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SACRAMENTO REGIONAL COUNTY SANITATION DISTRICT

Antidegradation Analysis for Proposed Discharge Modification for the Sacramento Regional Wastewater Treatment Plant

prepared by

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INTRODUCTION

The Sacramento Regional County Sanitation District (SRCSD or District) provides wastewater treatment for over one million residents within a 370 square-mile area in the Sacramento Metropolitan area, including the City of West Sacramento in Yolo County. Contributing agencies of the District include the Sacramento Area Sewer District (SASD), and the cities of Sacramento, Folsom, and West Sacramento. The cities of Sacramento, West Sacramento and Folsom are responsible for operation and maintenance of portions of the collection system within their city limits, and SASD is responsible for operation and maintenance of the collection system within the cities of Citrus Heights, Elk Grove, Rancho Cordova and portions of Sacramento and Folsom, as well as unincorporated areas of Sacramento County. Contributing agencies maintain and operate their own wastewater collection systems, delivering untreated wastewater to SRCSD's interceptor conveyance system for transport to the Sacramento Regional Wastewater Treatment Plant (SRWTP) for treatment and discharge.

Treated wastewater from SRWTP is discharged through a submerged 120-inch diameter multi-port diffuser anchored to the bottom of the Sacramento River immediately downstream of the Freeport Bridge. The SRWTP discharge is regulated by the California Regional Water Quality Control Board, Central Valley Region (Central Valley Regional Water Board) through a National Pollution Discharge Elimination System (NPDES) permit (No. CA0077682). The current permitted discharge rate is 181 million gallons per day (mgd) average dry weather flow (ADWF).

As part of its current NPDES permit renewal, SRCSD is requesting that the Central Valley Regional Water Board increase the permitted discharge of the SRWTP from 181 mgd (ADWF) to 218 mgd (ADWF) consistent with the SRWTP 2020 Master Plan (Master Plan) (Carollo, 2002a). The Central Valley Regional Water Board must address whether the proposed increase is consistent with federal and State antidegradation policies before it can grant the requested increase in discharge. This document is the ***Antidegradation Analysis*** for the proposed SRWTP discharge. Antidegradation policies have been issued at both the federal and State level. These policies are intended to protect existing water quality and associated beneficial uses. The federal policy is expressed as a regulation in 40 CFR § 131.12. The federal antidegradation policy requires protection of existing in-stream uses and water quality necessary to protect those uses. The federal policy also requires maintenance and protection of water quality beyond that required to support propagation of fish, shellfish and wildlife and recreation (i.e. meet "fishable, swimmable" standards), when high water quality exists, unless a State finds that lower water quality is necessary to accommodate important economic and social development. In that case, the federal antidegradation policy requires the State to assure that the highest regulatory requirements for point sources and all cost-effective and reasonable best management practices for non-point source control are achieved. The State policy, adopted in 1968 as a resolution of the State Water Resources Control Board (SWRCB) (Resolution 68-16) addresses the need to maintain high quality waters in California consistent with maximum benefit to the people of the State. The State policy requires that changes in water quality will not unreasonably affect beneficial uses, and that waste discharge requirements result in best practicable treatment or control.

The proposed project would consist of the Central Valley Regional Water Board increasing the permitted discharge of secondary treated effluent to the Sacramento River from the currently permitted 181 mgd (ADWF) to 218 mgd (ADWF) consistent with the application filed by SRCSD (SRCSD, 2005a). The District has assessed the potential for the SRWTP effluent to affect the dissolved oxygen concentrations downstream of the discharge (SRCSD, 2009b), and as a means to prevent potential, summer episodic occurrences of low dissolved oxygen in the lower Sacramento River as existing SRWTP effluent flow increases, the District will appropriately limit the mass load of oxygen demanding substances in the effluent. As there are immediate opportunities for process optimization to reduce ammonia concentrations in the SRWTP effluent, the District's initial assessment only considered one alternative, the change in nitrogenous biochemical oxygen demand (NBOD), of which ammonia is the dominate species, and the affect on the downstream dissolved oxygen concentrations.

To maintain the dissolved oxygen concentrations in the Sacramento River downstream of the discharge above the Basin Plan objective, the assessment concluded that for discharge capacities of 181 mgd and 218 mgd, the effluent ammonia concentrations should be 17 mg/L as N and 14 mg/L as N, respectively. The assessment acknowledges that if other components of the oxygen demanding substances are concurrently reduced, the ammonia concentrations in SRWTP effluent could be correspondingly higher. The assessment concluded that the limitations were only necessary during the summer months (May through September) and would be accomplished through one or a combination of alternatives, including process optimization, treatment of internal processes return flows, increased water recycling, and/or advanced or additional treatment of a portion of SRWTP effluent flow. To be consistent with the assessment and the District's commitment to comply with the dissolved oxygen Basin Plan objective, in the antidegradation analysis the summer operations of the SRWTP are assumed to attain the ammonia concentrations identified in the assessment, and the winter operations of the SRWTP are assumed to proceed at current SRWTP ammonia effluent concentrations. For the SRWTP discharge, ammonia is the dominant species of both total nitrogen and total Kjeldahl nitrogen, and in the antidegradation analysis both measures of nitrogen are reduced during summer operations to reflect corresponding reductions in effluent ammonia concentrations. The District is committed to controlling oxygen demanding substances in its effluent to prevent causing excursions below the dissolved oxygen Basin Plan objective in downstream water and ensure compliance with the dissolved oxygen receiving water limits in the SRWTP discharge permit.

The purpose of this report is to provide an antidegradation analysis for a requested increase in SRCSD's permitted discharge to the Sacramento River from 181 mgd (ADWF) to 218 mgd (ADWF). The information contained in this analysis is intended to provide the Central Valley Regional Water Board with the information needed to determine whether to certify that the proposed permitted discharge increase is consistent with State and federal antidegradation policies.

REGULATORY REQUIREMENTS

The antidegradation analysis described in this report follows the guidance provided by the SWRCB regarding the implementation of the federal and State antidegradation policies in NPDES permits (SWRCB, APU 90-004, 1990). This analysis follows the provisions for a 'complete analysis' and evaluates whether changes in water quality resulting from the proposed discharge increase are consistent with maximum benefit to the people of the State, will not unreasonably affect actual or potential beneficial uses, and will not cause water quality to be less than water quality objectives and makes sure that the discharge provides protection of existing in-stream uses and water quality necessary to protect those uses. Federal and State antidegradation policies also allow the preparation of a 'simple' antidegradation analysis in certain circumstances (e.g. where a proposed discharge will not constitute a substantial increase in mass emissions of a constituent). Although, the best available scientific information indicates a 37 mgd (ADWF) increase in SRWTP discharge will not produce significant receiving water quality impacts, the heightened concern over the Delta ecosystem and its water supply prompted SRCSD to perform a complete antidegradation analysis.

Any simple antidegradation analysis is required to address the following provisions stated in SWRCB APU 90-004 to maintain consistency with State and federal antidegradation policies.

- Whether a reduction in water quality will be spatially localized or limited with respect to the water body; e.g., confined to the mixing zone;
- Whether the proposed increase in discharge of treated effluent will produce minor effects which will not result in a significant reduction of water quality;
- Whether the proposed increase in discharge of treated effluent has been approved in a General Plan, or similar growth and development policy document, and has been adequately subjected to the environmental and economic analysis required in an environmental impact report (EIR) required under the California Environmental Quality Act (CEQA); and
- Whether the proposed project is consistent with maximum benefit to the people of the State.

In addition, the following items are to be addressed in a complete antidegradation analysis:

- A comparison of the projected receiving water quality to the water quality objectives and/or criteria used to protect designated beneficial uses, and
- A socioeconomic analysis to establish the balance between the proposed action and the public interest.

Determining applicable water quality objectives and other guidelines for assessing antidegradation was a first step in the analysis. The Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins provides numeric and narrative water quality objectives for selected parameters in the Sacramento River basin. Water quality objectives and standards promulgated in the California Toxics Rule (CTR) (U.S. EPA, 2000) and the National Toxics Rule (U.S. EPA, 1995) for other parameters are also applicable to the Sacramento River and Delta. For each constituent, the most stringent water quality objectives or criteria are used in this antidegradation analysis for assessment of impacts on water quality and compliance with water quality objectives. Beneficial uses defined in the Basin Plan, 303(d) listings, and current NPDES permit limits were also evaluated in the course of performing the current antidegradation analysis.

ENVIRONMENTAL SETTING

Sacramento-San Joaquin Delta and Sacramento River

The receiving water for the discharge of treated wastewater from the SRWTP is the Sacramento River and the Sacramento-San Joaquin River Delta. The Sacramento River drains 27,000 square miles of northern California, extending from the Cascade Mountain Range in the north to the Sierra Nevada Mountain Range in the east and the eastern slopes of the Coastal Mountain Ranges in the west. The lower Sacramento River, defined as the portion of the river downstream from the town of Freeport, is predominantly channelized with levees and bordered by agricultural lands. Aquatic habitat in the lower Sacramento River is characterized primarily by slow-water glides and pools, depositional in nature, and has reduced water clarity and habitat diversity, relative to the upper portion of the river. A number of fish species utilizing the upper Sacramento River and its tributaries also use the lower river to some degree, even if only as a migratory corridor to and from upstream spawning and rearing areas. The lower river also is used by fish species (e.g., striped bass, delta smelt) that make little to no use of the upper river.

The Delta is a network of interconnected waterways covering approximately 1,500 square miles that receives runoff from over 40 percent of the State's land area. Inflow to the Delta includes flows from the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras rivers. The California Water Code (Section 12220) defines the upper boundary of the Delta as the I Street Bridge in Sacramento. The SRWTP discharges treated effluent to the Sacramento River just downstream of the Freeport Bridge, which is located approximately 12 miles downstream of the I-Street Bridge, and therefore is within the legal boundary of the Delta (see **Figure ES–1**). At the point of the SRWTP discharge, the Sacramento River is approximately 600 feet wide at the surface and normally varies in depth between 25 to 30 feet.

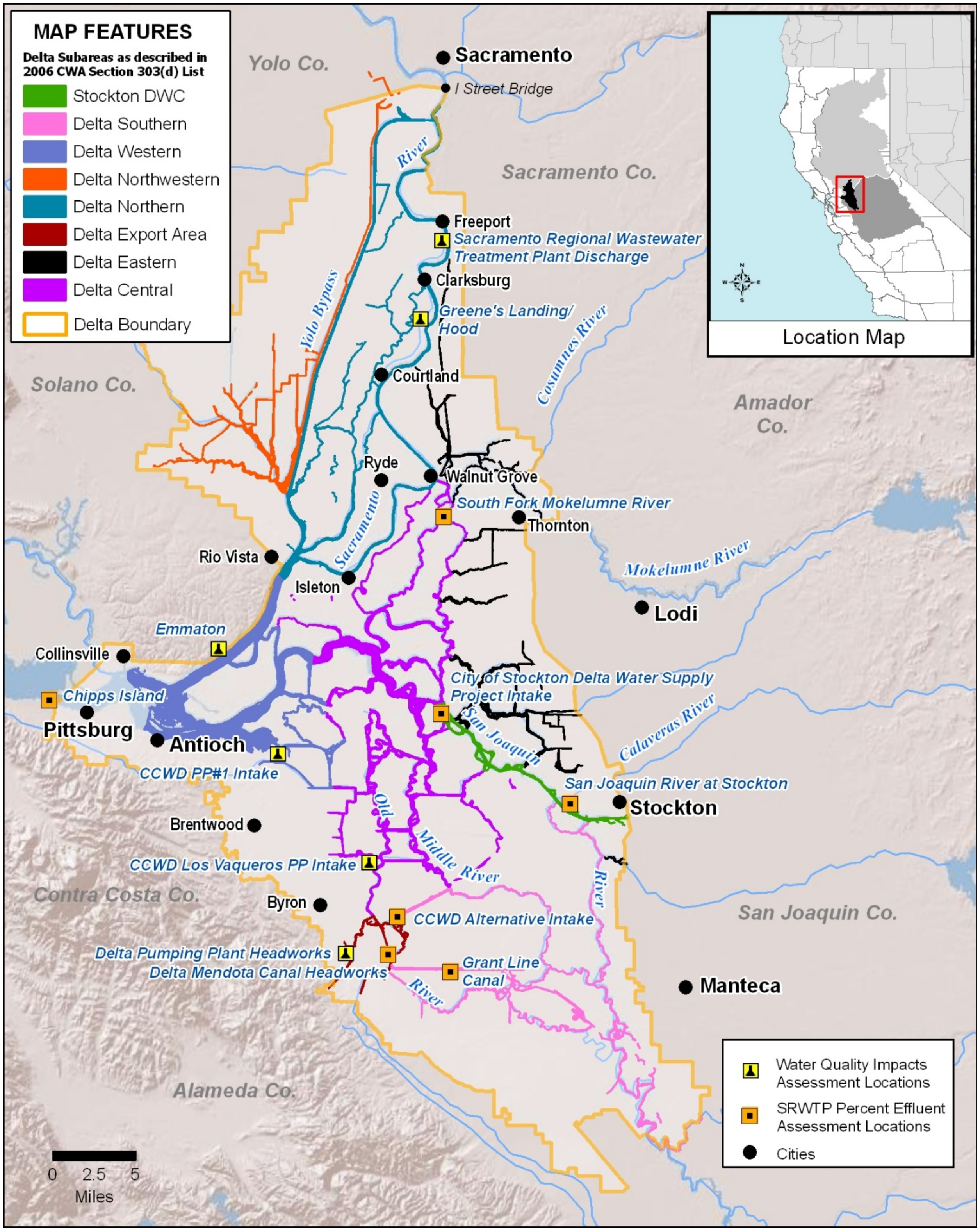


Figure ES–1: Delta Locations Modeled to Assess Impacts of Proposed SRWTP Discharge Increase from 181 mgd (ADWF) to 218 mgd (ADWF).

Sacramento River Hydrology

The lower Sacramento River, the site of the SRWTP discharge location (Freeport), drains a massive basin that extends from the inner Coast Range Mountains to the ridge-crest of the Sierra Nevada. The sources of surface runoff in this basin are diverse: forested watersheds, agricultural lands, and urbanized zones.

Flows in the Sacramento River are strongly influenced by precipitation (rainfall and snowpack/snowmelt) and reservoir operations. Irrigation diversions and agricultural return flows also affect the river's hydrologic regime. Winter and spring flows in the Sacramento River average 45,000 cubic feet per second (cfs). Summer flows average 10,000 cfs, but can fall to minimums of 6,000 cfs. Daily flow probabilities for the Sacramento River at Freeport, based on U.S. Geologic Survey (USGS) flow data collected over the last six decades, indicate that there is a 10% probability of flows less than or equal to 9,200 cfs, and a 10% probability of flows greater than 55,000 cfs. Future minimum flows in the river are predicted to be equal to or greater than historical minimum flows due to changes in reservoir system operation to meet environmental and salinity standards in the Delta.

As indicated above, the Sacramento River Valley experiences a wide range of hydrologic conditions from year to year. The California Department of Water Resources characterizes Sacramento River flows as falling into distinct hydrologic classifications as defined in SWRCB Decision 1641. These hydrologic classifications are comprised of a *water year type* and a *water year index* based on Sacramento River unimpaired runoff. Water year types in the Sacramento River watershed fall into five categories: wet, above normal, below normal, dry, and critical. The model simulations (described below) performed as part of the antidegradation analysis employed a hydrologic data set that includes representation from all five water year types. The hydrologic data set spans a 70-year period (1922 to 1991), accounting for a full spectrum of climatological conditions in the Sacramento River Valley. Ambient water quality conditions in the Sacramento River and Delta were evaluated for the antidegradation analysis using data from various sources for the period January 1998 through July 2008.

Regional Environmental Issues of Concern

A number of significant ongoing regional issues exist in the Sacramento-San Joaquin Delta that serve as a background for this analysis. These issues include:

- Pelagic organism decline
- Salt accumulation in the Central Valley
- Methylmercury levels in fish
- Surface water quality concerns for water used for municipal purposes

ASSESSMENT OF WATER QUALITY IMPACTS

SRCSD has developed sophisticated modeling tools to assess potential impacts to water quality and aquatic life in the Sacramento River and Delta that may result from the proposed SRWTP discharge. These modeling tools were developed to address both permit requirements and increases in discharge flows as projected in the Master Plan. These tools are useful in the examination of potential impacts to water quality in the immediate vicinity of the discharge point (near-field), and at various locations downstream in the Delta (far-field).

In October 2002, SRCSD conducted an Independent Technical Review (ITR) of its modeling tools. Three national modeling experts, with expertise in hydrodynamics/hydrology, probabilistic/statistics, and water quality, formed the ITR Committee. The Committee evaluated the modeling tools and endorsed their use. On April 2, 2009, the Central Valley Regional Water Board provided a letter to the District approving the use of the District's modeling tools for the NPDES permitting process and Antidegradation Analysis. This approval was based on an in-depth review of the modeling tools by a second group of national modeling experts commissioned by the U.S. EPA and Central Valley Regional Water Board.

Criteria Compliance

In its ambient water quality criteria documents for the protection of aquatic life, U.S. EPA states that freshwater aquatic organisms and their uses should not be affected unacceptably if the recommended criteria are not exceeded more than once every 3 years, on the average. A one-day exceedance in 3 years equates with 99.91% compliance, while a one-hour exceedance in 3 years corresponds to 99.9962% compliance. It is apparent that compliance with the U.S. EPA criteria is intended to provide a very high degree of protection of aquatic life beneficial uses.

Consideration of Constituents of Concern

Selection of constituents for the antidegradation analysis was based in part on the constituents for which there are water quality objectives or criteria applicable to the Sacramento-San Joaquin Delta. Constituents were also selected based on known concerns of the Central Valley Regional Water Board or interested parties. SRWTP effluent data were reviewed for these constituents during the time period June 2005 through July 2008. Summary statistics for SRWTP effluent data are presented in **Table 5–1** in the body of the report. Constituents for which there were more than 10% detected data during this time period were evaluated quantitatively with respect to potential water quality impacts in the near-field.

Where sufficient data exists, quantitative evaluations were conducted using modeling tools as described in more detail below. For constituents with more than 20% of the data measured above detection limits, a regression-on-order statistical analysis was used to generate summary statistics. For constituents with less than 20% of the data measured above detection limits, the following protocols taken from the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California* (known as the State Implementation Policy (SIP), effective 4/28/00 and amended 7/13/05) were followed when generating the summary statistics:

- Effluent values below detection limits were assumed to be equal to one half (½) the detection limit, as described in the SIP protocol for calculating effluent limits and determining compliance.
- Receiving water values below detection limits were assumed to be equal to the detection limit, as described in the SIP protocol for determining the need for and calculating effluent limits

- The coefficient of variation was assumed to be 0.6 and standard deviation was assumed to be the mean multiplied by the coefficient of variation, as described in the SIP protocol for calculating effluent limits

Constituents with less than 10% detected values in the effluent were determined to not have adequate data to provide a meaningful quantitative assessment using dynamic modeling techniques and were considered to be unlikely to have a measurable impact on the receiving water. Under the SIP protocol for determining a constituent's reasonable potential to cause or contribute to exceedances of a water quality objective/criterion in the receiving water, a single detected effluent data point greater than the applicable criterion can be the basis of a constituent's reasonable potential. Following this protocol, six constituents having less than 10% detection in SRWTP effluent show reasonable potential: carbon tetrachloride, pentachlorophenol, dibenzo(a,h)anthracene, 1,2-diphenylhydrazine, methyl-tert-butyl ether, and chlorine residual. However, based on these constituents' low detection rates in the effluent, future exceedances of receiving water quality objectives are not expected due to the substantial amount of effluent dilution that occurs in the receiving water. It is unlikely that a measureable impact to receiving water quality would result from such infrequent exceedances.

The constituents identified for evaluation in the antidegradation analysis (see **Table 5–1** in the body of the report) were further subdivided into three categories as follows:

- **Category 1:** These constituents are of concern regionally and, in particular, with respect to potential impacts on the Delta ecosystem and its water quality. These constituents were evaluated for water quality impacts both in the near-field within 700 feet downstream of the SRWTP discharge, and where relevant data were available, in the far-field at several locations throughout the Delta. Category 1 constituents include: ammonia, total nitrogen, nitrate plus nitrite, total Kjeldahl nitrogen (TKN), total phosphorus, electrical conductivity (EC), total dissolved solids, chloride, total organic carbon, mercury, and dissolved oxygen (see **Table ES–1**). Where sufficient historic water quality data were available, trend analyses were performed for Category 1 constituents. Additionally, statistical power analyses were performed to estimate the ability to measure their modeled water quality increments at far-field location.
- **Category 2:** These constituents were determined to be of concern with respect to localized impacts and were evaluated only with respect to near-field water quality impacts. These constituents are anticipated to have negligible impacts in far-field receiving waters. They include aluminum, cadmium, copper, zinc, temperature, and total coliform.
- **Category 3:** These constituents included all non-Category 1 and non-Category 2 constituents which generally have no history of contributing to adverse impacts in the Sacramento River. These constituents were evaluated with respect to near-field water quality impacts. Similarly to Category 2 constituents, they are anticipated to have negligible impacts in far-field receiving waters.

Water Quality Assessment Methodology

Due to the complexities of the Sacramento River flows, SRWTP effluent, near- and far-field mixing, and tidally influenced flow patterns in the Delta, no single model was available to adequately describe water quality and quantity conditions in the river near the discharge and downstream in the Delta. The models used in support of the water quality analyses, and approved for use by the Central Valley Regional Water Board, included: 1) the U.S. Bureau of Reclamation (USBR) Project Simulation Model (PROSIM); 2) Reclamation's temperature models for the Sacramento River system; 3) the Fischer Delta Model (FDM); 4) a near-field 3-dimensional (3-D) dilution model, FLOWMOD; 5) a longitudinal dispersion model for the Sacramento River; and 6) the U.S. EPA's Dynamic Toxicity Model (DYNTOX). The relationship between these models is illustrated in **Figure ES-2** and described in greater detail in Section 5.3.1 of the report.

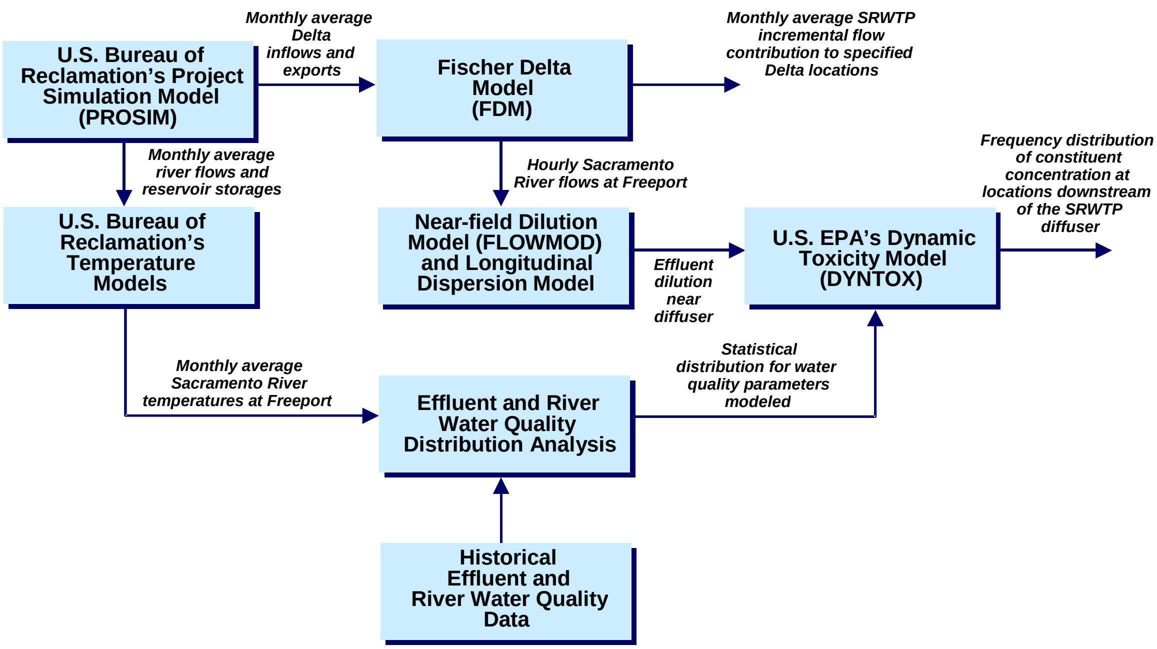


Figure ES–2: Linkages between the Hydrologic and Water Quality Models used to Evaluate Water Quality Conditions in the Sacramento River and Delta

Modeling of Near-Field and Far-Field Water Quality Impacts

The modeling components described above were used to estimate near-field and far-field water quality impacts resulting from an increase in SRWTP discharge from the current permitted condition (181 mgd) to the proposed permitted condition (218 mgd). Model simulations were used to evaluate water quality parameters in terms of near-field, in-plume water quality impacts at varying distances (30 – 700 feet) downstream of the SRWTP discharge. An estimation of near-field impacts was made by considering the incremental change in downstream receiving water concentration of a constituent due to the proposed permitted condition (218 mgd) as compared to the current permitted condition (181 mgd), as well as an evaluation of compliance with applicable water quality objectives. As described earlier, Category 1 constituents were also evaluated at several far-field Delta locations by calculating the incremental concentration of a constituent at those locations. Where ambient concentrations of the constituents evaluated were available, far-field water quality assessments considered the incremental impacts of the proposed discharge in comparison to those ambient levels. Additionally, incremental changes in the percentage of SRWTP effluent at various far-field locations were determined to demonstrate the far-field impacts of the proposed project on Delta water quality. Near- and far-field locations evaluated as part of the antidegradation analysis are shown in **Figure ES–1**.

INCREMENTAL WATER QUALITY IMPACTS OF AN INCREASE IN PERMITTED DISCHARGE

The near-field and far-field water quality impact assessments performed as part of the antidegradation analysis show that an increase in SRWTP discharge to the Sacramento River from 181 mgd (ADWF) to 218 mgd (ADWF) would generally have negligible to moderate impacts on the downstream water quality of the Sacramento River and Delta for those constituents evaluated (see **Table ES–1** for a summary of estimated impacts for Category 1 constituents; estimated impacts for Category 2 and Category 3 constituents are provided in **Table 5-188** in the body of the report). Because some Category 2 (aluminum and total coliform) and Category 3 (TSS) constituents are present at lower concentration in the SRWTP effluent than in the Sacramento River, these constituents are projected to show slight decreases in their downstream concentrations at well-mixed conditions with an increase in permitted discharge (218 mgd (ADWF)). Since SRWTP effluent quality would remain unchanged for all parameters except for ammonia, total nitrogen, and TKN during summer operations, the anticipated increase in SRWTP effluent mass loadings is proportional to the increase in discharge from 181 mgd (ADWF) to 218 mgd (ADWF). Under summer operating conditions, the total mass loadings of oxygen demanding substances would essentially remain at current levels.

With regard to acute and chronic toxicity testing of SRWTP effluent, aquatic toxicity bioassays performed during the period January 2005 through December 2008 indicate that the SRWTP effluent has no adverse impacts on the receiving water. Considering that the SRWTP effluent is not currently causing adverse effects on aquatic life in downstream receiving waters, and will continue to maintain its high water quality throughout and after implementation of the proposed project, it is projected that an increase in SRWTP flow rate from 181 mgd (ADWF) to 218 mgd (ADWF) will not produce adverse toxics effects in the Sacramento River and Delta.

The water quality parameters considered in this antidegradation analysis are generally expected to exhibit only negligible to moderate increases in concentration in the receiving water at well-mixed conditions downstream of the SRWTP discharge at the proposed 218 mgd (ADWF) discharge. None of these constituents are anticipated to exceed relevant water quality objectives, and, on average, are estimated to be present at concentrations well below objectives that will not significantly affect actual or potential beneficial uses, with implementation of the proposed project.

Table ES–1: Summary of Water Quality Impacts for Category 1 Constituents due to the Proposed SRWTP Discharge Increase from 181 mgd (ADWF) to 218 mgd (ADWF).

Category 1 Constituent (mg/L unless noted)	In-Plume Assessment at 700 ft Downstream of SRWTP Diffuser: Modeled Median Concentration (181 mgd)	In-Plume Assessment at 700 ft Downstream of SRWTP Diffuser: Modeled Median Concentration Increment (218 mgd)	Sacramento River at Greene's Landing/Hood: Modeled Median Concentration (181 mgd)	Sacramento River at Greene's Landing/Hood: Modeled Median Concentration Increment (218 mgd)	Characterization of Incremental Change in Downstream Receiving Water Concentration due to Proposed 218 mgd Discharge
Ammonia[1] (mg/L as N)					
Summer Operations	0.55	<0.01	0.25	<0.01	Negligible Increase
Winter Operations	0.72	0.11	0.31	0.09	Moderate Increase
Total Nitrogen[1]					
Summer Operations	0.84	<0.01	0.64	<0.01	Negligible Increase
Winter Operations	1.01	0.11	0.70	0.09	Moderate Increase
Nitrate + Nitrite (mg/L as N)	0.12	0.01	0.12	<0.01	Negligible Increase
Total Kjeldahl Nitrogen[1]					
Summer Operations	0.85	<0.01	0.51	0.01	Negligible Increase
Winter Operations	1.03	0.12	0.57	0.10	Moderate Increase
Total Phosphorus	0.11	0.01	0.08	0.01	Slight Increase
EC (µmhos/cm)	173	3	157	2.9	Slight Increase
Total Dissolved Solids	105	1	---[3]	---[3]	Slight Increase
Chloride	7.38	0.42	5.7	0.4	Slight Increase
Total Organic Carbon	2.59	0.08	2.30	0.06	Slight Increase
Total Mercury (ng/L)	4.07	<0.01	ISD	ISD	Negligible Increase
Dissolved Oxygen[1],[2]					
Summer Operations	8.73	-0.02	8.31[4]	-0.02[4]	Negligible Decrease
Winter Operations	10.91	-0.03	10.73[4]	-0.07[4]	Negligible Decrease

ISD = Insufficient data from 1998 to 2008 for determination of far-field ambient concentration increment resulting from the proposed project.

(1) Two scenarios (Summer Operations and Winter Operations) have been modeled for ammonia, total nitrogen, total Kjeldahl nitrogen, and dissolved oxygen due to the seasonal implementation of the District's assessment of controlling oxygen demanding substances in the summer months (May through September). The summer operations effluent concentrations for ammonia, TN, and TKN are expected to improve with the increase in discharge from 181 mgd to 218 mgd. As such, the increment of concentrations in the receiving water would be negligible during the summer months. On the other hand, winter operations effluent quality would stay the same at 181 and 218 mgd discharge capacities and as such, with the increase in discharge, the receiving water concentrations for ammonia, TN, and TKN are expected to moderately increase during winter time (SRCSD, 2009b).

(2) Dissolved oxygen levels in the receiving water remain virtually unchanged with the increase in discharge because of 1) Winter ambient conditions (i.e. Sacramento River flow and water temperature) act to prevent incidences of low dissolved oxygen in the receiving water during winter months and 2) implementation of seasonal controls act to prevent these incidents in the months (see also [a]) (SRCSD, 2009b). Difference between winter and summer dissolved oxygen concentrations reflective of seasonal difference in water temperature and corresponding difference in saturation concentration.

(3) Far-field water quality impacts analyses and trend analyses were not performed for TDS due to the extensive far-field assessments performed for EC (Section 5.4.11) and chloride (Section 5.4.13). Because TDS correlates strongly with EC, it would be expected that far-field impacts would be similar for these two constituents.

(4) Dissolved oxygen results presented at Rio Vista, the critical condition for dissolved oxygen (SRCSD, 2009b)

The water quality impacts assessed as part of the antidegradation analysis are evaluated in terms of the estimated incremental change in downstream receiving water quality due to the proposed project, and the effect that the incremental change is anticipated to have on beneficial uses identified for the receiving water. The incremental changes in near-field, downstream receiving water concentrations estimated for Category 1 pollutants (see **Table ES–1)** are expected to produce negligible to moderate reductions in water quality that will not significantly affect actual or potential beneficial uses. Additionally, far-field modeling results for Category 1 pollutants, combined with power and trend analyses, indicate that essentially immeasurable, incremental increases in far-field pollutant concentrations resulting from increasing SRWTP discharge to 218 mgd (ADWF) will not significantly impact Delta water quality. For Category 2 and Category 3 constituents, the incremental changes in near-field, downstream receiving water concentrations are expected to produce only negligible to slight reductions in water quality that will not significantly affect actual or potential beneficial uses (see **Table 5-188** in the body of the report). As such, these parameters are anticipated to have negligible impacts in far-field receiving waters.

COSTS AND BENEFITS OF ALTERNATIVES FOR MAINTAINING WATER QUALITY

In performance of a complete antidegradation analysis as defined in SWRCB APU 90-004 guidance, the costs and benefits of strictly maintaining existing water quality, through the elimination of all incremental loading increases, was evaluated. Maintaining existing water quality in the Sacramento River and Delta with an increase in SRWTP discharge could be approached through regionalization, expanded water recycling/reuse program, water conservation, pollutant source minimization, or additional wastewater treatment through the implementation of microfiltration, reverse osmosis, and ozone/hydrogen peroxide (MF/RO/peroxone). Of these five alternatives, only MF/RO/peroxone, also called the No Net Increase advanced treatment alternative, is considered as a potential treatment option due to the inadequacy of the other alternatives, alone or in combination, to reduce all incremental pollutant increases associated with the increased discharge. The reasons why four of the potential alternatives to maintaining existing water quality in the Sacramento River and Delta were not select for evaluation in the socioeconomic analysis are provided in **Table ES–2**. An estimated 48 mgd No Net Increase treatment capacity would be required to maintain total dissolved solids, mercury, copper, and other mass loadings in SRWTP effluent at pre-project levels when the SRWTP discharges 218 mgd (ADWF). A 48 mgd MF/RO/peroxone treatment facility would cost an estimated $665 million to construct and an additional $39 million per year to operate (estimated in January 2009 dollars). Servicing the debt incurred from construction of a MF/RO/peroxone treatment facility, along with annual operations and maintenance costs, would cost SRCSD ratepayers an estimated $92 million per year in addition to their current wastewater treatment fees. The costs of implementing the advanced treatment alternative would be above and beyond the costs associated with increasing SRWTP discharge to 218 mgd (ADWF).

Table ES–2: Potential Alternatives to Maintaining Existing Water Quality in the Sacramento River and Delta that Were Not Selected for Evaluation in the Socioeconomic Analysis

Potential Alternative for Maintaining Existing Water Quality	Reason Why Potential Alternative Was Not Selected for Further Evaluation in Socioeconomic Analysis
Regionalization	The formation of the SRCSD in 1973 was to provide a regional wastewater conveyance, treatment, and disposal system to serve the urbanized area of Sacramento, to eliminate wastewater discharges to the American River, minimize raw sewage overflows to the Sacramento River, and to replace 17 separate wastewater entities. To this end, the SRWTP has acted to regionalize wastewater treatment in Sacramento County. No other regional wastewater treatment plant exists that could accept the volume of influent currently treated by the SRWTP.
Expanded Water Recycling/Reuse	The District currently has not identified a sufficient number of individual water recycling/reuse projects that would collectively require 30 – 40 mgd of treated wastewater. Furthermore, regional, year-round recycled water consumptive demand is insufficient to offset current and future SRWTP treated effluent flows produced during the wet season, and it would be too costly to store treated effluent when demand for reuse doesn't exist. While cost-effective water recycling projects have not been identified to date, SRCSD intends to continue its search for viable recycling projects.
Water Conservation	An aggressive water conservation program implemented by the SRCSD would not be able to achieve a 37 mgd reduction in influent flows.
Pollutant Source Minimization	An aggressive pollutant source reduction program implemented by the SRCSD might be able to achieve load reductions for a small number of pollutants of concern, but would not be able to achieve sufficient reductions for all pollutants of concern such that the pollutants loadings in SRWTP effluent at 181 mgd would remain constant as the District increases its discharge to 218 mgd.

From a socioeconomic impacts perspective, construction and operation of a MF/RO/peroxone treatment facility would lead to decreases in "after tax" or disposable personal income (DPI) spending by ratepayers. Reductions in DPI in the SRCSD service area's local economy due to the financing of a MF/RO/peroxone treatment facility would result in fewer dollars being spent on non-essential goods and services by ratepayers. Decreased spending within an economy ultimately leads to decreases in labor demand, which further impacts household spending due to losses in employment. Increased monthly rates and connection fees for business, commercial, and industrial ratepayers would make areas within the SRCSD service area in Sacramento County and the City of West Sacramento less attractive locations to establish or expand such businesses when all other considerations remain unchanged. An economic impacts model, IMPLAN®, used to project socioeconomic impacts on an economy due to a proposed project estimated that the $92 million annual cost of MF/RO/peroxone treatment would result in a loss of 672 jobs per year from the SRCSD service area for the 20-year life-cycle of the alternative control measure. Additionally, the IMPLAN® model estimated that nearly $118 million fewer dollars would move through the economy of Sacramento Metropolitan area each year as a result of spending $92 million annually to provide MF/RO/peroxone treatment to 48 mgd of disinfected, secondary treated SRWTP effluent.

While MF/RO/peroxone treatment would provide sufficient removal of pollutants of concern from blended MF/RO/peroxone- and non-MF/RO/peroxone-treated SRWTP effluent discharged to the Sacramento River to maintain existing water quality and mass loading in the water body at the currently permitted 181 mgd (ADWF) levels, the No Net Increase treatment alternative would not significantly improve downstream water quality in the receiving water. Moreover, MF/RO/peroxone treatment would produce adverse environmental impacts resulting from the concentration of toxic compounds, removal and transference of these toxic substances to various other media, crystallized residuals disposal, and the substantial energy requirements of the process. These sizeable power demands would lead to increases in greenhouse gas emissions that would significantly expand the carbon footprint of the SRWTP and run contrary to the intent and stated goals of Assembly Bill 32 – the California Global Warming Solutions Act of 2006 – that seeks to establish a statewide greenhouse gases emissions cap for 2020 based on California's 1990 emission levels.

It is the District's perspective that the environmental and socioeconomic costs associated with MF/RO/peroxone treatment are not commensurate with the water quality benefits that would be achieved through the implementation of this alternative as a means of offsetting the incremental water quality changes projected for an increase in permitted discharge. For these reasons, it is not believed to be in the public interest to require the District to implement MF/RO/peroxone treatment of a portion of its disinfected, secondary effluent in order to avoid insignificant changes in water quality in the Sacramento River and downstream receiving waters.

PROPOSED PROJECT

The proposed project would allow an increase of the discharge of disinfected, secondary effluent to the Sacramento River from the currently permitted 181 mgd (ADWF) to 218 mgd (ADWF). The water quality impacts assessments performed as part of the antidegradation analysis show that SRWTP effluent undergoing existing, pure oxygen secondary treatment and chlorine disinfection generally results in water of high quality being discharged by the SRWTP into the Sacramento River (see **Table ES–1** and **Table 5-188** in the body of the report for a summary of impacts from the various constituents). *De minimis* decreases in the downstream concentrations of total aluminum, total coliform, and TSS are projected. Moderate increases in downstream concentrations are expected during the winter months (October through April) for ammonia, total nitrogen, and TKN. Because of the implementation of seasonal control of oxygen demanding substances during the summer months (May through September), these constituents are expected to display negligible changes in downstream concentrations during the summer period. Additionally, negligible changes in downstream concentrations are estimated for nitrate plus nitrite, total mercury, dissolved oxygen, dissolved cadmium, temperature, dissolved arsenic, total selenium, dissolved silver, 1,4-dichlorobenzene, bromodichloromethane, chloroethane, diethyl phthalate, di-n-butyl phthalate, methyl chloride, methylene chloride, tetrachloroethylene, and toluene. A slight increase in downstream Sacramento River concentration and mass loading is anticipated for total phosphorus, EC, TDS, chloride, TOC, dissolved copper, dissolved zinc, total antimony, dissolved chromium, dissolved lead, total molybdenum, dissolved nickel, total cyanide, bis(2-ethylhexyl)phthalate, and chloroform. None of the water quality parameters evaluated in this report are anticipated to exceed relevant water quality objectives as a result of the proposed project beyond a limited zone of initial mixing, and on average are estimated to be present at concentrations well below objectives. Additionally, the SRWTP would be required to operate in compliance with the NPDES regulatory program (i.e., future effluent limitations) which will make sure that water quality objectives in the receiving water are met. Furthermore, the small changes in water quality that would result from the increased permitted discharge will not unreasonably affect actual or potential beneficial uses.

CONSISTENCY WITH ANTIDEGRADATION POLICIES

A 37 mgd (ADWF) discharge increase to the Sacramento River below Freeport Bridge is believed to comprise best practicable treatment or control and be consistent with federal and State antidegradation policies for the following reasons:

- The increase in permitted discharge is necessary to accommodate important economic and social development in Sacramento County and the City of West Sacramento. Failure to approve the increase, or alternatively requiring the District to implement control measures that would maintain existing water quality and mass emissions in the Sacramento River, would have significant adverse economic and social impacts on the citizens and businesses of Sacramento County and the City of West Sacramento.
- The increase would not adversely affect existing or probable beneficial uses of the Sacramento River, nor will it cause water quality to fall below applicable water quality objectives.
- The increase, while causing slight to moderate increases in downstream water quality concentrations for some of the constituents in the analysis, would produce slight decreases in downstream concentrations for other analyzed constituents, and impart negligible changes in downstream concentrations for the rest of the analyzed constituents.
- The benefits of maintaining existing water quality and mass emissions for the constituents analyzed through a No Net Increase treatment scheme are not commensurate with the costs of additional advanced treatment processes. The small decrease in quality with respect to the constituents considered in the analysis is unlikely to affect beneficial uses of the Sacramento River and Delta.
- Based on the above, the requested increase in permitted capacity is consistent with federal and State antidegradation policies in that the lowering of water quality for a limited number of pollutants is necessary to accommodate important economic or social development, will not unreasonably affect beneficial uses, will not cause further exceedances of applicable water quality objectives, and is consistent with the maximum benefit to the people of the State.
- Based on the above, the requested increase in permitted capacity is consistent with the Porter-Cologne Act in that the resulting water quality will constitute the highest water quality that is reasonable, considering all demands placed on the waters, economic and social considerations, and other public interest factors.

1 Introduction

1.1 BACKGROUND

The Sacramento Regional County Sanitation District (SRCSD or District) provides wastewater treatment for over one million residents within a 370 square-mile area in the Sacramento Metropolitan area, including the City of West Sacramento in Yolo County. Contributing agencies of the District include the Sacramento Area Sewer District (SASD), and the cities of Sacramento, Folsom, and West Sacramento. The cities of Sacramento, West Sacramento and Folsom are responsible for operation and maintenance of portions of the collection system within their city limits, and SASD is responsible for operation and maintenance of the collection system within the cities of Citrus Heights, Elk Grove, Rancho Cordova and portions of Sacramento and Folsom, as well as unincorporated areas of Sacramento County. Contributing agencies maintain and operate their own wastewater collection systems, delivering untreated wastewater to SRCSD's interceptor conveyance system for transport to the Sacramento Regional Wastewater Treatment Plant (SRWTP) for treatment and discharge.

Treated wastewater from SRWTP is discharged through a submerged 120-inch diameter multi-port diffuser anchored to the bottom of the Sacramento River several hundred feet downstream of the Freeport Bridge. SRWTP's discharge is regulated by the California Regional Water Quality Control Board, Central Valley Region (Central Valley Regional Water Board) through a National Pollution Discharge Elimination System (NPDES) permit (No. CA0077682). The current permitted discharge rate is 181 million gallons per day (mgd) average dry weather flow (ADWF).

The District has prepared the 2020 Master Plan to describe the proposed expansion of wastewater treatment and disposal capacity of the SRWTP (the Project). The SRWTP 2020 Master Plan (Master Plan) (Carollo, 2002a) is the central wastewater treatment facility planning document for most of Sacramento County. The purpose of the Master Plan is to identify wastewater treatment and reuse/disposal/facility needs for a 20-year planning period. The overall goal of the Master Plan is to provide a phased program of recommended facilities to accommodate planned growth while at the same time maintaining treatment reliability, meeting future regulatory requirements and optimizing costs. The Master Plan considers existing and new treatment facilities and programs that will be needed to serve projected population growth in the SRCSD service area through the year 2020. As a means to appropriately meet the future wastewater treatment needs of the SRCSD service area, the District will regularly evaluate projected influent flows and phase SRWTP expansion to accommodate these flows in a timely and cost-efficient manner. Presently, SRCSD's approval of the Master Plan itself is a subject of litigation under the California Environmental Quality Act (CEQA). The antidegradation analysis in this report pertains only to the Central Valley Regional Water Board's approval of an increase in permitted discharge.

As part of its current NPDES permit renewal, SRCSD is requesting that the Central Valley Regional Water Board increase the permitted discharge of the SRWTP from 181 mgd (ADWF) to 218 mgd (ADWF). Considering this request, the Central Valley Regional Water Board must address whether the proposed increase is consistent with federal and State antidegradation policies before it can grant the requested increase in discharge. This document is the

Antidegradation Analysis for the proposed SRWTP discharge increase. Antidegradation policies are intended to protect existing water quality and associated beneficial uses.

The federal policy is expressed as a regulation in 40 CFR § 131.12. The federal antidegradation policy requires protection of existing in-stream uses and water quality necessary to protect those uses. The federal policy also requires maintenance and protection of water quality beyond that required to support propagation of fish, shellfish and wildlife and recreation (i.e. meet "fishable, swimmable" standards), when high water quality exists, unless a State finds that lower water quality is necessary to accommodate important economic and social development. In that case, the federal antidegradation policy requires the State to assure that the highest regulatory requirements for point sources and all cost-effective and reasonable best management practices for non-point source control are achieved.

The State policy is embedded in the *Statement of Policy with Respect to Maintaining High Quality Waters in California,* a resolution of the State Water Resources Control Board (SWRCB) (Resolution 68-16) adopted in 1968. Resolution 68-16 addresses the need to maintain high quality waters in California consistent with the maximum benefit to the people of the State. The State policy requires that changes in water quality will not unreasonably affect beneficial uses, and that waste discharge requirements result in best practicable treatment or control.

1.2 PROJECT LOCATION

Treatment facilities proposed as part of the Master Plan would be located at the SRWTP, at the terminus of Laguna Station Road, within Sacramento County, as shown in **Figure 1-1**. The SRWTP facilities occupy 900 acres and are located near the center of an approximate 3,500-acre site owned by the SRCSD approximately 10 miles south of downtown Sacramento. The remaining 2,600-acres of SRCSD property comprise open space land and provide a buffer zone (referred to as the Bufferlands) between the facilities and surrounding land uses (see **Figure 1-2**). Nearby land uses include residential development to the north, east, and south, industrial development to the south, and Interstate 5 to the west. A 1,000 foot wide restricted development area is located to the south of the SRCSD property and provides similar buffering benefits as the Buffer lands. Further, any land uses that would not be consistent with residential development are restricted in this area.

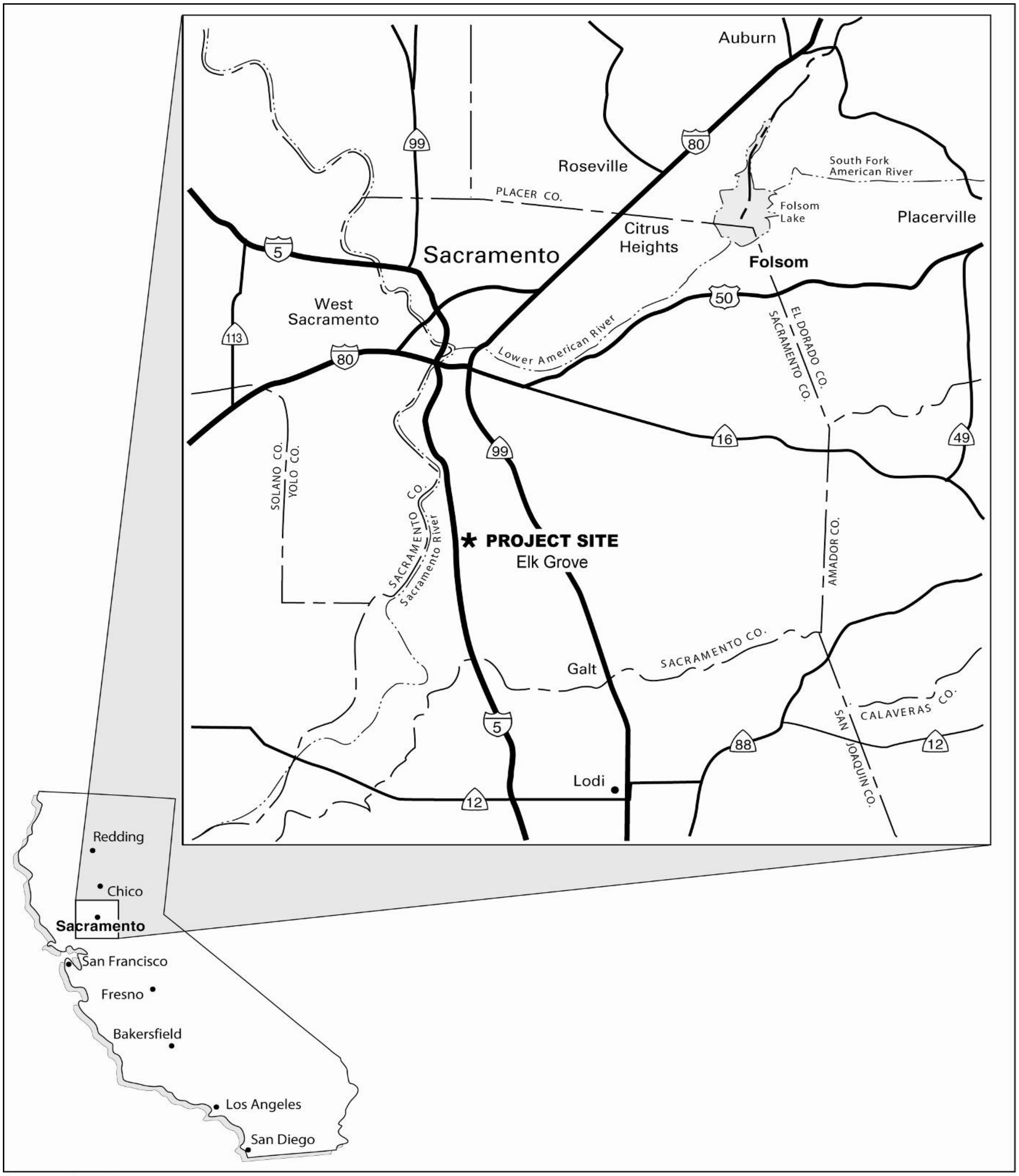
1.3 PROJECT DESCRIPTION

The proposed project as considered in this antidegradation analysis relates to the Central Valley Regional Water Board's approval of an increased in permitted discharge from the SRWTP from the current permitted rate of 181 mgd (ADWF) to 218 mgd (ADWF) consistent with the application filed by the SRCSD (SRCSD, 2005a). The proposed discharge increase would accommodate anticipated community growth in the SRCSD service area projected by the Master Plan. As wastewater flows and loads increase, additional treatment facilities will need to be constructed. Existing treatment facilities at the SRWTP were designed to be expanded gradually as future wastewater flows and loads increase. Future facility expansion increments will be large enough to provide reasonable economies of scale and small enough to minimize the size of underutilized facilities.

Existing SRWTP facilities consist of a preliminary treatment system, primary treatment system, secondary treatment system, effluent storage and discharge, disinfection, solids treatment system, odor control, 5-mgd water recycling plant, and support facilities. The SRWTP treats wastewater to a “secondary” level using a series of mechanical and biological systems to remove wastes. “Secondary level” means that organic wastes are removed by biological treatment with clarification and disinfection. Small concentrations of contaminants remain in the discharge. Processes employed at SRWTP include raw influent and effluent pumping, primary clarification, secondary treatment with high-purity oxygen activated sludge (HPOAS), cryogenic oxygen production, disinfection, solids thickening, and anaerobic solids digestion. The treatment processes convert raw wastewater into treated and disinfected effluent, which is discharged to the Sacramento River below Freeport Bridge via a diffuser, and provide up to 5 mgd of recycled water for landscape irrigation through the SRCSD’s water recycling facility.

The proposed project would increase the permitted discharge of secondary treated effluent to the Sacramento River from the currently permitted 181 mgd (ADWF) to 218 mgd (ADWF) by augmenting and enhancing existing capacity-limiting facilities consistent with the application filed by the SRCSD (SRCSD, 2005a). The District has assessed the potential for the SRWTP effluent to affect the dissolved oxygen concentrations downstream of the discharge (SRCSD, 2009b), and as a means to prevent potential, summer episodic occurrences of low dissolved oxygen in the lower Sacramento River as existing SRWTP effluent flow increases, the District will appropriately limit the mass load of oxygen demanding substances in the effluent. As there are immediate opportunities for process optimization to reduce ammonia concentrations in the SRWTP effluent, the District’s initial assessment only considered one alternative, the change in nitrogenous biochemical oxygen demand (NBOD), of which ammonia is the dominate species, and the affect on the downstream dissolved oxygen concentrations.

To maintain the dissolved oxygen concentrations in the Sacramento River downstream of the discharge above the Basin Plan objective, the assessment concluded that for discharge capacities of 181 mgd and 218 mgd, the effluent ammonia concentrations should be 17 mg/L as N and 14 mg/L as N, respectively. The assessment acknowledges that if other components of the oxygen demanding substances are concurrently reduced, the ammonia concentrations in SRWTP effluent could be correspondingly higher. The assessment concluded that the limitations were only necessary during the summer months (May through September) and would be accomplished through one or a combination of alternatives, including process optimization, treatment of internal processes return flows, increased water recycling, and/or advanced or additional treatment of a portion of SRWTP effluent flow. To be consistent with the assessment and the District’s commitment to comply with the dissolved oxygen Basin Plan objective, in the antidegradation analysis the summer operations of the SRWTP are assumed to attain the ammonia concentrations identified in the assessment, and the winter operations of the SRWTP are assumed to proceed at current SRWTP ammonia effluent concentrations. For the SRWTP discharge, ammonia is the dominant species of both total nitrogen and total Kjeldahl nitrogen, and in the antidegradation analysis both measures of nitrogen are reduced during summer operations to reflect corresponding reductions in effluent ammonia concentrations. The District is committed to controlling oxygen demanding substances in its effluent to prevent causing excursions below the dissolved oxygen Basin Plan objective in downstream water and ensure compliance with the dissolved oxygen receiving water limits in the SRWTP discharge permit.



Source: EDAW, Inc. 2001.

Figure 1-1: SRWTP Location Map

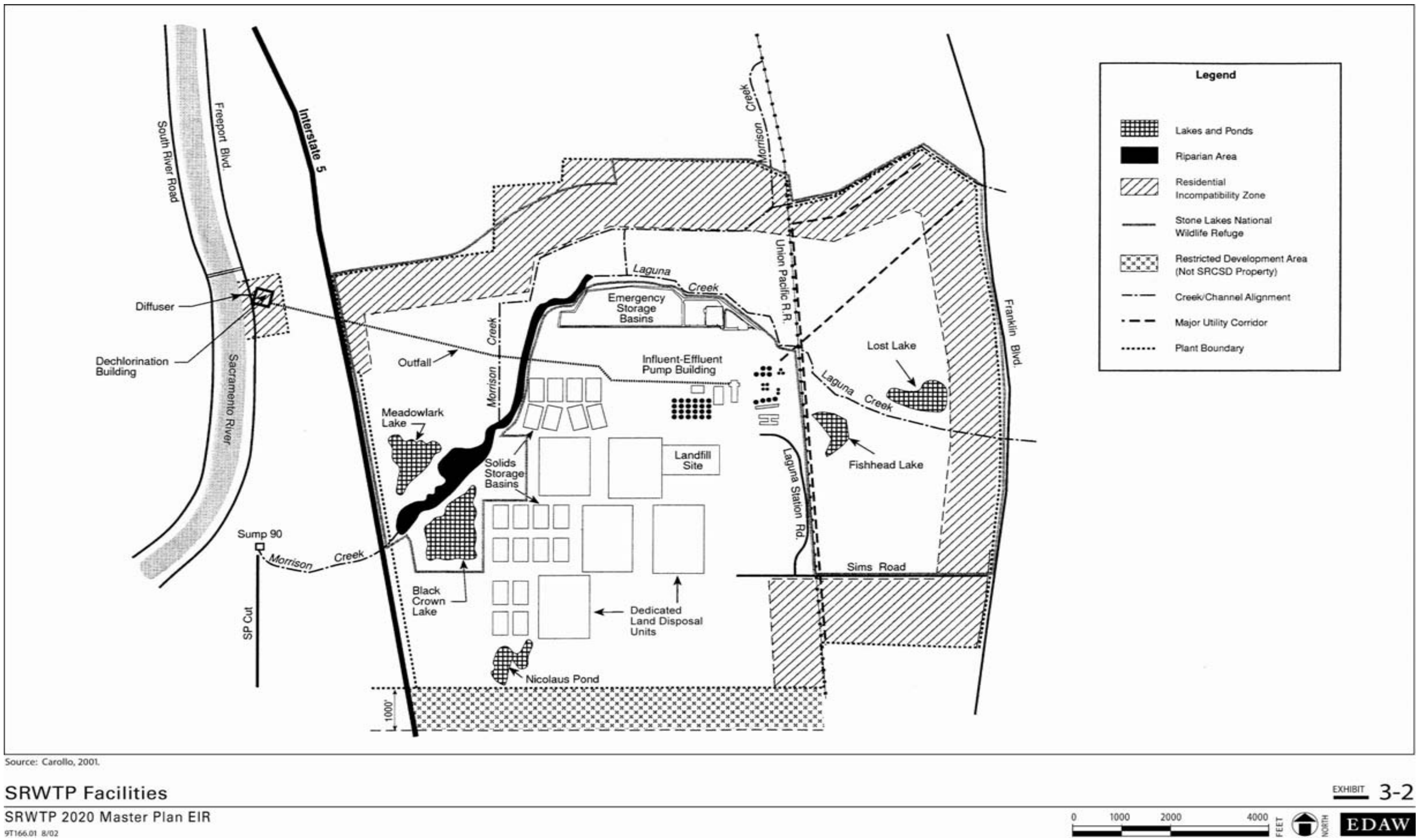


Figure 1-2: SRWTP Facilities

1.4 PURPOSE OF REPORT

The purpose of this report is to provide an antidegradation analysis for a requested increase in SRCSD's permitted discharge to the Sacramento River from 181 mgd (ADWF) to 218 mgd (ADWF). The information contained in this analysis is intended to provide the Central Valley Regional Water Board with the information needed to determine whether to certify that the proposed permitted discharge increase is consistent with State and federal antidegradation policies.

