONTHS
WET
B. NORMAL
DRY
CRITICAL


MIDDLE RIVER AT HOWARD ROAD BRIDGE
MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4-10
SALINITY IN EC (MMHOS)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
JAN
MAR
MAY
JUL
SEP
NOV
MONTHS
WET
A. NORMAL
B. NORMAL
DRY
CRITICAL


OLD RIVER AT TRACY ROAD BRIDGE
MONTHLY MEAN OF YEAR TYPES FIGURE 5.3.3.4-11
SALINITY IN EC (MMHOS)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
JAN
MAR
MAY
JUL
SEP
NOV
MONTHS
WET
B. NORMAL
DRY
CRITICAL

- San Francisco Bay Agriculture

  Until additional information is obtained that identifies the needs of Bay agriculture, no objectives can be set for Bay agriculture.

  The optimal level of protection for agricultural beneficial uses in the Delta is presented in Table 5.3.3.4.-1.

5.3.4 Chinook Salmon

5.3.4.1 No Action Alternative

The 1978 Delta Plan contains flow objectives for the protection of Chinook salmon migration throughout the year in the Estuary. These standards are 30 day running averages of daily flows at Rio Vista (see Table 5.3.4.1-1) which provide protection of Sacramento River Basin salmon. Special agreements, not included in the Delta Plan, which provide protection to salmon are discussed in Section 5.3.4.3. Figure 5.3.4.1-1 is a schematic representation of the location of sites, facilities and channels to be discussed.

The Delta Plan also requires the SWP and CVP, in all water year types, to close the Delta Cross Channel gates at Walnut Grove when the daily Delta Outflow Index at Chipps Island exceeds 12,000 cfs between January 1 and April 15. The intent is to minimize diverting fry, which rear in the north Delta, into the central or southern Delta. Under the Delta Plan's striped bass standards, DFG can request that the gates be closed between April 16 through May 31 for up to 20 days but not more than two out of four consecutive days. Such closures provide incidental protection for emigrating smolts.

The Delta Plan contains limitations and/or requirements for operation of SWP and CVP fish protective facilities at their respective Delta pumping plants and for maintenance of fish salvage records (SWRCB,1978,40). The Delta Plan operational criteria for the fish protection facilities, however, apply to the CVP secondary fish screening system only to the extent that they are compatible with water export rates.

The Delta Plan limits total Delta exports to 6,000 cfs for both the CVP and SWP (3,000 cfs each) in May and June for striped bass protection. However, the entire San Joaquin River flow may be diverted in May and June of most years (T,XXXVI,166:13-19) when exports exceed San Joaquin River inflows. As exports increase relative to inflows, more of this River's flow is drawn towards the CVP and SWP pumps via Old River (DFG,15,28; DWR,50) (see Figure 5.3.4.1-2) and flows in the lower reaches of Old, Middle, and the San Joaquin rivers may reverse and move upstream towards the export pumps.

TABLE 5.3.3.4-1

OPTIMAL LEVEL OF PROTECTION FOR AGRICULTURAL USES

Beneficial Use Protected and Location	Parameter	Description	Year Type	Dates	Values or Limit
AGRICULTURE					
Western and Interior Delta Irrigation				Dates	EC
Sacramento R. at Emmaton	Electrical Conductivity	Maximum 14-Day Running Average Mean Daily EC, mmhos/cm	All	4/1 - 8/15	1.5
San Joaquin R. at Jersey Point					
Mokelumne R. at Terminous					
San Joaquin R. at San Andreas Ldg.					
Cache Sl. at Junction Pt.					
South Delta Irrigation					
San Joaquin R. near Vernalis	Electrical Conductivity	Maximum 14-Day Running Average Mean Daily EC, mmhos/cm	All	4/1 - 8/31 9/1 - 3/31	0.7 1.0
San Joaquin R. at Mossdale					
Bifurcation of Old and Middle rivers					
Middle R. at Howard Rd. Bridge					
Old R. at Tracy Rd. Bridge					
San Joaquin R. at former site of Brandt Bridge					
Delta Leaching (Ponding)					
Emmaton Jersey Point Cache Slough at Junction Point San Andreas Landing	Electrical Conductivity	Maximum monthly average of mean daily EC, mmho/cm	All	12/1-2/28	1.7

Table 5.3.4.1-1--1978 Delta Plan Salmon Standards

I. Salmon Migration-30 Day Running Average of Mean Daily Flow at Rio Vista in cfs

Water Year Type

Time Period	Wet	Above Normal	Below Normal	Dry	Critical
January	2,500	2,500	2,500	1,500	1,500
February 1-March 15	3,000	2,000	2,000	1,000	1,000
March 16-June 30	5,000	3,000	3,000	2,000	2,000
July	3,000	2,000	2,000	1,000	1,000
August	1,000	1,000	1,000	1,000	1,000
September 1-December 31	5,000	2,500	2,500	1,500	1,500

II. Cross Delta diversion of salmon fry

Jan 1-Apr 15 — Close Delta Cross Channel Gates at Delta Outflow Index > 12,000 cfs

III. CVP and SWP Delta pumping plant fish protective facilities

SWP

Nov 1-May 14

(a) approach velocity 3.0-3.5 fps
(b) bypass ratio-1.2:1.0 to 1.6:1.0 in primary and secondary channels
(c) primary bay-use Bay B as first choice
(d) velocity of water exiting the screened water system not to exceed secondary channel approach velocity

CVP

*Feb-May
**June-Aug 31[1/]

Secondary system to be operated as shown below to the extent compatible with export rates:

*(a) secondary velocity 3.0-3.5 fps
**(b) secondary velocity not to exceed 2.5 fps (preferably 1.5 fps). secondary velocity ratio not reduced below 1:1.0
(c) screened water discharge to lowest possible level consistent with its purpose
(d) bypass ratio in the seconday should prevent excessive velocities in the holding tanks but should not be less than the secondary approach velocity

[1/] Applies to all fish

FIGURE 5.3.4.1-1 Schematic representation of the Delta and experimental smolt release sites

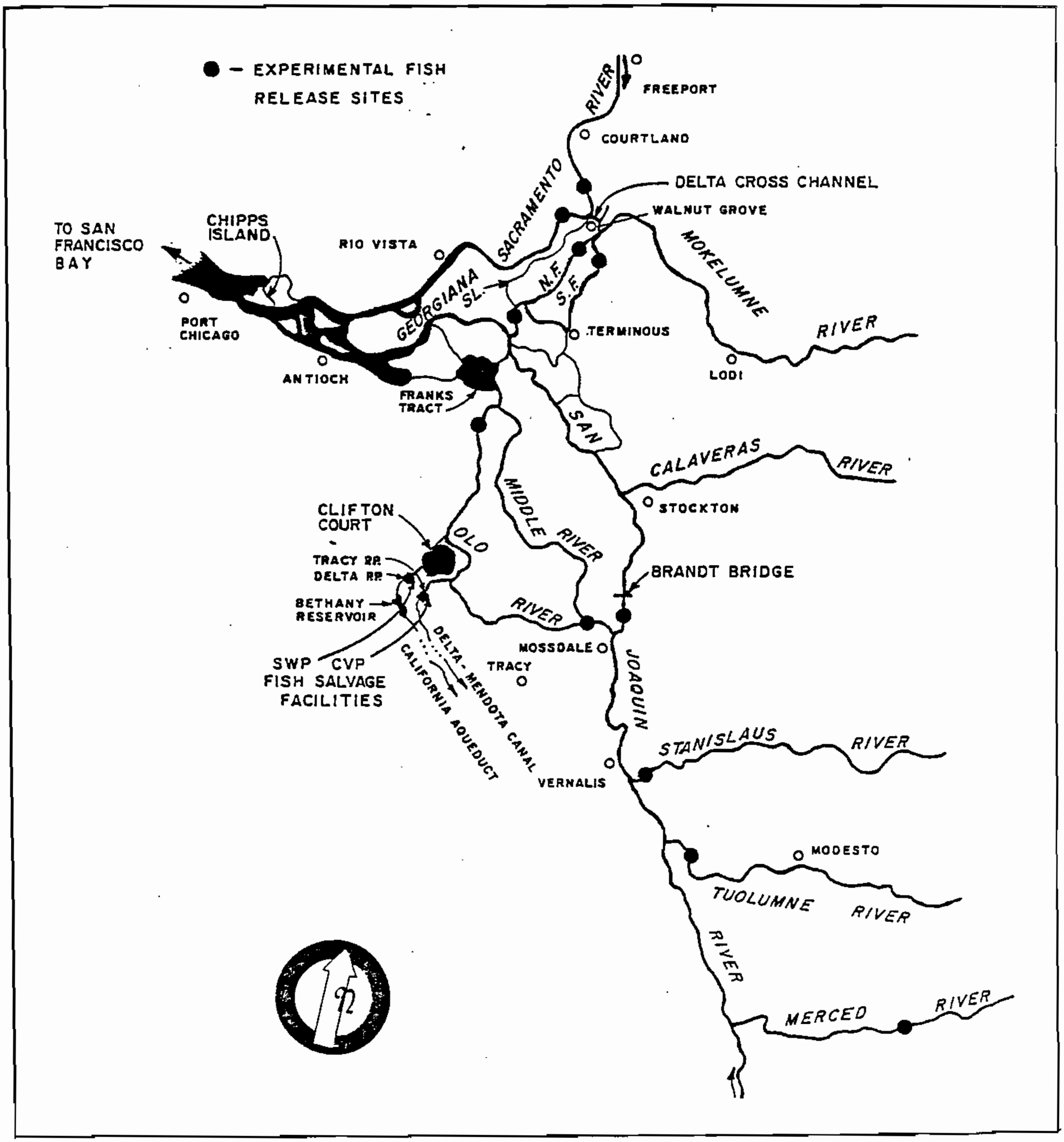
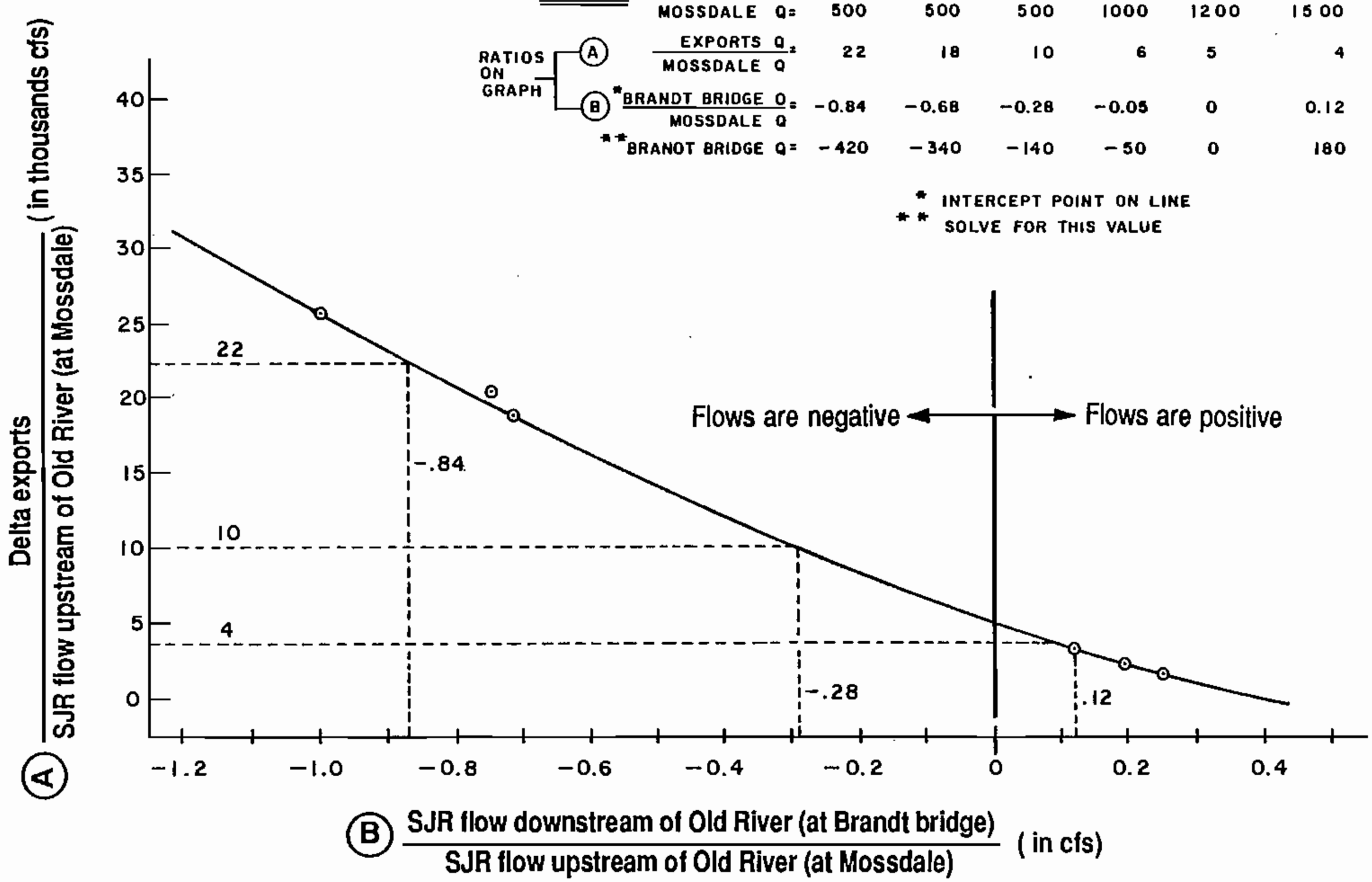


FIGURE 5.3.4.1-2 Relationship between Delta exports and flows in the San Joaquin River upstream and downstream of its confluence with Old River. This shows that as Delta exports increase relative to San Joaquin River inflows at Mossdale, flows downstream at Brandt Bridge will reverse and flow upstream (T, I I, 194:1-197:13) (from DWR 50)

EXAMPLE;		UPSTREAM FLOW (CFS)				STAGNANT	DOWNSTREAM FLOW (CFS)	
	EXPORT Q=	11000	9000	5000	6000	6000	6000	6000
	MOSSDALE Q=	500	500	500	1000	1200	1500	3000
RATIOS ON GRAPH	(A) EXPORTS Q / MOSSDALE Q =	22	18	10	6	5	4	2
	(B) *BRANDT BRIDGE Q / MOSSDALE Q =	−0.84	−0.68	−0.28	−0.05	0	0.12	0.32
	**BRANOT BRIDGE Q=	−420	−340	−140	−50	0	180	960

* INTERCEPT POINT ON LINE
** SOLVE FOR THIS VALUE



Smolts of the four Chinook salmon races are emigrating through the Delta from about October through June, with the greatest abundance typically from April through June when the fall run emigrates. Average monthly salvage of Chinook salmon at the Harvey O. Banks Delta Pumping Plant reflects this seasonal abundance of young salmon in the Estuary (see Figure 4.5.1.2-3) (T,XXXVII,128:13-129:1).

Since the 1978 Delta Plan was approved, the survival of fall run smolts emigrating through the Estuary to the ocean has been identified as an issue of concern. Little information was available during the hearing for this plan. Since then, the USFWS on behalf of the Interagency Ecological Studies Program, carried out studies to evaluate the survival of fall run smolts during their emigration through the Estuary. These studies provide significant new information about relationships between smolt survival and Delta conditions under the 1978 Delta Plan, which are discussed in detail in section 5.3.4.3. USFWS has concentrated on Delta conditions affecting fall run smolts emigrating from the Sacramento River Basin. Generally they found that smolt survival improved with increasing flow, up to a maximum. Limited data from studies of San Joaquin Basin smolts show similar results. Evidence was not presented on the effects of existing estuarine conditions on the immature life stages of the other three races of Chinook salmon.

The recent evidence developed by USFWS indicates that, if the 1978 Delta Plan salmon migration flows were the controlling flow standard, fall run smolt survival would be minimal (see Table 5.3.4.1-2). However, under present conditions, other water quality standards and operational constraints on the SWP and CVP result in substantially higher flows during the April through June fall run smolt emigration period. Currently flow requirements to protect agricultural, fish and wildlife, and striped bass beneficial uses provide higher flows than those required for salmon migration (see Table 5.3.4.1-3). Uncontrolled flows during, and sometimes later than, April in wetter water years, also contribute to Rio Vista flows exceeding 1978 Delta Plan requirements (see Table 5.3.4.1-4).

Very little information is available about the effects of present conditions on salmon smolts migrating through the Bay. Information on Bay survival will not be available for several years.

5.3.4.2 Advocated Levels of Protection

Most of the parties presenting testimony on Chinook salmon agree that the 1978 Delta Plan salmon flow standards provide inadequate protection for fall run smolts, and that specific causes of salmon mortality upstream and in the Delta should be addressed to improve survival rates of immature fish. Most participants analysed the same data in preparing their testimony. The major differences dealth with: (1) when, where,

Table 5.3.4.1-2--Estimated Survival[1/] Index Values Under 1978 Delta Plan Salmon Migration Flow Standards during April-June

	Water Year Type									
	Wet		Above Normal		Below Normal		Dry		Critical	
Time Period	Flow (cfs)	Survival Index	Flow (cfs)	Survival Index	Flow (cfs)	Survival Index	Flow (cfs)	Survival Index	Flow (cfs)	Survival Index
April-June 30	5,000	0.02	3,000	0.0	3,000	0.0	2,000	0.0	2,000	0.0

[1/] Survival=0.000056Q-0.258 where Q=Rio Vista flows from 4,600-22,000 cfs (from USFWS,31)

Table 5.3.4.1-3--Estimated Controlling Delta Outflows[1/] Under the 1978 Delta Plan During Fall Run Smolt Migration Period. Values in parentheses are the estimated survival index values (from USFWS,31) if these flows occurred at Rio Vista

Water year Type

		Wet	Above Normal	Below Normal	Dry	Critical
Time Period	Flow in cfs	Flow in cfs	Flow in cfs	Flow in cfs	Flow in cfs	Mean Smolt Survival
April	10,000 (0.30)	7,600 (0.17)	7,600 (0.17)	7,600 (0.17)	4,500 - 6,700[3/] (0.0 - 0.12)	0.16-0.19
May 1-5	10,000 (0.30)	7,600 (0.17)	7,600 (0.17)	7,600 (0.17)	4,500 - 6,700[3/] (0.0 - 0.12)	0.16-0.19
May 6-31	7,600 - 14,000[2/] (0.17 - 0.53)	7,600 - 14,000[2/] (0.17 - 0.53)	7,600 - 11,400[2/] (0.17 - 0.38)	7,600 (0.17)	3,900 (0.0)	0.14-0.32
June 1-15	7,600 - 14,000[2/] (0.17 - 0.53)	7,600 - 10,700[2/] (0.17 - 0.34)	7,600 - 9,500[2/] (0.17 - 0.27)	7,600 (0.17)	3,900 (0.0)	0.14-0.26
June 16-20	7,600 - 14,000[2/] (0.17) - 0.53)	7,600 - 10,700[2/] (0.17 - 0.34)	7,600 - 9,500[2/] (0.17 - 0.27)	4,700 (0.01)	3,900 (0.0)	0.10-0.23
June 21-30	7,600 - 14,000[2/] (0.17 - 0.53)	7,600 - 10,700[2/] (0.17 - 0.34)	5,400 - 9,500[2/] (0.04 - 0.27)	4,700 (0.01)	3,900 (0.0)	0.08-0.23
Mean Survival	0.21-0.45	0.17-0.31	0.15-0.25	0.12	0-0.04	0.13-0.24

1/ Flow Estimates derived from DWR, personal communication, to R. Satkowski,SWRCB,dated 2/9/88.
2/ If subnormal snowmelt lower value applies.
3/ If SWP and CVP users are taking deficiencies in firm supplies lower value applies.

Table 5.3.4.1-4--Comparison of Mean Monthly Controlling Delta Outflows and Actual Delta Outflows in cfs (from DWR Dayflow).

Water Year	Year Type	April		May		June	
		Actual	Controlling[1/]	Actual	Controlling	Actual	Controlling
77-78	W	61,276	10,000	40,874	13,360	9,086	14,000
78-79	D	14,485	7,600	13,435	7,600	5,326	6,150
79-80	W	28,689	10,000	20,912	13,360	14,870	14,000
80-81	D	11,653	7,600	9,143	7,600	4,596	6,150
81-82	W	140,163	10,000	57,876	13,360	28,515	14,000
82-83	W	113,053	10,000	97,996	13,360	72,154	14,000
83-84	W	14,732	10,000	11,204	7,984	8,038	7,600
84-85	D	6,913	7,600[3/]	7,378	7,600	5,215	6,150
85-86	W	46,572	10,000	15,911	13,360	9,322	14,000
86-87	C	6,291	6,700	4,951	4,348	3,496	3,900

1/ Controlling or minimum required Delta Outflow flows as shown on Table 5.3.4.1-3 from DWR tables revised March 1986 sent to R. Satkowski of SWRCB, 1/9/88. If controlling flow varies within the month each flow is weighted by the number of days in that month for which it applies. Carriage water is not included in these values.

2/ Subnormal snowmelt criteria apply.

3/ Differences due to imprecision in channel depletion estimates and correlations between flow and EC used to determine minimum required Delta Outflow. These do not represent violations of Delta Plan standards.

and what actions should be taken; and (2) which factors were considered the most influential on adult and/or young salmon survival and production. Only the fishery agencies and environmental groups advocated levels of protection essentially different from those of the 1978 Delta Plan.

The positions taken by the parties at Phase I of the hearing on Chinook salmon are summarized below and in Tables 5.3.4.2-1 through 5.3.4.2-4:

- SWC (SWC,201,22-27;T,LIX,170:7-173:13)

  - Existing Delta Plan striped bass flow standards should be maintained as the salmon flow objectives until adequate data are available to determine whether changes are required.

Table 5.3.4.2-1 shows what the striped bass flows would be from May 6 through June under the 1978 Delta Plan and represents an estimate of the levels of protection advocated by the SWC, USBR, and DWR. USFWS data were used to calculate the estimated smolt survival index under these flows to compare with levels of protection advocated by other parties. For comparison, Table 5.3.4.1-3 gives an estimate of controlling flows during the entire April through June smolt emigration period.

- DWR (T,XLIII,219:2-221:8)

  - The existing striped bass standards should be the salmon standards.

  - Recent historical levels of catch and escapement are already being maintained.

- USBR (T,LXI,120:24-131:6)

  - Natural salmon production should be increased.

  - A system-wide management plan that addresses conditions in all salmon habitats should be developed.

  - Structural solutions, such as screens, to improve Delta survival would be preferred to flow increases since they would minimize impacts on other beneficial uses.

  - Continue interagency studies and refine monitoring to determine effectiveness of new programs.

  - Allow operational flexibility to respond to recommendations of the five-agency salmon group, composed of the USFWS, DFG, NMFS, DWR and USBR, recently formed to reduce or solve salmon problems identified in the Phase I hearings.

Table 5.3.4.2-1--Recommended Salmon Flow Standards with present Delta Plan Delta Outflows for Striped Bass (SWC, USBR, DWR). (USFWS survival index values are shown in parentheses).

Period	Wet	Ab. Norm.	B. Norm.	Subnormal Snowmelt	Dry[1/]	Dry or Critical[2/]
	Water Year Type					
	Flow in cfs					
May 6-31	14,000 (0.53)	14,000 (0.53)	11,400 (0.38)	6,500 (0.11)	4,300 (0.0)	3,300 (0.0)
June	14,000 (0.53)	10,700 (0.34)	9,500 (0.27)	5,400 (0.04)	3,600 (0.0)	3,100 (0.0)

[1/]Dry year following a wet, above normal or below normal year, from D-1485 Table 2

[2/]Dry year following a dry or critical year

- Do not change existing standards until the recommendations of the five-agency salmon group can be evaluated.

- DTAC, TID/MID (TID/MID,Brief,9-14)

  - The smolt survival index should not be used as a standard.

- USFWS (USFWS,31,31d-j and 47)

  - Sacramento Basin fall run smolts should be protected April 1 through June 30 and San Joaquin Basin smolts from April 1 through June 15.

  - Sacramento River flows at Rio Vista, depending on water year type, should range from 21,500-10,000 cfs and provide smolt survival indices at the 1940's level, ranging from 0.95 in wet years to 0.30 in critical years.

  - San Joaquin River flows at Vernalis should range from 12,000-4,000 cfs, depending on water year type.

  - Eliminate reverse flows during smolt emigration.

  - Prevent delays to adult migrants, maintain unobstructed migration route, and maintain DO above 5 mg/l between Stockton and Turner Cut in the fall.

  - Survival goals could be achieved by a combination of flow, operational and physical modifications.

  Table 5.3.4.2-2 summarizes the protection levels recommended by USFWS and other fishery advocates.

- NMFS (T,LXI,22:24-28:4)

  - In the Sacramento River system, Delta smolt survival for all four races should be that which occurred under 1940 levels of water development (see Table 5.3.4.2-2).

  - The Water Quality Control Plan should contain a blend of physical and operational management measures as well as some increment of flow increase to improve smolt survival.

  - Interim standards should be established for the San Joaquin River system to improve salmon production.

- DFG (T,XLIII,76:24-80:24;DFG,64, and DFG,30)

  - Survival of each race in the Delta should be based on 1940 historical levels (see Table 5.3.4.2-2).

Table 5.3.4.2-2--Recommended Objectives for Chinook Salmon (USFWS,DFG,NMFS) (from USFWS,31d-i and 47)

	Sacramento Basin Smolts	
Water Year Type	April - June Survival Index	April - June Rio Vista Flow (CFS)
Wet	0.95	21,500
Above Normal	0.85	20,000
Below Normal	0.75	18,000
Dry	0.65	16,000
Critical	0.30	10,000

1. Keep smolts out of central Delta.
2. Keep temperatures below 66 degrees F.
3. Keep smolts out of upper Old River.
4. Positive net flow in the San Joaquin, Old, and Middle rivers.

San Joaquin Basin Smolts

1. Same survival levels as for the Sacramento Basin.
2. Vernalis in flows ranging from 12,000 cfs in wet water years to 4,000 in critical water years.

Central Valley Adults

1. Maintain unobstructed migration route.
2. Dissolved oxygen $\geq$ 5 mg/1 between Stockton and Turner Cut on the San Joaquin River.

- Survival rate for Sacramento Basin fall run salmon should based on the USFWS flow-to-survival relationship in Exhibit 31.

- Eliminate flow reversals by 1995 in the San Joaquin River and in Old and Middle rivers.

- Survival levels in the San Joaquin River should also be based on historical levels but these still need to be defined.

- Physical and operational measures should be considered to achieve protection.

• EDF (EDF,23)

  - USFWS flows recommended for Sacramento Basin smolt migration should be adopted.

  - Vernalis flows should range from 11,000-5,000 cfs depending on water year type.

  - Delta outflows should range from 31,000-10,000 cfs, depending on water year type.

Table 5.3.4.2-3 summarizes the flow conditions recommended by EDF.

• BISF (BISF,Brief,85-86 and 93-98)

  - The spring Delta outflows at Chipps Island, measured as a combination of Sacramento and San Joaquin River flows, should not be less than 38,500 cfs averaged over three to five year periods.

  - Outflows could be reduced in dry years provided compensating flows are available in other years.

  - There should be objectives for wet, median and dry year spring flows at levels greater than D-1485.

  - Endorses other measures proposed by USFWS.

Table 5.3.4.2-4 summarizes the standards recommended by BISF.

5.3.4.3 Optimal Levels of Protection

Evidence presented in Phase I of the hearing indicates that Delta Plan objectives do not fully protect all the different life stages of Chinook salmon using the Estuary. The parties presenting evidence at the hearing reviewed much of the same data and generally agreed that under existing conditions the Delta is a source of significant mortality for smolts emigrating from upstream areas. This section summarizes available information on the factors contributing to reduced

Table 5.3.4.2-3--Recommended April-June Salmon Smolt Migration Standards (EDF) (from EDF,23)

Water Year Type	Annual Survival Index Goal	Sacramento R. Rio Vista (cfs)	Sacramento R. Freeport (cfs)	Sacramento R. Diversion1/ Above RV (cfs)	San Joaquin R. at Vernalis (cfs)	Total River (Freeport + Vernalis)	Estimated4/ Export + Ch. Depl.- E. Side (cfs)	Estimated Delta Outflow (cfs)
Wet	0.95	22,000	26,000	4,000 2/	11,000	37,000	6,000	31,000
Above N.	0.86	20,000	24,000	4,000 2/	10,000	34,000	7,000	27,000
Below N.	0.75	18,000	22,000	4,000 2/	9,000	31,000	8,000	23,000
Dry	0.65	16,000	20,000	4,000 2/	8,000	28,000	9,000	19,000
Critical	0.30	10,000	15,000	5,000 3/	5,000	20,000	10,000	10,000

1/ From DWR Exhibit 50
2/ Cross Channel closed, Georgiana Slough only
3/ Cross Channel and Georgiana Slough
4/ Based on recent historic DAYFLOW records

Table 5.3.4.2-4--Recommended Salmon Smolt Protection Levels (BISF)
(BISF,Brief,85-86 and 93-98)

Controlling Year Type	Period	Protection Level (Delta Outflow in cfs)[1/]	Beneficial Use
Wet Years (wettest 10%)	Apr-Jun	38,500-42,000	salmon smolts, striped bass, shad
Median Years (years between wet and dry)	Apr-Jun	38,500-42,000	salmon smolts
Dry Years (driest 10%)	Apr-Jun	10,000	salmon smolts

1/ Combined Sacramento and San Joaquin River flows to meet outflow salmon production and hypothetical actions which would eliminate these mortality factors providing optimal protection for the salmon beneficial use in the Delta-Estuary. Much of the recent evidence was based on studies carried out since the 1978 Delta Plan went into effect. These study results were presented in terms of either: (1) correlations between fish survival and flow or other conditions in the Delta; or (2) descriptions of results for which only a few years' data were available and general, not always consistent, trends were apparent.

Evidence has been presented showing that natural populations of Sacramento salmon are declining and San Joaquin populations are undergoing extreme fluctuations. Also, Delta Plan salmon standards are not providing inadequate protection particularly with regard to conditions affecting the fall run smolts during their spring emigration.

Recent studies by the USFWS showed a significant positive correlation between April through June Rio Vista flows and survival of marked hatchery smolts migrating through the Delta (USFWS,31,33-41). Several years of data from the San Joaquin Basin suggest a similar relationship (USFWS,31,65-71). These studies also indicated a positive relationship between survival and keeping smolts in the main channels of the Sacramento and San Joaquin rivers (USFWS,31,72-73;T,XXXVI,152:6-155:23). Furthermore, survival in both basins may be reduced when spring water temperatures are above the stressful range of 66°to 70°F (T,XXXVI,159:17-20;DWR,562,60;TXXXVI,150:24-151:11; DFG,15,26-27).

The amount of flow is the major determinant of both the quantity and quality of fishery habitat. However, it is not feasible to try to establish or achieve precise numerical fish production goals since many factors, all of which may vary from year to year, influence the number of salmon returning to spawn. Instead, determination is made by fishery biologists as to the general habitat conditions needed to ensure the highest probability of reasonable or optimal fish production levels. This was the approach taken in the Interagency Delta salmon studies carried out by the USFWS. The point was made that correlation does not mean causation (T,XXXVIII,17:14-16) and that more study is needed before specific actions be taken to change beneficial use protection levels contained in the Delta Plan. However, as the SWC's consultant testified, the likelihood of being able to demonstrate causation when so many of the factors are interrelated (T,XXXVIII,17:17-24) is difficult (T,XXXVIII, 61:11-17).

In the following sections the factors affecting the salmon beneficial uses are discussed in detail. Recommendations are also made which would theoretically provide optimal protection to the fall run Chinook salmon in the Delta. No evidence regarding specific protection levels needed by smolts of the other three races was submitted, therefore, no discussion of them is presented.

- Problem 1: Decreased spring Delta inflows reduce fall run smolt survival.

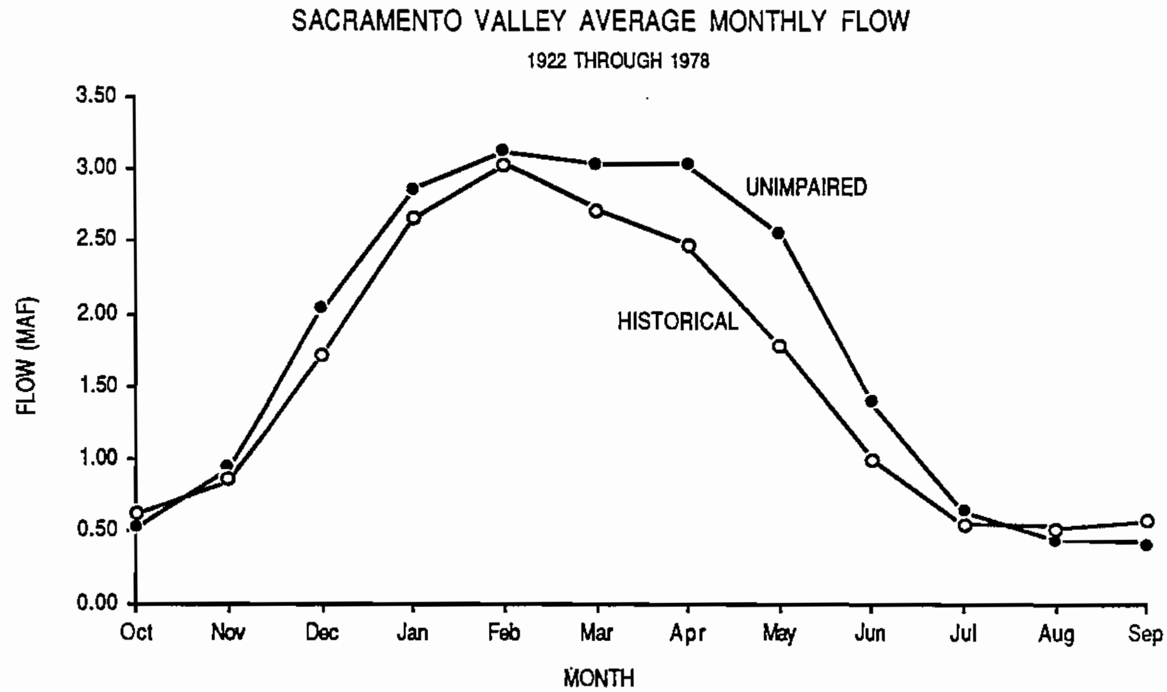
DFG testified that the primary factor limiting salmon survival in the Estuary is the survival rate for emigrants (T,XXXVII,66:11-14) and that "there are not substitute measures outside the Estuary that could compensate for all the potential harm that could result from decreased survival within the Estuary" (T,XXXVII,69:4-9).

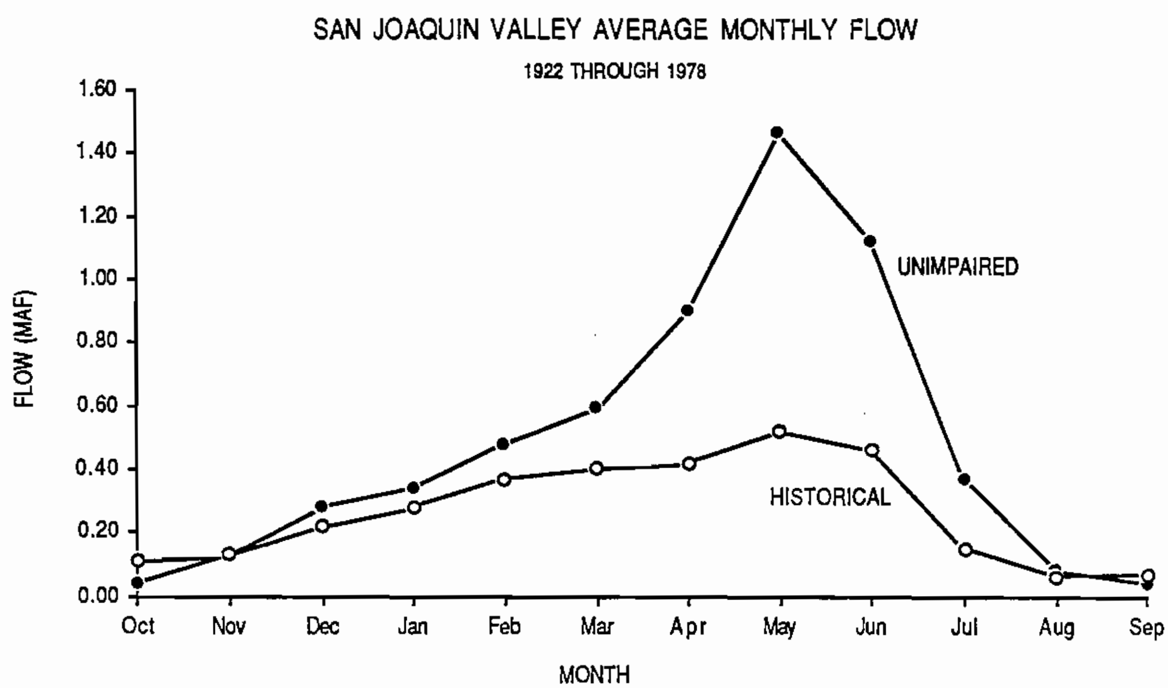
Since the 1940's upstream and in-Delta facilities have altered seasonal flow patterns. Reservoir operations and water diversions have decreased spring inflows to the Delta (see Figure 5.3.4.3-1).

Historically, the magnitude of spring flow during the fall run smolt emigration period has corresponded to the number of adults returning to spawn about two and one-half years later. In the Sacramento Basin before the improvement in hatchery production in the 1970's, spawning escapement fluctuated in relation to conditions during the smolt emigration period (DWR,561,17-20). An analysis performed by DWR's consultant indicated that prior to 1968, the two year moving average of monthly April-June Sacramento River flows during the smolt emigration period correlated significantly with the two year moving average of subsequent Sacramento Basin spawning escapement (monthly R ranging from 0.53-0.72, $P<0.01$ or <0.05 for April, May, and June). April through July Delta outflow also correlated significantly with spawning escapement (monthly R ranging from 0.52-0.77, $P<0.01$ or 0.05). After 1968 no significant correlation between smolt emigration flows and later adult escapement was found (DWR,561,34-48). Various events occurring after 1967 are thought to have eliminated this relationship, including, closure of the Red Bluff Diversion Dam on the upper Sacramento River (DWR,561,17-20;43-49), "an increase in Delta diversions by initiation of SWP exports, transfer of Trinity River water to the Sacramento Basin, and increased trucking of hatchery production around the Delta" (USFWS,31,77-79).

The practice of trucking and releasing hatchery reared smolts below the Delta has enabled the total adult Sacramento Basin fall run population to be stabilized despite the "persistent decline" of all races of naturally produced salmon and those hatchery reared fish which emigrate down the Sacramento River and through the Delta (T,XXXVII,153:-154:1). As discussed in section 4.5.1.2, survival of fish trucked around the Delta is established to be six to eight times greater than survival of hatchery produced smolts migrating through the Delta (T,XXXVII,161:22-162:1).

Figure 5.3.4.3-1 Change in Delta Inflows from Unimpaired Conditions



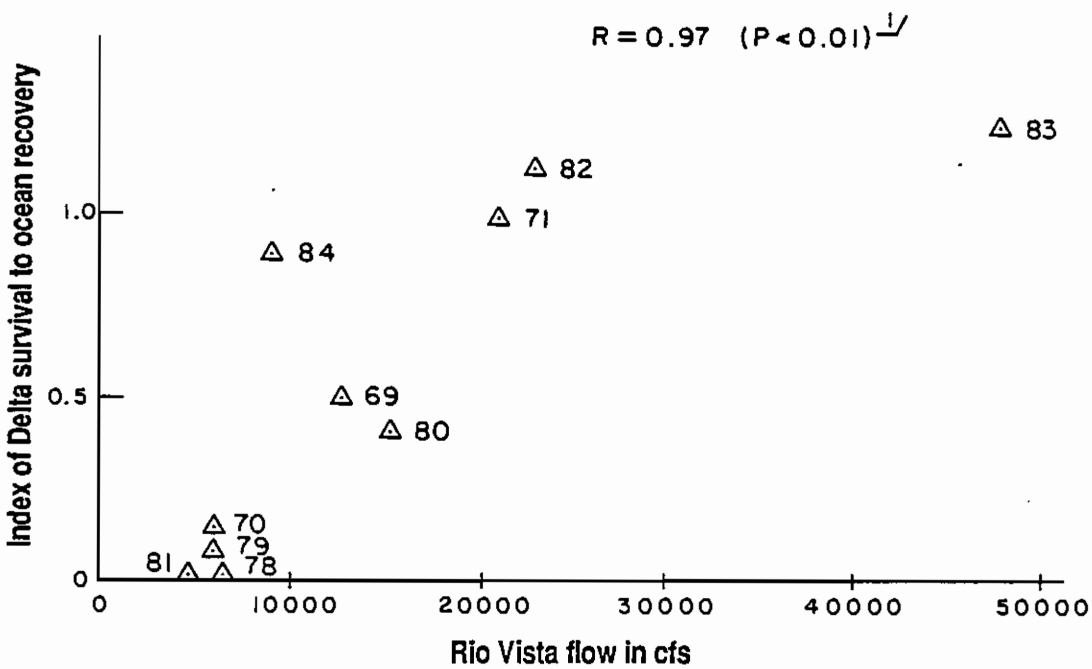


Salmon escapement to the Feather and American rivers has increased, even though reservoir storage has altered spring outflows, because hatchery rearing programs have replaced or augmented natural instream salmon production (DWR,561,49). Flows in the lower American River were reported to have no influence on escapement because the run is primarily maintained by planting smolts in the Estuary(DWR,561,49). Feather River escapement has continued to be significantly correlated with Sacramento River flows in June ($R=0.75,P<0.01$) and Delta outflow in July ($R=0.74,P<0.01$).Not all Feather River hatchery salmon are released in the Estuary which may account for the continued relationship between Sacramento River flows and escapement to the Feather River. Feather River escapement increases to about 50,000 fish when June flows in the Sacramento River range from about 16,000-25,000 cfs (DWR,561 40-50) and July Delta outflows range from about 6,000-12,000 cfs (DWR,561,41). Feather River escapement appears to have stabilized (DWR,561,25) and more escapement fish are produced at lower flows since hatchery production began in 1968 (DWR,561,49).

The support provided to the Sacramento Basin salmon fishery by hatchery production has hidden the decline of naturally produced fish migrating down the river (as shown in Figure 4.5.1.2-4). This practice has also counteracted the historical relationship between spring flow conditions and subsequent adult escapement. However, recent USFWS studies of spring inflow to the Delta and smolt survival through the Delta indicate there is still an important relationship between these factors.

USFWS found that Delta smolt survival, as calculated by ocean tag returns of adults marked and released as smolts in the Delta and harvested two to four years later, increases as mean daily flows measured from April through June at Rio Vista increased up to about 22,500 cfs ($R=0.97,P<0.01$) (USFWS,31,33-58) (see Figure 5.3.4.3-2). Based on the statistical relationship between Rio Vista flows and smolt survival, USFWS calculated that, under the 1978 Delta Plan salmon flow objectives, the spring smolt survival index would be less than 0.01 (USFWS,31,58). In other words, when the regression equation developed from the flow/survival relationship is used with the Delta Plan salmon flows, the resulting amount of salmn smolt expected to survive is less than one percent. The annual abundance of smolts at Chipps Island also increases up to a maximum Rio Vista flow of about 30,000 cfs (USFWS 31, 36-37). Smolt survival was negatively correlated with increasing water temperatures ($R= -0.86,P<0.01$) and percent of Sacramento

FIGURE 5.3.4.3-2 Relationship of smolt survival through the Delta to mean daily Rio Vista flow based on ocean recovery of tagged hatchery smolts. 1/
(from USFWS, 31, 35)



1/ The years 1982-1984 are not included in the regression equation because either fish were released downstream of Sacramento or survival was > 1.0.

2/ Survival = (0.000056 x Rio Vista flow) - 0.258

River flows diverted through the Delta Cross Channel at Walnut Grove during the fall run smolt emigration periodof April through June (R= -0.65,P<0.05). Sacramento River flow at Rio Vista was considered to be an index parameter representing the combined interaction of higher Sacramento River flows, lower water temperatures, and a decrease in the relative proportion of Sacramento River flows diverted through the Delta Cross Channel (USFWS,31,55; T,XXXVI,156: 15-23).

These experiments were carried out primarily under 1978 Delta Plan conditions, with normal exports and Cross Channel diversions. As discussed later in this section, these other factors also affect smolt survival.

In addition to calculating monthly survival indices under Delta Plan conditions, USFWS took this index and multiplied it by the percentage of fall run smolts passing Chipps Island in each month (as determined by annual trawl surveys) for 1978-1986 to derive an annual weighted survival index (USFWS,31,56-57) (see Table 5.3.4.3-1). As shown in Figure 5.3.4.3-3, annual weighted April through June smolt survival for all 1978-1986 appears to be much better, averaging 0.47, compared to expected survival under the controlling Delta Plan flow objectives which ranges from 0.13-0.24 (see Table 5.3.4.1-3 in section 5.3.4.1). The higher annual weighted survival values, ranging from 0.12-1.0 for any given year, reflect the fact that since 1978 six out of nine years have been wet. As mentioned previously, unregulated Delta flows in April and sometimes in May have been much higher than the controlling flow standards (see Table 5.3.4.1-4).

In order to estimate and compare salmon smolt survival for various historic periods, DWR Dayflow Rio Vista flows values from 1930 to 1987 were used in the USFWS smolt survival/Rio Vista flow equation. Smolt survival indices for mean unimpaired flows for each year type were also compared to the mean historical survivals as shown in Table 5.3.4.3-2. USFWS reported that estimated mean weighted smolt survival using DWRs 1940 level of development hydrology was 0.76 (USFWS,31e). The smolt survival index values based on selected historic periods indicate a declining trend, from an average of 0.75 under unimpaired conditions to 0.42 since 1968.

Several factors may have contributed some bias in the USFWS studies. Many of the experimental releases of smolts were made in May and June, although emigrating smolts are present throughout April. April conditions are thought to be more favorable to smolt survival (see Figure 5.3.4.3-3) so that the relationship observed between flow and survival may underestimate the mean April through June survival (USFWS,31,42-44). Recently planted hatchery fish may not survive as well as wild fish adapted to river conditions.

Table 5.3.4.3-1--Estimated Weighted Survival Indices Under Delta Plan Conditions[1/]
(Values in parentheses are the monthly percentage of smolts migrating past Chipps Island)

Year	Water Year Type	April[2/] Survival Index	(%)	May Survival Index	(%)	June Survival Index	(%)	Annual Estimated Survival Index[3/]
1978	W	1.0	(27)	0.69	(40)	0.07	(33)	0.57
1979	D	0.40	(19)	0.30	(52)	0.05	(29)	0.25
1980	W	0.74	(14)	0.40	(34)	0.33	(52)	0.41
1981	D	0.43	(34)	0.17	(50)	0.0	(16)	0.23
1982	W	1.0	(18)	1.0	(49)	0.80	(33)	0.93
1983	W	1.0	(19)	1.0	(49)	1.0	(32)	1.0
1984	W*	0.50	(11)	0.26	(66)	0.16	(23)	0.26
1985	D	0.09	(26)	0.14	(63)	0.13	(10)	0.12
1986	W	1.0	(37)	0.22	(55)	0.04	(08)	0.49
Mean		0.68	(23)	0.46	(51)	0.29	(26)	0.47

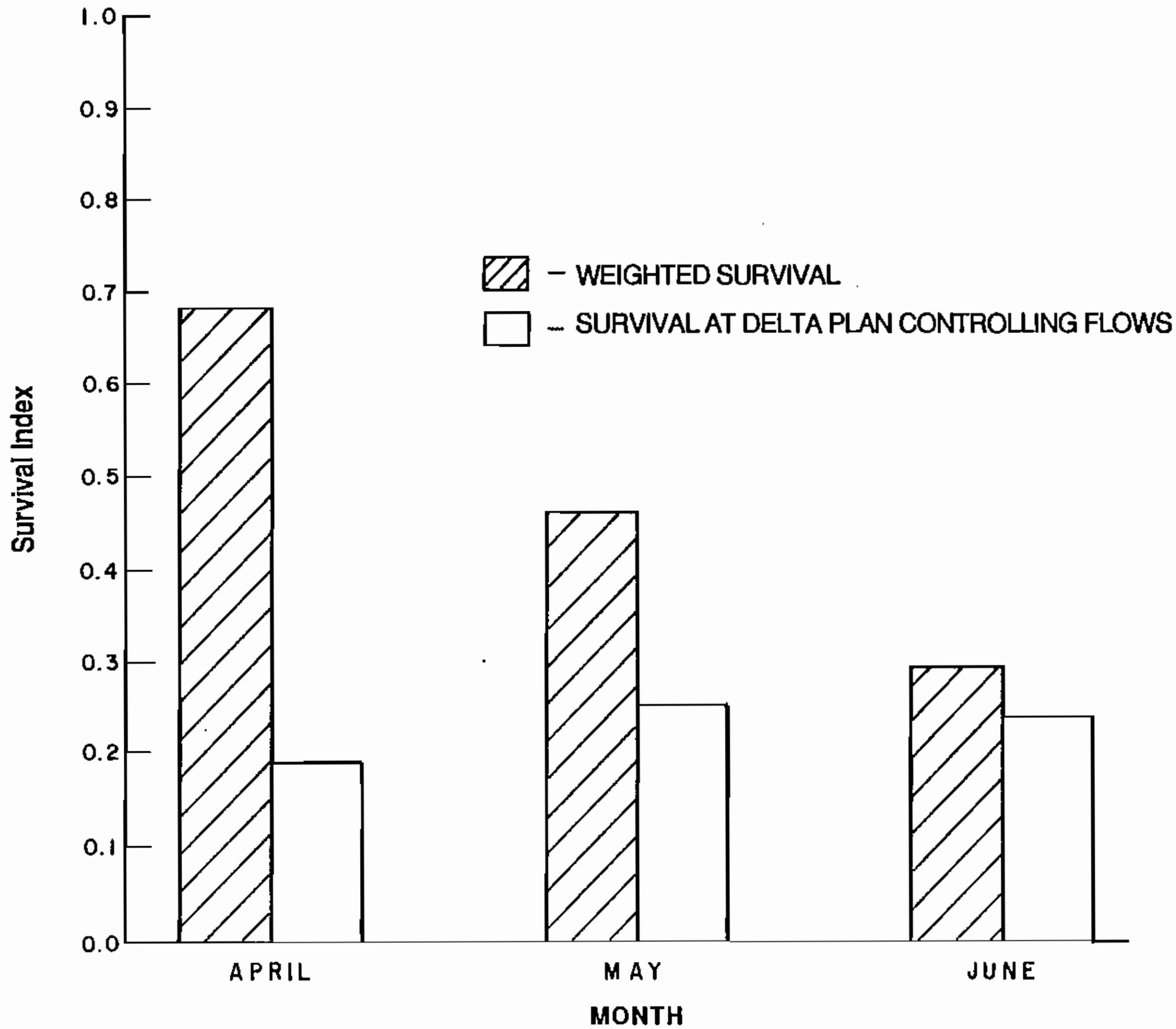
* Low spring flows due to subnormal snowmelt

1/ Numbers corrected from values in USFWS,31,57 Table 4-6, (P.Brandes pers. comm.)

2/ The monthly survival index is calculated using formula: S=0.000056 Q - 0.258; where S=survival and Q=mean monthly Rio Vista flow in cfs for flows between 4,500 and 22,500 cfs

3/ The weighted annual survival index is the sum of each monthly survival index times the percentage of smolts migrating past Chipps Island in that month

FIGURE 5.3.4.3-3 Comparison of mean monthly smolt survival for 1978 Delta Plan controlling flows 1/ versus weighted monthly smolt survival based on actual Rio Vista flows and percent smolts passing Chipps Island, 1978 - 1986



1/ Assumes the controlling Delta outflow equivalent occurs upstream at Rio Vista. The upper flow values from Table 5.3.4.1-2 were used so that if the lower flows apply, survival would be reduced from the values shown.

Table 5.3.4.3-2 COMPARISON OF APRIL-JUNE RIO VISTA FLOWS FOR SELECTED HISTORICAL PERIODS 1/ AND CORRESPONDING SMOLT SURVIVAL INDICES

YEAR TYPE 2/	APRIL		MAY		JUNE		AVERAGE
	Flow	Survival	Flow	Survival	Flow	Survival	Survival
			UNIMPAIRED FLOWS 3/				
Wet	67,308	1.00	54,248	1.00	30,468	1.00	1.00
Above Normal	51,279	1.00	33,291	1.00	16,690	0.68	0.89
Below Normal	35,669	1.00	28,869	1.00	12,785	0.46	0.82
Dry	24,205	1.00	21,444	0.94	12,356	0.43	0.79
Critical	12,757	0.46	8,601	0.22	4,488	0.00	0.23
Average	38,244	0.89	29,291	0.83	15,357	0.51	0.75
			1930-1987 FLOWS				
Wet	61,845(22414)	1.00	41,769(22035)	0.97	24,408(18,580)	0.78	0.92
Above Normal	46,753(22500)	1.00	23,808(20875)	0.90	10,714(10714)	0.29	0.73
Below Normal	16,933(16333)	0.66	14,672(14554)	0.56	7,563(7563)	0.17	0.46
Dry	13,205(12673)	0.45	10,818(10203)	0.31	6,619(6619)	0.12	0.30
Critical	8,749(8749)	0.26	4936(4936)	0.04	2,531(2531)	0.00	0.10
Average 4/	32,775(17355)	0.72	22,278(15653)	0.62	12,385(10576)	0.35	0.56
Weighted Avg.5/							0.57
			1953-1987 FLOWS				
Wet	56,542(22371)	0.99	33,327(21,802)	0.96	20,456(17,152)	0.70	0.89
Above Normal	35,681(22500)	1.00	16,812(16812)	0.68	7,038(7038)	0.14	0.61
Below Normal	14,178(14163)	0.54	11,558(11381)	0.38	7,331(7331)	0.16	0.36
Dry	8,177(8177)	0.20	7,027(7027)	0.14	4,841(4841)	0.03	0.12
Critical	6,690(6690)	0.16	5,165(5165)	0.05	3,715(3715)	0.00	0.07
Average 4/	27,874(15,401)	0.61	17,685(13,683)	0.51	10,903(9770)	0.30	0.47
Weighted Avg.5/							0.47
			1930-1952 FLOWS				
Wet	72,452(22500)	1.00	58,653(22500)	1.00	32,313(21436)	0.94	0.98
Above Normal	51,182(22500)	1.00	26,606(22500)	1.00	12,184(12184)	0.42	0.81
Below Normal	22,443(20672)	0.90	20,901(20901)	0.91	8,027(8027)	0.19	0.67
Dry	22,015(20551)	0.89	17,456(15762)	0.62	9,731(9731)	0.29	0.60
Critical	11,494(11494)	0.39	4,630(4630)	0.03	952(952)	0.00	0.14
Average 4/	40,234(20328)	0.88	29,268(18650)	0.79	14640(11802)	0.43	0.70
Weighted Avg.5/							0.70
			1953-1967 FLOWS				
ALL	29,332(16436)	0.66	21,290(15876)	0.63	11,980(10582)	0.35	0.55
			1968-1978 FLOWS				
ALL	24,649(14292)	0.56	13,464(12381)	0.44	8,873(8873)	0.25	0.42
			1979-1987 FLOWS				
ALL	29,387(15031)	0.58	16,835(11619)	0.39	11,588(9513)	0.28	0.42

Footnote 1: Flows obtained from DWR DAYFLOW for Rio Vista flows, 1930-1987. 1930-1987 is the period of record. The flow on the left is the actual average flow for all months in that year type. The value in parentheses is the average of the monthly flows with with a cap of 22,500 cfs on all individual monthly flows exceeding this value. This is because USFWS data showed that 22,500 cfs produced a maximum survival index of 1.00. It is assumed that flows in excess of 22,500 cfs would not increase smolt survival. 1953-1987 is the period when the major water projects and Delta facilities were in their present configuration. 1930-1952 is the before the CVP and SWP began major Delta expots. 1953-1967 is the pre-SWP period, 1968-1978 is the pre-Delta Delta Plan period, and 1979-1987 is the post- Delta Plan period. Survival=(Rio Vista Flow)*.000056-.258.

Footnote 2: April-July year type index

Footnote 3: From Flowscience

Footnote 4: Average flow for that month over all year types,not the average of the year type values shown above.

Footnote 5: Weighted survival is the average April-June survival times the number of years of each year type, divided by the total number of years in the historical period.

However, trawl samples of the abundance of unmarked fish at Chipps Island underwent similar numerical changes with changes in flow, temperature, and diversion rate as were observed for marked fish (USFWS,31). Therefore, the survival of the tagged hatchery fish was assumed to be representative of the general effects of certain Delta conditions on all emigrating smolts and accurate enough to be used as an index (USFWS,31,41).

In the San Joaquin Basin, large annual fluctuations in the magnitude of spring flows during the smolt migration are followed by similar fluctuations in adult spawning escapement (T,XXXVI,15:10-23) (see Figure 5.3.4.3-4). The amount of spring flows during the smolt emigration period correlates significantly with subsequent adult escapement two and one half years later ($R=0.82, P<0.01$) (see Figure 5.3.4.3-5). Between 1955 and 1985 when mean April through June flows at Vernalis were around 20,000 cfs or more during smolt emigration, maximum adult escapement of around 40,000 or more fish occurred two and one half years later. Outflows around 5,000 cfs or less were generally associated with subsequent spawning escapement of less than 10,000 fish (USFWS,31,65) (see Figure 5.3.4.3-4). The fluctuating salmon escapement seen in the San Joaquin Basin is probably more typical of the historical response of salmon to varying water supply conditions and the resultant availability of fish habitat with a minimal hatchery contribution; this escapement is similar to what occurred in the Sacramento Basin prior to the increased hatchery contribution of the 1970's (DWR,561,17-20).

Recent USFWS studies of tagged smolts released in the San Joaquin River tributaries in two wet water years when inflows exceeded exports (1982 and 1986), and one critical water year when exports exceeded inflows (1987), showed that the highest survival indices, 0.58 and 0.62, occurred when flows measured at Vernalis were about 8,700 to 12,000 cfs (1982 and 1986). The survival index dropped to 0.17 when Vernalis flows were 2,100 cfs (1987) (USFWS,31,70-71; T,XXXVI,163:11-21) (see Figure 5.3.4.3-6). Based on this limited data, extending a line to intersect the 100 percent survival level suggests that a Vernalis flow of about 20,000 cfs would be needed (see Figure 5.3.4.3-6). DFG estimated that April through early June San Joaquin River inflows to the Delta of about 17,000 cfs would produce 70 percent of historical salmon escapement in the San Joaquin Basin (DFG,15,49). The estimates were based on (1) correlations between spring flows and adult escapement by that year class; and (2) estimates of the channel capacity of a particular river (T,XXXVI,22: 17-23:12). Thus, several different evaluations suggest that the greatest salmon smolt survival and/or subsequent adult production occurs when spring flows at Vernalis are around 17,000-20,000 cfs.