1.5 REPORT CONTENTS

The remainder of this report is comprised of six additional sections plus glossary, references, and appendices, associated with the antidegradation analysis performed in support of a request for increased discharge from the SRWTP from the current permitted condition (181 mgd (ADWF)) to the proposed permitted condition (218 mgd (ADWF)). Items addressed as part of the current antidegradation analysis as directed by State and federal antidegradation policies are covered in the following sections of this report:

- Section 2: Regulatory requirements
- Section 3: Applicable water quality objectives
- Section 4: Environmental setting
- Section 5: Assessment of water quality impacts
- Section 6: Assessment of socioeconomic considerations
- Section 7: Evaluation of consistency with antidegradation policy

2 Regulatory Requirements

2.1 APPLICABLE LAWS AND POLICIES

The federal Clean Water Act (CWA) requires states to adopt, with United States Environmental Protection Agency (U.S. EPA) approval, water quality standards applicable to all intrastate waters (33 U.S.C. § 1313). U.S. EPA regulations also require state water quality standard submittals to include an antidegradation policy to protect beneficial uses and prevent further degradation of high quality waters (33 U.S.C. § 1313(d)(4)(B); 40 C.F.R. § 131.12). The State's antidegradation policy is embodied in SWRCB Resolution 68-16. The SRWTP's discharge of treated effluent to the Sacramento River below Freeport requires the application of water quality objectives contained in the Water Quality Control Plan for the Sacramento-San Joaquin River Basins (Basin Plan), as well as criteria promulgated by the U.S. EPA for California waters. Both the federal and State antidegradation policies apply to the proposed increase in permitted surface water discharge of treated effluent to the Sacramento River.

2.2 FEDERAL ANTIDEGRADATION POLICY AND GUIDANCE

The federal antidegradation policy is designed to protect existing uses and the level of water quality necessary to protect existing uses, and provide protection for higher quality and outstanding national water resources. The federal policy directs states to adopt a statewide policy that includes the following primary provisions (40 C.F.R. § 131.12).

(1) *Existing in-stream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.*

(2) *Where the quality of waters exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds, after the full satisfaction of the intergovernmental coordination and public participation provisions of the State's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the State shall assure water quality adequate to protect existing uses fully. Further, the State shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control*

(3) *Where high quality waters constitute an outstanding National resource, such as water of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.*

(4) *In those cases where potential water quality impairment associated with a thermal discharge is involved, the antidegradation policy and implementing method shall be consistent with Section 316 of the Act.*

Based on guidance developed by the U.S. EPA, Region 9 (*Guidance on Implementing the Antidegradation Provisions of 40 C.F.R. § 131.12* (U.S. EPA, 1987)) and guidance issued by the State Water Resources Control Board (SWRCB) with regard to application of the Federal Antidegradation Policy (Memorandum from William R. Attwater to Regional Board Executive Officers *Federal Antidegradation Policy* (Oct. 1987)), application of the federal antidegradation policy is triggered by a lowering, or potential lowering, of surface water quality. A proposed increase in the volume of an existing discharge to surface water is typically considered a trigger to the application of the federal antidegradation policy. Because the Project proposes to increase SRCSD's permitted discharge to surface water, the federal antidegradation policy applies.

The Sacramento River is not designated an outstanding natural resource water, and therefore the receiving water is not subject to that portion of the federal policy. The application to other portion of the policy is determined on a constituent-by-constituent basis. For a water body where water quality is not significantly better than needed to meet designated uses, either because it does not meet or it just meets applicable water quality objectives or criteria to protect beneficial uses, the expanded discharge cannot cause further impairment.

For waters with water quality that is better than necessary to support beneficial uses, the increase in permitted discharge may not lower water quality unless such lowering is necessary to accommodate important economic or social development. In August 2005, the U.S. EPA issued a memorandum discussing antidegradation reviews and significance thresholds (Memorandum from Ephraim S. King, Director, Office of Science and Technology, U.S. EPA, Office of Water to Water Management Division Directors, Regions 1-10 (August 2005)). As discussed in the memorandum, an intent of the policy "is to maintain and protect high quality waters and not to allow for any degradation beyond a *de minimis* level without having made a demonstration, with opportunity for public input, that such lowering is necessary and important." (Memorandum at p. 1). U.S. EPA has determined that the significance threshold of a 10% reduction in available assimilative capacity is "workable and protective in identifying those significant lowerings of water quality that should receive a full … antidegradation review, including public participation." (U.S. EPA, 2005). This determination by U.S. EPA is helpful in determining the magnitude of water quality change that is determined to be of significant interest in the antidegradation analysis.

2.3 STATE ANTIDEGRADATION POLICY AND GUIDANCE

2.3.1 Resolution 68-16

The State issued its own antidegradation policy in 1968 to protect and maintain existing water quality in California. The State's Resolution 68-16 is interpreted to incorporate the federal antidegradation policy and satisfies the federal regulation requiring states to adopt their own antidegradation policies. Resolution 68-16 states, in part:

> *(1) Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses of such water and will not result in water quality less than that prescribed in the policies.*

(2) *Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality water will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.*

2.3.2 1987 Policy Memorandum

In 1987, SWRCB issued a policy memorandum to the Regional Water Quality Control Boards (Regional Water Boards) to provide guidance on the application of the federal antidegradation policy for State and Regional Water Board actions, including establishing water quality objectives, issuing NPDES permits, and adopting waivers and exceptions to water quality objectives or control measures (Attwater, 1987). In conducting these actions, the Regional Water Boards must assure protection of existing in-stream beneficial uses, that significant lowering of water quality is necessary to accommodate important economic or social development, and that outstanding national resource waters be maintained and protected. The recent 2005 U.S. EPA guidance referenced in Section 2.2 above is useful in determining whether changes in water quality that may result from a proposed action are significant.

2.3.3 Administrative Procedures Update 90-004

SWRCB issued guidance (APU 90-004) to all Regional Water Boards in 1990 regarding the implementation of State and federal antidegradation policies in NPDES permits. By using this guidance, Regional Water Boards are to determine if a proposed discharge is consistent with the intent and purpose of the State and federal antidegradation policies. APU 90-004 provides Regional Water Boards with guidance on the appropriate level of analysis that may be necessary, distinguishing between the need for a "simple" antidegradation analysis and a "complete" antidegradation analysis. If it is determined that a simple analysis is not appropriate based on the estimated level of impact of the new discharge, then a more rigorous analysis – a complete analysis – is appropriate. A primary focus of the complete analysis is the determination of whether and the degree to which water quality is lowered. This determination greatly influences the level of analysis required and the level of scrutiny applied to the "balancing test" – that is, whether the discharge is necessary to accommodate important economic and social development, and whether a water quality change is consistent with the maximum benefit to the people of the State.

The antidegradation analysis addresses the following questions stated in SWRCB APU 90-004 to maintain consistency with State and federal antidegradation policies.

- Whether a reduction in water quality will be spatially localized or limited with respect to the water body; e.g., confined to the mixing zone;
- Whether the proposed increase in discharge of treated effluent will produce minor effects which will not result in a significant reduction of water quality;
- Whether the proposed increase in discharge of treated effluent has been approved in a General Plan, or similar growth and development policy document, and has been

adequately subjected to the environmental analysis required in an environmental impact report (EIR) required under the California Environmental Quality Act (CEQA); and

- Whether the proposed project is consistent with maximum benefit to the people of the State.

In addition, the following items are to be addressed in a complete antidegradation analysis:

- A comparison of the projected receiving water quality to the water quality objectives and/or criteria used to protect designated beneficial uses, and
- A socioeconomic analysis to establish the balance between the proposed action and the public interest.

Factors to be considered in determining whether a proposed discharge is necessary to accommodate important economic and social development and is consistent with maximum benefit include:

- Past, present, and probable future beneficial uses.
- Economic costs to maintain water quality compared to the benefits.
- Environmental aspects of the proposed discharge.
- Consideration of feasible alternative control measures which might reduce, eliminate, or compensate for negative impacts of the proposed discharge.

The District has elected to follow the procedures provided in the guidance for conducting a complete antidegradation analysis to provide the Central Valley Regional Water Board with the maximum information available to use in its consideration of whether State and federal antidegradation requirements have been satisfied with regard to the proposed discharge increase.

2.4 APPROACH TO ANALYSIS

The antidegradation analysis described in this report follows the guidance provided by SWRCB regarding the implementation of the antidegradation policy in NPDES permits (SWRCB, APU 90-004, 1990). This analysis follows the provisions for a 'complete analysis' and evaluates whether changes in water quality resulting from the proposed discharge increase are consistent with maximum benefit to the people of the State, will not unreasonably affect actual or potential beneficial uses, and will not cause water quality to be less than water quality objectives and makes sure that the discharge provides protection of existing in-stream uses and water quality necessary to protect those uses.

The complete antidegradation analysis is comprised of two main components: (1) a comparison of the projected receiving water quality to the water quality objectives and/or criteria used to protect designated beneficial uses, and (2) a socioeconomic analysis to establish the balance between the proposed increase in permitted discharge and the public interest.

The following items are addressed in the antidegradation analysis described in this report:

- Determination of whether there are measurable water quality impacts and, if so, whether beneficial uses are impacted. This is accomplished by comparing receiving water quality to the water quality objectives and/or criteria established to protect designated beneficial uses.
- Evaluation of incremental loading increases and their impacts
- Evaluation of the costs and benefits of reducing or eliminating the load increase.
- A balancing of the proposed project against the public interest.

3 Applicable Water Quality Standards

3.1 BENEFICIAL USES

The Water Quality Control Plan for the Sacramento-San Joaquin River Basins (Basin Plan), originally adopted by the Central Valley Regional Water Board in 1975 and amended periodically, contains descriptions of the legal, technical, and programmatic bases for water quality regulation in the region. The Basin Plan describes the beneficial uses of major surface waters and the corresponding water quality objectives adopted to protect these beneficial uses. **Table 3-1** presents the existing beneficial uses for the Sacramento-San Joaquin Delta, the applicable water body downstream of the SRWTP discharge. Specifically, the SRWTP discharges secondary treated effluent to the Sacramento River below Freeport Bridge, a location that falls within the legal boundary of the Sacramento-San Joaquin Delta (Delta).

Table 3-1: Beneficial Uses Designated for the Sacramento-San Joaquin Delta.

Beneficial Uses for Surface Water defined in the Basin Plan	Designated for Sacramento-San Joaquin Delta
Municipal and Domestic Supply (MUN)	Yes
Agricultural Supply: Irrigation (AGR)	Yes
Agricultural Supply: Stock Watering (AGR)	Yes
Industrial Process Supply (PROC)	Yes
Industrial Service Supply (IND)	Yes
Industrial Power Supply (POW)	No
Water Contact Recreation: Contact Recreation (REC 1)	Yes
Water Contact Recreation: Canoeing and Rafting (REC 1)	No
Non-Contact Water Recreation (REC 2)	Yes
Warm Freshwater Habitat (WARM)	Yes
Cold Freshwater Habitat (COLD)	Yes
Migration of Aquatic Organisms: Warm Water (MIGR)	Yes
Migration of Aquatic Organisms: Cold Water (MIGR)	Yes
Fish Spawning, Warm Water (SPWN)	Yes
Fish Spawning, Cold Water (SPWN)	No
Wildlife Habitat (WILD)	Yes
Navigation (NAV)	Yes

Source: Water Quality Control Plan for the Sacramento River Basin and San Joaquin River Basin, Fourth Edition, Revised October 2007 (CVRWQCB, 2007)

3.2 WATER QUALITY OBJECTIVES/WATER QUALITY CRITERIA

To protect the designated beneficial uses, the Central Valley Regional Water Board applies water quality objectives contained in the Basin Plan and criteria adopted in the California Toxics Rule

(CTR) and the National toxics Rule (NTR) to the receiving water, the Sacramento River, and downstream receiving waters, including the Delta. The Central Valley Regional Water Board uses these objectives and criteria to determine if the SRWTP discharge will cause or contribute to an exceedance of an applicable water quality standard. **Table 3-2** presents the most conservative water quality criteria used to protect the most sensitive beneficial uses that apply to the Sacramento River and downstream Sacramento-San Joaquin Delta for select constituents. The water quality parameters included in **Table 3-2** are those for which the SRWTP discharge has adopted effluent limits, as well as pollutants of concern the Central Valley Regional Water Board has identified in other Central Valley permits and lists adopted under Section 303(d) of the CWA. Water quality objectives for toxic constituents come from either the CTR or NTR, as promulgated by the U.S. EPA (40 CFR § 131.38; U.S. EPA, 2000). The range of hardness-based acute and chronic freshwater aquatic life CTR objectives for dissolved copper, lead, silver and zinc included in **Table 3-2** were calculated using 5th and 95th percentile downstream hardness values calculated for the Sacramento River at River Mile 44.

Table 3-2: Applicable Water Quality Objectives and/or Criteria for the Sacramento-San Joaquin Delta.

		Most Stringent Water Quality Objective or Criterion		
Classification	**Constituent**	**Value**	**Unit**	**Reference**
Bacteriological	Fecal Coliform	200	MPN/100 mL	Basin Plan
	Total Coliform	N/A	N/A	N/A
Conventional	BOD	N/A	N/A	N/A
	Bromide	N/A	N/A	N/A
	Chloride	250	mg/L	Title 22 MCL (Secondary)/Basin Plan(1)
	Chlorine Residual	N/A	N/A	N/A
	Dissolved Oxygen	7	mg/L	Basin Plan
	Electrical Conductivity	900	μmhos/cm	Title 22 MCL (Secondary)/Basin Plan(1)
	Oil and Grease	Narrative	---	Basin Plan
	pH	6.5 ≤ pH ≤ 8.5	std. units	Basin Plan
	Settleable Solids	Narrative	---	Basin Plan
	Temperature	Narrative	°F	Thermal Plan(1)
	Total Dissolved Solids	500(2)	mg/L	Title 22 MCL (Secondary)/Basin Plan(1)
	Total Organic Carbon	N/A	N/A	N/A
	Total Suspended Solids	Narrative	---	Basin Plan
	Turbidity	Increase not to exceed 20%	NTU	Basin Plan (where natural turbidity is between 5 and 50 NTUs)
		Increase not to exceed 10 NTUs	NTU	Basin Plan (where natural turbidity is between 50 and 100 NTUs)

Table 3–2: Applicable Water Quality Objectives and/or Criteria for the Sacramento-San Joaquin Delta (Continued).

Classification	Constituent	Most Stringent Water Quality Objective or Criterion: Value	Unit	Reference
Metal	Aluminum, Total	200[3]	μg/L	Title 22 MCL (Secondary)/Basin Plan[1]
	Antimony, Total	6	μg/L	Title 22 MCL (Primary)/Basin Plan[1]
	Arsenic, Dissolved	10	μg/L	Basin Plan
	Cadmium, Dissolved	1.57 – 3.54[4]	μg/L	California Toxics Rule (Acute Freshwater, Aquatic Life)
		1.13 – 1.97[4]	μg/L	California Toxics Rule (Chronic Freshwater, Aquatic Life)
	Copper, Dissolved	5.65 – 11.43[4]	μg/L	California Toxics Rule (Acute Freshwater, Aquatic Life)
		4.08 – 7.73[4]	μg/L	California Toxics Rule (Chronic Freshwater, Aquatic Life)
	Chromium, Dissolved	50	μg/L	Title 22 MCL (Primary)/Basin Plan[1]
	Cyanide, Total	22	μg/L	California Toxics Rule (Acute Freshwater, Aquatic Life)
		5.2	μg/L	California Toxics Rule (Chronic Freshwater, Aquatic Life)
	Lead, Dissolved	23.4 – 53.5[4]	μg/L	California Toxics Rule (Acute Freshwater, Aquatic Life)
		0.91 – 2.09[4]	μg/L	California Toxics Rule (Chronic Freshwater, Aquatic Life)
	Mercury, Total	0.050	μg/L	California Toxics Rule (Human Health, Water & Organisms)
	Molybdenum	10		Agricultural Water Quality Limit[5]
	Nickel, Dissolved	215 – 405[4]	μg/L	California Toxics Rule (Acute Freshwater, Aquatic Life)
		23.9 – 45.0[4]	μg/L	California Toxics Rule (Chronic Freshwater, Aquatic Life)

Table 3–2: Applicable Water Quality Objectives and/or Criteria for the Sacramento-San Joaquin Delta (Continued).

Classification	Constituent	Most Stringent Water Quality Objective or Criterion		Reference
		Value	Unit	
Metal	Selenium, Total	5	µg/L	California Toxics Rule (Chronic Freshwater, Aquatic Life)
	Silver, Dissolved	0.71 – 2.57(4)	µg/L	California Toxics Rule (Acute Freshwater, Aquatic Life)
	Zinc, Dissolved	54 – 101(4)	µg/L	California Toxics Rule (Acute Freshwater, Aquatic Life)
		54 – 102(4)	µg/L	California Toxics Rule (Chronic Freshwater, Aquatic Life)
Nutrient	Ammonia	3.83 – 24.1(6)	mg/L as N	Basin Plan, U.S. EPA 1999 Update of Ambient Water Quality Criteria for Ammonia, Acute Objtv. (1-hour average)(5)
		1.55 – 6.70(7)	mg/L as N	Basin Plan, U.S. EPA 1999 Update of Ambient Water Quality Criteria for Ammonia, Chronic Objtv. (30-day average)
	Nitrate	10	mg/L as N	Title 22 MCL (Primary)/ Basin Plan(1)
	Nitrite	1	mg/L as N	Title 22 MCL (Primary)/ Basin Plan(1)
	Nitrate + Nitrite	10	mg/L as N	Title 22 MCL (Primary)/ Basin Plan(1)
	Total Kjeldahl Nitrogen	N/A	N/A	N/A
	Total Nitrogen	N/A	N/A	N/A
	Total Phosphorus	N/A	N/A	N/A
Organics	1,4-Dichlorobenzene	5	µg/L	Title 22 MCL (Primary)/ Basin Plan(1)
	Bis(2-ethylhexyl)phthalate	1.8	µg/L	California Toxics Rule (Human Health, Water & Organisms)
	Bromodichloromethane	0.56	µg/L	California Toxics Rule (Human Health, Water & Organisms)
	Chloroethane	N/A	N/A	N/A

Table 3–2: Applicable Water Quality Objectives and/or Criteria for the Sacramento-San Joaquin Delta (Continued).

Classification	Constituent	Most Stringent Water Quality Objective or Criterion		Reference
		Value	Unit	
Organic	Chloroform	80	μg/L	Title 22 MCL (Primary) for Reporting Disinfection Byproducts/Basin Plan(1)
	Chlorpyrifos	0.025	μg/L	Basin Plan 1-Hour Average
		0.015	μg/L	Basin Plan 4-Day Average
	Dibromochloromethane	0.41	μg/L	California Toxics Rule (Human Health, Water & Organisms)
	Diethyl Phthalate	23000	μg/L	California Toxics Rule (Human Health, Water & Organisms)
	Di-n-butyl Phthalate	2700	μg/L	California Toxics Rule (Human Health, Water & Organisms)
	Methyl Chloride	N/A	N/A	N/A
	Methylene Chloride	4.7	μg/L	California Toxics Rule (Human Health, Water & Organisms)
	Tetrachloroethylene	0.8	μg/L	California Toxics Rule (Human Health, Water & Organisms)
	Toluene	150	μg/L	California Toxics Rule (Human Health, Water & Organisms)

(1) Incorporated into the Basin Plan by reference (CVRWQCB, 2007).

(2) 500 mg/L is the low end of the acceptable Title 22 Secondary MCL recommended range for TDS.

(3) The Secondary MCL for aluminum has been determined to be the controlling water quality objective for the discharge to the Sacramento River and downstream Delta. The determination is made through evaluation of available aluminum toxicity bioassay results performed in the Central Valley (e.g., City of Manteca, City of Yuba City, and City of Modesto) which resulted in adjusted chronic criteria more than an order of magnitude greater than the 1988 U.S. EPA ambient water quality chronic criterion of 87 μg/L (U.S. EPA, 1988), and greatly exceeding the Secondary MCL concentration of 200 μg/L. Previously, the 304(a) 87 μg/L aquatic life criterion has been selected based on best professional judgment utilizing available information for use in Central Valley permits as an interpretation of the narrative toxicity objective in the Basin Plan. Considering the new information regarding the low aluminum toxicity in Central Valley waters provided by the bioassays, the fact that the Secondary MCL concentration is an order of magnitude less than the bioassay effects levels, and the fact that the U.S. EPA criteria document acknowledges many high quality waters with aluminum concentrations exceeding 87 μg/L and recommends consideration of the site specific waters in determining the appropriate aquatic life criterion, the use of the 200 μg/L Secondary MCL value is deemed appropriate.

(4) A range of receiving water criteria was calculated using downstream 5th percentile (39.9 mg/L) and 95th percentile (84.2 mg/L) hardness values for the Sacramento River at River Mile 44 collected during the period 1/22/1998 – 6/12/2008.

(5) Ayers and Westcot, 1985.

(6) Numeric criterion used to interpret narrative water quality objective. A range of ammonia acute criteria was developed using downstream Sacramento River at River Mile 44 5th percentile (7.0) and 95th percentile (8.2) pH values collected during the period 1/28/1998 – 6/12/2008.

(7) Numeric criterion used to interpret narrative water quality objective. A range of ammonia chronic criteria was developed using downstream Sacramento River at River Mile 44 paired pH and temperature values collected during the period 1/28/1998 – 6/12/2008. Calculated 5th percentile (1.55) and 95th percentile (6.70) ammonia chronic criteria comprise the range of values presented in the above table.

3.3 303(D) LISTINGS

Section 303(d) of the Clean Water Act requires states to develop lists of water bodies (or segments of water bodies) that will not attain water quality standards (“objectives”, in California) after implementation of minimum required levels of treatment by point-source dischargers (i.e., municipalities and industries). Section 303(d) requires states to develop a TMDL for each of the listed pollutant and water body combinations for which there is impairment. A TMDL is the amount of loading of a given constituent that the water body can receive and still meet water quality standards for that constituent. The TMDL must include an allocation of allowable loadings for both point and non-point sources, with consideration of background loadings and a margin of safety. NPDES permit limitations for listed pollutants must be consistent with allocations identified in adopted TMDLs.

The U.S. EPA finalized approval of California’s 2006 Section 303(d) List on June 28, 2007. This list represents the most current listing of impaired water bodies in the project area. Because of the downstream proximity of the Delta to the SRWTP discharge and the fact that the SRWTP discharges into the northern portion (subarea) of the Delta, 303(d) listed impairments in the Delta are considered in the current analysis. In contrast to the four Delta subareas included in the 2002 303(d) list, the 2006 303(d) list divides the Delta into eight subareas, each possessing a set of pollutants/stressors that have been identified as preventing the subarea from meeting water quality standards. The Delta region and its eight subareas are shown in **Figure 3-1**. Each of the eight new subareas are likely to receive a minor fraction of SRWTP effluent over the course of any given water year depending on flow conditions and hydraulic operations of the Delta. The subareas include the Central Delta, Eastern Delta, Export Area, Northern Delta, Northwestern Delta, Southern Delta, Stockton Ship Channel, and Western Delta. **Table 3-3** lists the constituents identified in the 2006 303(d) list for the eight Delta subareas, and **Table 3-4** presents potential sources and proposed TMDL completion dates for these listed constituents.

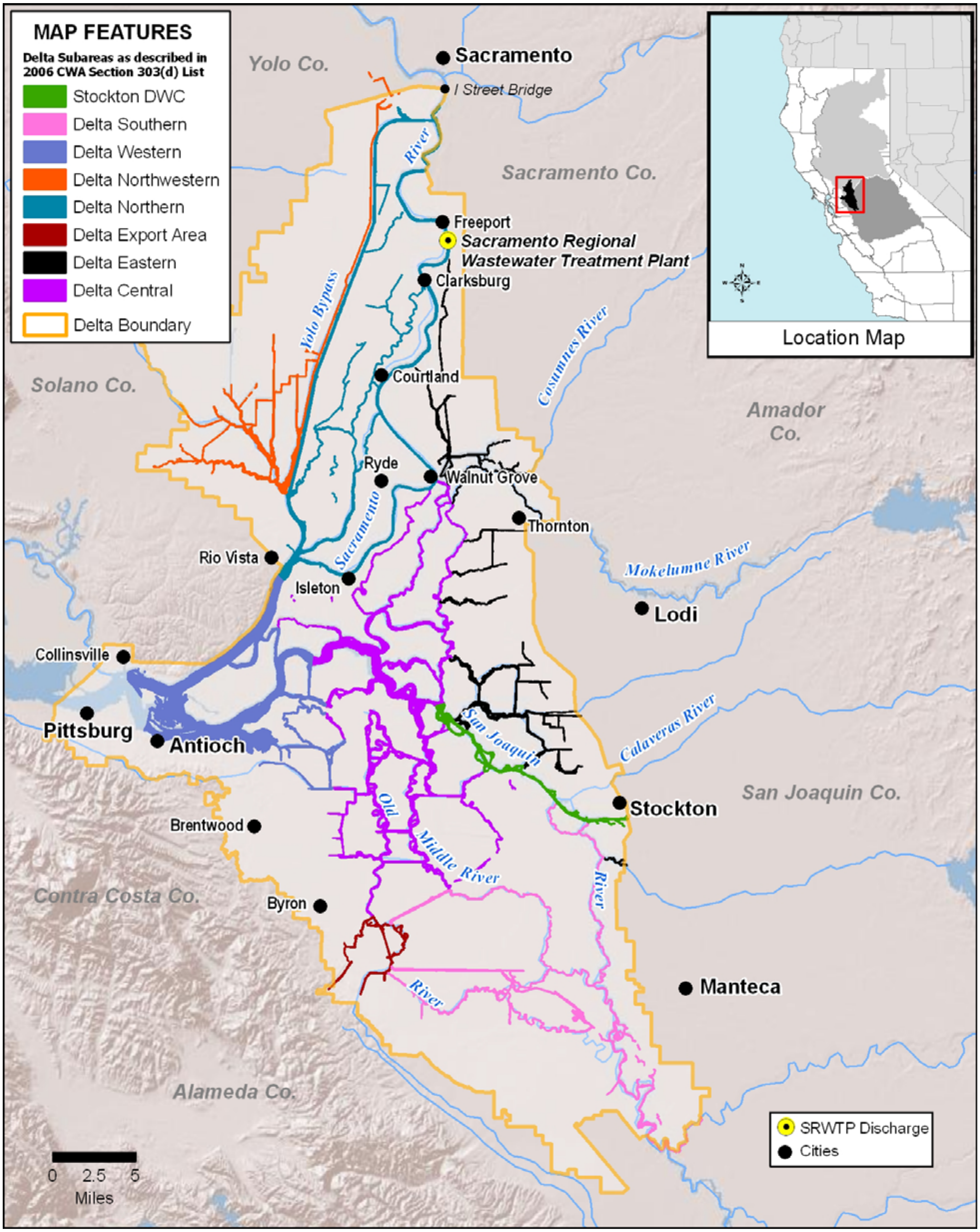


Figure 3-1: Sacramento-San Joaquin Delta Region showing Individual Delta Subareas.

Table 3-3: 2006 Clean Water Act Section 303(d) Listed Constituents as they pertain to Sacramento-San Joaquin Delta Waterways.

Pollutant/ Stressor	Delta Waterways							
	Central Portion	Eastern Portion	Export Area	Northern Portion	North-western portion	Southern Portion	Stockton Ship Channel	Western Portion
Chlorpyrifos	X	X	X	X	X	X	X	X
DDT	X	X	X	X	X	X	X	X
Diazinon	X	X	X	X	X	X	X	X
Dioxin							X	
Electrical Conductivity			X		X	X		X
Exotic Species	X	X	X	X	X	X	X	X
Furan Compounds							X	
Group A Pesticides	X	X	X	X	X	X	X	X
Mercury	X	X	X	X	X	X	X	X
Pathogens							X	
PCBs				X			X	
Unknown Toxicity	X	X	X	X	X	X	X	X

Table 3-4: Potential Sources and Proposed TMDL Completion Dates of Pollutants/Stressors for Delta Waterways contained in 2006 Clean Water Act Section 303(d) List.

Pollutant/Stressor	Potential Sources	Proposed TMDL Completion
Chlorpyrifos	Agriculture, Urban Runoff/Storm Sewer	2019
DDT	Agriculture	2011
Diazinon	Agriculture, Urban Runoff/Storm Sewer	2019
Dioxin	Point Source	2019
Electrical Conductivity	Agriculture	2019
Exotic Species	Source Unknown	2019
Furan Compounds	Contaminated Sediments	2019
Group A Pesticides	Agriculture	2011
Mercury	Resource Extraction (abandoned mines)	2006(1)
Pathogens	Urban Runoff/Storm Sewer, Recreational and Tourism Activities (non-boating)	2008(2)
PCBs	Point Source	2019
Unknown Toxicity	Source Unknown	2019

(1) The Central Valley Regional Water Board must consider for approval the Delta Mercury Control Program by October 2009.
(2) The Central Valley Regional Water Board adopted Resolution No. R5-2008-0030 on March 14, 2008, approving the TMDL of Pathogens in Stockton Urban Water Bodies, San Joaquin County.

3.4 NPDES PERMIT REQUIREMENTS

The SRSCD currently operates and discharges disinfected, secondary effluent to the Sacramento River below Freeport Bridge under the requirements of NPDES permit No. CA0077682, Order No. 5-00-188 (CVRWQCB, 2000a) and Thermal Plan Exception Resolution No. 5-00-192 (CVRWQCB, 2000b), adopted by the Central Valley Regional Water Board in August 2000. The District's NPDES permit includes effluent limitations for discharge to the Sacramento River when flows are at least 1300 cubic feet per second (cfs) as a means to comply with Discharge Prohibition No. A.3., which states, "… discharge to the Sacramento River is prohibited unless there is a minimum of 1300 cfs River flow and a 14:1 (river:effluent) flow ratio available in the River." The SRWTP has developed a plan of operation to meet this requirement and not discharge during periods of tidally-driven stoppages or reversals of river flow. The SRWTP Operations Plan has been developed, consistent with the NPDES permit, to regulate the SRWTP discharge during low-flow and flow reversal periods. When the downstream Sacramento River to effluent flow ratio falls below 14:1 (i.e., which indicates the onset of a flow stoppage or reversal), the discharge ceases and does not resume until the ratio of flow moving downstream to that of effluent is 14:1 or greater. During the period of no discharge, effluent is diverted to on-site emergency storage basins. When discharge resumes the diverted effluent stored in the basins is discharged along with the regular daily base flow discharge. The objectives of these operation rules are to ensure adequate initial jet diffusion mixing upon discharge and to avoid the thermal impact of discharge into a stopped or reversing water body.

Resolution No. 5-00-192, which was adopted simultaneously with the NPDES permit, grants an exception to objectives 5A(1)a[1] and 5A(1)b[2] of the Water Quality Control Plan for the Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California (Thermal Plan). Expressly, the Resolution states that the action waving Specific Water Quality Objective 5A(1)a is applied to the period 1 October through 30 April, and in the period of 1 October through 30 April, the temperature shall not exceed that natural receiving water temperature by more than 25 degrees Fahrenheit (F). **Table 3-5** presents the effluent limits contained in the District's NPDES permit as adopted by the Central Valley Regional Water Board in WDR Order No. 5-00-188.

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[1] Thermal Plan Objective 5A(1)a prohibits: A waste discharge to estuaries that exceeds the natural receiving water temperature by more than 20 degrees Fahrenheit (F).

[2] Thermal Plan Objective 5A(1)b prohibits: A waste discharge which causes more than 1 degree F (0.56 degrees Celsius ((C) rise in more than 25 percent of the receiving water cross section at the discharge location.

Table 3-5: Adopted Effluent Limits for SRCSD's SRWTP Discharge to the Sacramento River below Freeport Bridge.

Constituent (Units)	Yearly Total	Monthly Average	Weekly Average	Daily Average	Daily Maximum
BOD[1] (mg/L)	---	30	45	60	---
(lbs/yr)[2]	---	45,286	67,929	90,572	---
(lbs/yr)[3]	---	98,078	147,118	196,157	---
Total Suspended Solids (mg/L)	---	30	45	60	---
(lbs/yr)[2]	---	45,286	67,929	90,572	---
(lbs/yr)[3]	---	98,078	147,118	196,157	---
Chlorine Residual (mg/L)	---	0.011	---	0.018	---
(lbs/yr)[2]	---	17	---	27	---
(lbs/yr)[3]	---	36	---	59	---
Settleable Matter (ml/L)	---	0.1	---	---	0.5
Total Coliform (MPN/100 mL)	---	---	23 (median)	---	500[4]
Oil and Grease (mg/L)	---	10	---	---	---
(lbs/yr)[2]	---	15,095	---	---	---
(lbs/yr)[3]	---	32,693	---	---	---
Copper (μg/L)[5]	---	---	---	(9.7) 22.8	---
(lbs/yr)[2]	---	---	---	34	---
(lbs/yr)[3]	---	---	---	75	---
Lead (μg/L)[5]	---	---	---	(5.1) 7.8	---
(lbs/yr)[2]	---	---	---	12	---
(lbs/yr)[3]	---	---	---	26	---
Silver (μg/L)[5]	---	---	---	(0.57) 0.72	---
(lbs/yr)[2]	---	---	---	1.1	---
(lbs/yr)[3]	---	---	---	2.3	---
Zinc (μg/L)[5]	---	---	---	(46.7) 69.8	---
(lbs/yr)[2]	---	---	---	105	---
(lbs/yr)[3]	---	---	---	228	---
Cyanide (μg/L)[5]	---	---	---	(6.1) 10.8	---
(lbs/yr)[2]	---	---	---	16	---
(lbs/yr)[3]	---	---	---	35	---
gamma-BHC (Lindane) (lbs/yr)	19.0[6]	---	---	---	ND[7]
Mercury (lbs/yr)	5.1[6]	---	---	---	---
Methylene chloride (μg/L)	---	14.3	---	32.1	---
(lbs/yr)[2]	---	22	---	48	---
(lbs/yr)[3]	---	47	---	105	---

Table 3–5: Adopted Effluent Limits for SRCSD's SRWTP Discharge to the Sacramento River below Freeport Bridge (Continued).

Constituent (Units)	Yearly Total	Monthly Average	Weekly Average	Daily Average	Daily Maximum
Chloroform (μg/L)	---	37.3	---	55.3	---
(lbs/yr)(2)	---	56	---	83	---
(lbs/yr)(3)	---	122	---	181	---
Tetrachloroethylene (μg/L)	---	14.1	---	35.6	---
(lbs/yr)(2)	---	21	---	54	---
(lbs/yr)(3)	---	46	---	116	---
Dichlorobromomethane (μg/L)	---	3.6	---	7.2	---
(lbs/yr)(2)	---	5.4	---	11	---
(lbs/yr)(3)	---	12	---	24	---
Bis(2-ethylhexyl)phthalate (μg/L)	---	8.6	---	19.1	---
(lbs/yr)(2)	---	13	---	29	---
(lbs/yr)(3)	---	28	---	62	---

(1) 5-day, 20˚C biochemical oxygen demand.

(2) Based upon a design average dry weather flow capacity of 181 mgd, applicable from May through October.

(3) Based upon design peak wet weather flow capacity of 392 mgd, applicable from November through April.

(4) Daily Maximum limit, shall not be exceeded in any two (2) consecutive days.

(5) Trigger concentrations (in parenthesis) and interim limits per Effluent Limit B.9 and information Sheet Item No. 10.6. Trigger concentrations are not subsequently expressed as mass limits.

(6) As calculated per Effluent Limit B.8.

(7) Not applicable if Discharger is in compliance with time schedules of Provisions Nos. E.5, E.6, and E.7 and Finding No. 26.

Non-detectable (ND). The Discharger shall use EPA standard analytical techniques that have the lowest practical level for Lindane with a minimum acceptable reporting level of 0.02 μg/L. Detectable concentrations of Lindane less than 0.02 μg/L shall be considered in compliance with this effluent limit.

In addition to the effluent limitations listed in **Table 3-5**, the following requirements are also listed in Order No. 5-00-088:

1. The discharge of effluent in excess of the limits presented in **Table 3-5** is prohibited.
2. The arithmetic mean of 20˚C BOD (5-day) and total suspended solids in effluent samples collected over a monthly period shall not exceed 15 percent of the arithmetic mean of the values for influent samples collected at approximately the same times during the same period (85 percent removal).
3. The discharge shall not have a pH value of less than 6.0 nor greater than 8.5 as calculated by a running 20-minute average of continuously monitored effluent pH nor have a pH value greater than 7.5 as calculated by a running 1-hour average of continuously monitored effluent pH. As discussed in Finding 23 and 24 (see Appendix A) the upper limit of 7.5 as 1-hour average is an interim limit until completion of further studies at which time its necessity will be reassessed. Per Provision E.9 (see Appendix A), this limitation shall become effective 1 November 2000. In the interim, the effluent limits and monitoring and reporting requirements of the rescinded Order No. 94-006 will remain in effect.

4. The 30-day average dry weather flow shall not exceed 181 mgd.
5. The daily peak wet weather flow shall not exceed 392 mgd.
6. The effluent shall not cause acute toxicity to test fish in 96-hour continuous flow-through bioassays of undiluted waste performed as described in Monitoring and Reporting Program No. [5-00-188]. Tests resulting in survival less than the following criteria shall be considered violations of this limitation:
   a. Minimum for any one bioassay: 70%
   b. Median for any three or more consecutive bioassays: 90%
7. The maximum temperature of the discharge shall not exceed the natural receiving water temperature by more than 25˚F from 1 October through 30 April or by more than 20˚F from 1 May through 30 September.
8. The total annual mass discharge of mercury and lindane shall not exceed 5.1 lbs and 19.0 lbs., respectively, per year. These are an interim performance-based limit that shall be in effect until a final TMDL is established for both of these constituents. Actual mass loading over or under these limits shall be banked for future offset and shall not be considered a violation as long as the Discharger is in compliance with Provision E.7 (see Appendix A). The procedures for calculating mass loadings and banking are as follows:
   a. The total mercury mass load for each individual month shall be determined using an average of all concentration data collected that month and the corresponding average monthly flow. All monitoring data collected under the monitoring and reporting program, pretreatment program and any special studies shall be used for these calculations.
   b. In calculating compliance, the Discharger shall count all non-detect measures at one-half of the detection level. If compliance with the effluent limit is not attained due to the non-detect contribution, the Discharger shall improve and implement available analytical capabilities and compliance shall be evaluated with consideration of the detection limits.
   c. The Discharger shall submit a cumulative total of mass loadings for the most recent twelve months in accordance with the Monitoring and Reporting Program No. 5-00-188. The amount of this 12-month total over or under the interim limit shall be banked (added or subtracted) against a running net total of the same figures from all previous months.

   If mercury is found to be causing toxicity based on chronic toxicity test results, or if a TMDL program is adopted, this permit shall be reopened and the mercury mass effluent limit shall be modified (higher or lower) or an effluent concentration limitation imposed.
9. The effluent limits shown above in **Table 3-5** for copper, lead, zinc, and cyanide are interim limits as required by SIP Section 2.2.2. Once the Discharger has completed the studies in Provision E.4 (see A), the permit will be reopened to incorporate final limits, as needed, and the interim limits will be eliminated. Exceedance of the lower trigger concentration is not a violation of this Order, however, if the trigger concentration is exceeded in the effluent then an investigation into the cause of the exceedance shall be performed by the Discharger and the Regional Board notified of the results within 30

days. Upon review of the results of the investigation the Regional Board may require an action plan to address the cause of the exceedance.

The studies in Provision E.4 (i.e., Localized Impact Studies; see Appendix A) described in Effluent Limitation #9 in the above list were completed as required. A work plan to complete these studies was submitted to the Regional Board as required on October 1, 2001. The results of the studies were reported in the Draft and Final 2020 Master Plan EIR (SCDERA, 2003; SCDERA, 2004; respectively) and were summarized in the District's Supplemental Information Pertaining to NPDES Permit Renewal that was submitted to the Regional Board on March 30, 2005.

4 Environmental Setting

4.1 SACRAMENTO-SAN JOAQUIN DELTA AND SACRAMENTO RIVER BASIN

The receiving water for the discharge of treated wastewater from the SRWTP is the Sacramento River and the Sacramento-San Joaquin River Delta. The Sacramento River drains 27,000 square miles of northern California, extending from the Cascade Mountain Range in the north to the Sierra Nevada Mountain Range in the east and the eastern slopes of the Coastal Mountain Ranges in the west. The lower Sacramento River, defined as the portion of the river downstream from the town of Freeport, is predominantly channelized with levees and bordered by agricultural lands and several small communities. Aquatic habitat in the lower Sacramento River is characterized primarily by slow-water glides and pools, depositional in nature, and has reduced water clarity and habitat diversity, relative to the upper portion of the river. A number of fish species utilizing the upper Sacramento River and its tributaries also use the lower river to some degree, even if only as a migratory corridor to and from upstream spawning and rearing areas. Portions of the lower river also are used by fish species (e.g., striped bass, delta smelt) that make little to no use of the upper river.

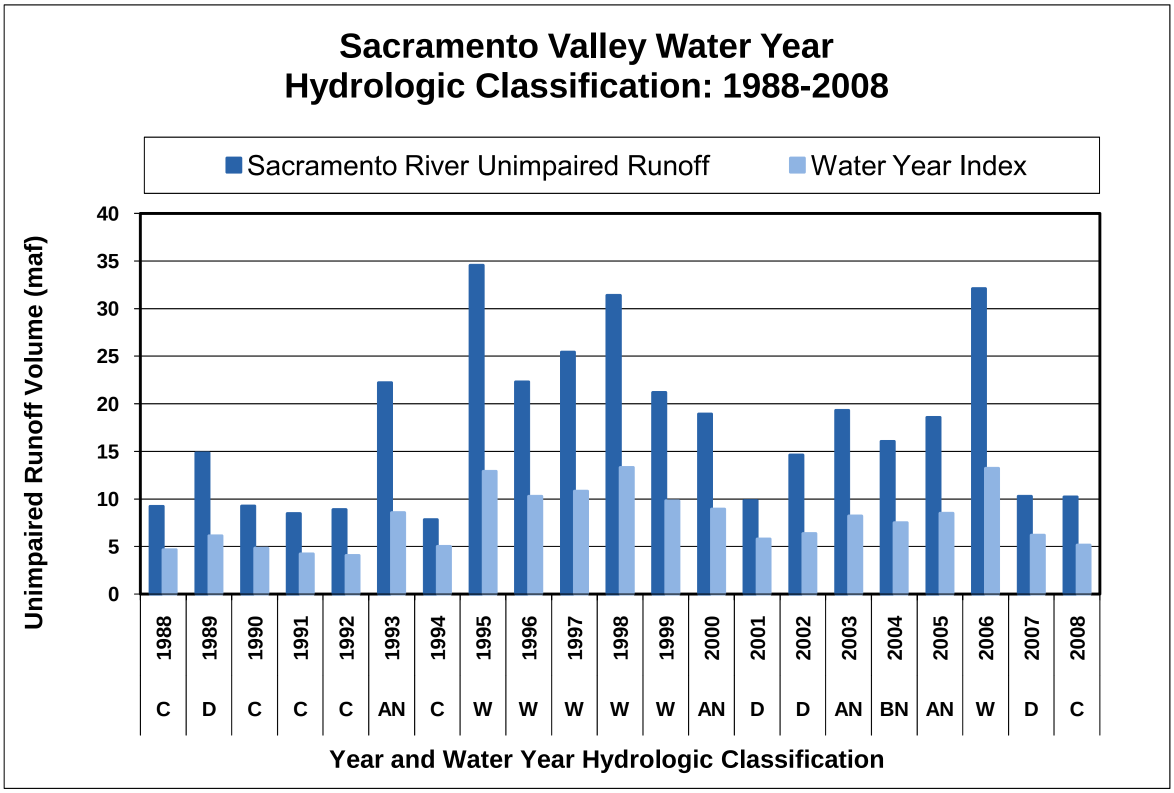
The Delta is a network of interconnected waterways covering approximately 1,500 square miles that receives runoff from over 40 percent of the State's land area. Inflow to the Delta includes flows from the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras rivers. The California Water Code (Section 12220) defines the upper boundary of the Delta as the I Street Bridge in Sacramento. The SRWTP discharges treated effluent to the Sacramento River just downstream of the Freeport Bridge, which is located approximately 12 miles downstream of the I-Street Bridge, and therefore is within the legal boundary of the Delta (see **Figure 3-1**). At the point of the SRWTP discharge, the Sacramento River is approximately 600 feet wide at the surface and varies in depth between 25 to 30 feet.

4.2 SACRAMENTO RIVER HYDROLOGY

The lower Sacramento River, the site of the SRWTP discharge location (Freeport), drains a massive basin that extends from the inner Coast Range Mountains to the ridge-crest of the Sierra Nevada. The sources of surface runoff in this basin are diverse: forested watersheds, open space, agricultural lands, and urbanized zones.

Flows in the lower Sacramento River are strongly influenced by precipitation (rainfall and snowpack/snowmelt) and upstream reservoir operations. Irrigation diversions and agricultural return flows also affect the river's hydrologic regime. Winter and spring flows in the Sacramento River average 45,000 cfs. Summer flows average 10,000 cfs, but can fall to minimums approaching 6,000 cfs. Daily flow probabilities for the Sacramento River at Freeport, based on U.S. Geologic Survey (USGS) flow data collected over the last six decades, indicate that there is a 10% probability of flows less than or equal to 9,200 cfs, and a 10% probability of flows greater than 55,000 cfs. Future minimum flows in the river are anticipated to be greater than historical minimum flows due to changes in water supply operation required to meet environmental and salinity standards in the Delta. The water quality models used to estimate water quality impacts due to the proposed increase in permitted SRWTP discharge (see Section 5.3) consider minimum flows that could occur under current reservoir operations.

As indicated above, the Sacramento River Valley experiences a wide range of hydrologic conditions from year to year. The California Department of Water Resources characterizes Sacramento River flows as falling into distinct hydrologic classifications as defined in SWRCB Decision 1641 (SWRCB, 2000). These hydrologic classifications are comprised of a *water year type* and a *water year index* based on Sacramento River unimpaired runoff, with a water year defined as extending from October 1 to September 30. Water year types in the Sacramento River watershed fall into five categories: wet, above normal, below normal, dry, and critical. The model simulations (described below) performed as part of the antidegradation analysis employed a hydrologic data set that includes representation from all five water year types. The hydrologic data set spans a 70-year period (1922 to 1991), accounting for a full spectrum of climatological conditions in the Sacramento River Valley. Sacramento Valley water year hydrologic classifications from 1988 through 2008 are shown in **Figure 4-1**.



Notes:

1. The data presented above were generated by the California Department of Water Resources (see http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST). These indices have been used operationally by DWR for planning and managing of water supplies since 1995, and are defined in SWRCB Decision 1641 (see http://www.waterrights.ca.gov/baydelta/d1641.htm).
2. A water year extends from Oct. 1 - Sep. 30 (e.g., 2008 Water Year = Oct. 1, 2007 - Sep. 30, 2008).
3. Unimpaired runoff represents the natural water production of a river basin, unaltered by upstream diversions, storage, or export of water to or import of water from other basins.
4. Sacramento River runoff is the sum (in maf) of Sacramento River at Bend Bridge, Feather River inflow to Lake Oroville, Yuba River at Smartville, and American River inflow to Folsom Lake.
5. Sacramento Valley Water Year Index = 0.4 * Current Apr-Jul Runoff Forecast (in maf) + 0.3 * Current Oct - Mar Runoff (in maf) + 0.3 * Previous Water Year's Index (if the Previous Water Year's Index exceeds 10.0, then 10.0 is used).
6. Sacramento Valley Water Year Hydrologic Classification:

Year Type:	Water Year Index:
W = Wet Year	Equal to or greater than 9.2
AN = Above Normal	Greater than 7.8, and less than 9.2
BN = Below Normal	Greater than 6.5, and equal to or less than 7.8
D = Dry	Greater than 5.4, and equal to or less than 6.5
C = Critical	Equal to or less than 5.4

Figure 4-1: Sacramento Valley Unimpaired Runoff and Water Year Classification for the Period 1988 – 2008.

4.3 SRCSD SERVICE AREA

The Sacramento Regional County Sanitation Districts provides wastewater services to approximately 1.3 million people in 416,000 homes and businesses within a 370 square-mile area in the Sacramento Metropolitan area, including the City of West Sacramento in Yolo County. In addition, SRCSD's Pretreatment Program includes approximately 80 permitted industries. SRCSD's contributing agencies include Sacramento Area Sewer District, and the Cities of Folsom, West Sacramento, and Sacramento. SRCSD also provides wastewater treatment services for a small number of residential customers in Roseville and south Placer County. A map of the service area is shown in **Figure 4-2**.

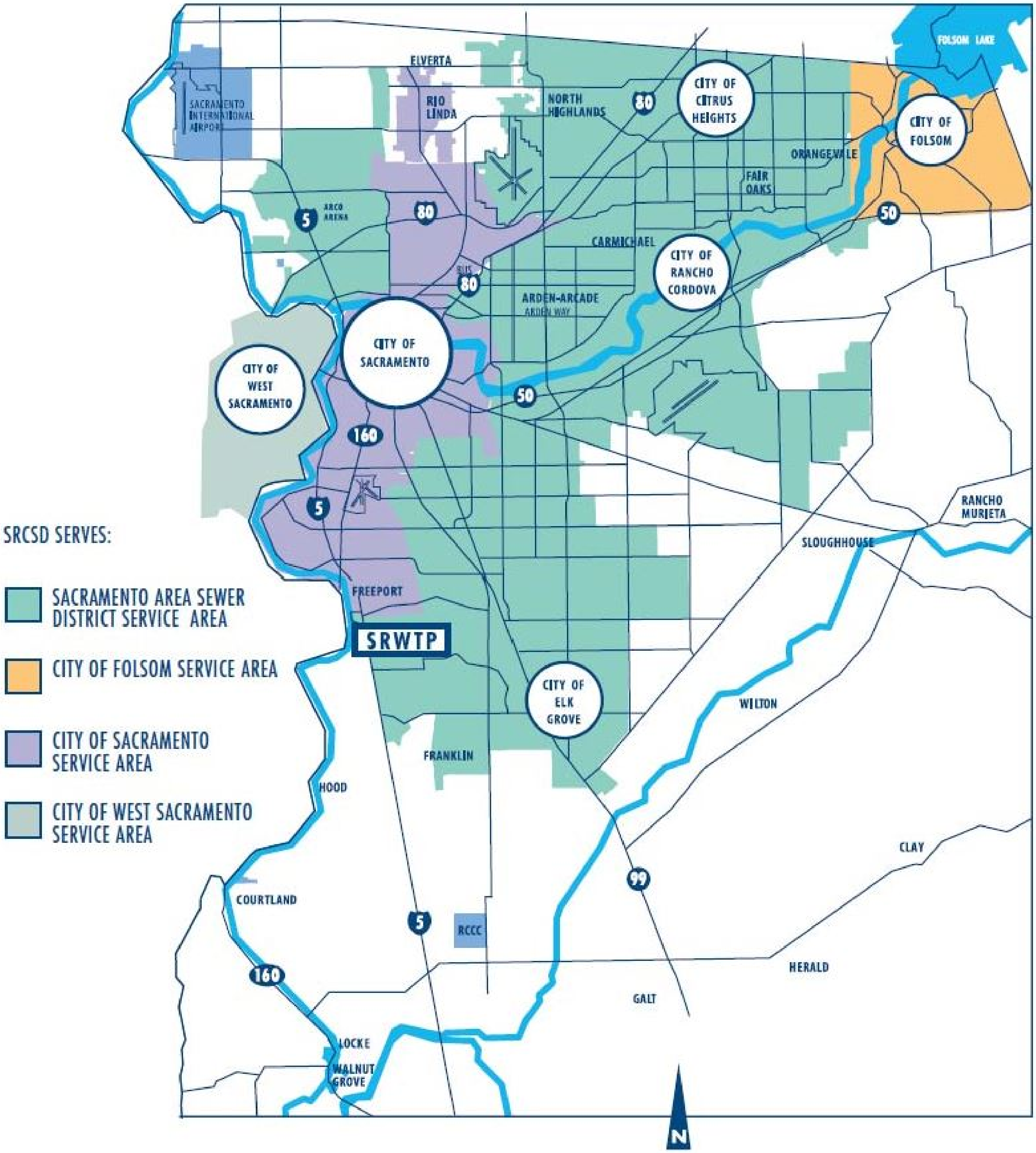


Figure 4-2: SRCSD Service Area, Including Jurisdictions of Tributary Agencies

4.4 SIMILARLY SITUATED DISCHARGES

The point has been raised that SRCSD should install advanced treatment processes because a number of other Central Valley communities have or are planning to install advanced treatment facilities (filtration, nitrification/denitrification). The following discussion provides information to identify dischargers that are similarly situated with SRCSD and to identify differences between other discharge situations in the Central Valley.

The amount of effluent dilution that occurs in a receiving water, the quality of a receiving water, and applicable water quality standards are important considerations for determining the appropriate level of treatment for any wastewater treatment plant regulated under the Clean Water Act and California Water Code. The national standard that must be met by all municipal wastewater treatment plants across the nation that discharge to surface waters is "secondary treatment" as defined in 40 CFR Part 133 (Secondary Treatment Regulations). Municipal wastewater treatment plants throughout the Central Valley, including the SRWTP, comply with the national Secondary Treatment Regulations.

Construction and operation of advanced treatment facilities at municipal wastewater treatment plants (i.e., facilities providing more advanced treatment than required by the Secondary Treatment Regulations) typically exist to provide recycled water supplies for meeting irrigation needs within the general vicinity of the plant, or because advanced treatment is required to meet applicable water quality standards and to adequately protect receiving water beneficial uses near the point of discharge. The latter reason for advanced treatment is often driven by low dilution of treated effluent that occurs in the receiving water, such as is typically the case for many Central Valley dischargers. The SRWTP discharge situation is rare among wastewater treatment plants within the region in that its receiving water – the Sacramento River at Freeport – currently provides a daily average dilution ratio of 20:1 or more at all times, and is expected to do so greater than 99.5% of the time under the proposed 218 mgd discharge scenario. Additionally, modeling performed for the 70-year (1922-1991) hydrologic period of record shows that the mean percentage of flow contributed by SRWTP discharge to the twelve Delta locations modeled for percent SRWTP effluent contribution as a result of the proposed project, would range from 0.01% at in the San Joaquin River near Stockton to 2.2% at in the Sacramento River Greene's Landing/Hood, indicating typical dilution ratios ranging from approximately 50:1 to 1000:1.

All of the communities in the Central Valley with existing discharges that have constructed or are constructing advanced treatment facilities have done so in reaction to water quality-based considerations influenced by the location and physical conditions that exist at their point of discharge to receiving waters. For communities that have established new discharges to receiving waters, applicable NPDES discharge requirements have resulted in the need to construct advanced treatment facilities to be able to achieve permit requirements upon commencement of the discharge. Examples of such new discharges include Iron House Sanitary District and the City of Rio Vista. In such cases, the dilution characteristics in the receiving water have not been a controlling factor in the decision to construct advanced treatment facilities. Because the dilution situation for the SRWTP discharge is distinctly different from most other municipal discharges within the region, many of which occur in effluent dominated water bodies, so too are the water quality-based factors that relate to the level of treatment required to comply with applicable standards and to protect downstream beneficial uses. This important factor of dilution was accounted for in the water quality modeling performed in support of the District's

Master Plan EIR, and was considered in this assessment. The water quality analysis provided in this antidegradation analysis, together with the assessment performed as part of the NPDES permit renewal, will be used to reach decisions regarding the future level of treatment required at the SRWTP, in accordance with the rules and policies existing under the Clean Water Act and California Water Code.

4.5 DELTA ECOSYSTEM CONCERNS

4.5.1 Pelagic Organisms Decline

Since 2000, the population levels of several pelagic fish species in the Delta have experienced a precipitous decline to historic low levels that continues to persist. The species in question include Delta smelt (*Hypomesus transpacificus*), longfin smelt (*Spirinchus thaleichthys*), threadfin shad (*Dorosoma petenense*), and juvenile striped bass (*Morone saxatilis*). The consequences of the decline have been most serious for the Delta smelt, a threatened species whose narrow range extends into the area of the Delta most impacted by the operation of the State and federal water supply pumping operations (Baxter et al., 2008).

The potential causes or contributors of the above described Pelagic Organism Decline (POD) which are under investigation include: (1) hydrologic modifications associated with Delta water supply projects, (2) entrainment of fish species and prey species in Delta pumps and pump intake facilities, (3) food web disruption caused by invasive clam and aquatic plant species, (4) predation by native and non-native species, (5) adverse impacts of contaminants, including pesticides, ammonia, trace metals, and other constituents of concern, (6) habitat quality decline, (7) stock-recruitment effects and (8) other factors. Various investigators have been and continue to research these potential causes of the POD, including State and federal fish and wildlife agencies charged with protection of threatened and endangered species in the Delta. A multiagency work team was assembled in 2005 which includes representatives from the following: DWR, California Department of Fish and Game (CDFG), Central Valley Regional Water Board, U.S. Bureau of Reclamation, U.S. EPA, USGS, California Bay-Delta Authority, UC Davis, and San Francisco State.

Litigation pertaining to the operational impact of the water projects on Delta smelt and other Delta fish species, including Salmonid species listed for special protection under the Endangered Species Act, has led to federal court rulings issued in the US District Court for the Eastern District of California by Judge Oliver Wanger. Judge Wanger ruled that revised biological opinions were required for Delta smelt and salmonids. Further, Judge Wanger imposed limitations on the operation of Delta pumps as a means of protecting listed species.

A revised biological opinion has been issued by the US Fish and Wildlife Service pertaining to Delta smelt. The December 15, 2008 opinion found that continued operation of the State Water Project and Federal Central Valley Project is likely to jeopardize the continued existence of Delta smelt and adversely modify its critical habitat. This opinion was rendered after examination and evaluation of the proposed Operation Criteria and Plan (OCAP) for the two projects. The biological opinion was developed in coordination with DWR and CDFG.

From the standpoint of the proposed increase in discharge of treated effluent from the SRWTP to the Sacramento River and resulting water quality changes in the Delta, the POD is an important consideration. The impact evaluations contained in Section 5 identify the magnitude of change in water quality associated with the proposed increase in discharge. Additionally, potential impacts related to the toxicity of the most sensitive aquatic species in national data sets are assessed through the use of U.S. EPA criteria and adopted water quality standards contained in the California Toxics Rule and National Toxics Rule. Additional pertinent information is also considered in the impact evaluations, where available.

4.5.2 Role of Nutrients in the Pelagic Food Web in the San Francisco Estuary and the Sacramento-San Joaquin Delta

Supplies of dissolved inorganic nitrogen (DIN, principally nitrate and ammonium) and dissolved inorganic phosphorus (DIP, principally phosphate) influence the pelagic food web of the Delta principally through their role in the production of phytoplankton and bacterial biomass. The principal environmental concern for many estuaries is that excessive nutrient loading promotes eutrophication, in which high endogenous organic matter production and subsequent microbial respiration deplete oxygen, producing anoxia in subsurface waters and sediments (Cloern, 2001). Until passage of the Clean Water Act and resulting improvements to sewage treatment in the 1960s-1970s, waters of the San Francisco Estuary (SFE)[3] were often depleted in oxygen because of excessive loading of organic matter. However, eutrophication is no longer widespread in the SFE. Since the l970s, depressed water column oxygen concentrations in the SFE have been confined to a portion of the Stockton Ship Channel (owing to a combination of nitrification and carbonaceous oxygen demand (Lehman et al., 2004) and local conditions or uncommon events (Cloern & Oremland, 1983). The principal reason for the current lack of widespread eutrophication in the SFE is the turbidity of the estuary, which results in light limitation of phytoplankton most of the time (Cole & Cloern, 1984, 1987). This condition is typical of estuaries with high turbidity (e.g., Hudson Estuary (Cole et al., 1992) and Gironde Estuary (Irigoien & Castel, 1997)). Light limitation is likely to be most severe in turbid waters of the Delta and in the low salinity zone (LSZ)[4] of the SFE.

Several factors which regulate phytoplankton production in the SFE – such as turbidity, freshwater flow, residence time, and benthic grazing – decrease its sensitivity to nutrient loading (Cloern, 2001). The SFE is commonly referred to as a “high nutrient/low productivity” estuary, owing in part to its position near the low end of the scale for an often-cited relationship between fishery yield and primary production for 36 marine systems published by Nixon (1988). A more recent meta-analysis of chlorophyll-a patterns in 154 estuaries worldwide shows that annual mean chlorophyll-a levels in the SFE are intermediate (Cloern & Jassby, 2008). Temporal patterns in chlorophyll-a and primary production in the northern SFE over the last three decades have not paralleled increasing trends in nitrogen loading. This may be a more common condition in estuaries than commonly acknowledged. A recent comprehensive compilation of data from 51 estuaries (Borum, 1996) shows that only 36% of the variation in phytoplankton production in these estuaries is correlated with total nitrogen (TN) loading. Van Nieuwenhuyse (2007) hypothesized that an approximately 1.5-fold reduction in Total Phosphorus (TP) loading in the Sacramento River in the early 1990s (linked to a decrease in the phosphorus content of effluent from the SRWTP) was responsible for a simultaneous 2.6-fold reduction in May-September chlorophyll-a levels in the freshwater Delta (based on data from three Interagency Ecological Program (IEP) monitoring stations). The possibility that changing TN:TP ratios, or a relative phosphorus limitation, contributes to primary production patterns during this season in the Delta has not received as much attention as competing hypotheses about the roles of other potentially

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[3] Following Kimmerer et al. (2009), the San Francisco Estuary is used herein to refer to the sum of the legal Delta, Suisun Bay, and San Pablo, Central and South Bays. The “northern SFE” refers to Suisun Bay plus the legal Delta.

[4] The low-salinity zone (LSZ) refers to the portion of the SFE in which salinity ranges 0.5-6 practical salinity units. The physical location of the LSZ shifts depending on the magnitude of Delta outflow, but is often centered in Suisun Bay.

limiting factors. This may be because neither nitrogen nor phosphorus is usually expected to reach absolute concentrations in this system that would be potentially limiting to phytoplankton growth. Jassby et al. (2002) found that nutrient concentrations were low enough to limit phytoplankton growth in the Delta in only about 0.1% of the measurements since the late 1960s – and most of these limiting concentrations occurred in the south Delta during the extreme El Niño-Southern Oscillation (ENSO)-related drought of 1976-1977.

Filtration by the invasive overbite clam *Corbula amurensis* is considered a major contributor to a step decrease in phytoplankton abundance (and diatom production) that occurred in Suisun Bay and the western Delta after its arrival in 1986 (Jassby et al., 2002; Kimmerer, 2005). Conservative grazing rates for *C. amurensis*, assuming a well-mixed upper water column, indicate the clams are capable of filtering a two-meter m water column four times a day (J. Thompson, USGS, unpublished). Given the measured doubling rate for phytoplankton in this system (0.1 d^{-1}) (Alpine & Cloern, 1992), this grazing rate appears sufficient to limit local phytoplankton production. Long-term patterns in chlorophyll-a concentrations show that the step decrease in phytoplankton biomass in Suisun Bay was accompanied by a parallel decrease in the Sacramento River as far upstream as Three-mile Slough (see **Figure 4-3**). Phytoplankton biomass in the central freshwater Delta has been shown to be inversely related to the biomass and estimated grazing rate of another benthic grazer, the introduced freshwater clam *Corbicula fluminea*. Shallow habitats colonized by *C. fluminea* appear to operate as net sinks of phytoplankton biomass in the freshwater Delta (Lopez et al., 2006, Lucas et al., 2002, Parchaso & Johnson, 2008). Chlorophyll-a concentrations in many (even nutrient rich) estuaries world-wide, including in 15 Canadian estuaries (Meeuwig, 1999), are strongly controlled by benthic suspension feeders (Cloern, 2001). In fact, new post-spring blooms of large diatoms in South San Francisco Bay since 1999 have been attributed to a trophic cascade in which recent population surges for *Crangon* shrimp, Dungeness crab, and English sole increased predation on bivalves, and in turn decreased losses of phytoplankton to benthic filtration (Cloern et al., 2007).

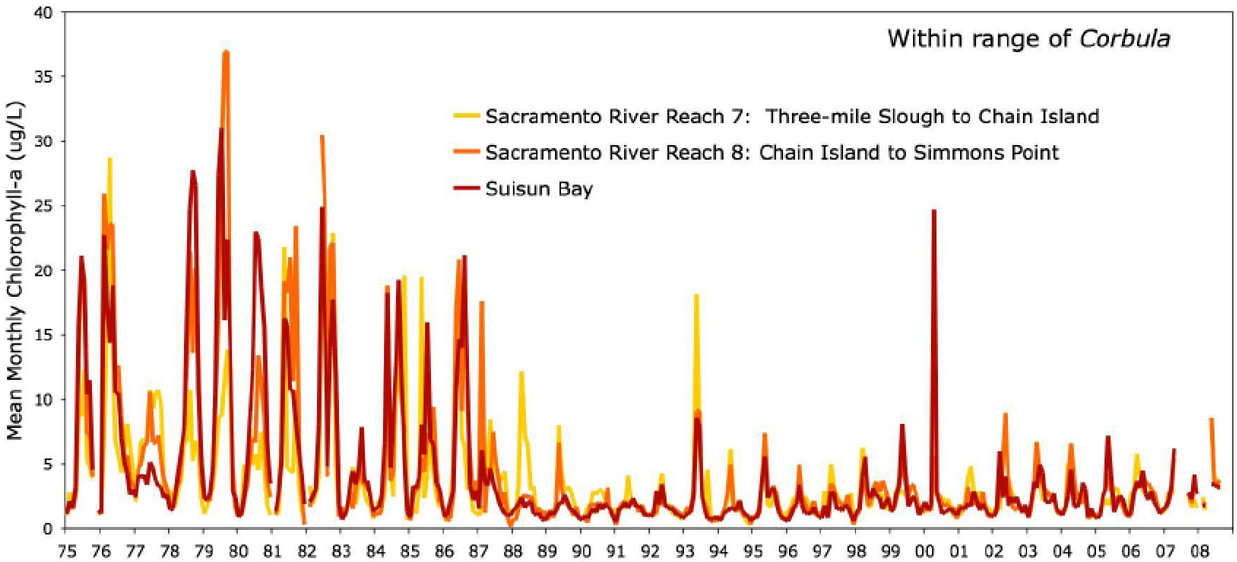

Figure 4-3: Time series for mean monthly chlorophyll-a from long-term monitoring stations in Sacramento River Reaches 7-8 and Suisun Bay. Location of reaches is shown in Figure 4-8 (A). Data used to generate monthly means were daily station means for surface grab samples (up to 2 m depth). Monitoring data were from the IEP/EMP, DWR-MWQI, and the USGS.

The SFE is a net heterotrophic system (Sobczak et al., 2005), as are many estuaries (Middleburg & Nieuwenhuize, 2000). This means that, within the system, consumption of organic matter exceeds *in situ* synthesis of organic matter by autotrophic organisms (phytoplankton, phytobenthos, and aquatic plants). In net heterotrophic systems, community metabolism is supported by organic matter imported from tributaries or marginal habitat, which may be in dissolved or particulate form. Endogenous phytoplankton production is a minor fraction of the total carbon budget of the Delta; tributary inputs of organic carbon exceed *in situ* phytoplankton gross production by factors of 3 (in normal water years) to 11 (in above normal water years) (Jassby et al., 1993; Jassby & Cloern, 2000). Accordingly, mean respiration:production rates (R:P) in the lower Sacramento River were found to be about 6 (Rudek & Cloern, 1996). However, phytoplankton-derived matter makes up a significant fraction of the exogenous organic matter transported by rivers to the Delta. As much as 18% on average of the total organic nitrogen (TON) entering the Delta may be in the form of phytoplankton and phytoplankton-derived detritus (Jassby & Cloern, 2000). External subsidies of riverine phytoplankton are hypothesized to be important for bacterial production in the LSZ and may be important for secondary production inside the Delta.

Overall, the bioavailability of the Delta DOC pool is low; estimates of median bioavailability range from 10-12% (Stepanauskas et al., 2005, Jassby & Cloern, 2000). However, standing stocks may fail to account for turnover of more labile DOC that cycles rapidly in the water column. DOC entering Delta waterways from island drains and tidal marsh is predominantly from terrestrial vascular plants or soils, and is more refractory than DOC in transport in the Sacramento and San Joaquin Rivers (Stepanauskas et al., 2005). The DOC from flooded Delta islands is more labile than DOC in tidal marsh and floodplain, likely owing to *in situ* phytoplankton production and aquatic vascular plants in these shallow water bodies (Stepanauskas et al., 2005). Although freshwater phytoplankton are transported to the LSZ in

Delta outflow, species composition of phytoplankton changes from a freshwater assemblage to a brackish assemblage near the LSZ. Osmotic stress, loss of DOC, and lysis of freshwater cells represents a source of DOC for bacterioplankton in the LSZ (Fisher et al., 1988).

Although bacteria are commonly viewed as net mineralizers of organic matter, these microbes commonly assimilate inorganic N and P from the water column to maintain cellular stoichiometery during the consumption of organic matter with high C:N and C:P ratios (Goldman & Dennett, 1991). In the marine environment, or where phytoplankton are limited by physical factors, planktonic bacteria can effectively compete with phytoplankton for DIN (Hoch & Kirchman, 1995). For example, microbial processing of organic carbon in the Delta represents a demand for inorganic nutrients that is independent of light availability, whereas phytoplankton demand for inorganic nutrients is linked to light availability. Ammonium is generally preferred over nitrate as a DIN source for heterotrophic bacteria in turbid estuaries (Middelburg & Nieuwenhuize, 2000). In turbid estuaries, nitrate turnover times are usually one order of magnitude higher than the residence time of water, whereas the turnover times for ammonium are often shorter than the residence time, indicating efficient recycling of ammonium within the system. Because the Delta is a nutrient-replete system, bacteria are more likely to be limited by supplies of labile carbon than by inorganic N and P. Hollibaugh and Wong (1999) hypothesized that variability in bacterial production in the northern SFE was due to period pulses of labile organic matter against a background of lower production supported by more refractory DOM.

The relative importance of heterotrophic and autotrophic nutrient uptake can vary seasonally and spatially in estuaries. The percent of total ammonium uptake attributed to bacteria (as opposed to phytoplankton) appears to increase along the gradient from estuarine to oceanic conditions (Hoch & Kirchman, 1995). Chesapeake Bay is primarily autotrophic in the spring when riverine inputs of new nitrogen (mostly nitrate) are high. As inputs of new nitrogen decrease, the bay becomes more heterotrophic and also more dependent on regenerated ammonium as a nitrogen source (Bronk et al., 1998). In Long Island Sound, ammonium uptake by the picoplankton increases from <10% during the winter to ~40% in summer (Fuhrman et al., 1988; Suttle et al., 1990). Whether or not the relative importance of bacterial versus phytoplankton uptake of inorganic nutrients varies seasonally in the SFE has not been resolved. Relative rates of bacterial and phytoplankton production in the LSZ of the SFE are currently being studied by investigators at San Francisco State University (SFSU) where preliminary information suggests that the fraction of total water column production accounted for by bacteria has increased (Parker, 2009; Kimmerer, 2009).

4.5.3 Nutrients and Invasive Aquatic Plants

Non-native, invasive aquatic plants in the Delta include the free-floating water hyacinth (*Eichhornia crassipes*), and several submerged species. The main three exotic invasive submerged plants within the Delta are the Brazilian waterweed (*Egeria densa*), Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potamogeton crispus*). Water hyacinth was introduced to the Sacramento River in 1904 by horticulturalists (Hestir et al., 2008), and now obstructs navigable waterways, fouls water pumps, blocks irrigation channels, and has caused significant changes to ecological assemblages throughout the Delta (Toft et al., 2003). The California Department of Boating and Waterways (DBW) attempts to control water hyacinth with herbicides and mechanical shredding.

Submerged aquatic vegetation, or SAV, is an important form of cover for the young of some estuarine fishes (Rozas & Odum, 1987; Wyda et al., 2002). It has recently been shown that SAV is also a comparatively productive rearing habitat for fishes in the Delta (Grimaldo et al., 2004; Nobriga et al., 2005). Unfortunately, SAV in the Delta has become dominated by *E. densa* which grows in denser stands than native SAV and seems to mainly provide rearing habitat to centrarchid fishes and other non-native species. In 2006, *E. densa* was estimated to occupy approximately 11,500 to 14,000 acres in the Delta, or about 17 to 21 percent of the Delta Region water acres (DBW, 2006). In addition, in areas where *E. densa* is abundant, the water is slowed and suspended matter that is normally exported from the Delta settles. The result is localized, heavy organic loading of shallow sloughs. *E. densa* changes the architecture of shallow water ecosystems forming walls between deepwater and inter-tidal habitat which may affect the use of the littoral zone by fish. Light penetration, water velocity, and salinity are the factors likely controlling the distribution of *E. densa* in the Delta (Hauenstein & Ramirez, 1986; Bini & Thomaz, 2005). In clear water, *E. densa* can grow to depths of 6 m (Anderson & Hoshovsky, 2000). Owing to the trend of decreasing turbidity in Delta waters, it seems likely that *E. densa* will spread into progressively deeper water. The DBW has operated the *Egeria densa* Control Program (EDCP) in the Delta since 2001. During 2001-2005, a total of 2328 acres in 19 locations were treated with herbicides (DBW, 2006).

Relationships between dissolved nutrient availability and the distribution of invasive aquatic plants in the Delta have not been studied. A few macrophytes are indicators of the availability of particular nutrients. *Callitriche stagnalis*, *Ceratophyllum demersum*, *C. submersum*, *Potamogeton polygonifolius*, *P. praelongus*, and *Utricularia* spp. are useful indicators of high nitrogen conditions. *Myriophyllum spicatum* may be more common in eutrophic water bodies (Lacoul & Freedman, 2006, and references therein), and has been shown to have a preference for ammonium over nitrate (Nichols & Keeney, 1976). However, relatively small numbers of aquatic plants are reliable indicators of trophic conditions and of limitation by specific nutrients—most species have a broad tolerance for conditions across nutrient spectra (Lacoul & Freedman, 2006). Artificial eutrophication usually leads to a decline in the abundance of SAV and perennial macroalgae, due to shading by phytoplankton, fouling with epiphytes, and low dissolved oxygen levels near the substrate (Cloern, 2001). In general, high ammonium conditions are not tolerated by submerged macrophytes (Lacoul & Freedman, 2006).

Owing to its use in phytoremediation projects, there are numerous studies in the literature which measured the growth rates of water hyacinth over a range of nutrient concentrations and different N:P ratios (too numerous to review herein). Most of these studies utilized nutrient concentrations in mesocosms that were higher than those expected in natural waters. A common finding in these studies is that growth rates of water hyacinth and tissue N or P concentrations are related to concentrations of N or P in water – a result which is not surprising for a free-floating macrophyte which lacks access to sediment-N or P. For example, one study observed that net productivity of water hyacinth increased with N supply rates between 0.5-50.5 mg-N/L, but not at higher concentrations (Reddy et al., 1989). A related study by the same authors showed that hyacinth biomass increased with increasing P supplies between 0.06-10.06 mg-P/L, but not at higher concentrations (Reddy et al., 1990). In natural waters where N and P concentrations fall within these ranges, it might be reasonable to expect a relationship between nutrient supply and growth rates of water hyacinth. Interestingly, N and P storage and productivity of hyacinth are highest in frequently harvested cultures (Reddy & D'Angelo, 1990), apparently because the ability of water hyacinth to respond to increased water nutrients through absorption and biomass production decline as plants age (Xie et al., 2004) and shoot density increases (Reddy et al., 1989; Wilson et al., 2005). This has implications for unintended consequences of mechanical removal projects for hyacinth in the Delta.

Few studies address nutrient use by *Egeria*. In a continuous flow microcosm experiment, Reddy et al. (1987) demonstrated a preference by *E. densa* for ammonium over nitrate when both ions were in equivalent concentrations (10.5 mg-N/L, to simulate sewage effluent). A study of a third order stream in Argentina showed that biomass of *E. densa* was positively correlated with ammonium in stream water and sediment total nitrogen. Nitrogen content of *Egeria* was positively correlated with ammonium, and negatively correlated with nitrate (Feijoo et al., 1996). Mean ammonia concentrations at the study site were high (0.11 mg-N/L). The P content of plant tissue was highly correlated to water-soluble reactive phosphorus (SRP), but not sediment P. In a microcosm experiment by the same authors, *E. densa* absorbed one order of magnitude more phosphorus (as SRP) from water as from sediment, and absorbed more ammonium-N than nitrate-N from water. The larger uptake of ammonium-N did not result in higher biomass, instead, it resulted in N accumulation in tissue (Feijoo et al., 2002). Because the photosynthetic efficiency of *E. densa* appears positively correlated with the nitrogen content of upper stem tissue (Pennington & Sytsma, 2005), high ammonium/nitrate ratios might increase the growth efficiency of *E. densa*.

4.5.4 Ammonia

Ammonia is a natural compound and is a typical component of municipal wastewater. Ammonia is not among the 126 “priority pollutants” identified by the U.S. EPA, but rather is identified as a “non-priority” pollutant (U.S. EPA, 2006). Ammonia is present in either the un-ionized form (as NH_3) or in the ammonium ion form (as NH_4^+).

Ammonia (NH_3) and the ammonium ion (NH_4^+) always exist in equilibrium as shown below, with the relative concentrations determined by the ambient pH:

$$NH_3 + H^+ \rightarrow NH_4^+$$

The addition of a hydrogen ion (H^+) to ammonia creates ammonium. At a pH of about 9.3, the concentrations of NH_3 and NH_4^+ are roughly equal. The pH of the Sacramento River at Greene’s Landing/Hood is in the range from 6.5 to 8. At these pH conditions, the ammonium concentration predominates and un-ionized ammonia concentrations are quite low.

A time series of the concentration of ammonia in SRWTP effluent for the period June 2004 through July 2008 is shown in **Figure 4-4**.

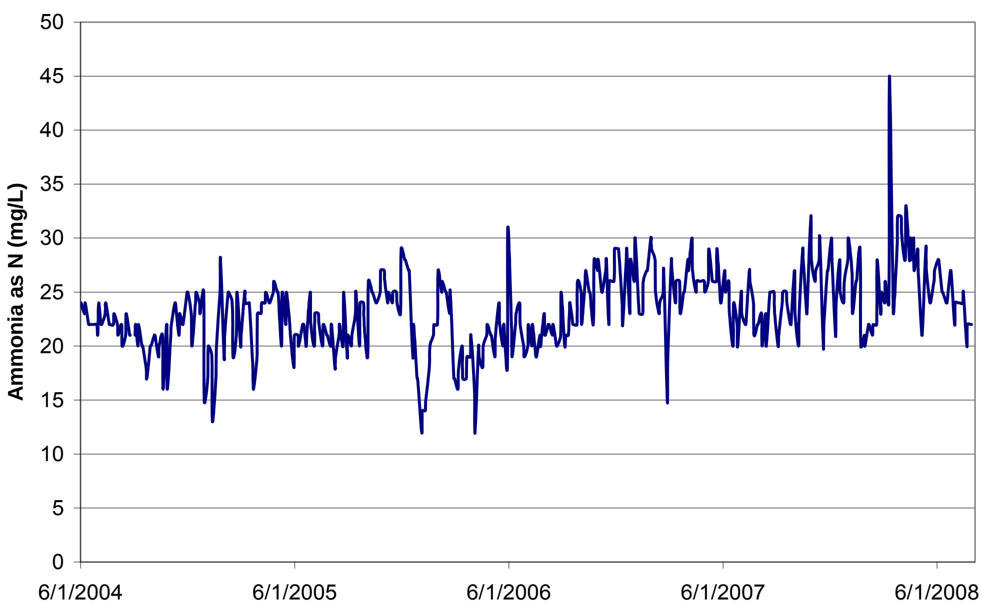

Figure 4-4: Time Series of Ammonia Concentration (mg/L as N) in SRWTP Effluent for the period June 2004 through July 2008.

The ammonia discharged from the SRWTP is partially converted to nitrate as the effluent mixes with receiving waters and moves downstream. The rate of this conversion is temperature dependent and is significantly greater in the warm dry season than in the colder winter months.

Ammonia concentrations in the Sacramento River and Delta waters are of potential concern based on several water quality considerations: (a) potential toxicity to sensitive aquatic life, primarily due to the concentration of the un-ionized form (NH_3); (b) potential impacts on dissolved oxygen levels, due to the consumption of oxygen as ammonia is oxidized in the aquatic environment, first to nitrite (NO_2) and ultimately to nitrate (NO_3); (c) potential impacts to the aquatic food web, where ammonia may inhibit nitrate uptake and cause an associated reduction in phytoplankton growth, and (d) potential impacts to the aquatic ecosystem based on a concern that ammonia may encourage the growth of various nuisance species of algae or aquatic plants.

An ammonia standard is not included in either the California Toxics Rule (CTR) or the National Toxics Rule (NTR); also, the Sacramento-San Joaquin Basin Plan does not contain a numeric ammonia objective. However, U.S. EPA has established ambient freshwater acute and chronic criteria for the protection of freshwater aquatic life (U.S. EPA, 1999). The Central Valley Regional Water Board uses the U.S. EPA recommended ammonia criteria to interpret the narrative toxicity objective that is adopted in the Basin Plan. Because U.S. EPA's recommended criteria for the protection of freshwater aquatic life for acute and chronic toxicity vary based on receiving water pH, temperature, and presence/absence of salmonids and early life stages of fishes, no single ammonia criterion value can be stated. Mathematical modeling performed to assess near field compliance with U.S. EPA criteria accounts for the co-occurring ammonia, pH and temperature conditions. The current SRWTP NPDES permit does not contain an effluent limitation for ammonia, but does contain narrative receiving water limitations requiring that the discharge not cause toxicity in the Sacramento River.

Interactions between ammonium and nitrate uptake appear to influence the timing and magnitude of spring phytoplankton blooms in the northern SFE. Most of the bloom organisms in the northern estuary have been diatoms (Cloern et al., 1983; Kimmerer, 2004; Lehman, 1996), and the percentage that was diatoms increased during blooms in Suisun Bay (Cloern et al., 1983). In the past, most of the blooms in the brackish regions of San Pablo and Suisun bays were of the diatom *Skeletonema costatum* (Cloern, 1979; Cloern & Cheng, 1981), possibly seeded by populations from the coastal ocean (Cloern, 1979). Wilkerson et al. (2006) showed that spring blooms of phytoplankton in Central, San Pablo, and Suisun Bays occurred when at least two conditions were satisfied: (1) vertical salinity stratification improved light conditions, and (2) ambient concentrations of ammonium were below a threshold of about 4 μM. Tracer experiments using water from Central, San Pablo, and Suisun Bays (Dugdale et al., 2007) indicated that above this ammonium threshold, phytoplankton almost exclusively took up ammonium (leaving the nitrate pool little changed), but the ammonium uptake was not accompanied by significant increases in algal biomass. When ammonium levels dropped below this threshold (~4 μM or ~0.056 mg-N/L), chlorophyll increases were observed. However, it was not until ammonium dropped below about 1 μM that rapid nitrate uptake commenced and rapid growth of phytoplankton took place. Owing to these studies, hypothesized suppression of phytoplankton blooms by ambient ammonium levels has been added to the list of factors that may be affecting the base of the pelagic food web in the northern SFE, and is currently being investigated in the freshwater Delta.

Although ammonium concentrations have been increasing in the Sacramento River downstream from the SRWTP, recent chlorophyll-a data suggest that the Sacramento River gains phytoplankton biomass below the SRWTP. **Figure 4-5** shows the seasonal patterns for chlorophyll-a for the most recent decade (1999-2008) in Suisun Bay and selected reaches of the Sacramento River for which long term chlorophyll-a data are available. During the spring bloom period (March-May), mean monthly chlorophyll-a has been higher in all reaches downstream of the SRWTP discharge than in the reach directly above it. These field data are consistent with the results of two preliminary grow-out experiments by A. Parker and R. Dugdale of SFSU in July and November, 2008, using river water from above the SRWTP discharge (Garcia Bend) and below the discharge (River Mile 44 – about 2 miles below the discharge). More chlorophyll-a was produced in these experiments in river water from below the discharge (Foe, 2008). Further testing is scheduled for spring and summer 2009.

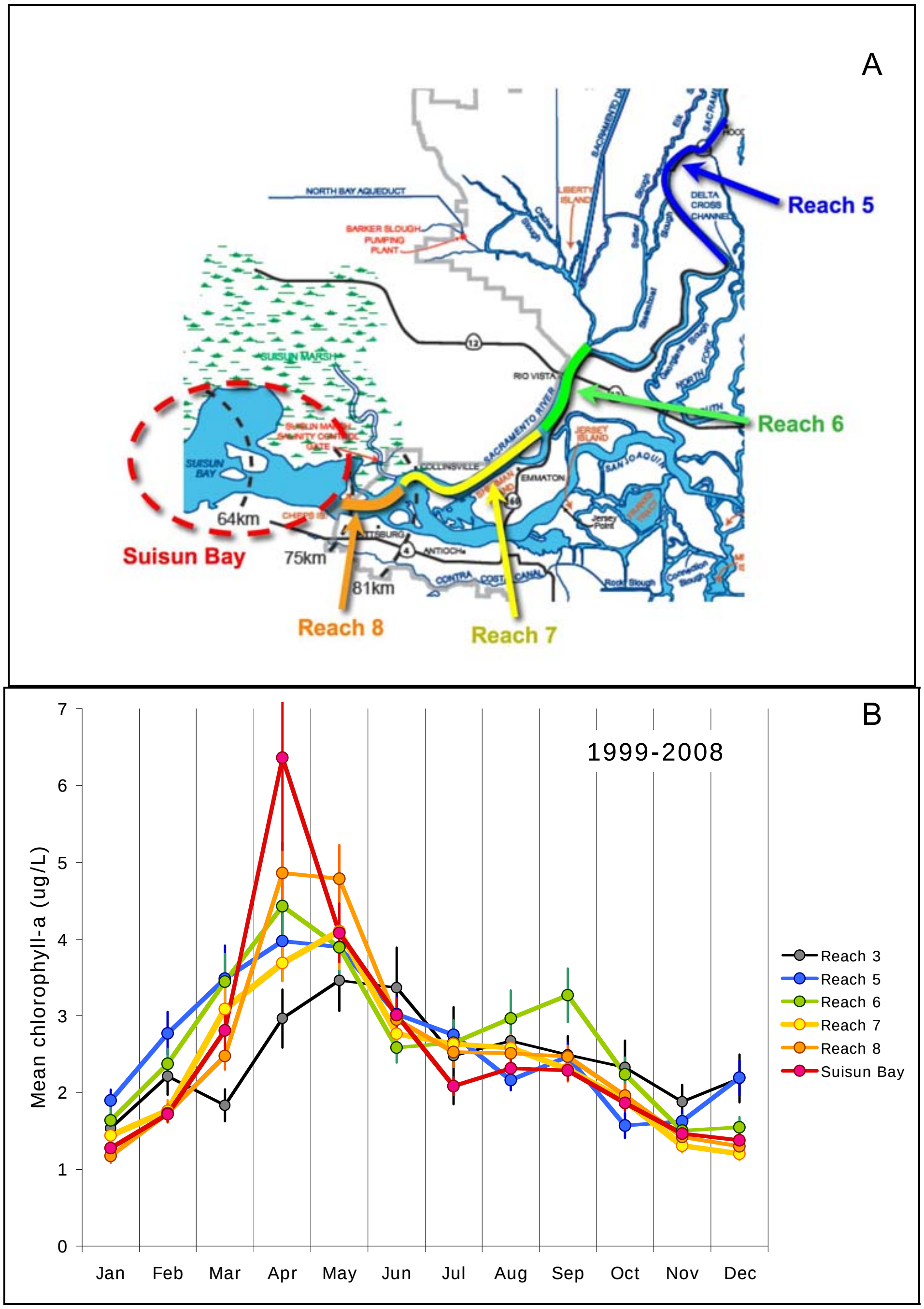

Figure 4-5: (A) Location of reaches to which long-term sampling stations from the IEP, DWR-MWQI, USGS, and USFWS were assigned. Reach 3, not shown, was the Freeport locale above the SRWTP discharge. (B) Mean monthly chlorophyll-a concentrations in surface grab samples for 1999-2008. Error bars are standard errors. Data from multiple agencies were combined for reaches. Data for Reach 3 are for 1999-2003.

Interactions between the uptake and assimilation of ammonium and nitrate by algae are complex, producing a wide range of outcomes that can be demonstrated in growth experiments, including (a) bonafide preference for ammonium (ammonium uptake is faster than nitrate uptake when each is supplied as the sole N source), (b) bonafide preference for nitrate (nitrate uptake is faster than ammonium uptake when each is supplied as the sole N source), (c) ammonium inhibition of nitrate uptake (nitrate uptake is delayed, or slowed, when both compounds are supplied, compared to nitrate uptake when only nitrate is supplied), and (d) nitrate inhibition of ammonium uptake (ammonium uptake is delayed, or slowed, when both compounds are supplied, compared to ammonium uptake when only ammonium is supplied). All of these types of interactions have been documented in the literature – and individual taxa can exhibit different types of N-uptake behavior in different environmental conditions.

Enzymatic disruption of nitrate reductase during ammonium assimilation is one of the proposed mechanisms for true inhibition (Dortch, 1990). In a well-cited review of ammonium and nitrate interactions, Dortch (1990) explains that, strictly speaking, ammonium inhibition can be demonstrated only when specific uptake rates for nitrate (V_{NO3}) are measured in the presence *and* absence of ammonium, which is not feasible in field experiments or when ambient water containing both forms of DIN is used to measure V_{NO3} or V_{NH4} in the laboratory setting. Many reports of ammonium inhibition in the literature result from experiments which are not properly designed to distinguish ammonium *preference* from ammonium *inhibition*. Also, inhibition generally varies inversely with the degree of nitrogen deficiency. In other words, phytoplankton that are not N-limited are less likely to exhibit ammonium inhibition of nitrate uptake. This is potentially an important factor influencing ammonium/nitrate interactions in the Delta, which is not considered a nutrient limited environment.

Although ammonium concentrations of ~1 μM are commonly cited as thresholds for inhibition of nitrate uptake by phytoplankton, little is known about how ammonium/nitrate interactions – and thresholds for interactions - differ among taxonomic classes of phytoplankton. There is a large and sophisticated literature concerning interactions between the uptake and assimilation of nitrate and ammonium by marine and freshwater phytoplankton (Dortch, 1990). The literature (impractical to review herein) indicates that several factors determine which kinds of nitrogen uptake interactions will be observed for a particular phytoplankton taxon under particular environmental or experimental conditions. The nitrogen status of algal cells (are they N-limited or N-sufficient?), the N exposure history – or *preconditioning* – of algal cells (have they been in a high nitrate, high ammonium, or other type of nitrogen environment?), light levels, and water temperature all influence whether ammonium inhibits nitrate uptake at a given place and time in the lab or in nature (Dortch et al., 1991; Lomas & Glibert, 1999). Such factors play a role in N uptake kinetics because they affect the mechanisms of transport of compounds across cell membranes, ratios of nitrogen compounds inside cells, and intra-cellular or extra-cellular supplies of enzymes, such as nitrate reductase, urease, and amino acid oxidase. In addition, there is growing evidence that many species of marine and freshwater phytoplankton are also able to utilize amino acids, amides, urea, humic substances, and other dissolved organic nitrogen (DON) compounds as sources of nitrogen (Bronk et al., 2007). DON uptake has been shown to satisfy up to 80% of the total measured N uptake by coastal phytoplankton assemblages.

The trophic significance of ammonium inhibition in the Delta would depend on at least four factors: (1) the relative importance of ammonium inhibition compared to other factors that influence diatom abundance in the estuary; (2) the importance of diatoms for zooplankton nutrition compared to other taxa; (3) the energetic status of zooplankton; and (4) the relative importance to zooplankton of food sources in the phytoplankton- and bacteria-based food webs. These factors are briefly addressed below.

Factors independent from nutrient supply can affect the relative abundance of diatoms in estuaries . Owing to relatively rapid rates of cell division compared to other taxa, diatoms can have a competitive advantage over other taxa when residence times are low. Consequently, the amount and timing of freshwater flows in the estuary can influence competitive outcomes among diatoms and other phytoplankton taxa. For example, a decline in the last two decades in the relative biomass of diatoms in the Delta and Suisun Bay has been attributed to regional climate shifts, which decreased river flows in the estuary and increased residence times in Delta waterways (Lehman, 1996, 2000a). Variation in freshwater flows may interact with channel morphology to influence diatom abundance in parts of the Delta. Diatoms settle more rapidly than other phytoplankton taxa. The deep, pool-like bathymetry of the Stockton Deepwater Ship Channel is hypothesized by some investigators to function as a trap for diatoms in transport in the San Joaquin River; unless current speeds are high, diatoms cannot remain in suspension for the length of the ship channel (Lehman, 2009). Changes in benthic grazing pressure may have also contributed to changes in the relative abundance of diatoms in the northern SFE. Clam grazing selectively removes larger particles (Werner & Hollibaugh, 1993); clams may consume a larger fraction of diatoms than smaller cells such as flagellates. Kimmerer (2005) used long-term dissolved silica dynamics, corrected for mixing in the LSZ, as an indicator of diatom productivity in the northern SFE. He showed that there was a step decrease in annual silica uptake after 1986, which he attributed to efficient removal of diatoms by *Corbula amurensis* after its introduction in 1986. The extent to which benthic grazing and interannual variation in freshwater flows contribute to shifts in diatom abundance in the SFE is not yet known.

The food web supporting metazoan biomass in the SFE is believed to be largely supported by phytoplankton production (Sobczak et al., 2002, 2005; Mueller-Solger et al., 2002). An observed shift in phytoplankton community composition from dominance by diatoms to increasing dominance by other, mostly smaller, taxa including miscellaneous (green) phytoflagellates (Lehman, 2000b, 2004), and the recent occurrence of blooms of cyanobacteria (*Microcystis aeruginosa*) (Lehman et al., 2005, 2008), underlies a hypothesis that the quality of the phytoplankton assemblage as food for zooplankton - and thus the overall productivity of the pelagic food web - is decreasing in the estuary. Diatoms and cryptophytes are generally considered good food for estuarine and freshwater consumers, while green algae and especially blue-green algae (cyanobacteria) are deemed nutritionally inferior (Brett & Mueller-Navarra, 1997). However, the large diatom *Aulacoseira* (formerly *Melosira*) *granulata*, which is one of the more abundant taxa in blooms in the freshwater Delta, may not be very nutritious for zooplankton (Orsi, 1995).

Currently, there is little published evidence that zooplankton in the Delta are food limited. Probably the best evidence of potential food limitation for a copepod in the SFE is provided by Kimmerer et al. (2005) who measured egg production by *Acartia* on several occasions during 1999-2002, and discovered that egg production during most of the year was below that observed during month-long spring phytoplankton blooms. Kimmer and Orsi (1996) concluded that competition for food with the introduced clam *Corbula amurensis* was a probable mechanism for the steep decline in abundance of a mysid shrimp (*Neomysis mercedis*). Direct mortality of copepod nauplii from entrainment by filtering clams was shown to be a better explanation than food limitation for declines in three species of estuarine copepods after the arrival of *Corbula amurensis* in SFE (Kimmerer et al., 1994). One study commonly cited as evidence of food limitation for zooplankton in the SFE (Mueller-Solger et al., 2002) was a laboratory test of the growth rates of one species, *Daphnia magna*, incubated in water collected from different locations in the estuary and the Delta. However, *Daphnia magna*, and cladocera in general, are not dominant prey of pelagic fishes. Ongoing research is comparing zooplankton production rates in the field in LSZ with rates in food-replete laboratory microcosms; the research should help to elucidate the potential role of food limitation in zooplankton dynamics in the estuary (Kimmerer, 2009).

There is growing evidence that detrital pathways for energy transfer may contribute more to the pelagic foodweb in the Delta than has been acknowledged. For example, several zooplankton species in the SFE can shift between consumption of phytoplankton and consumption of heterotrophic microbes. In feeding experiments using natural plankton assemblages from the SFE, a cladoceran (*Daphnia*), a calanoid copepod *Acartia*, and two cyclopoid copepods (*Oithona davisae* and *Limnoithona tetraspina*), all grazed heterotrophic ciliates at higher rates than diatoms (Gifford et al., 2007). The raptorial-feeding *L. tetraspina*, which has accounted for a large proportion of copepod biomass in the estuary LSZ since its introduction in 1993, was observed to feed on mixotrophic and heterotrophic ciliates, but rarely on diatoms (Bouley & Kimmerer, 2006). Significant grazing on heterotrophic ciliates was also observed for both the filter-feeding calanoid copepods *Pseudodiaptomus forbesi* (a common Delta smelt prey item) and *Eurytemora affinis* (Bouley & Kimmerer, 2006). *E. affinis* and *P. forbesi* were more successfully cultured in the lab when fed the motile cryptophyte alga *Cryptomonas* than when fed the diatom *Skeletonema* or the green alga *Scenedesmus* suggesting these calanoid copepods might prefer motile prey (Hall & Mueller-Solger, 2005). Rollwagen-Bollens and Penry (2003) found that the diet of *Acartia* spp. (an important calanoid copepod genus in the estuary) in San Pablo Bay was dominated by heterotrophic prey (especially protozoa such as ciliates and non-pigmented flagellates). Ongoing research in the LSZ indicates that bacteria and small-sized phytoplankton contribute to a complicated food web with many trophic levels between bacteria and the copepod prey favored by pelagic fish (Kimmerer, 2009). Such studies are significant because they show that non-diatom organisms occupy an important position at the base of the pelagic food web in the SFE. Recent findings such as these led the IEP to make the following acknowledgement in its 2007 Synthesis of Results (Baxter et al., 2008):

> "...it is possible that the hypothesis that the San Francisco Estuary is driven by phytoplankton production rather than through detrital pathways may have been accepted too strictly."

4.6 DELTA WATER SUPPLY CONCERNS

The major direct concern expressed by water supply agencies regarding nutrient loadings and concentrations in the Delta is the impact of these factors on the growth of algae species which produce episodic taste and odor problems. The argument raised by water supply agencies is that nutrient loadings to the Delta must be reduced and nutrient concentrations in ambient Delta waters must be reduced to extremely low levels that would preclude the growth of taste and odor-producing algae species in water supply reservoirs that receive Delta water (e.g. Castaic Reservoir in Southern California) and in water supply aqueducts that transport Delta water to water intake locations (e.g. South Bay Aqueduct). Currently, water supply agencies use copper sulfate treatment and other means to remedy episodic taste and odor episodes. A fundamental question exists whether the decision to utilize an estuarine source such as the Delta as a municipal water supply is the key determinant regarding the need for taste and odor control by water agencies. Efforts to increase nutrient loadings and enhance the productivity of the Delta that are proposed by water agencies under the BDCP speak to the cross purposes of water supply and ecosystem health and raise obvious questions about the ability or wisdom of seeking to effect net decreases in Delta nutrient concentrations.

In addition to nutrients, and among other concerns, water supply agencies also expressed concerns regarding salts, organic carbon, and pathogens. The specific concerns associated with nutrients, salts, organic carbon, and pathogens and their relationship to wastewater discharges are discussed below.

4.6.1 Nutrients and Taste and Odor Problems in Drinking Water Sources

A diverse array of volatile organic compounds (VOC) has been blamed for taste and odor (T&O) problems in drinking water supplies. Chrysophytes (a class of eukaryotic algae) can produce fishy/rancid/‘‘cucumber smelling” polyunsaturated fatty acid (PUFA) derivatives (mainly unsaturated aldehydes). Cyanobacteria are a frequent source of VOCs such as terpenoids, thiols, and pigment derivatives, which differ markedly from the PUFA derivatives in biochemistry, production, and release dynamics. Two earthy/muddy/musty smelling terpenoids, geosmin and 2-methylisoborneol (2-MIB; hereinafter MIB), account for the global majority of drinking water T&O complaints. Geosmin and MIB are produced by cyanobacteria, actinomycete bacteria such as *Streptomyces* and *Nocardia*, especially in relation to bivalve colonies (Zaitlin et al., 2003;Zaitlin & Watson, 2006), myxobacteria (slime molds), fungi (especially in activated filters and distribution pipes), the amoeba *Vanella* (in Lake Mathews, California), and even a liverwort (Juttner & Watson, 2007). Geosmin and MIB are detectable to humans at very low concentrations (<10 ng/L), stable, and resist conventional water treatment. There is a tremendous range in the intrinsic capacity of organisms to produce geosmin and MIB, even among even closely related taxa (Watson, 2003). During growth, most geosmin and MIB produced by cyanobacteria is retained within the cells (tightly bound to thylakoids); release into surrounding waters occurs at senescence, death, or during grazing or treatment (Durrer et al., 1999; Juttner & Watson, 2007). Another class of T&O compounds, isopropylthiols, is excreted during growth by certain strains of *Microcystis aeruginosa*. The musty-tobacco-smelling pigment derivative b-cyclocitral is released by all *Microcystis* spp. upon cell damage or death (Juttner, 1984). However, both isopropylthiols and b-cyclocitral are short-lived in the water and rapidly lost by volatilization and chemical–photooxidative breakdown. As a result, *Microcystis* rarely causes T&O problems in treated drinking water supplies because it does not produce either of the more resilient T&O compounds, geosmin and MIB.

Nutrient control measures have proven to be ineffective as management tools to control T&O events or the distribution and abundance of T&O-causing microbes. Outbreaks of Chrysophytes and their PUFA derivatives show little apparent relationship to nutrients on a broad scale (Watson et al., 1997, 2001a). Erratic rancid- or fishy-smelling blooms can occur in oligotrophic surface waters in response to small or undetectable changes in nutrient levels (<5–10 mg/L), and may develop as deep-layer or under-ice populations (Watson et al., 2001b). Chrysophytes also produce major outbreaks in eutrophic systems, and remedial nutrient reduction may actually increase these episodes (Juttner et al., 1986; Yano et al., 1988; Nicholls, 1995). Where T&O episodes have been linked to pelagic cyanobacteria, the events are not well-explained by the nutrient status or planktonic productivity of the systems. For example, as with other remediated water bodies, the Great Lakes have undergone significant shifts in nutrient and food-web regimes. However, they are now exhibiting erratic T&O outbreaks, despite reduced offshore nutrient levels (Watson et al., 2008). For example, planktonic chlorophyll-a and algal biomass are very low in Lake Ontario and its outflow, the upper St. Lawrence River – low enough for the system to be characterized as oligomesotrophic – but geosmin and MIB-associated T&O events occur along the shoreline of the basin where planktonic algal biomass is low. However, in a shallow embayment of Lake Ontario, Bay of Quinte, which is more nutrient rich (meso-eutrophic), odor impairment is less extensive and has little impact on municipal drinking water supplies (Watson et al., 2007). Despite more than five years of extensive field and laboratory research by the Ontario Water Works Research Consortium to determine the major causes of T&O outbreaks and identify key predictors, managers are still not able to predict the interannual variation in the intensity of the events (Watson et al., 2007). T&O episodes are typically a summertime phenomenon. Although nutrient concentrations are poor predictors for T&O events, regression approaches using a suite of environmental variables have shown air and/or water temperature to be a strong correlate with T&O compound concentrations in at least four reservoirs (Tung et al., 2008; Uwins et al., 2007; Yen et al., 2007).

Strain specificity makes it difficult to determine *a priori* that occurrence of a particular taxon in the plankton (or benthos) of a drinking water source will lead to T&O events. For example, in Castaic Lake, a terminal reservoir of the SWP in southern California, a T&O event in 1993 was blamed on a strain of *Pseudanabaena* in the plankton (Izaguirre & Taylor, 1998). However, *Pseudanabaena* is common in southern California waters, and most strains isolated over a 23-year period have not caused T&O problems. According to Izaguirre and Taylor (1998), because MIB production is a rare phenomenon in this genus, it is difficult to predict T&O events involving the organism, or those involving other taxa such as *Synechococcus* (Izaquirre et al., 1984), *Hyella*, and *Oscillatoria limosa* (Izaguirre & Taylor, 1995). There is a large literature (impractical to review herein) describing efforts to isolate and identify strains of algae, cyanobacteria, and other T&O compound-producing organisms.

Remedial action plans for T&O problems are often unsuccessful because they attempt control of noxious metabolites through a reliance on water treatment and broad-scale nutrient–biomass models. Nutrient control approaches are undermined by several factors, including the facts that (1) different T&O compound-producing taxa show disparate patterns across nutrient and mixing regimes; (2) epibenthic and periphytic microbes are widespread culprits in the production of T&O compounds and growth of attached microbes is more weakly linked to conditions in the water column than phytoplankton; (3) deep-layer cyanobacteria maxima, supplied by internally recycled nutrients in the hypolimnion, can be a source of T&O compounds; (4) nutrient reduction strategies have increased water transparency and littoral production in many systems, improving conditions for attached algae: and (5) other groups of MIB and geosmin-producing organisms are not algae, but actinomycete bacteria, myxobacteria, fungi, and others (Juttner & Watson 2007). In conclusion:

> "There are no robust relationships between total plankton biomass, toxins, and T&O compounds in the Great Lakes and other source waters" (Watson et al., 2008).

Although surface blooms are perceived as primary sources of water odor, twice as many known odor-causing cynanobacterial species are epibenthic, not planktonic (Jutter & Watson, 2007). In addition, two cyanobacteria genera (*Hyella* and *Microcoleus*), which form biofilms on aquatic macrophytes, have been associated with T&O events. Attached cyanobacteria have been implicated as sources of MIB or geosmin in many studies of lakes, reservoirs, or rivers (Burlingame et al., 1986; Sugiura et al., 1998; Watson & Ridal, 2004; Baker et al., 2006). Benthic cyanobacteria are responsible for most of the T&O events reported in the literature in terminal reservoirs receiving water from the SWP. Almost all of the T&O events in Diamond Valley Lake are associated with films of benthic cyanobacteria (*Oscillatoria* or *Phormidium spp*. that grow on sides of the reservoir and on the dam. The benthic colonies in Diamond Lake form on sediments 3-17 m deep (Izaguirre & Taylor, 2007), usually in late summer. This indicates that they are frequently positioned near the thermocline, where they would have greater access to diffusive fluxes of nutrients released at the sediment/water interface during summer stratification. MIB producing strains of *Oscillatoria* that have been isolated from other southern California reservoirs (Lake Mathews, Las Virgenes Reservoir, Lake Bard, Lake Skinner, and Silverwood Lake) are also benthic forms (Izaguirre & Taylor, 2007). The range of depths – and thus total surface area – available to these colonies will vary positively with water clarity. Consequently, decreases phytoplanktonic biomass (such as might be the aim of nutrient reduction strategies) could have the unintended consequence of increasing the available substrate for the main culprits of T&O episodes in these reservoirs. Although periphytic algae associated with aquatic macrophytes or macroalgae (e.g., *Cladophora*) have been blamed for T&O events, at least one study indicates that MIB and geosmin production may be higher in biofilms growing on inert substrates (e.g. rocks) than on macrophytes (Ridal et al., 2007). The importance of epibenthic microbes as T&O producers indicates that reservoir bathymetry and patterns of reservoir drawdown, will be more effective management tools in the control of T&O causing organisms than nutrient control in source waters.

Lee (2008) summarized T&O-related presentations by J. Janik, R. Losee, and P. Hutton (MWD), given at the March 25, 2008, California Water and Environmental Modeling Forum (CWEMF) "Delta Nutrient Water Quality Modeling Workshop". Main points from the talks included the following:

- T&O problems in reservoirs supplied by the SWP are caused primarily by geosmin and MIB released by benthic cyanobacteria.
- At this time there is limited ability to relate nutrient loads or in-channel (aqueduct) concentrations to domestic water supply water quality.

- Efforts to model the relationship between nutrient load to a water body and the development of benthic and attached algae in that water body have not been successful.
- Overall, it is not possible to predict how reducing the nutrient loads to the Delta and from in-Delta sources will impact the location, magnitude, or frequency of taste and odors problems. Because of the characteristics of T&O sources, a potential conclusion is that the control of nutrients should not be based on an attempt to control algae-caused taste and odors.

4.6.2 Nutrients and Harmful Algal Blooms

Although dinoflagellate species are observed in the plankton of San Francisco Bay (SFB), harmful algal blooms (HAB) caused by dinoflagellates (i.e., red tides) are not characteristic of the system. An anomalous dinoflagellate bloom dominated by *Akashiwo sanguinea* occurred in September 8-14, 2004 in South SFB (Cloern et al., 2005). *A. sanguinea* is an allochthonous marine species that occurs only in the seaward regions of SFB. The red tide inside the bay in 2004 was seeded by an offshore population of *A. sanguinea* that developed during a summer with extraordinarily weak upwelling conditions within the California Current System. The bloom inside SFB occurred during an anomalous period of thermal stratification in the SFB, coinciding with 4 consecutive days of record high air temperature and weak winds coupled with a low-energy neap tide. The rare red tide was thus triggered by physical forces during the temporal coincidence of local and large-scale climatic anomalies.

The single-celled form of *Microcystis aeruginosa* has been a common cyanobacterium in the northern SFE over the last few decades, but not bloom forming. Toxic blooms of the colonial form of *M. aeruginosa* have occurred in the northern SFE during summer months (June-November) since 1999 and are the first recorded toxic phytoplankton blooms in this part of the estuary (Lehman et al., 2005). There is evidence from one study that *M. aeruginosa* may produce more biomass per unit N-uptake than the diatom *Aulacosiera distans* (Marinho et al., 2007), but stratification and low turbulence (Huisman et al., 2004), high temperature (above 20°C (Jacoby et al., 2000)), and long residence times (Reynolds, 1997) appear to be as important for bloom formation by this slow growing species as nutrient-related factors. Because *Microcystis* is not a heterocystic cyanobacterium (i.e., does not fix atmospheric nitrogen), both N and P are required for bloom formation. Lehman et al. (2008) performed canonical analysis on data from a Delta-wide sampling program for 17 environmental factors, *Microcystis aeruginosa* cell abundance, and microcystin cell content. East side stream-flow, Contra Costa Canal pumping, and water temperature were the primary factors explaining the abundance and microcystin content of *Microcystis* in the brackish and freshwater reaches of the Delta. Total dissolved solids and nutrient concentrations were of secondary importance. Ammonia and nitrate concentrations were weakly negatively correlated with *Microcystis* abundance, meaning that higher ammonia and nitrate concentrations were associated with fewer *Microcystis*. Sacramento and San Joaquin River flows were strongly negatively correlated to *Microcystis* abundance, while East Side stream flow was strongly positively correlated with *Microcystis* abundance.

4.6.3 Delta Salts

The Central Valley Regional Water Board is in the early stages of developing an overarching management program for salt in the Central Valley. The program (Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS)) is a collaborative basin planning effort aimed at developing and implementing a comprehensive salinity and nitrate management plan. The program was initiated in 2006 and is being performed in coordination with the State Water Board. A May 2006 report titled "Salinity in the Central Valley – An Overview" outlines the concerns that exist regarding increases in concentrations of salt in surface and ground waters, sources of salt and previous and ongoing efforts to manage ambient salt levels in the Central Valley. Efforts are under way to move the CV-SALTS program forward. After completion of the requisite planning, modeling and policy development work, implementation measures and regulatory requirements developed as a result of the CV-SALTS program will be incorporated into NPDES permits and other regulatory vehicles in the Central Valley.

Salt concentrations in the Delta are a water supply concern for several reasons. For water supply agencies in Southern California, which use Delta supplies to reduce salt concentrations in their alternative supply sources (Colorado River and local groundwater basins), their interest is best served if salt levels in the water that is exported to them from the Delta is maintained or decreased. It is argued that reduced salt concentrations in the Delta improves the ability to recycle water in Southern California and facilitates management of salt in Southern California groundwater basins. For Bay area and other users of Delta supplies, the desire to maintain or decrease salt levels is based on a desire to maintain or improve the quality of waters obtained for their customers. Reductions in salt levels in water supplies also have incremental long term benefits associated with reduced scale and corrosion in plumbing systems which may, or may not, measurably affect the useful life of these systems.

Salt levels in the Sacramento River and most areas of the Delta are typically less than the secondary MCL concentration of 500 mg/l which has been established by U.S. EPA and the California Department of Public Health. This salt level has been established to protect the aesthetics of water supplies and is not required to protect human health.

4.6.3.1 Carriage Water and Water Project Operations

Carriage water is defined as the additional water that needs to be released from upstream reservoirs in order to maintain salinity while exporting water through the State and federal water projects. This section will discuss the potential impacts of SRWTP discharges on the need for changes in carriage water releases to support operations of the State and federal water projects. Among the several sources of water commingled in the Delta, the Sacramento River is the major source of freshwater inflow. Freshwater inflow to the Delta is the primary means of managing salinity intrusion from San Francisco Bay, through Suisun Marsh and, therefore, the volume and quality of inflow affects water quality in the Delta.

The Central Valley Project (CVP) and State Water Project (SWP) have primary responsibility for maintaining water quality in the Sacramento-San Joaquin Delta (Delta) in compliance with the water quality objectives for beneficial uses contained in SWRCB Water Right Decision 1641 (D-1641). These two projects are able to influence the volume of Sacramento River inflow to the Delta through releases from upstream CVP and SWP reservoirs on, or tributary to, the Sacramento River.

The water quality of Sacramento River water is much better than that of the saline bay water; however, quantity rather than quality of the freshwater inflow is paramount to meeting the Delta water quality objectives. In fact, real-time CVP/SWP water quality operations in the Delta do not consider the quality of freshwater inflow, only quantity of inflow (Sandberg, 2009). Water quality objectives in the Delta are achieved by balancing the saline water intrusion from the bay with freshwater flows into and out of the Delta. One objective is the Net Delta Outflow Index (NDOI, see Appendix B), a water operations procedure used to calculate the resultant freshwater inflow “pushing” out against the saline bay water. The NDOI calculates the difference between Delta inflow (i.e., from upstream river flows) and both within Delta consumptive water use and exports from the Delta into the CVP/SWP projects, the Contra Costa Canal, and the North Bay Aqueduct. Managing the NDOI is accomplished by either increasing/decreasing: 1) Sacramento River freshwater inflow, 2) export pumping at H.O. Banks and Jones pumping plants, or 3) a combination of 1 and 2.

The SRWTP discharges treated effluent to the Sacramento River below Freeport Bridge. This contributes to the volume of water available for managing salinity intrusion by increasing the inflow in the NDOI equation. Note that water quality is not a variable in the calculation of NDOI. Several Delta water quality objectives for fish and wildlife are directly tied to either inflow or NDOI, including minimum Monthly Delta Outflow, minimum Sacramento River Flow at Rio Vista, and maximum E/I Ratio (Export to Inflow Ratio)[5]. Complying with these objectives is made easier by increasing freshwater inflow. Therefore, the SRWTP effluent discharge enhances the ability of the CVP and SWP to meet these flow-related objectives.

Some Delta water quality objectives are expressed as chloride or EC concentrations, and the quality of SRWTP effluent for some constituents is lower than Sacramento River water quality measured just upstream of the SRWTP discharge. However, while the SRWTP effluent is of lower quality for some constituents as compared to the upstream receiving water, the treated effluent is still of much better quality than the saline bay water. In fact, the average chloride concentration (91 mg/L) of the SRWTP effluent discharged to the Sacramento River is less than the Title 22 Secondary MCL for chloride (250 mg/L) applied to Delta waters. Similarly, average EC (764 µmhos/cm) of SRWTP effluent discharged to the river is lower than the Title 22 Secondary MCL (900 µmhos/cm) applied to downstream receiving waters. Historical average monthly flows (water years 1949-2007) in the Sacramento River exceeded 12,000 cfs, while the minimum monthly average flow was 4,494 cfs in 1977. Assuming a SRWTP effluent discharge rate of 218 mgd (ADWF) (338 cfs), a worst-case ratio of effluent to Sacramento River water would be 1:13.30, thus the resultant Sacramento River chloride and EC concentrations flowing into the Delta would be far better than the Delta water quality objectives require.

When considered in the context of highly variable and uncontrolled, and in some instances unmeasured, parameters such as Delta consumptive use, Sacramento River accretions/depletions, river flow and reservoir release measurement inaccuracies, tidal influence, and meteorological conditions (e.g., wind and barometric pressure) that can impact Delta flows by hundreds of cfs, the influence of SRWTP effluent quality on the ability to meet Delta salinity standards is nominal at best. Yet, the fact that the quantity of SRWTP effluent discharged to the Sacramento River always increases NDOI is a benefit to achieving flow-related and salinity water quality

[5] D-1641 Water Quality Objectives.

objectives in the Delta. Therefore, rather than increasing carriage water releases as a result of SRWTP discharges, the CVP/SWP projects account for and correspondingly reduce carriage water releases due to SRWTP dischargers.