FIGURE 5.3.4.3-4 Mean April through June San Joaquin River flows at Vernalis during smolt emigration and subsequent adult escapement 2 1/2 years later. (from USFWS, 31, 66, Figure 4-8)

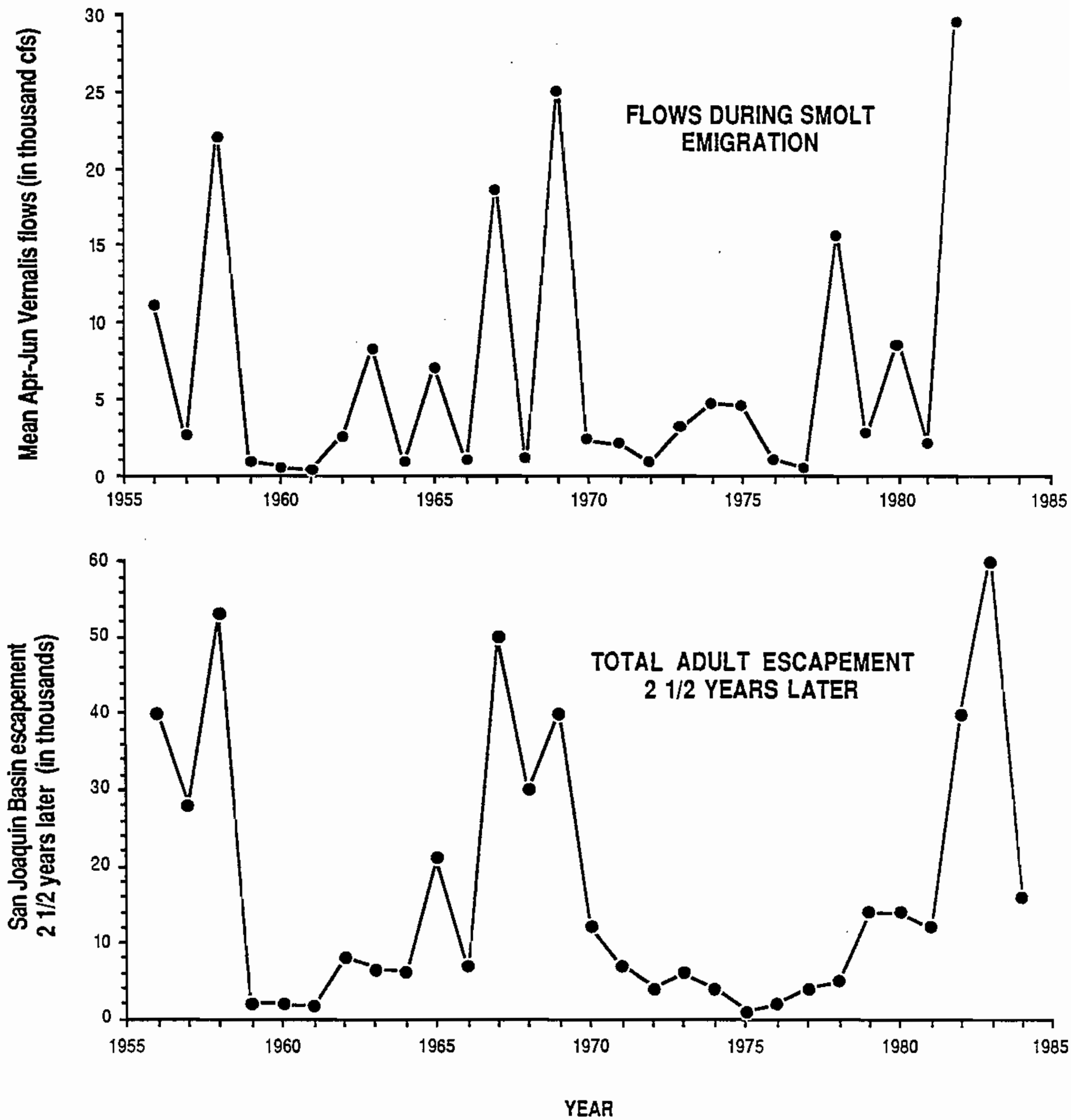


FIGURE 5.3.4.3-5 Relationship between mean April through June flows at Vernalis and adult spawning escapement 2 1/2 years later, 1956-1984 (USFWS, 31, 65)

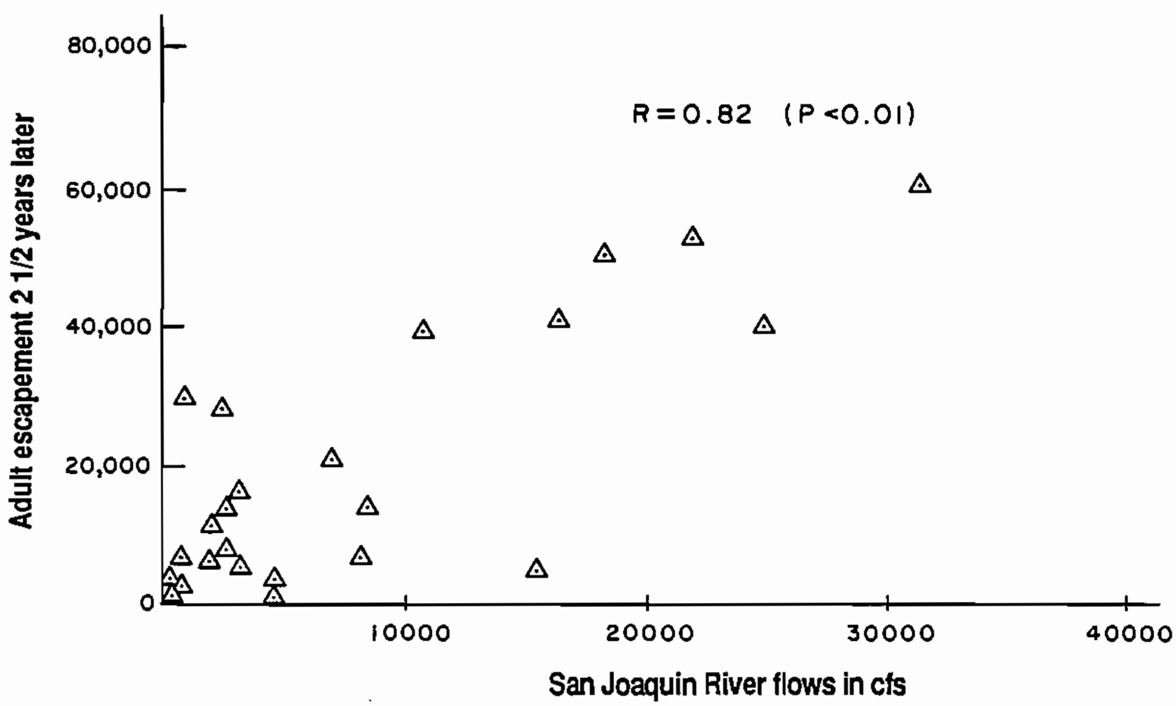
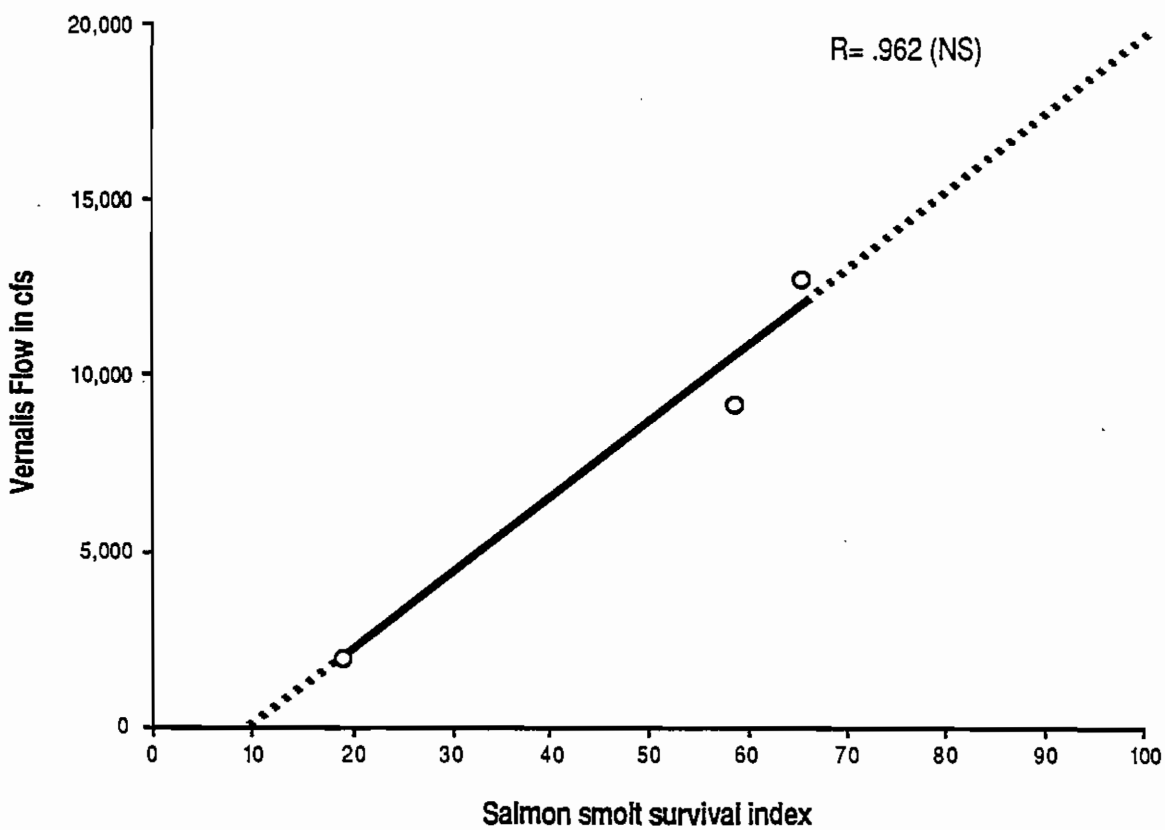


FIGURE 5.3.4.3-6 Mean April to June flows at Vernalis and the corresponding estimated smolt survival index[1] for marked smolt. Projected flows corresponding to maximum adult escapement 2 1/2 years later are shown by the dashed line. (from USFWS, 31,70) (This relationship is shown for informational purposes only since only 3 years of data are available and there is no significant correlation)



[1] Survival = 0.0046 (Mean Apr - Jun Vernalis flow) + 9.733

The optimal protection level described below is based on the flows that would, according to the available evidence, confer optimal habitat protection and facilitate maximum smolt survival without regard to other factors which may also influence Delta smolt survival. Reliance on hatcheries and trucking young fish around conditions shown to cause significant mortality in order to maintain adult production and harvest does not constitute optimal protection of this beneficial use.

- Recommendation: For optimal protection of fall run smolts emigrating down the Sacramento River, the April, May and June mean monthly flows at Rio Vista should be 22,500 cfs.

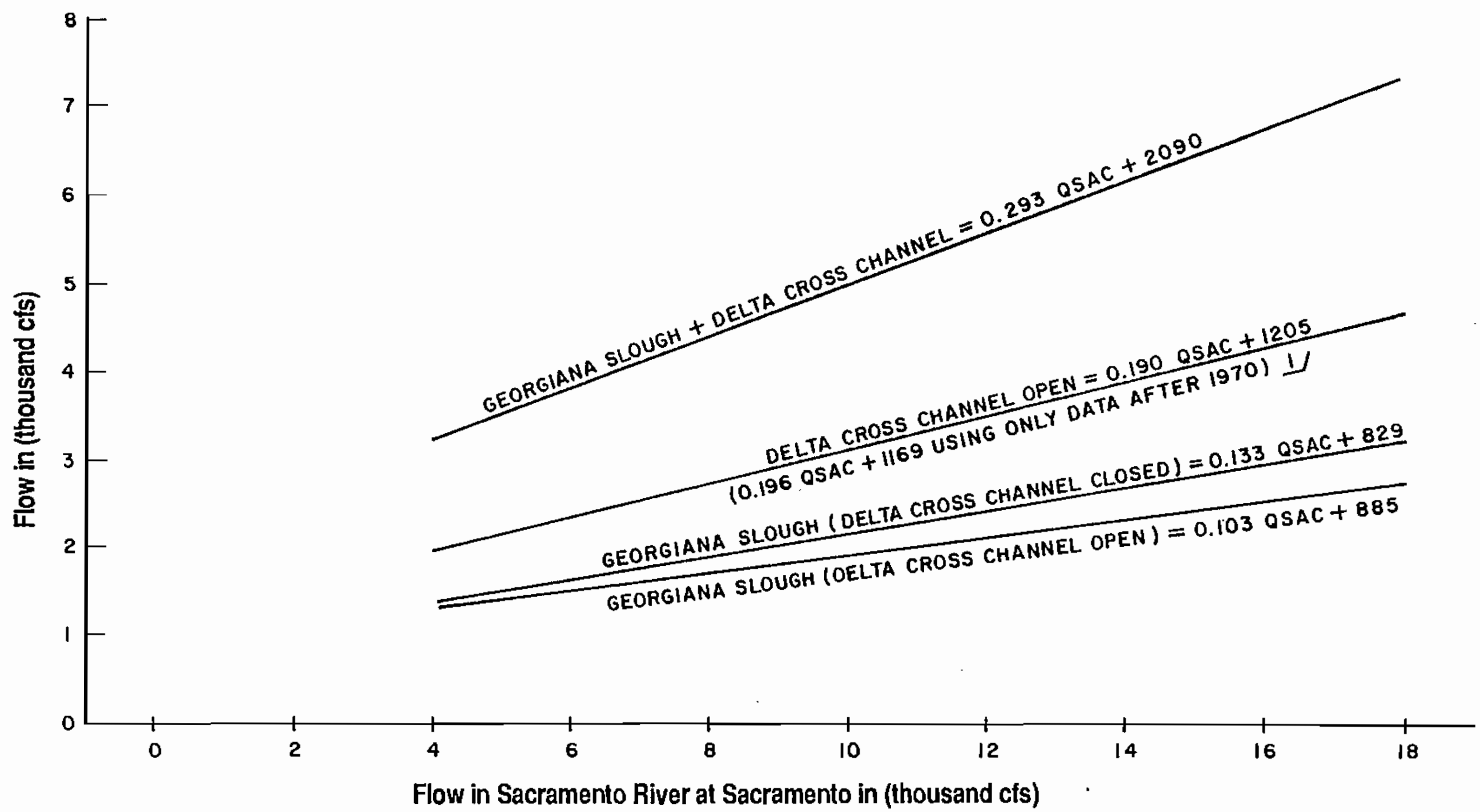
  For the protection of fall run smolts emigrating down the San Joaquin River, the mean April, May and June flow should be 20,000 cfs.

- Problem 2: Diversion of emigrating smolts from historical migration routes reduces their survival.

Tagging studies show that Delta survival decreases when smolts are diverted out of the main channels of the Sacramento and San Joaquin rivers during emigration. Central and southern Delta conditions believed to contribute to reduced smolt survival include: temperatures at stressful, to near lethal, levels during the late spring emigration period; possible poor food supplies; migration delays due to diversion from normal migration routes and reverse flows in Old, Middle, and the lower San Joaquin rivers carrying fish to the CVP and SWP export pumps; high predation rates near the SWP's Clifton Court Forebay; and the fish salvage process atthe CVP and SWP export pumps (USFWS,31,51-53).

The Delta Cross Channel, which began operating in 1950, splits the Sacramento River flow near Walnut Grove causing more young fish to be diverted into the central and southern Delta than would have passed via Georgiania Slough alone into these areas. Figure 5.3.4.3-7 shows the relationship between Sacramento River flows and flows in the Delta Cross Channel and Georgianna Slough (DWR,50). Even with the gates closed, a certain amount of Sacramento River flow still moves into the Mokelumne River and the interior Delta via Georgianna Slough (see Figure 5.3.4.1-1). At low flows, a greater proportion of the Sacramento River flow moves through the Cross Channel than at high flows. For example, at Sacramento River flows of 4,000 cfs, about 3,200 cfs or 75 percent is diverted while at flows of 16,000 cfs in the Sacramento River about 6,800 cfs or 42 percent is diverted through the Cross Channel.

FIGURE 5.3.4.3.-7 Empirical relationships between flows in Georgiana Slough, Delta Cross Channel and the Sacramento River
(from DWR,50)



1/ Flow split changed slightly after SWP went into operation but the two equations are not significantly different (T,IV, 45: 9-21).

The USFWS reported that one study showed the density of salmon above the Cross Channel to be similar to density in the Cross Channel itself when the gates are open suggesting that fish may be diverted in proportion to the flow split (USFWS,31,44). At lower river flows a greater relative proportion of fish as well as water may therefore be diverted.

If smolts enter the central Delta via Georgiana Slough or the Cross Channel, they can still emigrate successfully by moving down the Mokelumne River and turning west where it joins the San Joaquin River, then following the San Joaquin downstream (see Figure 5.3.4.1-1) (USFWS,31,49). However, smolts migrating to the Bay via the interior Delta travel a longer, more circuitous route and are exposed to increased predation, higher temperatures, and many unscreened agricultural diversions (USFWS,31,44). At the junction of the Mokelumne and San Joaquin rivers they may also encounter reverse flows moving southward toward the SWP and CVP pumping plants (USFWS,31,44-45).

Smolt survival, as measured by ocean tag recoveries, was negatively correlated with the percent of the Sacramento River flow diverted through the Delta Cross Channel ($R=-.65, P<0.05$) flow at Sacramento (USFWS,31,46) (see Figure 5.3.4.3-8). Evaluation of the survival of tagged smolts shows that, with the Cross Channel gates open, smolts released upstream of Walnut Grove survived approximately half as well as smolts released below the Cross Channel in three out of four years (See Table 5.3.4.3-3). Survival of smolts released above the Cross Channel with the gates closed (under low flow conditions and temperatures about 66° F) was about 68 percent greater than with the gates open. When the gates were closed, survival of fish released above the Cross Channel was similar to that of fish released below. Overall, these experiments showed that survival of Sacramento Basin smolts is greatest when they are not diverted into the Delta Cross Channel (T,XXXVI,152:10-155:23).

Studies were also carried out on smolts released at various locations in the central and southern Delta to test the survival of fish diverted from the main river channels via: (1) the Cross Channel; (2) export pumping from Old River; or (3) reverse flows. Although the results of studies in the central Delta are not as clear as those carried out in the Sacramento River, fish released into the central Delta exhibited somewhat lower survival in two out of three years compared to those migrating down the Sacramento River with the Cross Channel closed (T,XXXVI,155:10-17) (see Table 5.3.4.3-3 and Figure 5.3.4.3-8). Overall, survival of smolts released in Old River, where they would be subject to export pumping, was generally lower then the other groups studied except in 1985 (USFWS,31,48-51;T,XXXVI,155:1-23) (see Table 5.3.4.3-3 and Figure 5.3.4.3-9).

FIGURE 5.3.4.3-8 Delta smolt survival (based on ocean tag recoveries of marked salmon) versus percent diverted off the Sacramento River into the Cross Channel and Georgiana Slough at Walnut Grove during the time the marked fish were migrating downstream
(USFWS, 31, 46)

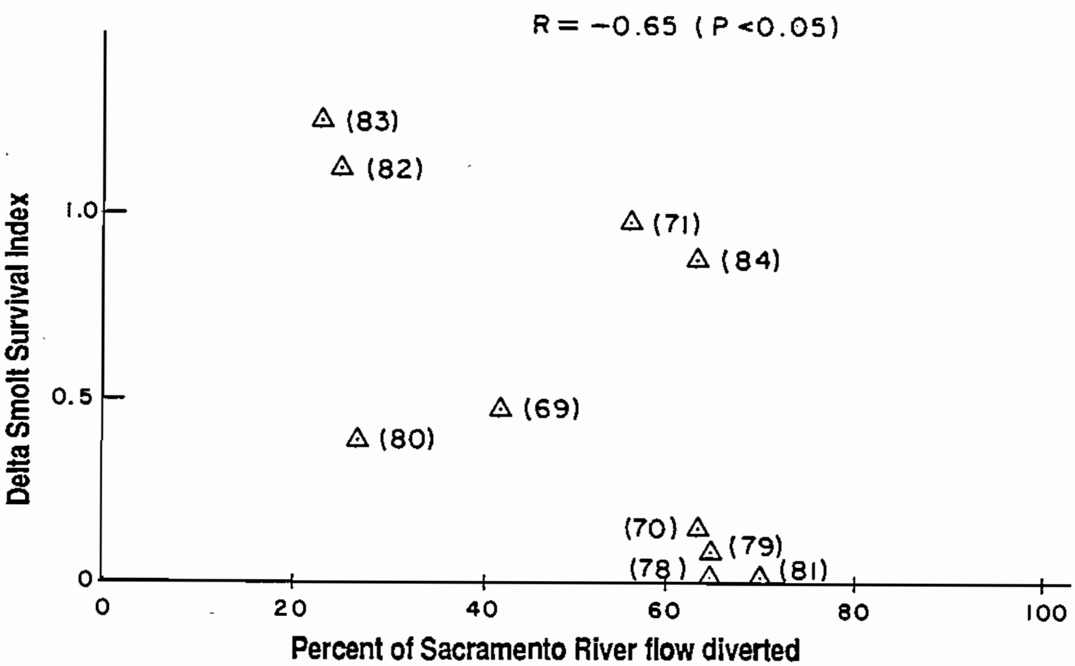


TABLE 5.3.4.3-3 Survival of marked smolts released at different locations in the Delta

RELEASE LOCATION	Year	% River Diverted	Survival Index to Chipps Island: Gates Open	Gates Closed	Below Gates
SACRAMENTO[1] RIVER (Delta Cross Channel)	1983	23	-	1.06 [2]	1.33 [2]
	1984	62	0.61	-	1.05
	1985	65	0.34	-	0.77
	1986	64	0.35	-	0.68
	1987 (0)	69	0.40	-	0.88
	1987 (c)	29	-	0.67	0.85
	Mean =		0.42	0.83	0.86

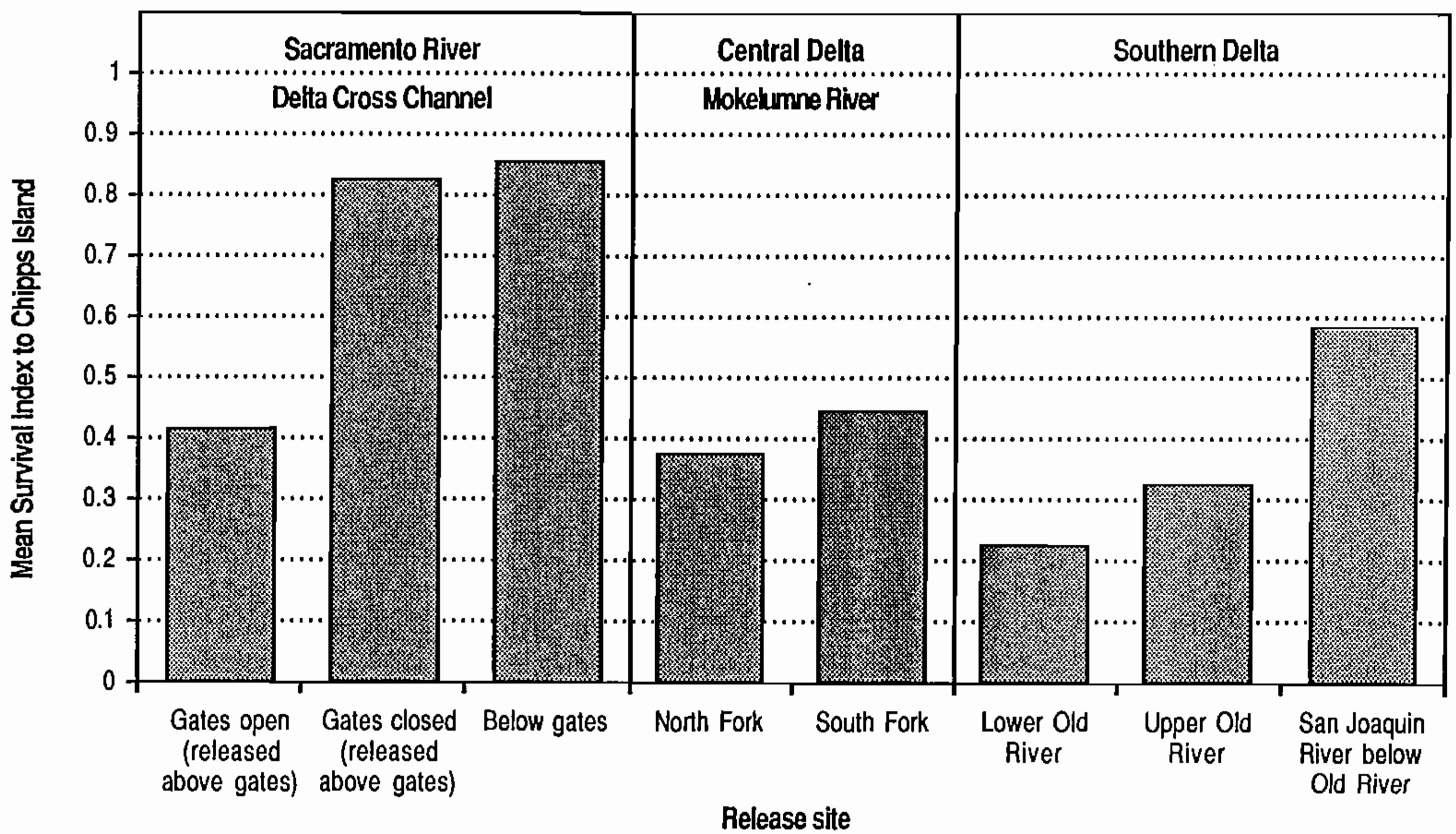
RELEASE LOCATION	Year	Survival Index to Chipps Island: North Fork	South Fork	Lower
CENTRAL DELTA[1] (Mokelumne River)	1983	-	-	1.13
	1984	0.51	0.86	-
	1985	0.28	0.23	-
	1986	0.36	0.26	-
	Mean =	0.38	0.45	

RELEASE LOCATION	Year	Survival Index to Chipps Island: Lower[1] Old River	Upper[3] Old River	San Joaquin R.[3] below Old River
SOUTHERN DELTA	1982	-	-	0.60
	1983	0.33	-	-
	1984	0.16	-	-
	1985	0.21	0.62	0.59
	1986	0.23	0.20	0.34
	1987	-	0.16	0.82
	Mean =	0.23	0.33	0.59

(1) from USFWS, 31, 48, Table 4-2
(2) values >1.0 suggest some sampling error and were reduced to 1.0 when calculating the mean
(3) from USFWS, 31, 70, Table 4-9

FIGURE 5.3.4.3-9 Mean Survival of tagged smolts released at different locations and recovered at Chipps Island

(after USFWS, 31, Tables 4-2 and 4-9)



Export pumping is a factor believed to contribute to reduced smolt survival (USFWS,31,44-51). As discussed in Section 5.3.4.1, export pumping in the spring frequently diverts the entire San Joaquin River inflow via Old River and can also reverse flows in the lower reaches of the San Joaquin, Old and MIddle rivers downstream of the pumps. Even when most of the San Joaquin River inflows were exported from Old River, smolts generally survived better if they remained in the main channel of the San Joaquin River (T,XXXVI,165: 17-23). To test this, groups of smolts were released in the San Joaquin River below its junction with Old River and in upper Old River enroute to the export pumps. Fish released in the San Joaquin River downstream of its junction with Old River had, on average, higher survival rates compared to smolts released in Old River (T,XXXVI,165:7-23) where they would be carried towards the export pumps (see Table 5.3.4.3-3 and Figure 5.3.4.3-9). Of smolts released in upper Old River (upstream of the export pumps) in 1985, 1986 and 1987, 25 percent, 74 percent and 27 percent, respectively, turned up at the pumping plant fish protective facilities compared to 3 percent, 3 percent and 8 percent of smolts released in the San Joaquin River below its junction with Old River (T,XXXVIII,47:10-15;USFWS,31,70). However, recovery of experimental smolts at Chipps Island is highest when smolts remain in the main channels of the Sacramento and San Joaquin Rivers (USFWS,3,45-49; Id.,74). Tagging studies show that, even though all flows may be diverted through the pumping plants, some smolts are able to find their way to Chipps Island (T,XXXVII,47:10-48:4).

Fry also rear in the Delta and, as was mentioned in Section 5.3.4.1, the 1978 Delta Plan provides for closure of the Cross Channel gates when Sacramento River flows exceed 12,000 cfs between January 1 and April 15. Fry are mostly present in the Delta from about January through April (T,XXXVI,169:8-10), with the highest abundance in the Delta in February or March (USFWS,31,82).As inflows to the Delta increase so do the number of fry.Also, their distribution extends further downstream, sometimes as far as San Francisco Bay (T,XXXVI,169:13-18). In wet years USFWS reported that fry survival in the central Delta was no different than that in the north Delta, but in dry years it was lower (USFWS,31,88). Ocean tag recoveries indicate that survival of fry in the northern Delta is better than that of fry released in the central Delta. Survival of Delta fry is better than that of fry released in San Francisco Bay (T,XXXVI,169:21-170:4). This evidence suggests that fry survival is improved if they are kept out of the central Delta in drier years but that their location in the Delta makes little difference in wet years; furthermore, fry carried into the Bay by very high flows may not survive well.

- Recommendations: Diversion of smolt or fry from their historical migration route or nursery areas can reduce survival. For optimal protection of fry rearing in the Delta, the Cross Channel gates should remain closed between January and April under below normal, dry, and critical water year conditions. For optimal protection of fall run smolt emigration, the Cross Channel gates should remain closed from April 1 through June 30.

- Problem 3: CVP and SWP export pumping from the Delta decreases salmon survival.

USFWS presented evidence, described in the previous section, suggesting that smolts subjected to reverse flows associated with export pumping do not survive as well as smolts which are not. Flows in the lower San Joaquin, Old and Middle river typically reverse when Delta exports exceed Vernalis inflows. In the 20 years, from 1968 to 1987, the mean April through June exports exceeded mean Vernalis inflows 15 times (see Figure 5.3.4.3-10). TID/MID's model of factors affecting salmon production also suggests that increasing spring Delta exports contribute significantly to decreases in the magnitude of subsequent adult escapement to the San Joaquin Basin (TID/MID,2,1-4). In addition to diverting emigrating smolts from their normal migration routes, there are direct losses of fish at the Delta pumping plants which increase with increasing export rates (see Figure5.3.4.3-11)

Salmon losses and salvage values are influenced by the timing, abundance and distribution of salmon in the Estuary, hydrologic conditions and project operations (DFG,17,28; T,XXXVII,35:11-15;T,XXXVII,124:5-22). DFG testified that losses reflect the amount of water going through the pumping plants when fish are present in the Delta (T,XXXVII,38: 9-14). Monthly fish losses and salvage are highest during April through June and lowest during July through September (see Figure 4.5.1.2-3) (DFG,17,Appendix Table 4). There are year to year shifts in the peak of emigration through the Delta due to factors upstream of the Delta. In general, San Joaquin Basin smolts migrate somewhat earlier than Sacramento Basin smolts. Many Sacramento River Basin hatchery smolts released upstream of the Delta reach the Delta in June. Tagging studies show that Sacramento Basin smolts are mostly entrained at the SWP facilities while San Joaquin Basin smolts show up at the CVP fish screens (USFWS,31,53-55). The CVP exports averaged about 2,000-3,000 cfs from the Delta during the spring in the 1950's (see Figure 5.3.4.3-10). The SWP began exporting from the Delta in 1968, and, under the 1978 Delta Plan, combined CVP and SWP exports during the spring smolt migration period have increased to around 6,000 cfs (see Figure 5.3.4.3-10). While average salmon losses associated with CVP exports have remained similar since 1968, average losses associated with SWP operations have more than tripled since the 1978 Delta Plan became effective (see Table 5.3.4.3-4).

FIGURE 5.3.4.3-10 Comparison of mean April - June Delta exports and inflows at Vernalis, 1956 - 1987 (from DWR, Dayflow)

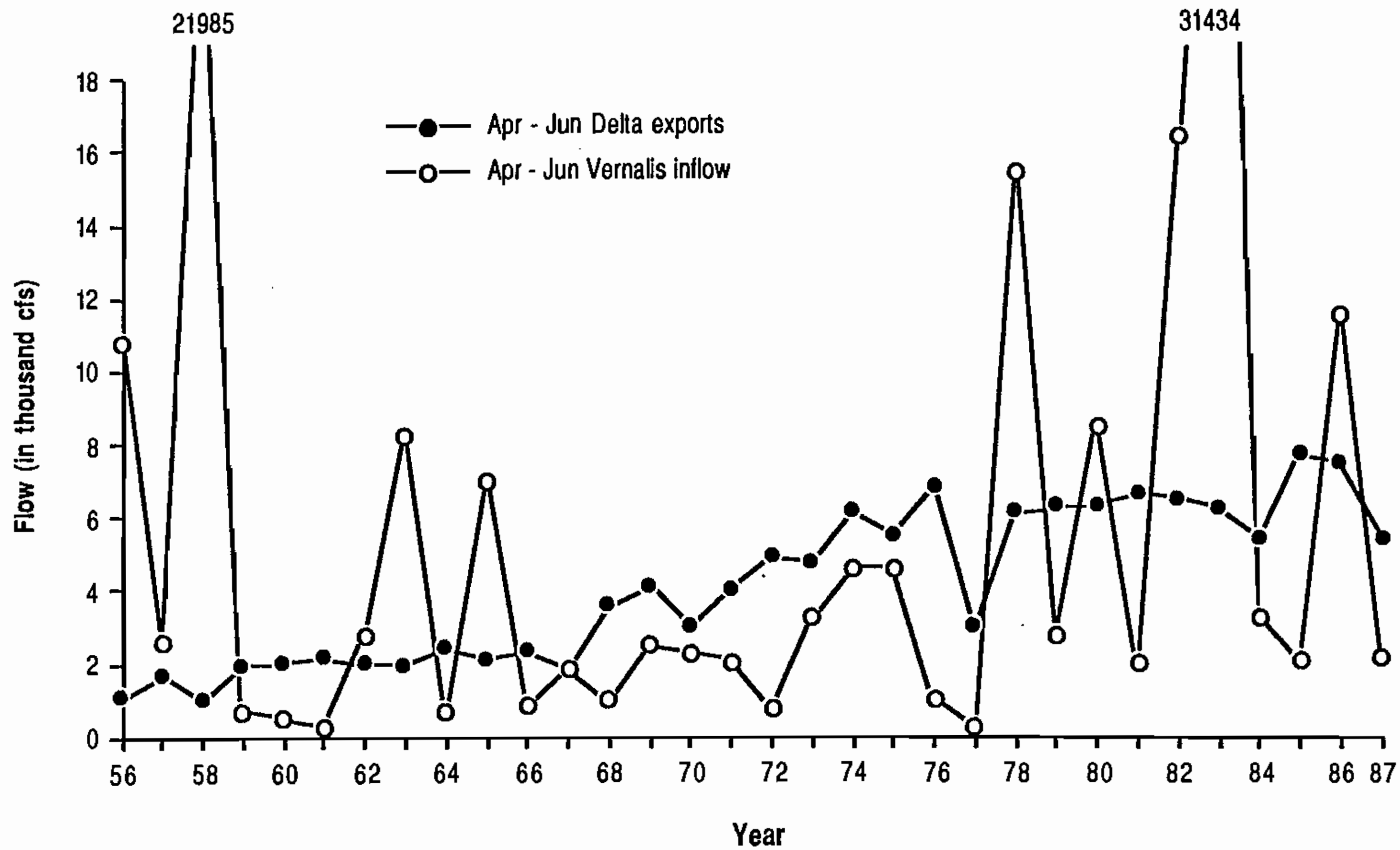


FIGURE 5.3.4.3-11 Change in mean monthly annual Delta exports and estimated Chinook salmon losses, 1956 - 1986 (from DWR, Dayflow, and DFG, 17)

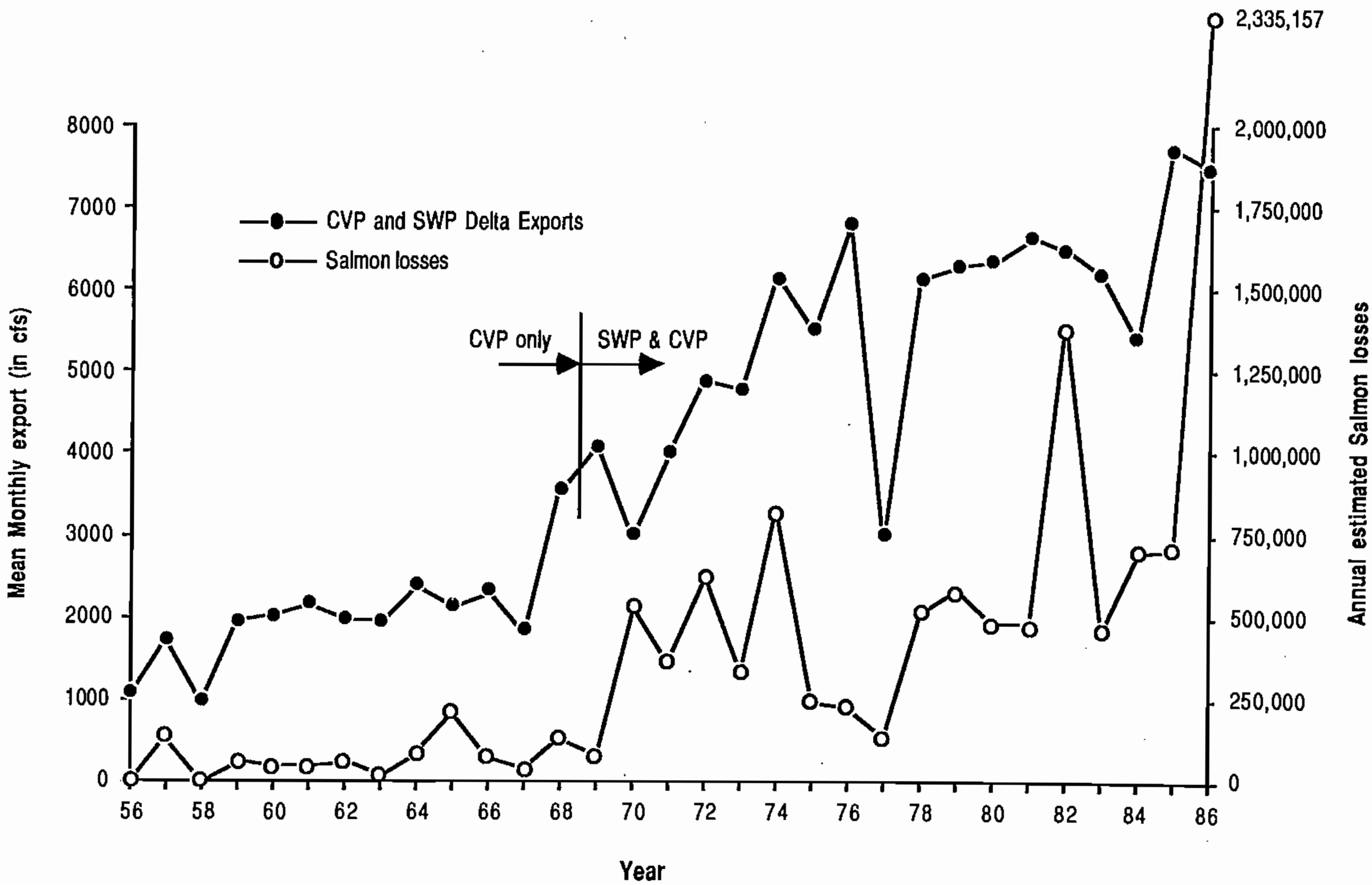


Table 5.3.4.3-4--Comparison of Mean Annual Estimated Chinook Salmon Losses and Monthly Exports at the CVP and SWP Fish Protection Facilities

1957-1986 (from DFG,17) and Mean Annual Exports in cfs (DWR,Dayflow)

	CVP		SWP		Total	
Period [1/]	Mean Annual Salmon Losses	Mean Annual Exports	Mean Annual Salmon Losses	Mean Annual Exports	Mean Total Losses	Mean Total Exports
1957-1967	68,886	1,843	0	0	68,886	1,843
1968-1977	136,865	2,865	108,540	1,592	345,405	4,446
1978-1986	129,442	3,314	719,275	3,133	848,717	6,447

[1/] Begins 1957 when fish losses calculated. Contra Costa Water District exports not included in total

The much higher losses at the SWP's Harvey O. Banks Delta Pumping Plant compared to the CVP's Tracy Pumping Plant may be related to several factors. Forebay conditions, including the presence of predators, contribute to this situation (DFG,17,16; DWR,560,2-3;DWR,560-6). Predation losses for salmon in Clifton Court average 75 percent (DFG,17,17). Prescreening mortality for salmon was estimated to average 75 percent at the SWP facilities as compared to 15 percent at the CVP facilities (DFG,17,14; T,XXXVII,38:4-8; T,XXXVII,35:22-36:8). The large increase in losses at the SWP facilities suggest that as exports of water from the Sacramento River Basin, which produces many more salmon, have increased so has the quantity of fish entrained. The USFWS testified that fish salvage operational criteria in D-1485 may provide some protection for fish at the CVP and SWP pumping plants (T,XXXVI,166:20-21). However, according to DFG, these criteria preclude the flexibility needed to alter operations in response to yearly shifts in the timing of peak fish abundance (T,XXXVII,134:1-19).

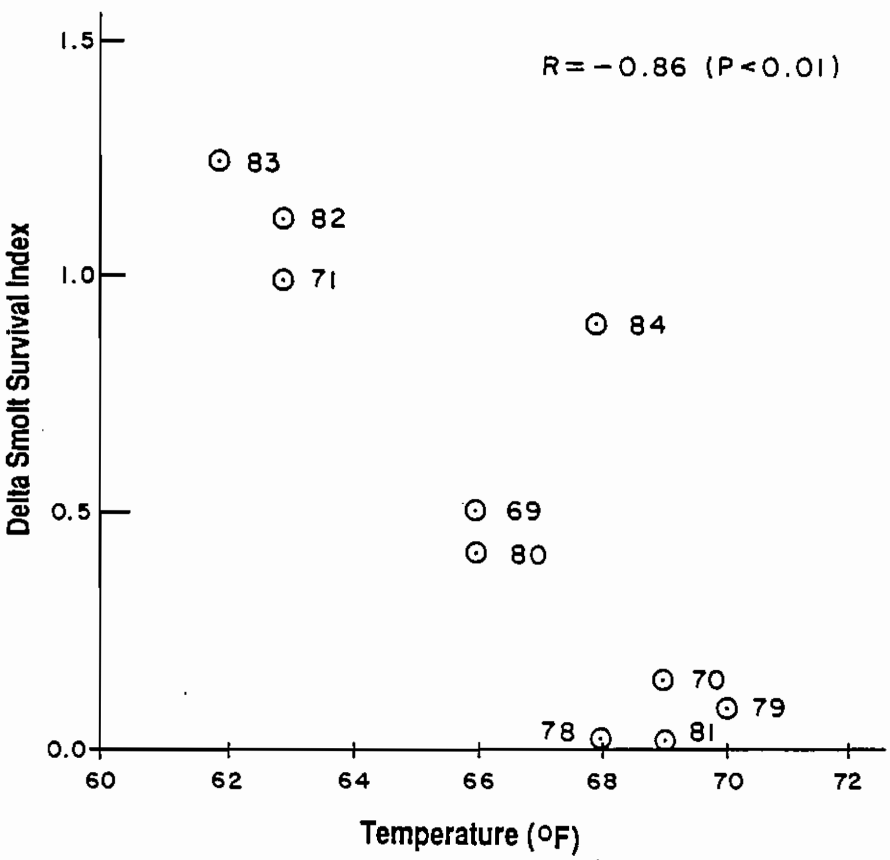
DFG and DWR entered into an agreement, which became effective in 1986, for a program to offset losses of salmon, steelhead, and striped bass at the Harvey O. Banks Delta Pumping Plant (DWR,569,1). According to the agreement, habitat restoration and other non-hatchery measures are to be given priority, and special emphasis is to be given to the San Joaquin River system for salmon habitat (DWR,560,6). No specific plans to reduce fish losses in Clifton Court forebay are contained in this agreement (DWR,560,9).

- Recommendation: Salmon survival is reduced during export of water from the Delta by the CVP and SWP. For optimal protection of fall run smolts, no water should be exported from the Delta by the CVP and SWP between April 1 and June 30.

- Problem 4: Water temperatures during the spring smolt emigration period reach levels that cause stress to fish.

Water temperature is another factor identified as affecting smolt survival in the Delta (see section 4.5.1.2). DWR's consultant testified that since 1978, temperatures at Sacramento have been two to three degrees centigrade (about four to six degrees Farenheit) higher (T,XXXVII,157:11-15). Consequently, smolts emigrating later in the season are likely to suffer higher mortalities (T,XXXVII,226:15-20). Sacramento Basin smolts would be affected, particularly hatchery reared fish which are released late in the spring, because the peak of emigration occurs somewhat later than in the San Joaquin Basin (T,XXXVII,215:17-22;T,XXXVII,225:23-226:7; DFG,15,17-23;USFWS,31,23). USFWS found that based on ocean tag recoveries, smolt survival decreased as water temperatures increased ($R=-0.86$ $P<0.01$) (see Figure 5.3.4.3-12). On the other hand, the survival index exceeded 50

FIGURE 5.3.4.3-12 Relationship between mean water temperatures and survival of marked smolts between Sacramento and Suisun Bay (based on ocean recoveries) (from USFWS, 31, 43)



percent when Sacramento River temperature at Freeport was 66°F or less (USFWS,31,43). Although temperature generally decreases as flow increases, there is a large temperature range at any given flow (T,XXXVII,157:4-8). In May, Sacramento River temperatures (at Freeport) are typically less than 66°F at flows between 25,000-30,000 cfs. San JoaquinRiver temperatures are generally less than 66°F atVernalis flows of 5,000 cfs or more (DWR,562,54; USFWS,31,148;DFG,15,26). When Sacramento River flows are below 20,000 cfs in June, the 5 day mean water temperature exceeds 66°F about half the time (T,XXXVII,156:24-157:2). By June temperatures do not drop below 66°F unless flows are about 30,000-40,000 cfs at Freeport (DWR,562,55; USFWS,31,148).

Laboratory studies have shown that a smolt's tolerance of elevated temperatures is improved when food supply is optimal (DWR,563,1-3). DWR's consultants testified that DFG's records indicate that the abundance of Neomysis, one of the primary foods of emigrating salmon (T,XXXVII,207:23-25), has decreased significantly in the last 20 years (T,XXXVII,207:25-208:1) and that upstream and estuarine food supplies may be poor. Taken together, these conditions could aggravate the effects of higher temperatures during emigration (T,XXXVII,207:3-9).

- Recommendation: The recommended flows for optimal protection of fall run smolts should significantly decrease May and June water temperatures in the Sacramento and San Joaquin rivers.

- Problem 5: Water quality conditions may block upstream migration in the San Joaquin River.

Within the Estuary, upstream migration of adult Chinook salmon occurs year round. The largest numbers of adult salmon are present in the Estuary from July through November (T,XXXVI,171:1-5) with the fall run predominating during much of this period. The fall run, which migrates upstream from July through November, is the only race in the San Joaquin Basin, while the late-fall, winter and spring runs migrate to spawning grounds in the upper Sacramento Basin from October to August (see Figure 4.5.1.2-1). As discussed in Section 4.5.1.2, adults follow olfactory cues contained in downstream flows of water from their homestream. The 1978 Delta Plan contained specific monthly Rio Vista flows for salmon migration ranging from 1,000 to 5,000 cfs (see Table 5.3.4.1-1). No minimum flows of homestream water have been identified for successful upstream migration, though it has been reported that salmon were able to migrate up the San Joaquin River when flows past Stockton were as low as 500 cfs (1978 Delta Plan draft EIR, p.III-80). It has been found that temperatures of about 65°F and DO levels below 5 mg/l in the fall have sometimes partially blocked adult migration in the San Joaquin River near Stockton (USFWS,31,94).

To address this problem in the San Joaquin River, an agreement was reached in 1969 among the USBR, DWR, and DFG (an agreement still in effect although not incorporated into the 1978 Delta Plan conditions) under which DWR monitors DO levels in the San Joaquin River between Stockton and Turner Cut (Stockton Ship Channel) during the fall migration. If DO drops below 6 mg/l, a temporary rock barrier is installed across the head of Old River to increase San Joaquin River flows past Stockton thus improving DO levels (T,XXXVII,85:4-22). Better treatment of cannery wastes since 1978 (reducing the biochemical oxygen demand) and improved flows and water quality from New Melones Reservoir operations were reported to have helped alleviate this problem (USFWS,31,94). Since then, the Old River barrier has been installed in the fall of 1979, 1981, 1984 and 1987 (H. Proctor,DWR,pers.comm).

- Recommendation: For the protection of adult Chinook salmon migration in the Estuary, there should be downstream flows in the Sacramento River equal to or greater than those required under the 1978 Delta Plan for salmon migration. Minimum flows in the San Joaquin River past Stockton should be 500 cfs from July through November for protection of fall run upstream migration. DO should not fall below 6 mg/l in the San Joaquin River between Stockton and Turner Cut during these months.

  The theoretical objectives which would provide optimal protection for salmon in the Estuary are summarized in Table 5.3.4.3-5.

5.3.5 Striped Bass

5.3.5.1 No Action Alternative:

Striped bass are included specifically in the beneficial uses protected under the Delta Plan (Table VI-1, pp. VI-31-33,35). Included are specific electrical conductivity and flow standards as well as certain operational constraints required of the SWP and CVP. These standards evolved out of negotiations conducted among DFG, DWR, USFWS, and USBR prior to the Delta Plan hearing as part of a draft Four-Agency agreement; this agreement was never implemented (DFG,25,133). These standards have not accomplished the intended goal of maintaining the actual Striped Bass Index (SBI) at a long-term average of 79 (the so called "Without Project" conditions). Based on a mathematical relationship (predicted SBI; see below) developed by DFG, the actual SBI under the Delta Plan (1979-1985) should have averaged about 65 (corrected from DFG,25,134-136 after consultation with DFG staff). In fact, during those years (excluding 1986, in which the index reached predicted levels), the actual SBI averaged 22.4, about one third of the predicted SBI (corrected from DFG,25,136). In 1988, the actual SBI reached an all-time low of 4.6.

Table 5.3.4.3-5--Optimal Levels of Protection for Salmon

Time Period	Location	Objective/Action	Use Protected
July 1-November 30	San Joaquin River between Stockton and Turner Cut	Maintain DO $\geq$ 6 mg/1	Adult Migration (fall run)
July 1-November 30	San Joaquin River at Stockton	500 cfs flow	(fall run)
All Year	Sacramento River	flows $\geq$ Delta Plan	(all runs)
January-1 April-30	Delta Cross Channel	Close gates under below normal, dry, and critical water years	Fry Rearing (fall run)
April-1 June-30	Delta Cross Channel	Close gates	Smolt Emigration (fall run)
April-1 June-30	Sacramento R. at Rio Vista	22,500 cfs flow	Smolt Emigration (fall run)
April-1 June-30	San Joaquin R. at Vernalis	20,00 cfs flow	Smolt Emigration (fall run)
April-June-30	Delta pumping plants	No exports	Emigration/ Rearing (fall run)

The actual SBI is a value obtained after extensive field sampling and measuring of larval striped bass each summer. This value is a measure of the relative abundance of young striped bass in the Estuary when their average length is 38 mm (1.5 inches). It is called an index because it is a relative value and is not directly translatable into an absolute value of the number of larvae in the Estuary. However, it is a legitimate and relatively sensitive measure of the change in abundance of larvae between years. The actual SBI tends to underestimate the larval abundance in very high outflow years (such as 1983) because many of the larvae are carried downstream beyond the DFG sampling stations. The actual SBI has been measured every year since 1959, except 1966.

The actual SBI is not the only measurement of striped bass populations. A variety of sampling programs are employed in monitoring various components of the striped bass population (Table 5.3.5.1-1). While the decline rates and patterns may vary somewhat, all programs measuring striped bass abundance show large declines from the levels measured in the 1960's (DFG,25,6:25,9).

Table 5.3.5.1-1--Methods to Assess Population Levels of Striped Bass

ADULTS

1. Petersen Estimate--Mark and recapture method; 1969 to present; in Delta and Sacramento River; statistical analysis of number of fish recaptured which were marked in previous years.

2. Catch Per Unit Effort (CPUE) Index--Index of population based on number of fish caught per standardized unit of time; same locations as for Petersen estimate; 1969 to present except 1977, 1978, and 1981; possibly more reliable than Petersen estimate (DFG,25,Appendix 1).

3. Tag Returns--1958 to present, except 1962-1964 and 1967-1968; analysis of tags returned by fisherman; provides basis for comparison of fishing vs. "natural" mortality.

4. Party Boat Census--Annual reports submitted by party boat operators; provides information on numbers of fish caught, number of angler-days, and related information.

5. Creel Census--Informal surveys of shorelines, piers and private boats to examine catch rates, fish sizes and other information for other than party boat operations; done sporadically, with reduced effort in recent years.

EGGS, LARVAE AND JUVENILES

1. Petersen Fecundity Estimate--Annual since 1977; combines Petersen population estimate with fecundity (egg number) data from Striped Bass Health Monitoring Program, with certain correction factors (age and number of fish spawning) to estimate total number of eggs produced.

2. CPUE Fecundity Index--Uses same procedure as above except that uses catch per unit effort (CPUE) index value for number of spawing females rather than Petersen estimate.

3. Egg and Larva Survey--Area sampled variable but standardized in recent years to Suisun Bay, central and western Delta, and Sacramento River to Colusa; 1966-1973, 1975, 1977, 1984-1986; intensive sampling at 75 stations in spring to monitor number, growth, movement and mortality of larvae up to about 14 mm in length; Sacramento River stations also monitor egg abundance and movement.

4. Tow Net Survey--1959 to present except 1966; Delta and Suisun Bay; biweekly sampling at 30-40 stations in summer until average length of larvae exceeds 38 mm length; provides index of abundance (actual Striped Bass Index, or SBI) and distributional information.

5. Midwater Trawl--Throughout Bay-Delta Estuary up to Rio Vista and Clifton Court Forebay; 1967 to present except 1974 and 1979; typically monthly tows between September and December at a variable number of stations; gives measure of young-of-the-year abundance; more variable than SBI.

Table 5.3.5.1-1 (Continued)

RELATED SURVEYS

1. Salvage Records--Provides numbers of fish salvaged from Skinner Fish Protective Facility in Clifton Court Forebay; annual from about 1970 to present; provides general estimate of population trends and densities based on number salvaged over time.

2. Striped Bass Health Monitoring Program--1978 to present, not all years; 1984 to present under consistent format; analysis of tissues of 40 prespawning adult female fish from Rio Vista and Antioch; provides samples for fecundity data.

3. Other--Various other special purpose studies which provide special information on striped bass (Export Curtailment Study, gut content analysis, spring die-off monitoring, etc.).

There has been considerable confusion in the testimony concerning whether the SBI in the Delta Plan has "worked" or "failed." This is because the Delta Plan set standards based on a predicted SBI, a mathematical formula based on the relationship of the historical record of larval abundance (actual SBI) to spring Delta outflow and exports. This formula provided a prediction of what the SBI ought to be, given certain flow and export conditions, and it was used to develop the export and outflow standards in the Delta Plan. The discrepancy between the actual and the predicted SBI is the reason that some participants stated that "the SBI has failed". However, the actual SBI has not failed. It continues to provide a comparative measure among years. In fact, the actual SBI simply reflects the fact that the Delta Plan standards have been inadequate to maintain striped bass at 1975 levels, much less restore them to "without project" levels.

The actual SBI is the sum of two separate indices: The Suisun Bay index and the Delta index (Table 5.3.5.1-2). Throughout the 1960's, the Delta index has been the major contributor to the overall actual SBI (Figure 5.3.5.1-1). Generally in the 1970's and 1980's the actual SBI declined, in large part because of the decline in the Delta index (Figure 5.3.5.1-2). As shown in Table 5.3.5.1-2, during the period 1959-1970 (except 1966) the Delta index was greater than 60 percent of the total actual SBI in five of eleven years, and was less than 40 percent of the total actual SBI in only one year (1967). By contrast, during the 18-year period 1971-1988, during which a significant increase in Delta exports had occurred (see section 5.3.5.3), the Delta index was greater than 60 percent of the total actual SBI in only two years (1977 and 1988, both critically dry years with very low outflow and low SBI's), and was less than 40 percent of the total actual SBI in 12 of 18 years. For the ten-year period in which the Delta Plan standards were in effect (1979-1988), the Delta index was greater than 60 percent of the total actual SBI only in 1988, and was less than 40 percent in seven of the ten years. These results indicate a substantial shift in the survival patterns of striped bass larvae in recent years. The probable reasons for this shift are discussed in Section 5.3.5.3.

5.3.5.2 Advocated Levels of Protection

The extensive testimony and exhibits presented on striped bass emphasize the point that, despite years of study, there is no consensus on the causes of the striped bass decline. As a result, two main and highly divergent approaches to the problem evolved during Phase I of the hearing. These approaches may be summarized as follows:

TABLE 5.3.5.1-2 STRIPED BASS INDEX DATA

YEAR	YEAR TYPE (1)	YEAR TYPE (2)	DATE SET	JULIAN DATE	DELTA INDEX	SUISUN INDEX	TOTAL INDEX	5-YEAR RUNNING AVERAGE	DELTA % OF TOTAL	PRED. INDEX	ACTUAL % OF PRED.
1959	D	D	JULY 12	193	30.7	3.0	33.7	-	91.1	34.1	98.8
1960	BN-SNSM	D	JULY 17	199	32.0	13.6	45.6	-	70.2	55.1	82.8
1961	D	D	JULY 21	202	25.2	6.4	31.6	-	79.7	45.5	69.5
1962	BN	BN	JULY 26	207	46.8	32.1	78.9	-	59.3	79.1	99.7
1963	W	W	AUG 03	215	38.2	43.5	81.7	54.3	46.8	87.3	93.6
1964	D	D	AUG 02	215	54.7	20.7	75.4	62.6	72.5	63.3	119.1
1965	W	W	JULY 31	212	49.4	67.8	117.2	77.0	42.2	87.7	133.6
1966	BN-SNSM	BN	NOT DETERMINED						NOT DETERMINED		
1967	W	W	AUG 12	224	35.1	73.6	108.7	95.8	32.3	92.7	117.3
1968	BN-SNSM	D	JULY 19	201	39.6	17.7	57.3	89.7	69.1	44.5	128.8
1969	W	W	AUG 09	221	33.6	40.2	73.8	89.3	45.5	92.7	79.6
1970	W-SNSM	D	JULY 18	199	36.6	41.9	78.5	79.6	46.6	66.8	117.5
1971	W	W	AUG 11	223	24.6	45.0	69.6	77.6	35.3	83.4	83.5
1972	BN-SNSM	BN	JULY 25	207	13.4	21.1	34.5	62.7	38.8	33.7	102.4
1973	W	BN	JULY 15	196	15.6	47.1	62.7	63.8	24.9	53.8	116.5
1974	W	W	JULY 22	203	17.4	63.4	80.8	65.2	21.5	63.1	128.1
1975	AN	W	JULY 30	211	23.4	42.1	65.5	62.6	35.7	83.8	78.2
1976	C	C	JULY 16	198	21.1	14.8	35.9	55.9	58.8	45.6	78.7
1977	C	C	JULY 24	205	8.3	0.7	9.0	50.8	92.2	47.5	18.9
1978	W	AN	JULY 23	204	16.5	13.1	29.6	44.2	55.7	65.1	45.5
1979	D	BN	JULY 19	200	5.4	11.5	16.9	31.4	32.0	54.9	30.8
1980	W	BN	JULY 15	197	2.8	11.2	14.0	21.1	20.0	80.5	17.4
1981	D	C	JULY 02	183	15.4	13.7	29.1	19.7	52.9	58.0	50.2
1982	W	W	JULY 30	211	9.5	39.2	48.7	27.7	19.5	79.3	61.4
1983	W	W	AUG 05	217	1.2	14.2	15.4	24.8	7.8	78.3	19.7
1984	W-SNSM	BN	JULY 13	195	6.3	20.0	26.3	26.7	24.0	68.6	38.3
1985	D	D	JULY 16	197	2.2	4.1	6.3	25.2	34.9	34.1	18.5
1986	W-SNSM	BN	JULY 09	190	23.8	41.1	64.9	32.3	36.7	65.1	99.7
1987	C	C	JUNE 22	173	7.3	5.3	12.6	25.1	57.9	43.5	29.0
1988	C	C	JULY 24	206	3.9	0.7	4.6	22.9	84.8	N.D.	N.D.

NOTES:

1. WATER YEAR TYPE (1) = BASED ON 1978 DELTA PLAN STANDARDS
2. WATER YEAR TYPE (2) = BASED ON PROPOSED SACRAMENTO VALLEY APRIL - JULY FORMAT
3. WATER YEAR TYPE CODE: W=WET; AN=ABOVE NORMAL; BN=BELOW NORMAL; D=DRY; C=CRITICAL; SNSM=SUBNORMAL SNOWMELT
4. 5 YEAR RUNNING AVERAGE INCLUDES 4 YEARS ONLY FOR 1967 - 1970
5. N.D. = NOT DETERMINED

FIGURE 5.3.5.1-1 STRIPED BASS INDEX

(NO SAMPLE IN 1966)

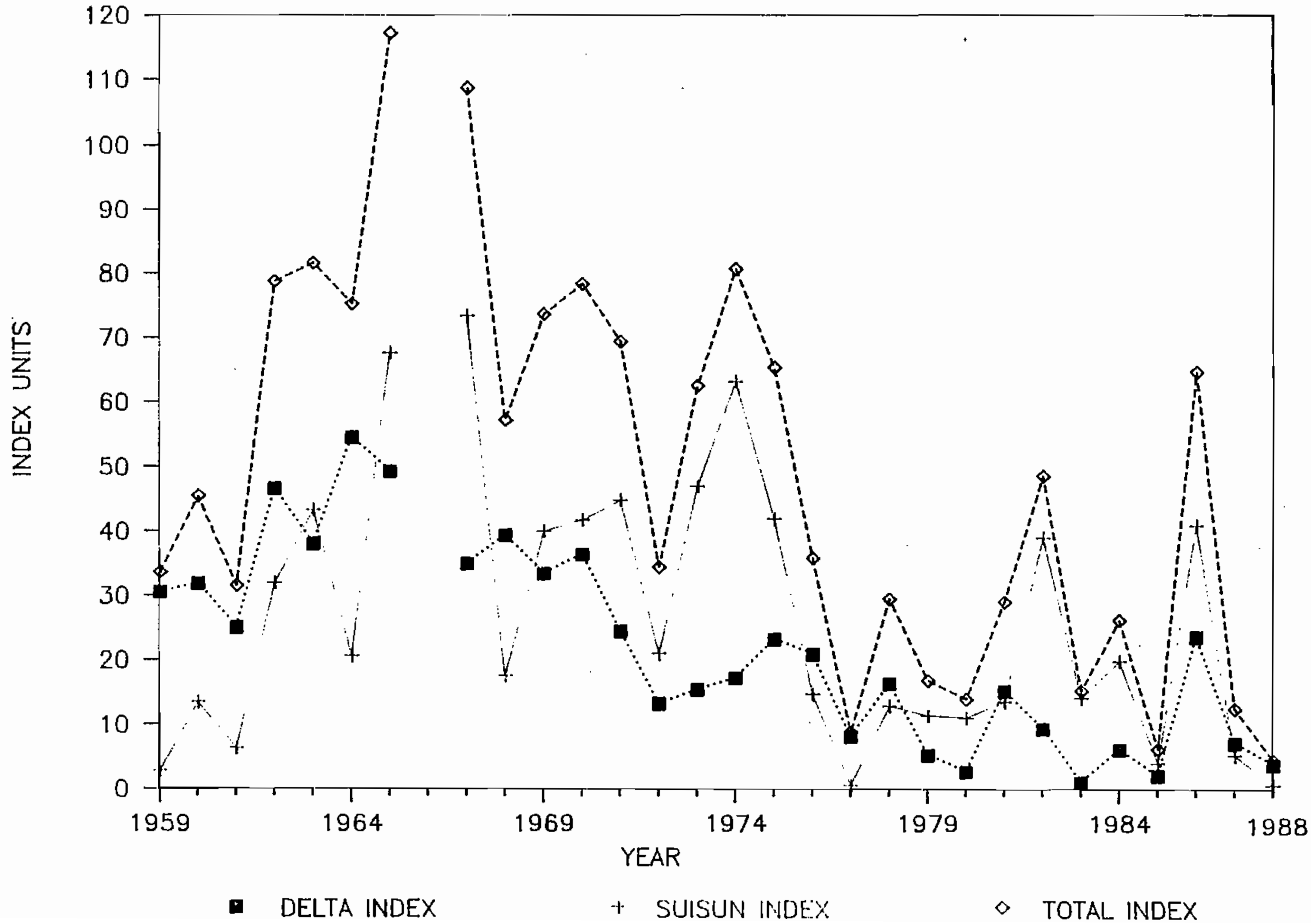
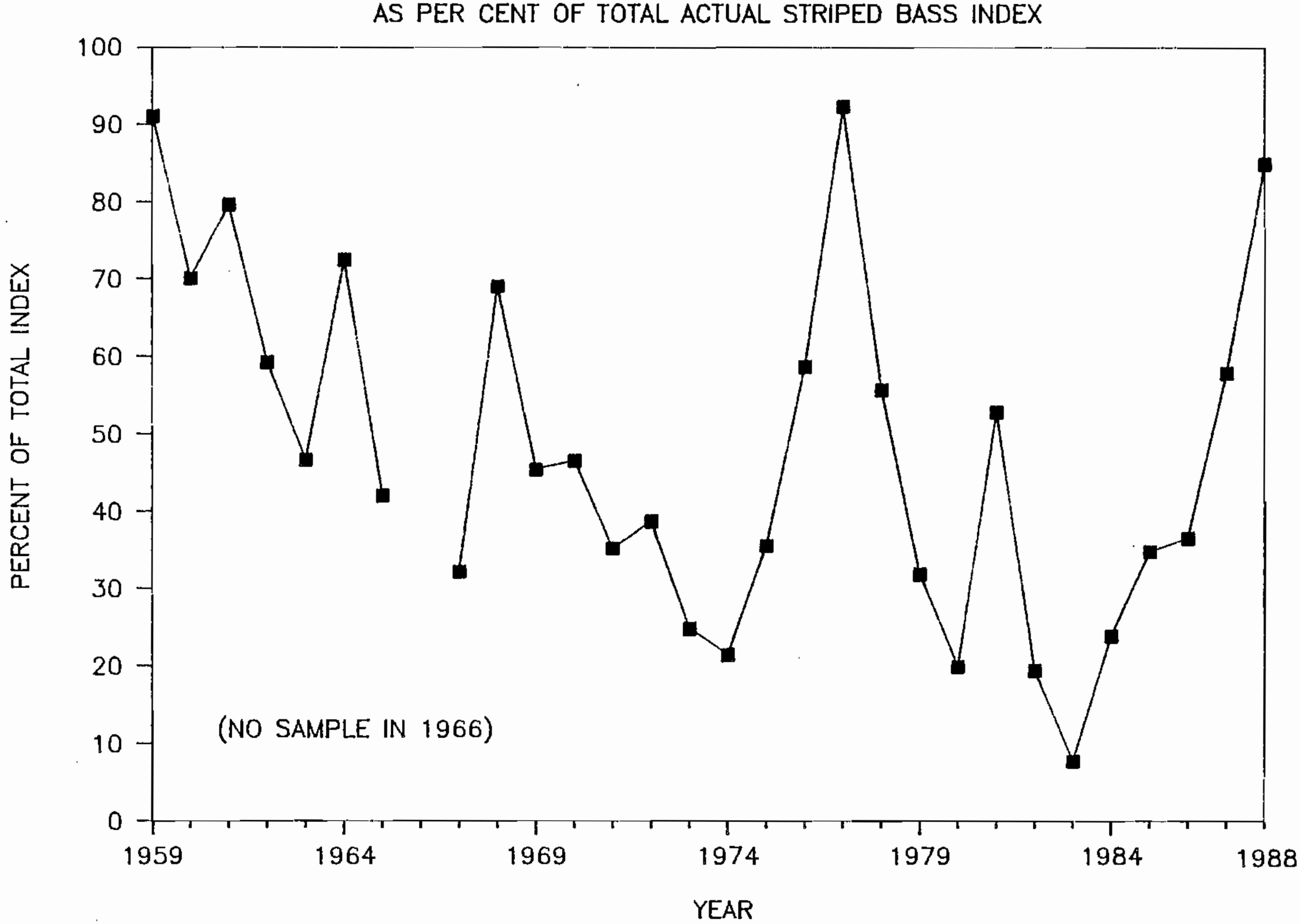


FIGURE 5.3.5.1-2 DELTA STRIPED BASS INDEX



- Retain Present Standards

  Because there is no agreement on what to do about striped bass, it was suggested that the present Delta Plan standards be retained for the most part until "cause and effect" relationships have been determined. This position was advocated by SWC, DWR, and others (SWC,203,4;DWR,602,2). SWC proposed five major hypotheses for the possible decline of striped bass (SWC,203,22). Four of these involve the effects of water export either directly or indirectly. The SWC, among others, advocate an extensive series of experiments to test these various hypotheses; but in the meantime, the current standards should be retained except to facilitate performing these tests. This approach is discussed further in Section 5.3.5.3.