4.6.4 Organic Carbon

Total organic carbon (TOC) levels have been of historic concern to drinking water agencies which rely on the Delta as a source of water supply. The concern stems from the fact that, for some water treatment systems, increased levels of TOC in source waters may lead to increased capital or operating expenses to achieve compliance with SDWA requirements.

There are many sources of organic matter in the Delta, including organic soils and sediments, algal growth, agricultural activities, animal waste, organic material transported by storm water runoff from both urban and natural sources, riparian growth along channels, wetlands, and wastewater treatment plants (Brown and Caldwell and others, 1995, as cited by DWR, 2001). Drainage discharges from Delta peat soil islands are sources of dissolved organic carbon (DOC) in the Delta. When vegetation decays, large humic and fulvic acid molecules are produced that subsequently enter watercourses. Organic carbon is vital to the health of the Delta ecosystem. Habitat restoration projects sponsored by water agencies to offset the impacts of water project operations on endangered fish species are intended to improve ecosystem quality by increasing levels of organic carbon and nutrients in the system.

Monitoring and control of TOC at some water treatment plants is currently required under the SDWA. The Stage 1 Disinfectants and Disinfection Byproduct Rule adopted in 1998 requires drinking water utilities using conventional treatment to reduce TOC concentrations by specified percentages using enhanced coagulation and enhanced softening prior to adding disinfectants, when the running annual average concentration of TOC in the source water is greater than 2 mg/L (see **Table 4-1**). These requirements were adopted because organic carbon in waters serving municipal uses can react with disinfectants during the water treatment process to form trihalomethanes (THMs) and other halogenated compounds, which pose potential carcinogenic risks to humans above certain levels.

Table 4-1: Required Total Organic Carbon Removal by Enhanced Coagulation and Enhanced Softening(1).

Source Water TOC (mg/L) (running avg. annual values)	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0 – 60	> 60 – 120	> 120(2)
> 2.0 – 4.0	35.0%	25.0%	15.0%
> 4.0 – 8.0	45.0%	35.0%	25.0%
> 8.0	50.0%	40.0%	30.0%

(1) Systems meeting at least 1 of the alternative compliance criteria in the rule are not required to meet removals in this table.
(2) Systems practicing softening must meet the TOC removal requirement in the last column to the right.

Water treatment plants that utilize Delta water are currently designed and operated to meet the 1998 requirements based on the ambient concentrations and seasonal variability that currently exists in the Delta. Significant changes in ambient TOC concentrations would need to occur for significant changes in plant design or operations to be triggered. Increased ambient TOC concentrations due to an increase in SRWTP discharge from 181 mgd to 218 mgd are projected to be small enough in magnitude that they will not require drinking water treatment plants to increase their levels of treatment for TOC above those currently employed.

4.6.5 Pathogens

4.6.5.1 Cryptosporidium and Giardia

Protozoan pathogens, *Cryptosporidium* and *Giardia* can be present in wastewater influent depending on their presence in the contributing community. Protozoa, which are resistant to conventional wastewater treatment processes, and infectious at low doses, are of particular concern where dilution and decay processes in discharge receiving waters are limited.

Cryptosporidium oocysts are particularly resistant to disinfection by chlorination – therefore wastewater treatment and drinking water facilities are concerned with their presence. The EPA estimated in the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR, or LT2) that mean probability of infection from ingesting a single infectious oocyst ranges from 7 to 10 percent (U.S. EPA, 2006). However, the EPA recognized in the LT2ESWR that numerous factors affect the infectivity of *Cryptosporidium,* such as variability in host susceptibility, response at very low oocyst doses typical of drinking water ingestion, and the relative infectivity and occurrence of different *Cryptosporidium* isolates in the environment (U.S. EPA, 2006).

4.6.5.1.1 Regulatory Background

Regulations have been established for levels of *Cryptosporidium* and *Giardia* in drinking water, but not for ambient levels in surface waters. The maximum contaminant level goal (MCLG) is zero for *Cryptosporidium* and *Giardia lamblia* in public drinking water supplies. Goals have not been set for ambient surface waters and pathogenic microorganisms are not generally monitored in surface waters.

The LT2ESWTR requires source water monitoring to determine the requisite degree of treatment for public water systems that use surface or groundwater under direct influence of surface water. Drinking water systems are classified into a "bin" based on the results of the source water monitoring, and the bin levels determine whether further treatment of *Cryptosporidium* is required (see **Table 4-2**).

Table 4-2: LT2ESWTR Bin Classification

Bin	*Cryptosporidium* Annual Average Concentration (oocysts/L)	Treatment Requirements
1	oocysts < 0.075	No additional treatment
2	0.075 ≤ oocysts < 1.0	Additional treatment required such that the total *Cryptosporidium* removal and inactivation is at least 4-log
3	1.0 ≤ oocysts < 3.0	Additional treatment required such that the total *Cryptosporidium* removal and inactivation is at least 5-log
4	oocysts ≥ 3.0	Additional treatment required such that the total *Cryptosporidium* removal and inactivation is at least 5.5-log

Under the LT2ESWTR, public water systems are classified in treatment bins according to the annual average of the total number of oocysts counted, without further adjustment for recovery or fraction of infectious oocysts. It is indicated in the LT2ESWTR that about 35-40% of the *Cryptosporidium* oocysts detected by U.S. EPA analytical methods 1622 or 1623 are capable of causing infection. However, it is not possible to establish a generally applicable value for method recovery or the fraction of oocysts that are infectious.

4.6.5.1.2 Levels of Oocysts Upstream and Downstream of SRWTP Discharge

The Coordinated Monitoring Program (CMP), a joint ambient monitoring program between the District and the Sacramento Stormwater Quality Improvement Partnership, collected data on *Cryptosporidium* and *Giardia* in the Sacramento River between 2001 and 2004. The CMP analyzed samples from three locations along the Sacramento River, at Veterans Bridge, Freeport, and River Mile 44 The occurrences of protozoa in the Sacramento River are shown in **Table 4-3** as percentages of samples in which protozoa were detected. Overall, *Giardia* was detected more frequently than *Cryptosporidium,* and both were detected typically in 10-66% of samples. In 2004, the District removed protozoan pathogens from its list of monitored constituents because earlier monitoring results were difficult to interpret due to deficiencies in the analytical test procedure (SRCSD, 2005b).

Table 4-3: Occurrences of *Cryptosporidium* and *Giardia* in the Sacramento River

Pathogen	Monitoring Time Period	Sacramento River at Veterans Bridge		Sacramento River at Freeport		Sacramento River at River Mile 44	
		N(1)	% det(2)	N	% det	N	% det
Cryptosporidium(3)	1992-2003	47	4%	---	---	25	16%
	2002-2003	12	0%	11	0%	11	9%
	2003-2004	41	10%	51	4%	29	31%
Giardia(3)	1992-2003	47	17%	---	---	23	40%
	2002-2003	12	17%	11	18%	11	36%
	2003-2004	40	45%	52	58%	29	66%

(1) Number of samples analyzed.
(2) Percent of samples in which analyte was detected.
(3)Pathogen data presented in this table collected by the Sacramento Coordinated Monitoring Program as reported in the CMP's 2002-2003 Annual Report (SRCSD, 2003) and 2003-2004 Annual Report (SRCSD 2004b).

SRCSD conducted monitoring of the SRWTP effluent for *Giardia* and *Cryptosporidium* from January 1997 to August 2002, and the data were summarized in the 2020 Master Plan EIR (SCDERA, 2004). The results indicated that protozoa were present in most samples, and were occasionally present at high concentrations (see **Table 4-4**). The recovery rates of *Giardia* and *Cryptosporidium* were not reported for the treated wastewater. Additionally, neither the viability nor infectivity of cysts or oocysts was determined in the testing performed.

Table 4-4: Concentrations of Protozoa Detected in SRWTP Effluent from January 1997- August 2002 (SCDERA, 2004)

Pathogen	No. of samples	Percent detected	Mean (cysts or oocysts/L)	Median (cysts or oocysts/L)	Range (cysts or oocysts/L)
Giardia	61	100%	44.7	39	2-192
Cryptosporidium	61	80%	7.3	1.9	0.08-84

The California SWP Sanitary Survey reported protozoan pathogens measured in source waters by a combination of different monitoring programs, including SWP Contractors and the Department of Water Resources (SWP, 2006). The Survey reported protozoan pathogens detected statewide at locations in the South Bay Aqueduct, North Bay Aqueduct, San Luis Reservoir, and East, West and San Joaquin divisions of the California Aqueduct. The Sanitary Survey reported that *Giardia* and *Cryptosporidium* are not detected frequently in SWP waters, despite being detected in treated wastewater. As shown in **Table 4-5**, the source waters for all of the drinking water treatment plants analyzed were classified as Bin 1 (no additional treatment required under LT2ESWTR, see **Table 4-2**), with the annual average *Cryptosporidium* level less than detection at all locations except the North Bay Aqueduct, which is uniquely impacted by local nonpoint source contributions.

Table 4-5: Numbers of Samples with Detected Protozoa, Reported in the SWP Sanitary Survey

Location		Monitoring Period	n	*Giardia* Detects n	*Giardia* Detects Level Detected (cysts/L)	*Crypto.* Detects n	*Crypto.* Detects Level Detected (oocysts/L)	Bin Level[a]
South Bay Aqueduct	Patterson Pass WTP	6/01 – 11/05	32	0	---	0	---	
	Del Valle WTP	6/01 – 9/03	8	0	---	0	---	1
	Penitencia WTP	1/00 – 12/05	54	1	0.1	0	---	
North Bay Aqueduct	Barker Slough Pumping Plant	1/00 – 12/05	(b)	6	0.1-1.4	5	0.1-0.8	1
San Luis Reservoir	Santa Clara Valley Water District	1/00 – 12/05	98	1	0.1	0	---	1
Coastal Branch of the CA Aqueduct	Central Coast Water Authority	2/03 – 6/07	~16	1	0.6	0	---	1
San Joaquin Field Division of the CA Aqueduct	Kern County Water Agency	9/01– 3/04	6	0	---	0	---	1
West Branch of the California Aqueduct	Metropolitan Water District of Southern California (MWDSC) and Castaic Lake Water Agency	1/00 –12/05	~72	0	---	1	0.1	1
East Branch of the California Aqueduct	Antelope Valley-East Kern Water Agency	2/04 – 2/06	~48	0	---	0	---	1
	MWDSC and Crestline Lake Arrowhead Water Agency	1/00 – 12/05	~ 2	0	---	2	0.1	

(a) Indicated in the Sanitary Survey as likely bin classification under the LT2ESWTR
(b) Sample size not indicated

4.6.5.2 Environmental Fate of Protozoa

Cryptosporidium oocysts and *Giardia* cysts are fairly robust, capable of surviving in the environment under unfavorable conditions for long time periods (Carey et al., 2004); however, they are subject to removal in the environment. Their persistence in surface waters is influenced by temperature, UV exposure, and removal from the water column by sedimentation processes. Protozoan pathogens have been found to be more resistant to UV than bacteria or viruses, but are still significantly impacted by exposure to sunlight (Ferguson et al., 2003). Sedimentation is an important removal mechanism in low-flowing aquatic environments (Dai & Boll, 2006), and may be a significant removal process in the Sacramento River due to its turbidity and velocity. *Cryptosporidium* oocysts and *Giardia* cysts are also subject to natural die-off as a result of combinations of abiotic and biotic stresses. Pathogens present in SRWTP effluent are expected to decrease with distance downstream from the point of discharge due to these environmental removal processes and natural die-off.

4.6.6 EBMUD Freeport Regional Water Project Sacramento River Intake

The Freeport Regional Water Authority (FRWA) is in the process of constructing a 185-mgd-capacity drinking water intake and pumping plant approximately 1.3 miles upstream of the SRCSD diffuser (see **Figure 4-6**). The FRWA is a joint powers authority whose members are the Sacramento County Water Agency (SCWA) and the East Bay Municipal Utility District (EBMUD). The FRWA facility will provide surface water from the Sacramento River to customers in Sacramento County and the East Bay for municipal use. Operation is projected to begin in December 2009 (www.freeportproject.org/nodes/project/timeline.php).

Occasionally, during low-flow periods in the Sacramento River, flow in the River may stop and reverse due to tidal influence from the San Francisco Bay. The SRWTP NPDES permit specifies that discharge to the river must cease when the river flow rate falls below 1,300 cfs or when a ratio of river flow to effluent flow is less than 14. During these time periods, treated effluent is stored in "emergency storage basins" (ESBs) at the SRWTP. Discharge to the river resumes when the tidal condition changes and the river resumes a downstream flow pattern. During reverse flow events, diluted effluent in the discharge plume is carried upstream of the diffuser, and then passes back over the diffuser when the river flow resumes in the downstream direction.

During the design of the FRWA project, it was recognized that the SRWTP discharge and the FRWA diversion have the potential to influence each other in several ways. First, the SRWTP effluent discharge has the potential to produce minor changes in water quality at the proposed FRWA diversion location since, as noted, previously discharged and diluted effluent may travel upstream of the SRWTP diffuser during reverse flow events. Second, the FRWA diversion has the potential to influence the quantity of Sacramento River water available for dilution at the SRWTP diffuser, since the FRWA diversion can remove up to 286 cfs from the river upstream of the discharge.

The potential for one project to influence the other was assessed through the following tasks: (1) an evaluation of the concentrations of treated effluent in the river during and following a reverse flow event; (2) an evaluation of the influence of FRWA diversions on flow rates in the Sacramento River (and subsequent impacts on the duration of SRWTP effluent diversions to ESBs); and (3) a development of an operations rule for use by the FRWA to avoid diversion of diluted SRWTP effluent. Concentrations of SRWTP effluent within the river are a function of two primary processes – advection and dispersion. Advection, the dominant process, is the transport of a solute with the mass of water containing it, and is a function of river velocity. Dispersion provides additional transport and mixing induced by the combined effects of a non-uniform velocity distribution (shear) and vertical and horizontal turbulent mixing (transverse diffusion). Evaluation of the effluent concentration in the river and development of the proposed operating rule considered both of these processes. The modeling effort associated with this evaluation is described in Appendix C.

Figure 4-6: SRWTP Discharge Local Area Map

Based on the results of this evaluation, SRCSD and FRWA voluntarily worked together to develop a plan of operations that would stop pumping at the FRWA intake when diluted effluent is present at the FRWA intake. This plan is intended to eliminate diversion of diluted SRWTP effluent into the FRWA intake during reverse flow events and to thereby avoid risk-related questions regarding the impact of SRWTP operations on the FRWA intake. In 2006, a Coordinated Operations Agreement between the SRCSD and FRWA was adopted describing the communications and operations of the facilities by the two agencies. According to the agreement, FRWA will cease diverting at the FRWA intake when the advective upstream distance traveled by the river reaches 0.9 miles upstream of the SRWTP diffuser. When the river begins flowing in the downstream direction again and the calculated advective distance is 0.7 miles or less upstream of SRWTP discharge, FRWA may resume diverting at the FRWA intake.

Since the characteristics of reverse flow events cannot be predicted accurately in advance and the proposed approach is reasonably achievable, the operations plan represents the best practical approach to FRWA pump operations. This plan is simple to implement, uses real-time data, and is intentionally conservative, thereby providing an operational safety factor for both the SRWTP discharge and the FRWA diversion.

4.6.7 Regional Water Quality Impacts Assessment

Results presented in this report deal with the specific incremental impacts associated with the proposed increase in permitted SRWTP's discharge from 181 to 218 mgd. Additional analysis exists for several of the constituents of concern addressed in Section 5 to provide perspective on the impact of the proposed discharge in comparison to other changes in water quality that may occur in the Sacramento River and Delta over the next 20 years. Those constituents include total organic carbon, total phosphorus, total nitrogen, and total dissolved solids.

The source document for this analysis is a memorandum prepared for SRCSD by Larry Walker Associates (LWA) dated November 20, 2008 that is included as Appendix D. This memorandum summarizes a spreadsheet modeling effort that was performed to support the activities of the Central Valley Drinking Water Policy Work Group. That work group is a stakeholder group formed to assist the Central Valley Regional Water Board with the development of technical information to support development of a Drinking water Policy in the Central Valley. The purpose of the memorandum was to project water quality changes at several key Delta locations in the year 2030 under "degraded" conditions (i.e. no additional regulatory requirements imposed beyond those in existence today) and "improved" conditions (i.e. where a suite of assumed new regulatory requirements would be implemented). In this section, only the "degraded" condition is described, consistent with the proposed secondary treatment expansion of the SRWTP.

Using a spreadsheet model, and based on assumptions regarding population growth and changes in the pollutant loadings from three major sources (wastewater effluent, urban storm water runoff, and agricultural runoff), projections of future changes in concentrations of several water quality parameters of interest at Hood have been developed. The assumptions used in the development of the future water quality projections are listed below.

4.6.7.1 Treated Wastewater Discharges

Projected 2030 load calculations from treated wastewater were based on assumed per capita daily wastewater flow rates and population growth rates to estimate the 2030 effluent flow rate. This flow rate was applied to primarily literature-based constituent concentrations based on treatment technology to estimate an effluent load for each wastewater treatment facility. A summary of the load calculations for each wastewater treatment facility is provided in Appendix D. The key assumptions to the calculation methodology are discussed below.

- 2004 and 2024 populations for each wastewater treatment facility are provided in the 2004 U.S. EPA Needs Survey[6]. An annual population growth rate was calculated for each wastewater treatment facility based on these end point population estimates. Using the calculated population growth rate, 2008 and 2030 population estimates were calculated for each treatment plant.
- 2004 total effluent flow data are also provided in the 2004 U.S. EPA Needs Survey. A 2004 total daily per capita wastewater flow (e.g., including industrial flow) was calculated using the 2004 population and flow data. The 2004 total wastewater flow per

[6] http://www.epa.gov/OW-OWM.html/mtb/cwns/2004rtc/toc.htm

capita was used to estimate total daily flow volume for 2008 (current) and 2030 “degraded” condition.

- Effluent water quality data primarily came from three sources: NPDES permits, LWA-compiled data sets (e.g., data sets from submitted reports such as Reports of Waste Discharge), or literature values based on treatment technology (Metcalf and Eddy, 2003). It should be noted that NPDES permits sometimes only contained maximum effluent concentrations for the constituents of interest. In cases where maximum values were used, the result is an overestimation of effluent constituent loadings.
- Constituent loads were calculated for the current 2008 condition and projected 2030 “degraded” condition using the current total daily wastewater flow per capita values for each wastewater treatment facility. For the projected 2030 “degraded” condition, it was assumed that only wastewater treatment plant upgrades currently planned will be implemented.
- The wastewater effluent loading analysis does not completely account for all current or future recycled water efforts. As such, surface water discharge constituent loadings are overestimated by the amount of future recycling that actually happens.

4.6.7.2 Urban Runoff

Projected 2030 urban runoff load calculations were based on hydrologic modeling performed as part of the Sacramento Stormwater Quality Partnership Discharge Characterization Program (DCP) continuous simulation model on a daily time step based on observed rainfall for a critical dry year (1992) and a wet year (1998). Daily dry weather flows were assumed constant with unique values for the wet and dry season. Daily urban area runoff volumes were scaled to match the projected 2030 urban area. The projected daily flows were multiplied by the median observed concentration to calculate a daily load. Load reduction factors were applied to the existing development area to account for improved management and system retrofit, and to the projected new development to account for development standards that remove volume and load from the discharge. The Sacramento results were then scaled to the in-Delta and San Joaquin urban areas with adjustments to account for lower annual precipitation and system “losses” through infiltration. A sample calculation is provided in Appendix D. The key assumptions to the calculation methodology are listed below.

- The Department of Conservation Farmland Mapping Program[7] maps urban area by county every two years. Based on historic urban area size data, an annual urban area growth rate was estimated. Using this calculated annual growth rate, 2008 and 2030 urban area sizes were estimated for each subarea using a detailed 2002 land use map developed by the California Department of Forestry and Fire Protection Fire and Resource Assessment Program. This base layer map was also used in the conceptual modeling effort.
- The DCP model was used in the preparation of the Antidegradation Analysis for the Sacramento Stormwater Program in 2007. The model of observed loads was adapted to

[7] http://www.conservation.ca.gov/dlrp/fmmp/Pages/Index.aspx

project urban runoff volume based on precipitation and hydrologic data from water years 1992 and 1998 that were "scaled" to the projected 2030 urban area. For the San Joaquin and in-Delta subareas, factors of 0.7 and 0.9, respectively, were used to adjust urban runoff volume to account for variation in precipitation totals as compared to precipitation in the Sacramento River watershed.

- For the San Joaquin and in-Delta subareas, a second factor of 0.7 was used to adjust urban runoff volume to account for non-surface water discharges (i.e., detention basins, rock wells, irrigation channels) that are more prevalent in those areas than the Sacramento urban area.
- From the DCP model, dry weather (wet season) and dry weather (dry season) urban runoff volumes were estimated to be 25,400 and 21,400 $ft^3/mi^2/day$, respectively based on observed data before 1996.
- Urban runoff water quality median concentration data from the Sacramento Stormwater Quality Partnership were used.
- Load reduction factors were applied separately to existing and projected new development through 2030 to account for anticipated reductions in flow and load through management programs, system retrofit, and new development standards. Flow reductions through low impact development (LID) standards are expected in this project horizon. These assumptions are intended to include the range of possible values. The assumed 2030 load reduction factors are presented in **Table 4-6**.

Table 4-6: Assumed 2030 Load Reduction Factors.

	Projected Worst-Case Condition	
Constituent	**Existing Developed Area**	**New Development Area**
Total Organic Carbon	0%	10%
Total Phosphorus	0%	10%
Total Nitrogen	0%	10%
Total Dissolved Solids	0%	0%

4.6.7.3 Agricultural Runoff

Projected 2030 agricultural runoff load calculations were based on agricultural area estimates developed by the Department of Conservation Farmland Mapping Program and constituent export rates developed in the conceptual models. For the in-Delta subarea, agricultural runoff flow rates estimated by DWR's Delta Island Consumptive Use (DICU) model and multiplied by median observed concentration to calculate a daily load. Load reduction factors were applied to existing areas to account for improved management and system retrofit. A sample calculation is provided in Appendix D. The key assumptions to the calculation methodology are discussed in the section below.

- The Department of Conservation Farmland Mapping Program estimates agricultural area by county every two years. Based on historic agricultural area size data, an annual reduction rate was estimated. Using this calculated annual reduction rate, 2008 and 2030 agricultural area sizes were estimated for each subarea using a detailed 2002 land use map developed by the California Department of Forestry and Fire Protection Fire and Resource Assessment Program. This base layer map was also used in the conceptual modeling effort.

- Agricultural source quality data from Colusa Basin Drain (Drinking Water Quality Policy Database) were used to estimate agricultural loads contributing to the Sacramento River.
- For the projected 2030 "degraded" condition, it was assumed that agricultural loads would not change with the exception of the reduction in agricultural land area converted to urban uses.

4.6.7.4 Results of Analysis

A spreadsheet model was used to develop water quality projections at several locations in the Delta. Water quality projections for the Sacramento River at Hood in 2030 are summarized in **Table 4-7**. These projections are based on projected worst-case estimates of future population growth and land use changes.

It should be noted that the projected SRWTP discharge in 2030 (188 mgd), which is included in the estimates shown in **Table 4-7**, is based on the population growth assumptions used in the spreadsheet model. This discharge magnitude is less than the proposed 218 mgd discharge evaluated in Section 5.

Examination of the information in **Table 4-7** indicates that the cumulative impacts projected to occur in 2030 in the Sacramento River at Hood for TOC, total N, total P and TDS are of similar magnitude to the impacts associated with the proposed 218 mgd discharge by SRWTP. This finding shows that the incremental changes for the proposed discharge are not anticipated to cause significant changes in existing ambient condition in the Sacramento River at Hood. Since that is a boundary condition for the assessment of water quality changes at more downstream locations in the Delta, it is also concluded that the proposed discharge will not significantly impact the cumulative 2030 water quality picture at those locations.

These results provide an indication of the magnitude of cumulative water quality change estimated to occur in 2030 for constituents of concern to water agencies and are helpful in putting the incremental changes associated with the proposed 218 mgd discharge in perspective.

Table 4-7 : Projected 2030 Median Concentrations (in mg/L) in Sacramento River at Hood[(1),(2)].

	Total Organic Carbon		Total Phosphorus as P		Total Nitrogen as N		Total Dissolved Solids	
Scenario	**Dry Year**	**Wet Year**	**Dry Year**	**Wet Year**	**Dry Year**	**Wet Year**	**Dry Year**	**Wet Year**
Current	2.0	1.9	0.11	0.09	0.8	0.6	99	85
2030 Projected Worst-Case Condition - Cumulative								
Incremental Change	0.2	0.1	0.03	0.01	0.2	0.1	6	1
Final Concentration	2.2	2.0	0.14	0.10	1.0	0.7	105	86
Projected Water Quality changes at proposed 218 mgd								
Incremental Change	0.06	---	0.01	---	0.08	---	1	---
Final Concentration	2.36	---	0.09	---	0.77	---	105	---

(1) Assuming a daily wastewater per capita flow rate of 100 gallons/capita/day.

(2) The sum of the current concentration and the incremental change may not appear to add up to the final concentration due to rounding.

5 Assessment of Water Quality Impacts

SRCSD has developed sophisticated modeling tools to assess potential impacts to water quality and aquatic life in the Sacramento River and Delta that may result from the SRWTP discharge. These modeling tools were developed to address both permit requirements and increases in discharge flows. These tools are useful in the examination of potential impacts to water quality in the immediate vicinity of the discharge point (near-field), and at various locations downstream in the Delta (far-field).

In October 2002, SRCSD conducted an Independent Technical Review (ITR) of its modeling tools. Three national modeling experts, with expertise in hydrodynamics/hydrology, probabilistic/statistics, and water quality, formed the ITR Committee. The Committee evaluated the modeling tools and endorsed their use. On April 2, 2009, the Central Valley Regional Water Board provided a letter to the District approving the use of the District's modeling tools for the NPDES permitting process and Antidegradation Analysis (see Appendix E). This approval was based on an in-depth review of the modeling tools by a second group of national modeling experts commissioned by the U.S. EPA and Central Valley Regional Water Board.

5.1 WATER QUALITY ASSESSMENT APPROACH

Water quality assessments were conducted for potential impacts on both near-field and far-field locations. Near-field assessment is conducted using dynamic modeling techniques for the establishment of water quality-based effluent limitations in NPDES permits. Dynamic models are authorized for use by both federal and State regulations. Where robust data sets for river flow and quality and effluent flow and quality exist, dynamic models provide a statistically defensible representation of in-stream conditions in the immediate vicinity of a discharge. In combination with a three dimensional plume model, the dynamic model can provide excellent information regarding concentration gradients within a mixing zone. The level of detail in the information provided by the dynamic model is far more descriptive and representative of actual field conditions than the information derived from steady-state modeling efforts.

5.1.1 Dynamic Models

Current U.S. EPA guidance (Technical Support Document for Water Quality-Based Toxics Control (TDS) (U.S. EPA, 1991)) allows the development of water quality-based effluent limits for toxic substances to be based on two types of water quality models: steady-state and dynamic. The TSD describes dynamic modeling concepts, which include continuous simulations, lognormal probability modeling and Monte Carlo approaches. The TSD lists a number of specific models which can be used in a dynamic modeling effort. The Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California (known as the Statewide Implementation Plan, or SIP (effective 4/18/00 and amended 7/13/05) applies to discharges of toxic pollutants into inland surface waters, enclosed bays, and estuaries. This policy allows the specific application of a dynamic model in the development of effluent limitations. In Section 1.4 of the SIP, dynamic models are listed as an alternative to the use of the steady-state modeling approach.

5.1.2 Mixing Zones

Mixing zones are allowed under federal and State rules and regulations. The CTR allows toxics criteria to be applied at the boundary of mixing zones, if mixing zones are permitted by the State. The Basin Plan for the Sacramento-San Joaquin Basin authorizes the use of mixing zones in permitting to account for dispersion and dilution of discharges in receiving waters. The SIP allows Regional Boards to grant mixing zones and dilution credits to dischargers in accordance with various provisions.

The U.S. EPA TSD states that it is not necessary to meet all water quality criteria within the discharge pipe to protect the integrity of the water body as a whole. Sometimes, it is appropriate to allow for ambient concentrations above the criteria in small areas near outfalls (e.g., in mixing zones). The TSD therefore allows water quality standards to be exceeded in areas of initial effluent mixing near outfalls. However, the TSD does state that the size of the mixing zone and the area within certain concentration isopleths should be evaluated for their effect on the overall biological integrity of the water body. The TSD states that if the total area affected by elevated concentrations within the mixing zone is small compared to the total area of a water body (e.g., a river segment), then the mixing zone will likely have little effect on the integrity of the water body as a whole.

The U.S. EPA TSD allows water quality standards to be exceeded in areas of initial effluent mixing near outfalls (i.e., in "mixing zones"), assuming the following conditions are met (U.S. EPA, 1991, 1994):

- Area of initial mixing does not impair the integrity of the water body as a whole.
- There is no lethality to organisms passing through the zone of initial mixing.
- There is no significant human health risk, considering likely pathways of exposure.
- Free-swimming organisms are provided a zone of free passage.
- Settleable materials do not form objectionable deposits.
- Floating debris, oil, scum, and other material do not occur in concentrations that form nuisances.
- Substances do not occur at concentrations that produce objectionable color, odor, taste, or turbidity.
- Substances do not occur at concentrations that produce undesirable aquatic life or result in a dominance of nuisance species.

The SIP (SWRCB, 2005) allows for mixing zones consistent with the U.S. EPA guidance discussed in the TSD. The SIP further states, consistent with U.S. EPA guidance, that mixing zones shall be as small as practicable, and that they shall not:

- Compromise the integrity of the entire water body.
- Cause acutely toxic conditions to aquatic life passing through the mixing zone.
- Restrict the passage of aquatic life.

- Adversely impact biologically sensitive or critical habitats, including, but not limited to, habitat of species listed under federal or State endangered species laws.
- Produce undesirable or nuisance aquatic life.
- Result in floating debris, oil, or scum.
- Produce objectionable color, odor, taste, or turbidity.
- Cause objectionable bottom deposits.
- Cause nuisance.
- Dominate the receiving water body.
- Overlap a mixing zone from different outfalls; or be allowed at or near any drinking water intake. (A mixing zone is not a source of drinking water. To the extent of any conflict between this determination and the Sources of Drinking Water Policy (Resolution No. 88-63 (SWRCB, 1988b), this determination supersedes the provisions of that policy.)

5.1.3 Criteria Compliance

In its ambient water quality criteria documents for the protection of aquatic life, U.S. EPA states that freshwater aquatic organisms and their uses should not be affected unacceptably if the recommended criteria are not exceeded more than once every 3 years, on the average. A one-day exceedance in 3 years equates with 99.91% compliance, while a one-hour exceedance in 3 years corresponds to 99.9962% compliance. It is apparent that compliance with the U.S. EPA criteria is intended to provide a very high degree of protection of aquatic life beneficial uses.

5.2 SELECTION OF WATER QUALITY CONSTITUTENTS

5.2.1 Consideration of Constituents of Concern

Selection of constituents for the antidegradation analysis was based in part on the constituents for which there are water quality objectives or criteria applicable to the Sacramento-San Joaquin Delta, as listed in **Table 3-2**. Constituents were also selected based on known concerns of the Central Valley Regional Water Board or interested parties. The dynamic modeling techniques used to evaluate potential water quality impacts for the antidegradation analysis require as model inputs SRWTP effluent quality data and upstream receiving water data. SRWTP effluent data used for dynamic modeling were collected during the period of June 2005 through July 2008. Effluent datasets with more than 10% detected data measured during this time period were evaluated quantitatively with respect to potential water quality impacts in the near-field. The group of constituents meeting the 10% detection in SRWTP effluent criterion, along with the bases for concern for these pollutants in receiving waters are shown in **Table 5-1**. Effluent and upstream receiving water (i.e., Sacramento River at Freeport) summary statistics for this group of constituents are provided in **Table 5-2**. The District's NPDES Monitoring and Reporting Program includes a receiving water monitoring location (R-1) upstream of the SRWTP discharge; the R-1 station is located in the Sacramento River at Freeport Bridge.

Where sufficient data exists, quantitative evaluations were conducted using modeling tools as described in more detail in Sections 5.3. For constituents with more than 20% of the data measured above detection limits, a regression on order statistical analysis was used to generate summary statistics. For constituents with less than 20% of the data measured above method detection limits, the following protocols taken from the SIP were followed when generating the summary statistics:

- Effluent values below detection limits were assumed to be equal to one half (½) the method detection limit, as described in the SIP protocol for calculating effluent limits and determining compliance.

- Receiving water values below detection limits were assumed to be equal to the method detection limit, as described in the SIP protocol for determining the need for and calculating effluent limits.
- The coefficient of variation was assumed to be 0.6 and standard deviation was assumed to be the mean multiplied by the coefficient of variation, as described in the SIP protocol for calculating effluent limits.

Constituents with less than 10% detected values in the effluent were determined to not have adequate data to provide a meaningful quantitative assessment using dynamic modeling techniques and were considered to be unlikely to have a measurable impact on the receiving water. Under the SIP protocol for determining a constituent's reasonable potential to cause or contribute to exceedances of a water quality objective/criterion in the receiving water, a single detected effluent data point greater than the applicable criterion can be the basis of a constituent's reasonable potential. Following this protocol, six constituents which have less than 10% of detected data in the effluent show "reasonable potential": carbon tetrachloride, pentachlorophenol, dibenzo(a,h)anthracene, 1,2-diphenylhydrazine, methyl-tert-butyl ether, and chlorine residual. However, based on these constituents' low detection rates in the effluent, future exceedances of receiving water quality objectives are not expected due to the substantial amount of effluent dilution that occurs in the receiving water. It is unlikely that a measureable impact to receiving water quality would result from such infrequent exceedances.

The constituents in **Table 5-2** were further subdivided into three categories as follows:

- **Category 1:** These constituents are of concern regionally and, in particular, with respect to potential impacts on the Delta ecosystem and its water quality. These constituents were evaluated for water quality impacts both in the near-field within 700 feet downstream of the SRWTP discharge, and where relevant data were available, in the far-field at several locations throughout the Delta. Category 1 constituents include: ammonia, total nitrogen, nitrate plus nitrite, total Kjeldahl nitrogen (TKN), total phosphorus, electrical conductivity (EC), total dissolved solids (TDS), chloride, total organic carbon, mercury, and dissolved oxygen. Where sufficient historic water quality data were available, trend analyses were performed for Category 1 constituents. Additionally, statistical power analyses were performed to estimate the ability to measure their modeled water quality increments at far-field locations.
- **Category 2:** These constituents were determined to be of concern with respect to localized impacts and were evaluated only with respect to near-field water quality impacts. These constituents are anticipated to have negligible impacts in far-field receiving waters. They include aluminum, cadmium, copper, zinc, total coliform, and temperature.
- **Category 3:** These constituents included all non-Category 1 and non-Category 2 constituents that generally have no history of contributing to adverse impacts in the Sacramento River. These constituents were evaluated only with respect to near-field water quality impacts. Similarly to Category 2 constituents, they are anticipated to have negligible impacts in far-field receiving waters.

Table 5-1: Constituents Evaluated for Potential Water Quality Impacts and their Bases for Concern in Receiving Waters

	Bases for Concern in Receiving Waters					
Constituents	**Aquatic Toxicity**	**Bioaccum-ulation in Aquatic Organisms**	**Habitat and Ecosystem Integrity**	**Drinking Water Supply**	**Agricultural Water Supply**	**Contact Recreation**
Category 1						
Ammonia	☑		☑			
Total Nitrogen			☑			
Nitrate plus Nitrite			☑	☑		
Total Kjeldahl Nitrogen			☑			
Total Phosphorus			☑			
Electrical Conductivity				☑	☑	
Total Dissolved Solids				☑	☑	
Chloride				☑	☑	
Total Organic Carbon				☑		
Mercury		☑		☑		
Dissolved Oxygen			☑			
Category 2						
Aluminum	☑			☑		
Cadmium	☑					
Copper	☑					
Zinc	☑					
Temperature			☑			
Total Coliform				☑		☑
Category 3						
Antimony	☑					
Arsenic	☑			☑		
Chromium	☑					
Lead	☑					
Molybdenum	☑					
Nickel	☑					
Selenium	☑					
Silver	☑					
Biochemical Oxygen Demand			☑			
Bromide					☑	
Chlorine Residual	☑					
Cyanide	☑					
Total Suspended Solids			☑			

Table 5-1: Constituents Evaluated for Potential Water Quality Impacts and their Bases for Concern in Receiving Waters (Continued)

Constituents	Bases for Concern in Receiving Waters					
	Aquatic Toxicity	Bioaccum-ulation in Aquatic Organisms	Habitat and Ecosystem Integrity	Drinking Water Supply	Agricultural Water Supply	Contact Recreation
Category 3						
1,4-Dichlorobenzene		☑		☑		
Bis(2-ethylhexyl)phthalate		☑		☑		
Bromodichloromethane		☑		☑		
Chloroethane		☑		☑		
Chloroform		☑		☑		
Diethyl Phthalate		☑		☑		
Di-n-butyl Phthalate		☑		☑		
Methyl Chloride		☑		☑		
Methylene Chloride		☑		☑		
Tetrachloroethylene		☑		☑		
Toluene		☑		☑		
Chlorpyrifos	☑			☑		
Dibromochloromethane		☑		☑		
N-Nitrosodimethylamine		☑		☑		

Table 5-2 : Statistical Input for Dynamic Model Analyses

			Effluent (µg/L unless specified)[1]					Ambient at R-1 (µg/L unless specified)[2]				
Cat	Constituent[3]		n	% detected	Std Dev	Mean	Normality[4]	n	% detected	Std Dev	Mean	Normality[4]
1	Ammonia (mg/L as N)											
	Winter[5]		334	100%	3.74	23.7	Normal[a]	515	10%	0.080	0.10	Log-normal[c]
	Summer[5] (181 mgd)		--				Normal[a]	515	10%	0.080	0.10	Log-normal[c]
	Summer[5] (218 mgd)		--				Normal[a]	515	10%	0.080	0.10	Log-normal[c]
1	Total Nitrogen (mg/L)											
	Winter[5]		38	100%	6.40	24.3	Normal[a]	162	47%	0.22	0.39	Log-normal[a]
	Summer[5] (181 mgd)		--		4.33	17.6	Normal[a]	162	47%	0.22	0.39	Log-normal[a]
	Summer[5] (218 mgd)		--		3.59	14.6	Normal[a]	162	47%	0.22	0.39	Log-normal[a]
1	NO_3+NO_2 (mg/L as N)		196	48%	0.19	0.13	Log-normal[a]	71	72%	0.14	0.16	Log-normal[a]
1	TKN (mg/L)											
	Winter[5]		38	100%	4.22	26.0	Normal[a]	48	71%	0.19	0.35	Log-normal[a]
	Summer[5] (181 mgd)		--		3.13	19.3	Normal[a]	48	71%	0.19	0.35	Log-normal[a]
	Summer[5] (218 mgd)		--		2.64	16.3	Normal[a]	48	71%	0.19	0.35	Log-normal[a]
1	Total Phosphorus (mg/L)		42	100%	0.43	2.34	Normal[a]	109	76%	0.33	0.11	Log-normal[a]
1	EC (µmhos/cm)		331	100%	81.5	764	Normal[a]	460	100%	58	163	Log-normal[a]
1	TDS (mg/L)		331	100%	44.4	410	Normal[a]	160	100%	23.9	98.0	Log-normal[a]
1	Chloride (mg/L)		33	100%	6.8	91	Normal[a]	98	92%	1.8	5.1	Log-normal[a]
1	TOC (mg/L)		180	100%	5.56	17.5	Log-normal[a]	70	96%	1.15	2.34	Log-normal[a]
1	Mercury, Total (ng/L)		224	100%	0.97	4.1	Log-normal[a]	113	100%	5.3	5.6	Log-normal[a]
1	Dissolved Oxygen[6] (mg/L)		--	--	1.09	1.57	Normal[a]	686				
2	Aluminum	TR	25	100%	8.49	23.3	Log-normal[a]	32	100%	1924	969	Log-normal[a]
2	Cadmium	TR	73	84%	0.024	0.023	Log-normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	60	63%	0.0053	0.0081	Log-normal[a]
2	Copper	TR	86	100%	0.73	4.31	Normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	70	100%	0.61	1.47	Log-normal[a]

Table 5-2: Statistical Input for Dynamic Model Analyses (Continued)

Cat	Constituent[3]		Effluent (µg/L unless specified)[1] n	% detected	Std Dev	Mean	Normality[4]	Ambient at R-1 (µg/L unless specified)[2] n	% detected	Std Dev	Mean	Normality[4]
2	Zinc	TR	86	100%	5.06	21.2	Normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	67	90%	0.37	0.57	Log-normal[a]
2	Temperature (C)		1157	100%	2.78	23.0	Normal[a]	657	100%	4.71	15.5	Normal[a]
2	Coliform, Total (MPN/100mL		1173	78%	26.2	7.77	Log-normal[a]	100	100%	4042	1983	Log-normal[a]
3	Antimony	TR	37	100%	0.049	0.32	Log-normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	13	92%	0.014	0.066	Log-normal[a]
3	Arsenic	TR	73	100%	0.38	1.64	Log-normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	30	100%	0.31	1.35	Log-normal[a]
3	Chromium	TR	73	93%	0.18	0.69	Normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	29	59%	0.089	0.15	Normal[a]
3	Lead	TR	86	99%	0.15	0.25	Log-normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	61	75%	0.022	0.030	Log-normal[a]
3	Molybdenum	TR	73	100%	0.72	2.83	Log-normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	26	100%	0.15	0.51	Log-normal[a]
3	Nickel	TR	73	100%	0.54	2.37	Normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	71	99%	0.35	0.67	Log-normal[a]
3	Selenium	Total	37	89%	0.13	0.79	Normal[a]	29	38%	0.21	0.21	Log-normal[a]
3	Silver	TR	86	97%	0.033	0.063	Normal[a]	---	---	---	---	---
		Diss	---	---	---	---	---	27	11%	0.0084	0.014	Log-normal[c]
3	BOD, 5 Day (mg/L)		1157	100%	2.45	7.59	Log-normal[a]	24	0%	1.28	2.13	Log-normal[c]
3	Cyanide		148	68%	1.89	5.12	Normal[a]	44	18%	2.35	3.92	Log-normal[c]
3	TSS (mg/L)		1157	99%	2.38	6.68	Log-normal[a]	102	97%	24.5	29.4	Log-normal[a]
3	1,4-Dichlorobenzene		205	52%	0.40	0.68	Normal[a]	62	0%	0.16	0.27	Log-normal[c]
3	Bis(2-ethylhexyl)phthalate		87	99%	1.38	2.60	Log-normal[a]	55	42%	0.12	0.11	Log-normal[a

Table 5 2: Statistical Input for Dynamic Model Analyses (Continued)

Cat	Constituent[3]	Effluent (µg/L unless specified)[1] n	% detected	Std Dev	Mean	Normality[4]	Ambient at R-1 (µg/L unless specified)[2] n	% detected	Std Dev	Mean	Normality[4]
3	Bromodichloromethane	73	88%	0.46	0.95	Normal[a]	43	0%	0.22	0.37	Log-normal[c]
3	Chloroethane	73	30%	0.21	0.28	Log-normal[a]	44	0%	0.25	0.42	Log-normal[c]
3	Chloroform	73	100%	5.10	15.0	Log-normal[a]	46	9%	0.56	0.93	Log-normal[c]
3	Diethyl Phthalate	87	30%	3.42	1.46	Log-normal[a]	53	32%	0.036	0.047	Log-normal[a]
3	Di-N-Butyl Phthalate	87	23%	1.73	1.35	Log-normal[a]	53	32%	0.18	0.072	Normal[a]
3	Methyl Chloride	73	56%	0.50	0.73	Log-normal[a]	44	5%	0.28	0.47	Log-normal[c]
3	Methylene Chloride	73	89%	0.75	1.00	Log-normal[a]	44	0%	0.41	0.69	Log-normal[c]
3	Tetrachloroethylene	73	14%	0.081	0.13	Log-normal[b]	43	2%	0.23	0.38	Log-normal[c]
3	Toluene	73	36%	0.14	0.25	Log-normal[a]	43	5%	0.22	0.36	Log-normal[c]
3	Chlorpyrifos	73	16%	0.003	0.0058	Log-normal[b]	108	2%	0.02	0.032	Log-normal[c]
3	Dibromochloromethane	73	18%	0.084	0.14	Log-normal[b]	44	0%	0.25	0.42	Log-normal[c]
3	n-Nitrosodimethylamine	97	13%	0.430	0.72	Log-normal[b]	47	0%	1.61	2.69	Log-normal[c]
	pH, lab and field	1145	100%	0.17	6.72	Normal[a]	670	100%	0.36	7.56	Normal[a]
	Hardness as $CaCO_3$ (mg/L)	216	100%	11.4	108	Log-normal[a]	100	100%	12.1	58.4	Normal[a]

[1] The effluent data date range is June 1, 2005 through July 31, 2008.
[2] The ambient station R-1 data date range is January 1, 1998 through July 31, 2008.
[3] TR = Total Recoverable; Diss = Dissolved.
[4] Normality was tested using 1/2 the detection limits for effluent non-detected data and the detection limits for non-detected ambient data.
- [a] A regression-on-order statistics tool (the Data Analysis Tool or DAT) was used to calculate the standard deviation and average by using regression on order statistics.
- [b] The average was calculated using 1/2 the detection limits, per SIP, as insufficient detected data were available to use the DAT. The standard deviation was calculated from the average and a default coefficient of variation of 0.6 (stdev = 0.6*average).
- [c] The average was calculated using the detection limits, per SIP, as insufficient detected data were available to use the DAT. The standard deviation was calculated from the average and a default coefficient of variation of 0.6 (stdev = 0.6*average).

[5] Summary statistics for effluent winter operations ammonia, TN, and TKN are based on year-round data. These concentrations are not expected to change with the increase in SRWTP discharge (SRCSD, 2009b). Summary statistics for effluent summer operations ammonia, TN, and TKN are determined in SRCSD 2009b. Two scenarios,181 mgd and 218 mgd, are modeled for the summer operations due to seasonal control of effluent oxygen demand which would gradually decrease effluent ammonia, TN, and TKN levels in the summer months.

[6] Dissolved oxygen measurements not available for SRWTP effluent. Distribution constrained between 0.1 mg/L and 4.0 mg/L (SRCSD, 2009b).

5.2.2 Data Compilation

Water quality data were compiled as input sources for near- and far-field water quality impacts analyses using the dynamic model techniques described later in this section. Compiled ambient water quality data were also used to perform a trend analysis of historic water quality data in the lower Sacramento River and Delta. All effluent and ambient water quality data were evaluated by a data screening process prior to use in the analysis. The data sources providing the data used in the analysis and the data quality screening procedures used to review the data are described in Appendix F. A detailed description of the regional surface waters trend analysis is included in Appendix G.

5.2.2.1 Data Compilation for Near-Field Water Quality Impacts Analysis

5.2.2.1.1 Effluent and Ambient Data Used for Near-Field Impacts Assessment

Near-field water quality assessments for the antidegradation analysis were conducted using the DYNTOX model. Statistics calculated from effluent and ambient water quality data were used as input to the DYNTOX model. NPDES effluent water quality monitoring data collected by SRCSD between June 2005 and July 2008 were used for the effluent model input (see summary statistics provided in **Table 5-2**). Ambient water quality data collected from the Sacramento River at Freeport (upstream of the SRWTP discharge) between January 1998 and July 2008 were used for the ambient water quality model input (see summary statistics provided **Table 5-2**). The Sacramento River at Freeport data set included data collected as part of the SRCSD's NPDES Monitoring and Reporting requirements (via the Sacramento River Coordinated Monitoring Program), as well as data collected by other regional monitoring programs as shown in **Table 5-3**. The dynamic model used flow data for the Sacramento River from flows generated by the United States Bureau of Reclamation (USBR) PROSIM model. Sacramento River and other Delta inflows were calculated using the USBR PROSIM model so that future reservoir management scenarios could be modeled. A 70-year record (1922-1991) of monthly PROSIM flows were used as input data. Real tides (astronomical tides) were used at the downstream (Bay) model boundary.

Table 5-3: Ambient Water Quality Monitoring Programs Collecting Data in the Sacramento River at Freeport that Were Used as Input to the DYNTOX Model.

Water Quality Monitoring Program	Monitoring Date Range
Sacramento Coordinated Monitoring Program (CMP)	Jan. 1998 – Jun. 2008
SRWTP additional receiving water monitoring	Jan. 1998 – Jul. 2008
SRWTP 13267 Monitoring	Dec. 2001 – Sep. 2002
SRWTP Pretreatment Pollution Prevention Program Monitoring (P4)	Mar. 1998 – Oct. 2004
Sacramento River Watershed Program (SRWP)	Nov. 1998 – May 2002
U.S.G.S. National Water Information System (USGS)	May 1998 – Sep. 2000

5.2.2.2 Data Compilation for Far-Field Water Quality Impacts Analysis and Trend Analysis

5.2.2.2.1 Effluent Data Used for Far-Field Impacts Assessment

DYNTOX model output was used in conjunction with the Fischer Delta Model (FDM) to estimate far-field concentrations increments resulting from the proposed 37 mgd (ADWF) increase in discharge. Statistics calculated from the same SRWTP effluent data set described above (covering the period June 2005 through July 2008) was used as the effluent model input for the DYNTOX model. As noted earlier, surface water quality data for the Sacramento River at Freeport, covering the period January 1998 through July 2008, were used as the ambient model input for the DYNTOX model.

5.2.2.2.2 Ambient Data Used for Far-Field Impacts Assessment and Trend Analysis

Ambient surface water data were compiled at downstream Delta locations to provide a baseline assessment of ambient water quality for a particular pollutant on top of which was added a modeled, far-field concentration increment due to the proposed 37 mgd (ADWF) increase in discharge. This addition of a concentration increment due to the proposed project on top of an ambient baseline provides an assessment of the proposed project's potential water quality impacts at far-field locations. Modeled, far-field concentration increments were combined with far-field ambient water quality data to assess potential water quality impacts at a handful of Delta locations downstream of the SRWTP discharge where sufficient ambient water quality data exists. These locations possessing sufficient ambient water quality data – termed, "water quality impacts assessment locations" (see **Table 5-4**) – are shown in **Figure 5-1**. Far-field locations lacking sufficient ambient water quality data covering the period 1998 through 2008 – termed, "SRWTP percent effluent assessment locations" (see **Table 5-4** and **Figure 5-1**) – were modeled using the FDM to determine the percent contribution of SRWTP effluent estimated to reach these locations. The increment of constituent concentration for a given location is proportional to the increment of percent effluent at that location. Therefore, the SRWTP percent effluent assessment locations provide a relative assessment of potential water quality impacts at these far-field locations due to the proposed 37 mgd (ADWF) increase in discharge. Additional discussion of percent contribution of SRWTP effluent at far-field locations in provided in Section 5.3.2.

The geographic locations providing ambient water quality monitoring data for the modeling of water quality impacts at a *water quality modeling location* are not always synonymous, as noted in **Table 5-4**. For example, ambient water quality data collected in Old River near Byron *and* Old River Pumping Plant on Highway 4 were used to estimate potential water quality impacts at Contra Costa Water District Los Vaqueros Intake due to the proposed project. While concentration-based analyses at far-field water quality impacts assessment locations considered ambient water quality covering the period January 1998 through July 2008, trend analyses conducted for Category 1 constituents at these locations used expanded ambient data sets covering two or more decades. These analyses were performed to determine whether any historic upward or downward trends in pollutant concentrations over time could be identified in the lower Sacramento River and Delta.

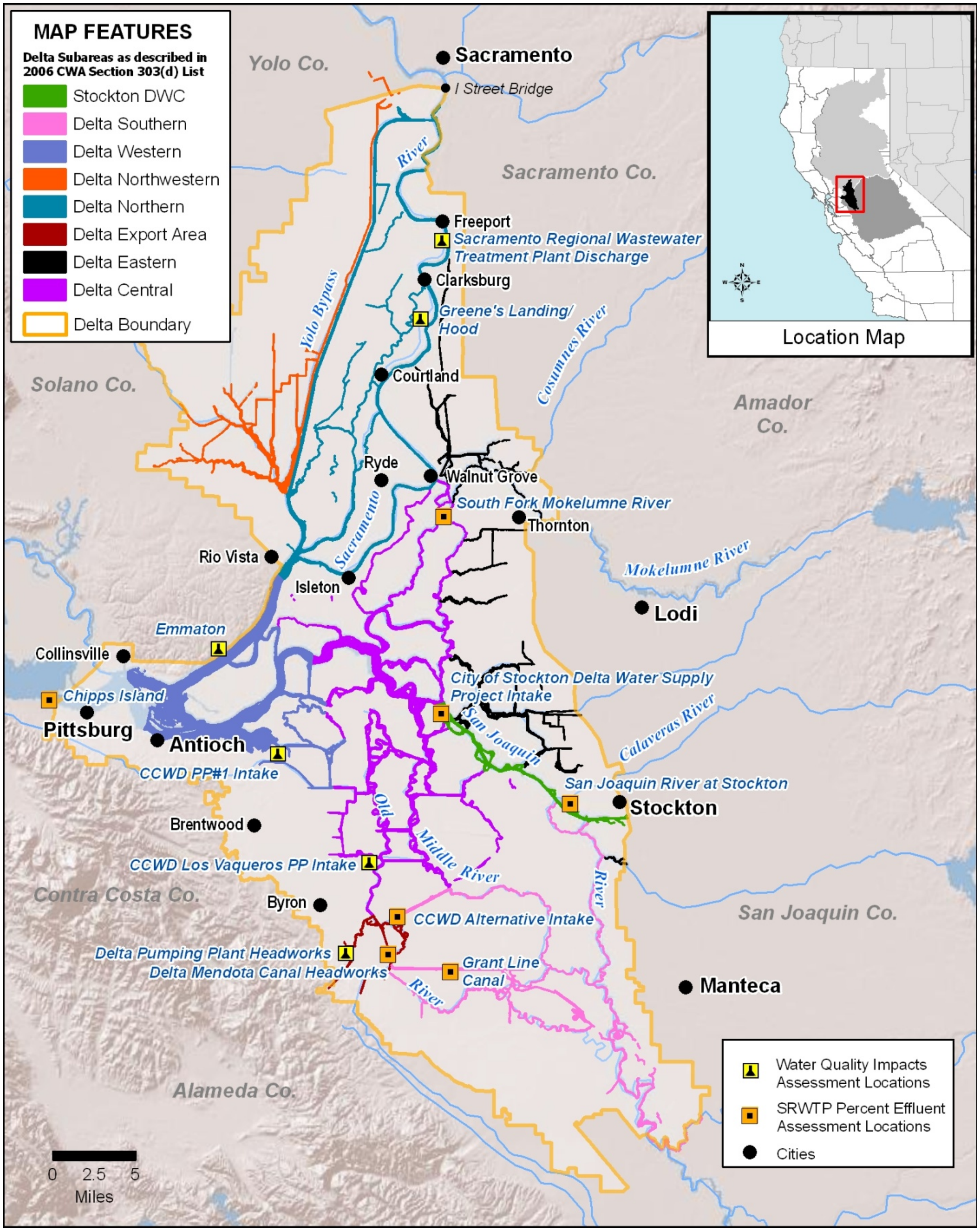

Figure 5-1: Sacramento-San Joaquin Delta Showing Water Quality Modeling Locations

Table 5-4: Water Quality Modeling Locations and Associated Ambient Water Quality Data Sources.

Water Quality Modeling Locations	Ambient Water Quality Data Source Used for Modeling Location
Water Quality Impacts Assessment Locations	
Sacramento River at Freeport	Sacramento River at Freeport
Sacramento River at Greene's Landing/Hood(1)	Sacramento River at Greene's Landing/Hood(1)
Sacramento River at Emmaton	Sacramento River at Emmaton
Contra Costa Water District Pumping Plant #1 Intake(2)	Contra Costa Water District Pumping Plant #1 Intake
Contra Costa Water District Los Vaqueros Intake	Old River near Byron and Old River Pumping Plant on Highway 4
Harvey O. Banks Delta Pumping Plant(3)	Harvey O. Banks Delta Pumping Plant
SRWTP Percent Effluent Assessment Locations	
South Fork Mokelumne River	Insufficient ambient water quality data covering the period 1998 – 2008
Chipps Island	
City of Stockton Delta Water Supply Project Intake	
San Joaquin River at Stockton(4)	
Contra Costa Water District Alternative Intake on Victoria Canal	
Delta Mendota Canal Headworks(4)	
Grant Line Canal	

(1) While Greene's Landing and Hood are distinct locations on the Sacramento River, they represent essentially the same water quality and have been combined for this analysis.

(2) Location also known as Contra Costa Water District Intake at Rock Slough.

(3) Far-field modeling performed at Clifton Court Forebay.

(4) Far-field concentration increment modeled by Flow Science, Inc. for the location and included in Appendix H; however, insufficient ambient data exist for concentration –based water quality impacts assessment.

5.3 WATER QUALITY ASSESSMENT METHODOLOGY

Due to the complexities of the Sacramento River flows, SRWTP effluent, near- and far-field mixing, and tidally influenced flow patterns in the Delta, no single model was available to adequately describe water quality and quantity conditions in the river near the discharge and downstream into the Delta. The models used in support of the water quality analyses have been approved for use by the Central Valley Regional Water Board and include: 1) the U.S. Bureau of Reclamation (USBR) Project Simulation Model (PROSIM); 2) Reclamation's temperature models for the Sacramento River system; 3) the Fischer Delta Model (FDM); 4) a near-field 3-dimensional (3-D) dilution model, FLOWMOD; 5) a longitudinal dispersion model for the Sacramento River; and 6) the U.S. EPA's Dynamic Toxicity Model (DYNTOX). The relationship between these models is illustrated in **Figure 5-2**. .

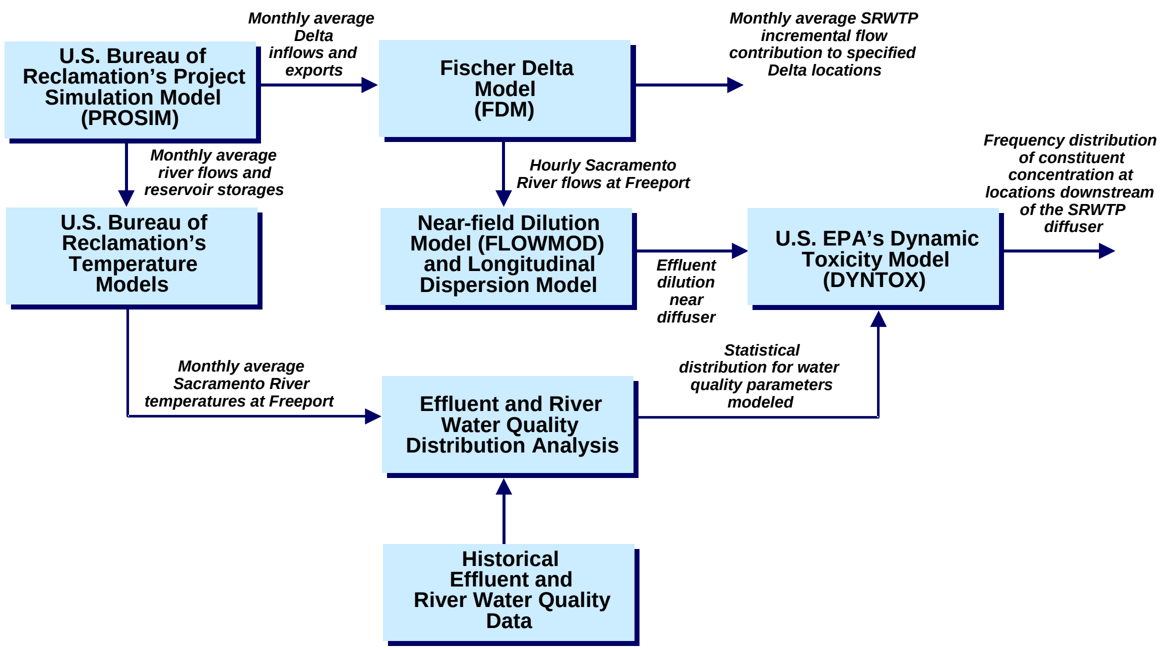

Figure 5-2: Linkages between the Hydrologic and Water Quality Models Used to Evaluate Water Quality Conditions in the Sacramento River and Delta.

PROSIM was used to define system-wide hydrologic conditions upon which water quality assessments were made. PROSIM simulates a 70-year hydrologic period of record (1922-1991, inclusive), which encompasses the full spectrum of climatological conditions that occur in the Central Valley. Alternative operations of the Central Valley Project (CVP) and the State Water Project (SWP), as well as current and future hydrology based on existing and projected land uses, were input into the model to characterize existing and future reservoir operations, river flows, Delta inflow, etc. River flow rates output from PROSIM served as input to the Delta models, to the dilution modeling, and to the temperature models. USBR's temperature models were used to simulate monthly average temperatures in the Sacramento River at Freeport under projected river flow conditions for the period of record. The FDM was used to obtain hourly flow rates at Freeport (from the PROSIM mean monthly flows and real – i.e., astronomical –

tides at the downstream boundary of the Delta) and to simulate impacts of the SRWTP discharge in the Delta.

A one-dimensional longitudinal dispersion model was used in conjunction with the near-field 3-D dilution model, FLOWMOD, to determine dilution ratios (i.e., river to effluent volume) under a variety of river and effluent flow conditions immediately downstream of the SRWTP diffuser. Dilution and constituent-specific effluent and upstream river concentration distributions were then input into U.S. EPA's DYNTOX model to conduct Monte Carlo analyses to estimate statistical distributions of water quality conditions in the near-field zone, downstream of the SRWTP diffuser, over a wide range of flow and seasonal conditions. This approach simulated the frequency and probability with which modeled conditions would be expected to occur in the near-field zone. Hence, Monte Carlo analysis is often referred to as "probabilistic" analysis.

Brief summaries of the models used are provided below. Additional information, including detailed calibration and verification results, can be found in *Water Quality Modeling Methodology for the Sacramento Regional Wastewater Treatment Plant, 2020 Master Plan EIR* (this document included as Appendix F in the 2020 Master Plan Draft Environmental Impact Report (DEIR); SCDERA, 2003). This modeling approach was peer-reviewed and sanctioned for use by the ITR Committee and later approved by the Central Valley Regional Water Board.

5.3.1 Model Description and Assumptions

The descriptions of and the assumptions made for the components used in the near- and far-field water quality impacts modeling are provided in the subsequent sections.

5.3.1.1 PROSIM Modeling

PROSIM provided a 70-year hydrologic period of record, used to characterize existing and future hydrologic conditions. Output from the PROSIM simulations served as input to the FDM and included: export pumping rates from the Tracy (CVP) and Banks (SWP) pumping plants, Contra Costa Water District (CCWD) pumping at Rock Slough and Old River, North Bay Aqueduct pumping, City of Vallejo pumping, net Delta consumptive use, Delta Cross Channel position, and Delta inflows from Yolo Bypass, San Joaquin River, Calaveras River, Cosumnes River, Mokelumne River, and the Sacramento River.

PROSIM simulates CVP and SWP operations and the hydrologic effects of those operations on major Central Valley river flows and reservoir storages. The model simulates system operations within the geographic area affected by CVP and SWP facilities, including the Delta. A network of 67 computation points, or nodes, represents river systems and project facilities. PROSIM uses a mass-balance approach to simulate the occurrence, regulation, and movement of water from one node to another. At each node, various physical processes (e.g., surface water inflow or accretion, flow from another node, groundwater accretion or depletion, and diversion) can be simulated or assumed. Operational constraints, such as reservoir size and seasonal storage limits or minimum flow requirements, can be defined for each node. The model uses a monthly time step. Flows are specified as a mean flow for the month, and reservoir storage volumes are specified as end-of-month volume in thousands of acre-feet (TAF).

PROSIM simulates operations of the following water storage and conveyance facilities: Trinity, Whiskeytown, and Shasta/Keswick reservoirs (CVP); Spring Creek and Clear Creek tunnels (CVP); Oroville Reservoir (SWP); Folsom Reservoir and Lake Natoma (CVP); Tracy (CVP), Contra Costa (CVP), and Banks (SWP) pumping plants; San Luis Reservoir (shared by CVP and SWP); and East Branch and West Branch SWP reservoirs. To varying degrees, nodes also define conveyance facilities including the Tehama-Colusa, Corning, Folsom-South, Delta-Mendota, and California Aqueduct canals.

Other water systems tributary to the Delta are modeled separately from PROSIM and are incorporated as input at a PROSIM node. These tributaries are the San Joaquin River, the New Melones/Stanislaus River system, and the east-side streams, consisting of the Cosumnes River, Mokelumne River, Calaveras River and several smaller creeks. These river systems are simulated by a combination of the USBR models, SANJASM and STANMOD.

PROSIM has been used extensively in support of a wide variety of projects. PROSIM has been used to provide hydrologic assessments for water contracts, including the P.L. 101-514 "Fazio" water contracts, USBR's long-term contract renewals, and numerous American River Basin water supply projects. PROSIM has also been used to provide hydrologic assessments of key Acts, Agreements, and Plans, including the Department of the Interior's Programmatic Environmental Impact Statement for the Central Valley Project Improvement Act, the Sacramento Area Water Forum Agreement, and the Central Valley Project Operations Criteria and Plan. Finally, PROSIM has been used for hydrologic assessments for flood control operations and has been used as USBR's CVP/SWP operations planning model.

5.3.1.2 Fischer Delta Model (FDM)

The FDM models complex bay-estuary-channel systems. The model was designed to simulate water flow and salinity (or solute) changes in the Delta as affected by physical and hydrological modifications in the Delta. It has been used extensively for the Delta to determine the movement and dispersion of pollutants from point sources and to study the effects of changes in water management and operations scenarios, the effects of artificial flow control structures and levee breaks, and the effects of changes in hydrologic conditions (e.g., timing and magnitude of exports and water system operations). The FDM has been successfully used for a variety of agencies, including CCWD, CALFED, DWR, the SWRCB, Metropolitan Water District of Southern California, and many other agencies and engineering/environmental consulting firms.

The FDM consists of two linked mathematical models: (1) a hydrodynamic model (DELFLO), which utilizes the fixed-grid method of characteristics to solve the Saint-Venant equations of one-dimensional fluid motion in channels; and (2) a salinity/tracer transport model (DELSAL), which uses a Lagrangian computational method to solve the advection-diffusion equation. DELFLO runs on a 90-second time step, while DELSAL is run on a 15-minute time step. The Delta is represented in the model as interconnected embayments and one-dimensional channel segments, which have rectangular cross-sections and constant widths. Inputs to the FDM include inflows from the Sacramento and San Joaquin rivers, San Francisco Bay, and smaller eastside streams, water exports, riparian diversions, and agricultural drainage returns. The model simulates open water areas and control structure operations and takes both rainfall and evaporation into account. The FDM has been validated by extensive field-testing in the Delta.

For this evaluation, an extensive calibration/validation process was conducted to calibrate the FDM in the vicinity of the SRWTP diffuser and to validate the newly calibrated model. Because low flow conditions were most critical, the calibration/validation process was performed using flow rates measured in the Sacramento River at Freeport for water years 1992 and 1997. These years included dry periods with a large number of tidally-induced reverse flow events, and the calibration/validation procedure satisfactorily duplicated flow rates for these conditions.

In support of the near-field modeling analysis, the FDM was used to simulate hourly flow rates for the Sacramento River at Freeport from the PROSIM 70-year record (1922-1991) of mean monthly flow output. Simulated monthly average Sacramento River flow rates from PROSIM were converted to hourly values using the DELFLO module of the FDM. Although DELFLO is run on a 90-second time step, Sacramento River flow rates at Freeport were "recorded" on an hourly basis. The simulated hourly flow data were used as input to the near-field water quality assessment using the 3-D dilution model and longitudinal dispersion model.

In support of the far-field analysis, the FDM was used to simulate hourly SRWTP effluent contributions at 12 key locations throughout the Delta. These locations, shown in **Figure 5-3** included the following: Greene's Landing/Hood, Emmaton, San Joaquin River at Stockton, CCWD Pumping Plant #1 Intake (a.k.a. CCWD Intake at Rock Slough), CCWD Los Vaqueros Intake, Clifton Court Forebay – Banks Delta Pumping Plant, Delta Mendota Canal Headworks, South Fork Mokelumne River, City of Stockton Delta Water Supply Project intake, CCWD Alternative Intake on Victoria Canal, Grant Line Canal, and Chipps Island. Of these 12 Delta sites, five were selected as water quality impacts assessment locations and seven were chosen as SRWTP percent effluent assessment locations based on availability of ambient water quality data. Locations possessing sufficient ambient water quality data are amenable to concentration-based impacts assessments resulting from the proposed 37 mgd (ADWF) increase in discharge. Before a final assessment of ambient water quality data availability was made, Flow Science, Inc. modeled pollutant concentration increments do to the proposed project for the Delta Mendota Canal Headworks and the San Joaquin River at Stockton. However, an assessment of available water quality data later determine that insufficient ambient water quality data covering the period January 1998 through July 2008 exist for these locations for the purpose of performing concentration-based water quality impacts assessments.

Dynamic modeling techniques were used to estimate receiving water pollutant concentrations downstream of the SRWTP discharge due to the proposed discharge increase from the current permitted condition (181 mgd (ADWF)) to the proposed permitted condition (218 mgd (ADWF)) at the five water quality impacts assessment locations (see **Figure 5-3**). The Sacramento River at Freeport location was used to determine upstream ambient water quality conditions used as one of the inputs to the dynamic model. Hourly SRWTP flow rates (rather than monthly average rates, as were used in the DEIR analysis) and historical astronomical tides (rather than a 19-year mean tide, as was used in the DEIR analysis) were used as input to the FDM. Two scenarios were run: annual dry weather flow (ADWF) rates of 181 mgd and 218 mgd.

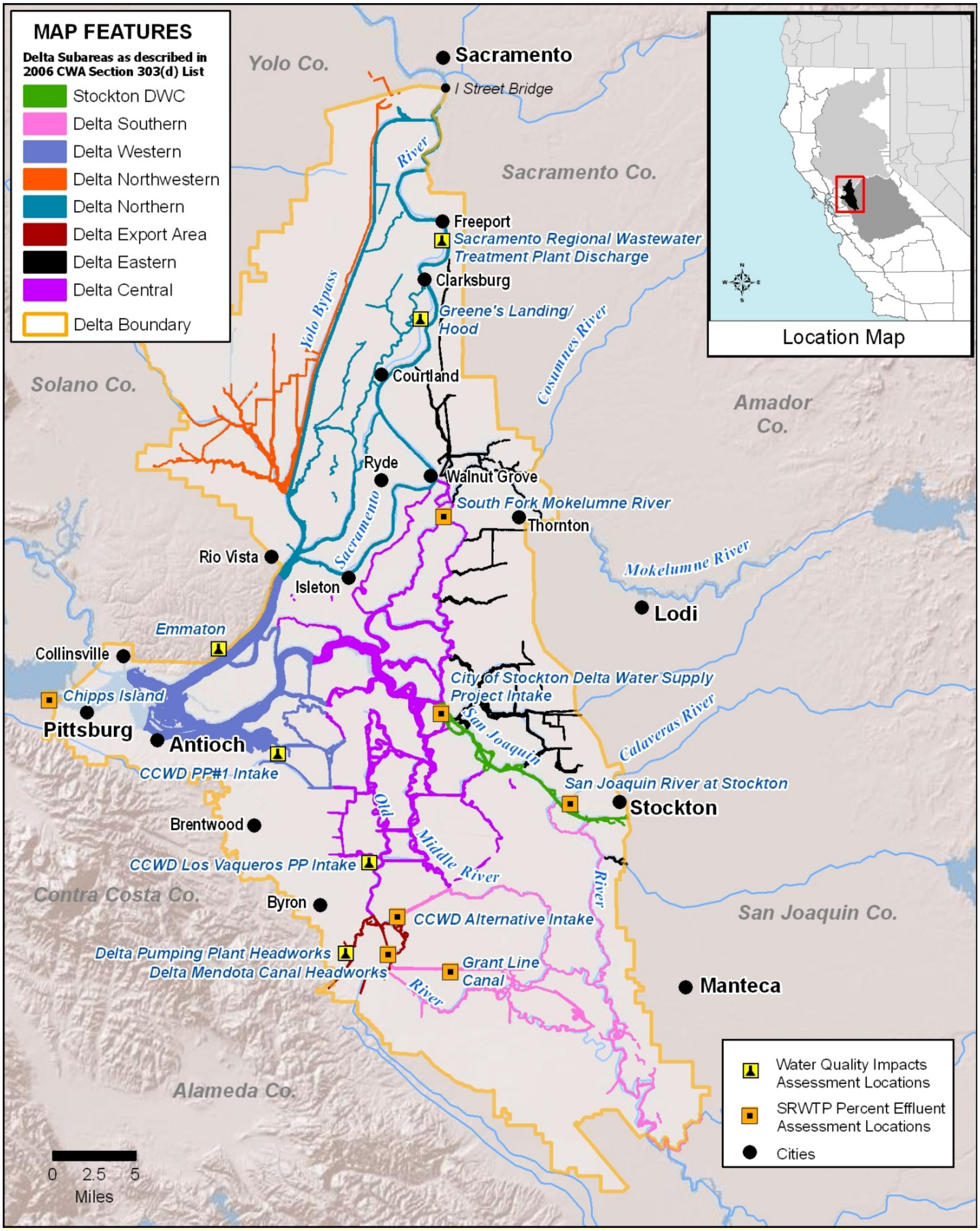

Figure 5-3: Far-Field Locations in the Sacramento-San Joaquin Delta Simulated with the Fischer Delta Model.

5.3.1.3 Simulation of Effluent Flow Rates

Just as hourly Sacramento River flow rates were simulated using the FDM to provide river-flow inputs to the near-field dilution analyses, so too were hourly effluent flow rates. Effluent flow rates were calculated from the hourly river flow data by relating both known daily and monthly effluent flow patterns and SRWTP diversion operations to river flow conditions.

Inflow into the SRWTP plant exhibits a regular daily pattern, called the "base flow," which can be related to the average daily flow rate (i.e., Q/Qave). In addition, inflow to the SRWTP varies seasonally. Based on this information, monthly average flow rates for all scenarios were projected. Hourly effluent flow rates were calculated by multiplying the ratio (Q/Qave) by the monthly average effluent flow rate (Qave) for the appropriate month.

Because Sacramento River flow is strongly tidal at times, the river flow can reverse during low flow conditions (i.e., the river may flow in an upstream direction during the flood tide). For the 70-year hydrologic period of record (1922-1991), hourly Sacramento River flow rates were developed using the FDM (as discussed above). From these simulations, reverse-flow and low-flow events in the Sacramento River at Freeport were identified for the 70 year hydrologic period of record.

The SRWTP Operations Plan, consistent with the plant's NPDES permit, provides for the diversion of effluent to basins (thereby ceasing discharge to the river) when the flow rate in the Sacramento River falls below 14 times the effluent base flow rate (called the "14:1 flow ratio"). When the flow rate in the Sacramento River is below this threshold, effluent that otherwise would have been discharged to the river is stored in the diversion basins. When the river flow rate later exceeds the 14:1 flow ratio, discharge to the river resumes, and treated effluent that was stored in the diversion basins is discharged to the river. Because the SRWTP continues to receive influent wastewater for treatment regardless of the river flows, this discharge from the diversion basins is added to the regular daily base flow discharge.

Hence, to describe SRWTP effluent discharge rates to the river accurately, these operational guidelines were simulated. During times when no low- or reverse-flow events occurred in the simulation period, the base flow was discharged to the river directly. When the simulated Sacramento River flow rate fell below the 14:1 flow ratio, the base effluent flow was simulated as being sent to the diversion basins. The volume of effluent stored in the diversion basins also was accounted for in the simulations. When flow in the Sacramento River later exceeded the 14:1 flow ratio, a new effluent flow rate was calculated. The post-diversion flow rate consisted of: 1) the base effluent flow rate; and 2) flow from the diversion basin, which was calculated as the volume of effluent contained in the diversion basin divided by either the length of time until the river flow rate again fell below the 14:1 flow ratio or 12 hours, whichever period of time was shorter. The following two additional constraints also were imposed on the simulation: 1) the ratio of river flow to the SRWTP effluent flow discharged to the river (i.e., the base flow plus any flow from the diversion basin) was not allowed to fall below the 14:1 flow ratio at any time; and 2) the SRWTP effluent flow rate was not allowed to exceed 410 mgd (634 cfs), the hydraulic capacity of the discharge system.

5.3.1.4 Near-Field Plume Modeling

The computational fluid dynamics model, FLOWMOD (also referred to as the "3-D dilution model"), developed by Flow Science Incorporated (FSI) was used to simulate effluent concentrations in the Sacramento River within close proximity of the SRWTP diffuser. FLOWMOD was used to calculate the concentration of effluent in each grid cell of the model domain for specific combinations of river and effluent flow rates. Effluent concentrations were simulated for distances downstream of the diffuser of 30 ft, 60 ft, 100 ft, 175 ft, 350 ft, and 700 ft, the latter distance corresponding to the downstream boundary of the model. Results from the model defined the average effluent concentration in the area of impact downstream of the diffuser.

FLOWMOD simulates 3-dimensional (i.e., vertical, lateral, and longitudinal) mixing of effluent with river water downstream of the SRWTP diffuser by discretizing and solving the three-dimensional, time-averaged Navier-Stokes fluid flow equations over a finite-difference grid across the river geometry. In computing turbulent incompressible fluid flows, the Navier-Stokes equations with a k-epsilon turbulence closure model are averaged over a small time-step, producing time-averaged governing equations. The time-averaged governing equations are then solved by relating the Reynolds stresses to mean flow quantities by a turbulent eddy viscosity. This is done by constructing transport equations for some of the turbulence quantities and modeling higher order terms involving turbulent kinetic energy transport.

FSI has used the FLOWMOD model to analyze the hydrodynamics of numerous flow scenarios, including flow in rivers, flow from diffusers, flow through intake structures, and flow in distribution storage reservoirs, clear wells, and basins throughout the United States. FLOWMOD modeling has been conducted for a wide variety of clients, including the City of San Francisco, Irvine Ranch Water District, the Massachusetts Water Resources Authority, the City of Phoenix, the Santa Clara Water Authority, and many others. Several of these applications have resulted in peer-reviewed publications.

In 1991 and 1992, FSI conducted field studies to measure effluent concentrations in the Sacramento River under several combinations of river and effluent flow. A dye, Rhodamine WT, was used as the tracer. Dye concentrations were measured at numerous locations up to approximately 200 ft downstream of the diffuser. FLOWMOD was later used to model river and effluent flow rates corresponding to the conditions encountered during the field study. .

Between October 2005 and November 2007, 4 additional dye studies were conducted to further characterize the plume and provide validation of the model.

The first of these studies, conducted in October 2005, (FSI, 2006b) showed that dye released from the diffuser was present in diluted concentrations near the water surface along the eastern bank of the river, where dye had not been measured in either the 1991 or 1992 dye studies. Discharge plume behavior downstream of the diffuser was otherwise consistent with observations from the 1991 and 1992 studies.

To further investigate the plume behavior on the eastern river bank, the second field study was conducted in June 2006. In this field study, data on the position and dilution of the discharge plume were gathered, and a multi-beam sonar survey was conducted to collect more detailed and more extensive river bathymetry data. In addition, river velocity profiles were measured during the June 2006 field study (FSI, 2006d)

Subsequently, a third field study of dye released from the diffuser was completed on November 3, 2006 (FSI, 2007b). This study also measured river flow velocities on November 1, 2006.

Consistent with prior studies, the November 2006 FLOWMOD simulations were unable to reproduce the effluent concentrations observed along the eastern bank of the river.

Based on the results of the dye studies, the District modified the diffuser by closing the twenty-five (25) eastern most ports of the 99 port diffuser. In addition, all remaining 8-inch reducers were removed, so that all seventy-four (74) open ports are currently 10 inches in diameter. Most recently, a final field dye study was conducted in November 2007 to study the effect of closing the diffuser ports on the distribution and dilution of the effluent plume in the Sacramento River. As before, dye concentrations were measured at specific river cross-sectional transect lines up to 700 feet downstream of the diffuser. (FSI, 2008a).

This change in diffuser configuration has eliminated the direct "short-circuiting" that carried effluent discharged from the diffuser directly to the eastern bank of the river adjacent to the diffuser under low river flow conditions. The FLOWMOD results reproduce the location and extent of the plume downstream of the diffuser initial mixing zone well. The envelope of measured dye concentrations (and inferred effluent dilution) downstream of the diffuser is also well predicted. In this study, and consistent with the Draft EIR model results (SCDERA, 2003), modeled concentrations were higher than measured concentrations of dye near the diffuser (i.e., model predictions are conservative within this zone). Farther downstream of the diffuser, dilution of the plume is quite rapid, and the model simulates the general shape of the plume and dye concentrations within the plume well. The model results also indicate that mixing occurs more quickly at higher river-to-effluent flow ratios, as expected.

Based on the diffuser modifications and subsequent November 2007 dye study, it appears that the model is accurate (conservative in the near field – less than 100 feet; very accurate from 100 to 700 feet) and validated by the field data collected in this study.

In performing the comparison between measured dye concentrations (from the field study) and modeled dye concentrations for the same flow and topography (from FLOWMOD), no parameters were changed, or "fit," for the verification runs. Rather, the FLOWMOD code was used as originally developed. A comparison of the results indicates that concentrations predicted by FLOWMOD are comparable to those measured in the field under corresponding conditions.

The FLOWMOD modeling results were parameterized into a three-dimensional array. For the 70-year simulations, average effluent concentrations at each of the downstream distances were interpolated from this three-dimensional array, according to effluent and river flow rate. These results were combined (superimposed) with results of the longitudinal dispersion modeling (described below). This interpolation method was tested with several events. For each test event, interpolation was used to obtain the concentration of effluent in the near-field zone (i.e., the value that would be used in the 70-year simulations for that test event). Though interpolated values tend to overestimate modeled values slightly, this range of error is considered conservative and acceptable.

To account for the change in diffuser configuration from 99 to 74 ports, concentrations were scaled by a ratio of 99:74 to account for the now narrower and more concentrated effluent plume to account for the diffuser modifications. Previous detailed analysis (FSI, 2007b) showed that scaling effluent concentrations from the EIR analysis (for the 99-port diffuser) adequately and conservatively matched effluent concentrations obtained from a model of the 74-port diffuser over a representative range of effluent and river flow rates, and thus was an appropriate method for use in this revised analysis.

5.3.1.5 Double Dosing

"Double dosing" is a term that describes discharge into a water body (e.g., river) under tidal influence when a discharge occurs into a parcel of water that has already been influenced by previously discharged. For a non-tidal river discharge, double dosing never occurs because river flow is always downstream; and no previously discharged effluent ever exists at the discharge location under downstream flow conditions.

The Sacramento River in the vicinity of the SRWTP discharge is affected by Delta tides and subject to periodic flow reversals when Sacramento River flow is small and Delta tides are larger. The astronomical tides in the Delta are diurnal with typically two high (flood) tides per day (i.e., approximately every twelve and half hours). Thus, during low-flow conditions in the Sacramento River there may be up to two flow reversal events per day when previously discharged effluent is carried upstream past the discharge location. When normal downstream flow resumes, this previously discharged effluent moves downstream past the discharge location and elevates the normal background pollutant concentrations in the river at the point of discharge. As the SRWTP resumes discharge to the river upon the river resuming its normal downstream flow direction, double dosing occurs over the short time period under which the effluent previously carried upstream of the outfall (during the period of flow reversal) is completely transported back downstream of the outfall.

As described in Section 4.6.6, the SRWTP Operations Plan has been developed, consistent with the NPDES permit, to regulate the SRWTP discharge during low-flow and flow reversal periods. The modeling assessment of SRWTP operations during double dosing events is one aspect of the near-field assessment and is described as part of Section 5.3.1.5

The top of **Figure 5-4** provides an idealized plan view schematic of the diffuser, river flow direction, and effluent concentration. Three major discharge phases are represented (from left to right): (1) continuous discharge with normal downstream river flow; (2) no discharge with effluent in the river moving upstream under a flow reversal; and (3) double dosing as normal downstream flow and discharge resume and mix with previously discharged effluent moving downstream. Once discharged effluent is transported upstream, the plume is colored dark blue to facilitate understanding the schematic. Double dosing occurs when the previously discharged plume (dark blue) and the newly discharged effluent (light blue) overlap (dark green). Note that the effluent plume disperses over time vertically, laterally (side to side) and longitudinally (upstream and downstream). This corresponds to a reduction in effluent concentration simulated by lighter color shading.

The bottom of **Figure 5-4** provides the corresponding idealized presentation of average effluent concentration versus time at a fixed location (just downstream of diffuser) both before and during a double dosing event. The actual effluent concentration will have a curved rather than box-shaped profile due to advection and dispersion in the river. The vertical dashed lines indicate when flow changes direction. The y-axis represents effluent concentration. In the idealized scenario presented in **Figure 5-4**, the discharge ceases and effluent concentration just downstream of the diffuser falls to zero one hour prior to flow reversal. One hour after the flow reversal begins (first dashed line), a portion of previously discharged effluent is carried back upstream past the diffuser and the effluent concentration increases (i.e., dark blue shading is less than the discharged concentration due to dilution). Note that not all of the previously discharged effluent passes upstream of the diffuser. At 8 hours the river resumes a downstream flow (i.e., second dashed line). At 9 hours, the river to effluent flow ratio increases to 14:1, and discharge resumes. Thus, newly discharged effluent mixes with previously discharged effluent and the total effluent concentration in the river increases beyond the previously high concentration (i.e., double dosing occurs; green shaded effluent contribution). After all the previously discharged effluent has passed downstream, the effluent concentration in the river decreases to the typical condition (i.e., without double dosing). Assumptions for **Figure 5-4** include constant river flow, instantaneous river flow direction changes, complete effluent mixing in the river cross-section during reversal, and discharge ceases one hour before flow reversal and resumes one hour after downstream flow resumes. So while **Figure 5-4** presents key elements of double dosing events, it is only approximate (idealized) because flow reversals are not instantaneous and percent effluent is a complex function of variable river and effluent flows, discharge period, vertical mixing, lateral dispersion, and longitudinal dispersion.

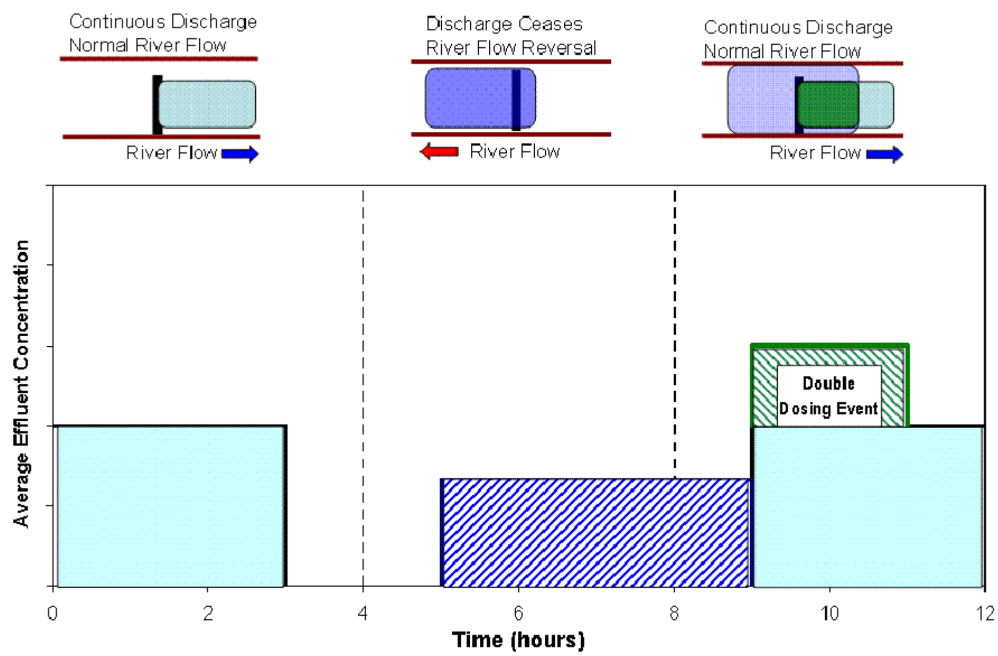

Figure 5-4 : Idealized Presentation Before and During a Double Dosing Event. The Top Schematics Provide a Plan View of a Diffuser, Effluent Plumes, and River Flow Under Three Different Discharge Phases. The Bottom Graph Indicates the Corresponding Average Effluent Concentrations Versus Time Before and During a Double Dosing Event. Vertical Dashed Lines Indicate a Change in Direction of River Flow.

5.3.1.6 Longitudinal Dispersion Model

As noted earlier, SRWTP effluent discharges to the Sacramento River cease when the river to effluent flow ratio falls below 14:1. During periods when net Sacramento River flow rates are low, the river may flow upstream during flood tides, potentially carrying previously discharged effluent upstream of the diffuser with the ambient river flow. When the flow in the river resumes in the downstream direction, the effluent discharge to the river is restarted. Under certain conditions, previously discharged effluent will be present in the river at the diffuser when the discharge resumes, thereby resulting in a "double dosing" effect. However, effluent that is carried upstream of the diffuser during a reverse-flow event will be diluted significantly by mixing. The concentration of previously discharged effluent will, therefore, be significantly lower as it passes the diffuser again (when coming back downstream) than when first discharged. Mixing occurs primarily due to two processes: (1) vertical mixing, which is very fast during flow reversals; and (2) longitudinal dispersion, which is streamwise (i.e., along-stream) mixing that occurs due to differences in flow velocity between the top and the bottom of the water column.

To account for this double-dosing effect, the longitudinal dispersion model was developed by FSI in 2000. This model was subsequently reviewed by the ITR Committee assembled to review the dynamic modeling approach for Master Plan EIR. This one-dimensional model simulates the advection and dispersion of effluent discharged to the Sacramento River, including during reverse flows. The model is used to estimate the effluent concentration in the vicinity of the diffuser following the start of a diversion event (i.e., diversion of effluent to storage when Sacramento River flows fall below that required to meet the minimum 14:1 flow ratio) and that is caused by effluent discharged prior to that diversion event. That is, the model simulates the elevated background concentrations in the vicinity of the diffuser that are caused by the presence of previously discharged effluent. The results from the longitudinal dispersion model (elevated background concentrations) are combined with the results from the FLOWMOD model (concentrations of newly-discharged effluent in the near-field zone), thus simulating the concentrations of effluent in the near-field zone that result from the presence of both effluent discharged prior to the diversion event and effluent that is discharged following a diversion event.

The longitudinal dispersion model contains 530 discrete spatial intervals, including the diffuser, and is 53,000 ft (10 miles) long. The model calculates effluent concentrations for each spatial interval at 400-second (6.7 minute) time-steps after accounting for diffusion of the effluent in the river and advection of the effluent by river flow. A modified cross-sectional area of approximately 8,000 sq ft (70% of the true cross sectional area of the river) was assumed; this is equivalent to the river cross-sectional area directly intercepted by the full length of the diffuser. The cross-sectional area was sized based on complete vertical mixing and limited lateral turbulent mixing assumptions. These assumptions are conservative given the findings of several dye studies performed by Flow Science (Flow Science 2002, 2006a, 2006b, 2006c, 2006d, 2007a, 2007b, 2008a, 2008b).

Because it is not possible to run the longitudinal dispersion model for every time-step of a 70-year simulation, the model was run for a representative sampling of events (90 events total) that spanned the range of effluent and river flow rates that may be observed during the 70-year simulations corresponding to periods of flow reversal at Freeport. Specifically, fifteen Sacramento River flow events were modeled using the longitudinal dispersion model. Thirteen events spanned the entire range of reverse-flow rates, with minimum Sacramento River flow rates ranging from near zero to the largest upstream flow rate observed in the 70-year simulation of the Existing Condition scenario. To simulate the effluent concentration that would occur in the near-field zone when the Sacramento River flow rate fell below the 14:1 flow ratio (i.e., when effluent discharge to the river ceased) but not below zero, two additional river flow events were modeled. All but one river flow event was modeled using flow rates and velocities measured at the Freeport gauging station. A synthetic flow record (i.e., results from the FDM modeling) was used for the maximum reverse-flow event, as this simulated upstream river flow rate exceeded the maximum measured historical upstream river flow rates.

For each river flow event, six effluent flow rates were simulated. As for the river flow rates, these effluent flow rates span the range that could be observed during the 70-year simulations. Thus, the longitudinal dispersion model was run for a total of 90 simulated cases spanning the entire range of conditions observed in the 70-year simulations, and the contribution of effluent discharged prior to every diversion event in the 70-year simulations (and therefore every possible double-dosing event) was interpolated from the results for the 90 simulated cases. For each combination of river flow and effluent flow, effluent discharge to the river was simulated as constant at the chosen flow rate until the river flow rate fell below 14 times the effluent flow rate, at which time the effluent flow rate was set to zero.

Two important conclusions can be drawn from the 90 longitudinal dispersion modeled cases. First, the maximum concentration of effluent that would occur in the near-field zone as a result of longitudinal dispersion (i.e., reverse flow) is just over 10%, corresponding to the 14:1 flow ratio spread over 70% of the river's cross-sectional area. Generally, reverse-flow events with higher upstream river flow rates have longer durations and lower concentrations than weaker reverse-flow events.

Figure 5-5 shows an example model output for 5 double dosing events in October 1976 during low-flow drought conditions. The top figure shows the river and effluent flow rates for the two and half day period, noon 10/1/76 through 10/3/76. The bottom two figures show the corresponding effluent concentration over this time period at 175 ft and 700 ft downstream of the diffuser. The blue line is the longitudinal dispersion model (LD) output showing elevated river background from previously discharged effluent; the magenta line is the near-field model output (FLOWMOD) from newly discharging effluent; and the yellow line shows the superposition of the two model outputs (i.e., river effluent concentration). Superposition of the longitudinal dispersion model output and the FLOWMOD output has been previously detailed (FSI, 2002). Thus, the blue line shows the previously discharged effluent (i.e., the "double dose"); the magenta shows the near-field concentration without double dosing; and the yellow line is the combined effect of double dosing on effluent concentrations in the river.

The two lower graphs in **Figure 5-5**, while very similar to the idealized graph of a double dosing event, show real world characteristics. For example, the FLOWMOD magenta line shows short peaks in effluent concentration at the start and end of each discharge event because river flow is increasing or decreasing at these times while effluent discharge is constant. As can be seen from Figure 2, the combination of the longitudinal dispersion model and FLOWMOD accurately capture the influence of astronomical tides, river and effluent flows, and SRWTP operations to accurately predict the river effluent concentration during double dosing events resulting from flow reversals in the Sacramento River.

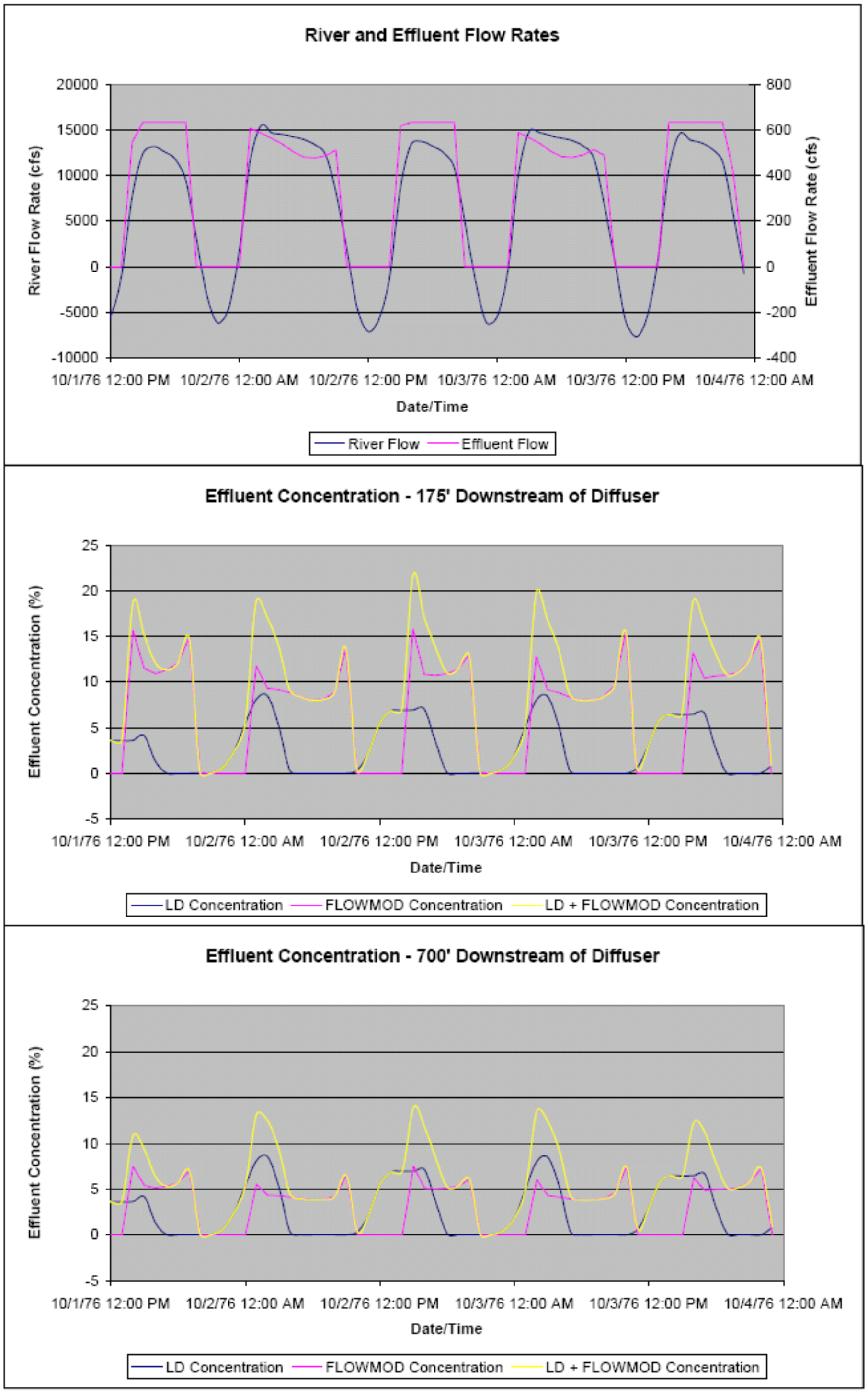

Figure 5-5: Modeled Effluent Concentrations Over Time at 175 feet and 700 feet Downstream of SRWTP Diffuser during Double Dosing Events in October 1976 from the 70-Year Simulations. Top Graph Shows Corresponding River and Effluent Flow Rates. Blue Line is the Longitudinal Dispersion Model (LD) Output Showing Elevated River Background from Previously Discharged Effluent; Magenta Line is the Near-Field Model Output (FLOWMOD) from Newly Discharged Effluent; and Yellow Line Shows Superposition of the Two (i.e., River Effluent Concentration).

5.3.1.7 Dynamic Modeling Analysis

The DYNTOX model was used to perform probabilistic analyses of near-field water quality for two scenarios—the 2020 future-with-project scenario (average dry weather flow (ADWF) of 218 mgd), and the 2020 future-without-project scenario (ADWF of 181 mgd). In addition, DYNTOX was used to perform toxicity evaluations for dissolved metals and ammonia for the 70-year simulations.

DYNTOX was developed in 1985 under U.S. EPA guidance. The model is designed for use in analysis of toxic substances and uses three different simulation techniques to calculate the frequency and magnitude of constituent concentrations and in-stream toxicity at different effluent discharge levels. Since 1985, the program has been upgraded to include the modeling of ammonia and hardness-dependent metals toxicity, based on U.S. EPA procedures.

DYNTOX can use three different probabilistic modeling methods: (1) continuous simulation; (2) Monte Carlo simulations; and (3) log normal analysis. For this project, continuous simulation was used with effluent and receiving water data distributions. The continuous simulation capability was used so that accurate river and effluent flow rates (and hence dilution), which were simulated as described above, could be used as inputs to the model. Effluent and river water quality distributions, which were developed as described in a subsequent section, were then randomly sampled. Thus, the model assessed the impact of effluent discharges on receiving water quality over the entire range of feasible conditions (encapsulated by the 70-year simulated record).

Statistical theory dictates that the distribution of results from numerous repetitive simulations will characterize the actual distribution of potential outcomes (i.e., the probabilities of various outcomes). This distribution can then be used to define the frequency and duration of constituent concentrations and toxicity that could occur under the conditions simulated. Because this type of analysis utilizes a probabilistic approach applied to hundreds of thousands of possible combinations of flow and water quality conditions, it is particularly useful for evaluating the likelihood of "worst-case" conditions and for evaluating the frequency of occurrence of in-stream concentrations at specific locations of interest.

The DYNTOX code was modified to support the SRWTP Master Plan EIR water quality modeling. The code changes did not affect the "core" DYNTOX calculations, but rather expanded the model's computational capabilities. The specific changes included:

- Modifications to use one hour time-steps instead of daily time-steps for the continuous simulation, thus allowing assessment of compliance with criteria based on an averaging period of one hour.
- Modifications to simulate concentrations at seven different locations downstream of the diffuser according to the dilutions calculated using FLOWMOD and the longitudinal dispersion model.
- Modifications to update the ammonia criteria equations from those used in the U.S. EPA's 1984 criteria to those derived for the 1999 criteria.

The concentrations of all water quality constituents, except pH, were calculated on the principle of mass conservation (i.e., mass balance). Because pH may not behave conservatively when mixing occurs, DYNTOX calculates the new pH by additionally considering the alkalinity of both the river and effluent waters.

The goal of the DYNTOX calculations is to model the concentrations of the various water quality constituents at seven distances downstream of the diffuser. By using hourly values for 70 years, more than 600,000 data points were calculated, which are fully representative of the possible concentration distributions from a statistical point of view. Therefore, DYNTOX was used to calculate one water quality value for each modeled constituent, for each hour in the 70-year simulation period, for each of six near-field distances downstream of the diffuser. The effluent and upstream river constituent concentrations were generated from the input effluent and river statistical distributions—which are based on available data (see below)—and an algorithm that randomly samples the input distributions. The large number of hourly data points generated (600,000+) is sufficient to generate a representative concentration distribution in the near-field zone downstream of the diffuser, for each water quality constituent.

The input parameters to the DYNTOX model were (a) hourly river flow rate, (b) river water quality, and (c) effluent flow rate and (d) effluent quality. Analyses of the interdependence of these various parameters were examined prior to use of the DYNTOX model. Where important interrelationships were observed, these functional relationships were incorporated into the DYNTOX input. Additional information regarding model development can be found in *Water Quality Modeling Methodology for the Sacramento Regional Wastewater Treatment Plant, 2020 Master Plan EIR* (this document included as Appendix F in 2020 Master Plan DEIR; SCDERA, 2003)..

5.3.2 Site Selection for Far-Field Evaluation

Using the modeling package discussed in the above sections, the hourly percent contribution[8] of SRWTP effluent in the water column at select far-field locations can be modeled. Twelve far-field locations downstream of the SRWTP discharge were selected for modeling of hourly percent SRWTP effluent contribution as a means to identify the extent and magnitude of SRWTP effluent reaching various far-field Delta locations. These sites were selected due to either their proximity to a drinking water intake, agricultural water supply intake, Delta water quality compliance point, or a location of general water quality interest in the Delta. These 12 far-field Delta modeling locations are shown in **Figure 5-3**, and include those sites labeled as “SRWTP percent effluent assessment locations” and “water quality impacts assessment locations” (with the exception of the Sacramento River at Freeport location which was used to determine upstream ambient water quality conditions used as one of the inputs to the dynamic model). The SRWTP percent effluent contribution simulations act as a first step used to calculate the incremental concentration of a constituent at a far-field location; however, the ambient concentrations of a constituent in the far-field is not directly reflected by the percent effluent contribution simulation. To fully evaluate the potential impact of the proposed permitted condition (218 mgd(ADWF)) on far-field locations throughout the Delta, ambient data must be available for the constituents of interest at the far-field locations. Those sites labeled as

[8] Percent contribution of SRWTP effluent at a given location is defined as the percent of a volume of water taken from the water column at a particular location that is comprised of SRWTP effluent. For example, if the percent contribution of SRWTP effluent at location X is 3%, then 3% of a volume of water at that site is comprised of SRWTP effluent.

"SRWTP percent effluent assessment locations" in **Figure 5-3** represent Delta locations for which adequate ambient water quality data covering the period January 1998 through July 2008 are not available, and therefore were not ultimately modeled in terms of potential water quality impacts, via estimated changes in far-field pollutant concentrations, due to the proposed increase in SRWTP discharge from 181 mgd (ADWF) to 218 mgd (ADWF). However, it is believed that these percent effluent assessment locations still provide useful information in terms of the potential for water quality impacts based on the amount of SRWTP effluent estimated to reach a particular far-field location.

5.3.2.1 Far-Field Percent Effluent

Distributions of the modeled percent effluent at far-field locations of interest are listed in **Table 5-5** corresponding to the current permit condition (181 mgd). The modeled percent effluent at far-field sites corresponding to the proposed permit condition (218 mgd) are listed for select probabilities of recurrence in **Table 5-6**. The increment in percent effluent at far-field locations corresponding to the difference between 218 and 181 mgd discharge rates are presented in **Table 5-7**.

As noted above, due to the lack of sufficient ambient water quality data covering the period 1998 – 2008, five far-field locations were modeled only in terms of the percent of SRWTP effluent contribution estimated to comprise a given volume of water at these sites under the current permitted (181 mgd (ADWF)) and proposed permitted (218 mgd (ADWF)) discharge conditions. The increment of constituent concentration is for a given location is proportional to the increment of percent effluent contribution at that location. Even though modeled, concentration-based results due to the proposed project were not generated for the South Fork of the Mokelumne River, for example, it is reasoned that the median 0.14% SRWTP effluent contribution increment (see **Table 5-7**) estimated for this site as a result of an increase in permitted discharge (218 mgd (ADWF)) would have a lesser impact on ambient water quality at this location than the median 0.35% SRWTP effluent contribution increment estimated for the Sacramento River at Greene's Landing/Hood would have at that location under a 218 mgd (ADWF) SRWTP discharge rate.

Table 5-5: Daily Average Percent SRWTP Effluent at Far-Field Locations for 181 mgd Discharge Rate.

	Distribution of SRWTP Effluent Contribution				
Location	**Mean**	**5%**	**50%**	**95%**	**99.91%**
Greene's Landing/Hood	1.86	0.53	1.81	3.41	5.03
Emmaton	1.63	0.39	1.65	2.80	3.81
San Joaquin River at Stockton	0.12	0.00	0.01	0.64	1.34
CCWD PP#1 at Rock Slough	1.41	0.15	1.47	2.59	3.53
Los Vaqueros Intake	1.30	0.05	1.36	2.53	3.33
Clifton Court Forebay – Banks Delta Pumping Plant	1.25	0.03	1.30	2.60	3.41
Delta Mendota Canal Headworks	0.78	0.01	0.80	1.71	2.21
South Fork Mokelumne River	1.04	0.00	0.69	3.07	4.24
City of Stockton Delta Water Supply Project Intake	1.32	0.02	1.40	2.70	3.41
CCWD Alternative Intake	1.06	0.00	1.14	2.23	2.93
Grant Line Canal	0.01	0.00	0.00	0.02	0.82
Chipps Island	1.09	0.37	1.10	1.74	2.38

Table 5-6: Daily Average Percent SRWTP Effluent at Far-Field Locations for 218 mgd Discharge Rate.

	Distribution of SRWTP Effluent Contribution				
Location	**Mean**	**5%**	**50%**	**95%**	**99.91%**
Greene's Landing/Hood	2.24	0.63	2.18	4.12	6.02
Emmaton	1.95	0.47	1.98	3.35	4.56
San Joaquin River at Stockton	0.14	0.00	0.01	0.76	1.60
CCWD PP#1 at Rock Slough	1.69	0.18	1.76	3.10	4.21
Los Vaqueros Intake	1.56	0.06	1.63	3.03	3.98
Clifton Court Forebay – Banks Delta Pumping Plant	1.50	0.04	1.55	3.11	4.08
Delta Mendota Canal Headworks	0.93	0.01	0.96	2.05	2.65
South Fork Mokelumne River	1.25	0.00	0.83	3.66	5.06
City of Stockton Delta Water Supply Project Intake	1.58	0.02	1.68	3.23	4.07
CCWD Alternative Intake	1.27	0.00	1.37	2.67	3.50
Grant Line Canal	0.01	0.00	0.00	0.03	0.99
Chipps Island	1.31	0.44	1.33	2.10	2.86

Table 5-7: Daily Average Increment of Percent SRWTP Effluent at Far-Field Locations Reflecting the Difference Between 218 and 181 mgd Discharge Rate Scenarios.

Location	Distribution of SRWTP Effluent Contribution				
	Mean	**5%**	**50%**	**95%**	**99.91%**
Greene's Landing/Hood	0.38	0.11	0.35	0.72	1.12
Emmaton	0.32	0.08	0.33	0.55	0.74
San Joaquin River at Stockton	0.02	0.00	0.00	0.13	0.26
CCWD PP#1 at Rock Slough	0.28	0.03	0.29	0.51	0.69
Los Vaqueros Intake	0.26	0.01	0.27	0.50	0.65
Clifton Court Forebay – Banks Delta Pumping Plant	0.25	0.01	0.26	0.51	0.67
Delta Mendota Canal Headworks	0.15	0.00	0.16	0.34	0.43
South Fork Mokelumne River	0.21	0.00	0.14	0.59	0.84
City of Stockton Delta Water Supply Project Intake	0.00	0.00	0.28	0.53	0.66
CCWD Alternative Intake	0.21	0.00	0.23	0.44	0.57
Grant Line Canal	0.00	0.00	0.00	0.01	0.16
Chipps Island	0.22	0.07	0.22	0.35	0.48

5.3.2.2 Far-Field Data Availability

The far-field locations modeled for the anti-degradation analysis and data availability by constituent at these sites are listed in **Table 5-8.** Constituents not listed in the table are either not of concern in the far-field or did not have sufficient data at any of the selected far-field locations. As noted above, due to the lack of sufficient ambient water quality data covering the period January 1998 through July 2008, seven far-field locations were modeled only in terms of the percent of SRWTP effluent estimated to comprise a given volume of water in the water column at any of these five locations. The modeled, concentration-based results from the far-field water quality impacts assessments are included in the individual pollutant discussions in beginning in Section 5.4.

Table 5-8: Data Availability for Far-Field Locations and Constituents of Concern.

Location	Constituent							
	NH_3	Tot. N	NO_3	TKN	Tot. P	EC	Cl^-	TOC
Greene's Landing/Hood	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Emmaton	No	No	No	No	No	Yes	No	No
San Joaquin River at Stockton	No	No	No	No	No	No	No	No
CCWD PP#1 at Rock Slough	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Los Vaqueros Intake	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clifton Court Forebay - Banks Delta Pumping Plant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Delta Mendota Canal Headworks	No	No	No	No	No	No	No	No
South Fork Mokelumne River	SRWTP Percent Effluent Assessment Location							
City of Stockton Delta Water Supply Project Intake	SRWTP Percent Effluent Assessment Location							
CCWD Alternative Intake	SRWTP Percent Effluent Assessment Location							
Grant Line Canal	SRWTP Percent Effluent Assessment Location							
Chipps Island	SRWTP Percent Effluent Assessment Location							

5.4 ASSESSMENT OF CATEGORY 1 CONSTITUENTS

As noted in Section 5.2, the selection of constituents for the antidegradation analysis was based in part on those constituents for which there are water quality objectives or criteria applicable to the Delta, and based in part on whether a constituent is associated with a known water quality concern in downstream receiving waters. A final consideration for inclusion in the analysis is that the constituent is detected in SRWTP effluent at a frequency greater than 10%. The selection process resulted in 44 constituents being identified for some level of water quality impacts assessment using the quantitative dynamic modeling techniques described in earlier sections of this report. As noted earlier, these 44 constituents were further subdivided into three categories with respect to the breadth of potential impacts they represent with respect to localized, near-field impacts downstream of the SRWTP discharge, as well as impacts to the Delta ecosystem and its water supply.

Category 1 constituents are those of concern regionally and, in particular, with respect to potential impacts on the Delta ecosystem and its water quality. The eleven (11) constituents assigned to this category (see below) received the broadest level of assessment among all of the water quality parameters considered in the antidegradation analysis.

Ammonia	**Total Phosphorus**	**Total Organic Carbon**
Total Nitrogen	**Electrical Conductivity**	**Mercury**
Nitrate plus Nitrite	**Total Dissolved Solids**	**Dissolved Oxygen**
Total Kjeldahl Nitrogen	**Chloride**	

Category 1 constituents were evaluated with respect to potential receiving water impacts resulting from an increase in permitted SRWTP discharge from the current permitted condition (181 mgd (ADWF)) to the proposed permitted condition (218 mgd (ADWF)) using the following water quality assessments:

- Near-Field Impacts Analysis
- Comparison to Water Quality Objectives
- Far-Field Impacts Analysis
- Surface Water Trend Analysis
- Consideration of Issues of Concern and Overall Evaluation of Constituent

General descriptions of these assessments and their presentation within individual pollutant evaluations are described below in more detail.

5.4.1 Near-Field Impacts Analysis

Near-field pollutant impact analyses include the presentation of modeled in-plume concentration results for a pollutant at varying distances downstream of the SRWTP diffuser: 30, 60, 100, 175, 350, and 700 feet. Modeled concentration results are presented in tabular form for both the current permitted condition (181 mgd (ADWF)) and the proposed permitted condition (218 mgd (ADWF)). These modeled data presentations are followed by the tabular presentation of the in-plume concentration increment due to the proposed 37 mgd (ADWF) increase in permitted

SRWTP discharge. The concentration increment is calculated by subtracting the modeled in-plume concentration for a pollutant at the discharge flow rate of 181 mgd (ADWF) from the modeled in-plume concentration of the pollutant at the discharge flow rate of 218 mgd (ADWF). For example, to determine the 99.91 percentile concentration increment, the 99.91 percentile modeled concentration at 181 mgd is subtracted from the 99.91 percentile modeled concentration at 218 mgd.

These tabular data presentations are followed by graphical presentations showing various percentile distributions (5%, 25%, 50%, 75%, 95%, 99.91%, and a mean) of the modeled in-plume concentration of a pollutant at 700 feet downstream of the SRWTP diffuser at both the 181 mgd (ADWF) "baseline" discharge flow rate and the 218 mgd (ADWF) proposed flow rate. In instances where the modeled pollutant concentration at 218 mgd (ADWF) results in an increase in receiving water concentration above the 181 mgd (ADWF) condition, the modeled pollutant concentration at 218 mgd (ADWF) appears as a blue-colored increment stacked on top of the baseline concentration. In instances where the modeled pollutant concentration at 218 mgd (ADWF) results in a decrease in receiving water concentration below that modeled for the 181 mgd (ADWF) condition, no such blue-colored increment is visible in the graph.

The next graphical data presentation included in all near-field impacts analyses is a graph showing the median modeled concentration of a pollutant at six distances downstream of the SRWTP diffuser at both the 181 mgd (ADWF) baseline discharge flow rate and the 218 mgd (ADWF) proposed flow rate. Similar to the explanation provided for the previous graph, increases in modeled in-plume pollutant concentrations at 218 mgd (ADWF) appear as blue-colored increments stacked on top of 181 mgd (ADWF) modeled concentrations. In instances where the modeled pollutant concentration at 218 mgd (ADWF) results in a decrease in receiving water concentration below that modeled for the 181 mgd (ADWF) condition, no such blue-colored increment is visible in the graph.

5.4.2 Comparison to Water Quality Objectives

Where a water quality objective or criterion exists for a constituent, the DYNTOX model was used to evaluate in-plume compliance with the objective or criterion downstream of the SRWTP diffuser. Where applicable, pollutant evaluations include the tabular presentation of DYNTOX modeled in-plume percent exceedance frequency for a constituent at 30, 60, 100, 175, 350, and 700 feet downstream of the SRWTP diffuser under the proposed permitted condition (218 mgd (ADWF)). Where a constituent has more than one criterion, for example CTR freshwater acute and chronic water quality criteria, compliance frequencies for all relevant criteria were evaluated using the DYNTOX model and presented for the pollutant.

The frequency of exceedance is determined by comparing the pollutant concentration generated by DYNTOX for each hour time-step in the 70-year period to the applicable criteria. For the acute criteria, exceedance percentages are calculated as the number of hourly values that exceed the criteria out of 613,420 (*i.e.*, 70 x 365 x 24 + 17.5 leap days x 24). For 30-day criteria, a 30-day average is generated for each hourly time step after the first 30 days (720 values) and the percent exceedance is based on the number of 30-day averages exceeding the criteria out of 612,900 values. Four day (4-day) average criteria exceedances are determined based on the number of 4-day averages exceeding the criteria out of 612,324 values.