- Change the Delta Plan Standards to Attempt to Provide Additional Protection

  This position was advocated by DFG, USFWS, EDF and others. The main argument here is that striped bass are not being protected by the Delta Plan standards, and the population is in serious decline. Therefore, something must be done now, even if all the reasons for the decline are not known; enough is known to at least proceed in some areas.

  The major proposal for changed objectives was put forth by DFG (DFG,64,6-12) with support from USFWS in their own recommendations (USFWS,47,5-6). Both agencies called for short-term measures, primarily in the form of greatly increased outflow and changes in the operation of the Delta Cross Channel gates. Long-term proposals included recommendations for eliminating reverse flows in the San Joaquin River by 1995, examination of new Delta water transfer facilities, possible operational changes, and evaluation of current research and monitoring programs required by the Delta Plan (DFG,64,14-19).

  The overall goal of DFG was to achieve an annual production of young striped bass equal to a long-term average actual SBI of 106, which they determined was the "historical level" (DFG,64,6). DFG believes this is not a realistic objective in the near future (DFG,64,6) and cannot be achieved with their present state of knowledge about striped bass (T,LX,102:24-103:16). In fact, DFG estimated that their increased flow recommendations and other changes would, on average, increase the SBI only to 28, which is six points, i.e., 25 percent, higher than the average of the 1979-1985 period (T,LX,102:3-21). The proposed flow objectives do not call for increased flow beyond the levels presently required under the Delta Plan for critical years, or for dry years following dry or critical years (DFG,64,6; T,LX,82:2-4). No changes in exports are proposed except that a limit of 5,000 cfs total diversions would be imposed in May and June, rather than the present 6,000 cfs, when water is being withdrawn from storage for export (DFG,25,7;T,LX,82:11-15).

A larger percentage of total Delta inflow is exported under low flow conditions in the Delta; this provision would somewhat reduce impacts on striped bass larvae. DFG also proposed expansion of the provision for closure of the Delta Cross Channel gates to include the ability to request closures when the Delta Outflow Index is less than 12,000 cfs. Under the Delta Plan, DFG can request closure of the gates only when the Delta Outflow Index is greater than 12,000 cfs. DFG did not recommend any change in the length of the period during which such requests can be made (April 16--May 31 in all years). All other Delta Plan standards would remain in effect (DFG,25,7).

USFWS proposed flow objectives and operational changes similar to DFG as short-term measures, as well as similar long-term recommendations, such as elimination of reverse flows in the lower San Joaquin River (USFWS,47,5-6). However, they also proposed that outflow be not less than 10,000 cfs during the May through July period "to keep larvae and young-of-the-year [striped bass] in Suisun Bay and maintain the null zone (spring-summer) no further [upstream] than Honker Bay" (USFWS,47,5). This contradicts their own recommendation in support of the Delta Plan flow standards, per DFG, for critical years, and dry years following dry or critical years. No testimony was presented to resolve this contradiction.

EDF also proposed increased outflow standards (EDF,25). The recommendations are similar to, and are based on DFG recommendations, but include a multiplier factor of 1.5 in May, 1.0 in June, and 0.7 in July to the recommended May-June flow increases to adjust for the greater densities of eggs and larvae which are present in the earlier months (T,LVII,78:21-79:4). The recommended flow levels were expected to provide survival approaching "without project" levels. However, it was EDF's opinion that protection at "historic levels" would require higher levels than those recommended; EDF did not determine what those flow levels might be (T,LVII,79:5-18). In some years, the recommended flows would actually be greater than unimpaired flows (T,LVII,80:7-81:5).

5.3.5.3 Optimal Levels of Protection

The striped bass problem in the Estuary is very complicated, and there probably is no single answer to the problem. However, important steps could be taken to protect striped bass that are not being employed at present. Therefore, the recommendation by some participants that the present Delta Plan standards remain in effect is rejected. The striped bass population has declined too much (perhaps in excess of 70 percent since the 1950's) to take no definitive actions to provide additional protection. None of the participants disputed the fact that there is a problem with striped bass, even if they differed on what course to take. The record low 1988 SBI of 4.6 further emphasizes the need to take immediate action.

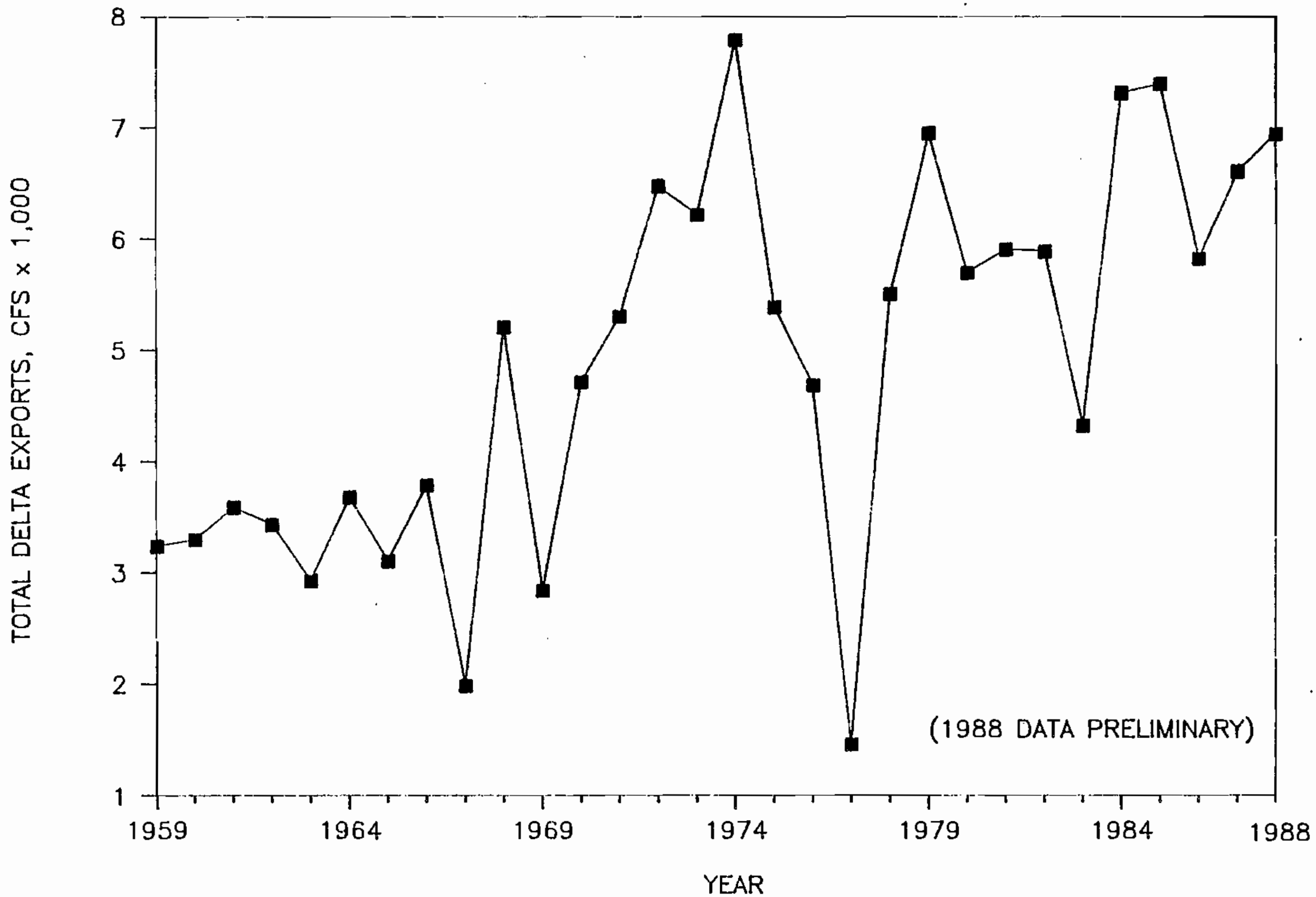
Changes in the Delta Plan are appropriate standards because they are not doing what they were intended to do i.e., provide reasonable protection for striped bass. This beneficial use is not being protected to the extent originally intended by the Board in the Delta Plan; therefore, steps must be taken to provide additional protection. Certain steps have been suggested which are not related to flow and salinity standards, or which are intended to provide "equivalent protection" for striped bass. In general, these proposed actions do not provide equivalent protection or are not relevant to actions included under this Plan. These alternative measures will be discussed in individual sections below as appropriate.

In rejecting continuation of the current Delta Plan standards, it is important to understand why those standards did not work. Spring flow and export standards have not worked because they were being applied to a situation in the Delta which was significantly different from the one under which the data used to develop the formulas for the predictive index were obtained. The original relationship among the predictive SBI, outflows and exports was based on data developed during the period 1959-1970. During this period, exports in the spring were primarily from the CVP, and certain major upstream storage projects (Oroville and New Melones) had not been completed or had not yet had a significant effect on the Delta. As shown in Figure 5.3.5.3-1, total Delta exports (SWP,CVP,and CCC) were relatively constant at about 3,500 cfs during the April through July period. However, during the 1971 through 1976 period, when the decline in the Delta portion of the SBI began to become apparent, total exports for the April through July period increased to an average of 6,000 cfs. When Delta Plan standards for striped bass were in effect (1979-1988), the average April through July total exports were about 6,300 cfs, or 80 percent higher than for the 1959-1970 period, and 45 percent higher than the 1959-1976 period (the period used for development of the predicted SBI in the Delta Plan).

The relationship for the May through July periods, on which the Delta Plan standards were set, shows a similar pattern. Average May through July total Delta exports for the period 1959-1970 were about 3,700 cfs. During the period 1971-1976, the average exports increased to 6,300 cfs. For the period that the Delta Plan standards were in effect (1979-1988), average May-July exports declined slightly from the 1971-1976 period to about 6,200 cfs, due to the export restrictions imposed by the Delta Plan. This restriction represents less than three percent reduction from the 1971-1976 period, when the Delta index was declining. In effect, the Delta Plan standards stabilized exports at post-1970 levels, but did nothing to provide protection comparable to that found under the original relationship from the 1959-1970 period. Under the Delta Plan, average total Delta exports in the months of May, June, and July are still 66 percent higher than the 1959-1970 period, and 34 percent higher than the 1959-1976 period (the period used as the basis for the predictive index).

FIGURE 5.3.5.3-1 TOTAL DELTA EXPORTS

COMBINED SWP, CVP, AND CCC; APRIL – JULY AVERAGE



The direct and indirect effects of these increased exports have most likely been the major factor in the recent decline of striped bass. As noted above, four of the five hypotheses proposed by the SWC are directly or indirectly related to flows and exports. All the participants acknowledge that exports and their attendant effects on flows in the Delta do have deleterious effects on striped bass. Below are presented the particular problems related to striped bass and the proposed recommendations to provide them optimal protection. These recommendations are summarized in Table 5.3.5.3-1. Acceptance or rejection of the proposed objectives of the participants will be discussed. As noted above, the proposal to retain the current standards is rejected.

TABLE 5.3.5.3-1
OPTIMAL LEVELS OF PROTECTION FOR STRIPED BASS

Time	Location	Recommendation	Protection
April 1--June 15 (all years)	San Joaquin R. Vernalis to Antioch Bridge	Maximum daily EC not to exceed 0.3 mmhos/cm	Adult striped bass migration and spawning
April 15--July 31 (all years)	Delta Cross Channel gates	Closed	Reduce trans-location of eggs and larvae
April 1--July 31 (all years)	Statutory Delta channels	No withdrawals or exports (except for emergency)	Reduce egg and larva entrain-ment
April 1--May 31 (all years)	Chipps Island	Daily Delta outflow at least 33,900cfs	Move larvae to Suisun Bay nursery area and keep null zone at Honker Bay or down-stream
June 1--June 30 (all years)	Chipps Island	Daily Delta outflow at least 32,400 cfs	Move larvae to Suisun Bay nursery area and keep null zone at Honker Bay or down-stream
July 1--July 31 (all years)	Chipps Island	Daily Delta outflow at least 29,100 cfs	Move larvae to Suisun Bay nursery area and keep null zone at Honker Bay or down-stream
April 1--July 31 (all years)	Vernalis	San Joaquin River component of Delta outflow equal to or greater than proportion under unimpaired flow	Maintain positive down-stream flow in all Delta channels

- Problem 1: Adult Striped Bass Spawning is Affected by Limitations on the Spawning Area.

  DFG has testified that the formation of a salinity barrier in the mainstem San Joaquin River above Venice Island tends to restrict spawning runs and spawning activity in that area (T,XLI,68:1-69:10). DFG also testified, and other evidence shows, that historically striped bass did spawn above the Delta in the San Joaquin River system. Striped bass are not able, under Delta Plan standards, to fully use the historical spawning habitat.

  Current Delta Plan standards provide for a maximum of 0.550 mmhos/cm EC at Prisoners Point, on the San Joaquin River from April 1 to May 5. DFG data (DFG,25,44-46) (shows that striped bass will not migrate through the eastern Delta into areas where EC is greater than 0.55 mmhos/cm. In addition, the majority of striped bass spawn in water with EC less than 0.3 mmhos/cm. Thus, the Delta Plan standard effectively blocks upstream migration of striped bass in the San Joaquin River beyond Prisoners Point in drier years, and may have an impact on spawning as well. The short period of time (35 days) which is covered by the Delta Plan standards may also be inadequate to provide full use of the San Joaquin River migration and spawning habitat.

  There are two aspects to the solution of this problem: Sufficient flows must be provided to break up this salinity barrier, and water quality in the San Joaquin River must be appropriate to promote migration and spawning upstream. Both can be accomplished by providing water of sufficient quality and quantity at Vernalis, provided that exports are not too large to prevent adequate flow down the mainstem San Joaquin River below Mossdale, and that the protection period is of sufficient length to utilize the habitat fully.

  None of the participants proposed any objectives to solve this problem, other than general proposals for greatly increased outflows for striped bass larvae. However, since San Joaquin River flows were not stipulated in these recommendations, it is assumed that this problem was not being specifically addressed.

  Based on evidence received, there appears to be no particular problem for adult striped bass, relative to habitat, in the Sacramento River, or to temperature regimes in either the Sacramento or San Joaquin rivers, since spawning tends to be initiated by increasing temperatures. The effects of warmer water in recent years is discussed below in relation to periods of time in which the objectives should apply.

  - Recommendation 1: Electrical conductivity in the mainstem San Joaquin River from Vernalis downstream to the Antioch Bridge should not exceed a daily maximum of 0.300 mmhos/cm from April 1 to June 15 in all water year types.

- Problem 2: Eggs and Larvae are Translocated into the Central Delta through the Delta Cross Channel and Georgiana Slough.

  Eggs and small larvae of striped bass are carried passively down the Sacramento River and are transported into the central Delta through the Delta Cross Channel and Georgiana Slough. Translocation to the central Delta exposes the eggs and larvae to increased mortality (DFG,25,54). The Delta area is less suitable as a nursery habitat than the Suisun Bay area. Screening is not effective for these small eggs and larvae.

  Existing Delta Plan standards call for closing of the Delta Cross Channel gates when the Delta outflow index (DOI) is above 12,000 cfs, but various conditions apply: DFG must request a closure, the potential closure period is only from April 16 through May 31, the maximum number of days available for closure within this period is 20, and no more than two out of four days may be consecutive. DFG has proposed expanding this standard to include closure when the DOI is less than 12,000 cfs, but for only a total of ten days in the period, and no more than one day out of four. Closure periods should be determined by real-time monitoring (DFG,64,7). The USFWS called for closure of the Delta Cross Channel gates and for modification of export operations "when densities [of eggs and larvae] are high" (USFWS,47,5). This recommendation is broader than the DFG recommendation, in that it appears to allow for more flexibility in the closure period to accommodate differences between years in striped bass spawning, but "high densities" is undefined. Neither recommendation provides optimal protection, however, since neither seeks to isolate Sacramento River eggs and larvae from the central Delta entirely.

  Georgiana Slough has no gates on it at present. Georgiana Slough intercepts little more than about 13 percent of the Sacramento River flow at Freeport (DAYFLOW documentation). Given the other recommendations proposed below to enhance downstream flows in the central Delta, no recommendation for protection of striped bass passing into Georgiana Slough appears to be warranted. However, losses through the Delta Cross Channel are larger, and protection can be provided with present facilities. In the absence of proven technology to provide real time monitoring, and because of the need to provide full protection, the following recommendation is made.

  - Recommendation 2: The Delta Cross Channel gates should remain closed for the period April 15 through July 31 in all water year types.

The above sets of recommendations are all inadequate to protect striped bass eggs and larvae fully because none provide flows sufficient to move all larvae out of the central Delta into Suisun Bay nursery areas in all year types. In addition, none call for curtailment of exports to reduce reverse flows and entrainment. On the other hand, the EDF, recommendation for 38,000 cfs seems excessive since DFG believes that 33,900 cfs will move 100 percent of the eggs and larvae past Collinsville. Since no recommendations for April flows were received, the DFG standard will be applied to April as well as May. April standards are needed because significant spawning occurs in the Delta in April, and these eggs and larvae also require protection.

The outflow recommendations proposed will still not assure positive downstream flows in all Delta channels. In particular, exports from the Delta by the SWP and CVP can induce reverse flows in Old and Middle rivers. Eggs and larvae in the central Delta can be drawn into these channels and entrained in the export facilities and agricultural diversions, or be carried to areas of the Delta which are unsuited for their survival. In addition, if, as a result of removal of the salinity barrier on the San Joaquin River, spawning returns to the area around and above Vernalis, eggs and larvae produced upstream will be pulled into Old River and entrained into the export facilities. These factors represent additional mortality for young striped bass.

Based on the above discussion, a series of recommendations to address these interrelated problems are proposed:

To prevent entrainment of striped bass eggs and larvae in municipal, industrial, and agricultural diversions and export facilities in the Delta:

- Recommendation 3-1: No withdrawals or exports of water from the statutory Delta for any purposes other than for emergency conditions should be permitted for the period April 1 through July 31 in any water year type.

To assure movement of striped bass eggs and larvae into the Suisun Bay nursery area and to keep the entrapment zone west of Collinsville:

- Recommendation 3-2: Daily Delta outflow should be no less than the following in all water year types:

April 1 through May 31------------33,900 cfs
June 1 through June 30------------32,400 cfs
July 1 through July 31------------29,100 cfs

- Problem 3: Striped Bass Eggs and Larvae in the Central Delta are Lost in Large Numbers.

  Considerable evidence has been presented by DFG and USBR, among others, to demonstrate that the central Delta is not an appropriate environment for survival of eggs and larvae of striped bass. The primary causes of these losses are entrainment in agricultural diversions, export facilities and M&I intakes. In addition, the reverse flows and longer residence times induced by the export pumps result in increased starvation of and predation on eggs and larvae. Flows are required to move the eggs and larvae down stream of Collinsville on the Sacramento River and into the Suisun Bay nursery area. Calculations developed by DFG (DFG,64,8) based on egg and larva sampling programs have determined that a Delta outflow of 33,900 cfs in May will move 100 percent of six mm striped bass larvae into the Estuary west of Collinsville. Equal protection in June would require 32,400 cfs, and in July (for seven mm fish, the smallest size class still present in that month) 29,100 cfs. The exhibit does not specify what export levels were present when the data to develop these calculations were collected. Nor does the exhibit present any indication of how the flow should be proportioned between the Sacramento and San Joaquin rivers. Despite evidence that spawning in the central Delta and the San Joaquin River occurs in April (DFG,64,9), no flow requirements or recommendations were presented for the month of April.

  USFWS recommendations (USFWS,47,5) basically support those of DFG, but also recommend that Delta outflow be not less than 10,000 cfs during the May through July period, and that reverse flows be eliminated in the lower San Joaquin River at Jersey Point. No recommendations for Delta outflow in April, for required flows in the San Joaquin River, or for elimination of reverse flows in Old and Middle rivers were presented.

  As discussed above (see section 5.3.5.2), EDF proposed Delta outflows based on the DFG data but weighted for the abundance of larvae in different months (more larvae present in May, fewer in July). EDF Exhibit 25 calls for flows of 38,000 for the period May 6 through May 31 in wet years, decreasing to 21,000 cfs in critical years. Lesser flows are proposed for the months of June and July. As with DFG and USFWS, no flow is apportioned to the San Joaquin River.

To assure that positive downstream flows are maintained in all Delta channels and to move eggs and larvae downstream from the San Joaquin River system:

- Recommendation 3-3: The contribution of the San Joaquin River to the total Delta outflow should be at least equal to that proportion of flow which would be present under unimpaired flow conditions.

- Problem 4: Disruptions of the Striped Bass Food Chain have occurred

  Striped bass may be starving because of loss of food from the central Delta. DFG presented evidence to indicate that zooplankton are becoming depleted, or the species composition of zooplankton has changed in the central Delta. This may have detrimental effects on striped bass when they first begin feeding (DFG,25,95-102).

- Recommendation 4: The above recommendations to maintain downstream flows in all Delta channels and to move the larvae rapidly into the Suisun Bay nursery area, where food of the appropriate species composition is available and more plentiful, should provide appropriate resolution of this problem. Should the other recommendations not be fully implemented such that the zooplankton food problem needs to be addressed, separate recommendations will be developed at that time. However, for the present, no recommendation for the protection of striped bass food supply is made.

- Problem 5: Pollutant Burdens

  Adult striped bass are burdened with a variety of pollutants which may affect their survival and reproductive potential. DFG and other participants have introduced evidence to indicate that adult striped bass are burdened with various organic and inorganic pollutants, which may affect their survival and their ability to reproduce, particularly through resorption of eggs in the ovaries. In addition, certain of these contaminants may pose a health risk to humans if striped bass are consumed too often. DFG fishing regulations include a precaution against consumption of too much striped bass because of mercury levels in their flesh.

- Recommendation 5:

  This subject is not directly relevant to Water Quality Control Plan standards. Actions proposed in the Pollutant Policy Document may have beneficial effects for striped bass. Other related recommendations are discussed in Chapter 8.

- Problem 6: Attraction to Effluents

  Evidence presented by DFG indicates that some striped bass may be attracted to certain components of industrial effluent streams and suffer deterioration and starvation. Laboratory tests indicate that the fish are attracted even when these chemicals are extremely diluted. The fish tend to remain in the effluent streams even though little or no food is available, and they undergo fin rot.

- Recommendation 6: Additional study of this phenomenon is warranted (see Chapter 8). Actions proposed in the Pollutant Policy Document may also have beneficial effects for striped bass.

- Other Problems and Considerations

  The above recommendations represent those levels of flow, salinity, and operational constraints which will, in theory, provide optimal protection for the striped bass beneficial use. Certain aspects of the problem of the decline of striped bass, such as pollutants, the Suisun Bay spring die-off, and effects of upstream diversions on survival of eggs and larvae, are beyond the scope of this Plan, in that they are not directly related to flow and salinity considerations in the Estuary.

- Hatcheries

  Certain other corrective or mitigative measures, such as hatcheries or grow-out facilities for fish salvaged at the export pumps, may be capable of providing some protection for striped bass. The question of hatchery production should not be considered at this time. Although there has been some recent success in producing striped bass in the hatchery, the fate of those fish in the Estuary (and ocean) and their recruitment to the fishery have not yet been determined. In addition, and most critically,even if some hatchery fish are recruited to the fishery and produce viable eggs and larvae, the purpose of that recruitment is lost if those eggs and larvae are subsequently lost to the fishery because of the various problems discussed above. Likewise, the question of other facilities cannot be addressed at this time, since no specific facilities have been proposed.

- Relationship of Recommended Outflows to Unimpaired Delta Outflow

  The Delta outflow recommendations proposed in Recommendation 5 above are as follows: 33,900 for April 1 through May 31; 32,400 for June 1 through June 30; and 29,100 for July 1 through July 31 in all years. Based on data developed for SWRCB exhibits, for unimpaired flow at Chipps Island for the years 1922-1978, the objective will be met with unimpaired flows as shown below:

Year Type	April	May	June	July
Wet	A	A	A	S
Above Normal	A	A	M	N
Below Normal	A	A	S	N
Dry	M	N	N	N
Critical	S	N	N	N

A = recommended flow level met in all years
M = recommended flow level met on average; met in most years
S = recommended flow level met in some years; not met on average
N = recommended flow level not met in any year

5.3.6 American Shad--Protection of Beneficial Uses

5.3.6.1 No Action Alternative

Under the Delta Plan there are essentially no standards to protect American shad. While the impacts of the Delta Plan on shad could not be quantified, it noted that the recommended plan for striped bass protection was expected to provide shad protection as well in wet, above normal, and dry water years, with a "definite lessening of protection" in critical years (Plan,V-39,VI-9).

The only specific standards for shad proposed in the Delta Plan (Table VI-1, pg.VI-35) concerned operation of the CVP's Tracy Fish Protective Facility. Certain secondary velocities and bypass ratios are required "to the extent possible" between June 1 and August 31 to increase screening efficiency for shad and other species. However, these standards are to be met "to the extent that they are compatible with export rates." Thus, shad protection is incidental to the operation of the CVP export pumps. There are no standards addressing shad for the SWP pumps.

5.3.6.2 Advocate Recommended Levels of Protection:

- WACOC

  WACOC recommended continuing the current practice of relating flow requirements for the protection of fish and wildlife to the variation of each year's runoff and storage conditions. Specifically, flow requirements "should be relaxed proportionately in the drier years to meet the reasonable beneficial needs of people, while maintaining reasonable minimum water quality standards for fish and wildlife" (WACOC,4,8).

- BISF/SCLDF

  BISF and SCLDF discussed three "perturbations" and resulting adverse effects on shad (BISF-SCLDF, Brief,57-58). These perturbations were: reduced river flow, reduced food supply for young fish, and losses of fish entrained in water diversions. General statements on corrective measures were presented, but no specific objectives were proposed.

- DFG

  DFG discussed the present level of knowledge about shad (DFG,23). They made no specific recommendations for protection of shad (DFG,64,12) because they believe the recommendations for protection of striped bass will provide benefits to American shad as well (see discussion of striped bass recommendations in Section 5.3.5.3).

- USFWS

  USFWS proposed an overall goal of increasing young-of-the-year (YOY) production of shad. Two main mechanisms ("objectives") were proposed to accomplish this goal. The first is to increase Delta inflow from April to June according to striped bass and salmon flow needs. Though unstated, USFWS appears to support DFG's basic determination that recommended flows for salmon and striped bass will benefit shad as well. The second objective is to reduce fish translocations from the Sacramento River into the central Delta during July to September. This reduction would make the larvae less susceptible to entrainment in all Delta water diversion facilities, and specifically would reduce entrainment at CVP and SWP facilities. A variety of implementation measures are proposed (USFWS,47,6).

5.3.6.3 Optimal Levels of Protection:

The testimony and exhibits indicate that current standards do not fully protect American shad. Evidence for this conclusion comes from several areas:

- The abundance of adult shad appears to have declined from levels early in this century, and more specifically from about 1945 on, although specific population measurements from those years are not available (DFG,23,1;DFG,23,16;T,XXXIX,13:15-17).

- The range of spawning runs has declined, particularly in the San Joaquin River system, where runs in both the mainstem San Joaquin and its tributaries used to occur (DFG,23,2; T,XXXIX,14:5-11;31:5-11;47:7-25).

- Up to 4.4 million shad have been salvaged annually at the CVP and SWP export pumps, and about half of those salvaged do not survive; many more larvae and small fish are entrained and lost (DFG,23,20-22;T,XXXIX,17:4-18:4).

- Evidence was presented to indicate that a variety of factors may be involved in the current limited protection for shad. Each factor will be discussed in turn, followed by recommendations for optimal protection. The recommendations for optimal levels of protection are summarized in Table 5.3.6.3-1.

- Problem 1: Effects of Decreased River Flows on Spawning Runs.

  Decreased flows in the Sacramento and San Joaquin rivers and their tributary streams have reduced spawning runs or have limited the dispersion of adult shad into tributary streams (DFG,24,4;DFG,23;T,XXXIX,14:12-22;16:14-18;31:5-9; 33:12-34:14). According to DFG testimony, actual inflow to the Delta in the spring was 32 to 66 percent less than would have been available under unimpaired inflows for the years 1978-1982 (DFG,23,24). USFWS (USFWS,47,6) has recommended that Delta inflow should be increased in the April-June period according to levels demonstrated by DFG to have positive effects on shad YOY production. DFG's data (DFG,23,19) are shown in Figure 4.5.1.4-1. This relationship appears to have a decided break near the 20,000 cfs level; above this level of Delta inflow the relationship between YOY shad abundance and inflow does not appear to be statistically significant. However, since spawning continues into early July, the period of protection should extend beyond that recommended by USFWS (T,XXXIX,14:23-24).

- Recommendation 1

  Total daily Delta inflow in all year types should be a minimum of 20,000 cfs from April 15 to July 15. The contribution of the San Joaquin River to total Delta inflow should be at least equal to that proportion of flow which would be present under unimpaired flow conditions.

- Problem 2--Effects of Flow on Larval and YOY Shad.

  Variations in flows in the Sacramento and San Joaquin rivers and their tributaries may affect the distribution and outmigration of larval and YOY American shad (DFG,23,10; T,XXXIX,16:4-11;16:23-17:3). Lower flows may concentrate the larvae in limited areas, resulting in depletion of the food supply. Lower flows also lengthen the time required for larvae to get to suitable nursery habitat (DFG,23,23). Appropriate flows are required to disperse and transport the eggs, larvae and YOY down the tributary streams and through the Delta. Some young shad do not migrate through the Delta immediately but remain in summer nursery areas in the Sacramento and Feather rivers and the southern Delta. These shad begin their outmigration through the Delta later in the

TABLE 5.3.6.3-1
OPTIMAL LEVEL OF PROTECTION FOR
AMERICAN SHAD

Time	Location	Recommendation	Protection
April 15--July 15 (all years)	Delta	Minimum daily total Delta inflow cfs. San Joaquin R. component at least equal to proportion of total inflow present under unimpaired flow	Adult shad migration and spawning habitat
May 1--November 30	Delta	Same as Above	Egg and larval outmigration, nursery habitat, zooplankton
May 1--November 30 (all years)	Delta Cross Channel Gates	Closed	Reduce trans-location of eggs and larvae
May 1--November 30 (all years)	Statutory Delta Channels & SWP, CVP, CCC	No withdrawals or exports (except for emergencies)	Reduce egg, larval and YOY entrainment

year and continue to do so at least through November (DFG,23,10-11). Flows are required to facilitate this late outmigration as well as the spring and early summer outmigration (May to July). In order to restore runs in the San Joaquin River and its tributaries, total Delta inflow should be divided between the Sacramento River and the San Joaquin River in proportion to what would be present under unimpaired flow conditions.

- Recommendation 2

  Total daily Delta inflow in all water year types should not be less than 20,000 cfs from May 1 to November 30. The contribution of the San Joaquin River to total Delta inflow should be at least equal to that proportion of flow which would be present under unimpaired flow conditions.

- Problem 3--Losses of Larval and YOY Shad to Diversions and Exports.

  Shad larvae and YOY are subject to mortality from diversions and export facilities in the Delta. Shad originating in the Sacramento River system may be translocated into the central Delta, resulting in entrainment in local agricultural diversions (DFG,23,20;DFG,23,25) which are for the most part unscreened (T,XXXIX,17:9-10). These shad, plus those originating in the Delta or the San Joaquin River system, are also subject to entrainment at the CVP and SWP pumps (DFG,23,8-11;DFG,23,20-21). Although the export facilities have screens, they are ineffective for eggs and small larvae, and larger fish are subject to as much as 50 percent handling mortality because of their fragility (DFG,23,20-22;T,XXXIX,17:11-18:4).

  Based on these findings, a series of recommendations is presented as follows:

  To reduce translocation of shad eggs, larvae and YOY into the central Delta:

- Recommendation 3-1

  The Delta Cross Channel gates should be closed from May 1 to November 30 in all water year types.

  To reduce entrainment of shad eggs, larvae and YOY into municipal, industrial and agricultural diversions in the Delta and into the export pumps.

- Recommendation 3-2

  No withdrawals or exports of water from the statutory Delta for any purpose other than emergencies should be permitted from May 1 to November 30 in all water year types.

- Problem 4--Disruption of Larval Shad Food Chain.

  Abundance of larval shad may be reduced because zooplankton on which they feed are reduced. This reduction in zooplankton abundance may result from direct entrainment in water diversion facilities, or from high net flows in Delta channels, due to export pumping, which provide a less stable environment for zooplankton, (T,XXXIX,18:6-18). The combination of the proposed recommendations and those proposed for protection of other beneficial uses in the Delta and Suisun Bay should provide adequate protection for the shad food chain. Should the proposed measures be determined to not provide adequate protection, separate recommendations specific to zooplankton will be addressed at that time. However, for the present, no recommendation for the protection of the American shad food chain is proposed.

- Problem 5--Loss Measurement and Mitigation.

  At present, American shad losses at the SWP export pumps are not covered under the Two-Agency Fish Mitigation Agreement, and there is no agreement for mitigation of losses at the CVP pumps (T,XXXIX,32:24-33:9). In addition, no evaluations of screening efficiency for American shad have been made (DFG,23,20). These factors will be discussed further in Chapter 8.

  When combined, recommendations 1 and 2 above require daily total Delta inflow to be at least 20,000 cfs from April 15 to November 30 in all year types, with proportions of San Joaquin River flow the same as would be present under unimpaired flow conditions. The approximate amount of San Joaquin River flow required in the April-November period in different year types, and the probability of meeting those flows under unimpaired flow conditions, are summarized in Tables 5.3.6.3-2--5.3.6.3-4.

  Table 5.3.6.3-2 is derived from data used to prepare SWRCB Exhibit 110, and it indicates the average percent of total inflow in the Delta which would originate from the San Joaquin River under unimpaired flow conditions. Table 5.3.6.3-3 converts the percentages to recommended flow values by multiplying each percentage by 20,000 cfs, the recommended level of total Delta inflow. Table 5.3.6.3-4 indicates the unipaired flow at Vernalis (based on model results used in SWRCB Exhibit 110) and indicates the probability of meeting the recommended level of San Joaquin River inflow.

TABLE 5.3.6.3-2 SAN JOAQUIN RIVER - PERCENT OF TOTAL DELTA INFLOW
(UNIMPAIRED FLOW CONDITIONS; 1922 - 1978)

YEAR TYPE	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	# OF YEARS
WET	20	34	45	43	24	12	6	8	15
AB NRML	24	38	46	39	18	8	9	11	12
BL NRML	21	32	39	26	10	8	8	10	14
DRY	22	38	36	21	9	6	7	13	6
CRITICAL	27	35	29	13	7	7	10	9	10

TABLE 5.3.6.3-3 FLOW REQUIRED AT VERNALIS (IN CFS) TO MEET RECOMMENDED
PERCENT OF 20,000 CFS TOTAL DELTA INFLOW

YEAR TYPE	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV
WET	4084	6824	8936	8657	4773	2468	1194	1606
AB NRML	4769	7511	9174	7710	3562	1578	1800	2181
BL NRML	4220	6418	7724	5280	2031	1582	1582	2026
DRY	4500	7506	7249	4112	1727	1260	1420	2523
CRITICAL	5356	6975	5825	2540	1400	1432	1920	1869

TABLE 5.3.6.3-4 ESTIMATED UNIMPAIRED FLOW AT VERNALIS (IN CFS) AND PROBABILITY
OF MEETING RECOMMENDED FLOW UNDER UNIMPAIRED CONDITIONS

YEAR TYPE	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV
WET	21012	37369	33876	12847	3014	1249	509	1818
	A	A	A	A	S	N	N	N
AB NRML	18861	28015	20695	6604	1515	568	831	1928
	A	A	A	S	N	N	S	S
BL NRML	12889	19490	15059	3861	815	356	752	3134
	A	A	M	S	N	N	S	M
DRY	10499	16214	9373	1992	556	449	607	2828
	A	A	M	N	N	N	N	M
CRITICAL	8823	9773	4676	966	465	537	963	1021
	M	M	S	N	N	S	S	S

=========
A = MET IN ALL YEARS
M = MET ON AVERAGE; MET IN MOST YEARS
S = MET IN SOME YEARS; NOT MET ON AVERAGE
N= NOT MET IN ANY YEAR

5.3.7 Suisun Marsh Wildlife Habitat Beneficial Use Alternative

5.3.7.1 No Action Alternative

Absent any other action by the Board, operators of the SWP (DWR) and the CVP (USBR) will continue to be bound to meet the wildlife protection terms of the Delta Plan. These terms include measures to meet or exceed certain standards for water quality in the channels of the Delta and Suisun Marsh (SWRCB,1978,22). The terms for protection of wildlife were unchanged by the 1985 amendments, except for some changes in monitoring locations, and time for implementation. The original terms required permittees DWR and USBR, in cooperation with other agencies, to develop by July 1, 1979, a plan for protection of the Suisun Marsh (Marsh Plan). This Marsh Plan together with EIR/EIS documentation, was to provide a monitoring network, construction of physical facilities, operation and management procedures for the facilities and assurances by land managers to maintain the Marsh as a brackish water wetland (SWRCB,1978,26). The permittees were required to manage the Marsh to produce high quality feed and habitat for waterfowl and other wildlife and to implement the Marsh Plan for full protection of the Marsh by October 1, 1984 (SWRCB,1978,26-27). Subsequent extensions of time and modifications to monitoring locations were granted by the Board (DWR,505).

In the event the Board takes no action, the terms of the Delta Plan, as extended in 1985, remain in effect. These terms provide interim partial protection to Suisun Marsh wildlife in the managed wetland area as well as in part of the natural tidal brackish water marsh area (SWRCB,14,VII-4). Approximately 40 percent of the 10,000 acres of unmanaged tidal brackish marshes around Suisun Bay were originally protected by the Delta Plan BCDC,5,12;BAAC,4;USFWS,17; 18;19;20).

5.3.7.2 Advocated Levels of Protection

- DWR, USBR, DFG, SRCD--Four Party Agreement

  At the Phase I of the hearing that addressing wildlife, DWR provided testimony and exhibits describing the measures agreed upon by DWR, USBR, DFG and SRCD (hereafter referred to as Four Parties) to meet the the Delta Plan requirements (DWR,503; 504; 506A; 506B; 507A; 507B; 508A; 508B; 509; 510; 511; 512; 513; 514; 517 A-B; 518; 519; 520 & 521). The measures included a Suisun Marsh Preservation Agreement, a Mitigation Agreement, a Monitoring Agreement, and a Plan of Protection for the Suisun Marsh.

  There are differences between standards set in the Delta Plan and its extension (used herein as the No Action Alternative) and those agreed upon by the Four Parties. Principal differences are the addition of a dry year modification of water quality standards in the Suisun Marsh, changes in the Chipps Island EC standard and a lower minimum mean monthly Delta Outflow Index (DWR,506(B),5). The monitoring requirements in the Delta Plan for the Suisun Marsh (Terms 4 and 5) are silent on rare, threatened, or endangered species, although by inference the plan of protection (Marsh Plan) required in Order term 7(a) is intended to ensure protection of all Marsh wildlife. The monitoring agreement developed by the permittees calls for census and surveys of only the salt marsh harvest mouse, and these would only be done if changes in the general plant community are found (DWR,508 B,3). There are no provisions for monitoring other threatened or endangered plants or animals. The Board has not yet found that the plan of protection, which was required under the Delta Plan and prepared by DWR, DFG and USBR (DWR,511) is fully consistent with Term 7(a) of the Delta Plan. According to testimony, the Four Parties have an agreement to implement the plan of protection they have developed (T,XXIX,27,7-23), including the monitoring. The agreement binds the parties to petition the Board to find that the actions are appropriate to protect the Marsh and to substitute the proposed standards for Delta Plan standards (DWR 506A,14,15). There is nothing in the agreement which requires it to be approved by the Board. Thus, in the event of no action by the Board, the parties to the agreement would be obligated to continue to operate their projects under the D-1485 amended standards. These call for standards to be met at some locations on October 1, 1988; in the northwestern Suisun Marsh on October 1, 1991; in the southwestern Marsh on October 1, 1993; and in Suisun Slough at Volanti Slough and at Chipps Island and Van Sickle Island waterfowl management area water supply intakes on October 1, 1997 (DWR,505,1-2).

- BCDC

Experts testifying on behalf of BCDC proposed that the Board revoke its decision of December 5, 1985 amending the standards compliance schedule in the Delta Plan and changing the locations (BCDC,5,31;T,XXIX,238:22-25). The BCDC testimony also proposed an additional standard to protect tidal marshes adjacent to Suisun Bay (BCDC,5, T4;T,XXIX,239:25-240:2). It is BCDC's position that the Board's 1985 amendments to the Delta Plan reduced protection for unmanaged tidal marshes as well as delaying the implementation of measures to protect water quality and beneficial uses in the managed wetlands of the Suisun Marsh (BCDC,5,5).

- BAAC

BAAC recommended a flow and salinity standard which provides greater protection for brackish water tidal marshes than does the Delta Plan (T,XXX,52:6-22). In addition, recommended salinity standards for water quality in tidal marshes (levels not specified) be set for summer rather than ending in May (T,XXX,54:10-21). The position of BAAC was that the brackish water marshes have already been degraded and they would like to see them improved and restored more toward their natural condition, which would require more stringent salinity standards (T,XXX,94:20-95:2). The BAAC testimony did not explicitly state what those freshwater flows or what salinity standards should be to adequately approach natural conditions.

- PRBO

PRBO advocated freshwater outflow through the Golden Gate as a means to provide a food supply to seabirds ten to 15 miles away in the Farallones National Marine Life Refuge (T,LIV,140:6-143:8). The San Francisco Bay plume of freshwater is an important foraging area in April and May (T,LIV,145:10-12,21-24). The salinity differential and nutrient input produce a concentration of food organisms for seabirds (T,LIV,150:17-23). Birds use the plume for feeding when the normal marine food web closer to the Farallon Islands fails to develop (T,LIV,154:21-23). According to PRBO testimony, during El Nino events, when upwelling of deep-coastal water is less than normal, marine food chains are less productive and seabirds are more dependent on the San Francisco Bay plume (T,LIV,155:10-14). El Nino events are possible during dry years (T,LIV,155:4-6). The PRBO position is that if the plume is less extensive or less frequently close to the Farallones during the breeding season, seabirds which feed there will decline in abundance (T,LIV,160:24-161:1). During cross-examination,it became clear that the linkage between bird populations and the size of the plume is not completely predictable, as populations have increased during some El Nino periods when there was little outflow, such as 1977 (T,LIV,164:8-23). In other years, El Nino events coincided with extraordinarily wet years (T,LIV,154:19-155:1). The plume is a primary foraging area from February through May, while birds resort to the plume if it is present and if upwellings fail during June and July (T,LIV,161:22-24; T,LIV,162:20-22). No testimony or evidence was provided to indicate how often El Nino years would coincide with low outflow under unimpaired conditions.

5.3.7.3 Optimal Level of Protection

Considerations which were not addressed in detail in prior hearings on the Bay-Delta Estuary include the beneficial uses of water by threatened and endangered species. Protection for these species is required by both the state and federal Endangered Species Acts. The Delta Plan did not weigh the obligation of non-project diverters to protect water quality for endangered species or other public trust beneficial uses. The Board has the authority, as the public trustee of water quality for fish and wildlife, to condition all water uses to reasonably protect fish and wildlife including threatened and endangered species.

The salinity of water provided to tidal wetlands of the Suisun Marsh influences the survival and reproduction of marsh plants. For example, the California Native Plant Society (CNPS) exhibit (CNPS,3) and testimony (T,XXX,66:11-25;T,XXX,67:2-13;T,XXX,76:15-23) identified five rare, threatened or endangered plant species, four of which would be less likely to survive, have reduced growth or seed production, or become less numerous because of changes in flow or salinity in the Suisun Marsh portion of the Bay-Delta. Some 50 additional species would be indirectly affected, becoming less abundant or widespread as a result of land use changes induced by newly available water supplies (T,XXX,110:25-111:23). The directly affected rare plant species occur in the tidal marshes. The CNPS testimony indicates that even during normal years, freshwater flow to the Suisun Marsh has been insufficient to prevent reductions in productivity (T,XXX,,79:18-20).

With rare species, once a population is eliminated, it is very unlikely to reinvade because of the scarcity of seed sources. Thus, although common species such as alkali bulrush may be adequately protected or or able to recover from higher salinity exposure during a critical dry year, rare species would be at risk (T,XXX,81:22-24). A salinity standard capable of preventing reductions in numbers and range of threatened or endangered species might therefore require a smaller dry year adjustment of the salinity standard. It would have to be set at a level at which the species were capable of sustaining normal survival, productivity and germination. The Suisun Marsh Preservation Agreement, proposed by the Four Parties, does not adequately address these needs in its proposed standards. It is therefore recommended that the Board retain jurisdiction to require additional protection for sensitive special status species rather than fully endorse the Agreement.

Suitable pore water salinity for five sensitive plants ranges from zero to minus two megapascals (comparable to a range of zero to four parts per thousand (ppt) salinity, or electrical conductivity of zero to 6.25 mmhos/cm) for freshwater plants in the Delta (California hibiscus, Delta tule pea) to minus two to minus three megapascals in Suisun Marsh (four ppt to six ppt, 6.25 to 9.36 mmhos/cm) for Mason's lilaeopsis and Suisun aster, which tolerate somewhat brackish conditions (T,XXX,76:5-23). On the other hand, salt marsh bird's beak which grows in saline areas could tolerate minus four to minus five megapascals (eight ppt to ten ppt, 12.5 to 15.6 mmhos/cm). These pore water potentials should not occur until after the growing season, which extends from March to July (T,XXX,79:12-14).

The DFG has proposed a method to produce certain salinities in the root zones of managed wetlands based on surface water quality and timing of applied water (DFG,5,T3). To protect the unmanaged vegetation along the channels of the adjacent tidal marsh, comparable application timing and water quality to that DFG proposed for managed wetlands may be needed. If this standard were set, it would require studies relating pore water salinities in the root zones of rare plants to flow and salinity in channels adjacent to those plants. There is little information in the exhibits or testimony which addresses the relationship between the salinity of applied water and the pore water salinity outside of managed wetlands. If studies showed pore water salinity remained suitable for sensitive plant species even when channel salinities reached high values, relatively little Delta outflow would be required. Conversely, if studies showed pore water salinities were at levels which cause stress or reduced productivity of threatened or endangered plants, improved water quality in adjacent channels would be needed to prevent a significant impact.

Water quality in Suisun Marsh tidal channels for protection of rare and threatened plant species should therefore conform to the dates and salinity levels specified in DFG's Table 3 (DFG,5,T3). Further, applied water salinity should remain at or below seven ppt (approximately 10.9 mmhos) through July to fully protect threatened and endangered plant species (T,XXX,79:12-14). The optimal objective for tidal channels within Suisun Marsh is set forth in Table 5.3.7.3-1. The optimal objective for tidal wetlands adjacent to Suisun Bay, but outside the Suisun Marsh is set forth in Table 5.3.7.3-2. It should be noticed that the likely soil water salinity based on DFG's Table 3 would be at nine ppt in March, April, and May, corresponding to the minus four to minus five megapascals tolerated by salt marsh bird's beak, but unsuitable for Mason's lilaeopsis and Suisun aster. The existing distribution of rare, threatened and endangered species is thought to reflect the availability of water meeting the optimal objectives in tidal marshes during recent years. These objectives specifically for plants in the Suisun Marsh, as set forth in Table 5.3.7.3-3, should be continued while the relationship between applied water quality and soil water salinity in the rare plant root zone along tidal channels is determined. Provision of water meeting these objectives to managed wetlands only would not guarantee protection threatened and endangered species on tidal channel wetlands.

TABLE 5.3.7.3-1

OPTIMAL LEVEL OF PROTECTION FOR WILDLIFE
(Including Rare, Threatened and Endangered)
USE IN SUISUN MARSH TIDAL CHANNEL WETLANDS

Time	Location Station, Name	Level of Protection (Section Proposed)	Species Protected
October-July	C2, Montezuma Slough at Collinsville	TABLE 5.3.7.3-3 soil water salinity no more than 9 parts per thousand (PPT) TDS	Suisun aster(SA), Mason's Lilaeopsis (ML)
"	D7A, Grizzly Bay	during growing season, met by providing a schedule of lowering salinity in channels	salt marsh harvest mouse (SMHM), California clapper rail (CR)
"	D10, Chipps Island	prior to growing season by maintaining 7 PPT TDS	CR, Delta tule pea (TP)
	S10, Suisun Slough at Boynton	in channels through July of all year types. (Footnote 1)	CR, SA, slough thistle (ST)
"	S17, Cordelia Slough at Ibis		TP
"	S31, Suisun Slough at mouth		CR, SMHM
"	S94, Suisun Slough at Hunter's Cut		SA, TP
"	S42, Suisun Slough at Volanti Slough		CR, SMHM, ML
"	S48, Montezuma Slough at Cutoff Slough		TP, SMHM, soft bird's beak (SBB)
"	S63, Denverton Slough		SBB
"	S93, Hill Slough		CR, SMHM, SA, ML

Footnote 1: Objectives based on DFG,5,T3.

TABLE 5.3.7.3-2

OPTIMAL LEVEL OF PROTECTION FOR WILDLIFE
(Including Rare, Threatened and Endangered)
USE IN SUISUN BAY TIDAL CHANNEL WETLANDS
OUTSIDE SUISUN MARSH

Time	Location Station, Name	Level of Protection (Section Proposed)	Species Protected
Oct-May All Years	8, Point Edith	Same as original D-1485, Table II	black rail (BR), salt marsh harvest mouse (SMHM), least tern (LT)
"	D8b, Middle Point, Suisun	"	BR, SMHM, LT, California clapper rail (CR)
"	9, Port Chicago	"	SMHM, CR
"	D9a, Spoonbill Cut	"	CR, SMHM
"	D11a, Sherman Lake	"	Mason's Lilaeopsis (ML)
"	12, Brown's Is.	"	CR, ML, Suisun aster (SA) Delta tule pea (TP)
"	13, Antioch	"	SA, SMHM, ML
"	21, Point Sacramento	"	ML
"	f57, Suisun Bay at Roe Is.	"	CR
"	f59, Suisun Bay at Seal Island	"	CR

TABLE 5.3.7.3-3

OPTIMAL OBJECTIVES FOR SALINITY OF WATER IN SUISUN MARSH TIDAL CHANNELS TO MAINTAIN SENSITIVE PLANT SPECIES*

Month	Applied Water Salinity EC (mmho/cm)	Applied Water Salinity TDS (p/thous)		Pore Water Salinity EC (mmho/cm)	Pore Water Salinity TDS (p/thous)	Ratio, Pore Water Salinity to Applied Water Salinity
October	18.8	12	footnote 1	50.0	32	2:1
November	15.6	10	footnote 2	37.5	24	2:1
December	15.6	10		31.2	20	2:1
January	12.5	8		25.0	16	2:1
February	7.8	5		15.6	10	2:1
March	7.8	5		14.1	9	1.8:1
April	10.9	7		14.1	9	1.3:1
May	10.9	7		14.1	9	1.3:1
June	10.9	7	footnote 3	14.1	9	1.3:1
July	10.9	7		14.1	9	1.3:1

1/ The salinity of water applied in October (12 ppt) dissolves surface salts and is increased by 4 ppt (to 16 ppt), hence the 32 ppt TDS in the soil, which has a 2 to 1 ratio to applied water salinity (DFG,5,T3).

2/ The salinity of water applied in November is increased by 2 ppt TDS (to 12 ppt) due to residual surface salts, hence the 24 ppt TDS in soil (DFG,5,T3)

3/ The salinity of applied water and soil water in June and July is assumed to continue unchanged from May.

* Table adapted from DFG,5,22.

5.3.8 Other (i.e., Navigation/Recreation)

Other beneficial uses of the Estuary affected by flow and salinity are commercial navigation, and contact and non-contact-water recreation. Uses that are part of non-contact-water recreation include esthetic appreciation and educational and scientific study (RWQCB 5,1975,5B,I-2-2).

5.3.8.1 No Action Alternative

Under a no action situation, flow and water quality standards established by the Delta Plan would be continued and navigation uses and other beneficial uses would continue to receive the same level of protection they now have.

No explicit standards for the protection of the beneficial uses of navigation or recreation were addressed in the Delta Plan. Because both are among the uses generally considered to fall within the public trust purview, the Board must provide for the protection of these uses, even if no participant addressed the needs during Phase I of the hearing.

Because the existing water quality and fish populations are in large measure attributable to the standards set by the Delta Plan, a no action alternative would provide for continuation of current recreation, navigation and esthetic appreciation beneficial uses.

5.3.8.2 Advocated Levels of Protection

- PICYA/EBPRD

The PICYA prepared and submitted an exhibit regarding beneficial uses relating to recreational navigation, but their exhibit was never made part of the hearing record. The essence of the PICYA submittals was that swimmable, fishable waters which supported existing populations and runs of fish were an important part of their recreational boating experience (PICYA,1,3). In addition, the PICYA document proposed improvements for boat passage at the Delta Cross Channel, protection of existing unleveed Delta islands and maintenance of through navigation (PICYA,4).

EBRPD submitted testimony and exhibits which showed that rapid growth (122 percent increase in two years) in water-oriented recreation was taking place within their jurisdiction (EBRPD,34,1). These two parties emphasized their interest in providing abundant supplies of uncontaminated fish to provide boaters and fishers with an opportunity to experience successful fishing (PICYA,1,3; EBRPD,34,3).

- SWC

  SWC presented testimony and exhibits which estimated the economic value of recreation at CVP and SWP reservoirs and proposed that flow reduction in the Delta would be of less economic harm than reduction in flows to reservoirs and canals in the export area (SWC,66,13). No explicit objectives for flow or salinity were proposed by SWC for the protection of recreational uses in the Bay-Delta. SWC argued instead that added diversions would have no effect on recreational fishing, and be to the state's economic advantage, because of higher recreational values in southern California (SWC,66,12).

- BISF

  BISF submitted exhibits and testimony regarding recreational uses of the San Francisco Bay area (BISF,38,T2;T,XXX,174:2-9), and identified the values of a variety of water-oriented recreational activities from the California State Parks and Recreation Department's PARIS model (BISF,38,T3). Cross-examination indicated that some of the recreational activities added into the tabulation were such that they were clearly poorly related to the flow and salinity in the Bay-Delta Estuary (T,XXX,199:17-,200:19). Although BISF did not propose flow and salinity objectives during the session on recreation, they did so in a later session (T,LVIII,236:18-240:18). It was not clear that their recommendations for flow and salinity at the later session were fully keyed to the recreational values earlier described.

- Commercial Navigation

  No advocate for commercial navigation presented any testimony on flow or water quality during Phase I of the hearing. A standard exists for protection of shallow draft commercial navigation; the requirement being 5,000 cfs year-round in the Sacramento River at Wilkins Slough near the Tisdale Weir. This standard reflects historical, rather than current uses.

5.3.8.3 Optimal Level of Protection

To protect navigation in the Bay-Delta Estuary, flows in the upper reaches of the system must be sufficient to maintain the draft in Delta channels (Table 5.3.8.3-1). Recent measures taken by DWR to control salinity in south Delta channels (DWR,349,3) and structural measures to control flows in the Suisun Marsh have been in potential conflict with navigation. Features such as boat locks have been included in some (e.g., Montezema Slough) but not all of these structures. The Montezuma Slough Control Structure includes a boat lock, but Roaring River Intake does not. If flow and salinity in the Estuary are to be controlled by structural facilities, the impacts on navigation will have to be considered, and the balance of public interest in flows, salinity and navigation addressed.

Based on a recent survey prepared for the California State Lands Commission (CSLC, May, 1986) of existing marina capacity in the general vicinity of Sacramento, 26 percent of moored boats were under 25 feet long, 65 percent were between 25 and 40 feet long, and 9 percent were over 40 feet long. This survey indicated that moored boats tended to be larger, as a class, than the entire class of boats registered in the area by the Department of Motor Vehicles. When considering total boat population, easily trailered boats (those under 21 feet long) made up about 87 percent of the total (CSLC,May,1986). The ability of Bay-Delta channels to serve recreation and navigation is partially related to the size and draft of the boats using the channels.

Boater activity data derived from DWR studies indicate about 59 percent of the boaters' time is spent fishing, 4 percent water skiing, 36 percent general pleasure boating, and less then 1 percent sailing or jet skiing (SRRS,1980). The season of use for boat fishing has a peak of 27.9 percent of year-round activity during April and 16.8 percent in May, and a lesser peak of 12.0 percent in October corresponding to striped bass (spring) and salmon (fall) runs. Water skiing, a year round activity, is concentrated during June, July and August, with about 85 percent of all such use occurring in these months. Cruising and general boating have nearly the same pattern. Reduced river flows and reduced channel width and depth during these seasons would affect navigation.

There is a relationship between river flow and the width of the channel, with the channel narrowing during low flow periods. During these lowered flows, there is less room to pass other boats and moored vessels, and traveling boats are required by federal law (33 USC Sec.1006) to slow down to avoid damaging vessels and docks with their wakes. The State has adopted the federal criteria (Title 14, California Administrative Code, Section 6615) and added specific speed constraints for vessels passing within 100 feet of swimmers or 200 feet of beaches, floats, lifelines or mooring areas (Harbors and Navigation Code, Section 655.2). At extreme low water in Sacramento (approximate elevation 4 feet), channel widths are as narrow as 300 feet at some locations, compared to widths of nearly 700 feet at extreme high water (elevation 29 feet). The result is that flow affects not only depths, which will conflict with navigation by larger boats, but if low flows or structures reduce the available channel width, below 200 feet in areas where people swim, boat speeds will be constrained as well.

The flow and water surface elevation needed to prevent adverse effects on navigation will differ in each channel. As a rule, to protect recreational boating beneficial use, channels must remain open to passage. Furthermore, the water in any channel must be sufficiently deep to permit passage by any boats which ordinarily use that channel. These effects must be considered on a case-by-case basis, rather than by adopting a uniform objective.

TABLE 5.3.8.3-1
OPTIMAL LEVEL OF PROTECTION FOR NAVIGATION USE

Time	Location	Level of Protection	Protected
All Year	Wilkins Slough near Tisdale Weir	5,000 cfs	Commercial shallow draft navigation
All Year	All Channels	Maintain open to navigation at existing speeds by recreational watercraft on a case-by-case basis.	Recreational boating
All Year	Channels affected by flow control or salinity control structures	Maintain existing channel widths where over 100 feet, and with no swimming use of bank side development. Maintain existing channel widths where over 200 feet and adjacent to beaches, floats, lifelines or mooring areas. Decision to be made on a case-by-case basis.	High speed boating water skiing

5.4 Summary

Table 5.4-1 was prepared to show the flows and water quality objectives needed in the Sacramento-San Joaquin Delta to provide optimal protection for beneficial uses such as municipal, industrial, agriculture, fish, wildlife, and wetland habitat.

Objectives for optimal protection of wetland habitat in the tidal channels of the Suisun Marsh appear in the form of electrical conductivity levels, which have been converted to approximate Delta outflows, based on a series of curves presented in DWR-57, Revised. For example, the electrical conductivity objective for February is 7.8 mmhos/cm which would be accomplised in Suisun Bay by a Delta outflow of about 17,000 cfs. Other flows and water quality objectives are introduced earlier in this chapter.

TABLE 5.4-1

OPTIMAL WATER QUALITY OBJECTIVES (Footnote 1) FOR M & I, AGRICULTURAL, WILDLIFE, SALMON AND DELTA FISHERY USES

Beneficial Use Protected and Location	Parameter	Description	Year Type	Dates	Values or Limit
MUNICIPAL					Cl-
Contra Costa Canal at Pumping Plant #1	Chloride	Maximum Mean Daily Chloride, mg/l	All	1/1-12/31	250
Clifton Court Forebay Intake at West Canal	"	"	"	"	"
Delta Mendota Canal at Tracy Pumping Plant	"	"	"	"	"
North Bay Aqueduct at Barker Slough	"	"	"	"	"
City of Vallejo Intake at Cache Sl.	"	"	"	"	"
INDUSTRIAL					
Contra Costa Canal Intake at Pumping Plant #1 -or- Antioch Water Works Intake on San Joaquin R.	Chloride	Maximum Mean Daily Chloride, mg/l	All	1/1-12/31	150
AGRICULTURE				Dates	EC
Western and Interior Delta Irrigation Sacramento R. at Emmaton	Electrical Conductivity	Maximum 14-Day Running Average Mean Daily EC, mmhos/cm	All	4/1 - 8/15	1.5
San Joaquin R. at Jersey Point		"	"	"	"
Mokelumne R. at Terminous		"	"	"	"
San Joaquin R. at San Andreas Ldg.		"	"	"	"
Cache Sl. at Junction Pt.		"	"	"	"
South Delta Irrigation San Joaquin R. near Vernalis	Electrical Conductivity	Maximum 14-Day Running Average Mean Daily EC, mmhos/cm	All "	4/1 - 8/31 9/1 - 3/31	0.7 1.0
San Joaquin R. at Mossdale		"	"	"	"
Bifurcation of Old and Middle rivers		"	"	"	"
Middle R. at Howard Rd. Bridge		"	"	"	"
Old R. at Tracy Rd. Bridge		"	"	"	"
San Joaquin R. at former site of Brandt Bridge		"	"	"	"
Delta Leaching (Ponding)					
Emmaton Jersey Point Cache Slough at Junction Point San Andreas Landing	Electrical Conductivity	Maximum monthly average of mean daily EC, mmho/cm	All	12/1-2/28	1.7

Footnote 1: Optimal levels of protection designed to protect beneficial uses without consideration of impact on other beneficial uses or water needs.

TABLE 5.4-1 cont'd.

OPTIMAL WATER QUALITY OBJECTIVES (Footnote 1)
FOR M & I, AGRICULTURAL, WILDLIFE, SALMON AND DELTA FISHERY USES

Beneficial Use Protected and Location	Parameter	Description	Year Type	Dates	Values or Limit				
FISH and WILDLIFE									
Suisun Marsh Wildlife Habitat Channels adjacent to brackish tidal wetlands	Electrical Conductivity, Delta Outflow (Footnote 2)	Staff estimate of salinity and flow (mmho/cm, cfs)needed to optimally protect tidal marsh habitat around Suisun Bay	All		EC	cfs			
				10/1-31	18.8	6000			
				11/1-12/31	15.6	8000			
				1/1-31	12.5	10000			
				2/1-3/31	7.8	17000			
				4/1-7/31	10.9	12500			
Delta Fisheries (Sacramento R.)									
Salmon Migration Rio Vista	Flow (Footnote 3)	Minimum daily flow (cfs)		9/1-12/31	1/1-31	2/1-3/15	3/16-31	7/1-31	8/1-31
			Wet	5,000	2,500	3,000	5,000	3,000	1,000
			Ab. Normal	2,500	2,500	2,000	3,000	2,000	1,000
			Bl. Normal	2,500	2,500	2,000	3,000	2,000	1,000
			Dry	1,500	1,500	1,000	2,000	1,000	1,000
			Critical	1,500	1,500	1,000	2,000	1,000	1,000
Salmon Smolt Outmigration Rio Vista	Flow	Minimum daily flow (cfs)	All	4/1-6/30 22,500					
Outmigrant Survival salmon, shad striped bass Delta Cross Channel	Flow Constraint	Cross Channel Gates Status of both gates	All	4/1-11/30 closed					
Salmon Fry Rearing Delta Cross Channel	Flow Constraint	Cross Channel Gates Status of both gates	Below Normal, Dry, Critical	1/1-3/31 closed					
Delta Fisheries (San Joaquin R.)									
Adult Salmon Migration Stockton	Flow	Minimum daily flow (cfs)	All	7/1-11/30 500					
Between Stockton and Turner Cut	Dissolved Oxygen	Minimum daily value (mg/L)	All	7/1-11/30 6.0					
Salmon Smolt Outmigration San Joaquin R nr. Vernalis	Flow	Minimum daily flow (cfs)	All	4/1-6/30 20,000					
Striped Bass Adult Migration and Spawning San Joaquin R nr. Vernalis to Antioch Bridge	Electrical Conductivity	Mean daily value not to exceed (mmho/cm)	All	4/1-6/15 0.3					
Delta Fisheries									
Shad Migration, Spawning and Larval Outmigration									
Sacramento R at Freeport San Joaquin R nr. Vernalis	Combined Inflow Sacramento plus San Joaquin riv.	Sum of minimum daily flows not less than (cfs) (Footnote 4)	All	4/15-11/30 20,000					
Shad and Striped Bass Larvae, Salmon Smolt Survival Throughout Statutory Delta	Export and Diversion	Flow permitted except in emergencies (cfs)	All	4/1-11/30 0					
Striped Bass Larvae Movement to Suisun Bay Chipps Island	Delta Outflow	Minimum daily outflow (cfs)	All	4/1-5/31 33,900	6/1-6/30 32,400	7/1-7/31 29,100			

Footnote 1: Optimal levels of protection designed to protect beneficial uses without consideration of impact on other beneficial uses or water needs.
Footnote 2: Objective estimated to fully protect tidal wetlands of Suisun Bay including habitat of rare, threatened and endangered species.
Footnote 3: Retain Delta Plan conditions in the absence of evidence that these flows are not optimal.
Footnote 4: Proportion of San Joaquin River flow to total Delta inflow to be the same as would occur under unimpaired flow conditions (see Table 5.3.6.3-3).

References:

- California State Lands Commission, May 1986, River Marina Carrying Capacity Study, 160 pp. 5 appendices. Table 1, pg. 10, Table 14 and Appendix 1.

- California Department of Water Resources (Northern District), 1982. Sacramento River Recreation Study, 1980.

6.0 DETERMINATION OF REASONABLE NEEDS FOR CONSUMPTIVE USES OF BAY-DELTA WATERS

6.1 California Water Ethic

California's ground and surface waters are a precious, but limited resource. Water supplies, vital to homes, industry, agriculture, and fish and wildlife, while abundant in one year, can become critically limited in another. In the past, dams were built to control flooding and provide appropriate supplies during prolonged dry periods. Today the sum of water demands exceeds the reliable supply. Additional actions are required. All Californians must become involved in the reasonable use of water. All water users throughout the state will be required to participate in the task of sharing water.

6.1.1 Balancing

This Water Quality Control Plan balances the reasonable water quality and instream flow needs which protect the beneficial uses of Bay-Delta Estuary waters against the reasonable consumptive demands for Estuary water both in- and outside the watershed. These consumptive demands occur upstream in the Sacramento River Basin and San Joaquin River Basin and in export areas south and west of the Delta in the San Francisco Bay area, San Joaquin Valley and southern California. The beneficial uses in the Estuary include productive and valuable biological assets, over 1/2 million acres of fertile farm land in the Delta, and extensive wildlife habitats. The Estuary also provides water quality protection to those who divert water for use elsewhere. Because the entire state will be affected in some way by this Plan and its implementation, it has become necessary to develop a water ethic that involves all Californians.

The water ethic includes the coordination of several programs, in varying degrees, in every region of the state. Best management practices related to the use of water are needed throughout the state. Many benefits can be realized. Careful water use can decrease pollutant loadings as well as reduce water demands. The following are assumptions forming the basis of the California water ethic:

- <u>Conservation</u>--Municipal and industrial water users (residential, industrial and commercial) will be metered. With improved plumbing, appliances, leak detection, and landscape irrigation practices, per capita water use will be significantly reduced. All agricultural users will use water as efficiently as feasible, particularly those who contribute drainage flows to salt sinks which preclude recovery or reuse.

- Reclamation--Where feasible, water reclamation and recycling consistent with state laws shall be required to reduce the demand on existing potable water supplies. Water reclamation includes the enhanced treatment of wastewater for reuse, the conversion of saline water to freshwater, and the treatment of ground water to a sufficient level to allow subsequent beneficial use.

- Conjunctive Use--Ground water storage basins will be effectively utilized in conjunction with distribution of surface water.

- Sharing Responsibility--Adequate flows for beneficial uses in the Estuary are the responsibility of all water users in the Bay-Delta watershed.

- Physical Facilities--To better manage California's water resources, the development of physical facilities is encouraged.

- Pollution Control--Maximum practical pollution control takes precedence over releases of freshwater for flushing flows.

6.1.2 Actions Needed

All users of Estuary waters, persons north, south and within the Estuary must share in the responsibility of meeting objectives to protect Bay-Delta beneficial uses. Also, all users should pursue the reclamation and reuse of water to its maximum potential. Water conservation and reclamation will need to be practiced in all areas, not just those south of the Estuary. Water users in the areas of water origin will also need to participate in this new water ethic.

This new water ethic forms the basis for determining reasonable consumptive water needs upstream, within, and south of the Estuary as well as water project operations which affect water flows into and through the Estuary. These changes in use of water come with associated costs. Within the limits of the available data, these costs have been considered here; additional information on this subject should be received in Phase II.

6.2 Reasonable Needs for Consumptive Uses

A review of optimal levels described in Chapter 5 shows that full protection of all beneficial uses in all water years is impossible. There simply is not enough water. Some beneficial uses have competing needs for limited supplies, and some, as noted, conflict with each other. Some accommodation has to occur. Practical application of the principles developed from the California water ethic can help identify reasonable consumptive needs for Bay-Delta water in areas upstream, within, and exported from the Estuary. These reasonable needs show that current water supplies can be managed in ways that satisfy existing and future needs. In fact, a rigorous application of the California water ethic indicates that substantial savings can be realized.

Reasonable consumptive needs are projected 2010 agricultural, municipal and industrial demands minus those potential savings achieved through water conservation and reclamation practices. Following the California water ethic, water saving methods can be used which will decrease water needs yet provide adequate supplies to support the beneficial uses made of the water.

These reasonable consumptive needs and water saving methods are discussed below. The ability to increase April through July Sacramento and San Joaquin river flows through the conjunctive use of surface and ground water and the alteration of reservoir operations are also evaluated.

6.2.1 Reasonable Consumptive Agricultural Needs

Using projected changes in demand and potential savings due to more efficient water use, projected 2010 consumptive agriculture needs in areas receiving Bay-Delta water will be about 1,007 TAF/yr less than present needs (see Table 6.2.1-1). This overall savings could be used for other beneficial uses.

The water conservation potential identified in Table 6.2.1-1 for the San Joaquin and Tulare Lake basins is based on a modification of the methodology of the Central Valley Water Use Study Committee (CVWUSC) (CVAWU, 64A). CVWUSC's methodology defines water conservation as a reduction of deep percolation losses to saline sinks, an area of about 1.7 million acres in the San Joaquin Valley (0.37 million acres in the San Joaquin Basin and 1.34 million acres in the Tulare Lake Basin). For comparison, the total irrigated acreage in the San Joaquin Valley in 1980 was 5.37 million acres (2.06 million acres in the San Joaquin Basin and 3.31 million acres in the Tulare Lake Basin (DWR, 14, 29)). The area of saline sinks includes most of the west side of the San Joaquin Valley. The total water conservation savings for this area at an Irrigation Application Efficiency (IAE) of 80 percentwas considered to be about 230 TAF/yr by the CVWUSC. Instead, 550 TAF/yr is considered to be a reasonable water conservation goal at 80 percent IAE based upon the modifications to the CVWUSC methodology discussed below.

SWRCB changes

- Contribution of shallow ground water (SGC) toward meeting the evapotranspiration (ET) requirement of a crop. For areas of salt tolerant crops (only cotton and alfalfa are considered here) grown on land overlying shallow ground water, 20 percent of the ET is assumed to be satisfied by the ground water. Thus, for these areas the IAE is redefined as follows:

$$IAE = \frac{ET-SGC}{\text{Applied Water}}$$

- Analysis of net tailwater and ground water losses to the San Joaquin River, in areas draining to the San Joaquin River. The CVWUSC excluded all but 100,000 acres of the west side of the San Joaquin River from consideration for water conservation under the assumption that all losses returned to the San Joaquin River. Instead, lateral flow rates from recent studies of ground water on the west side were considered. These flow rates show that not all of the losses return to the San Joaquin River. Thus, the water conservation potential on all 345,200 acres of the west side of the San Joaquin River (DWR's Detailed Analysis Unit #216) which overlie a saline sink was evaluated.

- Assumption that the minimum leaching requirement is met by the 20 percent deep percolation which occurs at the IAE of 80 percent

TABLE 6.2.1-1

REASONABLE CONSUMPTIVE AGRICULTURAL NEEDS
(TAF/yr)

Basin	Present (1985)	Future (2010)	Water Cons. (2010)	Reasonable Needs (2010)
Upstream[1]				
o Sacramento	6,338[4]	6,505[4]	0	6,505
o SJ (w/o salt sinks)	4,505[4]	4,589[4]	0	4,589
Bay-Delta				
Delta[1]	935[5]	933[6]	0	933
S.F. Bay[2]	118[4]	94[4]	0	94
Export[2]				
SJ (w/salt sinks)	1,390[7]	1,390[7]	235[7]	1,155
Tulare Lake	10,680[4]	10,781[4]	315[7]	10,466
Central Coast[3]	388[8]	354[8]	0	354
S. California	1,405[7]	1,108[7]	452[7]	656
TOTALS	25,759	25,754	1,002	24,752

1/ Based on net water use
2/ Based on applied water use
3/ Santa Barbara and San Luis Obispo areas only
4/ From DWR, 707, Statistical Appendix; adjusted for Delta agricultural needs
5/ From DWR, 30b
6/ From DWR, 701b
7/ From staff analysis
8/ From T,XIX,166:9-14

(assuming recycling of all tailwater). Thus, in this analysis no additional water for leaching was added to the applied water needs, as was done by the CVWUSC.

By the CVWUSC definition, the areas in the Bay-Delta watershed outside of the 0.37 million acres in the San Joaquin Basin overlying saline sinks (i.e., the rest of the upstream areas and the Delta) do not have any potential for water conservation. The losses in these areas are all considered by the CVWUSC to be recoverable and contribute to net Delta outflow. However, in the case of losses to usable ground water, the recovery of the losses usually comes at the expense of water quality degradation and a time lag. The water quality degradation occurs by dissolution of soil minerals from percolating water which over time will lead to expansion of the area of saline sinks. The time lag involved in ground water flow means that the return of the water to a river system may come at a time when additional flows are not needed. Therefore, water conservation may provide real water savings in these areas. Unfortunately, they cannot be quantified at this time. Nevertheless, since these losses in the upstream areas and the Delta are considered generally recoverable, the consumptive agricultural needs are based on net water use (i.e., crop ET). In areas not contributing to net Delta outflow, the consumptive agricultural needs are based on applied water use.

The water conservation potential identified in Table 6.2.1-1 for southern California is based on hearing testimony by Imperial Irrigation District (IID) and SWRCB's analysis assuming a goal of 80 percent IAE for Coachella Valley Water District (CVWD). Losses from IID and CVWD both go to a saline sink, the Salton Sea, and are thus irrecoverable losses. Based on hearing testimony by IID, certain projects could be undertaken which would provide a water conservation potential of up to 368 TAF/yr in IID. A combined savings of 84 TAF/yr in the CVWD and the Desert Water Agency service areas is based on increasing their IAE to 80 percent.

Although this analysis of agricultural water conservation potential is focused on saline sink areas, the goal of 80 percent IAE should be applied to all agricultural areas in California. Excessive deep percolation in nonsaline sink areas will lead to other problems; e.g., contamination of ground water with pesticides, nitrates, heavy metals, and other constituents; high ground water problems; and expansion of saline sink area through dissolution of soil mineral salts. These problems could be reduced through improved irrigation management and achievement of a 80 percent IAE.

The annual costs associated with achieving an 80 percent IAE in the west side of the San Joaquin Valley have been estimated at $16 to $25 per acre (EDF, 11, Executive Summary; UC Committee of Consultants on Drainage Water Reduction, 1988). Based on an analysis for the west side of the San Joaquin Valley, these costs per acre translate to between $25 to $40/AF of water conserved. The cost estimates for IID water conservation projects range from MWD's estimate of $64/acre-foot of water conserved (SWRCB Order WR 88-20 p.22) to $160 - $275 of water conserved by IID (IID, 1987). The $160/AF figure only includes the program items with identified water savings, while the $275/AF includes several additional programs. These cost estimates are the subject of intense negotiations.

Much of the costs of agricultural water conservation would be incurred regardless of any decision by the SWRCB on water diversions from the Bay-Delta. For example, in September 1988 the SWRCB issued Water Rights Order WR 88-20, which requires IID to submit a written plan containing definite implementation measures designed to conserve at least 100,000 AF/yr by January 1994. It also states that the SWRCB finds the conservation of 367,900 AF/yr to be a reasonable long-term goal for IID, and it will retain jurisdiction to review future water conservation measures. The costs of water conservation in IID are not likely to be borne by IID or the farmers in IID because, as noted in WR 88-20, MWD (and possibly other agencies) have expressed an interest in purchasing the water saved by conservation from IID.

Agricultural water conservation savings on the west side of the San Joaquin River may be another example of savings which would occur regardless of a SWRCB decision on water diversions from the Bay-Delta. The level of these savings will depend on the water quality objectives set for the San Joaquin River by the California Regional Water Quality Control Board, Central Valley Region early next year. As with IID, there is the possibility of financing such conservation measures by selling conserved water to other water users. This possibility has been raised in several analyses of drainage problems in the San Joaquin Valley (e.g., San Joaquin Valley Drainage Program, 1987).

6.2.2 Reasonable Consumptive Municipal and Industrial Needs

The present (1985) and projected (2010) consumptive municipal and industrial needs in areas using Bay-Delta waters are summarized in Table 6.2.2-1.

assuming reasonable needs in 2010

The totals in Table 6.2.2-1 show that despite water conservation efforts an additional 1,076 TAF/yr will be needed by 2010 to satisfy municipal and industrial demand. Much of this increased demand could be satisfied by the savings from agriculture. As with the agricultural analysis, the municipal and industrial water conservation potential in the upstream areas and the Delta is considered to be unquantifiable at this time and therefore set to zero. This is because the losses can be recoverable and generally contribute to net Delta outflow. For the municipal and industrial analysis it is assumed that losses to saline sinks in the San Joaquin Basin are minimal due to the sparse population overlying these areas. Again, for areas where return flows do not contribute to net Delta outflow, the consumptive use is based on the applied water use; for other areas, the consumptive use is based on the net water use. For example, applied water use is used for Fresno and San Francisco, while net water use is used for Sacramento and Stockton. The projected water conservation savings in the San Francisco Bay Basin and export areas are based on an aggressive water conservation and reclamation program which includes the following assumptions for 2010:

aggressive conservation assumptions in SF Bay Basin

TABLE 6.2.2-1

REASONABLE CONSUMPTIVE MUNICIPAL AND INDUSTRIAL NEEDS
(TAF/yr)

Basin	Present (1985)	Future (2010)	Water Cons./ Recl. Savings (2010)	Reasonable Needs (2010)
Upstream 1/				
Sacramento	500 3/	679 3/	0	679
SJ River	248 3/	344 3/	0	344
Bay-Delta				
Delta 1/	27 4/	43 4/	0	43
S.F. Bay 2/	1,088 3/	1,222 3/	129 4/	1,093
Export 2/				
Tulare Lake	481 3/	729 3/	0	729
Central Coast	109 5/	136 6/	18 4/	118
S. California	3,609 4/	5,221 4/	1,089 4/	4,132
TOTALS	6,062	8,374	1,236	7,138

1/ Based on net water use
2/ Based on applied water use
3/ From DWR, 707, Statistical Appendix; adjusted for Delta M&I needs
4/ From staff analysis
5/ From T,XIX,166:9-14
6/ From SWC, 176, 3

SF Bay Basin conservation assumptions

- 95 percent compliance with the 1978 California Plumbing Code for all residences existing in 2010;
- About half of the water used by commercial and governmental/public customers is for outdoor irrigation or evaporative cooling; and
- As a result of improved irrigation efficiency and changes in landscaping practices, there will be a 20 percent reduction in existing outdoor residential, commercial and public water uses and a 40 percent reduction in new uses added between now and 2010.

Although the mix varies from agency to agency, in general the reasonable use analysis involves three areas of additional conservation: industrial use, indoor residential use, and outdoor use by residential, commercial, and public consumers. Additional conservation by industrial users is projected only for the MWD service area and the San Francisco Bay Basin, and is the smallest component of the proposed savings through conservation. This is because industrial water use in California has fallen by 50 percent or more over the past 15 years. This dramatic reduction in industrial water use is a nationwide trend that is attributable largely to enforcement of water pollution control laws. Because industrial use is now a relatively small component of total M&I use in California (about 10-13 percent), the gains from increased conservation in this component are relatively small.

The basis for the analysis of indoor residential conservation is the 1978 California Plumbing Code which mandated lower water-using toilets and showers in new construction. Typical indoor residential water use in a nonconserving home is about 77 gallons per capita per day (gpcd), and it has been estimated that the new standards contained in the 1978 Code would reduce this by about 15.2 gpcd if fully implemented. The appliances on sale in California now meet or exceed these standards, so the only lack of implementation can arise from existing toilets or shower heads that were installed before 1978 and meet the earlier standards. By 2010 all such shower heads, and many such toilets, are likely to have been replaced. For the purposes of analyzing reasonable use, it was assumed that there would be 95 percent compliance with the 1978 Code by the year 2010, which implies an average savings of about 14.5 gpcd. Some of the projections of 2010 M&I use presented during the Phase I hearing do not appear to incorporate any savings attributable to the 1978 Code at all, while others incorporate a smaller savings (for example, a savings of 11.5 gpcd, based on an assumption of 76 percent compliance). The incremental conservation in indoor residential use in 2010 that is implied by the reasonable use analysis is the difference between 95 percent compliance with the 1978 Code and the degree of compliance assumed in individual water agencies' projections -- i.e., the difference between 14.5 gpcd and, for example, 11.5 gpcd.

In the past, much of the effort aimed by California water agencies at conservation in M&I use has focused on industrial use and indoor residential use. However, 40 percent or more of all M&I use in California is outdoor use, primarily for lawn and garden irrigation by residential, commercial, and public-sector customers. This appears to have received relatively little attention. Whereas industrial water use has fallen by at least 50 percent over the past 15 years and indoor residential use is projected to fall by 15-25 percent by 2010 under existing conservation programs, no reduction is projected for outdoor uses. Indeed, there will probably be an increase in per-capita outdoor use by 2010 because of a trend to larger-sized lots, more development in the hotter, interior regions, and the growth of the commercial sector which appears to use significant quantities of water for outdoor irrigation and evaporative cooling. Because of the relative lack of attention, there are likely to be significant opportunities for conservation in outdoor use that have not yet been exploited. Accordingly, the third component of the reasonable use conservation analysis targets outdoor use by residential, commercial, and public consumers and proposed for 2010 reductions of 20 percent in currently existing uses and 40 percent in new uses developed between now and 2010. There is substantial evidence that such reductions are eminently feasible. DWR (1984), for example, asserts that improved irrigation practices on existing residential, commercial and governmental landscapes can reduce applied water by 20 percent, and changes in landscape design can reduce water use by 40-90 percent. Ferguson (1987) notes that even the cheapest and most primitive conservation measures can reduce urban irrigation use by 25 percent compared to a poorly designed or operated system, and argues that it is reasonable to shoot for 60-70 percent savings with more sophisticated planning and aggressive conservation measures.

In the San Francisco Bay Basin the present per capita water use is 190 gallons per capita per day (gpcd) and the 2010 water use is projected to be 179 gpcd. By applying the aggressive water conservation measures outlined above, the per capita water use in the San Francisco Bay Basin could be reduced by 19 gpcd to 160 gpcd, for a savings of 129 TAF/yr.

In the Central Coast Basin only the Santa Barbara and San Luis Obispo areas are considered in this analysis since they are the only areas planning to use Estuary water. In these areas, the aggressive water conservation and reclamation program outlined above could produce a municipal and industrial water savings of 18 TAF/yr in 2010. Based on these assumptions, M&I water use in the Santa Barbara and San Luis Obispo areas, which is currently 190 gpcd, could be reduced by 24 gpcd in 2010 from the State Water Contractors (SWC) projected level of 181 gpcd to 157 gpcd.

The major population centers in the Tulare Lake Basin, Fresno and Bakersfield, are outside of the designated saline sink area. Most of the wastewater produced in the basin is reclaimed for irrigation use. Thus, the only potential for water conservation in the Basin would be through reduced evaporation from regulating reservoirs (prior to irrigation). This amount is very small, and therefore the municipal and industrial water conservation potential is assumed to be zero.

The total water conservation and reclamation potential in the SWP service area of southern California shown in Table 6.2.2-1 is 1,089 TAF/yr in 2010. This value includes 924 TAF/yr of water conservation savings and 165 TAF/yr of increased reclamation. For Metropolitan Water District (MWD), total water conservation savings is 544 TAF/yr based on the aggressive water conservation assumptions shown earlier plus a small decrease in industrial water use. The present M&I water use in MWD is 207 gpcd. These conservation measures would reduce M&I use in the MWD service area from the 194 gpcd projected by the SWC for 2010 down to about 168 gpcd.

Water conservation savings in non-MWD areas of the SWP service area in southern California are estimated to be 380 TAF/yr. Of this total, 200 TAF/yr are based on the same reasonable use analysis as in MWD. As a result of that analysis, the non-golf course M&I use in these areas in 2010 is reduced from the level of 287 gpcd projected by SWC to about 222 gpcd. The other 180 TAF/yr represents potential savings in water use on golf courses. This savings is based on a 20 percent reduction in water usage on existing golf courses, plus an assumption that new golf course areas will increase by not more than 50 percent from 1985 to 2010, rather than the 300 percent increase assumed by the SWC.

Lastly, the increased reclamation of 165 TAF/yr is projected only for the MWD service area, and is based on data presented by MWD (SWC, 17, Table 2 and Figure 3; T, XVII, 3, 11, 69-71) identifying reclamation projects that could be developed by 2010 based on what MWD considers to be reasonable constraints on member agencies.

The primary motivating factor for additional water conservation by industry between now and 2010 will continue to be the enforcement of water pollution control regulations. This will occur regardless of any decision by the Board on water diversions from the Bay-Delta. Therefore, the incremental costs of such conservation should not be attributed to the aggressive water conservation plan described. The discussion here focuses specifically on the economic effects of conservation measures that are proposed in the analysis of reasonable use for 2010 and that go beyond those currently planned by M&I water agencies.

There are reasons to believe that the costs associated with indoor residential conservation are likely to be modest. For example, there have recently been proposals to revise the 1978 Code to require ultra-low flush toilets and shower heads in new construction, that have been made possible by newer technologies. If fully implemented, this could reduce indoor residential use in new units by an additional 11-15 gpcd as compared to the 1978 Code "at little or no cost to customers" (EBMUD, 1988). East Bay MUD has stated that, if the State Plumbing Code were revised in this way, it would consider requiring the replacement of existing toilets and shower heads in its service area with ultra-low flush units. Also, Monterey County has recently implemented a measure mandating the installation of ultra-low flush toilets on resale of residential units. MWD has recently announced a new program of Financial Incentives for Water Conservation under which it would subsidize part of the cost to member agencies of measures such as the installation of ultra-low flush toilet and shower head units. Such measures would more than meet the incremental indoor residential conservation implied by the reasonable use analysis.

The cost of outdoor water conservation would be greater for existing landscapes than for newly-developed landscapes. In smaller residential units without a sprinkler system, the costs of installing sprinklers or changing the landscaping can be substantial. In an efficient program, however, such users would be the last to be targeted; the initial focus would be on large commercial, public, and residential users of irrigation water. Moreover, significant savings may be obtained from existing users at relatively low cost through education and irrigation scheduling programs. Also, as noted in DWR 1984, replacing sprinkler heads and installing timers in existing sprinkler systems can be a cheap but effective way of reducing water use by 20 percent or more without harming the vegetation. Accordingly, while there will certainly be planning and management costs for water agencies administering an effective outdoor water conservation program, as well as retrofit or conversion costs for some existing users, it is believed that a well-designed program could achieve the outdoor conservation goals of the aggressive water conservation program at a reasonable cost and in an equitable manner.

The projections of increased reclamation are based on statements by the State Water Contractors about wastewater reuse projects which they intend to implement by 2010 (SWC, 17). There is no indication that the implementation of such projects would be attributable to specific actions by the SWRCB in connection with water diversions from the Bay-Delta. Therefore, these do not involve any additional economic impacts that are attributable to the aggressive water conservation and reclamation program discussed here.

It should be noted, lastly, that the reasonable use analysis assumes no reduction in population growth or new housing development from that projected for 2010 in the testimony presented during the Phase I hearing. New construction would have to incorporate more efficient plumbing fixtures and water-conserving landscaping, but all the available evidence suggests that these costs would be extremely small, both absolutely and in relation to the total price of the housing unit. Thus, no significant impacts on the housing industry are predicted as a consequence of the aggressive water conservation and reclamation program.

no pop or housing growth reduction assumed in the reasonableness analys

6.2.3 Southern California Water Balance

The present and future water supplies and demands in southern California are summarized in Table 6.2.3-1.

The decrease in total supply shown in Table 6.2.3-1 is due to two factors: (1) the projected decrease in Colorado River supply due to the Central Arizona Project, and (2) the reduced supply from the Los Angeles Aqueduct as a result of the Mono Lake litigation. The demands shown in Table 6.2.3-1 were discussed in Tables 6.2.1-1 and 6.2.2-1. With the conservation efforts outlined previously, the

TABLE 6.2.3-1

SUPPLY AND DEMAND FOR SOUTHERN CALIFORNIA AREAS WHICH RECEIVE STATE WATER PROJECT WATERS (IN MAF/YR)[1/]

	Present[2/]	Future[3/]
Supply		
o Local surface and ground water	2.19[4/]	2.19[4/]
o Colorado River	1.47[5/]	0.80[4/]
o State Water Project	0.79[6/]	0.79[6/]
o Los Angeles Aqueduct	0.42[4/]	0.40[7/]
o Wastewater reuse	0.15[4/]	0.34[8/]
o Total Supply	5.02[9/]	4.52
Demand		
o Agricultural w/o conservation	1.41[10/]	1.11[10/]
o Agricultural w/ conservation		1.03[11/]
o M&I w/o conservation	3.61[12/]	5.22[12/]
o M&I w/ conservation		4.30[13/]
o Total Demand w/o conservation	5.02	6.33
o Total Demand w/ conservation		5.33
Surplus/Deficit	0	-0.81
Transferable water supply from agricultural water conservation in IID		0.37[14/]
Transferable water supply from agricultural water conservation in SJV		0.34 to 0.48[15/]
Remaining Surplus/Deficit		-0.10 to 0.04

1/ - Area includes the following water districts: Antelope Valley-East Kern WA, Littlerock Creek ID, Palmdale WD, Coachella Valley WD, Desert WA, San Gorgonio Pass WA, Mojave WA, Crestline Lake Arrowhead WA, San Bernardino Valley WD, Castaic Lake WA, San Gabriel Valley MWD, Ventura County FCD, and Metropolitan Water District

2/ - 1985 level

3/ - 2010 level

4/ - From SWC, 4,3

5/ - By difference

6/ - 1985 deliveries; from DWR, 1987

7/ - Estimate of reduced supply due to Mono Lake litigation

8/ - From SWC, 4, 3 plus incremental reuse identified in SWC, 17, Table 2 and Figure 3

9/ - Set equal to demand for present

10/ - See Table 6.2.1-1

11/ - Includes conservation in CVWD only (0.08 MAF/yr)

12/ - See Table 6.2.2-1

13/ - Includes conservation only (reclamation of 0.17 MAF/yr was added to supply as wastewater reuse)

[14] Savings from the IID as discussed in Section 6.2.1

[15] 0.34 is agricultural water conservation and conveyance losses in areas supplied entirely with project water; 0.48 is agricultural water conservation and conveyance losses in areas supplied at least partially with project water (from staff analysis)

projected future (2010) demand would increase slightly, from 5.02 MAF/yr to 5.33 MAF/yr.

Despite water conservation efforts in southern California, Table 6.2.3-1 indicates that there would be a deficit of 0.82 MAF/yr in 2010. However, this deficit could probably be satisfied by transferring water savings from conservation: (1) of project water in the San Joaquin Valley , and (2) of Colorado River water in IID. The first transfer would come from increased SWP supply, but would not affect the total project exports from the Estuary.

6.2.4 Methods to Increase April through July Net Delta Outflow

The net Delta outflow could be increased in April through July by redistributing the annual inflows and/or outflows to/from the Delta. Two methods for accomplishing this seasonal redistribution of flow were evaluated:

(1) conjunctive use of surface and ground waters; and

(2) reoperation of Central Valley reservoirs.

These methods could be applied separately or together to provide increased April through July flows. Conjunctive use could be practiced in several upstream areas in the Sacramento and San Joaquin basins. Reoperation of reservoirs in this study entails meeting all the specific demands of reservoir operations (flood control, irrigation, fish flows) except power production. Only those releases from reservoirs which are made solely for power would be affected, since most power could still be produced within the constraints of the other operations. For example, reservoirs in the Central Valley could increase storage during August through March, while decreasing downstream flows in those months, and subsequently increase April through July discharges. However, during wetter years, reservoirs commonly reach their flood control maximum storage by December and are required to release water to maintain flood control space for spring runoff. In these cases, conjunctive use could be coordinated with reservoir reoperation to store the excess water downstream of the reservoir.

The potential for shifting August through March flows to April through July was evaluated for the San Joaquin Basin. The range would probably be from 170 TAF/yr during critically dry years to almost 700 TAF/yr during wet years. The average for the 1972-87 period over which this analysis was performed was 490 TAF/yr. Based on a percolation rate of one-third foot/day (from Kern Water Bank estimates), a spreading basin area of about 20,000 to 30,000 acres would be required, depending on whether the spreading basins are operated throughout the year on unused land or whether they are operated only during the nonirrigation season on existing farmland. Suitable sites for conjunctive use could probably be located in both the San Joaquin and Sacramento basins and in export areas.

The cost of conjunctive use in the San Joaquin Basin depends, to a great extent, on whether the operation is planned to be year-round on land purchased for spreading basins, or whether it is to be operated only during the nonirrigation season on farmland leased for spreading purposes. In either case, the cost estimate of $60/AF for the Kern Water Bank probably represents a good upper estimate of the costs of conjunctive use (DWR, 1986). The costs in the San Joaquin Basin, however, would probably be somewhat less than the Kern Water Bank due to two advantages of the San Joaquin Basin location: (1) more extensive existing water distribution systems, and (2) shallower depth to ground water. The cost of reservoir reoperation, probably about $15/AF, would primarily be the lost power revenue created by shifting the time of reservoir releases from August through March to April through July.

REFERENCES

- California Department of Water Resources. 1984. Water Conservation in California. Bulletin 198-84, July 1984.
- California Department of Water Resources. 1986. Final Environmental Impact Report - Artifical Recharge, Storage and Overdraft Correction Program, Kern County, California (Kern Water Bank). December 1986, p. 34.
- California Department of Water Resources. 1987. Management of the California State Water Project. Bulletin 132-87, September 1987.
- East Bay MUD. 1988. Water Supply Management Program Technical Report & Appendices. Oakland, September 1988.
- Ferguson, Bruce K. 1987. Water Conservation Methods in Urban Landscape Irrigation: An Exploratory Overview. Water Resources Bulletin, 23: 147-152.
- Imperial Irrigation District. 1987. Water Conservation Program, Implementation Plan. Exhibit 25 for SWRCB hearing, March 1988.
- San Joaquin Valley Drainage Program. 1987. Farm Water Management Options for Drainage Reduction. Agricultural Water Management Subcommittee, October 1987.
- University of California Committee of Consultants on Drainage Water Reduction. 1988. Associated Costs of Drainage Water Reduction. No. 2 in Series on Drainage, Salinity and Toxic Constituents, January 1988.

7.0 WATER QUALITY OBJECTIVES

7.1 Introduction

Chapter 5 identifies the optimal levels of protection for the beneficial uses of Bay-Delta waters. A review of these conflicting needs indicates that the watershed of the Bay-Delta Estuary does not possess enough water to satisfy all these demands except possibly in the wettest of years. Therefore, each of these demands must be reevaluated in light of the reasonableness to satisfy them. The concept of the California water ethic was presented in Chapter 6 to establish some ground rules to assess the reasonableness of water use. Chapter 6 also evaluates the reasonable needs of Bay-Delta water supplies for areas upstream and downstream of the Bay-Delta Estuary. Chapter 7 will present the information used to evaluate the reasonableness of instream flow and salinity objectives to protect the beneficial uses of Estuary water.

This chapter begins with an evaluation of each beneficial use and alternative levels of protection for each use. These alternatives were evaluated in light of the water ethic principles discussed in Chapter 6. The pertinent principles for this discussion are:

- Municipal and industrial water users should receive salinity protection of at least the secondary public health standard of 250 mg/l chloride.

- Delta agricultural users should receive water quality that fully protects their needs assuming that best management practices are being employed, to the extent that such quality was available under unimpaired conditions with present day channel configurations (see Cal. Const., Art X, Sec. 2).

- Aquatic life in the Estuary should receive salinity and flows at an appropriate historic level. The appropriate historic level is established during the balancing process as subsequently explained. (See Water Code Section 1243; Public Resources Code Section 21000, et seq.; State Board Resolution 68-16).

Once the alternative levels of protection for each beneficial use are determined, they are assembled into logical sets of alternative water quality objectives. Six alternative sets of objectives were developed and evaluated. The effects of each of these six sets of alternative water quality objectives on beneficial uses in the Estuary and the water supply and use community were assessed. Through the careful weighing of these effects a set of recommended water quality objectives is proposed.

7.2 Alternative Levels of Protection for Each Beneficial Use

This section presents the analysis of reasonable alternative levels of protection for each beneficial use in the Bay-Delta Estuary consistent with the water ethic (see Chapter 6).

7.2.1 Municipal and Industrial

As presented in Chapter 5, there are five major municipal and industrial water supply intakes in the Estuary. Water customers demand the best possible water quality they can obtain. However, what users would like to have and what is reasonable, when all competing demands are considered, are often very different.

Two major water quality issues were brought out during the Phase I hearing. The first deals with trihalomethanes and the second involves salinity.

7.2.1.1 Trihalomethanes

Trihalomethanes are known carcinogens that can be produced during some water treatment processes, such as chlorination, designed to purify water for drinking. Trihalomethanes are generated in higher concentrations when the source water contains high concentrations of two important precursors, organic compounds and halides, e.g., chlorides and bromides such as those found in sea water. Since the Delta contains significant amounts of organic soil formed when it was an inland marsh and since it is located near the ocean, the Delta contains ample quantities of both chlorides, bromides and organic materials.

Some hearing participants suggested that fresh water be used to flush chlorides and bromides away from municipal intakes. Others suggested that extensive agricultural drainage systems be installed to remove this unquantified portion of organic loading to locations far downstream of municipal intakes. Both of these proposals could reduce trihalomethane precursors. However, they will not guarantee that concerns over the formation of trihalomethanes will be resolved. Even water quality in the Sacramento River at the City of Sacramento will not attain the trihalomethane standard if it is lowered (from 100 mg/l to 50 mg/l or less as EPA is considering) and the water is treated through routine chlorination.

Based on the evidence presented during the Phase I of the hearing, the trihalomethane issue in the Delta is considered a water supply treatment issue. The establishment of reasonable water quality objectives in the Estuary will not resolve the issues surrounding the formation of trihalomethanes in the water supply treatment process. Technology curently exists for water purveyors who obtain water from the Estuary to treat their supplies (as does the Contra Costa Water District) without forming excessive trihalomethanes and other compounds.

7.2.1.2 Salinity

- Chlorides

  Salinity in drinking water can cause two types of concerns: taste and increased industrial processing costs due to high chloride levels.

  High chloride levels can impart an unpleasant taste to drinking water. All else being equal, most users would rather drink low salinity water than water with a slight salty taste. The Department of Health Services has recognized this and adopted a secondary drinking water standard of 250 mg/l for chlorides. This level of chlorides protects the public interest.

Groups of water users have expended funds to build projects to achieve water quality better than 250 mg/l chloride. These projects include diverting higher up on a water course, or the construction of storage facilities to store low saline water during the winter for dilution of saltier summer supplies. Such actions are local issues and are appropriate provided statewide interests are not unreasonably impaired.

In the 1978 Delta Plan, the Board developed water quality objectives for the Contra Costa Canal intake at Rock Slough for chloride levels of 150 mg/l for various times during the year, depending on the wetness of that year. This objective was intended to protect the historical water supply of two paper manufacturing industries.

Other industrial uses are reasonably protected at the 250 mg/l chloride objective. Some industries use special treatment processes to remove either salinity or other constituents that can affect their operations. However, such special processing is a matter for these industries to resolve with their water purveyor and not a matter of overriding statewide public interest. Therefore, the 150 mg/l chloride objective should be discontinued. The 250 mg/l chloride objective provides reasonable protection to municipal and industrial uses. It is used in each set of objectives presented in the next section to protect municipal and industrial beneficial uses.

- Sodium

A relatively new issue related to salinity involves the consumption of sodium. Diets high in sodium, especially for people with a history of heart problems, can contribute to heart problems. Some participants in the hearing suggested a sodium objective be adopted to protect against such concerns. Others were concerned about the effects of high sodium water on dialysis machines. The information presented to the Board shows that sodium contained in drinking water represents a very small portion of normal daily sodium intake. People on very restricted sodium diets should consult their physician and dietitian to revise their diet based on their local water supply or in very rare cases consider bottled water low in sodium. Concerns with dialysis machine operations can be resolved by switching to other lower saline sources when sodium levels become a problem.

Concerns raised, related to sodium, do not warrant the adoption of specific sodium water quality objectives. This concern can be reasonably resolved by achieving the 250 mg/l chloride objective in Delta waters or special actions by health professionals as they become more knowledgeable of the sodium levels in their water supply.

7.2.2 Agriculture

7.2.2.1 Western and Interior Delta Agriculture

Chapters 4 and 5 review the testimony presented during Phase I on the water quality needs of the mostly organic soils found in the western and interior Delta. Following the adoption of the 1978 Delta Plan, studies were designed to resolve concerns expressed by the Board on the lack of specific information about the needs of salt sensitive crops when grown using subirrigation on the Delta's rich organic soils. The results of this study show that corn (the most salt sensitive significant crop grown in the western and interior Delta) can be grown with no yield decrement in salinities that do not exceed 1.5 mmhos/cm EC during the growing season (April 1 through August 15). This assumes periodic leaching with water quality at least as good as 1.7 mmhos/cm EC during some winters.

One of the principles in the water ethic is that agricultural users should receive water quality to protect their reasonable needs as limited by the availability of this quality water under unimpaired water runoff conditions. Achievement of this level of water quality would protect this beneficial use to the extent it would have been protected if man's activities to modify river flows had not taken place. The level of salinities that would occur in these western Delta areas under these unimpaired water runoff conditions were reviewed. This review indicated that water qualities as good as 1.5 mmhos/cm EC occurred throughout the growing season except in the latter part of critically dry years. In order to reflect the water quality available under unimpaired conditions in critical years, values should be allowed to rise from 1.5 to 3.0 mmhos/cm EC beginning August 1 and remain no higher than that level through the end of the growing season (August 15). These salinity levels are appropriate to protect agriculture in the western and interior Delta. These proposed objectives along with leaching water requirements are used in each alternative set of objectives presented in the next section as the water quality objectives to protect western and interior Delta agriculture beneficial uses.

7.2.2.2 Southern Delta Agriculture

Water quality in the San Joaquin River as it enters the southern Delta near Vernalis has degraded in the last 50 years. Average salt concentrations have more than doubled during this period. This degradation is caused by a combination of two factors: increased salt loadings from upstream agricultural drainage and decreased flows, caused by upstream water development, that helped dilute high saline water.

In the 1978 Delta Plan, the Board adopted water quality objectives to protect southern Delta agriculture on the mineral soils in this area. These objectives differ from those set for the predominately organic soils found in the western and interior Delta. The Board delayed implementation of these objectives to allow interested parties time to negotiate a long-term agreement to achieve these objectives. While some progress has been made in this area, it has been too slow and decisive action is needed.

The 1978 Delta Plan objectives for the southern Delta have been reviewed in light of the testimony presented in the Phase I of the hearing. Beans, a salt sensitive crop, are grown in significant quantities in the southern Delta. With best management practices by the southern Delta farmers, the current Delta Plan objectives protect this and other crops grown during the primary irrigation season (April through August) and other less salt sensitive crops, e.g., alfalfa and sugar beets, grown during the remainder of the year.

However, two aspects of these objectives need review. First, the mean monthly monitoring frequency contained in the Delta Plan is too long, as explained by the South Delta Water Agency, and should be reduced to a 14-day running average consistent with western and interior Delta objectives. Second, the objectives need to be tested to see if they would be attained during unimpaired flow conditions. This analysis indicates that the 0.7 mmhos/cm EC set forth in the objectives during the primary irrigation season of April through August generally would be available under unimpaired runoff conditions during all water year types. This analysis used water quality to flow relationships for the San Joaquin River that existed prior to 1945 (SDWA Exhibit 123 and New Melones Hearing USBR Exhibit 43).

During the secondary irrigation season, September through March, the 1.0 mmhos/cm EC provides water quality sufficient to protect crops irrigated during this time of year, e.g., alfalfa, pasture and sugar beets. This quality protects the seedling stages of these crops and is sufficient for winter leaching. Also, analysis shows that 1.0 mmhos/cm EC generally would be achieved during these months under unimpaired runoff conditions. These objectives are used for each set of water quality objectives and are shown in detail in the recommended objectives presented later in this chapter.

7.2.2.3 Export Areas

Substantial quantities of water are exported from the Delta for use in areas outside the Delta. The locations of these diversions are the same as the municipal and industrial diversions discussed previously. The water quality objectives that protect drinking water supplies at these locations (250 mg/l chloride) also reasonably protect agricultural uses of water for irrigation of the crops grown in the Central Valley and southern California.

The SWP contractors have water supply contracts that have a goal of delivering water with a quality of 110 mg/l chloride. This delivered quality is achieved by blending good quality water diverted in the winter with the more saline water diverted during the summer. At times the SWP also allocates a portion of its water supply to improve water quality to approximately 100 mg/l chloride at Clifton Court. This "carriage water" requirement increases as exports increase during the summer. As much as one-third more water beyond that needed for export may be required to repulse sea water in some months. The water supply impact analysis discussed in Section 7.3.1 assumes a maximum 250 mg/l chloride level at SWP water supply intakes. The users may choose to allocate a portion of their limited supply to further improve the quality of exported water.

7.2.3 Delta Fisheries and Estuarine Habitat

There are two water project related effects on Delta fisheries. They are (1) River inflow and Delta outflow, which moves Delta fish downstream into the more biologically productive Suisun and San Pablo bays and away from the effects of the state and federal export pumps and other Delta diversions and (2) exports, which physically entrain fish, lead to increased predation, move fish into less biologically productive areas and generally decrease productivity of the Delta environment by increasing cross Delta flows.

7.2.3.1 Chinook Salmon

- Flow

As discussed in Chapters 4 and 5, evidence was presented showing that April through June inflows to the Delta affect the quality and quantity of fishery habitat, smolt survival during outmigration, and subsequent escapement of fall run Chinook salmon 2 1/2 years later. The Sacramento Basin produces up to 90 percent of Central Valley salmon. Since counts were first made in the 1950's, the natural salmon population has declined by an estimated 75 percent. In the last 20 years, although the natural population has continued to decline, an increase in hatchery produced fish has stabilized the total Sacramento Basin population (see Figure 4.5.1.2-4). This is achieved by releasing many hatchery reared fish downstream of the Delta, thus avoiding the poor environmental conditions in the Delta.

San Joaquin River salmon populations fluctuate markedly, partly in response to spring flow conditions, and range from less than one to 26 percent of the Central Valley salmon population. There are three other races of Chinook salmon in the Sacramento River, two of which have also experienced population declines since the late 1960's. One race was eliminated from the San Joaquin Basin by the construction of Friant Dam. Sufficient evidence was presented in the Phase I Hearing to determine Delta protections needed for the fall run salmon but not the other races of Chinook salmon on the San Joaquin or Sacramento River systems.

Available data indicate that river flows in April through June up to a certain limit (22,500 cfs on the Sacramento River at

Rio Vista and 20,000 cfs on the San Joaquin River at Vernalis) provide benefits to salmon migration. These benefits are linearly related to increasing Sacramento River flows. Limited data from the San Joaquin indicate a similar relationship.

In addition to the optimal level and the no action level, three alternative levels of salmon protection with different Delta inflow regimes were developed. One of the principles developed under the water ethic states that aquatic resources should receive protection equivalent to that received over some recent historical period. The alternatives presented below represent a range of historical periods and are evaluated later in this chapter to determine a reasonable level of protection for Chinook salmon. The alternatives are:

(1) Optimal protection - April through June average monthly flows of 22,500 cfs at Rio Vista on the Sacramento River and 20,000 cfs at Vernalis on the San Joaquin River.

(2) Average April through June flows in the Delta generally reflecting those prior to physical modifications to enhance water deliveries south of the Delta (1930-1952). The year 1930 represents the earliest year of flow data available for key interior Delta locations. Some modification to the actual historical value for each year type was made by decreasing wet year flows and increasing drier year flows as has been experienced in recent years.

(3) Average April through June flows for the entire period for which reliable data exist at key interior Delta locations (1930-1987).

(4) Average April through June flows which have occurred under the present physical configuration of the Delta (1953-1987).

(5) Flows as set forth in the 1978 Delta Plan for salmon.

The average April through June flows for the above alternatives are shown in Table 7.2.3.1-1. They are shown as averages for each month and are separated by water year type. These monthly average flows excluded flows that were above 22,500 on the Sacramento River at Rio Vista and 20,000 on the San Joaquin at Vernalis. Flows above these values were not included because there is no clear evidence that flows in excess of these amounts benefit salmon migration through the Delta. Figure 7.2.3.1-1 summarizes in graphic form how average April through June flows important to salmon have changed over various time periods and are expected to change in the future.

The USFWS and the DFG recommended the establishment of average Delta inflows generally reflective of conditions prior to 1950. The SWP contractors and others recommended maintenance of the 1978 Delta Plan fishery flows into the

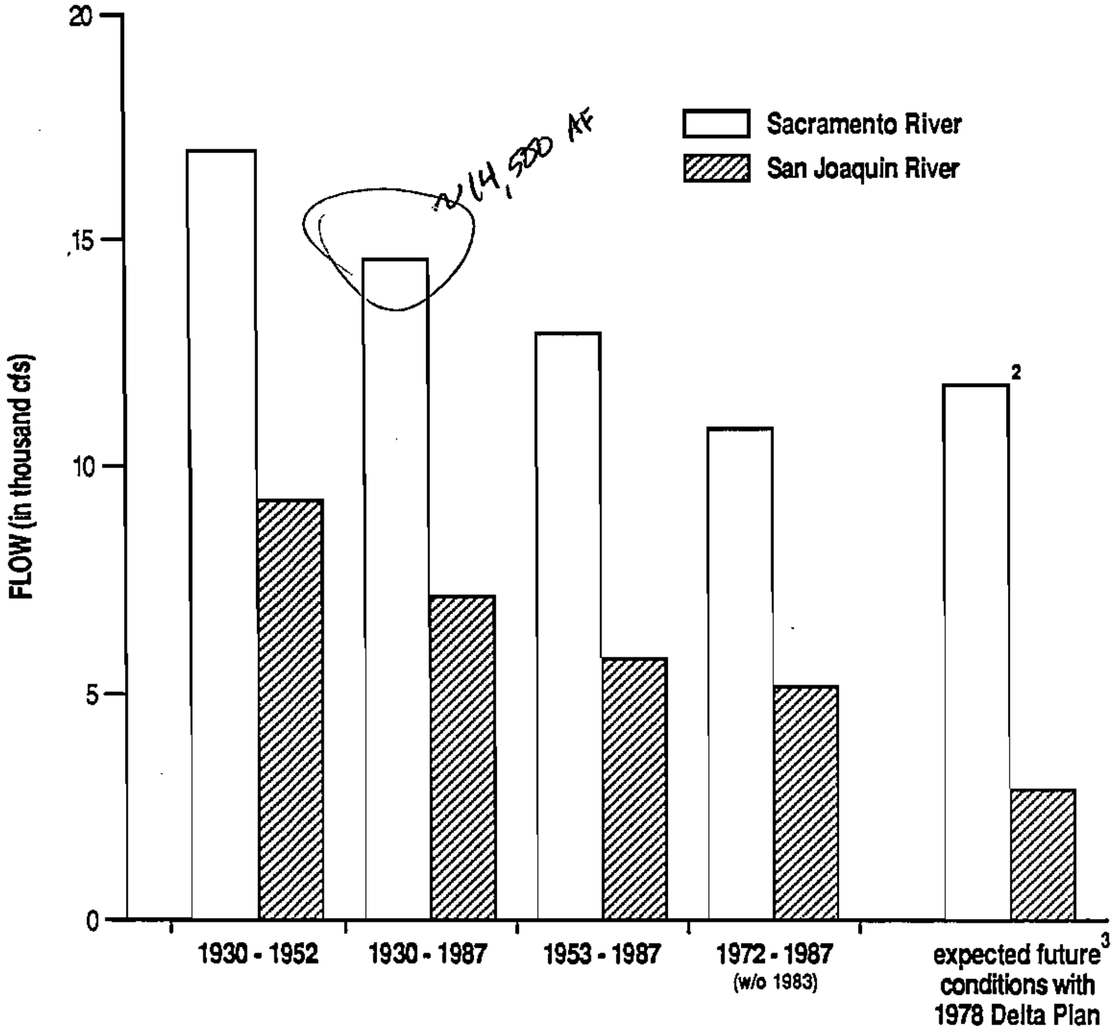
TABLE 7.2.3.1-1

ALTERNATIVE LEVELS OF PROTECTION
FOR SACRAMENTO AND SAN JOAQUIN SALMON OUTMIGRATION

Beneficial Use Protected and Location	Parameter	Description	Year Type	Values					
FISH HABITAT				Dates/ CFS 4/1-30	Cross Channel Status	Dates/ CFS 5/1-31	Cross Channel Status	Dates/ CFS 6/1-30	Cross Channel Status
o Sacramento Salmon Rio Vista 1930-1952	Flow at Rio Vista and Cross-Channel status. (see Footnote)	Flow pattern estimated to provide protection found from 1930-52, plus Cross-Channel closures to prevent smolt diversion	Wet	22,500	C	22,500	C	21,500	C
			Ab. Normal	22,500	C	22,500	C	12,000	C
			Bl. Normal	20,500	C	21,000	C	8,000	C
			Dry	20,500	C	16,000	C	9,500	C
			Critical	11,500	C	4,500	C	1,000	C
o San Joaquin River Salmon Vernalis 1930-1952	Vernalis Flow	Flow pattern estimated to provide protection found from 1930-52	Wet	17,000		19,000		19,000	
			Ab. Normal	12,000		14,500		11,500	
			Bl. Normal	2,500		4,000		4,500	
			Dry	1,500		2,000		1,000	
			Critical	1,500		1,500		1,000	
o Sacramento Salmon Rio Vista 1930-1987	Flow at Rio Vista and Cross-Channel status .	Flow pattern estimated to provide protection found from 1930-87	Wet	22,500	C	22,000	C	17,000	C
			Ab. Normal	22,500	C	21,000	C	7,000	C
			Bl. Normal	16,500	C	14,500	C	7,500	C
			Dry	12,500	C	10,000	C	5,000	C
			Critical	8,500	C	5,000	C	4,000	C
o San Joaquin River Salmon Vernalis 1930-1987	Vernalis Flow	Flow pattern estimated to provide protection found from 1930-87	Wet	15,000		15,500		13,500	
			Ab. Normal	9,000		11,000		9,000	
			Bl. Normal	2,500		3,500		3,500	
			Dry	1,500		1,500		1,000	
			Critical	1,500		1,000		1,000	
o Sacramento Salmon Rio Vista 1953-1987	Flow at Rio Vista and Cross-Channel status.	Flow pattern estimated to provide protection comparable to that from 1953 to 1987, plus Cross-Channel closures to prevent some smolt diversion	Wet	22,500	C	22,000	C	17,000	C
			Ab. Normal	22,500	C	17,000	C	7,000	C1
			Bl. Normal	14,000	C	11,500	C	7,500	C1
			Dry	8,000	C	7,000	C1	5,000	C1
			Critical	7,000	C	5,000	C1	4,000	O
o San Joaquin River Salmon Vernalis 1953-1987	Vernalis Flow	Flow pattern estimated to provide protection comparable to that from 1953-87 @ Vernalis (During buildup of SWP & CVP)	Wet	14,000		13,500		11,000	
			Ab. Normal	5,000		5,000		5,000	
			Bl. Normal	2,500		3,500		3,000	
			Dry	1,500		1,500		1,000	
			Critical	1,000		1,000		1,000	
							Subnormal Snowmelt		Subnormal Snowmelt
o Sacramento Salmon Rio Vista Delta Plan	Delta Outflow	Delta Plan had no specific protection for Salmon smolts but other standards provided protection as indicated	Wet	10,000	O	13,350	C 8,000	14,000	C 7,600
			Ab. Normal	7,600	O	12,950	C 7,600	10,700	O 7,600
			Bl. Normal	7,600	O	10,800	C 7,600	9,500	O 6,850
			Dry	7,600	O	7,600	O	6,150	O
			Critical	6,700	O	4,350	O	3,900	O
o San Joaquin River Salmon Vernalis Delta Plan	Vernalis Flow	Delta Plan had no specific protection for Salmon smolts							

Footnote: C = closed, C1 = closed, open weekends only, O = open

FIGURE 7.2.3.1-1 Average April-June flows[1] for selected historical periods providing different levels of protection for Salmon



[1] Average monthly flows calculated with a maximum Sacramento River flows at Rio Vista of 22,500 cfs and maximum San Joaquin River flows at Vernalis of 20,000 cfs because maximum salmon survival/production was shown by USFWS and DFG to occur at these flows. Therefore, it is assumed there is no additional benefit to fisheries at flows exceeding these values.

[2] The apparent increase in Sacramento River flows over the 1972 - 1987 period is due to the fact that the average April-July runoff for the 1922 - 1978 hydrology used to calculate the expected flows is 14% wetter than the 1972 - 1987 period for the Sacramento River Basin. Average unimpaired runoff for both time periods on the San Joaquin system are within 1% of each other.

[3] Expected future conditions with the 1978 Delta Plan are those shown in DWR's 1990 Level of Development operations study using 1922-78 hydrology (DWR, 30)

future. As can be seen from Figure 7.2.3.1-1, continuation of the existing flow objectives in the Delta Plan (which do not specifically protect salmon outmigration) will result in a relative decline in important salmon smolt flows on the San Joaquin River system when compared with flows experienced in the recent past. The apparent increase in Sacramento River flows under expected future conditions is due to the fact that the 1922-78 period used in this analysis is 14 percent wetter on the Sacramento system than the 1972-1987 period. The two hydrologic periods on the San Joaquin system, however, are essentially the same (less than one percent difference). Some hearing participants recommended that activities outside the Estuary be tried to resolve salmon survival concerns. Activities such as upstream habitat improvements might be successful on the Sacramento River system given the small expected decrease in spring flows under the no action alternative. However, it is unlikely that such actions would be successful on the San Joaquin River system with the decrease in April-June flows expected in the future.

Some parties suggested that additional fishery catch restrictions or other activities outside the scope of the Board's authority be pursued to address salmon concerns. While the option exists to take no action related to the further regulation of flows and exports, it is not reasonable to rely on "out of Estuary" measures to correct habitat concerns related to factors in the Estuary. To do so would be to have one segment of society mitigate for the effects not caused by their actions. Furthermore, fishery agencies testified that "out of Estuary" restrictions would have relatively little beneficial effect if smolts migrating through the Delta continued to experience poor conditions within the Delta.