5.4.3 Far-Field Impacts Analysis

Far-field pollutant impact analyses provide a graphical presentation showing various percentile distributions (5%, 25%, 50%, 75%, 95%, 99.91%, and a mean) of the modeled concentration of a pollutant in the Sacramento River at Greene's Landing/Hood under the proposed permitted condition (218 mgd (ADWF)) stacked on top of the median ambient baseline condition (181 mgd (ADWF)). Similar graphical presentations of modeled far-field data at locations downstream of Greene's Landing/Hood are not included in pollutant evaluations because the greatest far-field water quality impacts resulting from the proposed 37 mgd (ADWF) increase in permitted SRWTP discharge are estimated to occur at Greene's Landing/Hood as a result of this location receiving a larger percent contribution of SRWTP effluent relative to other downstream locations. This is because the increment of constituent concentration for a given location is proportional to the increment of percent effluent contribution at that location.

Median modeled concentration increments due to the proposed permitted condition (218 mgd (ADWF)) are provided in tabular form for far-field locations (Greene's Landing/Hood, CCWD Pumping Plant #1 at Rock Slough, CCWD Los Vaqueros Intake, and Banks Delta Pumping Plant) where sufficient ambient water quality data exist (covering the period 1998 – 2008) to allow for the calculation of median and 95th percentile ambient concentrations under a 181 mgd (ADWF) SRWTP discharge rate. Ambient baseline water quality concentrations were determined by calculating a modeled ambient increment from 154 mgd to 181 mgd and adding this increment to either the median or 95th percentile of available ambient water quality data. This calculation provides an estimate of ambient water quality reflective of the SRWTP discharging at its current permitted discharge rate of 181 mgd (ADWF). In each far-field analysis, a tabular data presentation provides information regarding a typical or median (50th percentile) concentration increment from 181 mgd to 218 mgd that could be observed in the far-field on top of median (50th percentile) and substantially elevated (95th percentile) ambient water quality conditions. The median concentration increment is calculated by subtracting the median modeled concentration at 181 mgd from the median modeled concentration at 218 mgd.

This tabular data presentation is followed by a graphical presentation of these data where the modeled median increment due to the proposed permitted condition (218 mgd (ADWF)) appears as a blue-colored increment on top of bars representing 50th and 95th percentile ambient concentrations under a 181 mgd (ADWF) SRWTP discharge rate. Modeled far-field pollutant increments for those locations (Sacramento River at Emmaton, Delta Mendota Canal Headworks, and San Joaquin River at Stockton) lacking sufficient ambient water quality data covering the period January 1998 through July 2008 for estimation of concentration-based potential water quality impacts are provided in Appendix H. It should be noted that the Sacramento River at Emmaton location was only evaluated with respect to the proposed project's potential water quality impacts on electrical conductivity due to (a) this site's status as a Delta salinity compliance location and (b) a deficiency of ambient water quality data for other constituents covering the period January 1998 through July 2008.

Statistical power analyses were also performed for Category 1 constituents as a mean to determine the minimum sample size required to observe a modeled increment in pollutant concentration at a far-field location. *Power* is broadly defined as "the probability that a statistical significance test will reject the null hypothesis for a specified value of an alternative hypothesis. Stated differently, power is "the ability of a test to detect an effect, given that the effect actually exists." Considering the small magnitude of many of the modeled concentration increments and the variability in ambient concentrations of many constituents, the question arises regarding how much effort, in terms of additional water quality monitoring, would be required in order to detect a modeled concentration increment for a particular pollutant at a given far-field monitoring location. Power analyses performed on the far-field concentration increments modeled for Category 1 constituents provided results ranging from just a handful to several million additional water quality data points required to detect a modeled increment. However, with reference to concentration increments that could likely be detected with a few hundred additional water quality samples, these samples could not be collected in relatively rapid succession over a short period of time because this type of sampling effort would preclude the identification of the existing variability in Delta water quality conditions due to seasonal changes and water project operations. To this end, increased frequency of water quality monitoring with the purpose of detecting a modeled concentration increment resulting from the proposed 37 mgd (ADWF) increase in permitted SRWTP discharge would need to be implemented over multiple monitoring seasons.

5.4.4 Surface Water Trend Analysis

As a means to determine whether or not ambient water quality concentrations for Category 1 constituents have changed upstream and downstream of the SRWTP discharge over time, a trend analysis of regional surface water data was conducted. After preliminary data distribution testing was performed and data were transformed accordingly, single and multiple regression analyses were performed to determine whether the ambient data appear to be affected by time, season, and/or river flow. Regression analysis was used to determine whether regional ambient water quality data show statistical trends with time, season, and/or river flow, the direction of the trend, and the statistical significance of each relationship. A more detailed description of the trend analysis effort is included in Appendix G.

Trend analysis results are used to determine whether incremental increases in modeled pollutant concentrations due to a 37 mgd (ADWF) increase in permitted SRWTP discharge would impact a far-field location already experiencing an historic upward trend in a pollutant’s concentrations, currently encountering a decrease in a pollutant’s concentration over time, or meeting with no discernable change in a pollutant’s concentration during the period analyzed.

5.4.5 Consideration of Issues of Concern and Overall Evaluation of Constituent

Category 1 pollutant evaluations are concluded with a consideration of the relevant, salient issues surrounding a constituent in terms of concerns related to aquatic toxicity, bioaccumulation in aquatic organisms, habitat and ecosystem integrity, drinking water supply, agricultural water supply, and/or contact recreation. The results of near-field and far-field water quality impacts analyses, evaluations of DYNTOX modeled in-plume water quality objective compliance frequencies at the proposed permitted condition (218 mgd (ADWF)), and trend analyses are discussed in the context of relevant issues of concern surrounding a given constituent. All of these elements are used to provide an overall evaluation of the potential near- and far-field water quality impacts for a pollutant due to the proposed 37 mgd (ADWF) increase in permitted SRWTP discharge.

The Category 1 pollutant evaluations that follow are organized in a similar manner and, where necessary, changes in the organization of individual pollutant evaluations are noted.

5.4.6 Ammonia

Ammonia discharges may have the potential to impact water quality directly as evaluated by acute and chronic water quality criteria as discussed below in Section 5.4.6.2. In addition, ammonia discharges may have the potential, under certain conditions, to impact dissolved oxygen levels downstream of the SRWTP discharge. The ammonia impacts are discussed in Section 5.4.16. As the discharge flow rate is increased, limitation of the oxygen demanding substances during periods of higher river temperature and lower river flow rate (i.e., summer months) becomes necessary to ensure the discharge does not result in excursions below the dissolved oxygen Basin Plan objective downstream of the discharge. The District evaluated seasonal operation of ammonia control in the *Low Dissolved Oxygen Prevention Assessment* (SRCSD, 2009b) as an alternative to control oxygen demanding substances in the effluent, thereby controlling the potential dissolved oxygen sag downstream of the SRWTP. To comply with the dissolved oxygen Basin Plan objective, it is sufficient to implement summer operations from May through September limiting the oxygen demanding substances in SRWTP effluent. Under winter operations from October through April, it would not be necessary to limit oxygen demanding substances to comply with the Basin Plan objective. Therefore, the near-field and far-field analyses were conducted for summer and winter operating conditions. The projected ammonia effluent concentrations at 181 and 218 mgd are shown in **Table 5-2**, and reflect summer operations controlling oxygen demanding substances through control of effluent ammonia concentrations (SRCSD, 2009b).

5.4.6.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for ammonia at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from ammonia measured in the Sacramento River at Freeport. For summer operations, effluent quality model inputs were derived based on projected ammonia concentrations needed to meet the dissolved oxygen Basin Plan objective and from ammonia measured in SRWTP effluent for the winter operations. The modeled in-plume ammonia concentrations for the existing permitted condition (181 mgd) and summer operations are shown in **Table 5-9**. Modeled in-plume ammonia concentrations at the proposed permitted condition (218 mgd) and summer operations are shown in **Table 5-10**. The modeled in-plume ammonia concentrations for the existing permitted condition (181 mgd) and winter operations are shown in **Table 5-11**. Modeled in-plume ammonia concentrations at the proposed permitted condition (218 mgd) and winter operations are shown in **Table 5-12**.

Table 5-9: Modeled Summer Operations In-Plume Ammonia Concentration (mg/L as N) at Varying Distances Downstream of the SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	4.01	2.57	1.72	1.19	0.76	0.64
Median	3.73	2.32	1.53	1.06	0.67	0.55
95%-ile	8.32	5.60	3.75	2.57	1.66	1.43
99.91%-ile	12.00	9.24	6.61	4.86	3.39	2.94
5%-ile	0.38	0.38	0.38	0.36	0.29	0.23

Table 5-10: Modeled Summer Operations In-Plume Ammonia Concentration (mg/L as N) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	3.88	2.48	1.66	1.14	0.72	0.60
Median	3.78	2.30	1.50	1.03	0.65	0.53
95 %-ile	7.54	5.23	3.54	2.42	1.53	1.29
99.91 %-ile	10.20	7.89	5.61	4.04	2.83	2.50
5 %-ile	0.18	0.18	0.18	0.18	0.18	0.17

Table 5-11: Modeled Winter Operations In-Plume Ammonia Concentration (mg/L as N) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	5.56	3.55	2.37	1.62	1.03	0.85
Median	5.18	3.20	2.09	1.43	0.89	0.72
95%-ile	11.5	7.78	5.20	3.55	2.27	1.94
99.91%-ile	16.8	12.8	9.19	6.74	4.69	4.05
5%-ile	0.48	0.48	0.48	0.47	0.37	0.30

Table 5-12: Modeled Winter Operations In-Plume Ammonia Concentration (mg/L as N) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	6.52	4.14	2.74	1.86	1.16	0.95
Median	6.35	3.83	2.48	1.67	1.03	0.84
95 %-ile	12.7	8.80	5.93	4.03	2.52	2.10
99.91 %-ile	17.3	13.3	9.45	6.78	4.73	4.16
5 %-ile	0.21	0.21	0.21	0.21	0.21	0.21

The incremental differences of modeled in-plume ammonia concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented for summer operating conditions in **Table 5-13** and for winter operating conditions in **Table 5-14**. At 218 mgd for summer operating conditions, the median incremental increase in ammonia concentrations would range from 0.05 mg/L as N at a distance of 30 feet downstream from the diffuser to -0.01 mg/L as N at a distance of 700 feet downstream from the diffuser . The negative increments reflect the slightly lower mass load of ammonia discharged at 218 mgd to comply with the dissolved oxygen Basin Plan objective downstream of the discharge. At 218 mgd, the median incremental increase in ammonia concentrations would range from 1.17 mg/L as N at a distance of 30 feet downstream from the diffuser to 0.11 mg/L as N at a distance of 700 feet downstream from the diffuser.

Table 5-13: Increments of Modeled Summer Operations In-Plume Ammonia Concentrations at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L as N)					
	30 ft	**60 ft**	**100 ft**	**175 ft**	**350 ft**	**700 ft**
Mean	-0.13	-0.09	-0.07	-0.05	-0.04	-0.03
Median	0.05	-0.02	-0.03	-0.03	-0.02	-0.01
95%-ile	-0.78	-0.37	-0.21	-0.15	-0.13	-0.14
99.91%-ile	-1.80	-1.35	-1.00	-0.82	-0.56	-0.44
5%-ile	-0.20	-0.20	-0.20	-0.18	-0.11	-0.06

Table 5-14: Increments of Modeled Winter Operations In-Plume Ammonia Concentrations at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L as N)					
	30 ft	**60 ft**	**100 ft**	**175 ft**	**350 ft**	**700 ft**
Mean	0.96	0.59	0.38	0.24	0.13	0.10
Median	1.17	0.63	0.39	0.24	0.14	0.11
95%-ile	1.20	1.02	0.73	0.48	0.25	0.16
99.91%-ile	0.50	0.50	0.26	0.04	0.04	0.11
5%-ile	-0.27	-0.27	-0.27	-0.25	-0.16	-0.09

The probability distributions of modeled summer ammonia concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-6**. The median summer ammonia concentrations in the discharge plume at 181 mgd and the median incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-7**. It should be noted that in general, ammonia concentrations within the plume are lower for the proposed 218 mgd discharge than for the 181 mgd discharge due to projected lower ammonia concentrations for summer operations at 218 mgd, however the increments are exceedingly small and plot within the line thickness of the graph.

The probability distributions of modeled winter ammonia concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-8**. The median winter ammonia concentrations in the discharge plume at 181 mgd and the median incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-9**.

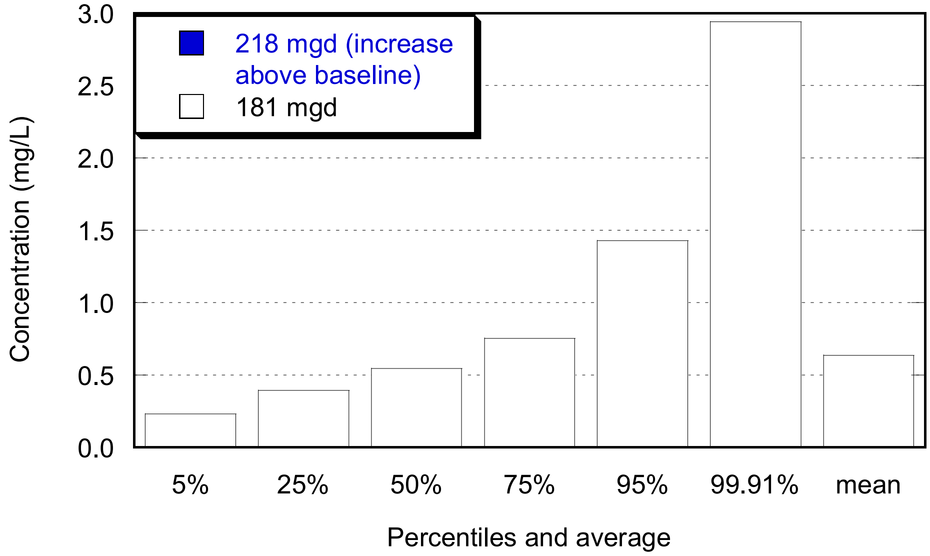

Figure 5-6: Distribution of Modeled Summer Operations Ammonia Concentrations (mg/L as N) 700 feet Downstream from SRWTP Diffuser.

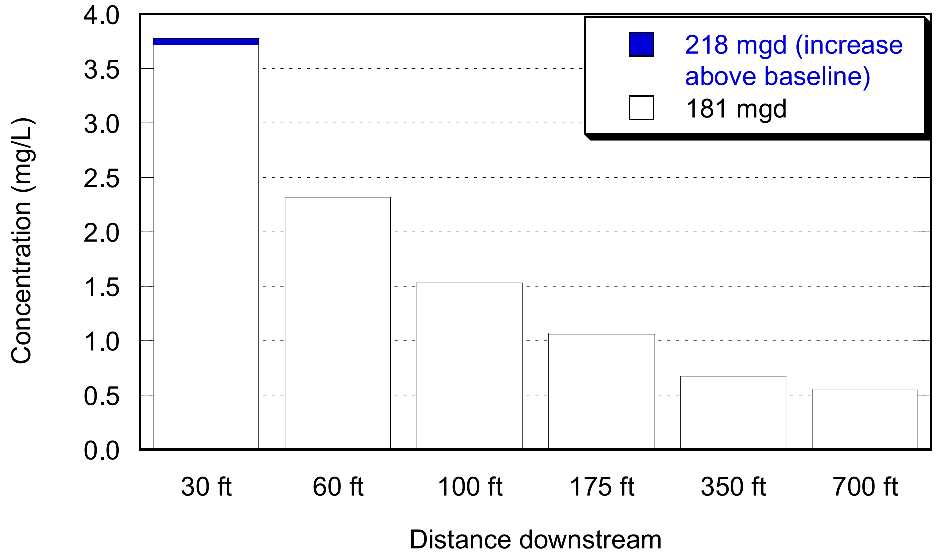

Figure 5-7: Median Modeled Summer Operations Ammonia Concentration (mg/L as N) Downstream of SRWTP Diffuser.

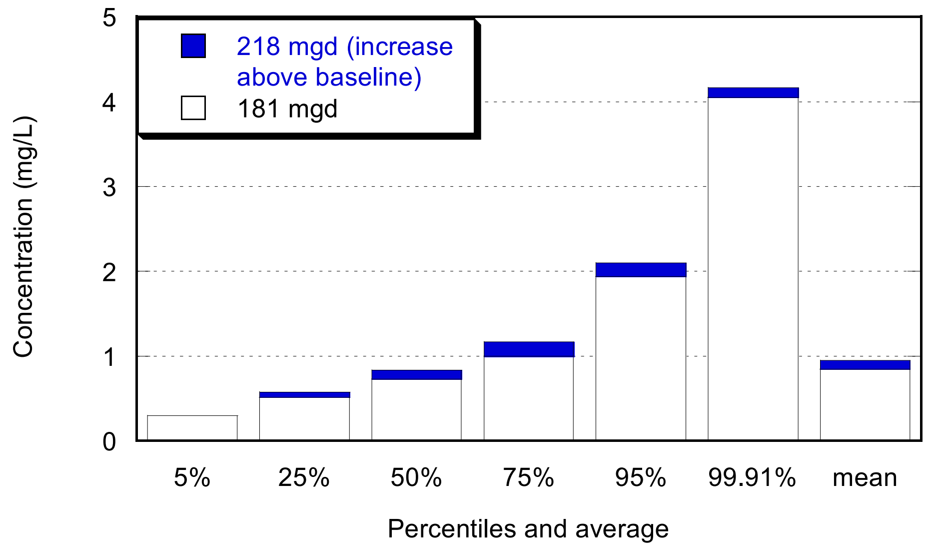

Figure 5-8: Distribution of Modeled Winter Operations Ammonia Concentrations (mg/L as N) 700 feet Downstream from SRWTP Diffuser.

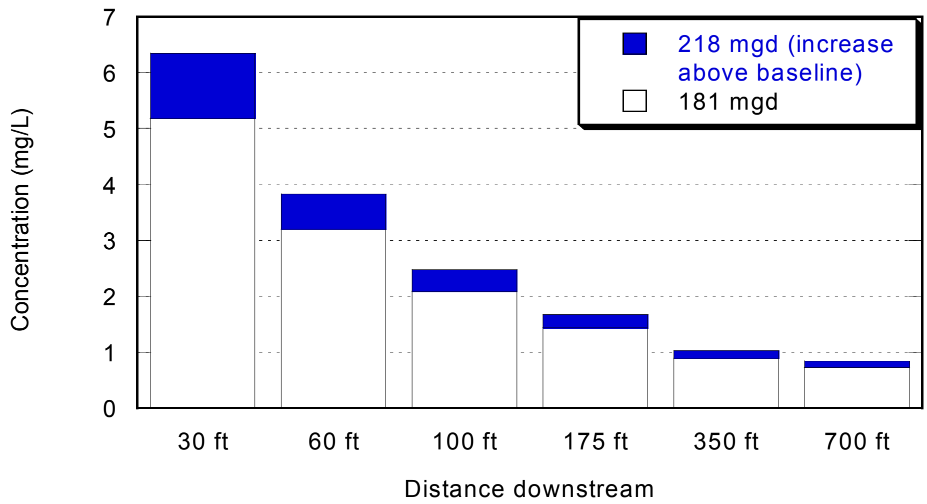

Figure 5-9: Median Modeled Winter Operations Ammonia Concentration (mg/L as N) Downstream of SRWTP Diffuser.

5.4.6.2 Comparison to Water Quality Objectives

The applicable water quality objective for ammonia in the Sacramento River is the narrative toxicity objective in the Basin Plan. For ammonia, the Central Valley Regional Water Board uses the 1999 U.S. EPA ambient freshwater aquatic life criteria to interpret the narrative toxicity objective.

The U.S. EPA criteria for ammonia consist of acute criteria with an averaging period of one-hour, and two chronic criteria, with averaging periods of 4-days and 30-days. The acute criterion is dependent on pH; the chronic criterion is dependent on pH and temperature. Criteria are more stringent when salmonids are present in the receiving water. For this analysis, the Salmonids present criteria are applicable and have been used. Although the criteria are based on total ammonia concentrations, the toxic fraction of concern is the un-ionized ammonia concentration. The percentage of un-ionized ammonia present at a given concentration of total ammonia is based on pH and temperature.

The percent exceedances of the acute and chronic freshwater objectives for ammonia at various distances downstream from the SRWTP diffuser are listed in **Table 5-15** for summer operations and **Table 5-16** for winter operations. As shown in the tables, at 218 mgd, the concentrations of ammonia are projected to exceed the 30-day chronic criteria values in the discharge plume near the point of discharge. Since the chronic criteria are based on a 30-day period of exposure, it is not projected that the ammonia concentrations which exceed those criteria at a distance of up to 175 feet downstream from the SRCSD diffuser during summer operations or between 175 feet and 350 feet during winter operations would adversely impact fish, since the plume is located along the bottom half of the river and small fish floating through the plume would be exposed for periods of minutes rather than days. In addition, exceedances are not projected for the 4-day chronic criteria under summer operations and infrequently within 60 feet of the diffuser under winter operating conditions. For larger fish, the relatively small section of the plume with elevated ammonia levels can be avoided since it occupies a relatively small portion of the overall river cross section.

Table 5-15: DYNTOX Modeled Percent Exceedance Frequency for Summer Operations Ammonia at Various Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
4-day Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
30-day Chronic	35.75%	1.65%	0.00%	0.00%	0.00%	0.00%

Table 5-16: DYNTOX Modeled Percent Exceedance Frequency for Winter Operations Ammonia at Various Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
4-day Chronic	0.47%	0.00%	0.00%	0.00%	0.00%	0.00%
30-day Chronic	76.7%	53.1%	18.5%	0.11%	0.00%	0.00%

5.4.6.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-9** and **Table 5-11**) and proposed discharge (see **Table 5-10** and **Table 5-12**) illustrate similar characteristics in terms of ammonia concentration magnitude over distance from the SRCSD diffuser. Ammonia concentrations are greater near the diffuser, since the effluent concentration is generally greater than the receiving water concentration. Furthermore, as listed in **Table 5-14**, the proposed increase in SRWTP effluent discharge would slightly increase ammonia concentrations in the Sacramento River throughout the modeled plume based on winter operating conditions, with the greatest incremental increases occurring near the diffuser and then gradually tapering off with downstream distance. However, as seen in **Table 5-13**, the proposed increase in SRWTP effluent discharge would slightly decrease ammonia concentrations in the Sacramento River throughout the modeled plume based on the summer operating conditions. This occurs because the summer operations would result in lower ammonia effluent concentrations at 218 mgd to ensure compliance with the Basin Plan dissolved oxygen objective.

5.4.6.4 Far-Field Model Analysis Results

Far-field modeling results were used to determine incremental contributions of ammonia resulting from an increase in SRWTP discharge from 181 mgd to 218 mgd at seven far-field locations. The far-field modeled results are shown graphically in **Figure 5-10**through **Figure 5-13**. **Figure 5-10** and **Figure 5-11** show percentile modeled incremental change in ammonia concentrations associated with the proposed 218 mgd discharge added to the median ambient concentration estimated to occur at the current permitted 181 mgd discharge in the Sacramento River at Greene’s Landing/Hood, during summer and winter operations, respectively. Note that the summer operations incremental change of ammonia concentrations at Greene’s Landing/Hood are expected to be near zero. There are sufficient ambient ammonia data at four of the seven primary far-field locations to confidently present the median incremental ammonia concentration differences between the modeled existing condition (181 mgd) and proposed permitted condition (218 mgd), as shown in **Table 5-17** and **Table 5-18**, respectively for summer and winter operations. Modeled, median incremental change in ammonia concentration on top of ambient median (50th percentile) and 95th percentile concentrations estimated to occur at the current permitted 181 mgd discharge at four Delta locations are displayed in **Figure 5-12** and **Figure 5-13**, respectively for summer and winter operating conditions.

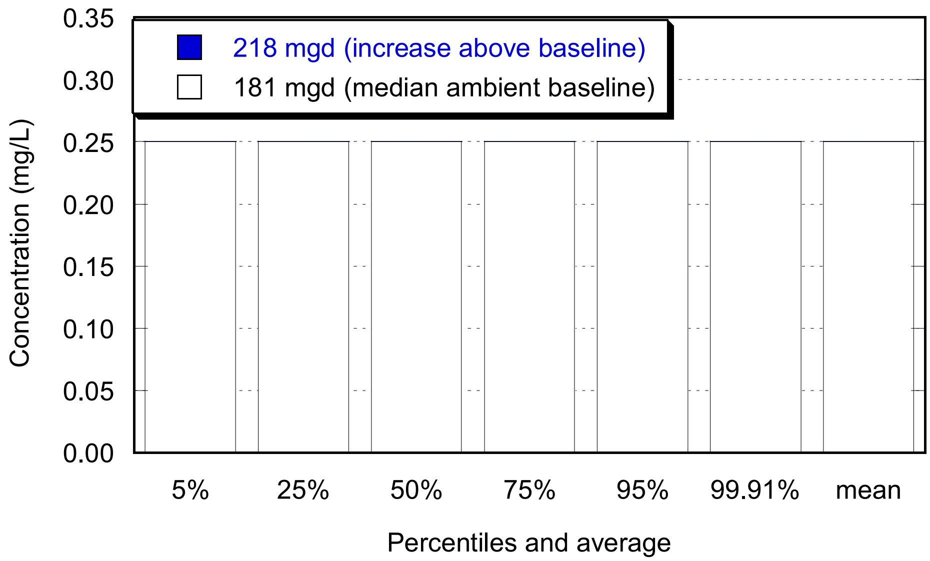

Figure 5-10: Percentiles of Modeled Incremental Change in Summer Operations Ammonia Concentration (mg/L as N) in the Sacramento River at Greene's Landing/Hood.

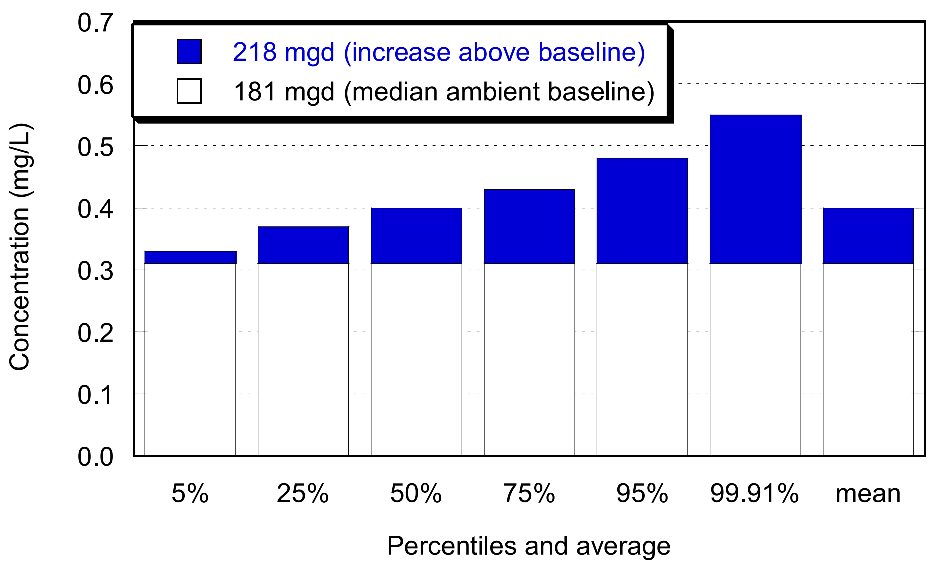

Figure 5-11: Percentiles of Modeled Incremental Change in Winter Operations Ammonia Concentration (mg/L as N) in the Sacramento River at Greene's Landing/Hood.

Table 5-17: Incremental Difference in Modeled Summer Operations Ammonia Concentrations (mg/L as N) Downstream of the SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95^{th} Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	0.25	0.86	<0.01
CCWD PP#1	0.02	0.10	<0.01
CCWD Los Vaqueros Intake	0.04	0.14	<0.01
Banks Delta Pumping Plant	0.05	0.13	<0.01

Table 5-18: Incremental Difference in Modeled Winter Operations Ammonia Concentrations (mg/L as N) Downstream of the SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95^{th} Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	0.31	0.98	0.09
CCWD PP#1	0.07	0.18	0.07
CCWD Los Vaqueros Intake	0.08	0.22	0.07
Banks Delta Pumping Plant	0.10	0.22	0.06

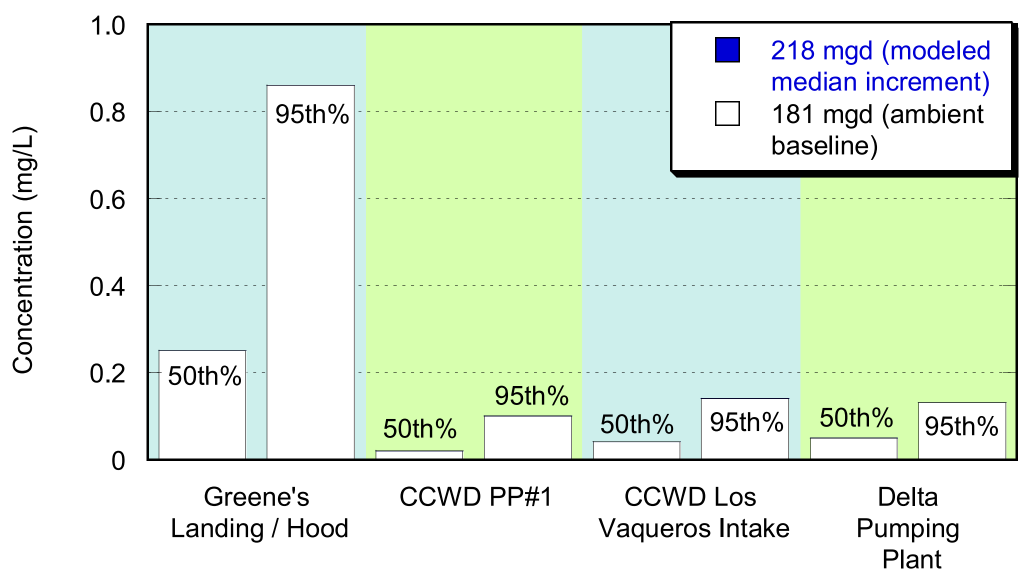

Figure 5-12 Median Modeled Incremental Summer Operations Ammonia Concentration (mg/L as N) at Far-Field Downstream Locations.

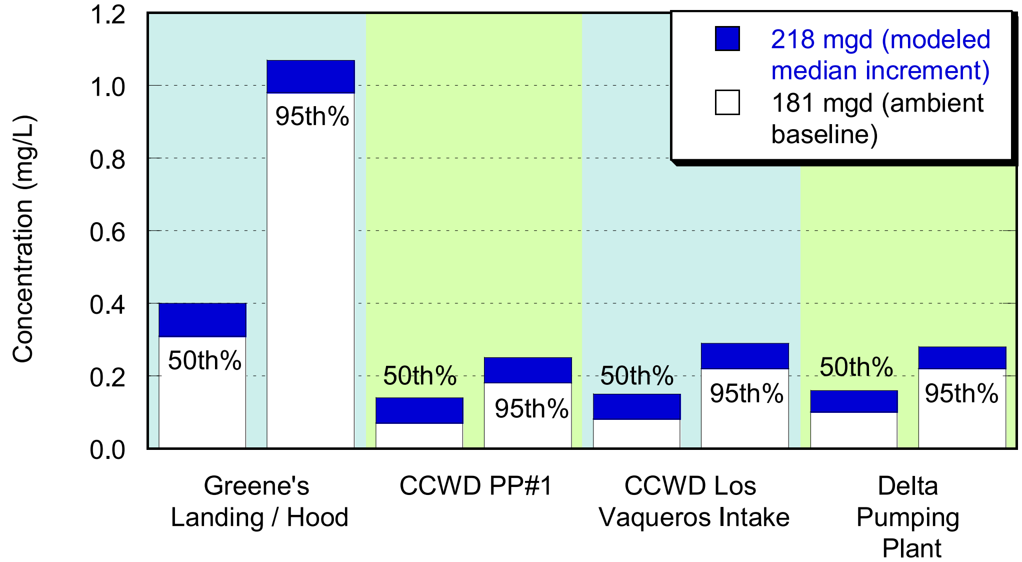

Figure 5-13: Median Modeled Incremental Winter Operations Ammonia Concentration (mg/L as N) at Far-Field Downstream Locations.

5.4.6.5 Far-Field Evaluation

Fischer Delta Model (FDM) far-field modeling results for the Sacramento River at Greene's Landing/Hood are presented in **Figure 5-10** and **Figure 5-11**, for summer and winter operations, respectively. These figures graphically displays all modeled distributions of ambient, median ammonia concentrations at the existing permitted condition (181 mgd) on top of which are placed modeled, median ammonia concentration increments estimated for the proposed permitted condition (218 mgd). The 99.91 percentile concentration increment at Greene's Landing/Hood represents the largest modeled far-field increment attributable to the proposed permitted condition (218 mgd) due to the fact that the percent SRWTP effluent contribution is greatest at this modeled far-field location as compared to other downstream locations. **Table 5-17** and **Table 5-18** provide median (50th percentile) and 95th percentile ammonia concentrations at the existing permitted condition (181 mgd), for summer and winter operations, respectively, at four far-field Delta locations for which sufficient ambient data were available. Additionally, the tables present the modeled, median ammonia concentration increment at the proposed permitted condition (218 mgd) for the Delta locations considered. The modeled results are graphically represented in **Figure 5-12** and **Figure 5-13**. This figure shows the range in ambient ammonia concentrations for modeled Delta far-field locations under the existing permitted (181 mgd) and proposed permitted conditions (218 mgd). While ambient concentrations vary widely, it should be noted that the modeled, median ammonia increment under the summer operations proposed permitted condition (218 mgd) is remarkably small compared to ambient concentrations, as shown in **Table 5-17** and **Table 5-18**. A statistical power analysis ($\alpha = 0.05$, $\beta = 0.1$) was performed to determine how many water quality samples would need to be collected and analyzed in order to dected the modeled far-field increments in ammonia concentration due to the proposed permitted discharge of 218 mgd. For winter operating conditions, the results ranged from 11 samples at Contra Costa Pumping Plant #1 to

210 samples at Greene's Landing/Hood. The results for summer operations ranged from hundreds to thousands of samples needed at the various far-field Delta locations indicating that for any reasonable monitoring frequency, the modeled increments are immeasureable at far-field Delta locations.

5.4.6.6 Trend Analysis Results

The results of the near- and far-field trend analyses are presented below in the form of a summary table and time series graphs. These graphs were developed showing actual ambient concentrations beside the concentrations provided by the regression equations. A best-fit line through the predicted concentrations visually shows the direction of the trend, where a trend with time was determined to exist. There were sufficient detected ammonia data at five locations to employ a parametric regression analysis to determine whether trends exist between ambient ammonia concentrations and time. The results of the trend analyses are shown in **Table 5-19**, and the historic ammonia data with applicable trend lines (regression lines) are shown in **Figure 5-14** through **Figure 5-18**.

Table 5-19: Trend Analysis Results for Ammonia

Location	Count	% Detected	Start Date	End Date	Trend Result with Time	R^2 (adj)	Regression Fit
Freeport	501	36%	10/17/79	7/28/08	Downward	10.6%	Fair
Greene/Hood	527	99%	1/16/79	8/4/08	Upward	66.4%	Excellent
CCWD PP #1	88	78%	6/6/96	8/5/08	Downward	20.3%	Good
CCWD Los Vaqueros Intake	94	99%	6/12/96	6/2/08	No trend	32.8%	Good
Delta PP	144	99%	3/27/91	5/21/08	Downward	28.6%	Good

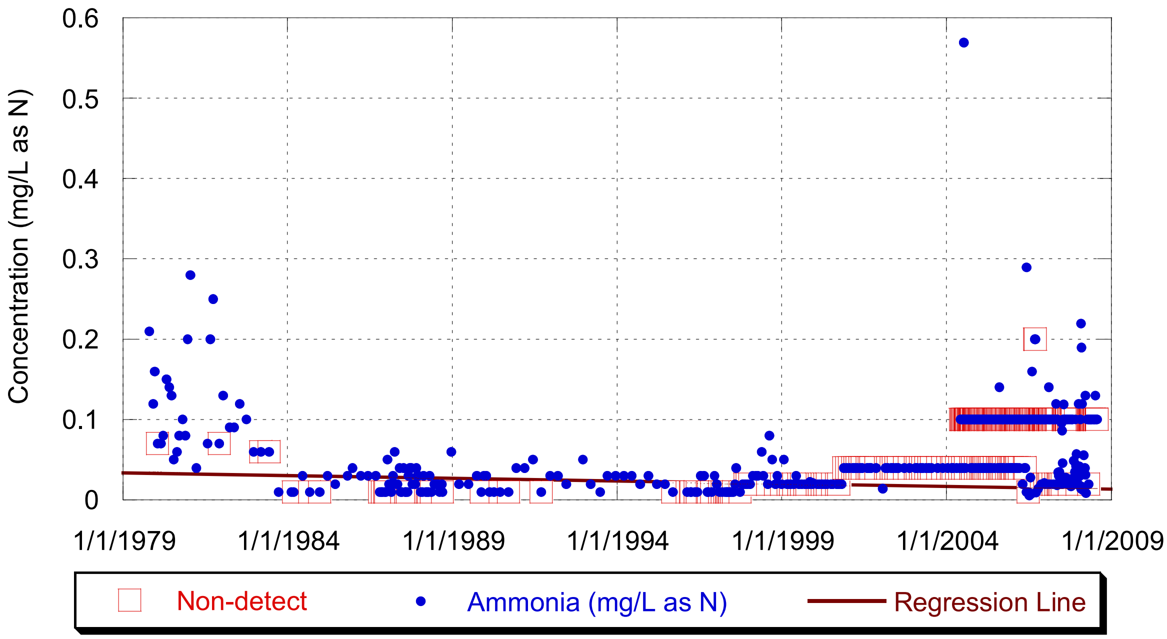

Figure 5-14: Historic Data and Regression Analysis Trend Line for Ammonia in the Sacramento River at Freeport.

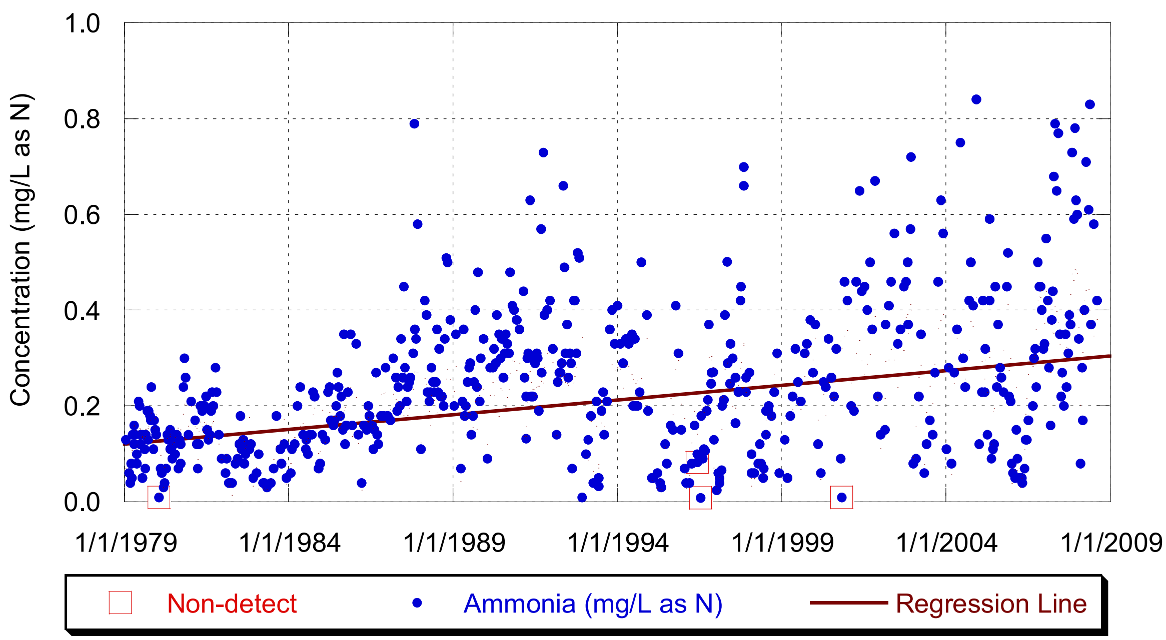

Figure 5-15: Historic Data and Regression Analysis Trend Line for Ammonia in the Sacramento River at Greene's Landing / Hood.

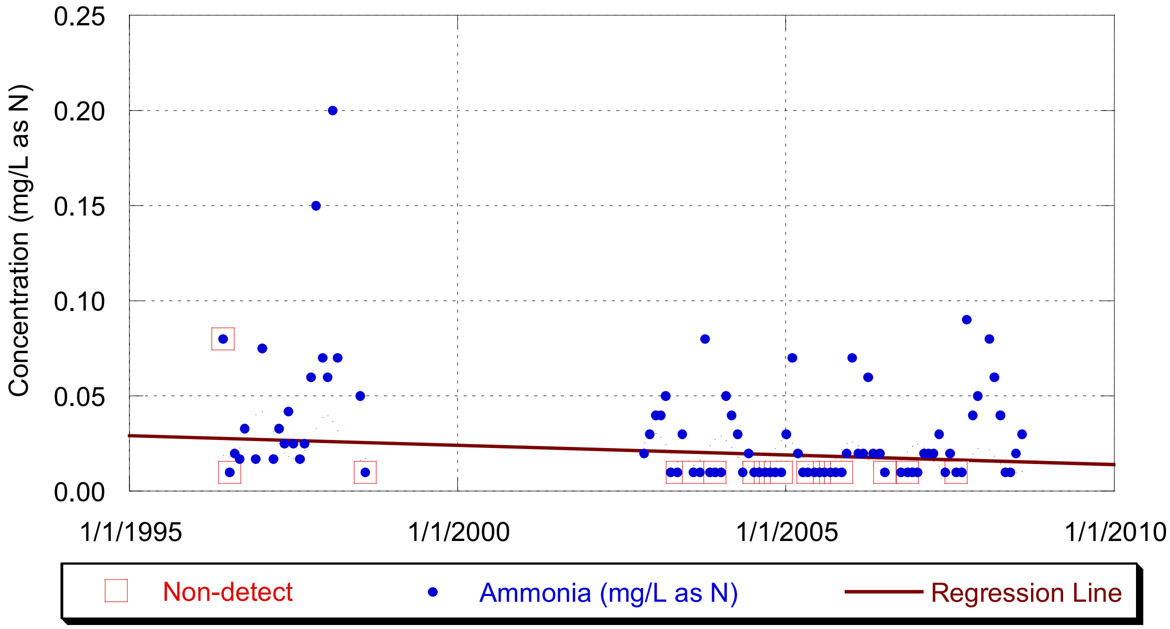

Figure 5-16: Historic Data and Regression Analysis Trend Line for Ammonia at Contra Costa Water District Pumping Plant #1.

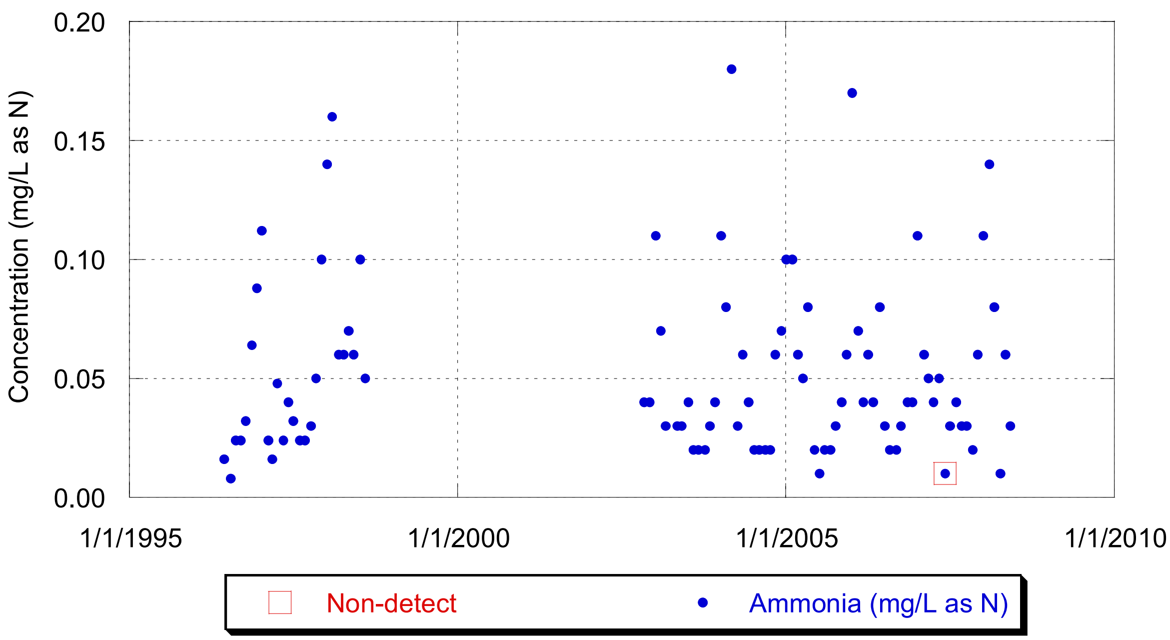

Figure 5-17: Historic Data for Ammonia at the Contra Costa Water District Los Vaqueros Intake.

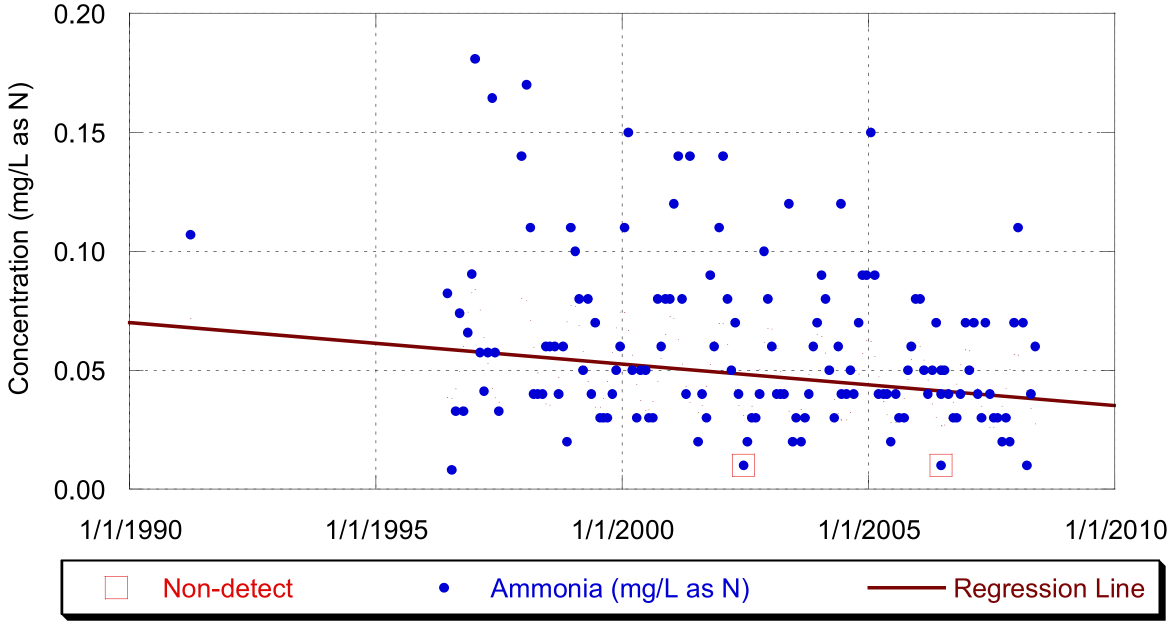

Figure 5-18: Historic Data and Regression Analysis Trend Line for Ammonia at the Harvey O. Banks Delta Pumping Plant Headworks.

5.4.6.7 Trend Analysis Evaluation

The trend analyses performed on ambient ammonia data collected upstream (Sacramento River at Freeport) resulted in a determination of a downward trend. As such, the use of the upstream data in the near-field modeling effort to predict ammonia levels in the discharge plume resulted in accurate or slight overestimates of ammonia levels in the plume. An upward trend was seen at the closest downstream location (Sacramento River at Greene's Landing/ Hood), due to the fact that ammonia levels in effluent have exhibited a similar trend over recent years. Downward trends in ammonia levels have been observed at two of the downstream Delta locations: CCWD Pumping Plant No. 1 and the Banks Delta Pumping Plant in the South Delta. Analysis of the data at the Contra Costa Water District Los Vaqueros Intake showed no observable trend in ammonia concentrations with time. Moderate incremental increases in ambient downstream winter ammonia concentrations are projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-18**). Negligible incremental increases in ambient downstream summer ammonia concentrations are projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-17**). These incremental changes are anticipated to have a negligible effect on the long-term ammonia concentration trends identified in the project area in the current trend analysis evaluation.

5.4.6.8 Overall Ammonia Evaluation

Analysis has been performed to quantify the changes in ambient ammonia levels in the near and far-field associated with a proposed increase in discharge from the SRWTP from 181 to 218 mgd for winter and summer operations. These results are important in the assessment of whether projected incremental increases in ambient ammonia concentrations are substantial. A power analysis was employed to gain insight into the ability to measure the projected incremental changes through a field sampling program. The results of that analysis indicate that the projected incremental changes are sufficiently small that they would likely not be measureable under summer operations. Additionally, for summer operations, ammonia concentrations in the effluent are projected to be lower at 218 mgd than at 181 mgd which should eliminate any direct impact of the increased discharge on ammonia concentrations or loads in the receiving water. The projected incremental change during winter operations are determined to reflect a moderate increase in ammonia concentration. These findings support a conclusion that the incremental changes are not substantial and would not be inconsistent with antidegradation policies. Additionally, since downstream ambient concentrations are generally not increasing, the incremental changes associated with the proposed discharge are not likely to create substantially different conditions than have been observed historically.

In addition to the questions regarding consistency with the antidegradation policies, four areas of potential concern exist regarding the discharge of increased amounts of ammonia into the Delta. Those concerns include: (a) ammonia toxicity to fish and invertebrates (near and far-field), (b) ammonia impacting the Delta food web (far field), (c) ammonia's potential role in encouraging nuisance growths of algae or aquatic plants in the Delta (far-field), and (d) effect of ammonia nitrification on dissolved oxygen levels (far-field).

The above analysis addresses the concern regarding ammonia toxicity to fish and invertebrates, using the U.S. EPA ammonia ambient acute and chronic criteria as a benchmark for toxicity. Information presented above indicates that the existing discharge is not causing ammonia toxicity and that the proposed discharge would not result in ammonia toxicity near the discharge or in downstream waters.

Regarding impacts to the Delta food web, information provided in Section 4.5.4 indicates that Delta food web problems are still being investigated to determine the magnitude of this concern and that ammonia has not been conclusively linked to adverse food web impacts in the Delta. Best available information as described in Section 4.5.4does not suggest that ammonia in the SRCSD discharge is adversely impacting the Delta food web.

Regarding the linkage of ammonia to nuisance species of algae or plants, a qualitative evaluation of this concern is addressed in Sections 4.6.2 and 4.5.3, respectively. Available information indicates that at this time there is no clear evidence that ammonia levels in the Delta are driving the growth or proliferation of nuisance algae or aquatic plants.

Ammonia impacts on dissolved oxygen have been evaluated using available data and mathematical modeling tools as described in Section 5.4.16. This evaluation has established that as the SRWTP discharge rate is increased with current levels of ammonia and other oxygen demanding substances, there exists the potential for excursions below the Basin Plan objective for dissolved oxygen of 7.0 mg/L downstream of the discharge in warm summer months when dissolved oxygen saturation levels are low and nitrification of ammonia to nitrate is most pronounced. To remedy this potential future occurrence, it is proposed that a seasonal oxygen-demanding substances mass loading limit be established. Currently, the District is exploring alternatives, including ammonia mass limits, to prevent low dissolved oxygen downstream of the discharge. However, other alternatives are being developed and will be evaluated by the District. It is proposed that an oxygen demanding substances mass load limit would be established in the NPDES permit as a condition of the approval of a 218 mgd discharge. The magnitude of such a proposed limit would be slightly lower than the loading that would occur if the existing effluent were to be discharged at 181 mgd. With this limit in place and utilizing ammonia reductions to achieve the mass load limit, no incremental increases in ammonia would be allowed above the current permitted condition and the proposed discharge would satisfy all concerns related to antidegradation, from the standpoint of ammonia.

5.4.7 Total Nitrogen

As noted in the previous section, the District is evaluating control of oxygen demanding substances via ammonia reductions on a seasonal basis to ensure that during periods of higher river temperature and lower river flow rate (i.e., summer months) excursions below the dissolved oxygen Basin Plan objective downstream of the discharge do not occur. The reduced ammonia levels present in the discharge at 181 mgd and 218 mgd would result in corresponding reductions in total nitrogen levels. Therefore, the near-field and far-field analyses were conducted for summer and winter operations. The projected summer operations total nitrogen effluent concentrations are shown in **Table 5-2**.

5.4.7.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for total nitrogen at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from total nitrogen measured in the Sacramento River at Freeport. Effluent quality model inputs were derived based on projected total nitrogen concentrations corresponding to the projected ammonia concentrations for summer operating conditions and from total nitrogen measured in SRWTP effluent for the winter operating conditions. The modeled in-plume total nitrogen concentrations for the existing permitted condition (181 mgd) and summer operations are shown in **Table 5-20**. Modeled in-plume total nitrogen concentrations at the proposed permitted condition (218 mgd) and summer operations are shown in **Table 5-21**. The modeled in-plume total nitrogen concentrations for the existing permitted condition (181 mgd) and winter operations are shown in **Table 5-22**. Modeled in-plume total nitrogen concentrations at the proposed permitted condition (218 mgd) and winter operations are shown in **Table 5-23**.

Table 5-20: Modeled In-Plume Summer Operations Total Nitrogen Concentration (mg/L) at Varying Distances Downstream of the SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	4.37	2.91	2.04	1.50	1.07	0.94
Median	4.00	2.61	1.83	1.35	0.96	0.84
95%-ile	9.11	6.13	4.21	2.98	2.06	1.83
99.91%-ile	14.30	10.90	7.89	5.81	4.11	3.60
5%-ile	0.72	0.71	0.66	0.58	0.47	0.41

Table 5-21: Modeled In-Plume Summer Operations Total Nitrogen Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	4.26	2.82	1.98	1.45	1.03	0.90
Median	4.04	2.59	1.81	1.33	0.94	0.82
95 %-ile	8.45	5.82	4.02	2.84	1.94	1.71
99.91 %-ile	12.40	9.45	6.79	4.95	3.52	3.14
5 %-ile	0.50	0.50	0.50	0.48	0.42	0.37

Table 5-22: Modeled In-Plume Winter Operations Total Nitrogen Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	5.92	3.89	2.69	1.93	1.33	1.15
Median	5.38	3.45	2.38	1.72	1.18	1.01
95%-ile	12.6	8.42	5.71	3.99	2.66	2.33
99.91%-ile	20.1	15.3	10.9	8.02	5.59	4.86
5%-ile	0.82	0.80	0.75	0.66	0.54	0.47

Table 5-23: Modeled In-Plume Winter Operations Total Nitrogen Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	6.89	4.48	3.07	2.17	1.46	1.25
Median	6.50	4.07	2.76	1.96	1.32	1.12
95 %-ile	14.0	9.60	6.52	4.51	2.93	2.51
99.91 %-ile	21.1	15.9	11.3	8.14	5.65	4.99
5 %-ile	0.55	0.55	0.55	0.54	0.50	0.45

The incremental differences in modeled in-plume total nitrogen concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-24** for summer operating conditions and in **Table 5-25** for winter operating conditions. At 218 mgd, the median incremental increase in total nitrogen concentrations would range from -0.12 mg/L at a distance of 30 feet downstream from the diffuser -0.03 mg/L at a distance of 700 feet downstream from the diffuser for summer operating conditions. The negative increments reflect the slightly lower modeled mass load of total nitrogen in the effluent at 218 mgd in comparison to the load allowable at 181 mgd. At 218 mgd, the median incremental increase in total nitrogen concentrations would range from 1.12 mg/L at a distance of 30 feet downstream from the diffuser to 0.11 mg/L at a distance of 700 feet downstream from the diffuser for winter operating conditions.

Table 5-24: Modeled In-Plume Summer Operations Total Nitrogen Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	-0.12	-0.08	-0.06	-0.05	-0.04	-0.03
Median	0.04	-0.02	-0.02	-0.02	-0.02	-0.01
95%-ile	-0.66	-0.31	-0.19	-0.14	-0.12	-0.12
99.91%-ile	-1.90	-1.45	-1.10	-0.86	-0.59	-0.46
5%-ile	-0.22	-0.20	-0.16	-0.10	-0.05	-0.03

Table 5-25: Modeled In-Plume Winter Operations Total Nitrogen Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.97	0.60	0.38	0.24	0.13	0.10
Median	1.12	0.62	0.38	0.24	0.14	0.11
95%-ile	1.4	1.18	0.81	0.52	0.27	0.18
99.91%-ile	1.0	0.6	0.4	0.12	0.06	0.13
5%-ile	-0.26	-0.25	-0.20	-0.12	-0.04	-0.02

The probability distributions of modeled summer operations total nitrogen concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-19**. The median summer operations total nitrogen concentrations in the discharge plume at 181 mgd and the median incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-20**. It should be noted that total nitrogen concentrations within the plume 60 feet or more from the diffuser are slightly lower for the proposed 218 mgd discharge than for the 181 mgd discharge due to projected lower total nitrogen effluent concentrations for summer operations at 218 mgd.

The probability distributions of modeled winter operations total nitrogen concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-21**. The median winter total nitrogen concentrations in the discharge plume at 181 mgd and the median incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-22**.