Moderate flows are also needed for homing by adults during the upstream spawning migration from July-December. The 1978 Delta Plan contains minimum flow objectives for upstream salmon migration in the Sacramento River. These objectives were developed before the recent information on outmigrant smolts was known. In the absence of evidence to the contrary, these flows are assumed to be adequate and should be retained.

Currently there are no requirements for minimum upstream flows on the San Joaquin River for upstream salmon migration. Low dissolved oxygen at Stockton may also cause a blockage to upstream salmon passage. A 1969 agreement between DWR, USBR, and DFG provided for 1) installation of a temporary barrier across Old River when dissolved oxygen (DO) falls below 6 mg/l so that flows increase down the San Joaquin River, or 2) if that is not successful, increased flow releases. This objective should be incorporated in this Plan.

- Exports and Diversions

Salmon smolt migration through the Estuary is also affected directly by diversions and exports and indirectly by flow reversals caused by exports. Since 1967, export rates from the Estuary have increased over this same period while salmon populations have declined (see Figure 7.2.3.1-2). Alternatives to address these fishery impacts are discussed in the section below.

7.2.3.2 Striped Bass

- Outflow

Striped bass have undergone a decline in the numbers of young that survive their first summer. A gradual decline began soon after the start of operation of the SWP in 1967 and became precipitous in the late 1970's. This decline is shown on Figure 7.2.3.1-2. The exact cause for this decline is unknown. However, five causes have been postulated, of which four relate to water project operations and one relates to pollutants. The Board's Striped Bass Health Monitoring Program has indicated that the burdens of various pollutants in adult striped bass, and the percentage of egg resorption, have both improved in recent years. Yet the numbers of young striped bass, as measured by the striped bass index, continue to decline.

Outflows move the striped bass larvae (and young of American shad, salmon, etc.) out of the Delta and away from the influence of export pumps, diversions and power plants, and into the Suisun Bay nursery areas. A relationship of spring flow and exports to young bass populations in the summer was developed from data collected during the mid-1950's to the mid-1970's. However, in recent years, exports have increased beyond those for which this relationship was developed. Therefore, it is not surprising that this historic relationship no longer holds true. Higher outflows and reduced exports appear to be needed to help reverse this recent decline.

- Alternative Levels of Protection

New Delta outflow objectives for striped bass were recommended by DFG, USFWS and others. These agency recommendations are shown in Table 7.2.3.2-1. The dry water year following a dry or critical water year relaxation proposed by DFG has been deleted from that shown in Table 7.2.3.2-1 for the following reasons: (1) the year type definitions discussed previously now closely reflect April-July runoff conditions; (2) the year type definition already has a year after critical year relaxation built into it; and (3) recent project operations indicate that, while fishery standards are greatly relaxed in critical years, project operations are not modified commensurate to the fishery relaxation; operations, in fact, use the relaxation to

FIGURE 7.2.3.1-2

STRIPED BASS INDEX, SACRAMENTO/SAN JOAQUIN NATURAL SALMON POPULATION AND TOTAL DELTA EXPORTS

SBI: 1959 - 1988, EXCEPT 1966; POPULATION: SR 1953 - 1984, SJR 1953 - 1984; EXPORTS: AVERAGE APRIL - JULY EXPORTS, 1953 - 1987

(5 Year Running Average)

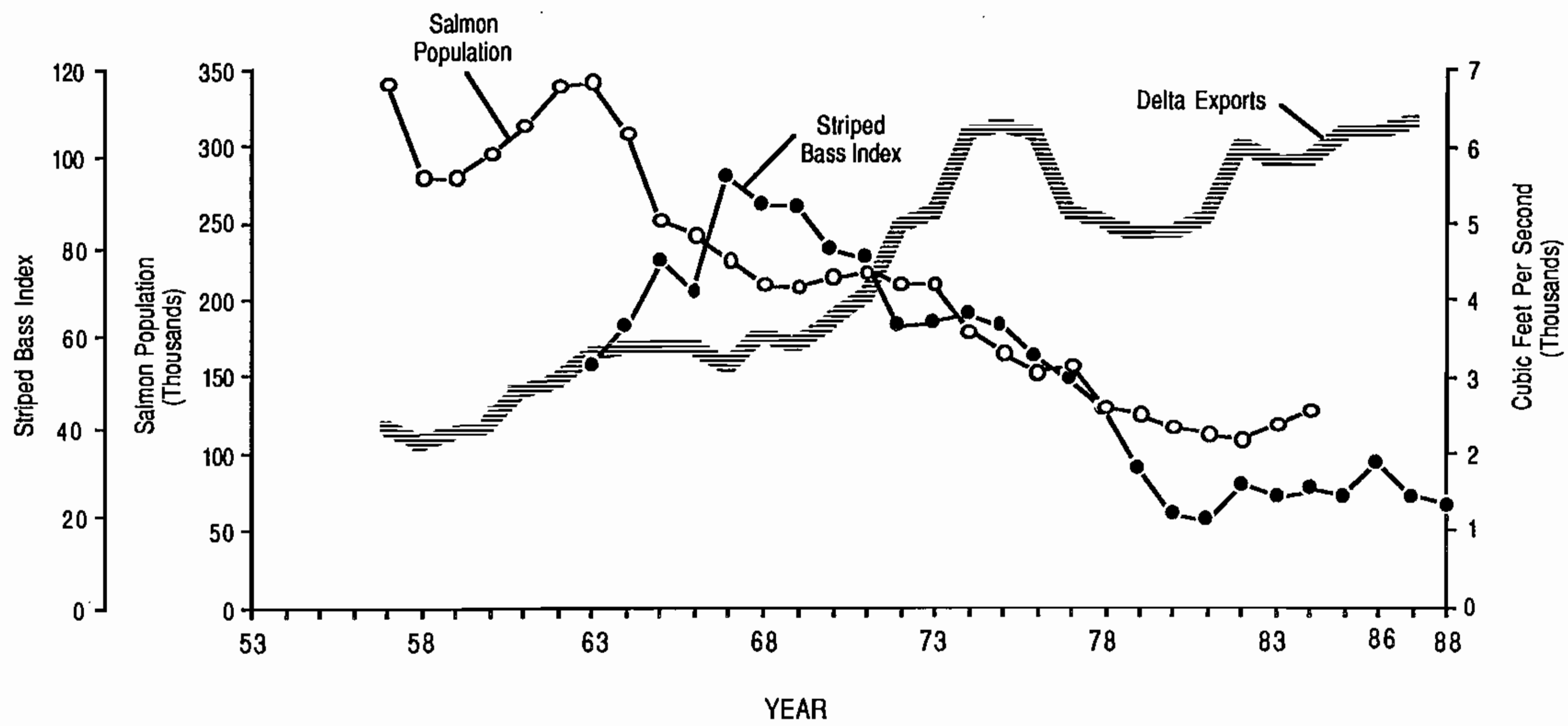


TABLE 7.2.3.2-1

ALTERNATIVE LEVELS OF PROTECTION
FOR DELTA FISHERIES (INCLUDING STRIPED BASS)
VIA DELTA OUTFLOW

Beneficial Use Protected and Method	Parameter	Description	Year Type	Values				
FISH HABITAT								
				4/1-30	5/1-31	6/1-30	7/1-15	7/16-31
o Delta Outflow Staff Recommendation	Mean Monthly Delta Outflow at Chipps Is.	Habitat quality to provide egg and larval transport through Delta and maintain suitable habitat for rearing in Suisun Bay.	Wet	32400	32400	32400	29000	29000
			Ab. Normal	26000	26000	20000	15000	15000
			Bl. Normal	22000	22000	16000	10000	NA
			Dry	12000	12000	12000	10000	NA
			Critical	9600	9600	9600	NA	NA
				4/1-30	5/1-31	6/1-10	6/11-17	6/18-7/31
o Delta Outflow DFG-USFWS Recommendation	Mean Monthly Delta Outflow at Chipps Is.	Habitat quality to provide egg and larval transport through Delta and maintain suitable habitat for rearing in Suisun Bay.	Wet	NA	30000	30000	20000	10000
			Ab. Normal	NA	25000	25000	17500	10000
			Bl. Normal	NA	22000	22000	16000	10000
			Dry	NA	12000	12000	10000	8000
			Critical	NA	3300	3300	3100	2900
				4/1-14	4/15-5/5	5/6-31	6/1-30	7/1-31
o Delta Outflow with limits from 1978 Delta Plan	Mean Monthly Delta Outflow at Chipps Is.	Habitat quality to provide egg and larval transport through Delta and maintain suitable habitat for rearing in Suisun Bay (includes EC at Antioch of 1.5 mmho/cm for spawning 4/15-5/5)	Wet	6700	7600	14000	14000	10000
			Ab. Normal	6700	7600	14000	10700	7700
			Bl. Normal	6700	7600	11400	9500	6500
			Dry	6700	7600	4300	3600	3200
			Critical	6700	7600	3300	3100	2900
			Dry & defic			3300	3100	2900

continue to meet full project demands. Therefore, such relaxation terms should be used only sparingly.

Upon review of the basic data presented on striped bass during the Phase I hearing, an alternative set of objectives has been proposed for consideration. This alternative set provides protection in April and increases critical year protection compared to DFG proposed levels. These values are shown in Table 7.2.3.2-1. Also shown in this Table are the 1978 Delta Plan flow objectives for striped bass.

- Export Flows

An integral factor affecting Delta fisheries is the exports from the CVP Tracy Pumping Plant and the SWP Banks Pumping Plant which can create flow reversals the lower San Joaquin, Old and Middle rivers. Appropriate limits on these large diversions are the subject of much debate. Fishery agencies and other interested parties recommended that, in the long term, improvement of the fisheries would result from positive downstream flows in Old and Middle rivers during the spring months. Such positive downstream flows result when San Joaquin River flows exceed exports and channel depletions in the southern Delta. Therefore, export rates that will achieve positive downstream flows must be matched month by month with the San Joaquin River inflows and channel depletions if the goal of positive downstream flows is to be achieved.

- Alternative Levels of Protection

Four alternative export water quality objectives have been developed for the April through July period. They are:

(1) Positive downstream flow in Old and Middle rivers by coordinating export levels with high San Joaquin River inflows resulting from the 1930-1952 flow objectives;

(2) Positive downstream flow in Old and Middle rivers by coordinating export levels with low San Joaquin River inflows resulting from 1953-1987 flow objectives;

(3) Average pre-SWP export conditions (1953-1967); and

(4) 1978 Delta Plan export limits.

All of these objectives are shown in Table 7.2.3.2-2. The first alternative evaluated the export rates that would allow positive downstream flows (about 500 cfs) in Old and Middle rivers in about 35 percent of the months assuming a San Joaquin River inflow generally equal to those that occurred during the period 1930-1952. The second alternative evaluated the export levels that were possible by using 1953-1987 San Joaquin River inflows, yet still maintaining approximately the same downstream flow pattern as in the first alternative.

TABLE 7.2.3.2-2

ALTERNATIVE LEVELS OF PROTECTION
FOR DELTA FISHERIES (INCLUDNG STRIPED BASS)
VIA EXPORT LIMITS

Beneficial Use Protected and Method	Parameter	Description	Year Type	Values in CFS			
FISH HABITAT							
				4/1-30	5/1-31	6/1-30	7/1-31
(1) Export Limits with Pre-1950 SJR inflows	Combined Exports by CVP and SWP	Export limits needed to help minimize loss of eggs, larval and young fish through export pumps and diversions by making flows positive (about 500 cfs) downstream in Old and Middle rivers.	Wet	7,000	7,000	6,000	7,000
			Ab. Normal	6,000	6,000	5,000	6,000
			Bl. Normal	5,000	5,000	4,000	6,500
			Dry	3,500	3,500	3,500	5,750
			Critical	3,500	3,500	3,500	NA
				4/1-30	5/1-31	6/1-30	7/1-31
(2) Export Limits with 1953-87 SJR Post-CVP inflows	Combined Exports by CVP and SWP	Export limits needed to help minimize loss of eggs, larval and young fish through export pumps and diversions by making flows positive (about 500 cfs) downstream in Old and Middle rivers.	Wet	10,000	8,000	6,000	4,000
			Ab. Normal	2,000	2,000	1,000	1,000
			Bl. Normal	1,000	1,000	1,000	1,000
			Dry	1,000	1,000	1,000	1,000
			Critical	1,000	1,000	1,000	NA
				4/1-30	5/1-31	6/1-30	7/1-15
(3) Export Limits with 1953-67 Pre-SWP Avg. exports	Combined Exports by CVP and SWP	Exports under recent historic conditions which restricted loss of egg and larval fish to pumps and diversions, flow in Old and Middle rivers generally downstream.	Wet	10,000	8,000	6,000	3,300
			Ab. Normal	2,000	2,900	3,700	4,200
			Bl. Normal	2,000	2,000	2,900	3,300
			Dry	3,000	3,300	4,000	4,600
			Critical	2,800	2,800	3,000	4,300
				4/1-30	5/1-31	6/1-30	7/1-31
(4) Export Limits Delta Plan	Combined Exports by CVP and SWP	Exports under Delta Plan conditions intended to reduce loss of egg and larval fish to pumps and diversions, no consideration for flow direction in San Joaquin, Old, or Middle rivers.	All	NA	6,000	6,000	9,200

3rd alternative pre-SWP export conditions 1953-67

The third alternative addresses the return to export conditions as they existed on the average after the start of substantial exports by the CVP and operation of the Delta Cross Channel gates (1953) but prior to the SWP operation in 1967. The export rates during April-July for the various water year types (based on the new San Joaquin River Basin definition) during this period were averaged to obtain these values. Exports were adjusted to be higher in wet years than those actually observed during the 1953-1967 period. Positive downstream flows in Old and Middle rivers would result with this alternative's high San Joaquin River inflows even at the elevated export rates.

During 1953-1967, exports were much lower than they are at present. Old and Middle river flows were not always positive, but the Delta fishery was less affected by the effects of exports than they are today. As discussed previously, of the five hypothesized causes for the recent striped bass decline, four relate to project operations. Returning to export rates reflective of a time when Delta fisheries (especially striped bass) were doing much better than they are today is no guarantee that the declines in these populations will be reversed. However, it does provide for improving spring Delta conditions which presumably will benefit the fishery. This alternative is a step toward achieving the fishery agencies' desired goal of positive downstream flow by reducing the magnitude of reverse flows. It is anticipated that the proposed conditions will also enhance overall salmon smolt survival through increased streamflow and reduced entrainment.

The fourth alternative would retain current export limitations for May, June and July contained in the 1978 Delta Plan, with no specific export limitations for April.

7.2.3.3 Other Beneficial Uses

- American Shad

As noted in Chapter 5, American shad have been impacted by the present Plan standards. The data presented by DFG do not provide an accurate picture of what these impacts are. In addition, much of the information developed on shad resulted as a by product of investigations of other species, rather than a detailed study of the particular needs of shad. In any case, DFG did not propose any specific objectives for shad, just as they did not in the 1978 Plan. Their belief, then as now, is that the striped bass objectives they proposed will benefit shad as well.

This concept of collateral protection for shad seems to be appropriate for the present Plan as well. An examination of the optimal needs for shad in Section 5.3.6 shows that, particularly during the spring, shad are quite similar to striped bass, in terms of the need for adequate flows, reduced translocation out of the Sacramento River into the central

Delta, and reduced entrainment by diversions and exports. The flows, export limitations and Delta Cross Channel gate operations discussed for salmon and striped bass should provide shad substantial increases in protection compared to the 1978 Plan.

The major difference between the shad and striped bass is that some young shad remain in the Delta or in tributary streams into the summer and fall, while the young striped bass tend to be largely out of the Delta by the end of July. These late summer and fall outmigrating shad will not receive specific protection under the proposed Plan. The proportion of the population which are late outmigrants is not known, but it is assumed that increased protection for striped bass provided in the April-July period will accomplish three things: 1) provide better migration and spawning habitat for adult shad; 2) provide increased protection for the earlier migrants; and 3) perhaps increase the proportion of early migrants because of the increasd flows in tributary streams during the April-July period to meet Delta inflow and outflow requirements. Better documentation of the population dynamics and needs of American shad need to be provided before definitive objectives can be considered for that species. As noted, the non-1978 Delta Plan levels of protection presented for striped bass should provide additional protection for shad, compared to present conditions.

- Migratory Fish Food Chains

The Phase I of the hearing included considerable discussion of the food chains in the Bay and Delta, particularly the food requirements of young outmigrating striped bass and shad. Limited information was presented on the requirements of salmon smolts. All three species begin feeding on very small invertebrates, such as copepods (and small insects in the case of salmon and shad), and then progress to larger invertebrate species, particularly Neomysis. The data presented indicate that the food chain of the Estuary, particularly the Delta, is in a very dynamic state at present. Delta phytoplankton blooms, presumed to be a major component of the base of the food chain, have been dominated by the chain diatom Melosira in recent years. The value of this species as food for copepods and Neomysis is unclear. In addition, the traditionally dominant copepod Eurytemora, a preferred food source for young striped bass, has been at least partially replaced by the introduced copepod, Sinocalanus. The recent appearances of the clam Potamocorbula amurensis, and the benthic amphipod Lagunogammarus, both recently introduced and rapidly expanding in range and numbers, further complicate our limited understanding of the food chain dynamics of young striped bass and shad. Attempting to set objectives in such a changing environment is not possible at present.

In general, the proposed increased spring flows and reduced exports may result in a Delta and Suisun Bay habitat more conducive to the propagation of those species which have been beneficial to species in food chains of young anadromous fish in the past, since the habitat will approximate those earlier conditions more closely. However, there is no guarantee that this will occur. In any case, the understanding of the dynamics and interactions of the food chains in the Estuary must be greatly increased before proposed objectives for protection of the food chains can be considered. Indeed, there has not been demonstrated at present solid evidence that the changes in the food chains are having a deleterious effect on young striped bass, salmon, shad, or other Estuary species. Considerable additional effort in this area is warranted.

- Striped Bass Migration Up the San Joaquin River

As discussed in Chapter 5, striped bass generally do not migrate upstream into water with an electrical conductivity (EC) in excess of about 0.550 mmhos/cm, and appear to prefer spawning in water fresher than about 0.300 mmhos/cm. The Delta Plan objectives call for a maximum of 0.550 mmhos/cm at Prisoners Point for the period April 1 to May 5. While this objective may still impose a migration limit on striped bass, the other proposed objectives may somewhat compensate for this limitation. Increased outflows and reduced exports during the April-July period should result in greater outmigration of larvae produced in the San Joaquin River spawning area than at present, with presumably greater survival. In addition, increased flows in the San Joaquin River in wet and above normal years, combined with the reduced exports, may result in water quality better than that provided by the proposed objective. This may result in removal of, or at least a reduction in, this upstream barrier in wetter years. Additional monitoring of salinity in the mainstem San Joaquin, combined with better sampling for striped bass eggs and larvae in the eastern Delta, will provide additional information on the effects of the proposed objectives and the potential use of the San Joaquin River by striped bass in wetter year types. Available data are not adequate to attempt to propose a lower EC objective in the San Joaquin River.

- Races of Chinook Salmon Other Than Fall Run

Very little information is available on the other three races of Chinook salmon using the Estuary. What was presented in the Phase I of the hearing was not sufficient to identify flow or water quality needs, nor to develop water quality objectives. Additional studies are needed to develop such information.

- Other Aquatic Resources

A variety of other aquatic resources considered in the Phase I of the hearing, including: phytoplankton and zooplankton in San Francisco Bay, Bay outflow and offshore habitat, freshwater and estuarine benthic organisms, bay fish, Delta resident and other anadromous fish, pollutant flushing flows, upstream uses, export fishery habitat, export recreation, and Estuary recreation. After due consideration, no specific flow or salinity objectives is proposed for any of these aquatic resources. In most cases, the absence of specific objectives is due to lack of sufficient information upon which to base objectives, or because the aquatic resources are already protected under another objective. For example, no specific objectives are proposed for export fishery habitat or export recreation because the Municipal and Industrial objectives discussed previously for export water provides adequate protection for these aquatic resources as well. The specific reasons for the absence of proposed objectives for these resources is discussed in Chapter 4.

7.2.3.4 Suisun Marsh

- Managed Wetlands

The Suisun Marsh consists of about 50,000 acres of managed wetlands and 7,000 acres of tidal marsh. DFG, Suisun Resource Conservation District, DWR and USBR have entered into an agreement to protect these managed wetlands and mitigate for the loss of about 900 acres of managed wetland and tidal marsh impacted by facility construction and reduced outflows. This agreement allows water quality relaxation beyond the water quality objectives contained in the 1978 Delta Plan, Water Right Decision 1485 and State Board Order of December 5, 1985. The only major difference between the objectives being considered and those in the agreement is in the determination of water year types. For consistency with the other objectives, compliance with these objectives will be determined by using the water year types set forth in Chapter 3. This includes the use of the 50th percentile forecast of future runoff conditions instead of the 20th percentile as set forth in the agreement.

- Tidal Marshes

One concern left unresolved in the testimony presented in Phase I is the protection of rare and endangered species that inhabit the tidal marsh in Suisun Bay and the Suisun Marsh areas outside the managed wetlands. The provision of flows specifically to protect these areas could result in an additional 600,000 acre-feet to be released on the average each year during dry periods. This amount is above and beyond that required under the alternatives discussed in the following section. The DFG, the agency responsible for the protection of rare and endangered species, is requested to provide the Board in Phase II with its recommendations on how rare and endangered species in the tidal marsh areas of Suisun Bay and Suisun Marsh should be protected via this Water Quality Control Plan.

7.2.3.5 San Francisco Bay

San Francisco Bay was discussed extensively during the Board's Phase I of the hearing. This information was addressed in detail in Chapters 4 and 5. The information presented did not provide an adequate connection between physical changes in the Bay due to inflows and the beneficial uses in the Bay. The evidence presented was judged not sufficient as a basis for water quality objectives. Further studies should be performed to address these concerns. The concerns regarding protection of San Francisco Bay should also be addressed during consideration of the water right permits of any large unconstructed water storage projects.

7.3 Development of Alternative Objectives

There are many possible alternative sets of water quality objectives that can be developed from the water quality and flow needs for Bay-Delta Estuary uses presented in the previous section. Six logical alternatives that span this range of needs have been selected. The alternatives and the level of protection provided each beneficial use are presented in Table 7.3-1.

This section discusses the global balancing of the various beneficial uses of Bay-Delta waters. This global process builds upon all the information presented thus far, especially the California water ethic, to produce a recommended set of water quality objectives that reasonably protect the beneficial uses of Bay-Delta Estuary waters.

good

In the balancing process, one must recognize that biological resources have declined and currently are not experiencing the same degree of protection as other beneficial uses. In light of the evidence submitted during the Phase I hearing, past attempts to protect biological resources in the Estuary have not achieved the level of protection sought. Declines in biological resources of the Estuary need to be taken into consideration in the current balancing process.

7.3.1 Effects on Water Availability

To develop balanced water quality objectives, assessment must be made of the impacts resulting from the objectives under consideration. This is done by determining the controlling flow and salinity objectives, i.e., those which require the most water to attain, for each alternative and comparing the water requirements against a base condition. Two base conditions were used to provide a range of impacts: (1) a 1990 level of development operations study which uses the water quality standards of the 1978 Delta Plan as a constraint and (2) the actual historical conditions that existed between 1972-1987, excluding the wettest year of record, 1983. (Excluding this year, the wettest of record that shows the average, makes the average San Joaquin River Basin April through July unimpaired flows for these two hydrologic periods almost identical.) The differences between the alternative and the base are then calculated for each month and summarized by water year type.

TABLE 7.3-1

ALTERNATIVE SETS OF WATER QUALITY OBJECTIVES

Alternatives	(1)	(2)	(3)	(4)	(5)	(6)
Description of key provisions	Optimal Level	High SJR Flows High Exports	Moderate SJR Flows Low Exports	Moderate SJR Flows Delta Plan Exports	Recommended Plan	No Action
Beneficial Use						
Municip. & Indust. (Footnote 1)	150 mg/l Chloride (Contra Costa Canal) 250 mg/l Chloride elsewhere	250 mg/l Chloride	250 mg/l Chloride	250 mg/l Chloride	250 mg/l Chloride	Delta Plan
West Delta Ag. (Footnote 2)	1.5 mmho/cm EC	1.5 mmho/cm EC 3.0 mmho/cm EC	1.5 mmho/cm EC 3.0 mmho/cm EC	1.5 mmho/cm EC 3.0 mmho/cm EC	1.5 mmho/cm EC 3.0 mmho/cm EC	Delta Plan
South Delta Ag. (Footnote 3)	Delta Plan	Delta Plan	Delta Plan	Delta Plan	Delta Plan	New Melones
Sacto. Salmon (Footnote 4)	22,500 cfs	1930-1952	1930-1987	1930-1987	1930-1987	Delta Plan
SJR Salmon (Footnote 4)	20,000 cfs	1930-1952	1953-1987	1953-1987	1953-1987	Delta Plan
Delta Fishery Outflow object. (Footnote 5)	Optimal Flows	Staff	Staff	DFG	DFG p.7-13	Delta Plan
Delta Fishery Export limit (Footnote 5)	No exports May-Nov	Pos. Dwnstream Flow High SJR	Pos. Dwnstream Flow Low SJR	Delta Plan Exports	1953-1967 exports	Delta Plan
Suisun Marsh (Footnote 6)	Optimal Salinities	4-Agency Agreement	4-Agency Agreement	Delta Plan	4-Agency Agreement	Delta Plan
San Francisco Bay (Footnote 7)	Further Study	Further Study	Further Study	Further Study	Further Study	

see pp. 7-7 & Table 7.2.3.1-1 p. 7-8

p. 7-16, 7-15 data table combined CVP&SWP.

Footnote 1: See Section 7.2.1 for further description.

Footnote 2: See Section 7.2.2.1 for further description.

Footnote 3: See Section 7.2.2.2 for further description.

Footnote 4: See Section 7.2.3.1 for further description.

Footnote 5: See Section 7.2.3.2 for further description.

Footnote 6: See Section 7.2.3.4 for further description.

Footnote 7: See Chapter 4 under San Francisco Bay for further description.

7.3.1.1 The 1990 Level of Development Operations Study

The Operations Study used is that which was presented as DWR Exhibit 30 during the Phase I of the hearing, except that a carriage water requirement to meet a 250 mg/l chloride objective was used. This study uses the 1978 Delta Plan and New Melones criteria for the southern Delta as the controlling Delta objectives. The operation study uses the hydrological runoff conditions experienced from 1922 through 1978.

DWR includes an export expansion factor in its study

There are certain peculiarities about this study that must be emphasized. First, the average annual exports are about 6.1 million acre-feet for the entire study, whereas the maximum export for any water year to date has been the 1985 level of approximately 5.5 million acre-feet. Apparently the 1990 operation study has a built-in expansion of exports of about 0.6 million acre-feet beyond that seen in any year since the CVP and SWP have been operating. Review of the data indicates that virtually all this increase occurs in the months of October-April. This factor is important when comparing the impacts of these studies to the reasonable consumptive needs discussed in Chapter 6.

Second, the operations study somewhat overstates DWR's 1987 estimates of current agricultural net use in the Sacramento and San Joaquin basins. This is important when comparing alternatives to present or expected future conditions. The 1990 operation has enough agricultural demand built into it to satisfy in-basin growth through the year 2010 and beyond.

Also, one must keep in mind that operations studies are estimates, not reality. They are, in effect, a set of common rules by which alternatives can be compared; they are not intended to reflect how projects will actually operate. The results here are presented only to compare alternatives.

The output of the 1990 operations study presented by DWR was used to perform the analysis of alternatives. By changing the controlling Delta inflow and outflow objectives or export limits and keeping all other aspects of the study the same, we can compare the increases, or decreases, in flow required each month for the alternative in question beyond that of the 1978 Delta Plan. Care must be taken when determining the flows required to meet the controlling objectives to evaluate controlling objectives separately for the San Joaquin River, Sacramento River, as well as Delta outflow. By carefully evaluating months with surpluses, one can determine if water is saved under the new alternative or is needed to satisfy the new objectives. The process is simple in concept but is complicated in practice. Only summaries of the results of these studies will be presented here.

7.3.1.2 The 1972-87 Historical Base

The second base from which water supply impacts of the various alternative plans are compared is the 1972-87 actual historical conditions. As stated previously, the year 1983 was not used in this analysis. During most of the 1972-87 period the 1978 Delta Plan was in effect. During the time prior to 1978, the objectives of the Delta Plan were generally met with extra flows in the Delta beyond water project needs. The base flows for each month in this period were compared with those needed to meet the flows of each of the alternatives based on year type. The historical base flows were obtained from the DWR DAYFLOW data set, except for Delta outflow which was estimated using DWR consumptive use planning values (SWRCB, 1, Q-4). The process of comparison used is the same as that discussed for the 1990 operations study.

7.3.1.3 Assumptions Used in the Evaluation of Alternatives

A schematic showing the Delta's hydrologic scheme used in the water supply impact analysis is illustrated in Figure 7.3.1.3-1. The following are the assumptions used to evaluate the water supply impacts of alternative water quality objectives. These assumptions apply to both the 1990 operations study and the 1972-1987 historical period:

(1) All of the Estuary water quality objective locations were assigned to the Sacramento River system April through July hydrologic classification, except the following locations, which were assigned to the San Joaquin River system April through July hydrologic classification:

- San Joaquin River near Vernalis
- San Joaquin River at Mossdale
- San Joaquin River at the former location of Brandt Br.
- Bifurcation of Old and Middle River
- Middle River at Howard Road Bridge
- Old River at Tracy Road Bridge
- Delta Mendota Canal at Tracy Pumping Plant
- Clifton Court Forebay Intake at West Canal

(2) The Delta flow and salinity conditions necessary to meet objectives can be achieved through control of flows, exports, or gate operations at the Delta "control points." If the control point flows, exports, or gate operations are adequate to meet the local controlling objective, the other (noncontrolling) objectives within local influence of the control points are assumed to be met. The Delta control points are as follows:

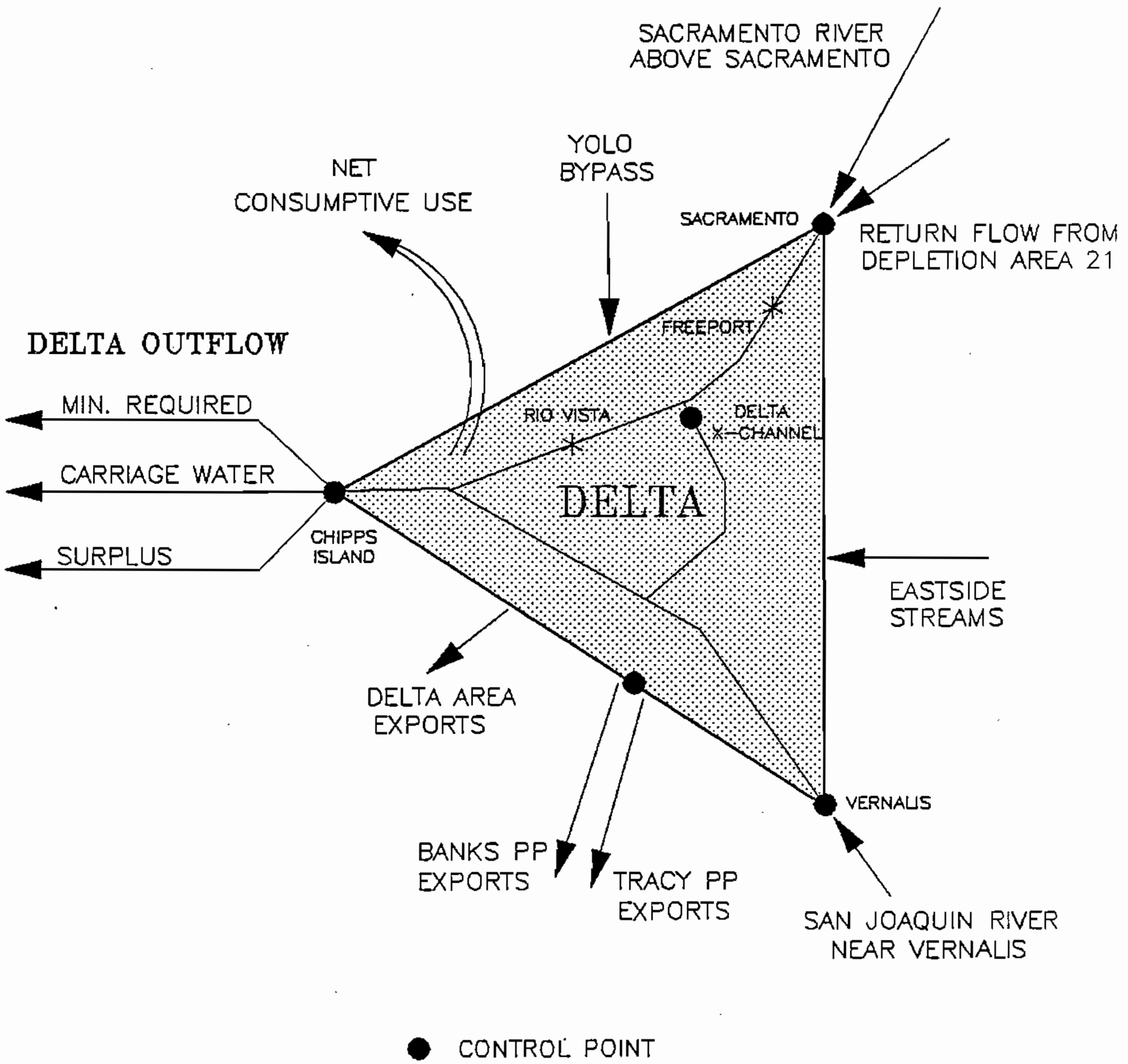
- Chipps Island
- San Joaquin River at Vernalis
- Sacramento River at Sacramento
- The Banks and Tracy Pumping Plants
- The Delta Cross-Channel near Walnut Grove

These control points are illustrated in Figure 7.3.1.3-1.

(3) The following basic equations apply for each of the hydrologic bases:

FIGURE 7.3.1.3-1

DELTA HYDROLOGIC SCHEME USED IN THE WATER SUPPLY IMPACT ANALYSIS



- The Delta outflow at Chipps Island, DO is defined as follows:

  DO = DI - NETCU - AREADIV - B&TEXP (1)

  where: DI = Delta inflow
  NETCU = Net Delta consumptive use
  AREADIV = Delta area diversions
  B&TEXP = Banks and Tracy Pumping Plan exports

- The Delta inflow, DI, is defined as follows:

  DI = SAC + YOLO + RF21 + SJR + EAST (2)

  where: SAC = Sacramento River flow above Sacramento
  YOLO = Yolo Bypass flow
  RF21 = Return flow from depletion ares 21
  SJR = San Joaquin River near Vernalis flow
  EAST = East side tributaries flow (Mokelumne, Cosumnes and Calaveras rivers)

- The net consumptive use, NETCU, is defined as follows:

  NETCU = CU - PREC (3)

  where: CU = Delta consumptive use
  PREC = Delta precipitation

- The Delta area diversions, AREADIV, is defined as follows:

  AREADIV = VALL + NBA + CCC + MDIV (4)

  where: VALL = City of Vallejo Diversions
  NBA = North Bay Aqueduct Diversions
  CCC = Contra Costa Canal Diversions
  MDIV = Miscellaneous Delta Diversions (MDIV = 0 for the 1990 level-of-development runs)

- The Banks and Tracy Pumping Plants' exports, B&TEXP, is defined as follows:

  B&TEXP = BANKS + TRACY (5)

  where: BANKS = Total Banks Pumping Plant exports
  TRACY = Tracy Pumping Plant exports

- The Delta outflow, DO, can also be divided into three components:

  DO = MINRQDO + CWDO + SURPDO (6)

where: MINRQDO = Minimum required Delta outflow at Chipps Island
CWDO = Carriage water requirement at Chipps Island
SURPDO = Surplus Delta outflow at Chipps Island

- The carriage water requirements can be adequately estimated using the method described in DWR Exhibit 30 and the effective export, EFFEXP. The effective export, EFFEXP, is defined as follows:

  EFFEXP = BANKS + TRACY - SJR - EAST - CCC (7)
  (see note below)

  Note: the CCC "export" was not included in DWR's 1990 level of development (LOD) analysis, even though the carriage water curves were developed using the "export" of the CCC; consequently, the alternative carriage water was estimated without the CCC to conform with the 1990 LOD analysis.

- The carriage water requirements for the alternatives were estimated using DWR's Carriage Water Table 5, which assumes the following objectives:

  - 250 mg/l chlorides at Clifton Court and Rock Slough in all years. (DWR assumed a Rock Slough "operational" objective of 225 mg/l chloride to provide an operational buffer to the 250 mg/l chloride objective.)

  - 1.5 mmhos/cm EC at Jersey Point from April 1 through August 15 in all years except EC critical; 1.5 mmhos/cm EC at Jersey Point from April 1 through June 30 and 3.0 mmhos/cm EC from July 1 through August 15 in critical water years.

If 1978 Delta Plan surplus Delta outflows occur, then projected reductions in minimum flow requirements in the San Joaquin River near Vernalis and the Sacramento River at Sacramento are considered water that could not be saved; conversely, if 1978 Delta Plan surpluses are zero, then projected reductions in minimum flow requirements are considered "savable" and are applied to offset water requirements in other months.

To the extent that surplus Delta outflow under the 1978 Delta Plan is available, it is used to reduce the impacts of the alternatives. The surplus Delta outflow is adjusted depending on the change in 1) Chipps Island minimum flow requirements, 2) carriage water requirements, and 3) Banks and Tracy exports. If the 1978 Delta Plan surplus is zero, the alternative surplus is also zero.

The YOLO, RF21, EAST, NETCU, and AREADIV alternative flows remain the same as in the 1978 Delta Plan.

Additional water needed to meet Delta objectives, exports or consumptive uses is obtained from the Sacramento River Basin through the Sacramento River at Sacramento.

7.3.2 Evaluation of Alternative Plans

In order to evaluate these alternative sets of water quality objectives, a determination had to be made as to whether the flow requirements of each could be achieved through implementation of the new California water ethic discussed previously or whether existing uses would need to be curtailed. The present and future reasonable water needs are discussed in Chapter 6. Important findings for San Joaquin River Basin, Sacramento River Basin, and export areas are discussed below:

In the San Joaquin River Basin April-July flows to the Delta can be increased through (1) an aggressive conjunctive use of surface and ground waters, and (2) a reoperation of existing reservoirs in the Basin. An analysis for the San Joaquin River Basin indicated that the potential increase in April through July flows would probably range from about 0.17 MAF/yr during critically dry years to almost 0.7 MAF/yr during wet years. The average between 1972-87 was estimated at about 0.49 MAF/yr.

In the Sacramento River Basin about 0.550 MAF of water supply reserves exist through the year 2010 (DWR Bulletin 160-87). This reserve supply could be used to meet additional flow requirements in the Bay-Delta Estuary.

For the entire State reasonable consumptive agricultural needs will decrease by about 1.0 MAF/yr from 1985 to 2010. However, reasonable consumptive municipal and industrial needs will increase by about 1.1 MAF/yr from 1985 to 2010.

The south Coastal Area can provide adequate water supplies to expected populations through the year 2010 at existing Bay-Delta export levels provided (1) aggressive water conservation and reclamation measures are pursued, and (2) water saved through agricultural water conservation in the Coachella and Imperial and San Joaquin Valleys is made available to augment expected decreases in water supplies to the south Coastal Area from the Colorado River Basin area.

An analysis has been made of the CVP and SWP ability to make up in other months, exports which are foregone in April through July. If exports are curtailed during the April-July period, about 0.7 to 0.8 MAF on the average can be made up annually by utilizing currently available pumping capacity in other months (up to the Corps of Engineers pumping criteria) provided (1) water supplies from the Sacramento River system are available to satisfy this demand and its carriage water requirements, (2) reservoir storage south of the Delta is more fully utilized during the spring and summer, and (3) municipal water users utilize alternative water sources during the spring and early summer rather than relying on Delta Supplies. These users could then switch to Delta supplies during the late fall and winter. This analysis utilized 1985 export rates (the highest to date and 16 percent higher than the 1979-1987 average) and compared them to exports expected in the fall and winter months under the 1990 operations study. The 1990 operations study shows that its average April through July exports are slightly higher than those experienced in 1985. However, it also shows higher pumping in the late fall and winter than currently exists under actual 1985 conditions by about 0.7 MAF per year. The 1990 operations study uses existing project facilities. Decreases in export pumping in April-July of around 0.7 MAF can be recouped in other periods.

Each alternative set of water quality objectives and their water supply impacts are discussed below. Table 7.3.2-1 tabulates the impacts of the alternatives compared to the 1990 level of development and Table 7.3.2-2 does the same but uses the historic base.

7.3.2.1 Alternative 1

Alternative 1 provides optimal protection to each beneficial use in the Estuary. This alternative was developed to provide a starting point for the analysis of the various other alternatives presented below. Each beneficial use in the Estuary for which adequate data are available was evaluated to determine what would be the ideal set of conditions for protection of that beneficial use. Each use was evaluated without regard for any other competing or complementary beneficial use. The purpose of this exercise was to indicate where different beneficial uses had similar needs, so that a single or few objectives could provide a measure of protection for several beneficial uses. For example, reductions in export levels in the spring months may provide benefit to the young of shad, salmon, and striped bass, as well as for western Delta agriculture. This knowledge provided greater flexibility in developing the other alternatives. Table 7.3.2-1 illustrates that April-July exports would be eliminated and average Delta outflow would increase by more than 7 million acre-feet. Large segments of California's population would no longer receive a water supply. The impacts of this alternative clearly are not reasonable.

7.3.2.2 Alternative 2

Alternative 2 provides the next highest level of protection of the beneficial uses for the Bay-Delta Estuary. Salmon fisheries are protected at the historical levels that existed generally prior to the 1950's. Flows for striped bass are set at levels initially proposed by State Board staff. The DFG and the USFWS recommended achievement of positive downstream flow in Old and Middle rivers during April-July. This alternative constrains exports in April-July to provide these flows about 38 percent of the time. Since striped bass and salmon have declined in the recent past, actions may be needed to prevent further decline and allow a reasonable recovery. Alternative 2 attempts to do this by increasing San Joaquin River flows on the average by about 1.0 to 1.3 million acre-feet during April-July (see Tables 7.3.2-1 and 7.3.2-2). This is an increase of about 200 percent. As stated previously, average flows in the San Joaquin can be increased by only about 0.5 MAF with an aggressive conjunctive use and reservoir reoperation program. Increases beyond this 0.5

TABLE 7.3.2-1

APRIL - JULY WATER SUPPLY IMPACTS
OF ALTERNATIVE SETS OF WATER QUALITY OBJECTIVES

1990 LEVEL OF DEVELOPMENT OPERATIONS STUDY (DWR 30)
AS THE BASE

Base Conditions (Millions of Acre Feet)		Change in Base Flows Needed to Meet Alternative (Millions of Acre-Feet)					
		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Average (Based on 57-year record)							
Sacramento *	5.074	2.2	0.402	0.579	0.689	0.358	0.000
San Joaquin	0.636	3.3	1.308	0.528	0.528	0.528	0.000
Exports(-)	1.735	-1.7	-0.465	-1.074	0.000	-0.676	0.000
Other Flows **	-0.268	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	3.707	7.2	2.175	2.181	1.217	1.562	0.000
Wet (18 years out of 57-year record)* **							
Sacramento	7.354	0.8	1.238	1.480	0.402	0.132	0.000
San Joaquin	1.102	3.0	1.525	0.979	0.979	0.979	0.000
Exports(-)	1.794	-1.7	-0.297	-0.539	0.000	-0.406	0.000
Other Flows	0.366	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	7.028	5.5	3.060	2.998	1.381	1.517	0.000
Above Normal (8 years out of 57) * **							
Sacramento	5.129	1.8	0.323	0.715	0.939	0.613	0.000
San Joaquin	0.654	3.4	1.635	0.621	0.621	0.621	0.000
Exports(-)	1.817	-1.8	-0.446	-1.200	0.000	-0.781	0.000
Other Flows	-0.187	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	3.779	7.0	2.404	2.536	1.560	2.015	0.000
Below Normal (14 years out of 57)* **							
Sacramento	4.190	2.5	-0.074	0.040	1.253	0.689	0.000
San Joaquin	0.399	3.6	1.531	0.347	0.347	0.347	0.000
Exports(-)	1.842	-1.8	-0.621	-1.604	0.000	-1.004	0.000
Other Flows	-0.596	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	2.151	7.9	2.078	1.991	1.600	2.040	0.000
Dry (11 years out of 57)* **							
Sacramento	3.717	3.1	-0.267	-0.214	0.473	0.098	0.000
San Joaquin	0.337	3.5	0.914	0.182	0.182	0.182	0.000
Exports(-)	1.729	-1.7	-0.633	-1.349	0.000	-0.823	0.000
Other Flows	-0.687	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.638	8.3	1.280	1.317	0.655	1.103	0.000
Critical (6 years out of 57)* **							
Sacramento	2.714	4.3	0.335	0.404	0.300	0.177	0.000
San Joaquin	0.320	3.4	0.419	0.104	0.104	0.104	0.000
Exports(-)	1.205	-1.2	-0.324	-0.775	0.000	-0.316	0.000
Other Flows	-0.728	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.101	8.9	1.078	1.283	0.404	0.597	0.000
1928-34 Dry Period (7 years)							
Sacramento	3.218	3.6	0.095	0.157	0.651	0.482	0.000
San Joaquin	0.346	3.5	1.070	0.226	0.226	0.226	0.000
Exports(-)	1.451	-1.5	-0.416	-1.197	0.000	-0.568	0.000
Other Flows	-0.67	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.443	8.6	1.581	1.580	0.877	1.276	0.000

* Includes return flows from Hydrologic Study Area 21.
** Banks and Tracy Pumping Plants only.
*** Alternatives are summarized based on Sacramento Basin year types. However objectives for San Joaquin River and exports were always based on San Joaquin Basin year types, even when different from Sacramento Basin year type.

TABLE 7.3.2-2

APRIL - JULY WATER SUPPLY IMPACTS
OF ALTERNATIVE SETS OF WATER QUALITY OBJECTIVES

HISTORICAL LEVEL OF DEVELOPMENT USING VALUES FROM
YEARS 1972-87 (EXCEPT 1983) AS BASE

Base Conditions (Millions of Acre Feet)		Change in Base Flows Needed to Meet Alternative (Millions of Acre-Feet)					
		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Average (Based on 15 years of record)							
Sacramento	4.558	2.671	0.401	0.525	0.687	0.474	0.000
San Joaquin	1.066	2.936	0.995	0.406	0.406	0.406	0.000
Exports(-) *	1.397	-1.397	-0.132	-0.556	-0-	-0.201	0.000
Other Flows	-0.202	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	4.025	7.004	1.528	1.487	1.093	1.081	0.000
Wet (3 of 15 years) **							
Sacramento	8.231	0.516	0.928	1.159	0.026	-0.064	0.000
San Joaquin	1.733	2.471	1.340	1.066	1.066	1.066	0.000
Exports(-)	1.506	-1.506	0.096	0.151	-0-	-0.118	0.000
Other Flows	1.541	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	9.999	4.493	2.172	2.074	1.092	1.12	0.000
Above Normal (1 of 15 years)							
Sacramento	5.495	1.748	0.605	0.826	0.671	-0.449	0.000
San Joaquin	2.905	1.241	0.730	0.224	0.224	0.224	0.000
Exports(-)	1.304	-1.304	0.302	0.357	-0-	-0.324	0.000
Other Flows	-0.233	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	6.863	4.293	1.033	0.693	0.895	0.099	0.000
Below Normal (6 of 15 years)							
Sacramento	3.995	2.669	0.117	0.243	1.137	0.787	0.000
San Joaquin	1.018	3.025	1.229	0.379	0.379	0.379	0.000
Exports(-)	1.510	-1.510	-0.168	-0.787	-0-	-0.380	0.000
Other Flows	-0.511	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	2.992	7.204	1.514	1.409	1.516	1.546	0.000
Dry (1 of 15 years)							
Sacramento	3.347	3.584	0.063	0.110	1.171	0.690	0.000
San Joaquin	0.539	3.323	0.643	-0.115	-0.115	-0.115	0.000
Exports(-)	1.738	-1.738	-0.790	-1.544	-0-	-0.740	0.000
Other Flows	-0.813	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.335	8.645	1.496	1.539	1.056	1.315	0.000
Critical (4 of 15 years)							
Sacramento	2.715	4.291	0.466	0.501	0.398	0.360	0.000
San Joaquin	0.309	3.480	0.541	0.127	0.127	0.127	0.000
Exports(-)	1.085	-1.085	-0.195	-0.722	-0-	-0.168	0.000
Other Flows	-0.882	-0-	-0-	-0-	-0-	-0-	-0-
Total Delta Outflow	1.057	8.856	1.202	1.350	0.525	0.655	0.000

* Banks and Tracy Pumping Plants only.
** Alternatives are summarized based on Sacramento Basin year types. However objectives for San Joaquin River and exports were always based on San Joaquin Basin year types, even when different from Sacramento Basin year type.

MAF level would likely require a curtailment of existing uses in the Basin. This alternative would provide greatly enhanced protection to Estuary uses over those existing levels while having a significant impact on upstream users. This does not appear to be reasonable.

7.3.2.3 Alternative 3

Alternative 3 provides protection to the salmon resources in the Sacramento River system by preserving the April-June flows (shown to be important to salmon) at levels that have existed on the average over the period of record (1930-1987). However, on the San Joaquin River system a more modest level of protection is sought. It represents a more recent period of flows reflective of the current Delta physical condition (1953-87). This level of protection is more achievable on the San Joaquin system than that provided under Alternative 2. This level of protection is better than that provided under the no action alternative. It would prevent the important spring flows in the San Joaquin River from dropping any lower in the future as would be expected under the no action alternative. Since the level of protection sought is an average over a 35-year period, and reflects a level that generally occurred before these two fishery resources were showing a dramatic decline, it actually provides some increase over present day flows.

Striped bass protection is at levels initially proposed by State Board staff. Exports are decreased to allow for positive net downstream flows in April-July about 35 percent of the time in Old and Middle Rivers.

As shown in Tables 7.3.2-1 and 7.3.2-2, Alternative 3 reduces the average April-July water flow demands on the San Joaquin River system between 0.53 and 0.41 MAF above the base flows. This is a more achievable level. However, in so doing, it also calls for reductions in spring exports over those planned in the future by about 1.1 MAF. This represents about a 65 percent decrease in April-July exports. Some of this decrease may be able to be regained through increased exports in other months at the cost of building addition storage south of the Delta. However, this entire amount could not be regained without additional facilities in the Delta.

7.3.2.4 Alternative 4

Alternative 4 is the same as Alternative 3 except it retains the export limitations set forth in the current Delta Plan and the Delta outflows for striped bass as recommended by DFG and the USFWS. This means that the only mechanism used to address the concerns raised regarding the status of the salmon and striped bass fisheries is to increase flows. Exporters are not asked to shoulder any of the burden even though export operations are known to have effects on internal Delta flows and physically remove milions of young fish each year. The water supply impacts are shown in Table 7.3.2-1 and 7.3.2-2. Although this alternative has the least overall impact on water users, it too does not provide an equitable sharing of responsibilities to protect beneficial uses in the Bay-Delta Estuary.

7.3.2.5 Alternative 5

Alternative 5 offers the level of flows for protection of salmon as set forth under Alternative 3. However, outflow protection provided to striped bass is commensurate with that recommended by the DFG and the USFWS. Both the DFG and the USFWS recommended that some reduction in spring exports be achieved. However, neither made specific recommendations. Under this alternative, in April-July exports are established to reflect the conditions that occurred during a time when both striped bass and salmon populations were in much healthier conditions, prior to the increased export of the SWP (1953-1967 - see Figure 4.5.1.2-4). Reducing exports to the period before the SWP does not always provide the positive downstream flow in Old and Middle rivers sought by many fishery groups. Under this alternative, positive flows occur only about 20 percent of the time during April-July. It does reduce the magnitude of reverse flows compared to present conditions. A safe level of exports is not known. However, pre-SWP spring export rates appears to be a reasonable interim goal until a safe level of exports is found.

670,000 AF impact on exports in spring

The average impact on existing and planned spring exports is a decrease of about 0.67 MAF. Compared to the last 15 years of spring exports, they would be reduced by about 0.2 MAF. In order to make up for this decrease in spring exports the CVP and SWP could increase exports in fall and winter months above today's levels as planned in their 1990 operations study. This is possible with existing facilities as shown in DWR's 1990 operations study. These actions would in effect freeze existing total annual exports at about the 1985 levels. The 1985 level of exports is the highest to date and 16 percent higher than the average level of exports since implementation of the 1978 Delta Plan. However, as shown in Chapter 6, this level of Delta supply is sufficient to meet reasonable water demands south and west of the Delta through the year 2010.

7.3.2.6 Alternative 6

Alternative 6 is the no action alternative. As stated previously, continuation of this alternative is expected to result in a decrease in April-June flows in both the San Joaquin River and the Sacramento River at Rio Vista. Exports in the October-April period will increase by at least 0.6 MAF above the highest levels experienced to date. All this will take place while the natural population of salmon continues to decline and the index of young striped bass is at its lowest levels ever recorded. In addition, the southern Delta will continue to receive inadequate protection.

In the face of these decreases in Estuary beneficial use protection and the benefits received by the water use community, the no action alternative appears to be inequitable.

7.3.2.7 Recommended Alternative

In light of this review, Alternative 5 is the recommended alternative.

Figure 7.3.2.7-1 and Figure 7.3.2.7-2 show in bar chart form the water supply impacts of the recommended alternative using the 1990 operations study as a base and the 1972-87 historical period as a base, respectively. The April-July data shown in these bar charts are from Tables 7.3.2-1 and 7.3.2-2. The figures allow the comparison of recommended changes to the average base condition for each control point in the Delta, i.e., Delta outflow, Sacramento River, San Joaquin River and Tracy and Banks exports.

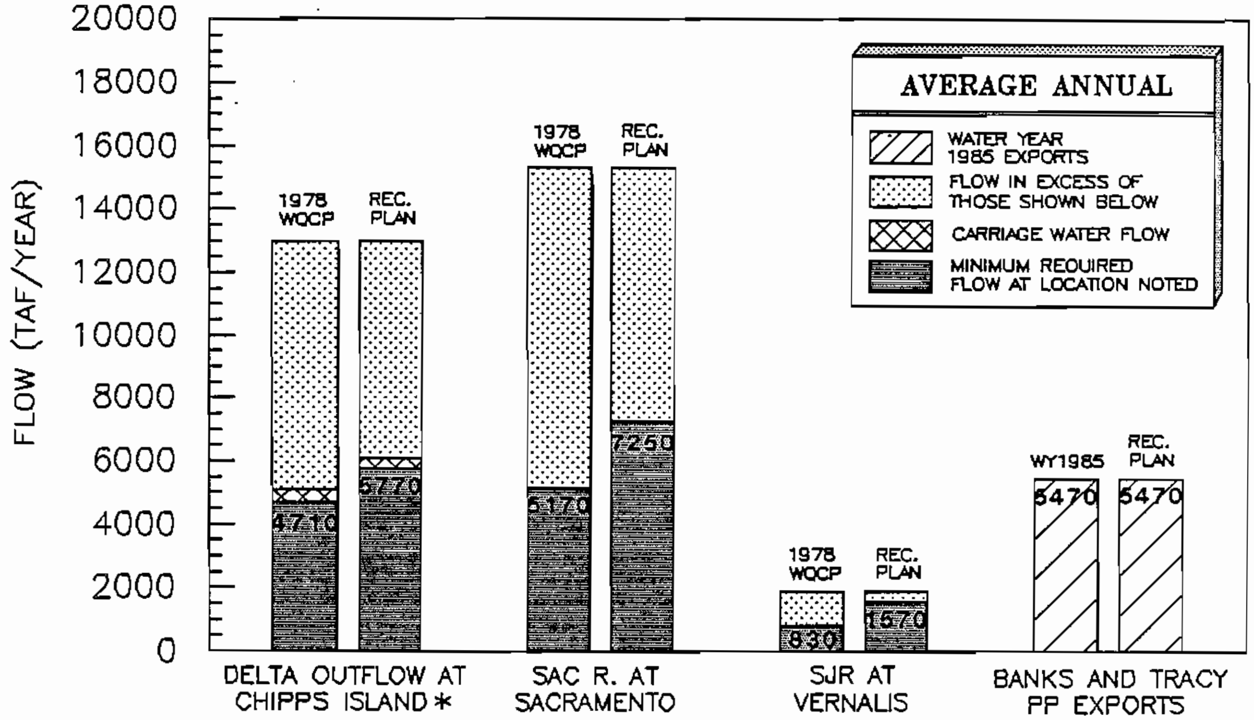
The water quality objectives derived from the recommended alternative are shown in Table 1 (see Chapter 1, Executive Summary).

FIGURE 7.3.2.7-1

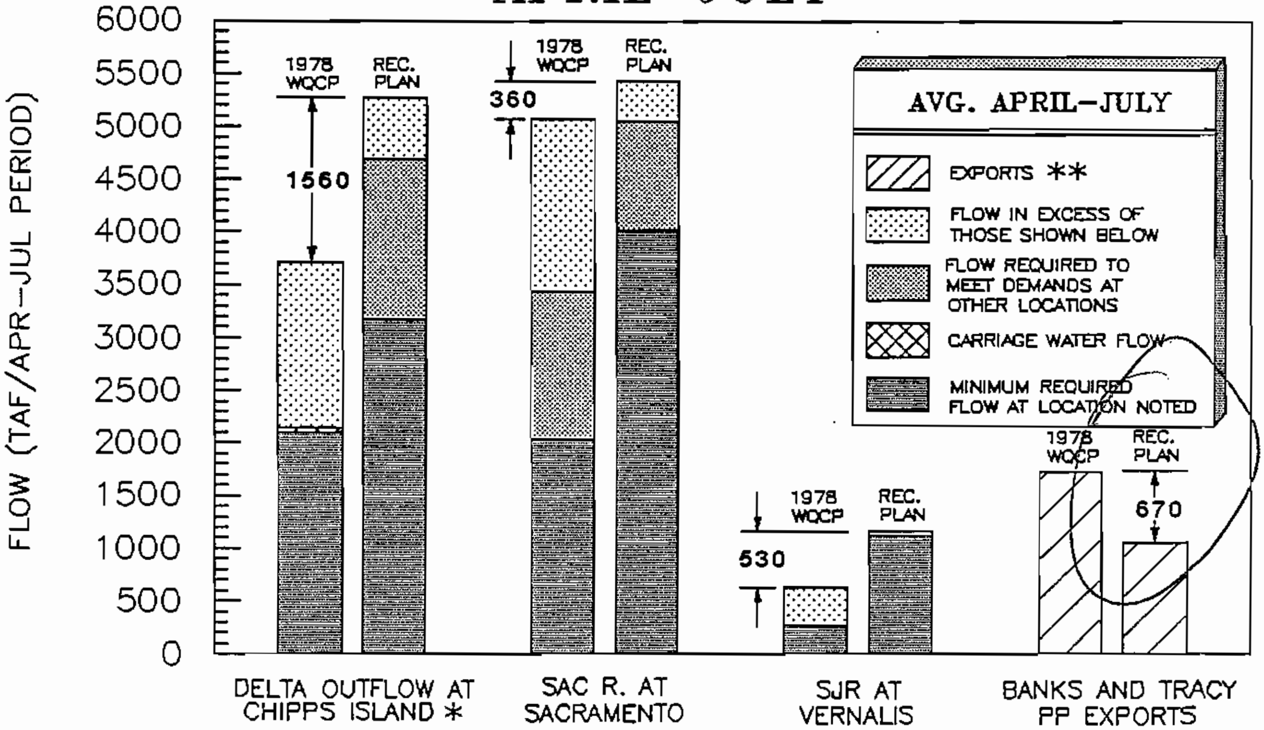
RECOMMENDED PLAN WATER SUPPLY IMPACTS

1922-78 HYDROLOGY UNDER THE PRESENT LEVEL-OF-DEVELOPMENT

AVERAGE ANNUAL



APRIL-JULY



* INCLUDES YOLO BYPASS FLOW

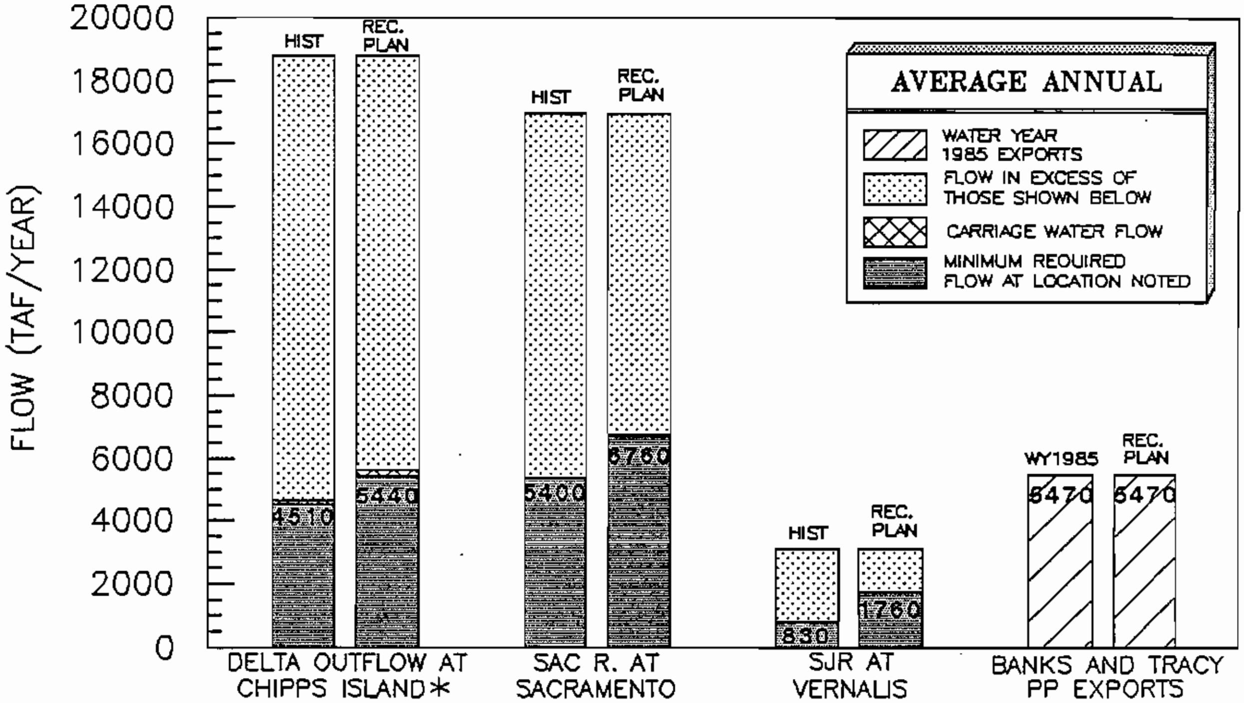
** 1985 EXPORT IMPACT = 680 TAF

FIGURE 7.3.2.7-2

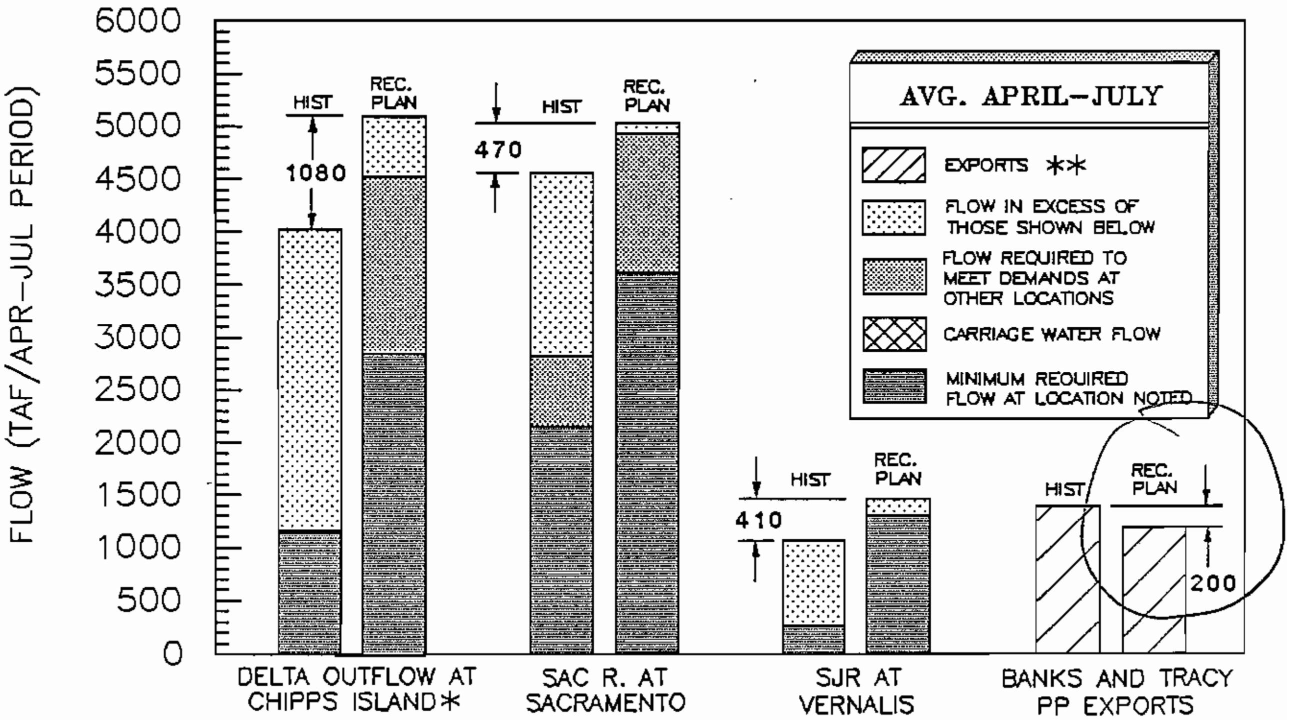
RECOMMENDED PLAN WATER SUPPLY IMPACTS

1972-1987 (W/O 1983) HISTORIC HYDROLOGY

AVERAGE ANNUAL



APRIL-JULY



* INCLUDES YOLO BYPASS FLOW ** 1985 EXPORT IMPACT = 540 TAF

8.0 PROGRAM OF IMPLEMENTATION

8.1 Introduction and Discussion of Issues

A Program of Implementation is required in all water quality control plans (WC Section 13242). This chapter provides the program of implementation, and includes: a discussion of how and when the water quality objectives set forth in this Plan are to be implemented; sampling and studies to be performed; and a time schedule.

The Board will use both its water quality and water right authorities to implement the objectives in this Plan. The most controversial aspects of this Plan are related to water rights. Water right issues will actually be determined by the Board during Phase III of the hearing process for the San Francisco Bay/Sacramento-San Joaquin Bay Delta Estuary. To help provide interested parties with an idea of some of the issues that will be discussed fully during Phase III, presented below are some of the concepts and conditions addressed in this Plan as they relate to water right aspects.

8.1.1 Water Right Issues

8.1.1.1 California Water Ethic

The California water ethic is fully discussed in Chapter 6 of this Plan (see 6.1). The principles developed from this ethic are discussed in sections of chapters 6 and 7 as they relate to determining reasonableness of consumptive use needs (chapter 6) and to determine appropriately balanced objectives for specific beneficial uses (Chapter 7). The Board can consider placing appropriate terms in water right licenses and permits to ensure more efficient use of the state's limited water supply consistent with the California water ethic. In Phase III the Board should consider the following in order to best conserve and utilize Bay-Delta waters:

- The annual combined export quantity per water year from the USBR Tracy Pumping Plant and the SWP Banks Pumping Plant be limited, except that in wet and above normal years, water above that required to meet objectives in the Bay-Delta may be pumped for conjunctive ground water storage and offstream surface storage; and

- The annual amount of water pumped per water year at the SWP Edmonston Pumping Plant for use in the southern California portion of the SWP service area be limited, except that: (1) an increase above that amount equal to the quantity of water conserved through increased agricultural efficiency in the San Joaquin Valley would be allowed; and (2) in wet and above normal years, water above that required to meet objectives in the Bay-Delta may be pumped for conjunctive ground water storage and offstream surface storage; and

- Agricultural users who contribute drainage flows to salt sinks should achieve a high but reasonably attainable water use efficiency.

8.1.1.2 Sharing the Obligation to Meet Water Quality Objectives in the Estuary

Currently, only certain permits of the CVP and SWP facilities are required to meet Bay-Delta Estuary water quality and flow objectives. These projects represent only about one-half of the almost 30 million acre-feet of water stored within the watershed. The Board will consider an equitable sharing of this responsibility among all users of Bay-Delta Estuary waters during Phase III. One possibility the Board may consider, to create a more equitable sharing, would be to expand the responsibility to maintain Estuary water quality to all reservoirs larger than 100,000 acre-feet. This action would add 31 reservoirs to the list of those assigned this responsibility. Almost 90 percent of the water stored in the watershed would then be operated to help maintain Estuary objectives.

In Water Right Decision 1594, the Board set forth the policy that all new water right permittees should not reduce flows needed to meet Bay-Delta water quality objectives by placing water right terms 91 and 93 into their permits. The Board determined that water for appropriation is no longer available when terms 91 and 93 are in effect. When this occurs new water users must cease diverting. If appropriators use water during this period, they must show the Board evidence that they have another water source being available to them and that they are using that alternaive source of supply. Terms 91 and 93 estimate on a real time basis when the CVP and SWP release their stored water to maintain Bay-Delta objectives. During Phase III, the Board may decide if similar terms should be placed in the permits and licenses of existing projects that are not currently operated to maintain water quality objectives in the Estuary. Such actions by the Board would redefine the water right rules upon which the water yield of not only these existing projects but also the water yield of the CVP and SWP are defined. Taking this action may require the phased implementation of the objectives contained in this Plan.

8.1.2 Water Quality Issues

In addition to the concerns, concepts, and analyses discussed in previous chapters which led up to the water quality objectives presented in Chapter 7, an additional issue not addressed heretofore is discussed below.

8.1.2.1 Salt Load Reduction Policy

Two occurrences have degraded water quality in the southern Delta. They are decreases in San Joaquin River flow and increases in salt loads to the river from irrigated agriculture. In this Plan, these flow issues and others are addressed. Upon adoption of this Plan, the State Board should consider requesting the Central Valley Regional Water Quality

Control Board to adopt a salt load reduction policy. The goals of this policy should be to stabilize and to reduce the salt loads discharged into the San Joaquin River. The policy should be achieved through amending existing and new waste discharge requirements, adopting nonpoint source controls, and amending the Basin Plan. The policy should reduce salinity levels to protect beneficial uses.

8.2 Monitoring and Special Studies

A monitoring program is necessary to assess compliance with the water quality objectives of the Water Quality Control Plan and to develop information to refine the water quality objectives in the future. Very little information was presented in Phase I regarding an appropriate monitoring program to be contained in the Water Quality Control Plan. The components of such a monitoring program should include:

- program coordination/data management and reporting
- compliance monitoring
- baseline studies and special studies

Concerns have been raised about the coordination and guidance provided by existing programs and the proper role of the State and Regional Boards in interagency efforts to study various aspects of the Estuary. Specifically, concern has been expressed that the Board's water quality monitoring programs which assess pollutant loads and effects need to be more closely integrated into other interagency studies of the Estuary. Also some groups believe the baseline studies required in D-1485 need to be better integrated into interagency study efforts and made more flexible.

Prior to the 1978 Delta Plan the State and Regional Board's had very little involvement in the interagency study efforts of the Estuary. In D-1485 the State Board required specific new studies of San Francisco Bay be performed. The Board has participated in studies of the Bay by sharing funding of the hydrodynamic element of the San Francisco Bay Program with the Interagency Study Program and by initiating the Aquatic Habitat Program to evaluate pollutant affects on the Bay. However, as discussed in the Pollutant Policy Document, better coordination of State and Regional Board studies on pollutant effects both in and upstream of the Estuary is needed. Consideration should be given for the Board to become a signatory to the Interagency Study Program so that the Board may better coordinate its studies in and upstream of the Estuary with the other agencies. This would include data manageent and reporting of this information.

This draft plan does not contain a specific baseline study program. The existing program as set forth in the 1978 Delta Plan has not been altered significantly since it was adopted. Baseline studies are necessary to identify long-term trends but they should also be continuously reevaluated and appropriate changes made as required in the 1978 Delta Plan and D-1485. This baseline study program should be reevaluated in Phase II and consideration should be given to merging it more closely with other interagency studies to make it more responsive to special study needs of these programs while still providing an appropriate long-term trend analysis on important parameters.

8.2.1 Compliance Monitoring

A compliance monitoring program will be established during Phase III to assess compliance with the water quality objectives contained in this Plan. The program will include continuous monitoring electrical conductivity recorders at each control station shown on Table 7.3.2.7-1 or a demonstration, to the satisfaction of the Board, that monitoring at a nearby location ensures demonstration of compliance. Funding of this program may be more complex since more parties may be required to help maintain these objectives. In Phase III the cost allocations for such a program will be decided.

8.2.2 Baseline and Special Studies

As stated earlier the baseline program in the 1978 Delta Plan needs to be reevaluated and made more flexible. Information regarding this reevaluation should be presented by the parties in Phase II.

Special studies are a more complex subject. In the 1978 Delta Plan the Board set forth specific special studies to be performed. The goal of these studies were to develop a better understanding of the hydrodynamics, water quality, productivity and significant ecological interactions in the Estuary so that more accurate predictions of the effects of water project operations on beneficial uses could be made. The most significant of these new studies were those in San Francisco and Suisun Bay. Unfortunately, while these studies provided information on the physical effects of flow changes on salinity gradients, phytoplankton production, and fish movement, they did not clearly address how these changes effect beneficial uses like fish and wildlife. Special studies in the San Francisco Bay, Suisun Bay and the Delta should continue to attempt to address this critical information link needed to develop water quality objectives.

Existing studies on the effects on water project operations or salmon and striped bass should continue and new studies to refine our knowledge in this area should be performed. Studies which quantify the effects of water project operations on shad and resident fish should also be performed.

If the State Board were a full member of the interagency study team it could provide more guidance to this group on the type of special studies that are most useful to the Board in setting water quality objectives. After going through the voluminous Phase I hearing record, the Board has identified information gaps that when filled should provide a firmer base upon which to set standards. The Board can help study teams formulate their study plans to gather this missing information.

Funding of baseline and special studies programs in the Estuary should be evaluated in Phase III.

8.3 Legislative Proposals

Although legislation is not required for the implementation of the water quality objectives in this Plan, there are specific areas in which new legislation may be helpful. They are:

- Legislation assisting the Board in implementing the new California water ethic through incentives to increase water conservation, reclamation, and conjunctive ground water and surface water use;
- Legislation to assure the Board's ability to enforce the foregoing recommendations.

New objectives must be implemented in large measure through regulation of water rights. In keeping with the appellate court decision, a much greater universe of water right holders will need to modify their water project operations to help achieve Bay-Delta water quality objectives. These changes in operations will have to be evaluated on a real-time basis in order to assess compliance. As demonstrated during the drought in 1988, the Board has minimal ability to assure compliance by even a small percentage of diverters. Also, increased monitoring and research will be needed to further refine the water quality objectives discussed in preceding sections. In order to achieve an equitable sharing of these responsibilities, the following changes are needed: (1) the water rights administration process should be streamlined to decrease requirements for small projects which have little potential for causing regional or statewide impacts; (2) compliance monitoring of larger projects needs to be automated; and (3) annual users fees should be imposed on permittees and licensees. These fees would be used to help fund the cost of continuing baseline and special studies on the water quality and instream flow needs of the Estuary, and to fund the compliance studies discussed in this Plan.

8.4 Time Schedule

The detailed time schedule for implementation of this Plan will be prepared at the conclusion of Phase III of the hearing process. An appropriate schedule cannot be prepared sooner because the responsibility for implementing various aspects of the Plan will not be addressed until Phase III. However, phased implementation of the objectives should be considered in no more than six years after adoption of this Water Quality Control Plan.

APPENDIX A

Past Proceedings Related to Flow and Salinity Objectives for the Bay-Delta Estuary

APPENDIX A -- Past Proceedings Related to Flow and Salinity Objectives for the Bay-Delta Estuary

Water quality objectives were first proposed for the Delta on November 19, 1965. Water Right Decision 1275 (D-1275) and Decision 1291 adopted in 1967, incorporated these objectives and other terms into the permits issued for the SWP. The State Boards' predecessor agency, the State Water Rights Board, issued a Water Quality Control Policy for the Delta and Suisun Marsh in 1967. This was amended in 1968. Pursuant to commitments made when D-1275 was issued, hearings regarding a salinity standard were initiated in July 1969. Following these hearings, Decision 1379 (D-1379), containing new water quality objectives for the Delta and Suisun Marsh, was issued in July 1971. However, subsequent litigation and court action stayed the implementation of D-1379 so that the requirements of D-1275 remained in effect. Regions 2 and 5 developed interim Basin Plans for their respective parts of the Estuary which were approved by the State Board in 1971. In 1973, in response to EPA concerns regarding the above mentioned 1967 Water Quality Control Policy, the State Board held a hearing and adopted a plan to supplement the 1967 policies. Comprehensive Basin Plans for the Sacramento-San Joaquin Delta Basin (Basin 5B) and the San Francisco Bay Basin (Basin 2), containing long-term water quality objectives, were approved by the State Board in 1975. Most of the water quality objectives incorporated into the Basin Plan for Basin 5B were similar to those of D-1379. In 1976 the State Board initiated a joint water quality and water right hearing to coordinate salinity objectives for the Delta and Suisun Marsh. This resulted, in 1978, in adoption by the State Board of the Water Quality Control Plan for the Sacramento-San Joaquin Delta and Suisun Marsh (Delta Plan) and Water Right Decision 1485 (D-1485). The Delta Plan contained flow and salinity objectives superseding those in the 5B Basin Plan. D-1485 placed permit conditions on the SWP and CVP to achieve salinity objectives in the Delta and Suisun Marsh through regulation of flows and operational constraints. In November 1983, the State Board adopted Water Right Decision 1594 pursuant to its reserved jurisdiction over more than 500 permittees in the Sacramento-San Joaquin Delta watershed. This decision placed conditions on permits issued since 1965, other than SWP and CVP, generally prohibiting diversions when natural and abandoned flows are insufficient to meet the D-1485 Delta water quality objectives. Under insufficient flow conditions the SWP and CVP have to release stored water to meet the objectives contained in D-1485.

APPENDIX B

DAYFLOW and Salmon Survival Data Sets

The following tables, B1 - B12, provide the flow data from DWR's DAYFLOW program which were used to calculate fishery protection levels and average historical conditions. Also included is the Sacramento River (Rio Vista) Estimated Salmon Survival Index. Year type classifications are the proposed April - July water year types as defined in the Draft Plan. Sacramento Valley year types are used throughout except for Delta exports and Vernalis (San Joaquin River) inflow, which use San Joaquin Valley year types. The effects of Delta island flooding and dewatering are discounted from the export values.

List of Tables

SACRAMENTO VALLEY HISTORIC FLOWS - CFS 1953-1987
(SACRAMENTO RIVER PLUS YOLO BYPASS) FROM DAYFLOW

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
1953	W	30,093	36,809	31,637	11,193	27,433
1954	AN	52,972	25,086	11,508	8,100	24,417
1955	BN	13,446	20,947	12,054	9,145	13,898
1956	W	32,506	43,788	25,660	12,413	28,592
1957	BN	20,040	31,856	16,871	9,353	19,530
1958	W	109,618	54,717	35,825	14,502	53,666
1959	D	13,964	11,435	8,030	10,562	10,998
1960	D	19,331	16,123	10,900	10,428	14,196
1961	D	17,037	13,160	10,965	10,558	12,930
1962	BN	28,359	19,823	13,066	10,262	17,878
1963	W	87,081	43,835	17,736	12,183	40,209
1964	D	12,538	13,970	11,166	11,639	12,328
1965	W	44,476	30,249	16,085	12,155	25,741
1966	BN	21,778	14,237	9,608	11,588	14,303
1967	W	55,513	53,324	44,511	19,520	43,217
1968	D	14,719	13,367	11,380	12,597	13,016
1969	W	46,420	41,299	23,271	14,248	31,310
1970	D	14,743	14,312	11,820	13,190	13,516
1971	W	39,121	29,779	27,734	20,995	29,407
1972	BN	13,126	12,856	13,854	15,002	13,710
1973	BN	21,338	16,505	14,974	15,182	17,000
1974	W	103,780	29,351	24,464	21,776	44,843
1975	W	34,889	30,551	23,738	18,297	26,869
1976	C	12,724	10,950	10,936	12,077	11,672
1977	C	5,962	7,598	6,866	8,249	7,169
1978	AN	40,261	25,215	12,677	14,317	23,118
1979	BN	16,577	18,015	12,225	16,428	15,811
1980	BN	22,643	15,930	17,842	17,753	18,542
1981	C	17,256	13,802	10,747	15,311	14,279
1982	W	114,798	42,674	26,126	17,662	50,315
1983	W	78,419	65,822	49,486	31,040	56,192
1984	BN	18,266	15,470	15,028	21,653	17,604
1985	D	12,495	13,432	13,310	16,035	13,818
1986	BN	26,978	12,804	11,863	16,924	17,142
1987	C	11,872	10,039	10,110	15,185	11,802

SACRAMENTO VALLEY FLOWS (SACRAMENTO R. + YOLO BYPASS) - CFS
YEAR TYPE SUMMARY FROM DAYFLOW

1953-1967

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
AVERAGE	W(6)	59,881	43,787	28,576	13,661	36,476
1954	AN(1)	52,972	25,086	11,508	8,100	24,417
AVERAGE	BN(4)	20,906	21,716	12,900	10,087	16,402
AVERAGE	D(4)	15,718	13,672	10,265	10,797	12,613
-	C(0)	-	-	-	-	-
GRND MEAN	15	37,369	26,065	15,812	10,661	22,477
WTDGNDMN	15	37,250	28,624	18,375	11,573	23,956

1968-1987

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
AVERAGE	W(6)	69,571	39,913	29,137	20,670	39,823
1978	AN(1)	40,261	25,215	12,677	14,317	23,118
AVERAGE	BN(6)	19,821	15,263	14,298	17,157	16,635
AVERAGE	D(3)	13,986	13,704	12,170	13,941	13,450
AVERAGE	C(4)	11,954	10,597	9,665	12,706	11,230
GRND MEAN	20	31,119	20,938	15,589	15,758	20,851
WGTGNDMN	20	33,319	21,989	17,423	16,696	22,357

1979-1987

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVERAGE
AVERAGE	W(2)	96,609	54,248	37,806	24,351	53,253
-	AN(0)	-	-	-	-	-
AVERAGE	BN(4)	21,116	15,555	14,240	18,190	17,275
1985	D(1)	12,495	13,432	13,310	16,035	13,818
AVERAGE	C(2)	14,564	11,921	10,429	15,248	13,040
GRND MEAN	9	36,196	23,789	18,946	18,456	24,347
WTDGNDMN	9	35,478	23,110	18,526	18,666	23,945

1953-1987

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
AVERAGE	W(12)	64,726	41,850	28,856	17,165	38,149
AVERAGE	AN(2)	46,617	25,151	12,093	11,209	23,767
AVERAGE	BN(10)	20,255	17,844	13,739	14,329	16,542
AVERAGE	D(7)	14,975	13,686	11,082	12,144	12,972
AVERAGE	C(4)	11,954	10,597	9,665	12,706	11,230
GRND MEAN	35	31,705	21,825	15,087	13,510	20,532
WTDGNDMN	35	35,004	24,832	17,831	14,501	23,042

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GRND MEAN = AVERAGE OF ALL YEARS IN GROUP
WTDGNDMN = AVERAGE OF ALL YEARS IN GROUP WEIGHTED BY FREQUENCY OF EACH YEAR TYPE IN GROUP

RIO VISTA FLOWS, 1930-1987
(From DWR DAYFLOW)

YEAR	YR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1930	D	27171	16841	6392	16801
1931	C	6070	3068	349	3162
1932	D	23686	29274	14925	22628
1933	D	18694	16171	12255	15707
1934	C	13762	5155	1590	6836
1935	W	79218	40679	16114	45337
1936	AN	38447	24393	14512	25784
1937	AN	46085	33492	12217	30598
1938	W	83013	72068	37227	64103
1939	C	14650	5668	916	7078
1940	AN	94517	25834	8923	43091
1941	W	92744	84952	50901	76199
1942	W	64020	46344	29054	46473
1943	AN	46645	25534	12415	28198
1944	BN	14454	19045	6689	13396
1945	BN	22542	21745	11063	18450
1946	BN	27988	22276	8786	19683
1947	D	18509	7536	5350	10465
1948	W	46700	44333	26828	39287
1949	BN	25825	19262	6574	17220
1950	AN	30215	23779	12852	22282
1951	BN	21406	22176	7023	16868
1952	W	69015	63542	33756	55438
1953	W	20947	25223	20307	22159
1954	AN	36875	16927	8247	20683
1955	BN	11231	17076	8597	12301
1956	W	27375	36915	20392	28227
1957	BN	12753	24266	10880	15966
1958	W	100201	46283	29308	58597
1959	D	7569	5319	2542	5143
1960	D	11337	8768	4577	8227
1961	D	9677	6598	4645	6973
1962	BN	17544	11366	6115	11675
1963	W	78676	36897	10514	42029
1964	D	6344	7205	4999	6183
1965	W	36728	24180	8253	23054
1966	BN	14142	7387	3667	8399
1967	W	48585	44945	36663	43398
1968	D	7988	6733	4914	6545
1969	W	39290	34409	15475	29725
1970	D	7979	7368	5265	6871
1971	W	32692	21483	16533	23569
1972	BN	6915	6345	6710	6657
1973	BN	13397	9454	8589	10480
1974	W	94216	18732	14241	42396
1975	W	25744	18912	13658	19438
1976	C	6814	4981	4602	5466
1977	C	1615	2990	1791	2132
1978	AN	34486	16697	5829	19004
1979	BN	11738	9996	5509	9081
1980	BN	17896	11775	10488	13386
1981	C	12321	7718	4464	8168
1982	W	104470	35529	18953	52984
1983	W	69581	56419	41173	55724
1984	BN	13515	9305	7497	10106
1985	D	6303	7197	6946	6815
1986	BN	22650	8605	5261	12172
1987	C	6008	4972	4002	4994
AVG 30-52		40234	29268	14640	28047
AVG 53-87		27874	17685	10903	18821
AVG 30-87		32775	22278	12385	22480
AVG 53-67		29332	21290	11980	20868
AVG 68-78		24649	13464	8873	15662
AVG 79-87		29387	16835	11588	19270
AVG 72-87		27979	14352	9982	17438
AVG 72-87(-83)		25206	11547	7903	14885

AVERAGE MONTHLY RIO VISTA FLOW,1930-1987
(Maximum set to 22,500 cfs)
(from,DWR,DAYFLOW)

YEAR	YR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1930	D	22500	16841	6392	15244
1931	C	6070	3068	349	3162
1932	D	22500	22500	14925	19975
1933	D	18694	16171	12255	15707
1934	C	13762	5155	1590	6836
1935	W	22500	22500	16114	20371
1936	AN	22500	22500	14512	19837
1937	AN	22500	22500	12217	19072
1938	W	22500	22500	22500	22500
1939	C	14650	5668	916	7078
1940	AN	22500	22500	8923	17974
1941	W	22500	22500	22500	22500
1942	W	22500	22500	22500	22500
1943	AN	22500	22500	12415	19138
1944	BN	14454	19045	6689	13396
1945	BN	22500	21745	11063	18436
1946	BN	22500	22276	8786	17854
1947	D	18509	7536	5350	10465
1948	W	22500	22500	22500	22500
1949	BN	22500	19262	6574	16112
1950	AN	22500	22500	12852	19284
1951	BN	21406	22176	7023	16868
1952	W	22500	22500	22500	22500
1953	W	20947	22500	20307	21251
1954	AN	22500	16927	8247	15891
1955	BN	11231	17076	8597	12301
1956	W	22500	22500	20392	21797
1957	BN	12753	22500	10880	15378
1958	W	22500	22500	22500	22500
1959	D	7569	5319	2542	5143
1960	D	11337	8768	4577	8227
1961	D	9677	6598	4645	6973
1962	BN	17544	11366	6115	11675
1963	W	22500	22500	10514	18505
1964	D	6344	7205	4999	6183
1965	W	22500	22500	8253	17751
1966	BN	14142	7387	3667	8399
1967	W	22500	22500	22500	22500
1968	0	7988	6733	4914	6545
1969	W	22500	22500	15475	20158
1970	D	7979	7368	5265	6871
1971	W	22500	21483	16533	20172
1972	BN	6915	6345	6710	6657
1973	BN	13397	9454	8589	10480
1974	W	22500	18732	14241	18491
1975	W	22500	18912	13658	18357
1976	C	6814	4981	4602	5466
1977	C	1615	2990	1791	2132
1978	AN	22500	16697	5829	15009
1979	BN	11738	9996	5509	9081
1980	BN	17896	11775	10488	13386
1981	C	12321	7718	4464	8168
1982	W	22500	22500	18953	21318
1983	W	22500	22500	22500	22500
1984	BN	13515	9305	7497	10106
1985	0	6303	7197	6946	6815
1986	BN	22500	8605	5261	12122
1987	C	6008	4972	4002	4994
AVG 30-52		20328	18650	11802	16927
AVG 53-87		15401	13683	9770	12951
AVG 30-87		17355	15653	10576	14528
AVG 53-67		16436	15876	10582	14298
AVG 68-78		14292	12381	8873	11849
AVG 79-87		15031	11619	9513	12054
AVG 72-87		14470	11417	8815	11568
AVG 72-87(-83)		13935	10679	7903	10839

RIO VISTA FLOWS, 1930-1987
(From DWR DAYFLOW)
(Maximum flow = 22,500cfs)

SALMON SMOLT SURVIVAL 1/

YEAR	YR TYPE	APR Q	MAY Q	JUN Q	YEAR	YR TYPE	APR S	MAY S	JUN S	AVG S	WEIGHTED SURVIVAL
1935	W	22500	22500	16114	1935	W	1.00	1.00	0.64	0.88	Survival=average
1938	W	22500	22500	22500	1938	W	1.00	1.00	1.00	1.00	Apr.-Jun survival
1941	W	22500	22500	22500	1941	W	1.00	1.00	1.00	1.00	* year type
1942	W	22500	22500	22500	1942	W	1.00	1.00	1.00	1.00	frequency
1948	W	22500	22500	22500	1948	W	1.00	1.00	1.00	1.00	
1952	W	22500	22500	22500	1952	W	1.00	1.00	1.00	1.00	
1953	W	20947	22500	20307	1953	W	0.92	1.00	0.88	0.93	
1956	W	22500	22500	20392	1956	W	1.00	1.00	0.88	0.96	
1958	W	22500	22500	22500	1958	W	1.00	1.00	1.00	1.00	
1963	W	22500	22500	10514	1963	W	1.00	1.00	0.33	0.78	
1965	W	22500	22500	8253	1965	W	1.00	1.00	0.20	0.74	
1967	W	22500	22500	22500	1967	W	1.00	1.00	1.00	1.00	
1969	W	22500	22500	15475	1969	W	1.00	1.00	0.61	0.87	
1971	W	22500	21483	16533	1971	W	1.00	0.95	0.67	0.87	
1974	W	22500	18732	14241	1974	W	1.00	0.79	0.54	0.78	
1975	W	22500	18912	13658	1975	W	1.00	0.80	0.51	0.77	
1982	W	22500	22500	18953	1982	W	1.00	1.00	0.80	0.94	
1983	W	22500	22500	22500	1983	W	1.00	1.00	1.00	1.00	
30-87	AVG	22414	22035	18580	30-87	AVG	1.00	0.98	0.78	0.92	0.29
53-87	AVG	22371	21802	17152	53-87	AVG	0.99	0.96	0.70	0.89	0.30
30-52	AVG	22500	22500	21436	30-52	AVG	1.00	1.00	0.94	0.98	0.25
1936	AN	22500	22500	14512	1936	AN	1.00	1.00	0.55	0.85	
1937	AN	22500	22500	12217	1937	AN	1.00	1.00	0.43	0.81	
1940	AN	22500	22500	8923	1940	AN	1.00	1.00	0.24	0.75	
1943	AN	22500	22500	12415	1943	AN	1.00	1.00	0.44	0.81	
1950	AN	22500	22500	12852	1950	AN	1.00	1.00	0.46	0.82	
1954	AN	22500	16927	8247	1954	AN	1.00	0.69	0.20	0.63	
1978	AN	22500	16697	5829	1978	AN	1.00	0.68	0.07	0.58	
30-87	AVG	22500	20875	10714	30-87	AVG	1.00	0.91	0.34	0.75	0.09
53-87	AVG	22500	16812	7038	53-87	AVG	1.00	0.68	0.14	0.61	0.04
30-52	AVG	22500	22500	12184	30-52	AVG	1.00	1.00	0.42	0.81	0.18

1944 BN	14454	19045	6689	1944 BN	0.55	0.81	0.12	0.49	
1945 BN	22500	21745	11063	1945 BN	1.00	0.96	0.36	0.77	
1946 BN	22500	22276	8786	1946 BN	1.00	0.99	0.23	0.74	
1949 BN	22500	19262	6574	1949 BN	1.00	0.82	0.11	0.64	
1951 BN	21406	22176	7023	1951 BN	0.94	0.98	0.14	0.69	
1955 BN	11231	17076	8597	1955 BN	0.37	0.70	0.22	0.43	
1957 BN	12753	22500	10880	1957 BN	0.46	1.00	0.35	0.60	
1962 BN	17544	11366	6115	1962 BN	0.72	0.38	0.08	0.40	
1966 BN	14142	7387	3667	1966 BN	0.53	0.16	0.00	0.23	
1972 BN	6915	6345	6710	1972 BN	0.13	0.10	0.12	0.11	
1973 BN	13397	9454	8589	1973 BN	0.49	0.27	0.22	0.33	
1979 BN	11738	9996	5509	1979 BN	0.40	0.30	0.05	0.25	
1980 BN	17896	11775	10488	1980 BN	0.74	0.40	0.33	0.49	
1984 BN	13515	9305	7497	1984 BN	0.50	0.26	0.16	0.31	
1986 BN	22500	8605	5261	1986 BN	1.00	0.22	0.04	0.42	
30-87 AVG	16333	14554	7563	30-87 AVG	0.66	0.56	0.17	0.46	0.12
53-87 AVG	14163	11381	7331	53-87 AVG	0.54	0.38	0.16	0.36	0.10
30-52 AVG	20672	20901	8027	30-52 AVG	0.90	0.91	0.19	0.67	0.15
1930 D	22500	16841	6392	1930 D	1.00	0.69	0.10	0.60	
1932 D	22500	22500	14925	1932 D	1.00	1.00	0.58	0.86	
1933 D	18694	16171	12255	1933 D	0.79	0.65	0.43	0.62	
1947 D	18509	7536	5350	1947 D	0.78	0.16	0.04	0.33	
1959 D	7569	5319	2542	1959 D	0.17	0.04	0.00	0.07	
1960 D	11337	8768	4577	1960 D	0.38	0.23	0.00	0.20	
1961 D	9677	6598	4645	1961 D	0.28	0.11	0.00	0.13	
1964 D	6344	7205	4999	1964 D	0.10	0.15	0.02	0.09	
1968 D	7988	6733	4914	1968 D	0.19	0.12	0.02	0.11	
1970 D	7979	7368	5265	1970 D	0.19	0.15	0.04	0.13	
1985 D	6303	7197	6946	1985 D	0.09	0.15	0.13	0.12	
30-87 AVG	12673	10203	6619	30-87 AVG	0.45	0.31	0.12	0.30	0.06
53-87 AVG	8171	7027	4841	53-87 AVG	0.20	0.14	0.03	0.12	0.02
30-52 AVG	20551	15762	9731	30-52 AVG	0.89	0.62	0.29	0.60	0.10

1931 C	6070	3068	349	1931 C	0.08	0.00	0.00	0.03	
1934 C	13762	5155	1590	1934 C	0.51	0.03	0.00	0.18	
1939 C	14650	5668	916	1939 C	0.56	0.06	0.00	0.21	
1976 C	6814	4981	4602	1976 C	0.12	0.02	0.00	0.05	
1977 C	1615	2990	1791	1977 C	0.00	0.00	0.00	0.00	
1981 C	12321	7718	4464	1981 C	0.43	0.17	0.00	0.20	
1987 C	6008	4972	4002	1987 C	0.08	0.02	0.00	0.03	
30-87 AVG	8749	4936	2531	30-87 AVG	0.26	0.04	0.00	0.10	0.01
53-87 AVG	6690	5165	3715	53-87 AVG	0.16	0.05	0.00	0.07	0.01
30-52 AVG	11494	4630	952	30-52 AVG	0.39	0.03	0.00	0.14	0.02

TOTAL WEIGHTED SURVIVAL, 1930-1987: 0.57
TOTAL WEIGHTED SURVIVAL, 1953-1987: 0.47
TOTAL WEIGHTED SURVIVAL, 1930-1952: 0.70

1/ Survival=(Rio Vista flow * .000056)-.258. From USFWS,31.

AVERAGE SURVIVAL,1930-1987: 0.51
AVERAGE SURVIVAL,1953-1987: 0.41
AVERAGE SURVIVAL,1930-1952: 0.64

RIO VISTA FLOWS, 1930-1987
(From DWR DAYFLOW)

YEAR	YR TYPE	APR Q	MAY Q	JUNE Q
1935	W	79218	40679	16114
1938	W	83013	72068	37227
1941	W	92744	84952	50901
1942	W	64020	46344	29054
1948	W	46700	44333	26828
1952	W	69015	63542	33756
1953	W	20947	25223	20307
1956	W	27375	36915	20392
1958	W	100201	46283	29308
1963	W	78676	36897	10514
1965	W	36728	24180	8253
1967	W	48585	44945	36663
1969	W	39290	34409	15475
1971	W	32692	21483	16533
1974	W	94216	18732	14241
1975	W	25744	18912	13658
1982	W	104470	35529	18953
1983	W	69581	56419	41173
30-87 AVG		61845	41769	24408
53-87 AVG		56542	33327	20456
30-52 AVG		72452	58653	32313
53-67 AVG		52085	35741	20906
68-78 AVG		47986	23384	14977
79-87 AVG		87026	45974	30063
1936	AN	38447	24393	14512
1937	AN	46085	33492	12217
1940	AN	94517	25834	8923
1943	AN	46645	25534	12415
1950	AN	30215	23779	12852
1954	AN	36875	16927	8247
1978	AN	34486	16697	5829
30-87 AVG		46753	23808	10714
53-87 AVG		35681	16812	7038
30-52 AVG		51182	26606	12184
53-67 AVG		35681	16812	7038
68-78 AVG		34486	16697	5829
79-87 AVG		34486	16697	5829
1944	BN	14454	19045	6689
1945	BN	22542	21745	11063
1946	BN	27988	22276	8786
1949	BN	25825	19262	6574
1951	BN	21406	22176	7023
1955	BN	11231	17076	8597
1957	BN	12753	24266	10880
1962	BN	17544	11366	6115
1966	BN	14142	7387	3667
1972	BN	6915	6345	6710
1973	BN	13397	9454	8589
1979	BN	11738	9996	5509
1980	BN	17896	11775	10488
1984	BN	13515	9305	7497
1986	BN	22650	8605	5261
30-87 AVG		16933	14672	7563
53-87 AVG		14178	11558	7331
30-52 AVG		22443	20901	8027
53-67 AVG		13918	15024	7315
68-78 AVG		10156	7900	7650
79-87 AVG		16450	9920	7189

YEAR	YR TYPE	APR Q	MAY Q
1930	D	27171	16841
1932	D	23686	29274
1933	D	18694	16171
1947	D	18509	7536
1959	D	7569	5319
1960	D	11337	8768
1961	D	9677	6598
1964	D	6344	7205
1968	D	7988	6733
1970	D	7979	7368
1985	D	6303	7197
30-87 AVG		10214	8719
53-87 AVG		6680	5934
30-52 AVG		22015	17456
53-67 AVG		8732	6973
68-78 AVG		7984	7051
79-87 AVG			
1931	C	6070	3068
1934	C	13762	5155
1939	C	14650	5668
1976	C	6814	4981
1977	C	1615	2990
1981	C	12321	7718
1987	C	6008	4972
30-87 AVG		8749	4936
53-87 AVG		6690	5165
30-52 AVG		11494	4630
53-67 AVG			
68-78 AVG		4215	3986
79-87 AVG		9165	6345

VERNALIS FLOWS, 1930-1987
(from DWR, DAYFLOW)

YEAR	YEAR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1930	D	2581	2214	2754	2516
1931	C	389	444	392	408
1932	AN	4814	11594	15100	10503
1933	BN	1147	1384	5308	2613
1934	C	702	639	627	656
1935	AN	14758	16384	15776	15639
1936	AN	13022	16784	11119	13642
1937	W	14463	20052	15558	16691
1938	W	22410	28345	36650	29135
1939	C	2467	2036	991	1831
1940	AN	16907	14300	10850	14019
1941	W	17087	21284	22303	20225
1942	W	13414	16532	22240	17395
1943	AN	18060	14973	11653	14895
1944	BN	2300	3827	3384	3170
1945	AN	8987	13915	11323	11408
1946	AN	6015	13058	5783	8285
1947	D	1488	2046	942	1492
1948	BN	1393	5001	8606	5000
1949	BN	2058	3530	2003	2530
1950	BN	5367	5012	5014	5131
1951	BN	2652	6525	3338	4172
1952	W	20197	27639	23340	23725
1953	BN	1520	3059	4914	3164
1954	BN	5059	6716	1286	4354
1955	BN	917	1150	1496	1188
1956	W	6261	13911	12251	10808
1957	BN	1326	2582	3759	2556
1958	W	27920	22419	15617	21985
1959	C	812	791	533	712
1960	C	517	618	293	476
1961	C	200	380	207	262
1962	AN	2085	2621	3497	2734
1963	AN	8616	9339	6663	8206
1964	D	764	703	650	706
1965	W	9859	5296	5650	6935
1966	D	982	863	570	805
1967	W	14495	20365	20000	18287
1968	C	1435	891	592	973
1969	W	22117	24613	27887	24872
1970	BN	1673	2393	2737	2268
1971	BN	1961	1833	2322	2039
1972	D	1037	744	587	789
1973	AN	4203	2937	2576	3239
1974	W	5850	4106	3860	4605
1975	W	3957	3972	5708	4546
1976	C	1293	939	798	1010
1977	C	212	400	118	243
1978	W	20030	19119	7069	15406
1979	AN	3506	2524	2254	2761
1980	W	10249	9912	5305	8489
1981	D	2532	1967	1499	1999
1982	W	22963	18654	7584	16400
1983	W	36447	31771	26083	31434
1984	BN	4285	3240	2297	3274
1985	D	2445	2134	1751	2110
1986	W	19590	8764	6233	11529
1987	C	2867	2178	1990	2345
30-87 AVG		7632	8300	7271	7734
30-52 AVG		8377	10762	10220	9786
53-87 AVG		7142	6683	5332	6386
72-87 AVG		8842	7085	4732	6886
72-87 AVG(-83)		7001	5439	3309	5250

VERNALIS FLOW, 1930-1987
(Maximum flow = 20,000 cfs)

YEAR	YEAR TYPE	APR Q	MAY Q	JUNE Q	AVG S
1930	D	2581	2214	2754	2516
1931	C	389	444	392	408
1932	AN	4814	11594	15100	10503
1933	BN	1147	1384	5308	2613
1934	C	702	639	627	656
1935	AN	14758	16384	15776	15639
1936	AN	13022	16784	11119	13642
1937	W	14463	20000	15558	16674
1938	W	20000	20000	20000	20000
1939	C	2467	2036	991	1831
1940	AN	16907	14300	10850	14019
1941	W	17087	20000	20000	19029
1942	W	13414	16532	20000	16649
1943	AN	18060	14973	11653	14895
1944	BN	2300	3827	3384	3170
1945	AN	8987	13915	11323	11408
1946	AN	6015	13058	5783	8285
1947	D	1488	2046	942	1492
1948	BN	1393	5001	8606	5000
1949	BN	2058	3530	2003	2530
1950	BN	5367	5012	5014	5131
1951	BN	2652	6525	3338	4172
1952	W	20000	20000	20000	20000
1953	BN	1520	3059	4914	3164
1954	BN	5059	6716	1286	4354
1955	BN	917	1150	1496	1188
1956	W	6261	13911	12251	10808
1957	BN	1326	2582	3759	2556
1958	W	20000	20000	15617	18539
1959	C	812	791	533	712
1960	C	517	618	293	476
1961	C	200	380	207	262
1962	AN	2085	2621	3497	2734
1963	AN	8616	9339	6663	8206
1964	D	764	703	650	706
1965	W	9859	5296	5650	6935
1966	D	982	863	570	805
1967	W	14495	20000	20000	18165
1968	C	1435	891	592	973
1969	W	20000	20000	20000	20000
1970	BN	1673	2393	2737	2268
1971	BN	1961	1833	2322	2039
1972	D	1037	744	587	789
1973	AN	4203	2937	2576	3239
1974	W	5850	4106	3860	4605
1975	W	3957	3972	5708	4546
1976	C	1293	939	798	1010
1977	C	212	400	118	243
1978	W	20000	19119	7069	15396
1979	AN	3506	2524	2254	2761
1980	W	10249	9912	5305	8489
1981	D	2532	1967	1499	1999
1982	W	20000	18654	7584	15413
1983	W	20000	20000	20000	20000
1984	BN	4285	3240	2297	3274
1985	D	2445	2134	1751	2110
1986	W	19590	8764	6233	11529
1987	C	2867	2178	1990	2345
30-87 AVG		7079	7671	6607	7119
30-52 AVG		8264	10009	9153	9142
53-87 AVG		6300	6135	4933	5790
72-87 AVG		7627	6349	4352	6109
72-87 AVG(-83)		6802	5439	3309	5183

VERNALIS FLOWS,1930-1987 (DWR,DAYFLOW by Year Type)

YEAR	YEAR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1937	W	14463	20052	15558	16691
1938	W	22410	28345	36650	29135
1941	W	17087	21284	22303	20225
1942	W	13414	16532	22240	17395
1952	W	20197	27639	23340	23725
1956	W	6261	13911	12251	10808
1958	W	27920	22419	15617	21985
1965	W	9859	5296	5650	6935
1967	W	14495	20365	20000	18287
1969	W	22117	24613	27887	24872
1974	W	5850	4106	3860	4605
1975	W	3957	3972	5708	4546
1978	W	20030	19119	7069	15406
1980	W	10249	9912	5305	8489
1982	W	22963	18654	7584	16400
1983	W	36447	31771	26083	31434
1986	W	19590	8764	6233	11529
30-87 AVG		16901	17456	15490	16616
53-87 AVG		16645	15242	11937	14608
30-52 AVG		17514	22770	24018	21434
1932	AN	4814	11594	15100	10503
1935	AN	14758	16384	15776	15639
1936	AN	13022	16784	11119	13642
1940	AN	16907	14300	10850	14019
1943	AN	18060	14973	11653	14895
1945	AN	8987	13915	11323	11408
1946	AN	6015	13058	5783	8285
1962	AN	2085	2621	3497	2734
1963	AN	8616	9339	6663	8206
1973	AN	4203	2937	2576	3239
1979	AN	3506	2524	2254	2761
30-87 AVG		9179	10766	8781	9576
53-87 AVG		4603	4355	3748	4235
30-52 AVG		11795	14430	11658	12627
1933	BN	1147	1384	5308	2613
1944	BN	2300	3827	3384	3170
1948	BN	1393	5001	8606	5000
1949	BN	2058	3530	2003	2530
1950	BN	5367	5012	5014	5131
1951	BN	2652	6525	3338	4172
1953	BN	1520	3059	4914	3164
1954	BN	5059	6716	1286	4354
1955	BN	917	1150	1496	1188
1957	BN	1326	2582	3759	2556
1970	BN	1673	2393	2737	2268
1971	BN	1961	1833	2322	2039
1984	BN	4285	3240	2297	3274
30-87 AVG		2435	3558	3574	3189
53-87 AVG		2392	2996	2687	2692
30-52 AVG		2486	4213	4609	3769
1930	D	2581	2214	2754	2516
1947	D	1488	2046	942	1492
1964	D	764	703	650	706
1966	D	982	863	570	805
1972	D	1037	744	587	789
1981	D	2532	1967	1499	1999
1985	D	2445	2134	1751	2110
30-87 AVG		1690	1524	1250	1488
53-87 AVG		1552	1282	1011	1282
30-52 AVG		2035	2130	1848	2004
1931	C	389	444	392	408
1934	C	702	639	627	656
1939	C	2467	2036	991	1831
1959	C	812	791	533	712
1960	C	517	618	293	476
1961	C	200	380	207	262
1968	C	1435	891	592	973
1976	C	1293	939	798	1010
1977	C	212	400	118	243
1987	C	2867	2178	1990	2345
30-87 AVG		1089	932	654	892
53-87 AVG		1048	885	647	860
30-52 AVG		1186	1040	670	965

VERNALIS FLOW,1930-1987 (Maximum flow = 20,000 cfs)

YEAR	YEAR TYPE	APR Q	MAY Q	JUNE Q	AVG Q
1937	W	14463	20000	15558	16674
1938	W	20000	20000	20000	20000
1941	W	17087	20000	20000	19029
1942	W	13414	16532	20000	16649
1952	W	20000	20000	20000	20000
1956	W	6261	13911	12251	10808
1958	W	20000	20000	15617	18539
1965	W	9859	5296	5650	6935
1967	W	14495	20000	20000	18165
1969	W	20000	20000	20000	20000
1974	W	5850	4106	3860	4605
1975	W	3957	3972	5708	4546
1978	W	20000	19119	7069	15396
1980	W	10249	9912	5305	8489
1982	W	20000	18654	7584	15413
1983	W	20000	20000	20000	20000
1986	W	19590	8764	6233	11529
30-87 AVG		15013	15310	13226	14516
53-87 AVG		14188	13645	10773	12869
30-52 AVG		16993	19306	19112	18470
1932	AN	4814	11594	15100	10503
1935	AN	14758	16384	15776	15639
1936	AN	13022	16784	11119	13642
1940	AN	16907	14300	10850	14019
1943	AN	18060	14973	11653	14895
1945	AN	8987	13915	11323	11408
1946	AN	6015	13058	5783	8285
1962	AN	2085	2621	3497	2734
1963	AN	8616	9339	6663	8206
1973	AN	4203	2937	2576	3239
1979	AN	3506	2524	2254	2761
30-87 AVG		9179	10766	8781	9576
53-87 AVG		4603	4355	3748	4235
30-52 AVG		11795	14430	11658	12627
1933	BN	1147	1384	5308	2613
1944	BN	2300	3827	3384	3170
1948	BN	1393	5001	8606	5000
1949	BN	2058	3530	2003	2530
1950	BN	5367	5012	5014	5131
1951	BN	2652	6525	3338	4172
1953	BN	1520	3059	4914	3164
1954	BN	5059	6716	1286	4354
1955	BN	917	1150	1496	1188
1957	BN	1326	2582	3759	2556
1970	BN	1673	2393	2737	2268
1971	BN	1961	1833	2322	2039
1984	BN	4285	3240	2297	3274
30-87 AVG		2435	3558	3574	3189
53-87 AVG		2392	2996	2687	2692
30-52 AVG		2486	4213	4609	3769
1930	D	2581	2214	2754	2516
1947	D	1488	2046	942	1492
1964	D	764	703	650	706
1966	D	982	863	570	805
1972	D	1037	744	587	789
1981	D	2532	1967	1499	1999
1985	D	2445	2134	1751	2110
30-87 AVG		1690	1524	1250	1488
53-87 AVG		1552	1282	1011	
30-52 AVG		2035	2130	1848	2004
1931	C	389	444	392	408
1934	C	702	639	627	656
1939	C	2467	2036	991	1831
1959	C	812	791	533	712
1960	C	517	618	293	476
1961	C	200	380	207	262
1968	C	1435	891	592	973
1976	C	1293	939	798	1010
1977	C	212	400	118	243
1987	C	2867	2178	1990	2345
30-87 AVG		1089	932	654	892
53-87 AVG		1048	885	647	860
30-52 AVG		1186	1040	670	965

TOTAL EXPORTS FROM THE DELTA, 1951 - 1987
AVERAGE DAILY FLOWS, CFS; YEARLY TOTALS, ACRE-FEET; FROM DAYFLOW

WATER YEAR	CVP	SWP /1/	CONTRA COSTA CANAL	TOTAL EXPORTS CFS /1/		TOTAL EXPORTS AC-FT	TOTAL CVP+SWP AC-FT
1950	0	0	30	30		21,719	0
1951	224	0	41	265		191,851	162,169
1952	228	0	41	269		195,281	1,657,428
1953	1,076	0	48	1,124		813,739	778,988
1954	1,386	0	58	1,444		1,045,408	1,003,418
1955	1,555	0	66	1,621		1,173,550	1,125,769
1956	994	0	61	1,055		765,878	721,595
1957	1,629	0	74	1,703		1,232,916	1,179,342
1958	907	0	66	973		704,420	656,638
1959	1,844	0	95	1,939		1,403,772	1,334,995
1960	1,910	0	105	2,015		1,462,790	1,386,565
1961	2,048	0	108	2,156		1,560,873	1,482,684
1962	1,864	0	99	1,963		1,421,147	1,349,474
1963	1,847	0	86	1,933		1,399,428	1,337,167
1964	2,266	0	113	2,379		1,727,036	1,645,004
1965	2,026	0	100	2,126		1,539,154	1,466,757
1966	2,200	0	116	2,316		1,676,707	1,592,727
1967	1,729	0	99	1,828		1,323,412	1,251,739
1968	2,749	653	133	3,535		2,566,235	2,469,683
1969	2,546	1,424	107	4,077	/2/	2,951,613	2,874,149
1970	2,281	574	130	2,985		2,161,041	2,066,926
1971	2,647	1,261	104	4,012		2,904,555	2,829,263
1972	3,232	1,508	143	4,883	/3/	3,544,816	3,441,005
1973	2,549	2,096	128	4,773	/3/	3,455,494	3,362,826
1974	3,376	2,645	109	6,130		4,437,917	4,359,005
1975	3,249	2,143	109	5,501		3,982,542	3,903,630
1976	4,146	2,513	153	6,812		4,945,174	4,834,104
1977	1,769	1,101	137	3,016	/4/	2,183,484	2,077,785
1978	3,134	2,872	106	6,138	/4/	4,443,709	4,348,145
1979	3,158	3,013	126	6,297		4,558,820	4,467,600
1980	2,764	3,463	120	6,347		4,607,607	4,520,493
1981	3,602	2,908	145	6,655		4,818,000	4,713,025
1982	2,729	3,651	104	6,484		4,694,201	4,618,909
1983	3,459	2,616	110	6,185		4,477,735	4,398,099
1984	3,018	2,268	135	5,421		3,935,377	3,837,374
1985	3,854	3,700	156	7,710		5,581,785	5,468,846
1986	3,616	3,683	152	7,451	/5/	5,394,277	5,284,235
1987	3,811	3,152	180	7,143		5,171,296	5,040,982

NOTES
/1/ Does NOT include diversions from Byron-Bethany Irrigation District; DAYFLOW includes BBID in channel depletions.
/2/ Total export value different from DAYFLOW; effects of Sherman Island flooding and dewatering (MISC) NOT included.
/3/ Total export value different from DAYFLOW; effects of Andrus and Brannon islands flooding and dewatering (MISC) NOT included.
/4/ Total export value INCLUDES export (MISC) to Mokelumne Aqueduct from Middle River (9/1/77 - 1/14/88), averaged over water years (1977 = 9 CFS; 1978 = 26 CFS).
/5/ Total export value different from DAYFLOW; effects of Delta island flooding and dewatering (MISC) NOT included.