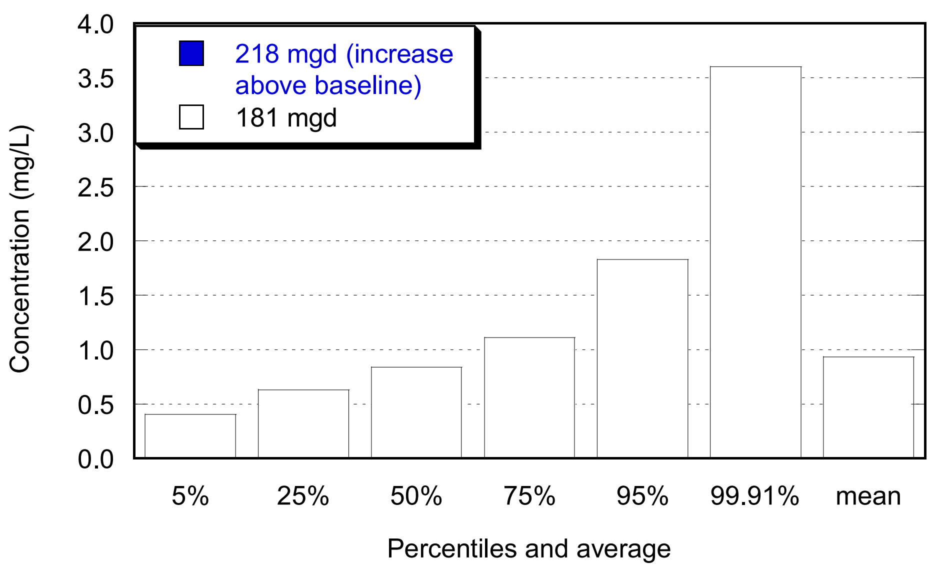

Figure 5-19: Distribution of Modeled Summer Operations Total Nitrogen Concentrations 700 feet Downstream from SRWTP Diffuser.

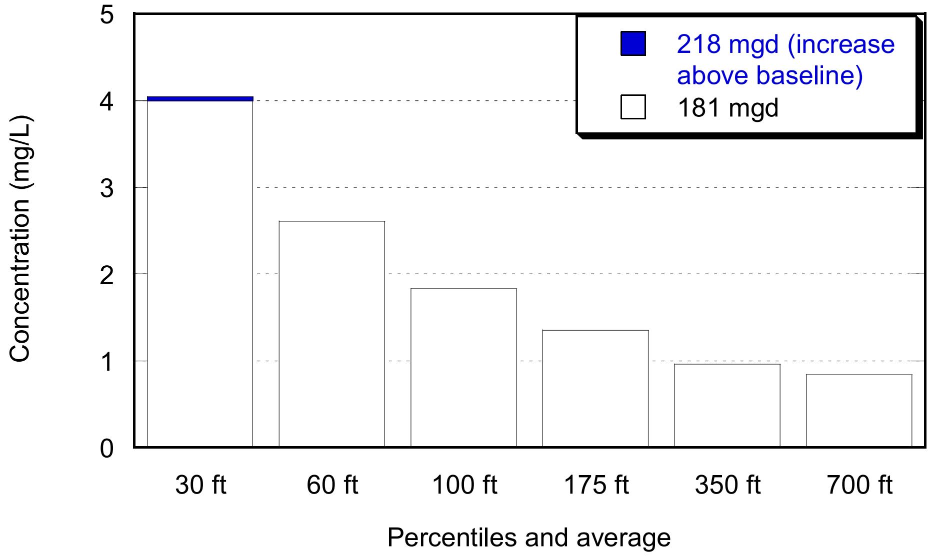

Figure 5-20: Median Modeled Summer Operations Total Nitrogen Concentration Downstream of SRWTP Diffuser.

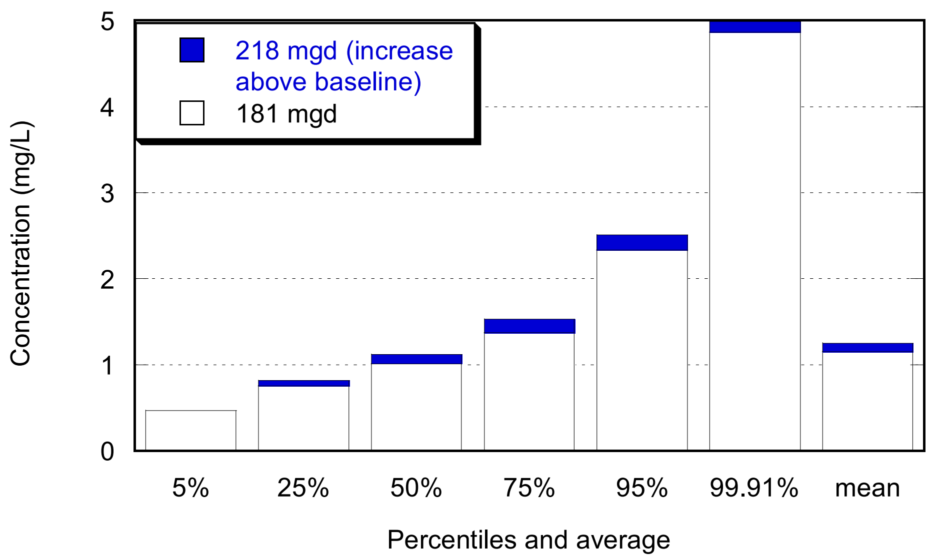

Figure 5-21: Distribution of Modeled Winter Operations Total Nitrogen Concentrations 700 feet Downstream of SRWTP Diffuser.

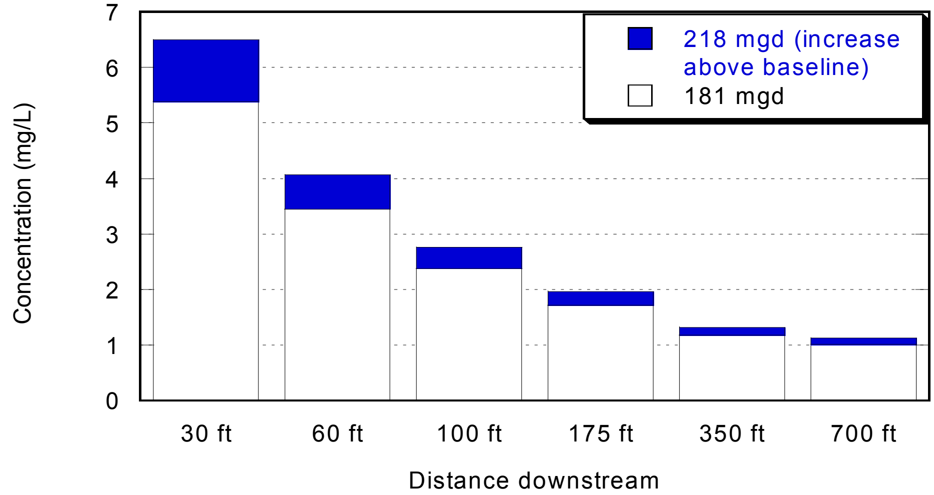

Figure 5-22: Median Modeled Winter Operations Total Nitrogen Concentration Downstream of SRWTP Diffuser.

5.4.7.2 Comparison to Water Quality Objectives

There are no applicable water quality objectives for total nitrogen. Discussions of specific concerns regarding the impact of nutrient loadings on the Delta ecosystem and Delta water supply are presented in Section 4.5 and Section 4.6, respectively..

5.4.7.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-20** and **Table 5-22**) and the proposed discharge (see **Table 5-21** and **Table 5-23**) show that similar spatial characteristics exist for changes in total nitrogen concentrations over distance from the diffuser. Total nitrogen concentrations are greater near the outfall, as the effluent concentration is generally greater than the background receiving water concentration. Furthermore, as listed in **Table 5-25**, the proposed increase in SRWTP effluent discharge would slightly increase total nitrogen concentrations in the Sacramento River throughout the modeled plume for winter operations, with the greatest incremental increases occurring near the diffuser and smaller changes occurring as downstream distance increases. In the summer, modeled total nitrogen concentrations in the Sacramento River would decrease slightly throughout the plume (see **Table 5-23**). The incremental change in total nitrogen concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight.

5.4.7.4 Far-Field Model Analysis Results

Far-field modeling was used to determine incremental contributions of total nitrogen resulting from an increase in SRWTP discharge from 181 mgd to 218 mgd at seven far-field locations. The far-field modeled results are shown graphically in **Figure 5-23**, **Figure 5-24**, **Figure 5-25,** and **Figure 5-26**. **Figure 5-23** and **Figure 5-24** shows percentile modeled incremental change in total nitrogen concentrations associated with the proposed 218 mgd discharge added to the median ambient concentration estimated to occur at the current permitted 181 mgd discharge in the Sacramento River at Greene's Landing/Hood, respectively for summer and winter operations. There were sufficient ambient total nitrogen data at four of the seven primary far-field locations to accurately depict the median incremental total nitrogen concentration differences between the modeled existing condition (181 mgd) and proposed permitted condition (218 mgd), as shown in **Figure 5-25** and **Figure 5-26**, respectively for summer and winter operations. Modeled, median incremental change in total nitrogen concentration added to ambient median (50th percentile) and 95th percentile ambient concentrations estimated to occur at the current permitted 181 mgd discharge at four Delta locations are displayed in **Figure 5-25** and **Figure 5-26**, respectively for summer and winter operations.

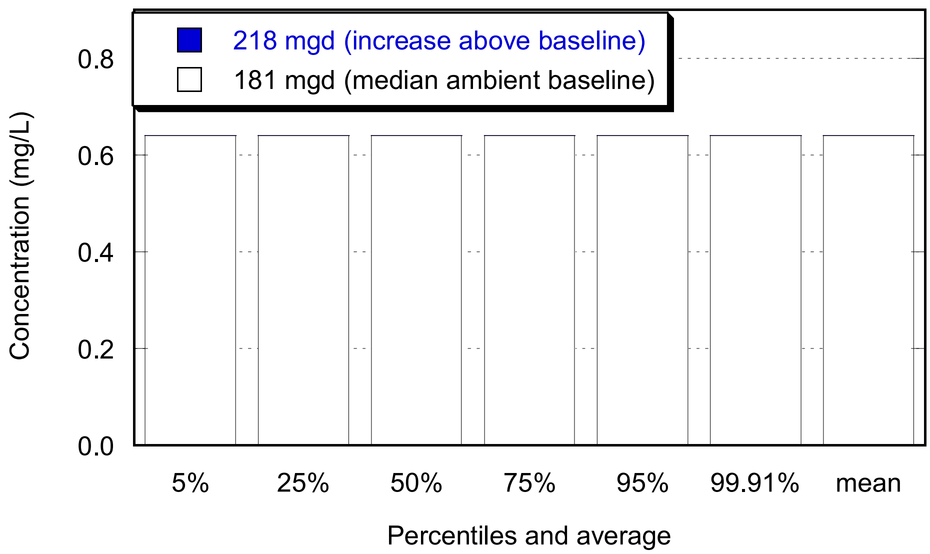

Figure 5-23: Percentiles of Modeled Incremental Change in Summer Operations Total Nitrogen Concentration in the Sacramento River at Greene's Landing/Hood.

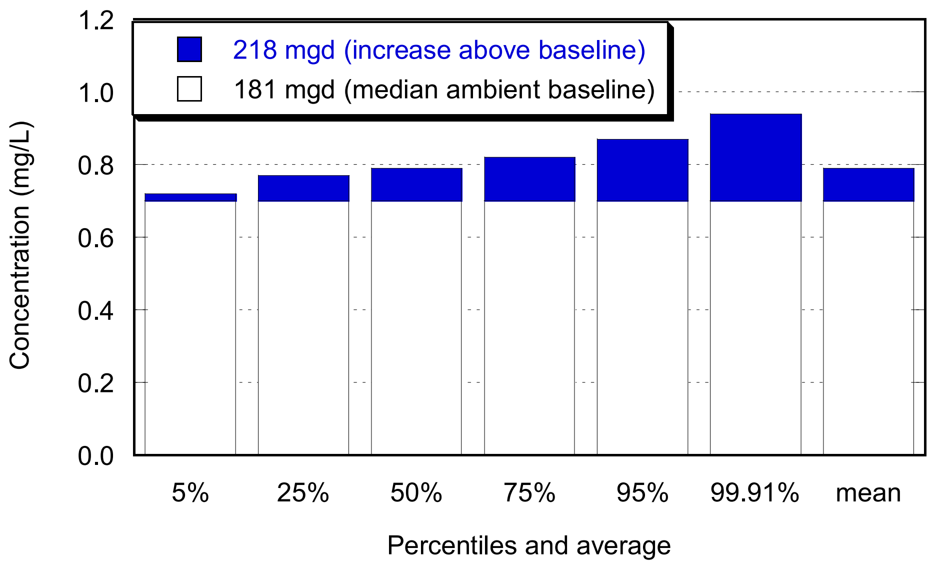

Figure 5-24: Percentiles of Modeled Incremental Change in Winter Operations Total Nitrogen Concentration in the Sacramento River at Greene's Landing/Hood.

Table 5-26: Incremental Difference in Modeled Summer Operations Total Nitrogen Concentrations (mg/L) Downstream of the SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95th Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	0.64	1.27	<0.01
CCWD PP#1	0.68	1.85	<0.01
CCWD Los Vaqueros Intake	0.84	1.97	<0.01
Banks Delta Pumping Plant	0.93	2.03	<0.01

Table 5-27: Incremental Difference in Modeled Winter Operations Total Nitrogen Concentrations (mg/L) Downstream of the SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95th Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	0.70	1.39	0.09
CCWD PP#1	0.73	1.94	0.07
CCWD Los Vaqueros Intake	0.89	2.06	0.07
Banks Delta Pumping Plant	0.98	2.12	0.06

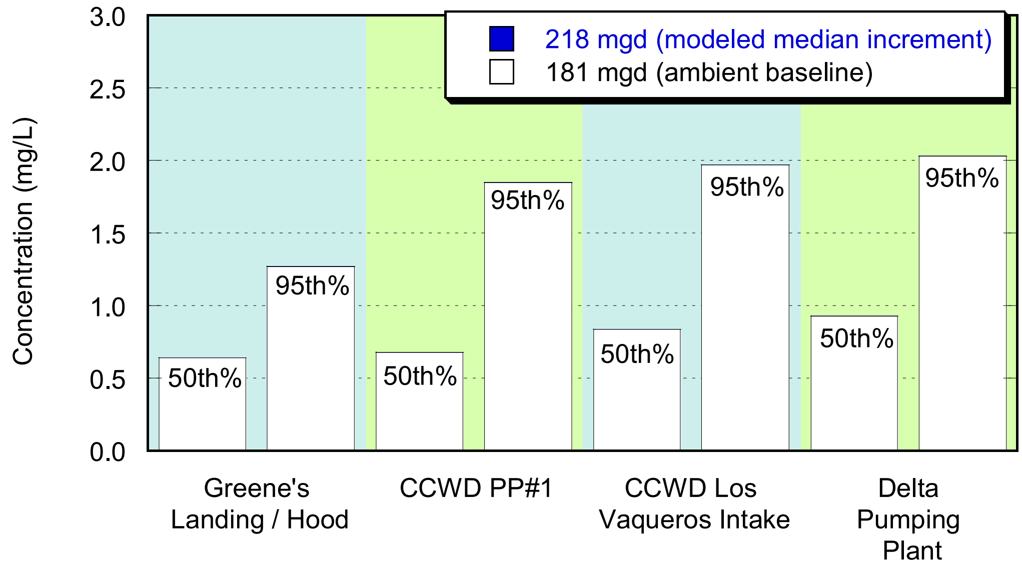

Figure 5-25: Median Modeled Incremental Summer Operations Total Nitrogen Concentration at Far-Field Downstream Locations.

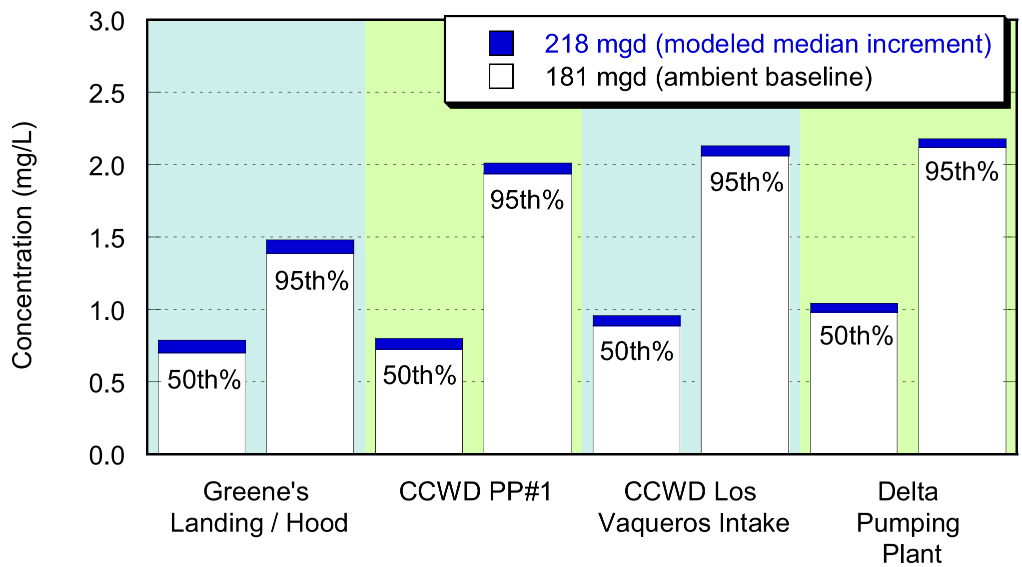

Figure 5-26: Median Modeled Incremental Winter Operations Total Nitrogen Concentration at Far-Field Downstream Locations.

5.4.7.5 Far-Field Evaluation

Fischer Delta Model (FDM) far-field modeling results for the Sacramento River at Greene's Landing/Hood are presented in **Figure 5-23** and **Figure 5-24**. This figure graphically displays all modeled distributions of ambient, median total nitrogen concentrations at the existing permitted condition (181 mgd), on top of which are shown the modeled, median total nitrogen concentration increments estimated for the proposed permitted condition (218 mgd).

Table 5-26 and **Table 5-27** provide projected median (50th percentile) and 95th percentile total nitrogen concentrations at the existing permitted condition (181 mgd) at four far-field Delta locations, for which sufficient ambient data were available in summer and winter operating conditions, respectively. Additionally, the tables present the modeled, median total nitrogen concentration increment corresponding to the proposed permitted condition (218 mgd) for the Delta locations considered. These modeled results are graphically represented in **Figure 5-25** and **Figure 5-26**, for summer and winter operating conditions, respectively. This figure shows the projected future range in ambient total nitrogen concentrations for modeled Delta far-field locations under the proposed permitted conditions (218 mgd). While ambient concentrations vary widely (as shown in upcoming **Figure 5-27** through **Figure 5-31**), it should be noted that the modeled, median total nitrogen increment under the proposed permitted condition (218 mgd) is remarkably small compared to ambient concentrations, shown in **Table 5-26** and **Table 5-27**. A statistical power analysis ($\alpha = 0.05$, $\beta = 0.1$) was performed to determine how many water quality samples would need to be collected and analyzed in order to dected the modeled far-field increments in total nitrogen concentration due to the proposed permitted discharge of 218 mgd. For winter operating conditions, the results ranged from 353 samples at Greene's Landing/Hood to 2,692 samples at the Banks Delta Pumping Plant. For summer operations, thousands of samples would need to be collected and analyzed to detect the modeled total nitrogen increments. The power analysis results indicate that for any reasonable monitoring frequency, the projected future incremental change at 218 mgd are immeasurable at far-field Delta locations.

5.4.7.6 Trend Analysis Results

The results of the near- and far-field trend analyses are presented below in the form of a summary table and time series graphs. A best-fit line through the predicted concentrations visually shows the direction of a temporal trend, where such a trend has been determined to exist. There were sufficient detected total nitrogen data at five locations to employ a parametric regression analysis to determine whether trends exist between ambient total nitrogen concentrations and time. The results of the trend analyses are shown in **Table 5-28**, and the historic total nitrogen data with applicable trend lines (regression lines) are shown in **Figure 5-27** through **Figure 5-31**.

Table 5-28: Trend Analysis Results for Total Nitrogen.

Location	Count	% Detected	Start Date	End Date	Trend Result with Time	R^2 (adj)	Regression Fit
Freeport	470	87%	2/1/73	6/3/08	Downward	21.7%	Fair
Greene/Hood	247	100%	6/19/74	6/2/08	Upward	38.0%	Good
CCWD PP #1	66	100%	11/5/02	8/5/08	No trend	15.6%	Fair
CCWD Los Vaqueros Intake	67	100%	11/5/02	6/2/08	No trend	34.3%	Good
Delta PP	128	100%	1/21/98	5/21/08	Downward	34.0%	Good

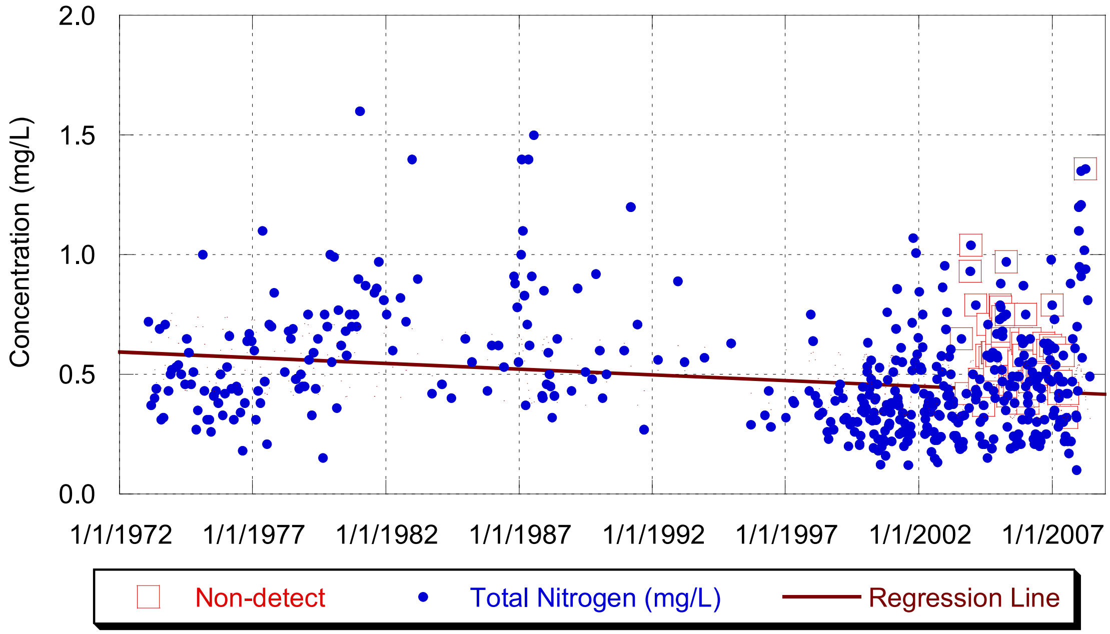

Figure 5-27: Historic Data and Regression Analysis Trend Line for Total Nitrogen in the Sacramento River at Freeport.

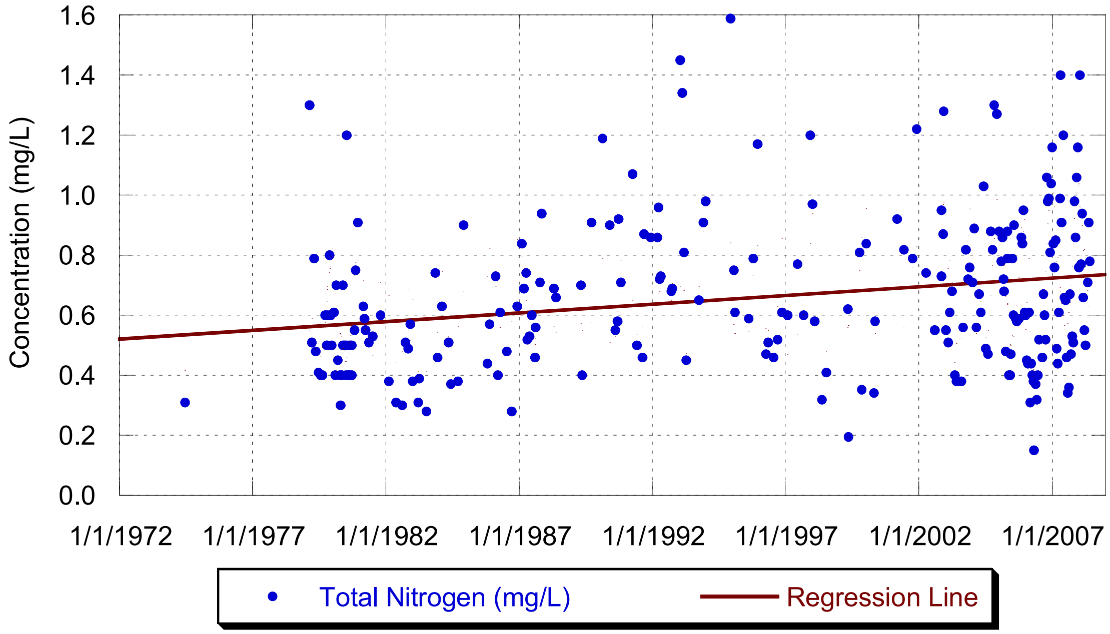

Figure 5-28: Historic Data and Regression Analysis Trend Line for Total Nitrogen in the Sacramento River at Greene's Landing / Hood.

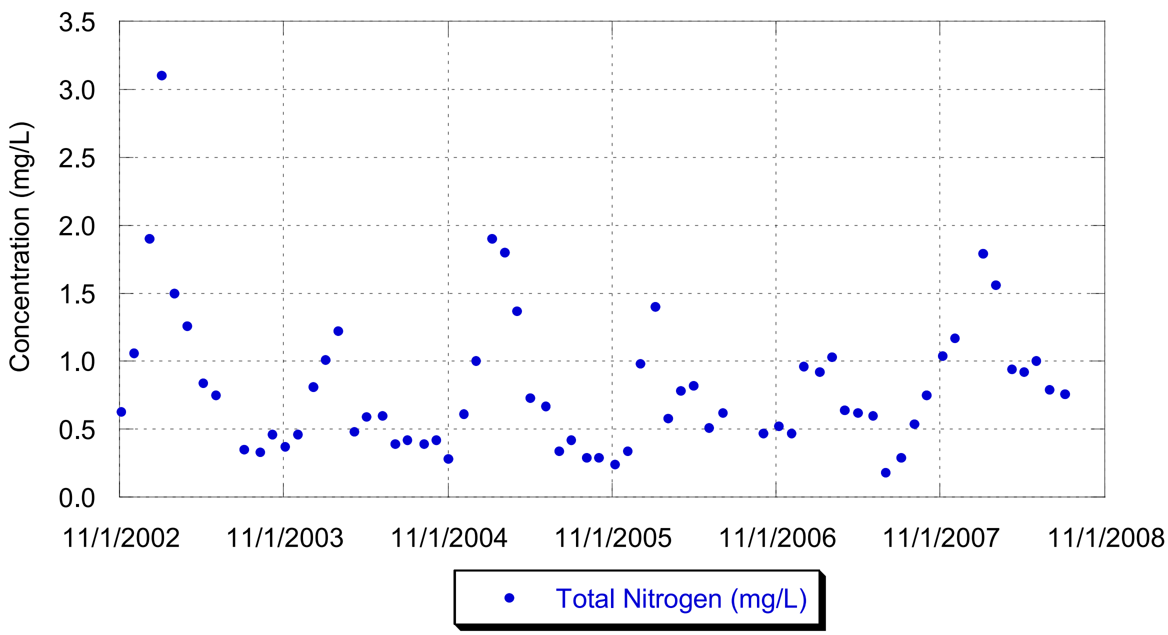

Figure 5-29: Historic Data for Total Nitrogen at Contra Costa Water District Pumping Plant #1.

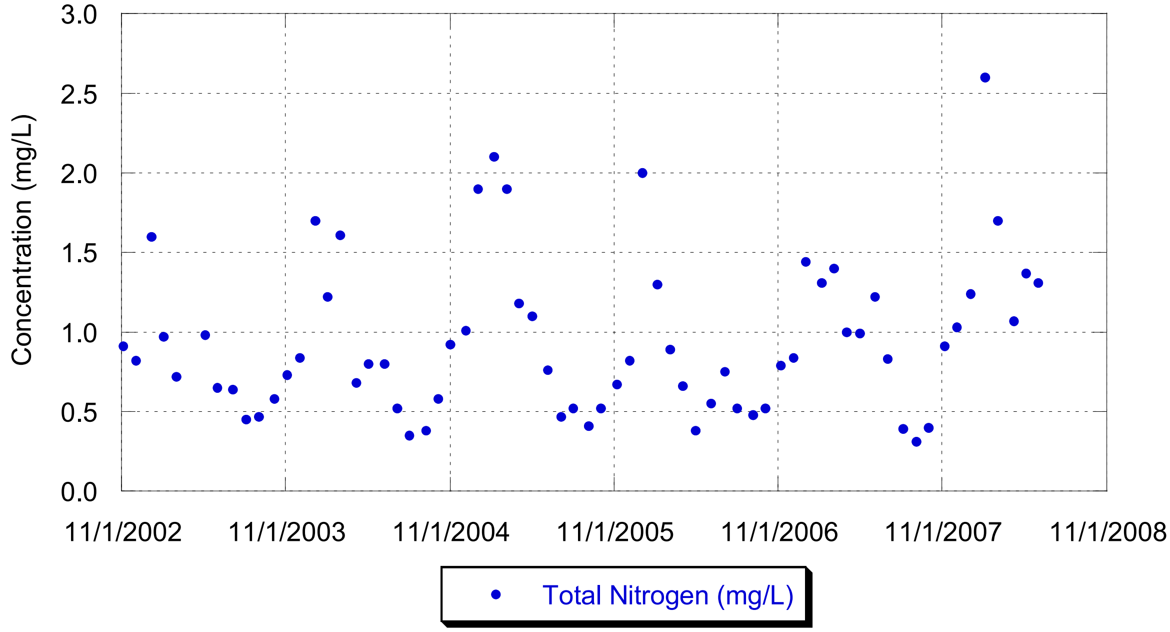

Figure 5-30: Historic Data for Total Nitrogen at the Contra Costa Water District Los Vaqueros Intake.

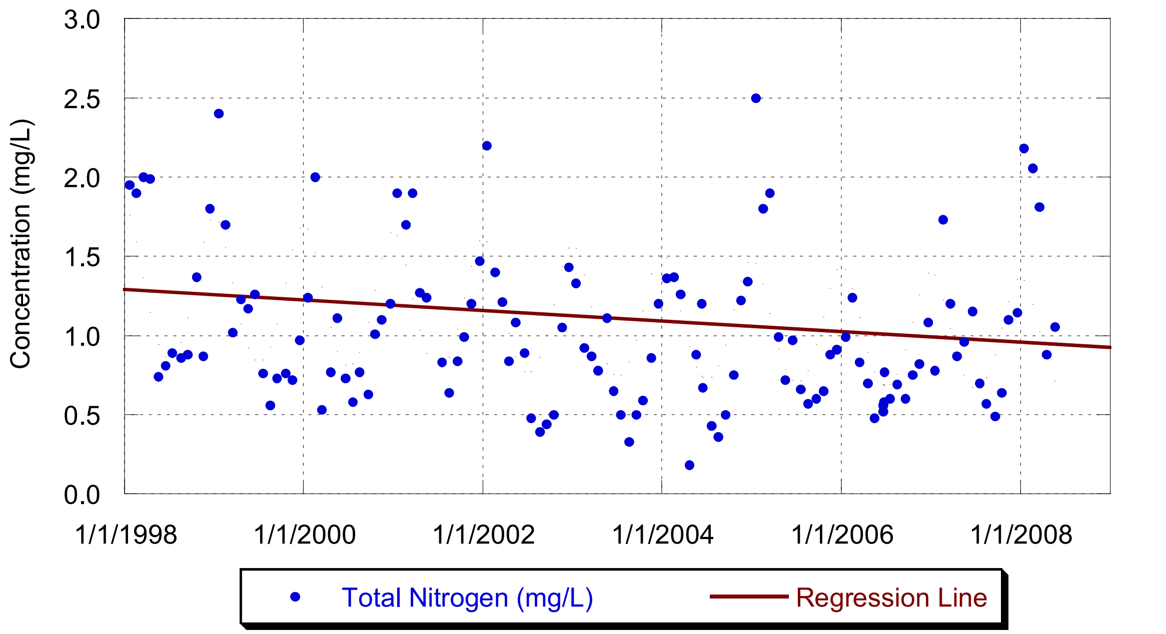

Figure 5-31: Historic Data and Regression Analysis Trend Line for Total Nitrogen at the Harvey O. Banks Delta Pumping Plant Headworks.

5.4.7.7 Trend Analysis Evaluation

The trend analyses performed on ambient total nitrogen data collected upstream from the SRWTP discharge (Sacramento River at Freeport) and downstream (all other far-field Delta locations) resulted in the determination of a downward total nitrogen trend with time at the upstream location and mixed results at the downstream stations. For the Sacramento River at Greene's Landing/ Hood, closest to the SRWTP discharge, an upward trend is observed. This trend is associated with an upward trend in total nitrogen discharges by the SRWTP in recent years. At the Contra Costa Pumping Plant #1 and Contra Costa Los Vaqueros Intake, no observable temporal trend was seen for total nitrogen concentrations, indicating a decreased influence from the SRWTP discharge. At the Banks Delta Pumping Plant, total nitrogen concentrations have decreased moderately over the past ten to twenty years. Moderate incremental increases in ambient downstream winter total nitrogen concentrations are projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-27**). Negligible incremental increases in ambient downstream summer total nitrogen concentrations are projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-26**). These estimated increases in ambient downstream total nitrogen concentrations projected as a result of the proposed permitted discharge (218 mgd) are anticipated to have a negligible effect on the long-term total nitrogen concentration trends identified in the project area.

5.4.7.8 Overall Total Nitrogen Evaluation

Mathematical modeling tools have been used to calculate the incremental changes in concentrations of total nitrogen in the receiving water downstream from the SRCSD diffuser in the Sacramento River that would result from a proposed future discharge of 218 mgd. As described in the above evaluation, increases of total nitrogen during winter operations would be greatest near the point of discharge and would decline with distance and travel time. For summer operations, the incremental change in total nitrogen is negligible. Based on examination of the magnitude of the incremental changes, a power analysis to assess whether such changes would be measurable, and a trend analysis to allow comparison of the incremental changes to the historical levels that have been observed, the conclusion to be reached is that the incremental increases in total nitrogen concentrations associated with the proposed 218 mgd discharge would not be substantial.

5.4.8 Nitrate plus Nitrite

5.4.8.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for nitrate plus nitrite at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from nitrate plus nitrite measured in the Sacramento River at Freeport. Effluent quality model inputs were derived from nitrate plus nitrite measured in SRWTP effluent. The modeled in-plume nitrate plus nitrite concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-29**. Modeled in-plume nitrate plus nitrite concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-30**.

Table 5-29: Modeled In-Plume Nitrate plus Nitrite Concentration (mg/L as N) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.15	0.16	0.16	0.16	0.16	0.16
Median	0.12	0.12	0.12	0.12	0.12	0.12
95%-ile	0.37	0.38	0.39	0.40	0.41	0.41
99.91%-ile	1.10	1.13	1.17	1.20	1.24	1.24
5%-ile	0.041	0.041	0.040	0.039	0.038	0.037

Table 5-30: Modeled In-Plume Nitrate plus Nitrite Concentration (mg/L as N) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.15	0.15	0.16	0.16	0.16	0.16
Median	0.12	0.12	0.12	0.12	0.12	0.12
95 %-ile	0.37	0.38	0.39	0.40	0.40	0.41
99.91 %-ile	1.11	1.12	1.16	1.20	1.23	1.24
5 %-ile	0.041	0.041	0.040	0.039	0.038	0.037

The incremental differences in modeled in-plume nitrate plus nitrite concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-31**. The median incremental increase in nitrate plus nitrite concentrations would be <0.01 mg/L as N at a distance of 30 feet downstream from the diffuser and <0.01 mg/L as N at a distance of 700 feet downstream from the diffuser.

Table 5-31: Modeled In-Plume Nitrate plus Nitrite Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L as N)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Median	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
95%-ile	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
99.91%-ile	0.01	-0.01	-0.01	<0.01	-0.01	<0.01
5%-ile	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

The probability distributions of nitrate plus nitrite concentrations in the plume 700 feet downstream from the diffuser at 181 mgd are presented in **Figure 5-32**. As indicated in **Table 5-31** and seen in **Figure 5-32** and **Figure 5-33**, the proposed discharge of 218 mgd would have no impact on nitrate plus nitrite concentrations in the discharge plume.

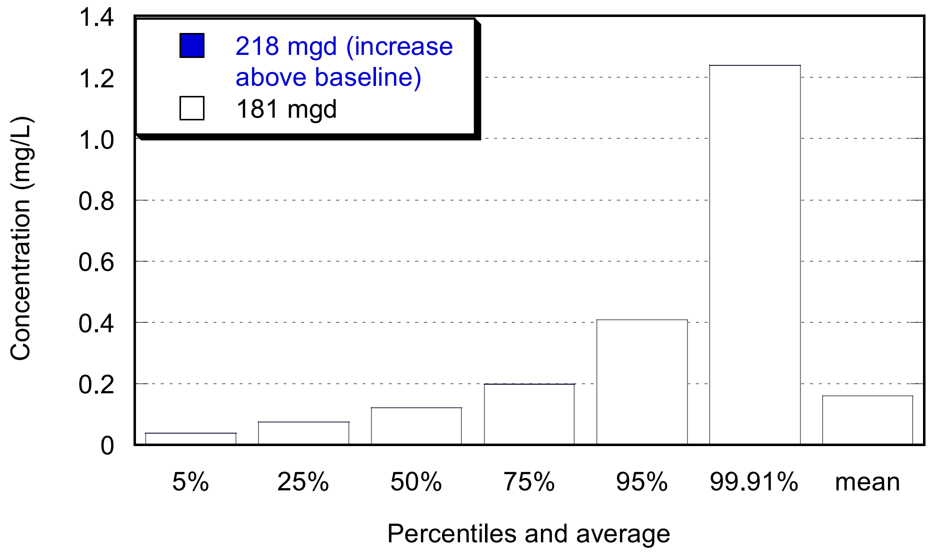

Figure 5-32: Distribution of Modeled Nitrate plus Nitrite Concentrations (mg/L as N) 700 feet Downstream from SRWTP Diffuser.

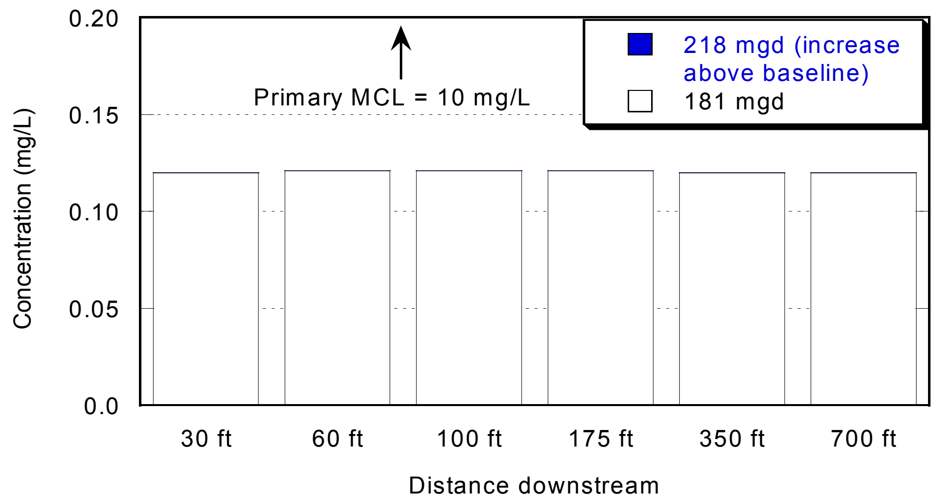

Figure 5-33: Median Modeled Nitrate plus Nitrite Concentration (mg/L as N) Downstream of SRWTP Diffuser.

5.4.8.2 Comparison to Water Quality Objectives

The most stringent water quality objective for nitrate plus nitrite in the Sacramento River is the California Code of Regulations Title 22 Primary MCL of 10 mg/L, incorporated into the Basin Plan by reference. The Primary MCL exists to ensure the safety of drinking water. The percent exceedances of the Title 22 Primary MCL for nitrate plus nitrite at various distances downstream from the SRWTP diffuser are listed in **Table 5-32**. As shown in the table, the Primary MCL for nitrate plus nitrite was not exceeded in the dynamic model simulations at any point within the modeled plume.

Table 5-32: DYNTOX Modeled Percent Exceedance Frequency for Nitrate plus Nitrite at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Primary MCL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 10 mg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-29**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-30**).

5.4.8.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-29**) and proposed discharge (see **Table 5-30**) have similar characteristics. Nitrate plus nitrite concentrations are smaller near the outfall, and increase with distance downstream, indicating that the receiving water concentrations are slightly greater than the effluent concentrations. Furthermore, as listed in **Table 5-31**, the proposed increase in SRWTP effluent discharge would slightly decrease nitrate plus nitrite concentrations in the Sacramento River throughout the modeled plume, with the greatest incremental decreases occurring near the discharge and then gradually tapering off with downstream distance.

The modeled near-field results project in-plume median nitrate plus nitrite concentrations that are substantially below the most stringent applicable water quality criterion, the Title 22 Primary MCL that exists to support consumer acceptance of finished drinking water. Both the modeled nitrate plus nitrite distributions at 700 feet downstream from the diffuser (see **Figure 5-32**) and the modeled, median nitrate plus nitrite concentration within the plume (see **Figure 5-33**) show no measurable increase in nitrate plus nitrite concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in no measurable increase in nitrate plus nitrite concentrations in the Sacramento River.

5.4.8.4 Far-Field Model Analysis Results

Far-field modeling results were used to determine incremental contributions of nitrate plus nitrite resulting from an increase in SRWTP discharge from 181 mgd to 218 mgd at seven far-field locations. The far-field modeled results are shown graphically in **Figure 5-34** and **Figure 5-35**. **Figure 5-34** shows percentile modeled incremental change in nitrate plus nitrite concentrations associated with the proposed 218 mgd discharge in relation to the median ambient concentration at the current permitted 181 mgd discharge in the Sacramento River at Greene's Landing/Hood. There were sufficient ambient nitrate plus nitrite data at four of the seven primary far-field locations to confidently present the median incremental nitrate plus nitrite concentration differences between the modeled existing condition (181 mgd) and proposed permitted condition (218 mgd), as shown in **Table 5-33**. Modeled, median incremental change in nitrate plus nitrite concentration on top of ambient median (50th percentile) and 95th percentile concentrations at the current permitted 181 mgd discharge at four Delta locations are displayed in **Figure 5-35**.

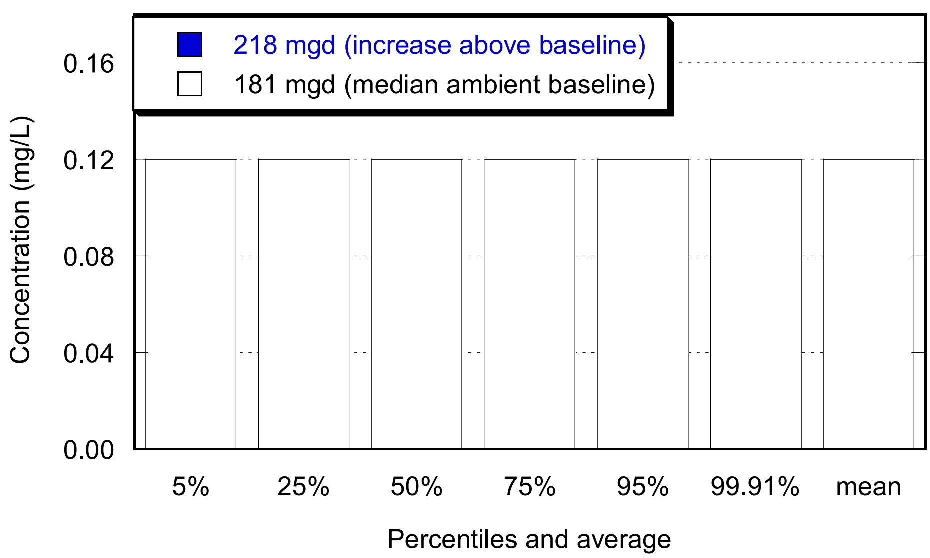

Figure 5-34: Percentiles of Modeled Incremental Change in Nitrate plus Nitrite Concentration (mg/L as N) in the Sacramento River at Greene's Landing/Hood.

Table 5-33: Modeled Nitrate plus Nitrite Concentrations (mg/L as N) Downstream of the SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95th Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	0.12	0.31	<0.01
CCWD PP#1	0.28	1.99	<0.01
CCWD Los Vaqueros Intake	0.45	1.37	<0.01
Banks Delta Pumping Plant	0.50	1.49	<0.01

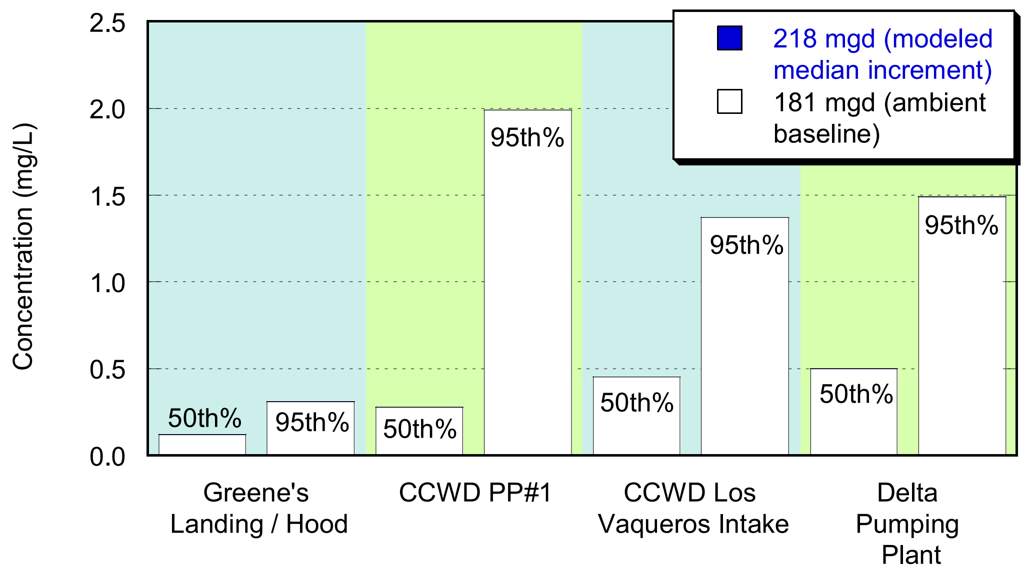

Figure 5-35: Median Modeled Incremental Nitrate plus Nitrite Concentration (mg/L as N) at Far-Field Downstream Locations.

5.4.8.5 Far-Field Evaluation

Fischer Delta Model (FDM) far-field modeling results for the Sacramento River at Greene's Landing/Hood are presented in **Figure 5-34** and **Figure 5-35** and **Table** 5-33. **Table** 5-33 modeled results are graphically represented in **Figure 5-35**. While ambient concentrations vary widely, it should be noted that the modeled, median nitrate plus nitrite increment under the proposed permitted condition (218 mgd) is remarkably small compared to ambient concentrations, as shown in **Figure 5-35** and **Table** 5-33. A statistical power analysis ($\alpha = 0.05$, $\beta = 0.1$) was performed to determine how many water quality samples would need to be collected and analyzed in order to dected the modeled far-field increments in nitrate plus nitrite concentration due to the proposed permitted discharge of 218 mgd, and the results ranged from 26,270 samples at Greene's Landing/Hood to 146,307 samples at Contra Costa Pumping Plant #1. The power analysis results indicate that the concentration increments are immeasureable based on monitoring at any reasonable sampling frequency at far-field Delta locations.

5.4.8.6 Trend Analysis Results

The results of the near- and far-field trend analyses are presented below in the form of a summary table and time series graphs. A best-fit line through the predicted concentrations visually shows the direction of the trend, where a trend with time was determined to exist. There were sufficient matching detected data for nitrate and nitrite to calculate nitrate plus nitrite and employ a parametric regression analysis at only one station. However, there were sufficient detected nitrate data at five locations to employ a parametric regression analysis and determine whether trends exist between ambient nitrate concentrations and time. Since nitrite typically comprises only a minor portion of the nitrate plus nitrite total, the results of the analysis of nitrate are shown in this section. The results of the trend analyses are shown in **Table 5-34**, and the historic nitrate data with applicable trend lines (regression lines) are shown in **Figure 5-36** through **Figure 5-40**.

Table 5-34: Trend Analysis Results for Nitrate.

Location	Count	% Detected	Start Date	End Date	Trend Result with Time	R^2 (adj)	Regression Fit
Freeport	516	91%	11/7/58	7/22/08	Downward	38.8%	Good
Greene/Hood	407	100%	4/3/72	6/2/08	Downward	23.1%	Fair
CCWD PP #1	137	93%	5/21/91	8/5/08	Downward	27.1%	Good
CCWD Los Vaqueros Intake	152	100%	1/24/90	6/2/08	No trend	24.6%	Good
Delta PP	164	100%	1/24/90	5/21/08	Downward	28.1%	Good

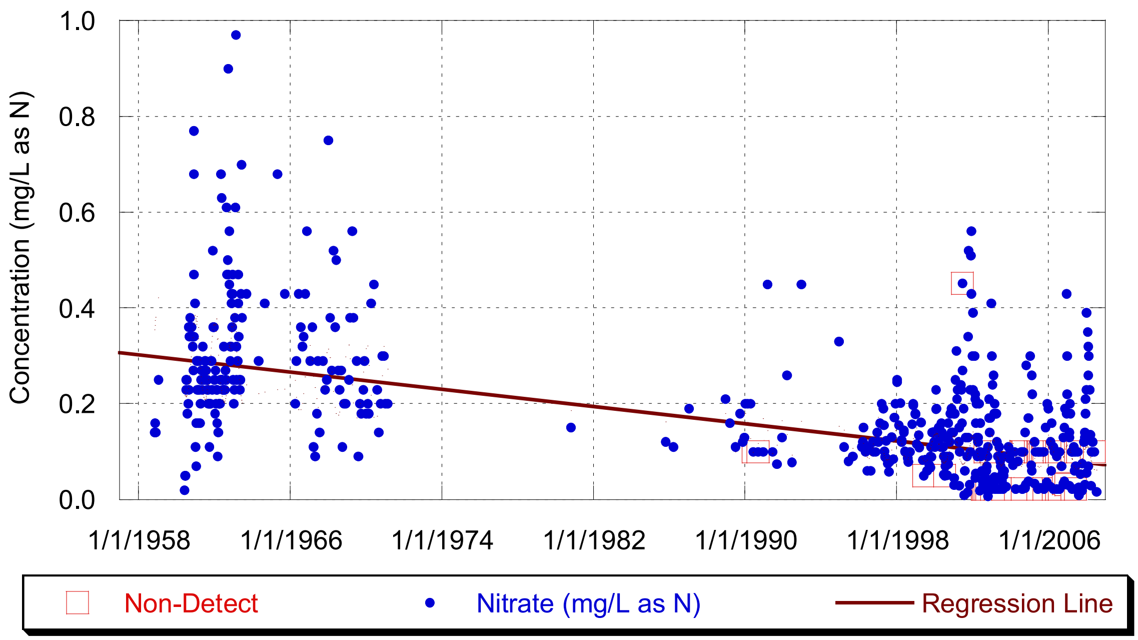

Figure 5-36: Historic Data and Regression Analysis Trend Line for Nitrate in the Sacramento River at Freeport.

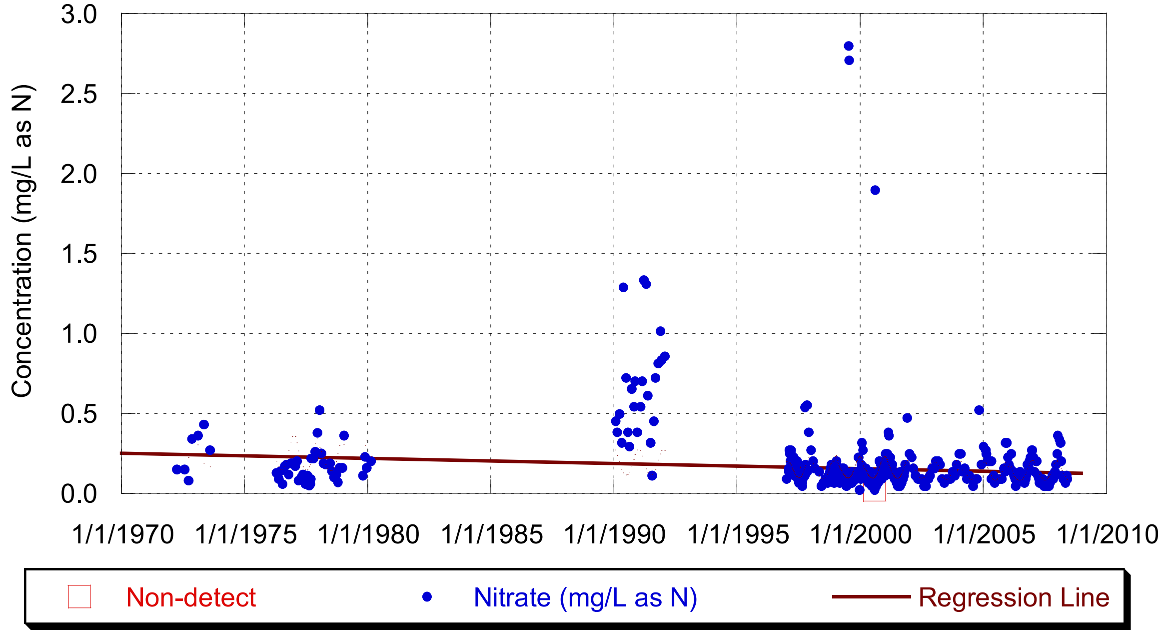

Figure 5-37: Historic Data and Regression Analysis Trend Line for Nitrate in the Sacramento River at Greene's Landing / Hood.

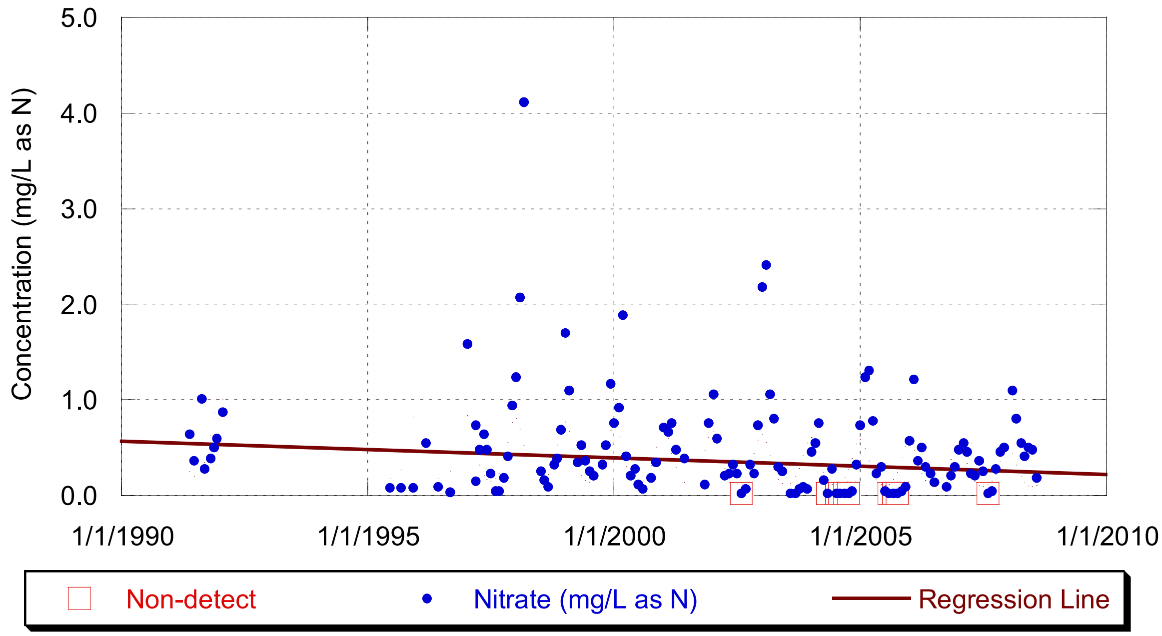

Figure 5-38: Historic Data and Regression Analysis Trend Line for Nitrate at Contra Costa Water District Pumping Plant #1.

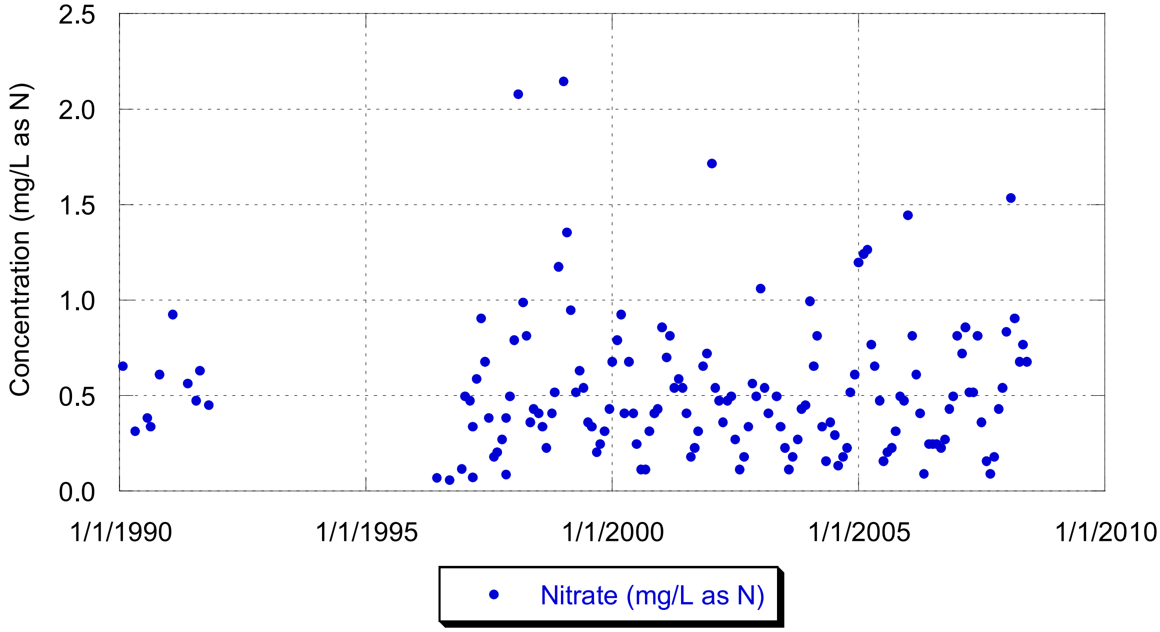

Figure 5-39: Historic Data for Nitrate at the Contra Costa Water District Los Vaqueros Intake.