AVERAGE EXPORTS (ACRE-FEET)

YEARS	TOTAL	CVP+SWP
1950-1987	2,644,073	2,606,541
1953-1967	1,283,349	1,220,857
1953-1987	2,859,026	2,777,970
1968-1987	4,040,784	3,945,804
1979-1987	4,804,344	4,705,507

TOTAL DELTA EXPORTS (CVP, SWP, AND CCC) - CFS
1953-1987 FROM DAYFLOW

WATER YR.	YR.TYPE	APRIL	MAY	JUNE	JULY	AVG
1953	BN	1,421	2,109	2,311	2,905	2,187
1954	BN	2,052	1,371	3,001	3,293	2,429
1955	BN	2,283	2,447	3,194	3,206	2,783
1956	W	704	423	1,179	3,248	1,389
1957	BN	2,353	2,186	3,277	3,591	2,852
1958	W	152	599	772	2,931	1,114
1959	C	2,757	2,661	3,564	4,005	3,247
1960	C	2,605	2,688	3,825	4,095	3,303
1961	C	2,900	2,837	3,992	4,656	3,596
1962	AN	2,761	2,963	3,799	4,229	3,438
1963	AN	1,231	2,774	3,543	4,198	2,937
1964	D	3,065	3,261	3,795	4,619	3,685
1965	W	1,204	3,193	3,694	4,361	3,113
1966	D	3,108	3,381	4,075	4,597	3,790
1967	W	1,207	1,921	2,162	2,697	1,997
1968	C	5,380	5,611	4,708	5,168	5,217
*1969	W	3,212	3,270	2,494	3,382	3,090
1970	BN	4,653	4,012	4,997	5,227	4,722
1971	BN	4,431	4,549	5,768	6,509	5,314
*1972	D	6,356	6,495	5,350	5,074	5,819
1973	AN	3,352	6,501	7,355	7,693	6,225
1974	W	4,203	7,130	9,130	10,691	7,789
1975	W	6,304	5,583	4,520	5,184	5,398
1976	C	5,037	5,488	4,152	4,109	4,697
1977	C	1,295	2,987	739	845	1,467
1978	W	3,271	3,058	7,621	8,088	5,510
1979	AN	5,882	6,245	6,341	9,339	6,952
1980	W	5,343	4,630	5,961	6,869	5,701
1981	D	8,090	4,478	4,032	7,046	5,912
1982	W	9,603	5,994	3,935	4,032	5,891
1983	W	3,814	3,293	5,010	5,207	4,331
1984	BN	7,685	5,929	6,165	9,457	7,309
1985	D	7,342	6,215	6,530	9,465	7,388
*1986	W	4,696	6,260	6,177	8,607	6,435
1987	C	7,021	5,313	5,183	8,952	6,617

*VALUES DIFFERENT FROM DAYFLOW; DO NOT INCLUDE EFFECTS OF DELTA FLOODING AND DEWATERING

TOTAL DELTA EXPORTS (CVP, SWP, AND CCC) - CFS
YEAR TYPE SUMMARY FROM DAYFLOW

1953-1967

WATER YR.	YR.TYPE	APRIL	MAY	JUNE	JULY	AVG
AVERAGE	W(4)	817	1,534	1,952	3,309	1,903
AVERAGE	AN(2)	1,996	2,869	3,671	4,214	3,187
AVERAGE	BN(4)	2,027	2,028	2,946	3,249	2,563
AVERAGE	D(2)	3,087	3,321	3,935	4,608	3,738
AVERAGE	C(3)	2,754	2,729	3,794	4,252	3,382
GRND MEAN	15	2,136	2,496	3,259	3,926	2,954
WTDGNDMN	15	1,987	2,321	3,079	3,775	2,791

1968-1987*

WATER YR.	YR. TYPE	APRIL	MAY	JUNE	JULY	AVG
AVERAGE	W(8)	5,056	4,902	5,606	6,508	5,518
AVERAGE	AN(2)	4,617	6,373	6,848	8,516	6,589
AVERAGE	BN(3)	5,590	4,830	5,643	7,064	5,782
AVERAGE	D(3)	7,263	5,729	5,304	7,195	6,373
AVERAGE	C(4)	4,683	4,850	3,696	4,769	4,499
GRND MEAN	20	5,442	5,337	5,419	6,810	5,752
WTDGNDMN	20	5,349	5,152	5,308	6,547	5,589

1979-1987*

WATER YR.	YR. TYPE	APR	MAY	JUN	JUL	AVG
AVERAGE	W(4)	5864	5044	5271	6179	5,589
1979	AN(1)	5882	6245	6341	9339	6,952
1984	BN(1)	7685	5929	6165	9457	7,309
AVERAGE	D(2)	7716	5347	5281	8256	6,650
1987	C(1)	7021	5313	5183	8952	6,617
GRND MEAN	9	6,834	5,576	5,648	8,436	6,623
WTDGNDMN	9	6,608	5,373	5,482	7,664	6,282

1953-1987*

WATER YR.	YR.TYPE	APRIL	MAY	JUNE	JULY	AVG
AVERAGE	W(12)	3,643	3,780	4,388	5,441	4,313
AVERAGE	AN(4)	3,307	4,621	5,260	6,365	4,888
AVERAGE	BN(7)	3,554	3,229	4,102	4,884	3,942
AVERAGE	D(5)	5,592	4,766	4,756	6,160	5,319
AVERAGE	C(7)	3,856	3,941	3,738	4,547	4,020
GRND MEAN	35	3,990	4,067	4,449	5,480	4,496
WTDGNDMN	35	3,908	3,939	4,353	5,359	4,390

GRND MEAN = AVERAGE OF ALL YEARS IN GROUP
WTDGNDMN = AVERAGE OF ALL YEARS IN GROUP WEIGHTED BY FREQUENCY OF EACH YEAR TYPE IN GROUP
* = VALUES DIFFERENT FROM DAYFLOW; DO NOT INCLUDE EFFECTS OF DELTA FLOODING AND DEWATERING IN 1969, 1972 AND 1986

CHIPPS ISLAND OUTFLOWS - CFS

1953-1987 FROM DAYFLOW

WATER YR.	YR. TYPE	APRIL	MAY	JUNE	JULY	AVG
1953	W	31,143	37,831	33,076	6,109	27,040
1954	AN	58,670	30,223	6,865	1,314	24,268
1955	BN	13,343	19,156	6,999	2,280	10,445
1956	W	40,217	59,667	35,498	8,795	36,044
1957	BN	20,480	32,732	15,581	2,427	17,805
1958	W	153,782	78,859	50,529	12,009	73,795
1959	D	11,607	7,303	1,322	2,561	5,698
1960	D	16,878	12,407	3,847	2,244	8,844
1961	D	13,397	8,580	3,541	1,672	6,798
1962	BN	27,385	18,173	10,317	2,795	14,668
1963	W	102,776	53,124	19,180	5,639	45,180
1964	D	9,187	9,784	5,302	3,185	6,865
1965	W	56,912	32,370	16,990	5,865	28,034
1966	BN	18,946	9,835	2,460	3,155	8,599
1967	W	77,685	74,550	61,265	23,864	59,341
1968	D	9,932	6,737	3,666	3,684	6,005
1969	W	69,375	64,564	46,596	13,143	48,420
1970	D	11,027	10,761	6,214	5,256	8,315
1971	W	36,983	26,406	21,218	11,654	24,065
1972	BN	7,542	5,140	2,891	6,211	5,446
1973	BN	22,191	11,699	7,211	4,599	11,425
1974	W	109,547	25,544	16,943	9,365	40,350
1975	W	34,519	28,796	22,508	11,129	24,238
1976	C	8,833	4,066	3,915	4,343	5,289
1977	C	3,083	3,999	2,521	3,212	3,204
1978	AN	61,276	40,874	9,086	3,974	28,803
1979	BN	14,485	13,435	5,326	5,384	9,658
1980	BN	28,689	20,912	14,870	11,191	18,916
1981	C	11,653	9,143	4,596	5,296	7,672
1982	W	142,203	57,876	28,515	16,849	61,361
1983	W	118,109	98,707	71,038	43,860	82,929
1984	BN	14,732	11,204	8,038	10,252	11,057
1985	D	6,913	7,378	5,215	4,934	6,110
1986	BN	46,572	15,911	9,322	7,384	19,797
1987	C	6,291	4,951	3,496	3,829	4,642

CHIPPS ISLAND OUTFLOWS - CFS
YEAR TYPE SUMMARY FROM DAYFLOW
1953-1967

WATER YR.	YR. TYPE	APRIL	MAY	JUNE	JULY	AVG
AVERAGE	W(6)	77,086	56,067	36,090	10,380	44,906
1954	AN(1)	58,670	30,223	6,865	1,314	24,268
AVERAGE	BN(4)	20,039	19,974	8,839	2,664	12,879
AVERAGE	D(4)	12,767	9,519	3,503	2,416	7,051
-	C(0)	-	-	-	-	-
GRND MEAN	15	42,140	28,946	13,824	4,193	22,276
WTDGNDMN	15	43,494	32,306	18,185	5,594	24,895

1968-1987

WATER YR.	YR.TYPE	APRIL	MAY	JUNE	JULY	AVG.
AVERAGE	W(6)	85,123	50,316	34,470	17,667	46,894
1978	AN(1)	61,276	40,874	9,086	3,974	28,803
AVERAGE	BN(6)	22,369	13,050	7,943	7,504	12,716
AVERAGE	D(3)	9,291	8,292	5,032	4,625	6,810
AVERAGE	C(4)	7,465	5,540	3,632	4,170	5,202
GRND MEAN	20	37,105	23,614	12,032	7,588	20,085
WTDGNDMN	20	38,198	23,405	14,659	9,277	21,385

1979-1987

WATER YR.	YR.TYPE	APR	MAY	JUN	JUL	AVE
AVERAGE	W(2)	129,108	77,936	50,335	30,365	71,936
-	AN(0)	-	-	-	-	-
AVERAGE	BN(4)	26,120	15,366	9,389	8,553	14,857
1985	D(1)	6,913	7,378	5,215	4,934	6,110
AVERAGE	C(2)	9,131	6,994	3,981	4,201	6,077
GRND MEAN	9	42,818	26,918	17,230	12,013	24,745
WTDGNDMN	9	43,097	26,522	16,822	12,031	24,618

1953-1987

WATER YR.	YR.TYPE	APRIL	MAY	JUNE	JULY	AVG.
AVERAGE	W(12)	81,104	53,191	35,280	14,023	45,900
AVERAGE	AN(2)	59,973	35,549	7,976	2,644	26,535
AVERAGE	BN(10)	21,437	15,820	8,302	5,568	12,781
AVERAGE	D(7)	11,277	8,993	4,158	3,362	6,948
AVERAGE	C(4)	7,465	5,540	3,632	4,170	5,202
GRND MEAN	35	36,251	23,818	11,869	5,954	19,473
WTDGNDMN	35	40,468	27,220	16,170	7,699	22,889

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GRND MEAN = AVERAGE OF ALL YEARS IN GROUP
WTDGNDMN = AVERAGE OF ALL YEARS IN GROUP WEIGHTED BY FREQUENCY OF EACH YEAR TYPE IN GROUP

APPENDIX C

Terms, Symbols and Abbreviations

BAY-DELTA HEARING
WATER QUALITY CONTROL PLAN

GLOSSARY

WORD/PHRASE	DEFINITION
1-in-20 dry year	A statistical term refering to a water year with a total annual runoff exceeded by 95% of the water years which are likely to occur.
Acre-Foot (AF)	The quantity of water which will cover an acre of land to a depth of one foot (i.e. 43,560 cubic feet or 325,900 gallons).
Algae	Simple rootless plants that grow in bodies of water at rates in relative proportion to the amounts of nutrients available in the water or, in the case of nitrogen, in the atmosphere overlying the water body.
Anadromous	Pertaining to fish that spend part of their life cycle in the ocean and return to freshwater streams to spawn (SWRCB Order no. WQ 85-1).
Arsenic (As)	A highly poisonous metallic element. Arsenic and its compounds are used in insecticides, weed killers and industrial processes (SWRCB Order no. W.Q. 85-1).
Banks, Harvey O. Pumping Plant	The Department of Water Resources' State Water Project main deltapumping plant located West of Tracy. The source of the water in the California Aquaduct.
Basin plan	A plan for the protection of water quality prepared by a Regional Water Quality Control Board in response to the federal Clean Water Act (SWRCB Order no. W.Q. 85-1).
Bathymetry	Measurements of the differences in depth between mean lower low water and the bottom of the bay.
Beneficial uses	"Beneficial uses" of the waters of the state that may be protected against quality degradation include but are not limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; esthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves. [Cal. Water Code Sec. 13050(f)]
Benthos	The whole assemblage of plants or animals living on the bottom of a water body: distinguished from plankton.
Best management practices	A practice, or combination of practices, that is determined after ...problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of

GLOSSARY

WORD/PHRASE	DEFINITION
	preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals. [40 CFR]
Biota	All living organisms that exist in an area.
Bloom	A proliferation of algae and/or higher aquatic plants in a body of water.
Carriage Water	The amount of Delta outflow needed to meet all of the water quality requirements of D-1485 less (minus) that needed to meet the requirements excluding those for Contra Costa Canal at Pumping Plant No. 1 (D5) and Clifton Court Forebay Intake at West Canal (C9). The quantity of additional Delta outflow (carriage water) is a function of Delta export pumping and south Delta inflow rates. It is necessary to reduce the effects of sea water intrusion into the Delta around the south side of Sherman Island (reverse flows up the San Joaquin River). This definition differs from that used by others in that it does not include additional Delta outflow which may be needed to meet certain contractual obligations of the Department of Water Resources.
Chloride (Cl)	The ionic form of the gaseous element chlorine, usually found as a metallic salt with potassium or sodium (SWRCB Order no. W.Q. 85-1).
Coagulation	A clumping of particles in water or wastewater which may result in the settling out of suspended materials. often induced by the addition of chemicals such as lime or alum, or a change in the dissolved ions in a water body such as that which occurs in an estuary when the fresh water inflow mixes with intruding seawater (i.e., in the entrapment zone).
Conservative constituent (or property)	A constituent (or property) the concentration of which is not effected by chemical or biological processes. [T,XLV,5:16-5:25]
Current flow conditions	Flow conditions as they exist at present. The factors considered when defining flow conditions include: land and water use patterns, reservoir capacities and operating rules, channel configurations, diversion point locations aand capacities, etc. Hydrologic investigations typically impose various sets of flow conditions upon the available "hydrologic record" and analyze the resultant effects. Within this Plan current flow conditions are those used by

GLOSSARY

WORD/PHRASE	DEFINITION
	the Department of Water Resources to produce the results from their 1990 level of development Operations Study (e.g., DWR Exhibit 30). The DWR Operations Study used the hydrologic record for WY 1922 through 1978.
DAYFLOW	A Department of Water Resources flow accounting model used to calculate daily Delta outflow at Chipps Island. It also estimates interior Delta flows at specified locations, and fish-related parameters and indices.
Delta	The Sacramento-San Joaquin rivers delta as defined in the California Water Code Section 12220.
Delta Channel Depletion	The diversions of Delta channel waters via pumps, siphons, and subsurface seepage onto the Delta uplands and lowlands for consumptive use by agriculture and native plants.
Dissolved oxygen (DO)	A measure of the amount of oxygen available for biochemical activity in a given amount of water. Adequate levels of DO are needed to support aquatic life. Low dissolved oxygen concentrations can result from inadequate waste treatment (Environmental Glossary 4th ed.).
Edmonston, A.D. Pumping Plant	The Department of Water Resources State Water Project (SWP) pumping plant located at the south end of the San Joaquin Valley. The prime mover for all SWP water used south of the Tehachapi Mountains, in Southern California.
Electrical Conductivity (EC)	Measures in milli- or micro- mhos, or milliSiemens per centimeter (mmhos/cm, umhos/cm or dS/cm, resp.). The ability of a particular parcel of water to conduct electricity. The EC of a water sample is an indirect measure of the total dissolved solids (TDS) or salinity levels of a water sample (i.e., the higher the EC the greater the TDS).
Entrainment	Direct entrainment occurs when fish are actually pulled along with water into a diversion structure because of strong currents created by pumps. Indirect entrainment is caused by the transport of eggs or larve into less desirable areas because of induced flows in channels surrounding diversion structures.
Entrapment Zone	An area in an estuary where suspended materials (including certain biota) accumulate. Net upstream transport of the particulate materials that settle into the bottom density current is nullified by the net downstream transport of materials in the river inflow. As a result, certain suspended materials concentrate in the area where the bottom currents are nullified (see Null Zone). [USBR,112,xi]

BAY-DELTA HEARING
WATER QUALITY CONTROL PLAN

GLOSSARY

WORD/PHRASE	DEFINITION
Escapement	The number of adult salmon escaping harvest and returning to the spawning grounds.
Estuary	The mouth of a stream which serves as a mixing zone for fresh and ocean water. Mouths of streams which are temporarily separated from the ocean by sandbars are considered as estuaries by the SWRCB. Estuarine waters are generally considered to extend from a bay or the open ocean to a point upstream where there is no significant mixing of fresh water and seawater. Estuarine waters are considered to extend seaward if significant mixing of fresh and seawater occurs in the open coastal waters (SWRCB, Water Quality Control Policy for the Enclosed Bays and Estuaries of California, May 1974).
Evapotranspiration	The quantity of water transpired (given off) and evaporated from plant tissue and surronding soil surfaces.
Flushing	The process by which contaminant concentrations in a body of water are diluted by river inflow and, where applicable, tidal exchange of "new" uncontaminated water combined with the net advection of the contaminants away from their source by residual currents.
Food chain	The pyramidal relationship of producers (plants) and consumers (animals) by which solar energy is converted through photosynthesis to plant tissue which is consumed by animals which are in turn consumed. At each step up the food chain consumers are usually larger but fewer in number.
Fry	The stage in the life of a fish between the hatching of the egg and the absorption of the yolk sac (same as sac fry or alevin). From this stage until they attain a length of one inch the young fish are considered advanced fry. (Bell, M.C., Fisheries Handbook of Engineering Requirements and Biological Criteria, U.S. COE, 1986)
Geometric Mean	The antilogarithm of the mean of a group of logarithms of a measured variable. The geometric mean is used to transform logarithmically distributed numbers for statistical purposes. (See definitions for Logarithm and Logarithmic Distribution.)
Grab sample	A single sample taken at an instant in time to represent the conditions at that instant.
Gravitational Circulation	Net internal motions caused by horizontal density gradients. The denser fluid flows along the bottom and lighter fluid

WORD/PHRASE	DEFINITION
	along the surface in an attempt to restore a stable vertical stratification. In the case of a longitudinal salinity gradient, this produces a net landward bottom current and compensating seaward current of fresher water at the surface. Also refered to as Baroclinic Circulation. (Also see Null Zone.)
Gravitational Overturn	The formation of a lens of fresh water on the surface of an estuary during a period of high runoff. Also refered to as Gravitational Overflow. This surface layer can spread beyond the mouth of the estuary into the ocean.
Grow-out facilities	Ponds at a hatchery or pumping facility where fish are kept until they are large enough to survive on their own.
Gyre	A circular or spiral motion: whirl: revolution.
Habitat	The sum of environmental conditions in a specific place that is occupied by an organism, population, or community.
Historic Flows	Depending on the context used can mean either (i) those flows before man began influencing river flows (i.e., the Natural Flow), or (ii) the actual flows recorded during a specific period of time in the past.
Hydraulics	The branch of physics having to do with the mechanical properties of water and other liquids and with the application of these properties in engineering.
Hydrodynamics	The motion and action of water and other liquids, i.e., the dynamics of liquids, and the study thereof.
Hydrology	The science of water in nature: its properties, distribution, and behavior.
Leaching	The flushing of salts from the soil by the downward percolation of water.
Logarithm (Log)	The exponent expressing the power to which a fixed number (the base) must be raised in order to produce a given number (the antilogarithm). The most common logarithms are for the base 10. For example, 3 is the base 10 logarithm of 1,000 -- 100 is the base 10 antilogarithm of 2.
Logarithmic Distribution	The distribution of a set of observations of a variable which is limited at its lower end by zero (i.e., cannot have a value of less than zero) but is otherwise unrestrained. The logarithms of the observations of a logarithmically distributed variable are symmetrical about (i.e., 50% above

WORD/PHRASE	DEFINITION
	and 50% below) the logarithm of the geometric mean of the variable.
Logarithmic Mean (or Log Mean)	See definition of geometric mean.
Lunar Day	The time of rotation of the moon about the earth, 24.84 hours.
Manganese (Mn)	A hard, brittle, grayish white metallic element, oxidizing readily and forming an important component of certain alloys, as manganese steel. (Funk & Wagnalls Standard College Dictionary, 1973)
Marsh or marshland	A tract of low, wet, soft land; swamp; bog; morass; fen.
Natural or True Natural Flow	The embayment and channel flows which existed at the time of the first Spanish exploration of California, i.e., before the Gold Rush.
Nickel (Ni)	A hard, ductile, mallable, silver-white metallic element of the iron-cobalt group.
Nitrate	An ion composed of one atom of nitrogen bound to three atoms of oxygen. An important plant nutrient. In high concentrations, it can bind to hemoglobin resulting in methemoglobinemia. also refers to salts of the nitrate ion with other ionic substances, usually metals. (SWRCB Order No. WQ 85-1)
Non-point Source	SWRCB Definition: Any source of discharge to a surface water body that is not from a point source. [CCWD,58A,G10] EPA Definition: Causes of water pollution that are not associated with point sources, such as agricultural fertilizer runoff, or sediment from construction. Examples include (i) Agriculturally related non-point sources of pollution including runoff from manure disposal areas, and from land used for livestock and crop production; (ii) Siviculturally related non-point sources of pollution; (iii) Mine-related sources of pollution including new, current and abandoned surface and underground mine runoff; (iv) Construction activity related sources of pollution; (v) Sources of pollution from disposal on land, in wells or in subsurface excavations that affect ground and surface water quality; (vi) Salt water intrusion into rivers, lakes, estuaries and ground water resulting from reduction of fresh water flow from any cause, including

WORD/PHRASE	DEFINITION
	irrigation, obstruction, ground water extraction, and diversion; and (vii) Sources of pollution related to hydrologic modifications, including those caused by changes in the movement, flow, or circulation of any navigable waters or ground waters due to construction and operation of dams, levees, channels, or flow diversion facilities. [40 CFR]
Null Zone	The region in a partially- or well-mixed estuary where the residual bottom currents are effectively zero. Landward of this point there is a net seaward residual velocity along the bottom caused by river inflow and seaward of the null zone, gravitational circulation produces a net landward transport of denser more saline water along the bottom. The null zone is the theoretical upstream boundary of the entrapment zone.
Partially-Mixed Estuary	An estuary in which vertical mixing due to tidal currents is large enough to prevent a distinct vertical density stratification between fresh and seawater but not strong enough to completely remove any vertical variation in density. The northern reach of San Francisco Bay is typical of a partially-mixed estuary.
Piscivore	Fish eater.
Point source	SWRCB Definition: Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. [CCWD,58A,G11] EPA Definition: The same wording as the SWRCB definition with the addition of an exclusion for return flows from irrigated agriculture. [40 CFR]
Potable water	Suitable for drinking (Funk & Wagnalls Standard College Dictionary, 1973).
Progressive Wave	A tidally-driven wave which travels along an estuary. This type of wave occurs in long shallow estuaries where there is a significant frictional resistance to the tidal flow and only weak wave reflection at the head of the estuary. The tide in the northern reach of San Francisco Bay travels upstream as a progressive wave.

GLOSSARY

WORD/PHRASE	DEFINITION
Pulse Flow	A substantial increase in the flow of water followed by a decrease within a relatively short period of time.
Quality of Water	Chemical, physical, biological, bacteriological, radiological, and other properties and characteristics of water which affect its use. [Cal. Water Code Sec. 13050(h)]
Recruitment	Addition by reproduction of new individuals to a population.
Residual Current	The net transport of a particle averaged over a complete tidal cycle.
Riparian	Pertaining to the banks and other terrestial environs adjacent to water bodies, watercourses, and surface-emergent aquifers (e.g. springs, seeps, oases), whose waters provide soil moisture significantly in excess of that otherwise available through local precipitation. Vegetation typical of this environment is dependent on the availability of excess water.
Riparian wetland	A zone which may be periodically inundated by water, characterized by moist soil and associated vegetation; typically bounded on one border by a drier upland and on the other by a freshwater body (SWRCB Order no. W.Q. 85-1).
Run	To migrate, especially to move in a shoal in order to spawn (American Heritage Dictionary 4th ed.).
Salinity	The total concentration of dissolved ions in water, a conservative property (T,XLV,5:12-5:25). The salt content of a water (SWRCB Order no. W.Q. 85-1). Usually expressed as ppt (g/l), or ppm (mg/l).
Salvage	Those fish diverted away from or removed from screens at intakes to diversion structures and subsequently returned to a water body.
San Francisco Bay-Delta Estuary (the Estuary)	San Francisco Bay, the Sacramento-San Joaquin Delta and Suisun Marsh, as defined in Section 29101 of the Cal. Public Resources Code, Sections 6610 and 66611 of the Cal. Government Code, and Section 12220 of the Cal. Water Code, respectively.
Selenium (Se)	A non-metallic element chemically resembling sulfur. Essential for animals at trace concentrations, selenium is toxic to animals in deficient or excesseive dietary exposure (SWRCB Order no. W.Q. 85-1).

GLOSSARY

WORD/PHRASE	DEFINITION
Semidiurnal Tide	A tidal variation consisting of two high and two low tides per lunar day (24.84 hrs). In San Francisco Bay, the cycle typically consists of a high high followed by a low low, a low high, a high low and back to a high high tide.
Shoal	A shallow place in any body of water, or an assemblage or multitude; throng (i.e., a school of fish (Funk & Wagnalls Standard College dictionary, 1973).
Smolt	An anadromous fish that is physiologically ready to undergo the transition from fresh to salt water; age varies depending on species and environmental conditions. (Bell, M.C., 1986).
Standing Wave	A wave which does not travel so the point of maximum amplitude (crest to trough) remains fixed in space. Standing waves occur in an estuary when the resistance to the flow is small. The tide in South Bay is an example of a standing wave.
Striped bass index (SBI)	An index of the number of young bass which have survived through their first summer. Young bass are sampled with nets which are most efficient for fish about 1.5 inches in length. Sampling methods are consistent (with respect to location, frequency, technique, etc) so that the number of young striped bass caught may be compared with the catch at various locations year to year. The number of young bass caught by the standard sampling methods allows statistical treatment of data to estimate the abundance of young striped bass and to correlate changes in the number caught with changes in environmental factors. (SWRCB, Final EIR for the 1978 WQCP and D-1485, August 1978)
Subsurface agricultural drainage system	A set of tile drains, collectors and, in most cases, one or more sump pumps which are installed in a field to remove water from the root zone of any crops which may be planted. Generally installed in areas with shallow perched water tables.
Tidal Prism	The increase in water volume landward of a given cross-section from low tide to high tide. Related to the tidal volume on the ebb and flood tide and the cumulative upstream inflows.
Tile drains	A System of clay pipes installed beneath irrigated lands to artificially remove water saturating the soil of the crop root zone by gravity flow.

BAY-DELTA HEARING
WATER QUALITY CONTROL PLAN

GLOSSARY

WORD/PHRASE	DEFINITION
Total dissolved solids (TDS)	A measure of the salinity equal to the amount of material remaining after evaporating a water sample at 103 to 105 degrees Celsius (formerly centigrade) for one hour (SWRCB Order no. W.Q. 85-1).
Tracy Pumping Plant	The U.S. Bureau of Reclamation Central Valley Project pumping plant in the Delta west of Tracy. The source of the water in the Delta-Mendota Canal.
Unimpaired Flow	The embayment and channel flows which would exist in the absence of upstream impoundments and diversions of rainfall or snowmelt runoff, but in the presence of existing channel configurations, both upstream and in the Delta.
Water Quality Control Plan	A designation or establishment for the waters within a specified area of (1) beneficial uses to be protected, (2) water quality objectives, and (3) a program of implementation needed for achieving water quality objectives. [Cal. Water Code Sec. 13050(j)]
Water Quality Objective	The measureable limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area and time frame. Factors to be considered in establishing water quality objectives shall include, but not be limited to all of the following: (a) past, present, and probable future beneficial uses of water, (b) environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto, (c) water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area, (d) economic considerations, and (e) the need for developing housing within the region. (California Water Code Section 13050 et seq.)
Water Quality Standard	A term used in connection with the federal Clean Water Act which is roughly equivalent to water quality objective, except that a water quality standard also includes a plan of implementation to achieve the standard.
Water rights	A form of property rights which give their holder the right to use public waters. During the history of California, a variety of procedures have been in effect by which a person could acquire a water right A summary follows:

BAY-DELTA HEARING
WATER QUALITY CONTROL PLAN

GLOSSARY

WORD/PHRASE	DEFINITION
	Appropriative rights initiated prior to December 19, 1914 - prior to the 1914 statutes which established the present system for appropriating water (taking water and putting it to a use removed from property adjoining the water source) two methods of appropriation existed. Prior to 1872, appropriative rights could be acquired simply by taking water and putting it to beneficial use. In 1872, Sections 1410 through 1422 of the California Civil Code enacted a permissive procedure by which priority of rights could be established as of the date of posting of notice of intention to appropriate water, subject to a show of diligence in carrying out construction of diversion works and actual use of water. Appropriators who did not follow the permissive procedure had priority from the date of actually putting the water to use. Because in an appropriative water rights system, first in priority means first served by available water, considerable advantage attaches to an earlier date of appropriation.
	Appropriative rights initiated after December 19, 1914 - an appropriation of water must now comply with provisions of Part Two, Division Two of the California Water Code. The right to use water appropriated under earlier procedures as well as under the current procedure maybe lost by abandonment or non-use.
	Riparian rights - an owner of land adjoining a water source has, under common law, the right to use a share of the water available from the source. Only those parcels of land adjoining the source may be served by it under riparian right, unless a nonadjoining parcel was at one time part of a riparian parcel and the riparian right was transferred when the parcel was sold. No priority is established for riparian rights, and all riparian users must share the available supply. Riparian owners have priority of use over all appropriators.
	Prescriptive rights - rights obtained when water is taken and put to use for five years even though other rightholders' interests are damaged, if the injured parties take no action in their own defense. California Water Code Section 1225 and State Water Resources Control Board policies have made obtaining secure prescriptive rights essentially impossible since 1914 (SWRCB Order no. W.Q. 85-1).
Watershed	The land area that drains into a body of water (Environmental Glossary 4th ed.).

GLOSSARY

WORD/PHRASE	DEFINITION
Yearling	An organism that is one year old but has not completed its second year.
Young-of-year (YOY)	Fish of other organisms less than one (1) year old.

ABBREVIATIONS FOR INFORMATION SOURCES AND CITATIONS

ABBREVIATION	NAME
ACH	THE CITIES OF AVENAL, COALINGA & HURON
ACWA	AMADOR COUNTY WATER AGENCY
AHI	AQUATIC HABITAT INSTITUTE
ANTIOCH	THE CITY OF ANTIOCH
AWWA	AMERICAN WATER WORKS ASSOCIATION: CALIF.-NEV. SECTION
BAAC	BAY AREA AUDUBON COUNCIL
BADA	BAY AREA DISCHARGERS ASSOCIATION
BALIA	BAY AREA LEAGUE OF INDUSTRIAL ASSOCIATIONS
BCDC	SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION
BCF	BUTTE CREEK FARMS
BISF	THE BAY INSTITUTE OF SAN FRANCISCO
CBE	CITIZENS FOR A BETTER ENVIRONMENT
CCCWA	CONTRA COSTA COUNTY WATER AGENCY
CCWD	CONTRA COSTA WATER DISTRICT
CDWA	CENTRAL DELTA WATER AGENCY
CFBF	CALIFORNIA FARM BUREAU FEDERATION
CNPS	CALIFORNIA NATIVE PLANT SOCIETY
CNRF	CALIFORNIA NATURAL RESOURCES FEDERATION
COE	U. S. ARMY CORPS OF ENGINEERS
CSPA	CALIFORNIA SPORTFISHING PROTECTION ALLIANCE
CVAWU	CENTRAL VALLEY AGRICULTURAL WATER USERS
CVPWA	CENTRAL VALLEY PROJECT WATER ASSOCIATION
CWA	CALIFORNIA WATERFOWL ASSOCIATION
DAWDY	DAVID R. DAWDY
DFG	CALIFORNIA DEPARTMENT OF FISH AND GAME
DHS	CALIFORNIA DEPARTMENT OF HEALTH SERVICES
DTAC	DELTA TRIBUTARY AGENCIES COMMITTEE
DWR	CALIFORNIA DEPARTMENT OF WATER RESOURCES
EA	EA ENGINEERING, SCIENCE AND TECHNOLOGY, INC.
EBMUD	EAST BAY MUNICIPAL UTILITY DISTRICT
EBRPD	EAST BAY REGIONAL PARK DISTRICT
ECCID	EAST CONTRA COSTA IRRIGATION DISTRICT
EDF	ENVIRONMENTAL DEFENSE FUND
EPA	U.S. ENVIRONMENTAL PROTECTION AGENCY
FAO	FOOD AND AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS
FDA	U.S. FOOD AND DRUG ADMINISTRATION
GDPUD	GEORGETOWN DIVIDE PUBLIC UTILITY DISTRICT
HASTINGS	HASTINGS COLLEGE OF THE LAW
JOHNSON	PETER JOHNSON
KCWA	KERN COUNTY WATER AGENCY
KINGS	KINGS COUNTY STATE WATER PROJECT AGRICULTURAL CONTRACTORS
MET	THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
MID	MODESTO IRRIGATION DISTRICT
NAPA	THE CITY OF NAPA
NAS	NATIONAL ACADEMY OF SCIENCES
NDWA	NORTH DELTA WATER AGENCY
NMFS	U.S. NATIONAL MARINE FISHERIES SERVICE

NOAA	U.S. NATIONAL OCEANOGRAPHIC AND ATMOSPHERIC ADMINISTRATION
NRDC	NATURAL RESOURCES DEFENSE COUNCIL
OWD	OAKLEY WATER DISTRICT
PALMDALE	PALMDALE WATER DISTRICT
PG&E	PACIFIC GAS & ELECTRIC
PICYA	PACIFIC INTER-CLUB YACHT ASSOCIATION
PRBO	POINT REYES BIRD OBSERVATORY
QED	QED RESEARCH, INC.
RD2068	RECLAMATION DISTRICT NO. 2068
RIC	RICE INDUSTRY COMMITTEE
RWQCB_2	SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD (REGION 2)
RWQCB_4	LOS ANGELES REGIONAL WATER QUALITY CONTROL BOARD (REGION 4)
RWQCB_5	CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD (REGION 5)
RWQCB_7	COLORADO RIVER BASIN REGIONAL WATER QUALITY CONTROL BOARD (REGION 7)
RWQCB_8	SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD (REGION 8)
RWQCB_9	SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD (REGION 9)
SACTO	THE CITY OF SACRAMENTO
SACTOCO	THE COUNTY OF SACRAMENTO
SAWPA	SANTA ANA WATERSHED PROJECT AUTHORITY
SCLDF	THE SIERRA CLUB LEGAL DEFENSE FUND
SDIEGO	SAN DIEGO COUNTY WATER AGENCY AND THE CITY OF
SDWA	SOUTH DELTA WATER AGENCY
SEHC	SACRAMENTO ENVIRONMENTAL HEALTH COALITION
SFBAWUA	SAN FRANCISCO BAY AREA WATER USERS ASSOCIATION
SFCC	SAN FRANCISCO COMMONWEALTH CLUB
SFEP	EPA's SAN FRANCISCO ESTUARINE PROJECT
SFRISCO	THE CITY AND COUNTY OF SAN FRANCISCO
SHELL	SHELL OIL COMPANY
SMUD	SACRAMENTO MUNICIPAL UTILITY DISTRICT
SRCD	SUISUN RESOURCE CONSERVATION DISTRICT
SRWCA	SACRAMENTO RIVER WATER CONTRACTORS ASSOCIATION
SWC	STATE WATER CONTRACTORS
SWRCB	STATE WATER RESOURCES CONTROL BOARD (STATE BOARD)
TIBCEN	THE ROMBERG TIBURON CENTER FOR ENVIRONMENTAL STUDIES
TID	TURLOCK IRRIGATION DISTRICT
TLBWSD	TULARE LAKE BASIN WATER STORAGE DISTRICT
TRACY	THE CITY OF TRACY
UAC	UNITED ANGLERS OF CALIFORNIA
USBR	U.S. BUREAU OF RECLAMATION
USDA-SCS	U.S. DEPARTMENT OF AGRICULTURE - SOIL CONSERVATION SERVICE
USFDA	U.S. FOOD AND DRUG ADMINISTRATION
USFWS	U.S. FISH AND WILDLIFE SERVICE
USGS	U.S. GEOLOGICAL SURVEY
WACOC	WATER ADVISORY COMMITTEE OF ORANGE COUNTY
WESTERN	WESTERN CONSORTIUM FOR THE HEALTH PROFESSIONS, INC.

MONITORING STATIONS

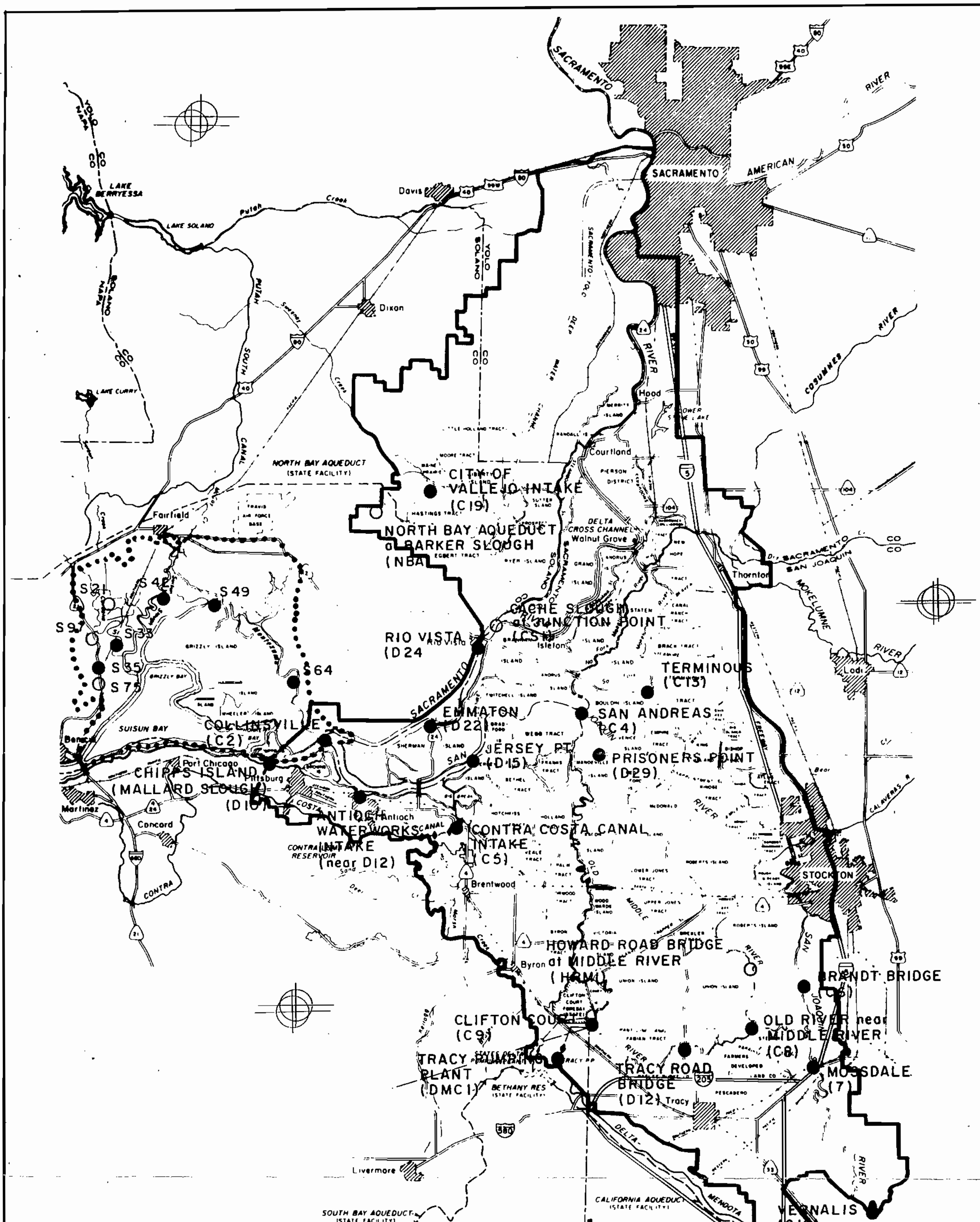
MONITORING SITE #	STATION NAME
C10	San Joaquin River near Vernalis
C13	Little Potato Slough at Terminous
C19	City of Vallejo Intake
C2	Sacramento River at Collinsville Road
C4	San Joaquin River at San Andreas Landing
C5	Contra Costa Canal at Pumping Plant #1
C6	San Joaquin River at Brandt Bridge
C7	San Joaquin River at Mossdale Bridge
C8	Old River at Middle River
C9	Clifton Court Forebay Intake at West Canal
CS1	Cache Slough at Junction Point
D10	Sacramento River @ Chipps Island
D12 (near)	Antioch Waterworks Intake on the San Joaquin River
D15	San Joaquin River at Jersey Point
D22	Sacramento River at Emmaton
D24	Sacramento River at Rio Vista Bridge
D29	San Joaquin River at Prisoner's Point
DMC1	Delta Mendota Canal @ Tracy Pumping Plant
HRM1	Middle River at Howard Road Bridge
NBA1	North Bay Aquaduct at Barker Slough
P12	Old River at Tracy Road Bridge (near Tracy)
S21 prop.	Chadbourne Slough @ Chadbourne Road (proposed)
S33	Cordelia Slough 500 ft West of Southern Pacific Crossing at Cygnus
S35	Goodyear Slough at Morrow Island Clubhouse
S42	Suisun Slough 300 ft South of Volanti Slough
S49	Montezuma Slough near Beldon Landing
S64	Montezuma Slough at National Steel
S75 prop.	Goodyear Slough South of Goodyear Slough Control Structure (proposed)
S97 prop.	Cordelia Slough at Cordelia-Goodyear Ditch (proposed)

LIST OF SYMBOLS AND ABBREVIATIONS

SYMBOL/ ABBREVIATION	DEFINITION
AF	Acre-Foot = 43,560 cubic feet = 325,900 gallons
As	Arsenic
BOD	Biochemical oxygen demand
CFR	U.S. Code of Federal Regulations
COD	Chemical oxygen demand
CVP	Central Valley Project
Cl-	Chloride ion
D-1485	SWRCB Water Rights Decision 1485
DMC	Delta-Mendota Canal
DO	Dissolved oxygen
DOI	Delta outflow index
EC	Electrical conductivity
Estuary	San Francisco Bay-Delta Estuary
FSA(s)	Flow study area(s)
MAF	Million acre feet
MGD	Million(s of) gallons per day
MLLW	Mean lower low water
Mn	Manganese
Ni	Nickel
PPD	Pollutant Policy Document
SBI	Striped bass index
SWP	State Water Project
Se	Selenium
TAF	Thousand acre feet
TDS	Total dissolved (filterable) solids
THM	Trihalomethane
WQCP	Water Quality Control Plan
WY	Water year (October 1 through September 30)
YOY	Young-of-year
ac	Acre = 43,560 square feet
cfs	Cubic feet per second = 448.8 gallons per minute = 1.983 acre-feet per day
ft	Foot or feet
g/l	Grams per liter
gpcd	Gallons per capita per day
hr(s)	Hour(s)
lb	Pound
m	Meter or meters = 3.28 feet
mg/l	Milligrams per liter
mmhos/cm	Millimhos per centimeter (a measure of electrical conductivity)
ppb	Parts per billion (approximately equal to ug/l)
ppm	Parts per million (approximately equal to mg/l)
ppt	Parts per thousand (approximately equal to g/l)
sq. ft.	Square foot or feet
sq. mi.	Square mile = 640 acres = 259 hectares
ug/l	Micrograms per liter
umhos/cm	Micromhos per centimeter

APPENDIX D

Map of Water Quality Control Stations



LEGEND

- ● Current Water Quality Control Station
- ○ New Water Quality Control Station
- • • • Suisun Marsh Boundary
- —— Legal Delta Boundary

C-2 Sacramento River at Collinsville Road
S-64 Montezuma Slough at National Steel
S-49 Montezuma Slough near Beldon Landing
S-42 Suisun Slough 300 ft. of Volanti Slough
S-75 Goodyear Slough South of proposed Goodyear Slough Control Structure
S-97 Cordelia Slough at Cordelia-Goodyear Ditch
S-21 Chadbourne Slough at Chadbourne Road
S-35 Goodyear Slough at Morrow Island Clubhouse
S-33 Cordelia Slough, 500 ft. West of Southern Pacific crossing at Cygnus

NOTE:
BASE MAP BY THE BUREAU OF RECLAMATION

WATER QUALITY CONTROL STATIONS

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD

SACRAMENTO-SAN JOAQUIN DELTA

MARK WEST CREEK FLOWS
(data attached separately as Appendix A-1)

APPENDIX A-1
MARK WEST CREEK FLOWS

THE RESOURCES AGENCY OF CALIFORNIA
Department of Fish and Game

STREAM SURVEY

FILE FORM No.

Date September 4, 1969

NAME Mark West Creek COUNTY Sonoma

STREAM SECTION Entire FROM Headwaters To confluence with Russian River LENGTH 29 mi.

TRIBUTARY TO Russian River hence the Pacific Ocean Twp. 8N R. 9W Sec. 31

OTHER NAMES Unknown RIVER SYSTEM Russian River

SOURCES OF DATA Data were obtained through the personal observations of Keith Himmelrick and Jim Michaels, and from talks with local residents.

EXTENT OF OBSERVATION
 Include Name of Surveyor, Date, Etc.
LOCATION
RELATION TO OTHER WATERS
GENERAL DESCRIPTION
 Watershed
 Immediate Drainage Basin
 Altitude (Range)
 Gradient
 Width
 Depth
 Flow (Range)
 Velocity
 Bottom
 Spawning Areas
 Pools
 Shelter
 Barriers
 Diversions
 Temperatures
 Food
 Aquatic Plants
 Winter Conditions
 Pollution
 Springs
FISHES PRESENT AND SUCCESS
OTHER VERTEBRATES
FISHING INTENSITY
OTHER RECREATIONAL USE
ACCESSIBILITY
OWNERSHIP
POSTED OR OPEN
IMPROVEMENTS
PAST STOCKING
GENERAL ESTIMATE
RECOMMENDED MANAGEMENT
SKETCH MAP
REFERENCES AND MAPS

EXTENT OF OBSERVATION: Mark West Creek was surveyed on July 22, 23, 24 and 25 by Keith Himmelrick and Jim Michaels. The stream was surveyed on foot, except for one mile of swamp and a 1/8 mile section upstream from the mouth, which were surveyed from a truck, with frequent stops for closer observation.

LOCATION: Mark West Creek traverses Sonoma County in a general east to west direction and empties into the Russian River approximately 5½ miles east of Guerneville.

RELATION TO OTHER WATERS: Mark West Creek is an important drainage of the Santa Rosa Valley and of the mountains to the east of the valley. The stream is an important tributary to the Russian River, contributing both summer and winter flows. The stream was discharging at approximately 4.16 c.f.s. during the time of the survey.

GENERAL DESCRIPTION:

WATERSHED: The topography was mountainous in the headwaters, becoming a flat valley near the mid section and turning to low hills near the mouth. The vegetative cover of the watershed near the headwaters and mouth was characterized by oaks, bays, redwoods, Douglas fir, maples, Horse Chestnut, and madrone trees. Manzanita brush was prevalent in the headwaters. The vegetative cover of the Santa Rosa Valley was characterized by pasture land, orchards, and vineyards.

IMMEDIATE DRAINAGE BASIN: Mark West Creek drains an area of approximately 40 square miles. The basin was a steep "V" shaped canyon near the headwaters, turning to open valley upon reaching the Santa Rosa Valley and then a wide "U" shaped canyon upon discharging into the Russian River. The stream was characterized by an incised channel near the headwaters and a bowl shape channel in the mid and lower sections of the stream. Stream-side vegetation was comprised of willows, oaks, bays, alders, blackberries, maples, and a few redwoods. Approximat 75% of the stream was sheltered.

ALTITUDE: The altitude ranged from approximately 1800' above sea level near the headwaters to approximately 40' above sea level near the mouth.

GRADIENT: The streambed dropped an average of approximately 61 ft. per mile. Gradient was near zero through the valley section and near the Russian River.

WIDTH: Width ranged from approximately one foot wide to 300' wide, and averaged approximately 14' wide. The swamp area averaged approximately 150-200 in width. The section of stream downstream from the swamp averaged approximately 20' in width.

DEPTH: Depth ranged from approximately 2" to 10' and averaged approximately 1.4 ft. in depth. The section of stream downstream from the swamp area averaged approximately 3' in depth.

FLOW: Flows were taken at three points along the stream.

1. Flow taken near headwaters approximately 200' downstream from the St. Helena Road bridge on 7/25/69 at 1630 hours. A flow of approximately 1.41 c.f.s. was recorded with the pigmy meter. Air temperature was 70 degrees F. and water temp. was 68^{O}F.

2. Flow taken near the mid section approximately 100' downstream from Slusser Road bridge on 7/24/69 at 1730 hours. A flow of approximately 1.10 c.f.s. was recorded with the pigmy meter. Air temp. was 74°F., and water temp. was 72°F.

3. A flow taken near the mouth approximately 10' upstream from the confluence with the Russian River, on 7/25/69 at 1345 hours. A flow of approximately 4.16 c.f.s. was recorded with the pigmy meter. Air temp was 70°F., and water temp. 74°F.

Subsurface flows were observed in various places along the section of stream between Porter Creek Road bridge and Calistoga Road bridge. Various sections of stream had subsurface flows in the section of stream from the St. Helena Road bridge to the headwaters.
VELOCITY: The velocity of Mark West Creek was rapid near the headwaters, turning to sluggish upon reaching and continuing through the Santa Rosa Valley.
BOTTOM: Bottom averaged approximately 25% gravel, 9% bedrock, 7% hardpan, 23% rubble, 21% silt and sand, 10% boulder and 5% mud.
SPAWNING AREAS: A total of approximately 2½ miles of stream appeared suitable for steelhead spawning. No spawning gravels were observed downstream from Windsor Creek, due to the turbidity of the water. Numerous redds were observed at various sections of stream during the time of the survey. Being crater shaped they were believed to be lamprey redds. See map.
POOLS: Pools observed in the section of stream from headwaters to St. Helena Road bridge averaged approximately 3' deep, 15' wide, and 30' long. The section of stream from St. Helena Road bridge to the Old Redwood Highway had pools averaging in size of 15' wide, 3' deep and 30' long. The section of stream from the Old Redwood Highway to the Mark West swamp had pools averaging in size of 20' wide, 100' long, 1½' deep. The section of stream from Windsor Creek to the confluence with the Russian River had pools ranging in size of approximately 20' wide, 3' deep, 150' long. Pools were numerous along the entire stream.
SHELTER: approximately 75% of the stream was sheltered by riparian vegetation. Other natural shelter areas for fish were created by fallen logs, boulders, deep pools and undercut banks.
BARRIERS: Numerous 4'-6' shoots and falls were observed near the headwaters. One 10' fall located approximately 2½ miles upstream from St. Helena Road bridge appeared to be a barrier to upstream steelhead migration. Trout, believed to be resident rainbows, were observed for approximately ½ mile upstream from the barrier. Numerous log jams and flashboard dams were observed at the time of the survey. Also a dam made from fruit boxes was observed. See attached map.
DIVERSIONS: A total of six 1" div., fourteen 2" div., one 3" div., ten 4" div. and one 6" diversion were active during the survey. One 4" inactive diversion was also observed. See attached map.
Temperatures:

1. Temperatures taken near the headwaters on July 22, 1969 at 1500 hours were: air temp. 86°F., water temp. 62°F.

2. Temperatures taken at St. Helena Road bridge on July 23, 1969 at 0900 hours were: air temp. 66°F., water temp. 62°F.

3. Temperatures taken at Calistoga road on July 23, 1969 at 1030 hours were: air temp. 71°F., water temp. 64°F.

4. Temperatures taken approximately 2 miles downstream from Calistoga Road bridge on July 23, 1969 at 1330 hours were: air temp. 72°F., water temp. 72°F. to 80°F. Algae was observed to be abundant in this section of stream.

5. Temperatures taken at the confluence with Mill Creek on July 23, 1969 at 1400 hours were: air temp. 77°F., water temp. 69°F.

6. Temperatures taken at Old Redwood Highway bridge on July 24, 1969 at 1000 hours were: air temp. 77°F., water temp. 69°F.

7. Temperatures taken approximately ½ mile upstream from Mark West slough on July 25, 196 at 1000 hours were: air temp. 69°F., water temp 69°F.

8. Temperatures taken approximately 10' upstream from the confluence with the Russian River on July 25, 1969 at 1300 hours were: air temp. 70°F., water temp. 74°F.

FOOD: Caddisfly larvae and cases were inhabiting the stream in numbers averaging approximately 10 per 10" rock. Mayfly larvae were also observed in numbers averaging approximately 1.5 per 10" rock. Aquatic snails were observed inhabiting the stream in numbers of approximately 5 per square foot of streambed.
AQUATIC PLANTS: Filamentous algae, sword grass, cattail, bullrush, duck weed were observed at the time of survey. Aquatic plants were abundant upon the entire stream.
WINTER CONDITIONS: The water level appears to rise approximately 1-1½' and filling a 15' wide channel near the headwaters during winter peak flows. The water level appears to rise 20'-25' above the level at the time of the survey, overflowing banks, near the confluence with the Russian River during peak flows.
POLLUTION: Three domestic dumps were observed on Mark West Creek. One was located approximate one mile downstream from Calistoga Road bridge. One was located approximately one mile upstrea from Slusser Road, and the last was located approximately 100 yards upstream from the Wohler Road bridge. The section of stream from the swamp to the confluence with the Russian River was so turbid that water clarity was reduced to 5 inches at the time of the survey. The turbidity appeared to be caused by suspended sands and silts.
SPRINGS: Several springs were observed during the survey, contributing only minor seepage.
FISH PRESENT AND SUCCESS: Steelhead were observed averaging 2" in the total length and ranging from 3/4" to 8" total length. They inhabited the stream in numbers of approximately 60 per 100' of stream, and were observed from the headwaters to the Mark West swamp. Sculpin were observed averaging 1" and ranging from 3/4"-1½" total length. They appeared to inhabit the stream in numbers of approximately 5 per 100' stream and were observed from headwaters to the Calistoga Road bridge. Roach were observed averaging 1" and ranging from ½" to 3" total length. They inhabited the stream in numbers of approximately 150 per 100' of stream, and were observed from the St. Helena Road bridge to the Mark West swamp. Green sunfish were observed averaging approximately 3" and ranging from 3-5" total length. They were observed to inhabit the stream in approximately less than 5 per 100' of stream, and were observed from the Calistoga Road bridge to the Mark West swamp. Carp were observed averaging 14" and ranging from approximately 6"-23" total length. They inhabited the stream in numbers of approximately 2 or less per 100' of stream, and were observed from the Mark West Springs Road to the Mark West swamp. Suckers were observed averaging 1" and ranging from ½"-16" in total length. They occupied the stream in numbers of approximately 50 per 100' of stream, and were observed from the St. Helena Road to the Mark West swamp. Gambusia were observed averaging ½" and ranging from ½-1" total length. They inhabited the stream in numbers of approximately 100 per 100' of stream. No other fish but Gambusia were observed in the section downstream from the swamp to the confluence with the Russian River. This was assumed due to the observers inabilit to make good observations through the turbid water in this section. A small fish kill was observed from Calistoga Road bridge and continuing for approximately 2 miles downstream. A total of 45 dead steelhead rainbow trout were observed within this section. The cause of death was believed to be high water temperature and a possible lack of oxygen, since the flow is subsurface at many points along this section. No signs of pollution were observed in this area.
OTHER VERTEBRATES: Cattle, deer and quail were observed.
FISHING INTENSITY: Fishing intensity was believed to be moderate as indicated by the numerous bait containers and discarded hook packs that were observed.

Community Clean Water Institute
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Mark West Creek Flow Study Report

Biology and Geology of Mark West Creek

The headwaters of Mark West Creek are located in the Mayacamas Mountain range, which border Napa and Sonoma County, where it then meanders south west until it merges with the Laguna De Santa Rosa. There it heads north and spills into the Russian River; the main channel of a watershed that provides drinking water to 600,000 residents in nine cities and special districts in Sonoma and Marin counties.

The Laguna-Mark West drainage is the largest catchment area contributing to the Russian River, making up approximately 21% of the total Russian River basin. Before MWC reaches the Laguna, it flows through residential areas of North West Santa Rosa and is an important water source for these communities.

The geology of the Mayacamas is mainly Pliocene volcanics, which contains rhyolite, andesite, basalt and other pyroclastics. This mountain range also contains Franciscan complex, which is an accretionary wedge complex, and contains sandstone, chirt, metabasalt, and gray wacky. The Franciscan complex was created in a high pressure, low temperature environment and has aluminum rich pelidic shale.

Serpentine is present on the slopes and ridges of the Mayacamas and these outcrops create habitats that promote chaparral plant communities specialized in living in soil made up of fine-grained, magnesium-rich igneous rocks. Chaparral shrub land is the dominate plant community in the Mayacamas Mountain range. Chaparral plant species thrive here because of their ability to resist draught during the summer and to survive wet and cold winters.

The banks of Mark West Creek have fertile soil and the vegetation is usually diverse and abundant, with many of the same riparian plants occurring throughout its stretch. The surrounding lands and hills within the watershed are where the biggest plant community changes occur. As this tributary follows the downward slope of the mountains, draught tolerant plants become less abundant as moisture becomes more available. Chaparral tree species, such as California Scrub Oak *Quercus dumosa,* begin to replace shrubs and dominate the landscape.

The upper reaches of Mark West Creek have spring-run steelhead and other anadromous fish rearing during the summer months. Steelhead Trout are salmonids and they often spawn in tributary systems like Mark West Creek between the months of December and May.

As Mark West Creek flows through the lower slopes of the Mayacamas, the climate becomes more favorable for a mixed hardwood forest and herbaceous chaparrals and scrub oaks become scarcer. Deciduous trees, including black oaks *Quercus Keloggi* and coniferous species, such Douglas Fir *Psuedotsuga menziesii* and redwoods hills and valleys south of the Mayacamas. These upland headland portions of the Russian River drainage basin are where we conducted our instream flow study.

In this report we included a map that shows the sub watershed of each site we monitored for this project. Understanding the geology of each of these individual sub watersheds, and how these factors effect water availability and instream would be beneficial. This would give us greater insight into the geological and hydrological processes occurring within the Russian River watershed basin.

Need for Study

Community Clean Water Institute received funding from America Water to conduct water quality and instream flows monitoring of Mark West Creek (MWC) during the summer and fall months of 2008. This study came out of local concerns for low summer and fall instream flow, decreased water levels, and the resulting poor water quality of the Mark West Creek watershed.

Mark West Creek is on the federal 303 (d) list for impaired waterways and the watershed has been deemed a Priority Conservation Area by the San Francisco Bay area joint agency coalition FOCUS, as well as by the Association of Bay Area Governments (ABAG) because of its decreasing instream flows and degraded water quality. This growing interest in conserving MWC is not only due to its contribution of drinking water to the Russian River watershed, but also because of the historical presence of Coho Salmon in this creek. Coho are a federally endangered salmonid species, which require extremely cold flowing water for their habitat, and are currently vanishing from local waterways.

Mark West Creek is also an important spawning area for Steelhead, another federally listed fish species found in this watershed. Since mid-July of this year, the people who live along Mark West Creek have been reporting the lowest creek flow levels in decades, and the lower portions of MWC is currently suffering extremely low dissolved oxygen readings. These low DO levels are partially caused by excessive vegetative growth in the creek (native and non-native plants, and algae), which can be connected to MWC's high nutrient levels caused by fertilizer runoff.

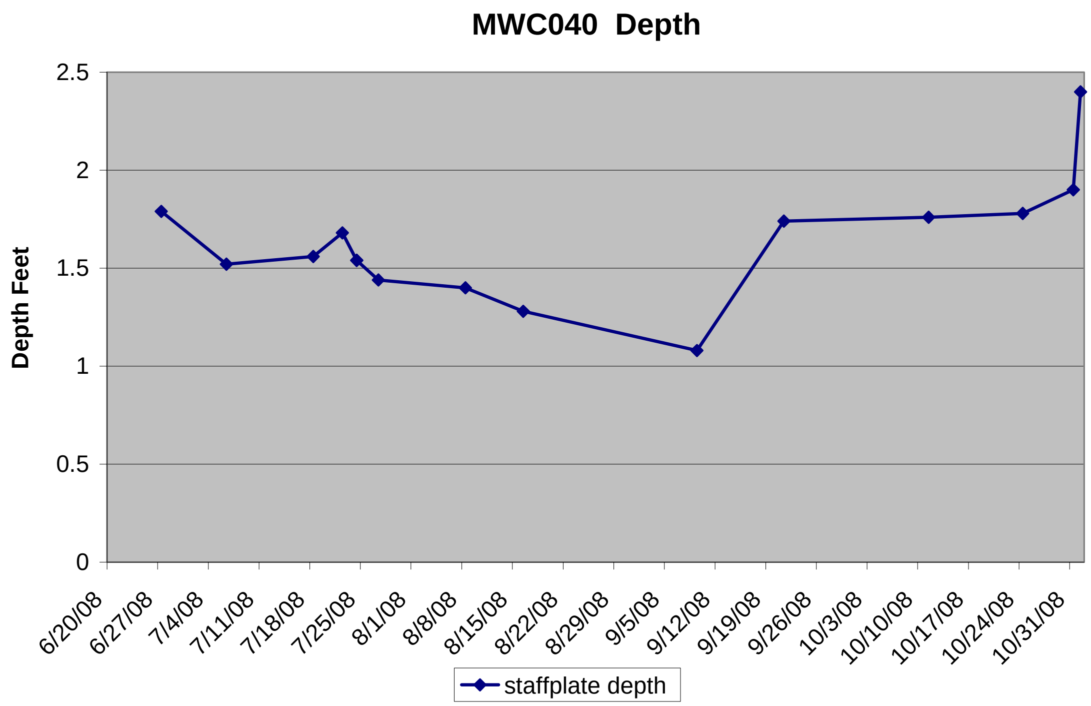
Creeks experiencing low flow are more susceptible to increased water temperatures, and warmer water has a lower holding capacity for oxygen than cold water. This situation can be detrimental for fish since their metabolic rates speed up as the water warms, which means they require more available oxygen to stay alive. These low stream flow levels, elevated water temperatures, and decreased dissolved oxygen, can lead to a dramatic increase in fish mortality.

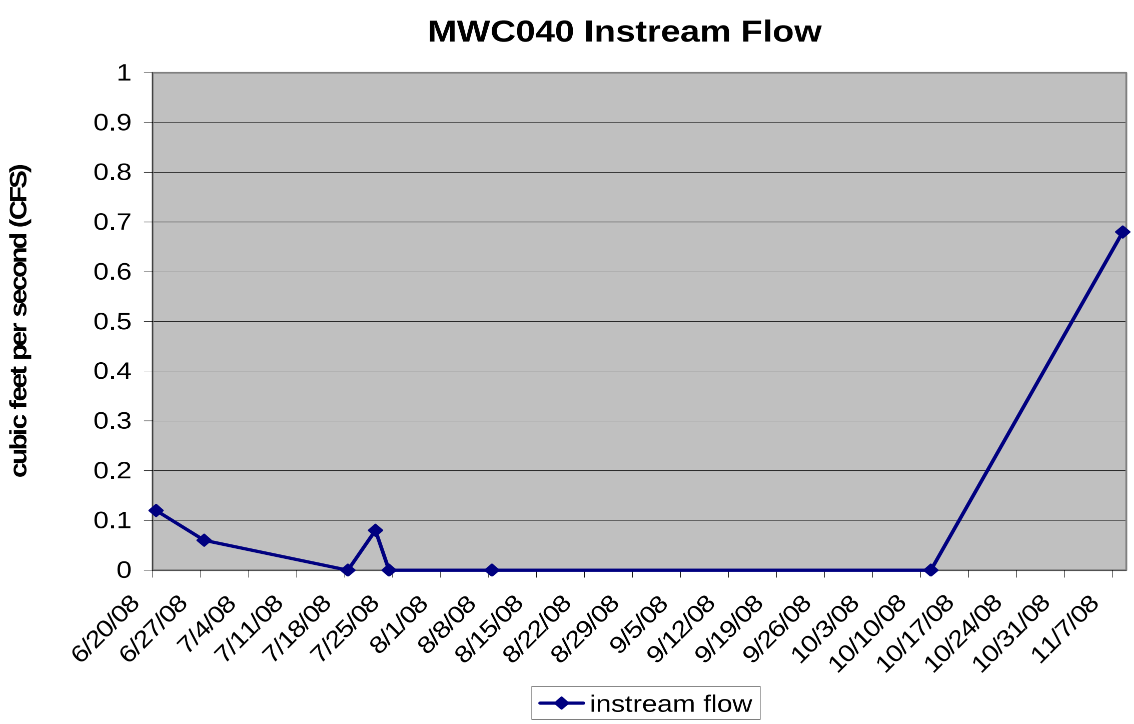
Methods and Results of Project

The methods involved in the Mark West Creek Water Quality and Instream Flows project were the construction of semi-permanent water level gauges (staff plates) at five locations along Mark West Creek and significant tributaries, and collect flow and water quality data at these monitoring stations over the course of the summer and fall. A Global Water Flow Probe was used to make flow measurements. We were not able to construct a staff plate at HHC020 because of the boulder substrate.

MWC040:

Located on Mark West Creek in Larkfield about 1000 feet downstream of the crossing of Old Redwood Highway and Mark West Creek. The staff plate is mounted on the bridge abutment of Old Redwood Highway (river right). The contributing watershed area to this point is 26.8 square miles.


MWC040 Depth
Depth Feet
2.5
2
1.5
1
0.5
0
6/20/08
6/27/08
7/4/08
7/11/08
7/18/08
7/25/08
8/1/08
8/8/08
8/15/08
8/22/08
8/29/08
9/5/08
9/12/08
9/19/08
9/26/08
10/3/08
10/10/08
10/17/08
10/24/08
10/31/08
staffplate depth


MWC040 Instream Flow
cubic feet per second (CFS)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6/20/08
6/27/08
7/4/08
7/11/08
7/18/08
7/25/08
8/1/08
8/8/08
8/15/08
8/22/08
8/29/08
9/5/08
9/12/08
9/19/08
9/26/08
10/3/08
10/10/08
10/17/08
10/24/08
10/31/08
11/7/08
instream flow

HHC020:

Located on Horse Hill Creek about 300 ft upstream of the confluence with Mark West Creek. The stage will be measured relative a specified point in a bedrock outcrop within the creek. The boulder substrate indicates that no staff plate could possibly withstand winter flows. The contributing watershed area to this point is 2.8 square miles.

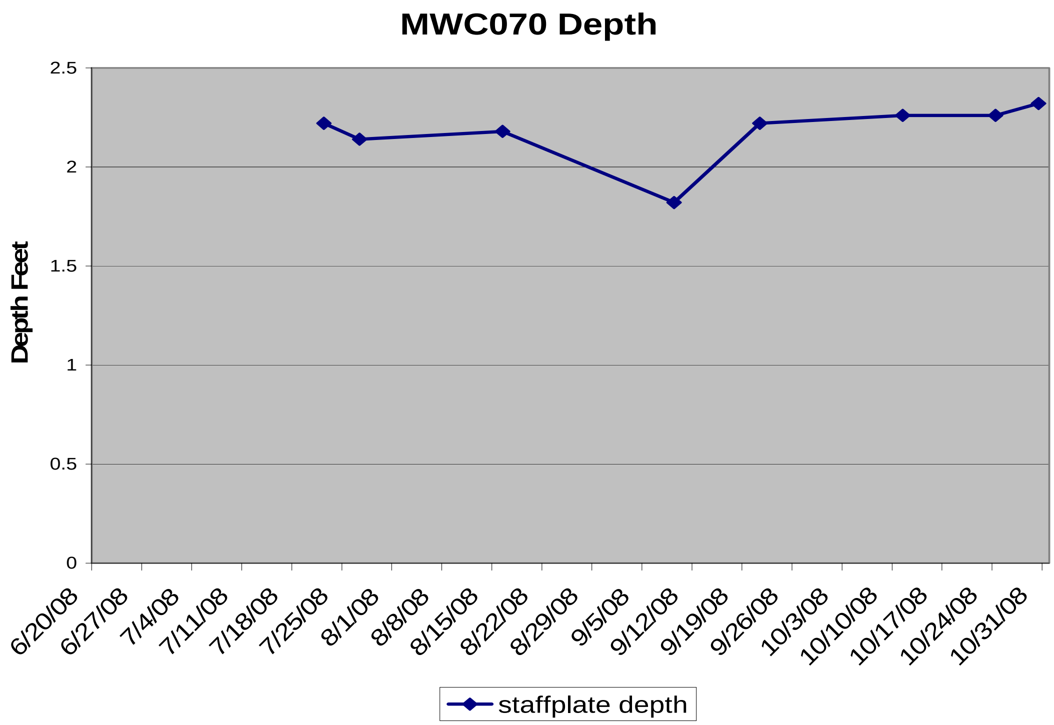
We couldn't get measurable flow reading for the duration of this project. There were a few small pools in which we were able to get some width, length, and depth measurements.

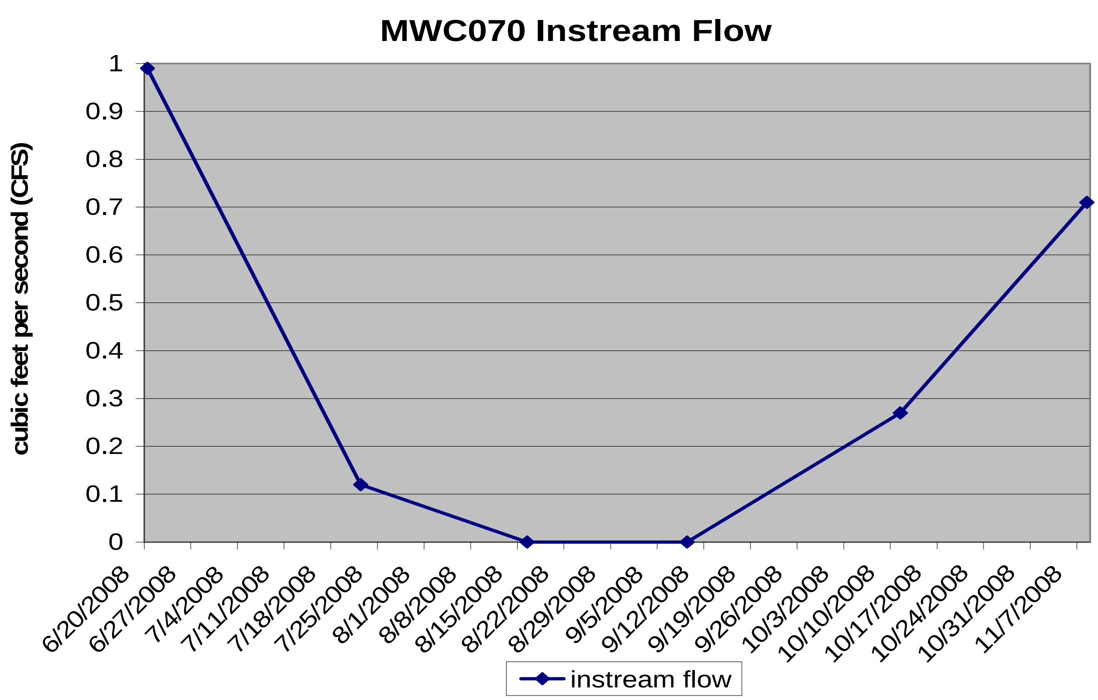
POR030:

Located under bridge where Porter Creek Rd meets Porter Creek. The site is adjacent to Safari West. The contributing watershed area to this point is 7.0 square miles.

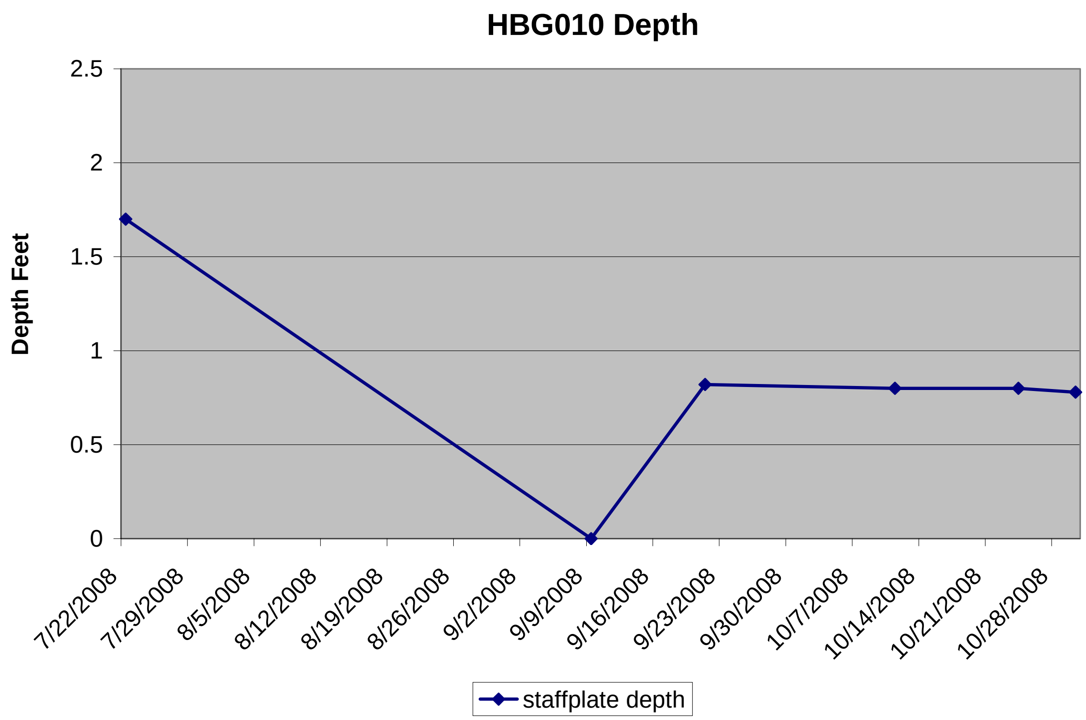
This site never had enough water to get a depth or flow reading. The creek bed was usually completely dry, with only small, separated pools present during one site visit.

MWC070: Located on Mark West Creek about 100 feet upstream of the bridge that accesses 5400 Alpine Road.





HBG010: Located on Humbug Creek at the crossing of Alpine Road and Humbug Creek. The contributing watershed area to this point is 2.8 square miles.



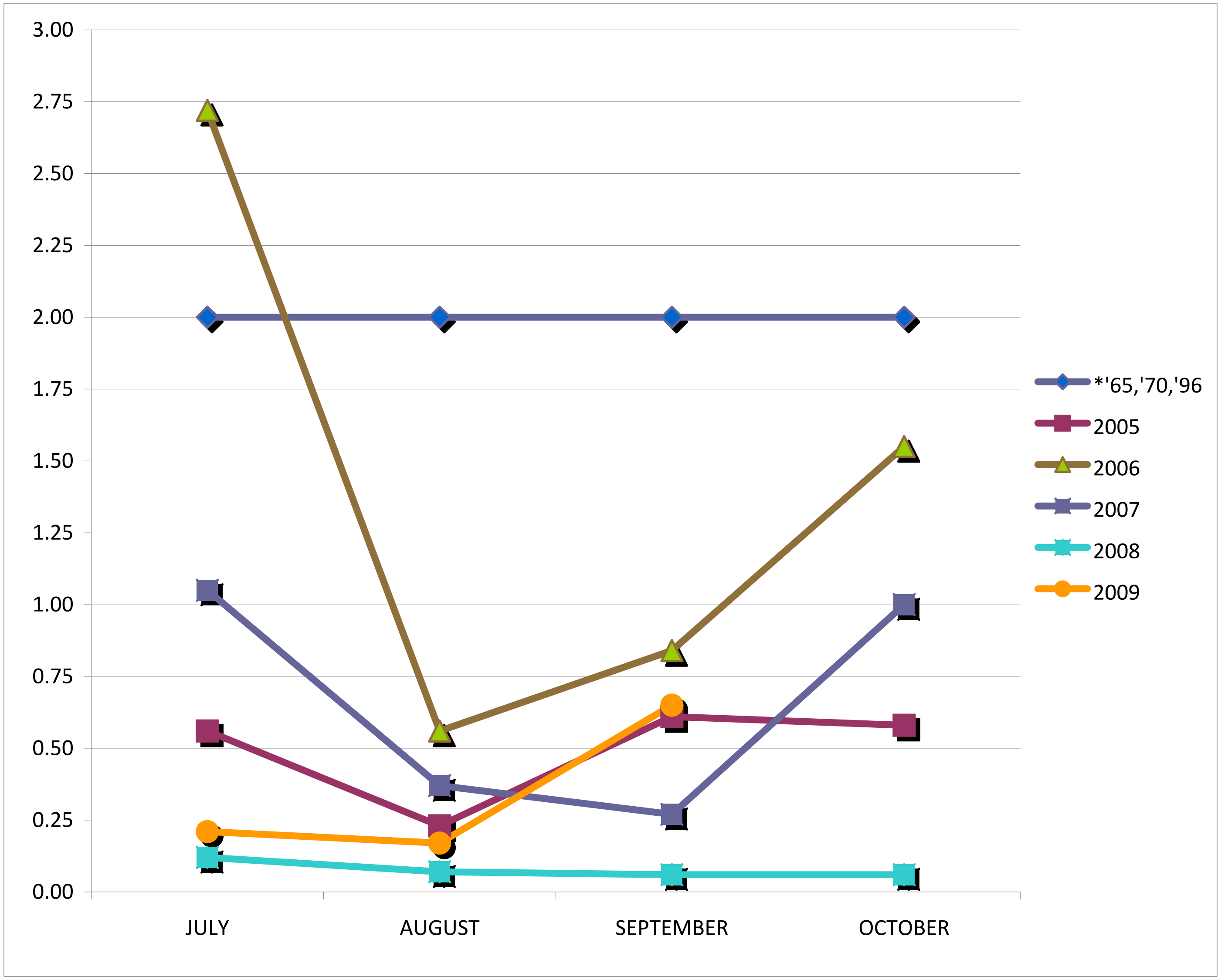
HBG010 did not have measurable flow for the duration of this project.

MWC095: Located at 5515 St. Helena Road; 1/4 mile up from Calistoga Road. Sample taken upstream of the vehicular bridge near the main house. The contributing watershed area to this point is 8.7 square miles.

This site only had measurable flow and/or surface water during two flow tests;

Sampled	Depth	Flow (CFS)
9-3-08	0.2	4.42
10-29-08	1.0	.06

DRY SEASON CREEK FLOW - MARK WEST CREEK 2005-2009 - Jim Doerksen
Comparison to Fish & Game Historical Flows 1965, 1970 and 1996



TO: BOARD OF ZONING ADJUSTMENT
Dave Hardy, Supervising Planner, PRMD

FROM: Jim Doerksen

RE: PROPOSED HENRY CORNELL WINERY - #UPE07-0008

DATE: November 13, 2008

My wife and I have lived at 7125 St. Helena Road, Santa Rosa and have almost one mile of Mark West Creek (Class I stream) flowing through our property. I have been here for over 40 years. We are the former Mark West Christmas Tree Farm. We also grow redwood and Douglas fir timber trees.

I intend to speak briefly at the November 13, 2008, hearing on this matter, but due to time constraints ask that this letter be accepted by this Board as my full and complete testimony and be made a part of the record.

I am a Civil Engineer and former hydrologist for Santa Clara County Flood Control & Water District, and am a retired City Engineer & Public Works Director. I have been in the timber business for almost 50 years. I have been awarded numerous environmental awards, one of which is for having the best tree farm (timber) in the western United States. My wife and I host up to 3,000 schoolchildren from schools throughout Sonoma County each year on our property; everything in these classes is centered around our segment of the Mark West Creek. (**See *Exhibit A***)

Now another winery wants to take the last few drops of water and put the last nail in the coffin. Let me explain why this should not happen.

Cornell started work on their vineyards in 2000. We always had a nice summer time flow with lots of fry. In the earlier part of this decade, we noticed the level of summer time flows being reduced and winter time flows resulting in flash floods.

Exhibit B shows that historical low summer flows to be very consistent around 2 cfs (cubic feet per second) irregardless of low or high seasonal rainfall. This work was done by Fish & Game. When severely dropping flows were noticed, a neighbor with the help of the Community Clean Water Institute started measuring creek flows. As the graph shows, the volumes continued to drop and this year in September, readings were at .06 cfs. This is only a few percent of normal summer time flows. It is important to emphasize that a drought may exaggerate the numbers, but the 98" of rain in 2005/2006 did nothing to reverse this trend of reduced summer time flow. The reading of summer time temperatures shows exactly the same trend. Temperatures keeps going up. This work was started by Sotoyome RCD (Regional Conservation District) on our property since 1999. The same is occurring at the Clean Water Institute site. In July this year, we observed lots of fry (steelhead & coho salmon). Upon our return from an extended vacation in September, no fish were found except for scaup fish that are not heat sensitive. This means that water temperatures were exceeding the 21.C˚ maximum temperature that the fish cannot survive.

What is causing this disaster and was I forewarned? Yes, I had been. Upstream neighbors who said both Pride Vineyards and Henry Cornell were cutting down forests and planting vines that will cause serious damage. All I can say now is I'm kicking myself for not getting involved sooner. Had no idea two vineyards (Cornell and Pride) and one winery could cause such serious damage to the watershed. ***Exhibit C*** is a letter from a property owner explaining what an adjacent vineyard was doing to Mark West Creek. I gathered considerable information from neighbors and all showed the same trend.

Many neighbors all along the creek from the upper reaches of Mark West Creek all the way to Wikiup have decided to see if we can save the last remaining water and then hope that steelhead and salmon will return. Why should two individuals, one not even living in California, cause so much destruction in their "wake"? Here is what we found out.

Pride started in the mid-nineties, and has expanded to become a 100+ acre vineyard, some of which appear to have been planted this year. (see ***Exhibit D*** aerial photo). Nobody in local government seemed to be aware of their continuous expansion. The creek levels dropped. Then along came Cornell vineyards in 2003. The creek levels started to drop precipitously and flash floods increased. Spawning coho and steelhead disappeared soon thereafter, parts of Mark West Creek went dry as did tributary streams feeding Mark West Creek, and local springs stopped supplying water.

Now the Board is being asked to approve an 18,670 sq. ft. winery on the Cornell vineyards on 245 Wappo Road, Santa Rosa. Reviewing the documentation on file at PRMD supporting the proposed winery, I find it fraught with errors, omissions and misrepresentations. I have not reviewed these documents by myself. I enlisted the help of neighbors, my engineering buddies, public agency experts, and they have helped with the research.

The *Pilot Study of Groundwater Conditions (Kleinfelder 2003)* was commissioned by the County in an effort to get an unbiased understanding of complex groundwater issues. This study includes the Mark West Springs area and discusses Mark West Creek. It makes some very significant findings germane to the Cornell project, summarized as follows:

- We are water scarce (p. 38)
- "Geology is considered the most important factor (for groundwater)" (p. 38)
- "The Franciscan Formation [predominant rock at Cornell] is mostly a tight, non-porous rock unit and groundwater occurs only in secondary openings such as joints, fractures, and shear zones. As a result, well yield is typically low, 1 to 3 gallons per minutes (gpm), although wells with yields as high as 68 gpm are recorded (Ford, 1975)" (p. 6)
- "DEPTH OF WELLS TREND in the Mark West Study Area [showed] the average depth of new wells has increased from about <u>120 feet in 1950 to about 300 feet in</u>

1997." "The trend seems to reflect lower water levels "…"not due to changing weather conditions." (emphasis added) (p. 35 & 36)

- "Water availability is limited in all water scarce areas of the county but it is particularly scarce in geologic materials such as the Franciscan and Petaluma formations. The composition and hydrologic characteristics of these formations and the nature of the materials in them limit key aquifer characteristics such as recharge potential, water storage capacity, and the ability of the formation to yield water. Or in other words, these factors determine how much water gets into the formation, how much water it can hold and how freely water flows from it" (emphasis added) "These poor aquifers have insufficient storage to supply some residents through the dry months of the year. In some areas, residents must supplement their water supply by trucking to their homes. This is evidenced by the frequent presence of water trucks on the roads." (emphasis added) (p. 38)

- "Additional development will likely increase overdraft." (p. 40)

- "The trend in depth to water in new wells shows evidence of an overdraft condition." (p. 39)

Cornell hired RGH in 2004 & Todd Engineering in 2006 to do groundwater availability studies, both of which include the vineyards and winery of Cornell since they have no effective way to separate them. PRMD then hired Kleinfelder, as a consultant to the County, to review the Todd Report. Inconsistencies were noted between Kleinfelder's 2003 "unbiased" overview and his 2007 review of Todd's report; significant Kleinfelder findings included:

- "The Cornell Farm's wells, although not tested, may be able to continuously and reliably produce 10 and 15 gpm". So why these suppositions when Kleinfelder (2003) states very clearly they will typically be 1 to 3 gpm? And why not test when they are required to do so? Kleinfelder now working for PRMD agrees with Todd---totally contradicting his accurate and well done report of 2003.

- "… we agree that anecdotal interviews with well owners and drillers are not necessary for this study." Not only another disagreement with his own report but bordering on irresponsibility. Pride Vineyards, a large 100+ ac. vineyard located above Cornell had its wells run out of water in May of 2008 and also last year and the previous. Todd has very carefully left Pride out of the equation. The Pride vineyards and winery, neighbors of Cornell, are not mentioned in Cornell's application.

  Exhibit E shows a water truck going to Pride Vineyards on July 21, 2008. The driver said they have been hauling to Pride since May 2008 from both Sonoma and Napa Counties. He also said he had hauled to Cornell. I have no evidence of that.

  One would have to assume that if Pride is dry, the same has already happened to Cornell or "very" close to it.

- "Checklist Item 31 requires discussion of potential impacts of surface water and aquatic habitat. The Todd report and letters address the potential impacts to surface water but do not mention aquatic habitat. However, since the overall conclusion is that there will be no significant impact on surface water, then it may also be concluded that there will be no anticipated significant impact to aquatic habitats".

- ❖ "A short explanation of the relationship between groundwater use by this project and surface water flows in Mark West Creek is required (number 21 on the checklist). If there is no connection between the two, then please make this clear." "We believe Todd makes a clear and concise description of the relationship between potential groundwater, groundwater conditions and withdrawals, and their interaction with Mark West Creek. Their approaches are sound and are within what would considered (sic) acceptable practice and standard of care."

I am outraged! Todd & RGH have been hired by Henry Cornell to sell you/us a bill of goods which most of us know little about. The Planning staff can see some serious omissions with these reports. They then hire Kleinfelder to give us an impartial review of the reports by Todd (Aug. 2006) and RGH (Jul. 2004). Unfortunately, Kleinfelder continually agrees with suppositions made by both reports in total contradiction of what he states in the Kleinfelder Report of 2003. He now really goes out on a limb when he states there will be no significant impacts on surface water, aquatic habitat, and Mark West Creek. ***Exhibit F-1*** -Press Democrat photo in 1999, 9/13/99, and ***Exhibit F-2*** photo taken in early summer of 2008 at same location.

Some Board members may not be as familiar with the connection of groundwater, streamflows and, of course, the steelhead and salmon. I have long been aware of this problem when I worked for Santa Clara county Flood Control and Water District in the 1960's. There has been lots of research on this subject for a very long time. Brock Dolman of the Occidental Arts & Ecology Center teaches and gives seminars on this subject. He has a great slide presentation showing in detail how water from creeks and springs are lost when aquifers are overdrafted especially in regards to vineyard and winery water usage that is now becoming very common in Sonoma County. Brock is the guru of andronamous salmonids in Sonoma County.

A Timber Harvest Plan (THP 1-00-411SON) was done in 2000. The following comments were made by Cherie Blatt of the NCRWQCB (No. Coast Regional Water Quality Control Board) in a letter to California Dept. of Forestry, dated February 28, 2001.

> "We are concerned about the water quality effects from the increase in flows due to vineyard clearing and timber harvesting. The THP does not address the potential change in runoff from the project. It has been documented that reductions in vegetative cover reduces evapotranspiration, rainfall interceptions, and fog interception. (Ziemer, 1998) This in turn, may cause bank and channel instabilities resulting from increased runoff. We are also concerned about potential changes in summer flows in the Class I and II watercourses. The THP lacks information regarding well development or surface water drafting from the creeks and the quantities needed for vineyard supply. Overdrafting of groundwater or surface waters may affect down stream summer flows. Changes in stream flow volume, increased storm flow discharges and changes to stream channel morphology along with the resulting adverse impacts to beneficial uses

should be addressed. In addition, the THP should mitigate these changes to protect the beneficial uses of water." (Emphasis added)

Unfortunately, Cherie Blatt's predictions came true:

- A Class I stream adjacent to the proposed winery has changed into a Class II and possibly Class III due to pumping and removal of trees. "Overdrafting of groundwater" has caused major changes in Mark West Creek resulting in large fish kills. ***Exhibit G*** shows a dry creek bed directly below the proposed winery site in May 2008.

- "…increased storm flow discharge" – I applied for flood insurance this year even though my home has been here since the 1850's and have never had to file a claim.

- "Changes in streamflow morphology" – ***Exhibit H*** shows the erosion along my streambanks due to flash floods (9 large trees fell due to this). ***Exhibit I*** shows steelhead eaten by turkey vultures because of the extremely low water level this last winter in Mark West Creek.

- "May cause bank and channel instabilities resulting from increased runoff." Added to this runoff was the removal of the trees on the proposed winery site without the benefit of a THP and "YOUR" approval. ***Exhibits J1 through J6*** shows the proposed winery site at different time periods.

  J1 – A 1988 photo taken by previous owner looking from Wappo Road across proposed winery site; and same location today in 2008.

  J2 – Shows the site being grubbed (illegal THP). Grubbed means to dig up by the roots according to Webster's dictionary. Owner's representative says the vegetation removed was only chamise, according to Jeri Finn of Calif. Dept. of Forestry (CDF/CalFire). Photos show otherwise.

  J3 – Google Earth shows over 30 such piles of wood (which was burned).

  J4 – Photo of site from neighbors. Note large amount of Douglas fir. Almost none existed in 1988 photos. This area had been burned and is still in a state of regeneration.

  J5 – Cleared site from the air. Note "new" grading on right.

  J6 – Cleared site adjacent to Wappo Road.

- A huge slide, just downhill from the winery site occurred. (***Exhibits K1 & K2***). This caused serious degradation to Mark West Creek and the spawning beds. One neighbor even used a pick to improve the impacted spawning areas. It is my opinion that more slides will occur. ***Exhibit L*** - Photo of edge of slide adjacent to proposed winery site. Note erosion, very steep banks and now a Class I stream is dry (May 2008).

On the follow-up (or resubmitted) THP 1-01-215SON Cherie Blatt of NCRWQCB arrives at the site to find trees being harvested prior to approval. She recommends Calif. Dept. of Forestry file a citation against Henry Cornell. Was this done?

The Sonoma County Grand Jury Report (July 1, 2004) and the League of Women Voters of Sonoma County report (October 2004) have a real good handle on these serious water issues. I even use these resources when I teach classes in forestry to Sonoma State and Santa Rosa Junior College students and classes in water management. Here is the Calif. Dept. of Fish & Game's take on this: "A substantial amount of coho salmon habitat has been lost or degraded as a result of water diversions and groundwater extraction (CDFG 1997, KRBFTF 1991)." "In some watersheds, the demand for water has already exceeded the available supply and some water rights have been allocated through court adjudication. " "Small coastal streams often rely on springs to maintain flows through the summer months, but the flow of these springs is often diminished by pumping from the aquifers that supply them. Many streams that once flowed year-round no longer do so, because of recent increases in hillside agricultural land conversion and reduction in local groundwater levels. The conversion of uplands from forest or grasslands to agriculture increase erosion and ground water use (CDFG 2001)".

Here is a short list of individuals that have a good understanding of the "problem". Ask them:

Christine Fontaine – Laguna de Santa Rosa Foundation
527-9277 E-mail: Christine@lagunafoundation.org

Dan Wilson – Calif. Dept. of Fish & Game
944-5534 E-mail: dwilson@dfg.ca.gov

Greg Damron – Pepperwood Preserve
542-2080, ext. 2 E-mail: gdamron@sonic.net

Dr. Matthew Deitch – Consultant, Center Eco System Management & Restoration
E-mail: deitch@cemar.org

Brock Dolman, Director, OAEC'S Water Institute
874-1557 E-mail: brock@oaec.org

Dr. Adina Merenlender – U.C. Berkeley
707-489-4362 E-mail: adina@nature.berkeley.edu

Don McEnhill – Russian Riverkeeper
433-1958 E-mail: rrkeeper@sonic.net

California Regional Water Quality Control Board (CRWQCB)
Cherie Blatt 576-2755 E-mail: CBlatt@waterboards.ca.gov
Charles Rich 916-341-5377 E-mail: CRich@waterboards.ca.gov

Mary Ann King – Trout Unlimited
510-649-9987 E-mail: mking@tu.org

David Bannister BTI Group
538-7738 E-mail: davidban@sonic.net

Todd Engineering also makes many statements/calculations not given to Kleinfelder by the County that appear to be very inaccurate and misleading. Examples are:

Todd says 1,2000,000 gal./yr. of water is needed for the vineyards and 96,000 for the winery. I have no expertise here so I consulted others. U.C. Davis, Richard Nagaoka (who has done considerable consulting on Spring Mountain), and a local vintner. The numbers ranged from 3,750,000 to over 5,000,000 gal./yr. All agreed this area cannot be "dry farmed".

Todd estimates recharge of groundwater to be 3%. Everyone else disagrees and the most optimistic figure was from No. Coast Regional Quality Control Board with ½%. Of course, the forested areas adjacent to the vineyards will have a much better recharge. I personally believe it is much closer to zero and Kleinfelder again agrees Franciscan has a very limited recharge potential. This has a dramatic effect on water that would be available.

Do I have other things to discuss? Of course, there are many other issues regarding both Todd & RGH, but water is, in my opinion, the most serious and the most threatened.

The other really significant item as I see it is CEQA review with a "full blown" EIR. Probably its most important function is to keep all parties honest. As a former City Engineer/Public Works Director, had I tried to avoid this process, I would have been in big trouble. The Cornell winery project is far more significant than any projects I was involved in as they only had local impacts where this is having a major regional impact. Based upon my education, training and professional experience, and living with and nearby the Mark West Creek for more than 40 years, I have reached certain conclusions which cause me to oppose the Cornell winery application and PRMD's decision to issue a Mitigated Negative Declaration in lieu of requiring an EIR for Cornell's project. I have concluded, and would so testify under oath, that since Cornell began planting vineyards, etc. in or about 2001, (1) there has been a significant reduction of available groundwater in this upper watershed area; (2) due to timber removal and conversion to grapes, winter storm run-off from Cornell into Mark West Creek has destabilized the banks of the Mark West Creek – (see previous ***Exhibit H)*** shows creek bank destabilization; (3) largely destroyed spawning areas of endangered or protected species of coho and steelhead by depositing impenetrable silt where gravel once facilitated spawning; (4) during the research, other items such as sedimentation, slides, erosion, possible illegal THP, etc. came up. Lots of other problems here and hope someone will address them. I don't believe Cornell has much water left, if any, and neighbor Pride is out, as I said earlier.

No further development should occur until streamflows can be restored.

Thank you for reviewing my statement and research.

Jim Doerksen
7125 St. Helena Road
Santa Rosa CA 95404
707-539-7004
betdoe6@yahoo.com

EXHIBIT A

NATURE'S GUARD
Casa Grande's Danny Ancheta feels a responsibility to help the environment/6

Family

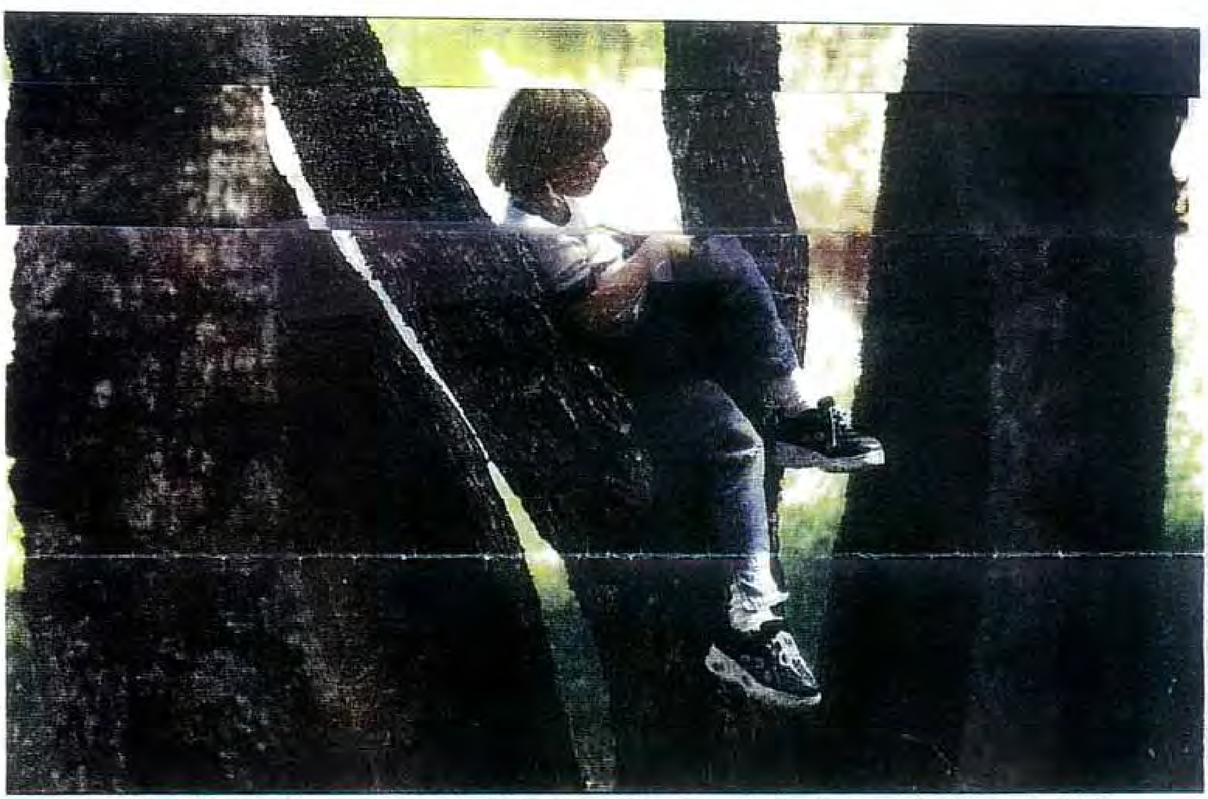
www.pressdemocrat.com

Lessons in Life: *Third graders from Fremont School play "salmon," a game that mimics the life cycle of the fish.*

"We're trying to instill an appreciation for the world around them."

HUGH SLESINGER
PROGRAM DIRECTOR

learning *to love their* land



lone With Her Thoughts: *Mary Thompson, a third grader at Fremont School in Santa Rosa, writes about her surroundings during a recent "In Our 'wn Backyard" outing at Ranchero Mark West.*

EXHIBIT A

'In Our Backyard' introduces kids to nature with hopes that someday they'll become stewards of the environment

STORY BY GEORGE LAUER ■ PHOTOS BY JOHN BURGESS/*Press Democrat staff*

Jose Hernandez, a rotund, impish third grader, grinned with pride.

"I'm in fish heaven," he said, a little out of breath, "but the good way."

Impersonating a salmon, Hernandez had just completed an obstacle course full of danger. He swam through a turbine generator (jump rope), evaded raccoons and bears (parents in drag), outsmarted fishermen (teachers) and finally climbed a fish ladder (carpet samples) to the piscine promised land.

The object of the lesson plan disguised as a game was to join the roughly 2 percent of salmon who successfully complete a life cycle from egg to old age. If you fall prey to an obstacle, you go directly to fish heaven and start over.

"I did it that time. I made it back alive," Hernandez said, enjoying his heavenly respite before starting a new life cycle.

Hernandez was one of 30 third graders from Fremont School in Santa Rosa making their third trip to their adopted piece of open space in a program called In Our Own Backyard, an environmental education program for Sonoma County schools.

At the beginning of the school year, about a dozen classrooms ranging from elementary to high school were paired with a piece of property and then scheduled for at least four field trips — one for each season. They learn biology, mapping, geography, botany, ecology and, ultimately, a sense of stewardship for "their" land.

Unless your kid is involved, you've probably never heard of this program, but if you're a taxpayer in Sonoma County, you should know about it. There is no roadside sign pointing to "Your Tax Dollars At Work," but it is precisely that. In Our Own Backyard is the educational arm of the Sonoma County Agricultural Preservation and Open Space District.

Ten years ago, Sonoma County voters became the first in the country to tax themselves to preserve their landscape. Every time you buy something in Sonoma County, you pay a ¼-percent tax used to buy property or conservation easements to preserve open space. The tax generates about $13 million a year. A small portion of that — about $64,000 this year — goes to LandPaths, a two-pronged nonprofit organization dedicated to getting people out onto the open space they're paying for.

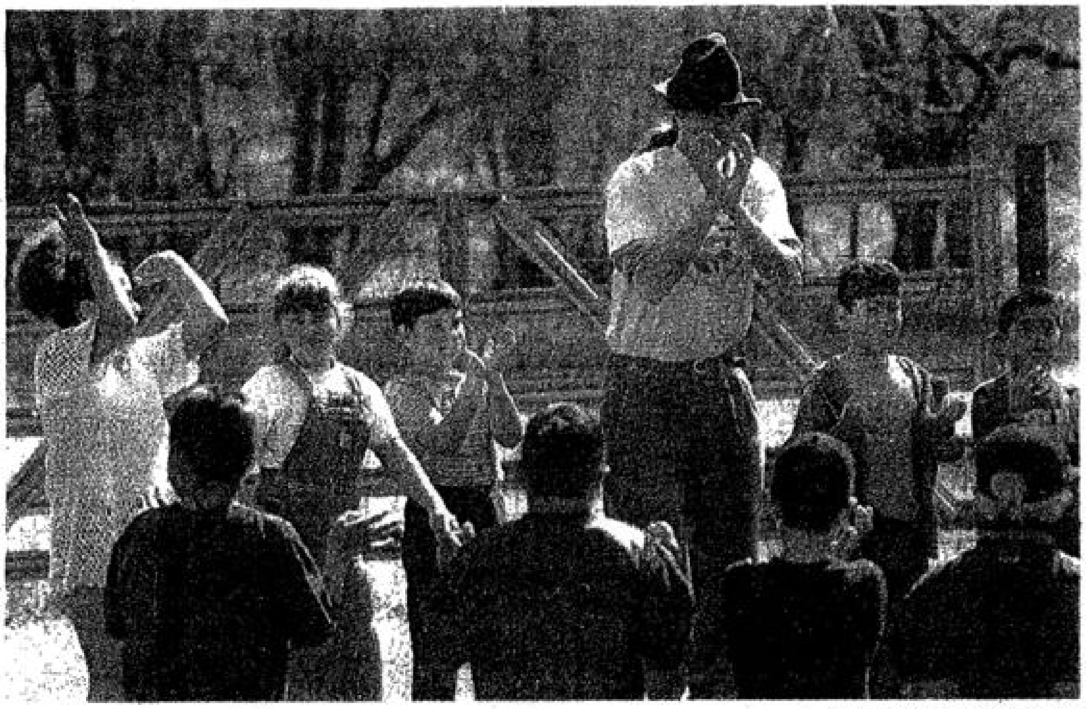
One prong, aimed at the general public, arranges and leads group excursions on preserved property. The other prong, In Our Own Backyard, works in partnership with schools.

Hugh Slesinger, with two teaching credentials and working on an interdisciplinary masters degree in education, is the maestro of In Our Own Backyard. Teachers and administrators are impressed with his work, but the toughest critics — the kids — go a step further.

"He's really neat," said Ruby McNulty.

See Land, Page D7

EXHIBIT A



JOHN BURGESS/PRESS DEMOCRAT

Hugh Slesinger, program coordinator for "In Our Own Backyard" leads a group of third graders from Fremont School in Santa Rosa in a song about the parts of plants.

Land

Continued from Page D1

"We were doing things with slugs last time, and he's reading us this story about apple trees. Look, there's a redwing blackbird," McNulty said peering through her mother's opera glasses, borrowed for the field trip.

Bruce Beasley, Sierra's dad, went along on last week's outing to see firsthand what he's been hearing about all year.

"She just loves this. For days after these outings we hear in great detail about how Hugh did this and Hugh did that. They have really made an impression," Beasley said.

It's not hard to see why. Slesinger and his co-teacher Jeff Domagalski use an effective combination of games, song and physical activity to engage the 9- and 10-year-old set. High school students do more hands-on projects, including mapping, wildlife observation, habitat restoration and stream enhancement. Older students are also involved in placing and monitoring nesting boxes for birds on several Open Space District parcels.

Fremont third graders in Jo Crouch and Paul Drake's classrooms have adopted Ranchero Mark West, 163 acres in the hills east of Santa Rosa. The Open Space District bought a conservation easement from landowner Jim Doerksen, who lives on the property.

"I think this is a great use of the property and of the program," Doerksen said. "You can see these kids beginning to develop a feel for the land, and it's pretty obvious they enjoy themselves when they get out here."

Slesinger, who has classroom teaching experience in Milpitas and Occidental and outdoor teaching experience in a variety of camps and environmental educational programs, says the focus and approach may differ depending on the age group, but the goals are the same.

"We're trying to instill an appreciation for the world around them that will carry on beyond their years as a student," Slesinger said.

Steve Sharpe, acting general manager of the Open Space District, said In Our Own Backyard's first year can be rated a success.

"This was really a big experiment for all of us this year and I think everyone involved has been pretty pleased with how it's turning out. You certainly can't argue about the importance of this kind of education," Sharpe said. "Kids are going to be the future. We'll all be long gone by the time they're running things. If they grow up with an appreciation for the natural world, we'll be doing the right thing."

• • •

By the end of the salmon life cycle game under the late-morning sun on a treeless field, every fish in the third-grade stream was sweating.

It's another learning opportunity for Slesinger and his students.

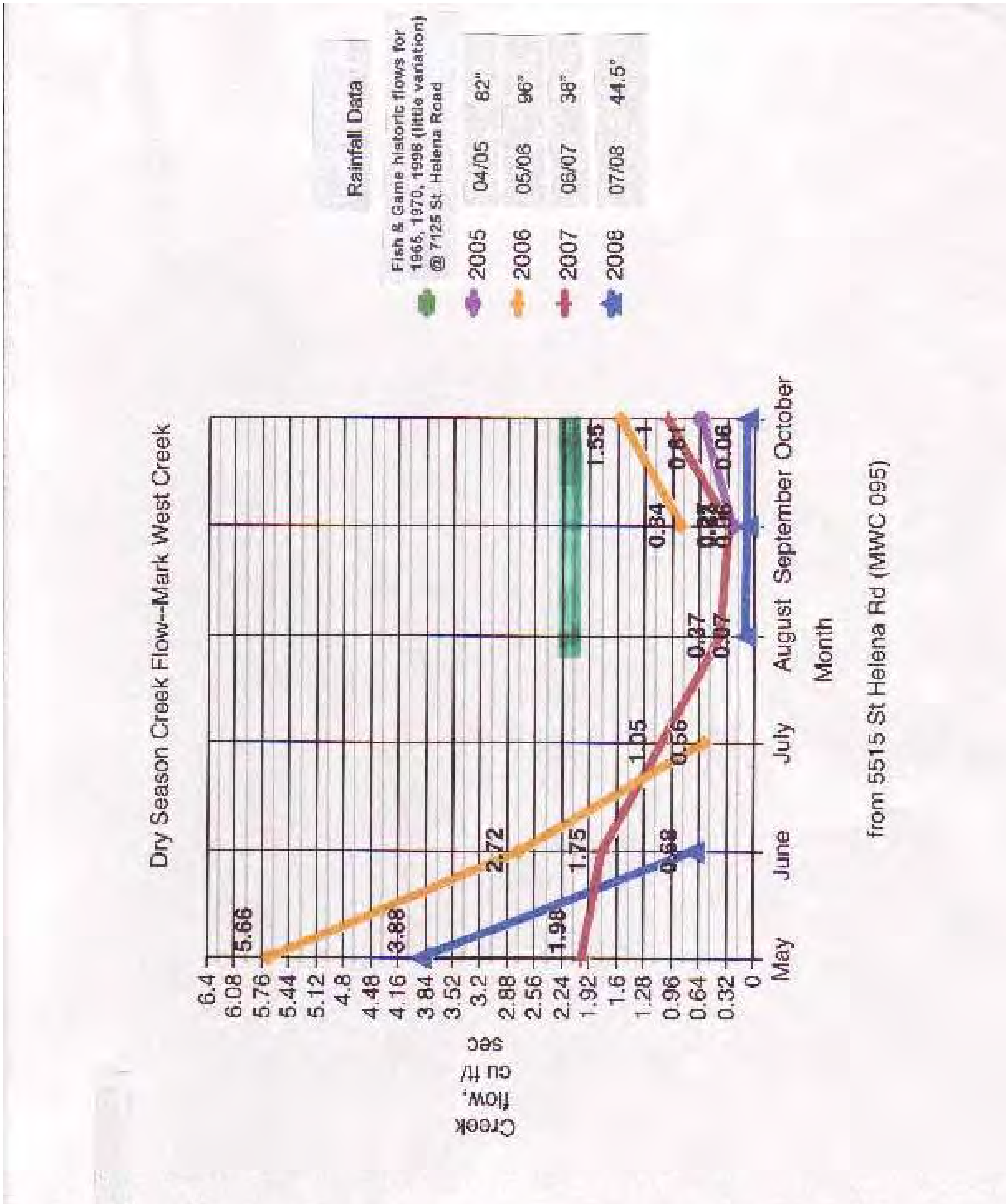
"Pretty hot out here, huh," Slesinger said. "Bet this would have been better in the shade."

"Yeah, way better," the third graders agree.

"It's the same for the salmon," Slesinger said. "If they don't have shade and cool water when they're trying to fight their way back up stream, they get overheated just like you do.

"Remember those acorns we found last time we were out here? Well, I stuck them in some dirt," he said, holding up a couple of 6-inch seedlings. "And now they're ready to plant. So to finish up today, we're going to plant these guys next to the creek to help the salmon get back upstream."

"Cool," said the third graders.



Dry Season Creek Flow--Mark West Creek
Creek flow, cu ft/ sec
6.4
6.08
5.76
5.44
5.12
4.8
4.48
4.16
3.84
3.52
3.2
2.88
2.56
2.24
1.92
1.6
1.28
0.96
0.64
0.32
0
May
June
July
August
September
October
Month
5.66
3.88
1.98
2.72
1.75
0.68
1.05
0.56
0.27
0.07
0.54
1.55
1
0.61
0.06
Fish & Game historic flows for 1966, 1970, 1998 (little variation) @ 7125 St. Helena Road
2005
2006
2007
2008
Rainfall Data
04/05 82"
05/06 96"
06/07 38"
07/08 44.5"
from 5515 St Helena Rd (MWC 095)

EXHIBIT 8

TO WHOM IT MAY CONCERN:

I purchased the property known as 100 Wappo Rd., Santa Rosa, CA (formerly known as 8561 St. Helena Rd.) in March 1994. At that time, and for approximately 3 years thereafter, the sole source of water for this property was Mark West Creek, which runs parallel to St. Helena Rd. St. Helena Rd. is the boundary to my property.

An electrical pump was located near the creek bank at the bottom of a hill. When switched on, the pump carried water from the creek to a water storage tank sitting at the top of that hill. This storage tank was located about 150 feet from the house. As the water tank sat on the top of a hill, it was significantly higher than the house and spigots located outside the house. Gravity caused the water to flow from the tank to the house and outside spigots at sufficient pressure to allow for watering domestic stock, taking showers, watering the garden, and other activities needing water. The tank took less than 5 minutes to fill after the pump was turned on.

This situation changed in the summer of 1998. A vineyard located east of my property began to irrigate the grapevines, which caused the creek to stop flowing. The pipe that carried the water from the creek to the holding tank was located in a fairly deep pool in the creek bed. When I attempted to fill the tank from this pool, the pool would be lowered to the point where the pipe would take in air, causing the flow of water to be broken. About 1/3 of the tank could be filled before the pump started to "suck air." I would have to wait approximately 45 minutes for the pool to refill above the end of the pipe, then prime the pump to start filling the tank again. The end of the pipe would again be above the water surface after filling another third of the tank. This process would have to be followed a third time to completely fill the tank. This size of the tank is not excessive; I believe that it has a capacity of 1,000 gallons.

In late summer or early fall of 1998 the pool in the creek rose so that the pipe remained filled with water long enough to fill the tank without having to start and stop as described in the paragraph immediately above. This increase in the availability of water coincided with the cessation of the vineyard's irrigation for the season.

EXHIBIT C – p. 1

Because a source of water is vital to raising animals, I hired a general contractor, Phil Farmer of Santa Rosa, and Weeks Drilling and Pump Company of Sebastopol, to drill a well, dig a trench from the well to the house, and lay the electrical lines and water pipes in the trench. As part of the project, Phil Farmer also poured a cement pad at the well head. The cost of drilling the well was in excess of $12,000, and the ancillary work was in excess of $6,000. These amounts were paid to Weeks and Farmer, respectively.

There is no question but that the irrigation of the vineyards directly affected the volume of water in Mark West Creek. I am concerned that additional water usage to irrigate newly planted vineyards near my property could negatively affect the existing water table to the extent that this well, which is now the sole source of water for my property, will no longer be productive.

Ali J. Farhat

June 15, 2008

EXHIBIT C - p. 2

Exhibit D – Aerial photo of Pride Vineyards & Cornell & proposed winery site.

Exhibit E **–** Water truck hauling to Pride Vineyards (July 21, 2008). The driver stated that they had been hauling to Pride since May 2008.

EXHIBIT F1

Rancher tends to damaged forest

3-decade effort draws acclaim

By TOM CHORNEAU
Staff Writer

Visitors to Jim Doerksen's ranch usually are invited up the hill to a peak overlooking his 130 acres and much of the Alpine Valley near the Napa County line.

Doerksen likes the spot because he can point to the hundreds of thousands of towering redwoods and thriving Douglas firs he's planted since taking ownership of the land in 1967.

It has taken 30 years, but observers say Doerksen's restoration has largely succeeded in overcoming nearly a century of disruptive logging and farm operations on the property.

"I'm not finished yet, but anyone who would have seen this ranch when we bought it and would look at it today would understand what we've accomplished," said Doerksen, who along with his wife, Betty, will be honored later this month by the American Forest Foundation for their land stewardship. "It's been a lot of work. A lot of days out there, clearing space and weeding out the brush."

By carefully selecting trees to cut and tearing out species that compete for water and sunlight, Doerksen said he has created an environment in which firs and redwoods can grow 10 times faster than they did under prior ownership. He estimates he actually has planted more than 1 million redwoods and Douglas firs on his land and parts of two adjoining parcels.

The process has allowed him to harvest nearly 3 million board feet from the property while still maintaining what experts say is a healthy forest — perhaps very similar to what once existed on the land before the arrival of man.

"His ranch is an excellent example of tree farming and forest management," said Dino Bonos, stewardship coordinator for the Sonoma County Agricultural Preservation and Open Space District. The district owns a conservation easement over the Doerksen Ranch and closely monitors land conditions.

"The forest itself is healthy and in good condition, as are wildlife habitats and the streams and creeks," Bonos said. "It is something that he can take a lot of pride in."

The property, once part of the holdings of Gen. Mariano Vallejo, is on St. Helena Road only five miles from Rincon Valley. Known locally for its patch of Christmas-tree pines sold [illegible]

See Forests, Page B2

MARY GARDELLA/PRESS DEMOCRAT

Jim and Betty Doerksen have received national recognition for reforestation work on their 120-acre ranch off St. Helena Road northeast of Santa Rosa.

P.D. 9/13/99

PRESS DEMOCRAT

NAME NEWS

Who: Jim Doerksen
Age: 60
Occupation: Retired engineer and real estate entrepreneur, named 1999 Western Regional Tree Farmer of the Year, American Forest Foundation

"It is amazing what nature will do if you help it along. We just weed out some of the brush and oaks to give the rest of the forest a chance."

[illegible] takes pulpit at gay church

By RANDI ROSSMANN
Staff Writer

GUERNEVILLE — Sonoma County District Attorney Mike Mullins took on the role as guest preacher Sunday morning at a small gay community church in Guerneville.

The Rev. John Torres invited Mullins to address the Metropolitan Community Church as part of bridge-building effort between the county's top prosecutor and the area's gay and lesbian community.

Torres said he received a couple of letters late last week from people saying Mullins was a poor choice, believing his office has not done enough in some cases of domestic violence against women.

Torres said that having Mullins as guest preacher was not an endorsement of everything his office has done. But with a growing gay and lesbian community in the county, it is important to continue to keep and nurture a relationship with elected officials, Torres said.

"I don't want to wait until there's a big controversy in the community. I want to talk now. Here's an olive branch," Torres said. "We're trying to connect with each other."

Of the 18 people who attended the service, several said they were glad he came.

Some people in the gay and lesbian community believe their community is left out when it comes to justice, said Steve Rickabaugh. Mullins' appearance was a "good connection we're trying to make. We need to connect with all parts of the community."

Mullins, the only one in a suit at the casual service, told the audience that he had a great-grandfather who had been a traveling Methodist minister and joked that

See Mullins, Page B4

Exhibit F1 – Press Democrat photo of Mark West Creek (9/13/99)

EXHIBIT F2 **–** Photo taken on Mark West Creek taken summer 2008 at same location as photo taken by Press Democrat in *Exhibit F1*.

Exhibit G – Dry creek bed directly below proposed winery site.

Exhibit H – Shows erosion along my streambanks in Mark West Creek

***Exhibit I* –** Steelhead eaten by vultures in Mark West Creek because of extremely low water level last winter (07/08).

Exhibit J1 **–** As the proposed winery site looked in 1988 (photo taken by previous owner).

Exhibit J1 **–** As the site looks today in 2008.

***Exhibit J2* –** Proposed winery site being grubbed showing larger trees.

***Exhibit J3* –** Google Earth shows over 30 such piles of wood (Nov. 2005)

Exhibit J4 – Photo of proposed winery site from neighbor's.

Exhibit J5 – Cleared proposed winery site from the air. Note new grading at right.

Exhibit J6 – Cleared proposed winery site adjacent to Wappo Road.

***Exhibit K1* –** Landslide below Cornell's graded area, close to proposed winery site (2006)

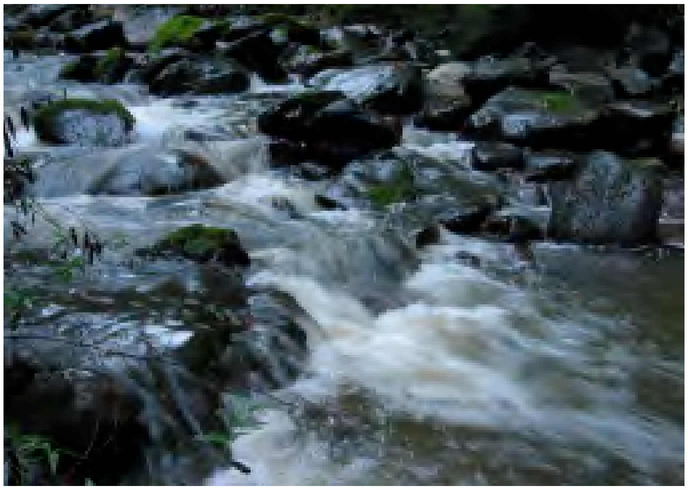
***Exhibit K2* –** Sediment entering Mark West Creek after landslide

***Exhibit L* –** Photo of edge of slide adjacent to proposed winery site

Sample_NUM	SITE_ID	Sample_Date	Sample_Time	Water_Temp_C_Dissolved_O2_meter	Water_temp_C_Thermometer	Dissolved_O2_mgL	Cu. Ft./sec (Flow)
8747	MWC095	11/29/2004	12:15:00	5.3	5.5	12.1	
8757	MWC095	12/17/2004	11:18:00	7.2	7.5	9.5	
8797	MWC095	01/27/2005	11:33:00	8.9	10	15.3	
8829	MWC095	02/25/2005	12:00:00	10.7	10.5	10.9	
8862	MWC095	03/25/2005	11:05:00		10	9.7	
8910	MWC095	05/13/2005	11:00:00		13	8.1	22.25
8965	MWC095	06/30/2005		19.1	19	11	10.87
9005	MWC095	08/05/2005	11:00:00	17	18	11	0.56
9025	MWC095	08/26/2005	11:30:00	14.6	15.5	9.7	0.23
9075	MWC095	09/30/2005	11:00:00	14.7	15	5.7	0.61
9120	MWC095	11/03/2005	13:30:00	9.6	10.5	4.3	0.58
9151	MWC095	12/02/2005	11:30:00	9	9	10.2	23.46
9204	MWC095	01/12/2006	14:10:00	9.2	9.5	10.1	8.97
9347	MWC095	04/28/2006	11:40:00	13.1		9.4	9.87
9377	MWC095	05/26/2006	09:50:00	11.3	12	9.9	5.66
9424	MWC095	06/30/2006	09:00:00	16.3	16.5	9.2	2.72
9455	MWC095	07/28/2006	09:07:00	17.1	18	7.8	0.56
9502	MWC095	09/01/2006	15:45:00	18	18	7	0.84
9540	MWC095	09/29/2006	13:40:00	14.3	14.5	8.4	1.55
9634	MWC095	12/01/2006	11:55:00	5.1	4.5	11.7	2
9807	MWC095	01/26/2007	13:30:00		5		1.35
9805	MWC095	03/31/2007	10:00:00	9.7	9	11.2	2.18
9802	MWC095	04/29/2007	11:45:00	14.6	14	10	1.98
9802	MWC095	04/29/2007	11:45:00	14.6	14	10.1	1.98
10494	MWC095	06/08/2007	15:00:00	17.2	16	9.1	1.75
10496	MWC095	07/06/2007	13:40:00	21.9	21.5	7.9	1.05
10025	MWC095	08/13/2007	12:15:00	17.5	17.5	8.6	0.37
10051	MWC095	09/07/2007	07:00:00	17.4	16	7.4	0.27
10090	MWC095	10/05/2007	09:15:00	10.8	10.5	8.9	1
10134	MWC095	11/01/2007	16:50:00	13.9	13.2	9.1	1.68
10167	MWC095	11/30/2007	10:00:00	5.3	5	10.8	1.4
10325	MWC095	02/01/2008	10:20:00		8		60.66
10440	MWC095	03/28/2008	11:00:00	8.7	8.5	11.1	3.93
10537	MWC095	05/23/2008	16:00:00	16.2	16	9	0.68
10475	MWC095	04/24/2008	18:15:00	13	12.5	10.4	3.88
10682	MWC095	09/03/2008	09:00:00	14.4	14	7.5	0.06
10763	MWC095	10/29/2008	13:30:00	12	11.5	9.6	0.06

Sample_NUM	SITE_ID	Sample_Date	Sample_Time	Water_Temp_C_Dissolved_O2_meter	Water_temp_C_Thermometer	Dissolved_O2_mgL	Cu. Ft./sec (Flow)
10878	MWC095	11/26/2008	10:16:00	8.8	9	9.9	4.46
10970	MWC095	02/05/2009	12:41:00	9.3	8	11.26	1.36
11109	MWC095	03/22/2009	14:35:00	11	9.5	10.96	6.24
11167	MWC095	04/17/2009	12:44:00	11.6	11.5	11.4	2.59
11254	MWC095	06/12/2009	11:35:00	9999	14	9999	
11296	MWC095	07/14/2009	12:30:00	21.1	20	8.02	0.22
11334	MWC095	07/29/2009	14:25:00	19.4	19.1	9.1	0.17
11406	MWC095	09/11/2009	10:37:00	16.1	16	8.3	
11460	MWC095	10/08/2009		14.1	14	8.56	0.08
11467	MWC095	10/13/2009	11:10:00				
11620	MWC095	02/01/2010	07:30:00	9.7	9	12.3	
11666	MWC095	03/02/2010	14:00:00	11.7	11	11.8	25.76
11698	MWC095	03/24/2010	01:15:00	13	12.5	13.2	8.95
11779	MWC095	04/30/2010	18:45:00	13.3	13	10.7	4.45
11830	MWC095	05/31/2010	14:30:00	15.7	15	9.44	2.3
11904	MWC095	06/30/2010	11:45:00	18.7	18	9.8	1.8

Photos of Mark West Creek, Russian River Watershed, Santa Rosa, CA



2003- Mark West Creek- still a healthy creek

2005-Receding water marks

2008-Reduced to a trickle

Steelhead die from lack of flows, eaten by turkey vultures

Photo credits: Kate Wilson

Damage from Henry Cornell Winery

Cornell Winery- deforesting for new wine caves 2005

Cornell clearing causes massive landslide, deposits 10,000 cubic yards of sediment into creek- 2006

Steelhead spawning grounds turned into "concrete" from landslide sediment

Vineyards continue to be allowed on steep slopes in upper watershed

Several vineyards in the upper Mark West Watershed have 1000 foot wells which have run dry. They are now trucking water in from another vineyard downstream, which is pumping the water from sub-surface flows of the creek. New vineyards continue to go in with little oversight. In the meantime, the Mark West has gone from a once-prisitine mountain stream to having the summertime flows of a garden hose.

APPENDIX B:
TMDL PROGRAMS THAT ADDRESS GROUNDWATER POLLUTION WITH SPECIFICITY

California

In 2002, EPA adopted Total Maximum Daily Loads (TMDL) for Toxic Pollutants in San Diego Creek and Newport Bay, California.[1] The TMDLs Source Analysis found that groundwater was a "significant and constant source of selenium to surface waters in the San Diego Creek watershed."[2] The TMDL recognized that "groundwater may seep into surface waters via natural processes, or it may be pumped as part of groundwater cleanup or dewatering operations which discharge into surface waters; thus selenium contributions to the watershed include both non-point sources (seepage) and point sources (cleanup and dewatering)."[3] The TMDL assigned allocations to groundwater cleanup and dewatering, with a recommendation to monitor flow and selenium concentrations to establish effluent limits in permits consistent with the TMDLs. The TMDL also assigned a wasteload allocation to a specifically named groundwater basin, the Silverado groundwater basin.[4]

In December 2005, the North Coast Regional Water Board adopted the Scott River Temperature TMDL, with an Action Plan that laid out the "Scott Valley Groundwater Study Plan."[5] In that case, Siskiyou County and the Regional Water Board found that hydrology of the entire valley needed to be understood in order to know the possible array of solutions to water issues in the Scott Valley. Siskiyou County, with its management jurisdiction over local groundwater, and the North Coast Regional Water Board pursued a community-based approach to groundwater management planning and study, the results of which the Regional Board subsequently used.

In another example, a study was initiated to develop a groundwater-surface water model for the Upper Santa Clara River Watershed through the "Upper Santa Clara River Chloride TMDL Collaborative Process."[6] Through a serious of technical reports, data gathering and analyses, models, monitoring and sampling, consultants determined the interaction between surface water and groundwater and its linkage to surface water and groundwater quality.[7] The model assessed the assimilative capacity of the surface water and groundwater systems in relation to existing Basin Plan water quality objectives for both groundwater and surface water with respect to chloride and total dissolved solids. In combination with the other TMDL studies, the Groundwater-Surface Water Interaction Model was used by the Regional Board to develop a site-specific chloride objective for the Upper Santa Clara River Watershed.[8]

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[1] U.S. Environmental Protection Agency, Region 9, Total Maximum Daily Loads For Toxic Pollutants San Diego Creek and Newport Bay, California (April 12, 2002) p. 34-37 ("*San Diego Creek and Newport Bay TMDL*"), available at http://www.pw.ucr.edu/textfiles/Newport_TMDL_summary0402.pdf.

[2] *San Diego Creek and Newport Bay TMDL* citing Hibbs, BJ and MM Lee. (2000) Sources of Selenium in the San Diego Creek Watershed.

[3] *Id.*

[4] *San Diego Creek and Newport Bay TMDL*; See Table 4-5 Wasteload and Load Allocations of Selenium for Newport Bay Watershed.

[5] *See* Scott Valley Community Groundwater Study Plan Website at http://groundwater.ucdavis.edu/ScottValley.htm.

[6] *See* documents and analysis at the website for the Upper Santa Clara River Chloride TMDL Collaborative Process http://www.santaclarariver.org/Content/10001/gwsim.html.

[7] *See* UCSR Collaborative Process Documentation, TMDL Task 5 – Groundwater Surface Water Interaction Model Study, http://www.santaclarariver.org/Content/10045/_.html.

[8] *Id.*

As one more example, the Lake Tahoe TMDL for phosphorous and nitrogen recognized that "groundwater flow contributes phosphorus and nitrogen to the lake at the aquifer-lake interface" and evaluated data to ensure that nutrient loading from groundwater was incorporated into the Lake Clarity model.[9]

Other States: Oregon, Florida, Washington

Other states have taken even more aggressive action to specifically identify and address groundwater contamination affecting surface water quality. For instance, after finding high levels of nitrates and other contamination in its groundwater wells, the Oregon Department of Environmental Quality created the Southern Willamette Valley Groundwater Management Area Action Plan. The Oregon Plan specifically cites the **"need for integration of groundwater quality protection strategies with other ongoing water quality improvement efforts, such as the total maximum daily load allocations for impaired waterways,"** as a primary purpose for initiating such an action.[10] For example, implementation of Oregon's Willamette Basin TMDL required consideration of groundwater management because of the close link between groundwater and surface water, especially regarding bacteria and nutrients.[11]

The Florida Department of Environmental Protection found that ground water contribution to surface waters "could obviously result in significant miscalculations in allocating waste loads to surface waters; thus in listing or delisting of water bodies respectively as 'impaired' or 'recovered' by the regulatory agencies."[12] To address this dilemma, the Hydrogeology Section commissioned research to develop a scientifically-based, yet simplified and economical, method of estimating groundwater contribution to surface waters.

In the state of Washington, the "Lower Yakima River Valley" is listed as impaired by nitrates.[13] The implementation plan for this impaired waterway region has a significant groundwater quality component due to nitrate contamination of the underlying groundwater basin, which many rely on for drinking water.[14]

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[9] California Regional Water Quality Control Board, Lahontan Region, Final Lake Tahoe Total Maximum Daily Load Report, Draft: June 2010 http://ndep.nv.gov/bwqp/file/LTTMDL_Final_v15.pdf *See* Section 7.2 Groundwater.

[10] Oregon Department of Environmental Quality, Southern Willamette Valley Groundwater Management Action Plan (August 2006), available at http://www.deq.state.or.us/WQ/groundwater/docs/swvgwma/draftactionplan.pdf (emphasis added).

[11] *See* Oregon Water Quality TMDL Program Implementation Guidelines and Tools: http://www.deq.state.or.us/WQ/TMDLs/implementation.htm.

[12] Florida Department of Environmental Protection, Simplified Method for Estimating Ground Water Discharge to Surface Water for the purpose of Total Maximum Daily Loads (TMDL) Allocation, available at http://www.dep.state.fl.us/geology/programs/hydrogeology/tmdl_radon.htm

[13] State of Washington Department of Ecology, Lower Yakima Valley Groundwater Quality, http://www.ecy.wa.gov/programs/wq/tmdl/yakima_wq/LowerYak-gw.html.

[14] *See* State of Washington Department of Ecology Groundwater Quality Information at http://www.ecy.wa.gov/programs/wq/grndwtr/index.html.