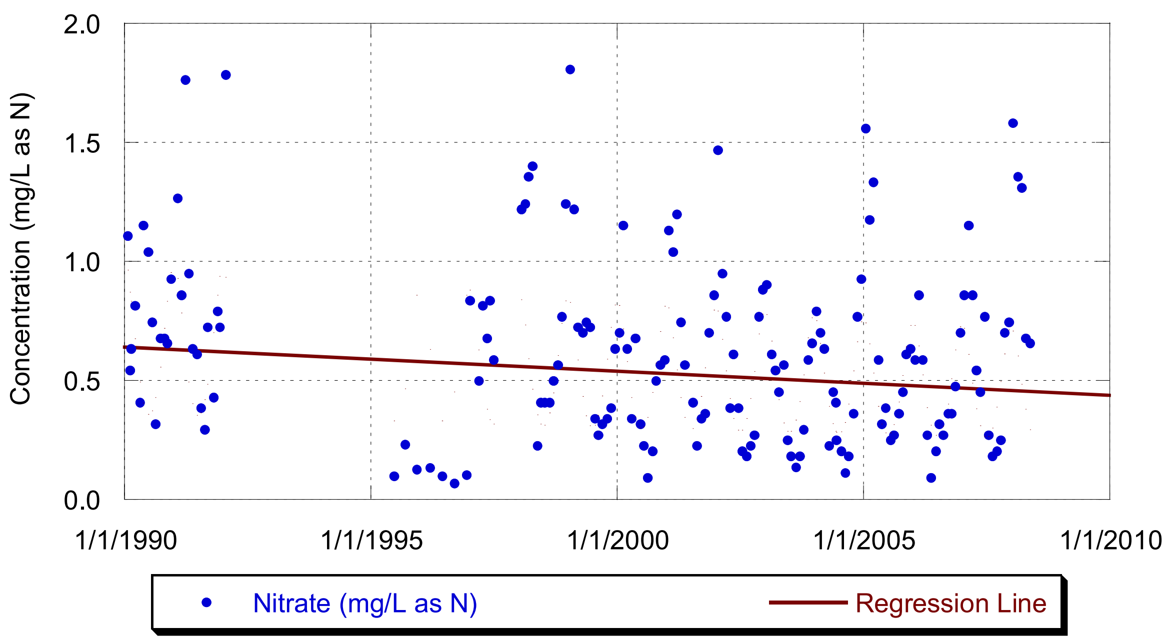

Figure 5-40: Historic Data and Regression Analysis Trend Line for Nitrate at the Harvey O. Banks Delta Pumping Plant Headworks.

5.4.8.7 Trend Analysis Evaluation

The trend analyses performed on ambient nitrate data collected upstream (Sacramento River at Freeport) and downstream (all other far-field Delta locations) of the SRWTP discharge resulted in the determination of a generally downward nitrate trend with time. While the trend analysis at the Contra Costa District's Los Vaqueros Intake showed no observable trend in nitrate concentrations with time, ambient nitrate concentrations at other locations upstream and downstream of the SRWTP discharge have decreased slightly to moderately over the past twenty or more years. It is important to note that this downward trend in ambient NO_3 concentrations has occurred despite increased discharge of ammonia by the SRWTP in recent years. The slight increase in ambient downstream NO_3 concentrations projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-33**) is anticipated to have a negligible effect on the long-term nitrate concentrations and, implicitly, in nitrate plus nitrite concentration trends in the Delta.

5.4.8.8 Overall Nitrate plus Nitrite Evaluation

The near and far-field modeling results described above indicate that the concentrations of nitrate plus nitrite projected to exist under the proposed permitted condition (218 mgd) would not exceed water quality objectives and would not affect beneficial uses. Additionally, the modeling results, combined with power and trend analysis evaluations, indicate that the immeasurable incremental increases in nitrate plus nitrite would not be substantial at downstream locations.

5.4.9 Total Kjeldahl Nitrogen

As noted in Section 5.4.6, the District is evaluating seasonal control of oxygen demanding substances loading from the SRWTP to ensure that ammonia levels during periods of higher river temperature and lower river flow rate (i.e., summer months) do not cause excursions of the dissolved oxygen Basin Plan objective downstream of the discharge. The District is currently considering implementing the reductions by controlling the ammonia concentrations in the SRWTP effluent. The reduced ammonia levels present in the discharge at 181 mgd and 218 mgd would result in corresponding reductions in Total Kjeldahl Nitrogen (TKN) levels. Therefore, the near-field and far-field analyses were conducted for summer and winter operating conditions. The projected summer operations TKN effluent concentrations are shown in **Table 5-2**.

5.4.9.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for TKN at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. TKN is a measurement of that fraction of overall nitrogen content that includes ammonia and organic nitrogen. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from TKN measured in the Sacramento River at Freeport.

Effluent quality model inputs were derived based on projected TKN concentrations corresponding to the projected ammonia concentrations for summer operating conditions (SRCSD, 2009b) and from TKN measured in SRWTP effluent for winter operating conditions. The modeled in-plume TKN concentrations for the existing permitted condition (181 mgd) and summer operations are shown in **Table 5-35**. Modeled in-plume TKN concentrations at the proposed permitted condition (218 mgd) and summer operations are shown in **Table 5-36**. The modeled in-plume TKN concentrations for the existing permitted condition (181 mgd) and winter operations are shown in **Table 5-37**. Modeled in-plume TKN concentrations at the proposed permitted condition (218 mgd) and winter operations are shown in **Table 5-38**.

Table 5-35: Modeled In-Plume Summer Operations Total Kjeldahl Nitrogen Concentration (mg/L) at Varying Distances Downstream of the SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	4.74	3.12	2.17	1.57	1.10	0.95
Median	4.42	2.84	1.96	1.42	0.99	0.85
95%-ile	9.60	6.53	4.47	3.14	2.14	1.88
99.91%-ile	13.90	10.70	7.77	5.78	4.12	3.61
5%-ile	0.71	0.71	0.70	0.62	0.50	0.42

Table 5-36: Modeled In-Plume Summer Operations Total Kjeldahl Nitrogen Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	4.69	3.08	2.14	1.54	1.07	0.93
Median	4.57	2.87	1.96	1.42	0.98	0.85
95 %-ile	8.93	6.26	4.31	3.03	2.02	1.76
99.91 %-ile	12.20	9.43	6.78	4.99	3.60	3.21
5 %-ile	0.47	0.47	0.47	0.47	0.43	0.38

Table 5-37: Modeled In-Plume Winter Operations Total Kjeldahl Nitrogen Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	6.28	4.10	2.82	2.00	1.36	1.16
Median	5.86	3.72	2.52	1.80	1.21	1.03
95%-ile	12.8	8.71	5.91	4.12	2.74	2.38
99.91%-ile	18.7	14.3	10.3	7.68	5.43	4.73
5%-ile	0.81	0.81	0.80	0.73	0.59	0.50

Table 5-38: Modeled In-Plume Winter Operations Total Kjeldahl Nitrogen Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	7.32	4.74	3.23	2.26	1.50	1.28
Median	7.14	4.40	2.94	2.06	1.36	1.15
95 %-ile	14.1	9.84	6.71	4.64	2.99	2.56
99.91 %-ile	19.4	14.9	10.6	7.76	5.51	4.88
5 %-ile	0.52	0.52	0.52	0.52	0.51	0.47

The incremental differences in modeled in-plume TKN concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-39** for summer operating conditions and in **Table 5-40** for winter operating conditions. At 218 mgd, the median incremental increase in TKN concentrations for summer operating conditions would range from 0.15 mg/L at a distance of 30 feet downstream from the diffuser to 0.0 mg/L at a distance of 700 feet downstream from the diffuser. Negative increments reflect the slightly lower mass load of ammonia modeled at 218 mgd in comparison to the levels at 181 mgd. At 218 mgd, the median incremental increase in TKN concentrations for winter operating conditions would range from 1.28 mg/L at a distance of 30 feet downstream from the diffuser to 0.12 mg/L at a distance of 700 feet downstream from the diffuser.

Table 5-39: Modeled In-Plume Summer Operations Total Kjeldahl Nitrogen Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	-0.04	-0.04	-0.03	-0.03	-0.03	-0.03
Median	0.15	0.03	0.00	0.00	-0.01	0.00
95%-ile	-0.67	-0.27	-0.16	-0.11	-0.12	-0.12
99.91%-ile	-1.70	-1.27	-0.99	-0.79	-0.52	-0.40
5%-ile	-0.24	-0.24	-0.22	-0.15	-0.06	-0.04

Table 5-40: Modeled In-Plume Winter Operations Total Kjeldahl Nitrogen Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	1.04	0.64	0.41	0.26	0.14	0.11
Median	1.28	0.68	0.42	0.26	0.15	0.12
95%-ile	1.30	1.13	0.80	0.52	0.25	0.18
99.91%-ile	0.7	0.6	0.3	0.08	0.08	0.15
5%-ile	-0.29	-0.29	-0.29	-0.22	-0.08	-0.03

The probability distributions of modeled summer operations TKN concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-41**. The median summer TKN concentrations in the discharge plume at 181 mgd and the median incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-42**.

The probability distributions of modeled winter operations TKN concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-43**. The median winter TKN concentrations in the discharge plume at 181 mgd and the median incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-44**.

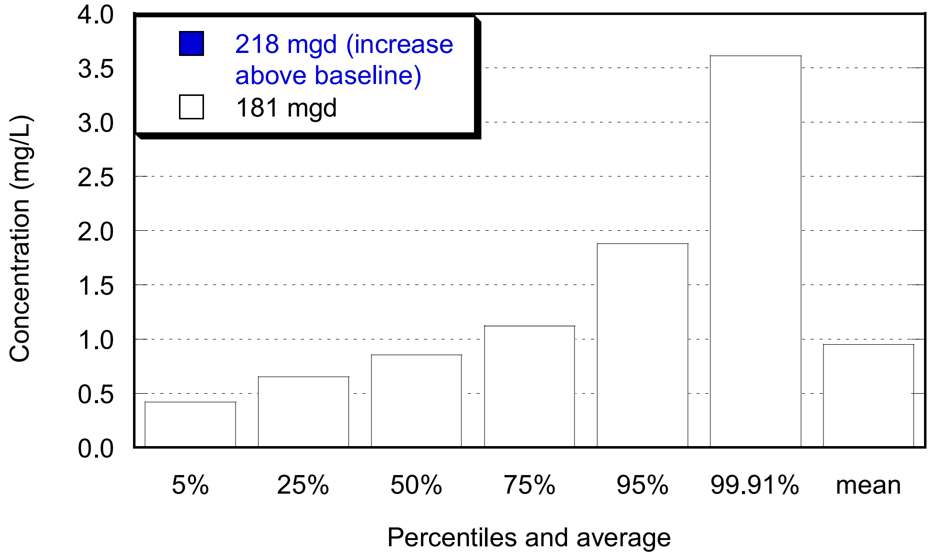

Figure 5-41: Distribution of Modeled Summer Operations Total Kjeldahl Nitrogen Concentrations 700 feet Downstream from SRWTP Diffuser.

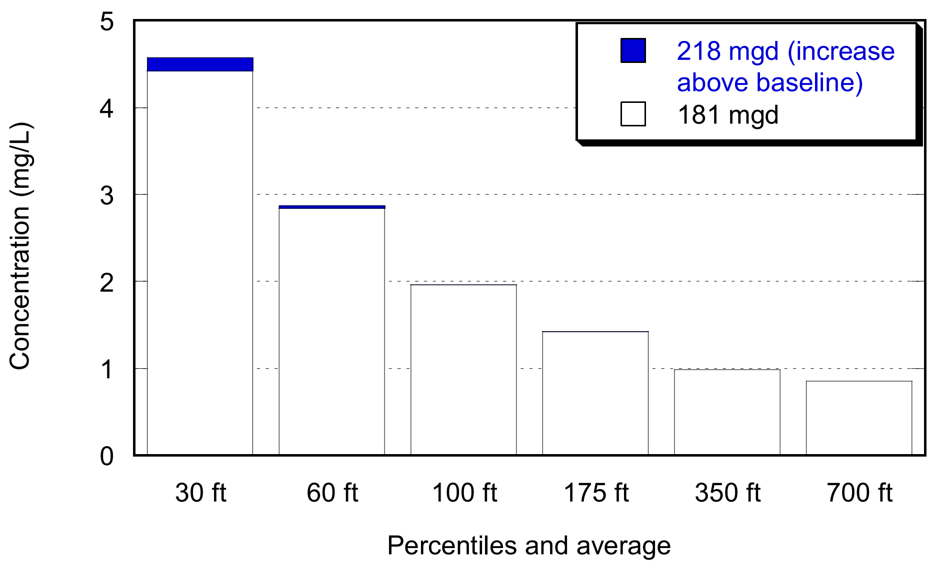

Figure 5-42: Median Modeled Summer Operations Total Kjeldahl Nitrogen Concentration Downstream of SRWTP Diffuser.

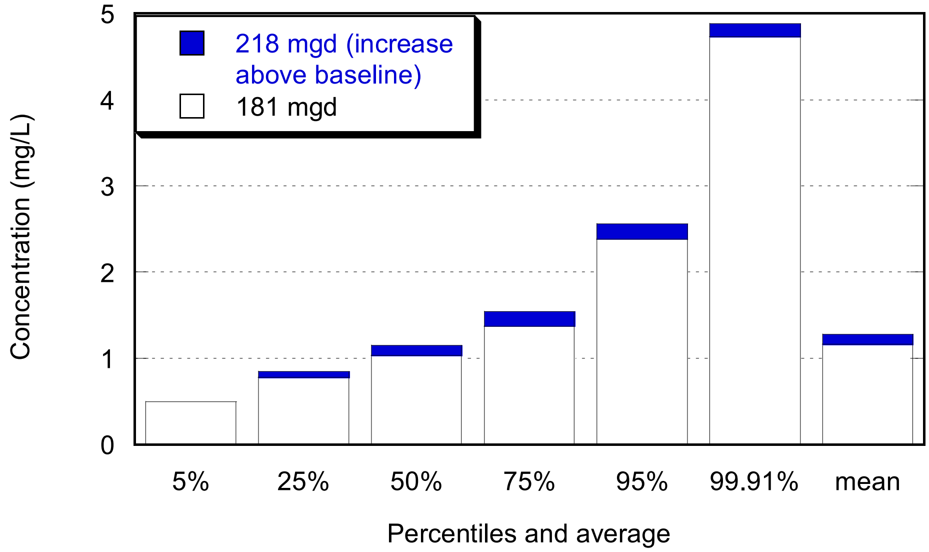

Figure 5-43: Distribution of Modeled Winter Operations Total Kjeldahl Nitrogen Concentrations 700 feet Downstream from SRWTP Diffuser.

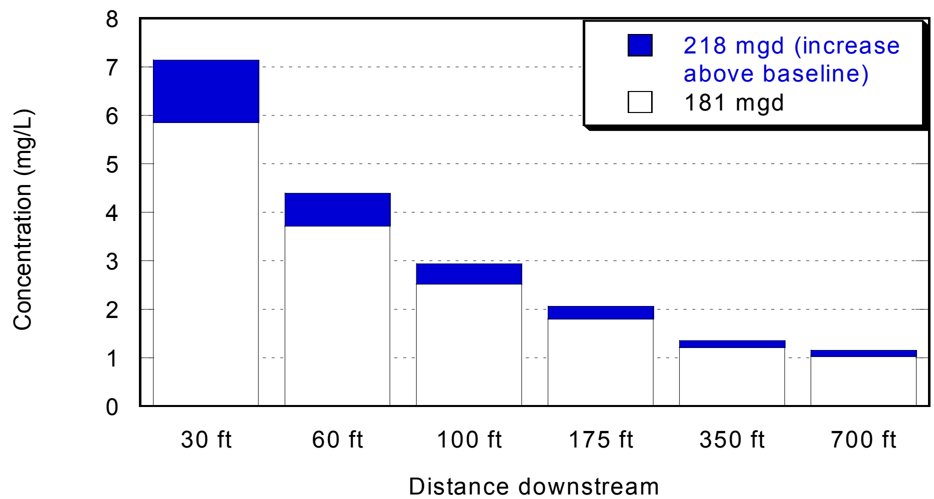

Figure 5-44: Median Modeled Winter Operations Total Kjeldahl Nitrogen Concentration Downstream of SRWTP Diffuser.

5.4.9.2 Comparison to Water Quality Objectives

There are no applicable water quality objectives for TKN. The narrative toxicity objective is applicable to ammonia, as described in Section 5.4.6. Discussions of specific concerns regarding the impact of nutrient loadings on the Delta ecosystem and Delta water supply are presented in Section 4.5 and Section 4.6, respectively.

5.4.9.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-35** and **Table 5-37**) and proposed discharge (see **Table 5-36** and **Table 5-38**) indicate that the concentrations of TKN in each scenario follow a consistent pattern. TKN concentrations are greater near the outfall, since the effluent concentration is generally greater than the background receiving water concentration. All percentile concentrations show a curvilinear decrease in the modeled plume with highest concentrations near the diffuser. As listed in **Table 5-39** and **Table 5-40** and as shown in **Figure 5-41** through **Figure 5-44**, the proposed increase in SRWTP effluent discharge to 218 mgd would slightly increase TKN concentrations in the Sacramento River throughout the modeled plume.

5.4.9.4 Far-Field Model Analysis Results

FSI performed a far-field modeling analysis to determine the percent of SRWTP effluent that is estimated to reach twelve far-field Delta locations under the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd). These far-field modeling results were used to determine incremental contributions of TKN resulting from an increase in SRWTP discharge from 181 mgd to 218 mgd at seven of the twelve far-field locations. The far-field modeled results are shown graphically in **Figure 5-45**through **Figure 5-48**. **Figure 5-45** and **Figure 5-46** show percentile modeled incremental change in TKN concentrations associated with the proposed 218 mgd discharge during summer and winter operating conditions, respectively. In the figures, the 218 mgd increments are depicted on top of the projected median ambient concentrations in the Sacramento at Greene's Landing/Hood at a 181 mgd discharge rate. There are sufficient ambient TKN data at four of the seven primary far-field locations to determine the median incremental TKN concentration differences between the existing (181 mgd) and proposed (218 mgd) permitted condition, as shown in **Table 5-41** and **Table 5-42**, respectively for summer and winter operating conditions. As well, the median incremental change in TKN concentration at 218 mgd is depicted on top of ambient median (50th percentile) and 95th percentile concentrations for the 181 mgd discharge scenario at four Delta locations in **Figure 5-47** and **Figure 5-48**, again for summer and winter operating conditions, respectively.

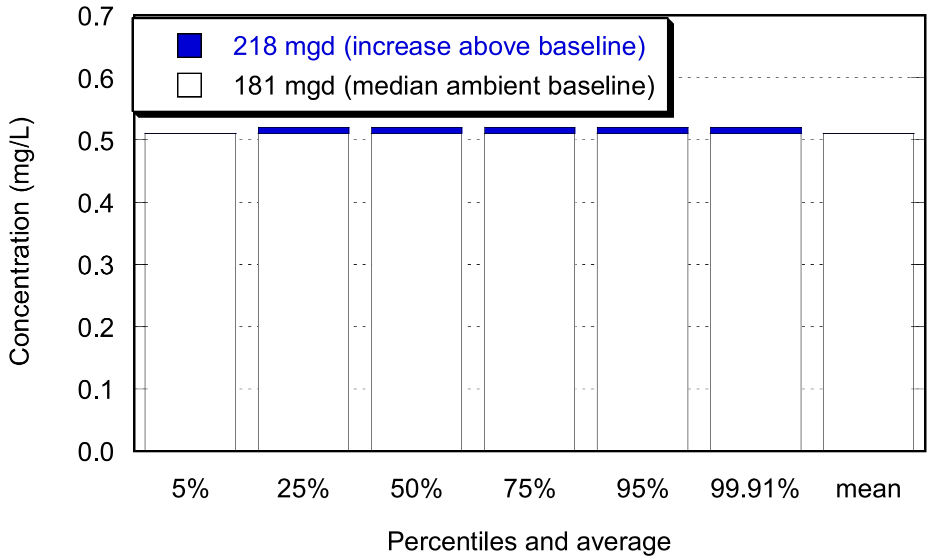

Figure 5-45: Percentiles of Modeled Incremental Change in Summer Operations Total Kjeldahl Nitrogen Concentration in the Sacramento River at Greene's Landing/Hood.

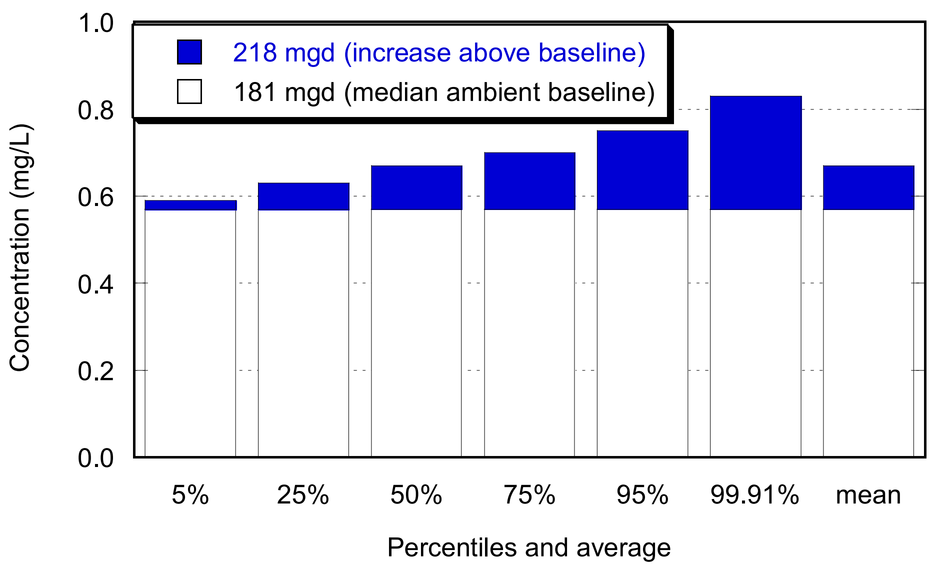

Figure 5-46: Percentiles of Modeled Incremental Change in Winter Operations Total Kjeldahl Nitrogen Concentration in the Sacramento River at Greene's Landing/Hood.

Table 5-41: Incremental Difference in Modeled Summer Operations Total Kjeldahl Nitrogen Concentrations (mg/L) Downstream of the SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95th Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	0.51	1.01	0.01
CCWD PP#1	0.39	0.67	0.01
CCWD Los Vaqueros Intake	0.36	0.69	0.01
Banks Delta Pumping Plant	0.39	0.70	<0.01

Table 5-42: Incremental Difference in Modeled Total Kjeldahl Nitrogen Concentrations (mg/L) Downstream of the SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95th Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	0.57	1.14	0.10
CCWD PP#1	0.44	0.76	0.08
CCWD Los Vaqueros Intake	0.41	0.78	0.07
Banks Delta Pumping Plant	0.44	0.80	0.06

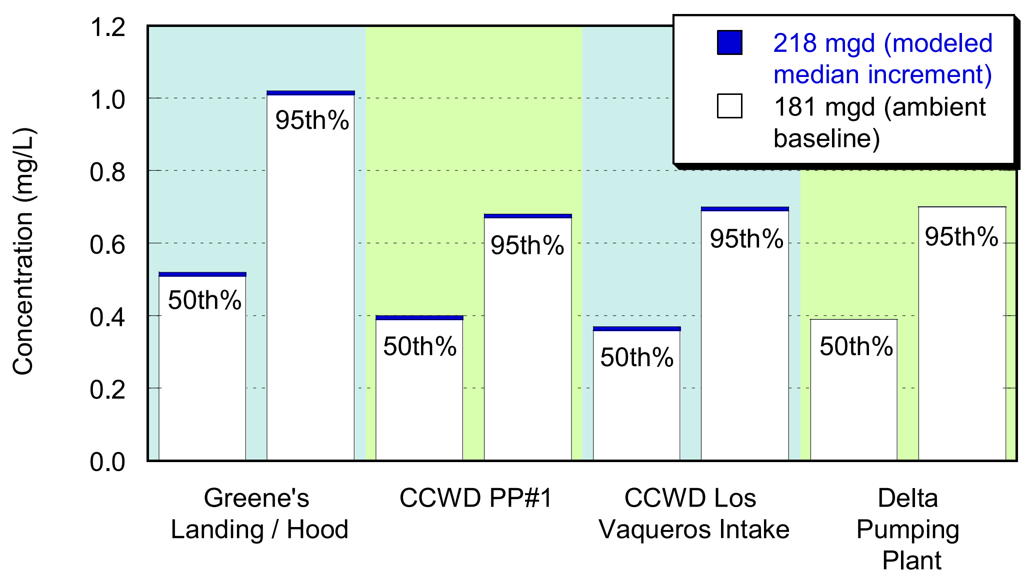

Figure 5-47: Median Modeled Incremental Summer Operations Total Kjeldahl Nitrogen Concentration at Far-Field Downstream Locations.

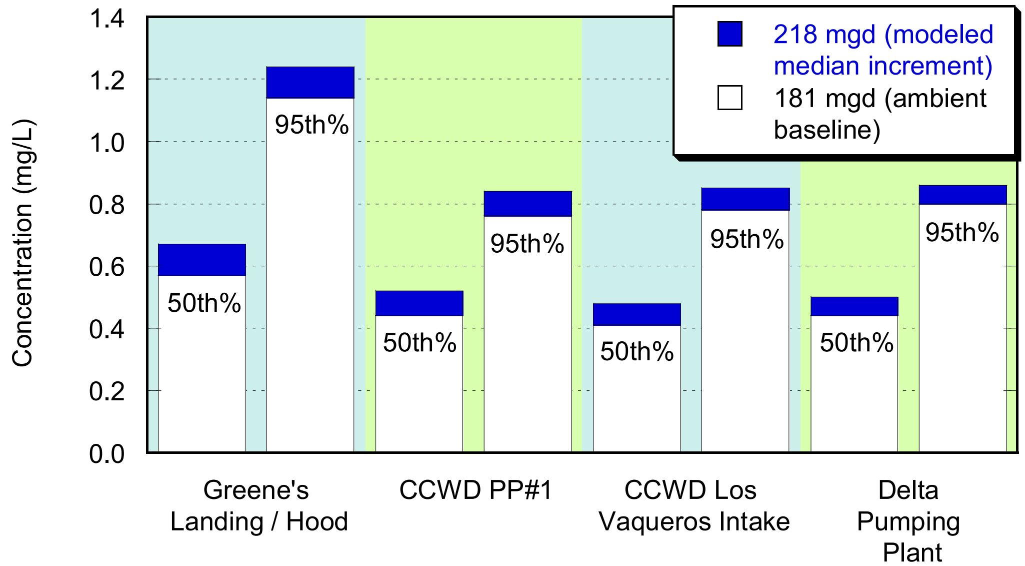

Figure 5-48: Median Modeled Incremental Winter Operations Total Kjeldahl Nitrogen Concentration at Far-Field Downstream Locations.

5.4.9.5 Far-Field Evaluation

Fischer Delta Model (FDM) far-field modeling results for the Sacramento River at Greene's Landing/Hood are presented in **Figure 5-45** and **Figure 5-46**. These figure graphically displays ambient, median TKN concentrations at the existing permitted condition (181 mgd) on top of which are placed projected median TKN concentration increments at the proposed permitted condition (218 mgd). **Table 5-41** and **Table 5-42** provide median (50^{th} percentile) and 95th percentile TKN concentrations at the existing permitted condition (181 mgd) at four far-field Delta locations and the median TKN concentration increment at the proposed permitted condition (218 mgd) at those locations. **Table 5-41** and **Table 5-42**, for summer and winter operations , respectively modeled results are graphically represented in **Figure 5-47** and **Figure 5-48**, for summer and winter operations, respectively. These figures show the range in ambient TKN concentrations for modeled Delta far-field locations under the proposed permitted conditions (218 mgd). It should be noted that the modeled, median TKN increment under the proposed permitted condition (218 mgd) is small compared to ambient concentrations, as shown in **Table 5-41** and **Table 5-42**, for summer and winter operations, respectively. A statistical power analysis ($\alpha = 0.05$, $\beta = 0.1$) was performed to determine how many water quality samples would need to be collected and analyzed in order to dected the modeled far-field increments in ammonia concentration due to the proposed permitted discharge of 218 mgd. For winter operating conditions, the results ranged from 113 samples at Contra Costa Pumping Plant #1 to 265 samples at the Banks Delta Pumping Plant. For summer operating conditions, thousands of samples would need to be colleted and analyzed to detect the projected TKN concentration increments at the far-field locations. The power analysis results indicate that for any reasonable monitoring frequency, the modeled increments are immeasureable at far-field Delta locations.

5.4.9.6 Trend Analysis Results

The results of near- and far-field trend analyses are presented below in a summary table and time series graphs. A best-fit line through the predicted concentrations visually shows the direction of the temporal trend, where such a trend was determined to exist. There were sufficient detected TKN data at five locations to perform the trend analysis. The results of the trend analyses are shown in **Table 5-43**, and the historic TKN data with applicable trend lines (regression lines) are shown in **Figure 5-49** through **Figure 5-53**.

Table 5-43: Trend Analysis Results for Total Kjeldahl Nitrogen.

Location	Count	% Detected	Start Date	End Date	Trend Result with Time	R^2 (adj)	Regression Fit
Freeport	385	85%	2/1/73	7/22/08	Downward	4.4%	Poor
Greene/Hood	602	100%	4/3/72	6/2/08	Upward	29.3%	Good
CCWD PP #1	66	98%	11/5/02	8/5/08	No trend	0.0%	Poor
CCWD Los Vaqueros Intake	67	100%	11/5/02	6/2/08	Upward	10.0%	Fair
Delta PP	129	99%	12/17/97	5/21/08	Downward	12.5%	Fair

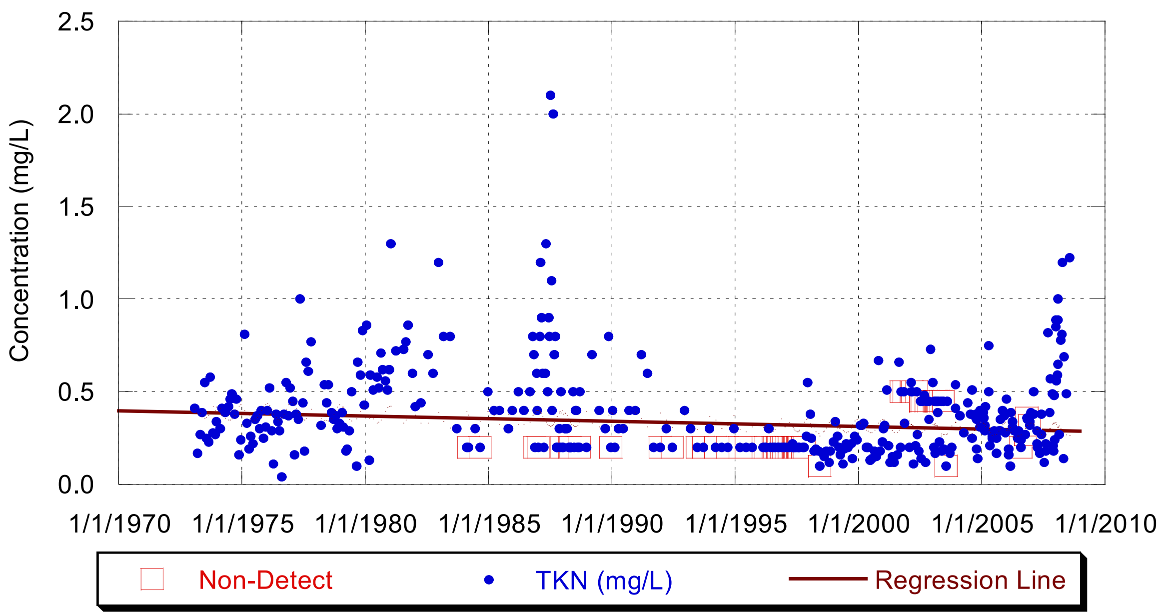

Figure 5-49: Historic Data and Regression Analysis Trend Line for Total Kjeldahl Nitrogen in the Sacramento River at Freeport.

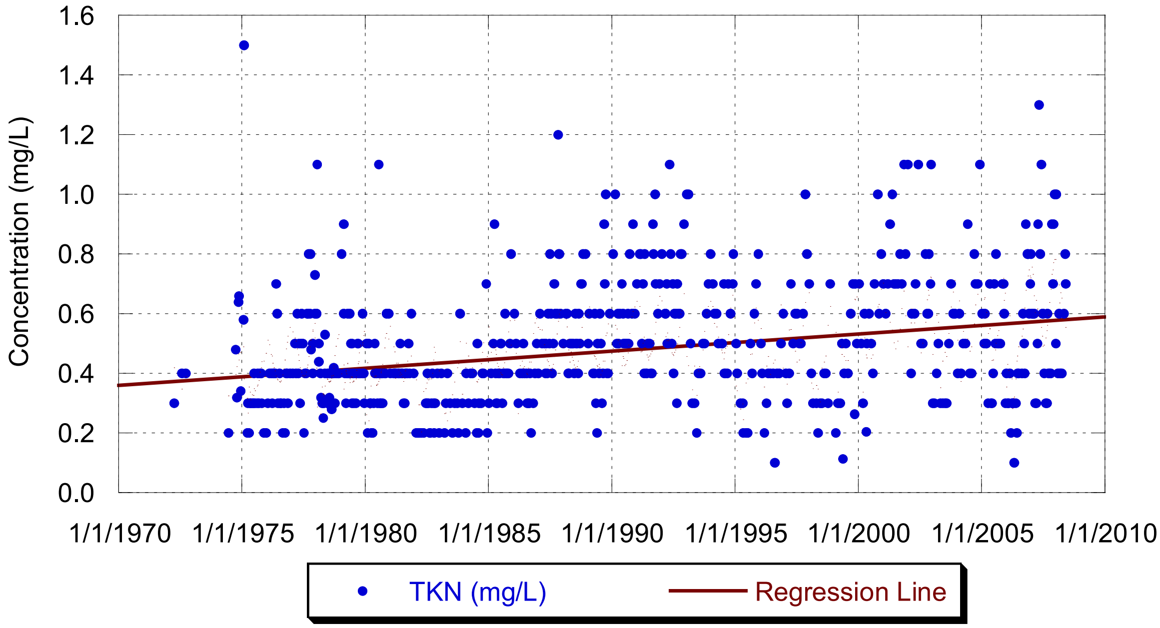

Figure 5-50: Historic Data and Regression Analysis Trend Line for Total Kjeldahl Nitrogen in the Sacramento River at Greene's Landing / Hood.

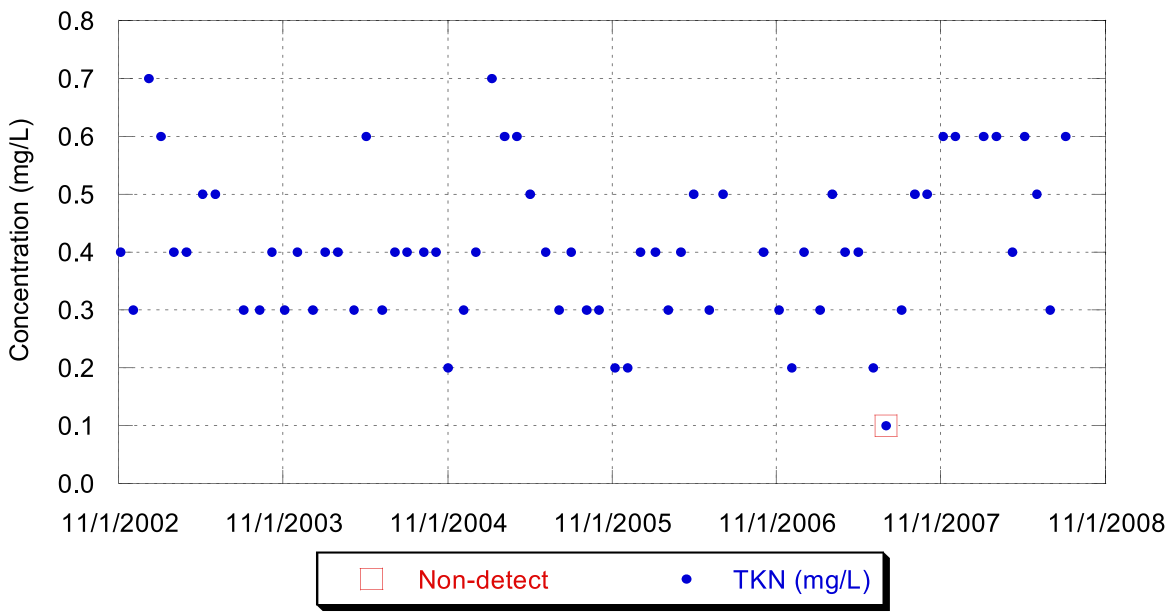

Figure 5-51: Historic Data for Total Kjeldahl Nitrogen at Contra Costa Water District Pumping Plant #1.

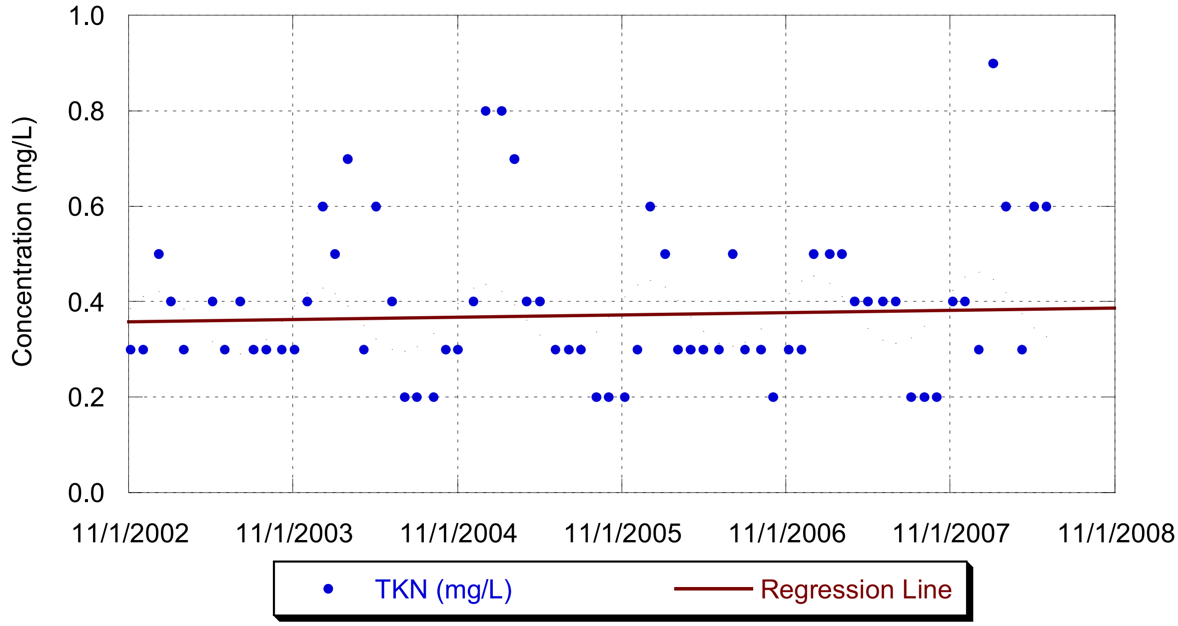

Figure 5-52: Historic Data and Regression Analysis Trend Line for Total Kjeldahl Nitrogen at the Contra Costa Water District Los Vaqueros Intake.

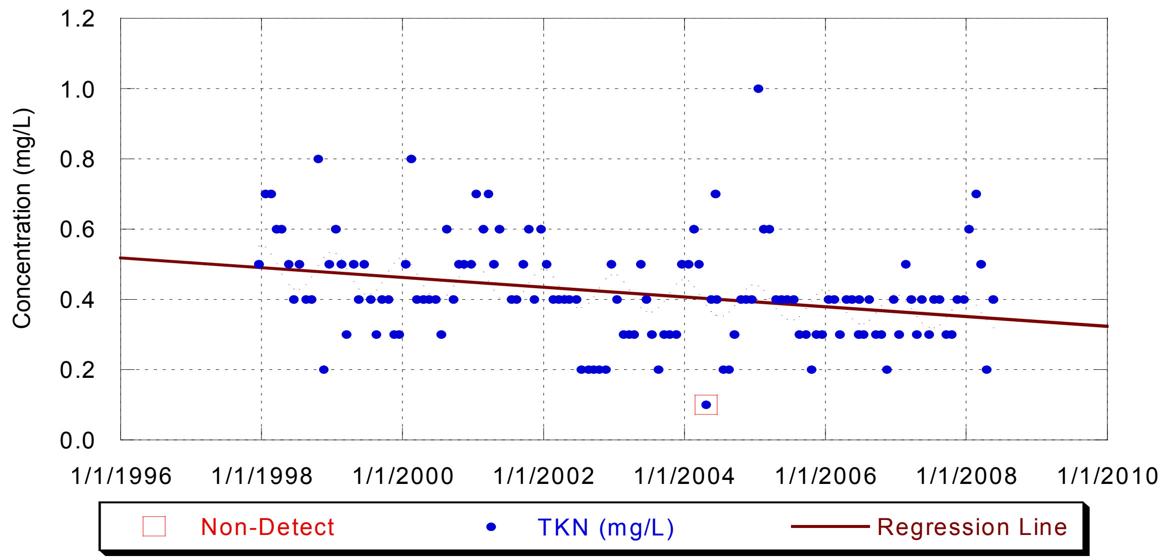

Figure 5-53: Historic Data and Regression Analysis Trend Line for Total Kjeldahl Nitrogen at the Harvey O. Banks Delta Pumping Plant Headworks.

5.4.9.7 Trend Analysis Evaluation

The trend analyses was performed on ambient TKN data collected upstream (Sacramento River at Freeport) and downstream (all other far-field Delta locations) of the SRWTP discharge. Results from the analysis indicated generally weak trends or no trend at most locations. An upward TKN trend was determined at the Sacramento River at Greene's Landing/ Hood, due to recent increases in TKN loadings from the SRWTP. Moderate incremental increases in ambient downstream winter TKN concentrations are projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-40**). Negligible incremental increases in ambient downstream summer TKN concentrations are projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-39**). These increases in ambient downstream TKN concentrations projected as a result of the proposed permitted discharge (218 mgd) are anticipated to have negligible effect on the long-term TKN concentration trends identified in the project area as part of the current trend analysis evaluation.

5.4.9.8 Overall TKN Evaluation

Based on the results of the analyses described above, the water quality impacts of the incremental changes in ambient TKN concentrations associated with the proposed 218 mgd discharge are not substantial and would not adversely affect beneficial uses. Power analysis results indicate that the incremental changes would not be measurable, and the trend analysis shows that the small changes that are projected would not significantly influence downstream concentrations. As described in Section 4.5, existing levels of nutrients in the Delta have not been scientifically linked to adverse impacts on the ecosystem.

5.4.10 Total Phosphorus

5.4.10.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for total phosphorus (TP) at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from TP measured in the Sacramento River at Freeport. Effluent quality model inputs were derived from TP measured in SRWTP effluent. The modeled in-plume TP concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-44**. Modeled in-plume TP concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-45**.

Table 5-44: Modeled In-Plume Total Phosphorus Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.63	0.44	0.32	0.25	0.20	0.18
Median	0.57	0.37	0.26	0.19	0.13	0.11
95%-ile	1.27	0.95	0.73	0.60	0.52	0.50
99.91%-ile	3.51	3.66	3.76	3.79	3.82	3.83
5%-ile	0.12	0.11	0.092	0.071	0.050	0.039

Table 5-45: Modeled In-Plume Total Phosphorus Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.72	0.49	0.36	0.28	0.21	0.19
Median	0.69	0.44	0.30	0.22	0.15	0.12
95 %-ile	1.38	1.03	0.78	0.62	0.53	0.50
99.91 %-ile	3.46	3.62	3.72	3.78	3.82	3.82
5 %-ile	0.079	0.078	0.077	0.068	0.051	0.041

The incremental differences in modeled in-plume TP concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-46**. The median incremental increase in TP concentrations is projected to range from 0.11 mg/L at a distance of 30 feet downstream from the diffuser to 0.01 mg/L at a distance of 700 feet downstream from the diffuser.

Table 5-46: Modeled In-Plume Total Phosphorus Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.09	0.06	0.04	0.02	0.01	0.01
Median	0.11	0.06	0.04	0.03	0.02	0.01
95%-ile	0.11	0.08	0.05	0.02	0.01	0.01
99.91%-ile	-0.05	-0.04	-0.04	-0.01	<0.01	-0.01
5%-ile	-0.04	-0.03	-0.015	-0.003	0.001	0.001

The probability distributions of modeled TP concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-54**. The median TP concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-55**.

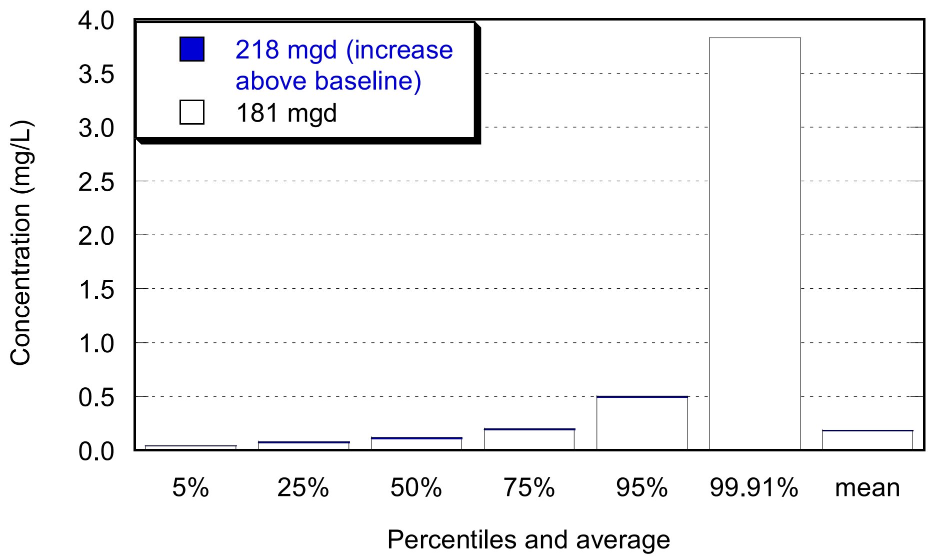

Figure 5-54: Distribution of Modeled Total Phosphorus Concentrations 700 feet Downstream of SRWTP Diffuser.

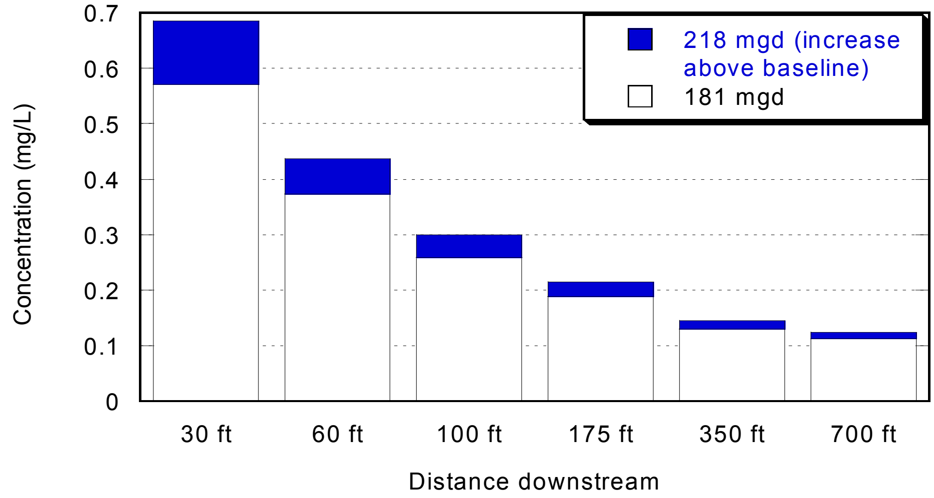

Figure 5-55: Median Modeled Total Phosphorus Concentration Downstream of SRWTP Diffuser.

5.4.10.2 Comparison to Water Quality Objectives

There are no applicable water quality objectives for TP.

5.4.10.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-44**) and proposed discharge (see **Table 5-45**) have similar characteristics. TP concentrations are greater near the outfall, since the effluent concentration is generally greater than the receiving water concentration. All percentile concentrations show a curvilinear decrease in the modeled plume with highest concentrations near the diffuser. As listed in **Table 5-46**, the proposed increase in SRWTP effluent discharge would slightly increase TP concentrations in the Sacramento River throughout the modeled plume, with the greatest incremental increases occurring near the discharge and tapering off to a negligible increment at 700 feet downstream.

The incremental change in TP concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight. Both the modeled TP distributions at 700 feet downstream from the diffuser (see **Figure 5-54**) and the modeled, median TP concentration within the plume (see **Figure 5-55**) show a slight incremental increase in TP concentration in the receiving water.

5.4.10.4 Far-Field Model Analysis Results

Far-field modeling results were used to determine incremental contributions of TP resulting from an increase in SRWTP discharge from 181 mgd to 218 mgd at seven far-field locations. The far-field modeled results are shown graphically in **Figure 5-56** and **Figure 5-57**. **Figure 5-56** shows percentile modeled incremental changes in TP concentrations associated with the proposed 218 mgd discharge in relation to the median ambient concentration at the current permitted 181 mgd discharge in the Sacramento River at Greene's Landing/Hood. There were sufficient ambient TP data at four of the seven primary far-field locations to confidently display the median incremental TP concentration differences at the modeled existing condition (181 mgd) and the proposed permitted condition (218 mgd). Modeled, median incremental change in TP concentration is portrayed on top of ambient median (50th percentile) and 95th percentile concentrations at the current permitted 181 mgd discharge at four Delta locations in **Figure 5-57**.

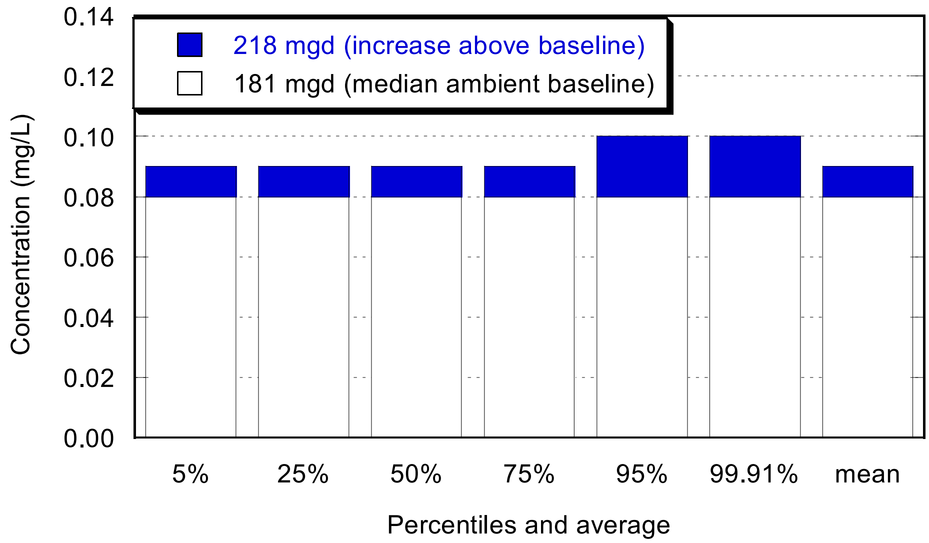

Figure 5-56: Percentiles of Modeled Incremental Change in Total Phosphorus Concentration in the Sacramento River at Greene's Landing/Hood.

Table 5-47: Modeled Total Phosphorus Concentrations (mg/L) Downstream of the SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95th Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	0.08	0.16	0.01
CCWD PP#1	0.06	0.12	0.01
CCWD Los Vaqueros Intake	0.08	0.15	0.01
Banks Delta Pumping Plant	0.11	0.18	0.01

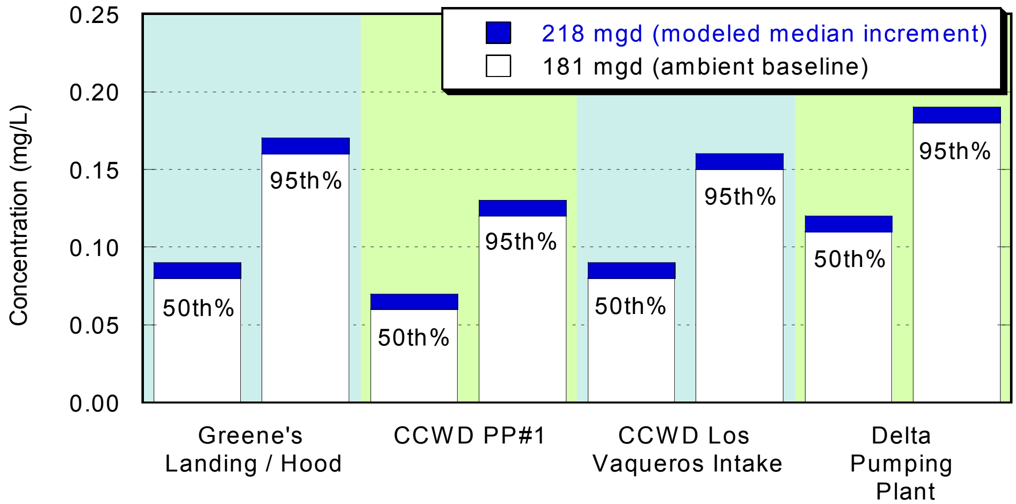

Figure 5-57: Median Modeled Incremental Total Phosphorus Concentration at Far-Field Downstream Locations.

5.4.10.5 Far-Field Evaluation

Fischer Delta Model (FDM) far-field modeling results for the Sacramento River at Greene's Landing/Hood are presented in **Figure 5-56**. This figure graphically displays all modeled distributions of ambient, median TP concentrations at the existing permitted condition (181 mgd) on top of which are placed modeled, median TP concentration increments estimated for the proposed permitted condition (218 mgd).

Table 5-47 provides median (50th percentile) and 95th percentile TP concentrations at the existing permitted condition (181 mgd) at four far-field Delta locations for which sufficient ambient data were available. Additionally, **Table 5-47** presents the modeled, median TP concentration increments at the proposed permitted condition (218 mgd) for the Delta locations considered. **Table 5-47** modeled results are graphically represented in **Figure 5-57**. This figure shows the range in ambient TP concentrations for modeled Delta far-field locations under the existing permitted (181 mgd) and proposed permitted conditions (218 mgd). While ambient concentrations vary widely, the median TP increment under the proposed permitted condition (218 mgd) is remarkably small compared to ambient concentrations, as shown in **Table 5-47**. A statistical power analysis ($\alpha = 0.05$, $\beta = 0.1$) was performed to determine how many water quality samples would need to be collected and analyzed in order to detect the modeled TP increment and the results ranged from 170 samples at Contra Costa Pumping Plant #1to 380 samples at the other three analyzed stations. The power analysis results indicate that the modeled far-field increments in TP concentration due to the proposed permitted discharge of 218 mgd are immeasurable at normal monitoring frequencies.

5.4.10.6 Trend Analysis Results

The results of the near- and far-field trend analyses are presented below in the form of a summary table and time series graphs. A best-fit line through the predicted concentrations shows the direction of the trend, where a temporal trend was determined to exist. There were sufficient detected TP data at five locations to employ a parametric regression analysis to determine whether trends exist between ambient TP concentrations and time. The results of the trend analyses are shown in **Table 5-48**, and the historic TP data with applicable trend lines (regression lines) are shown in **Figure 5-58** through **Figure 5-62**.

Table 5-48: Trend Analysis Results for Total Phosphorus.

Location	Count	% Detected	Start Date	End Date	Trend Result with Time	R^2 (adj)	Regression Fit
Freeport	545	94%	10/7/70	4/24/08	Yes, downward	19.6%	Fair
Greene/Hood	632	100%	6/16/71	8/4/08	Yes, downward	22.0%	Fair
CCWD PP #1	66	100%	11/5/02	8/5/08	Yes, downward	22.0%	Good
CCWD Los Vaqueros Intake	67	100%	11/5/02	6/2/08	No trend with time	0.0%	Poor
Delta PP	129	100%	12/17/97	5/21/08	Yes, downward	8.5%	Fair

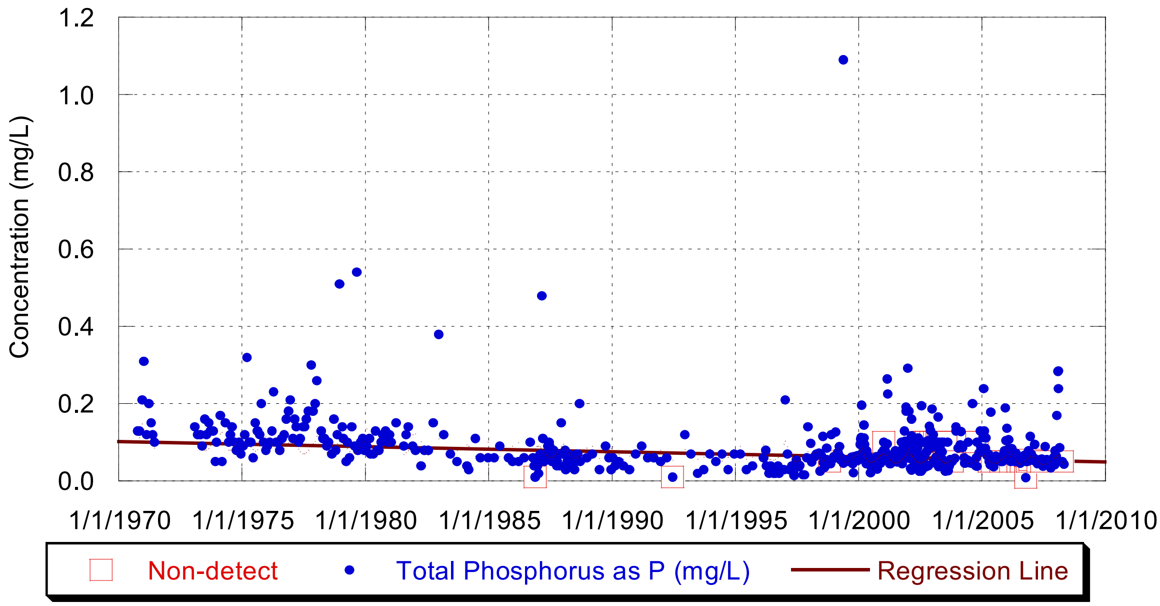

Figure 5-58: Historic Data and Regression Analysis Trend Line for Total Phosphorus in the Sacramento River at Freeport.

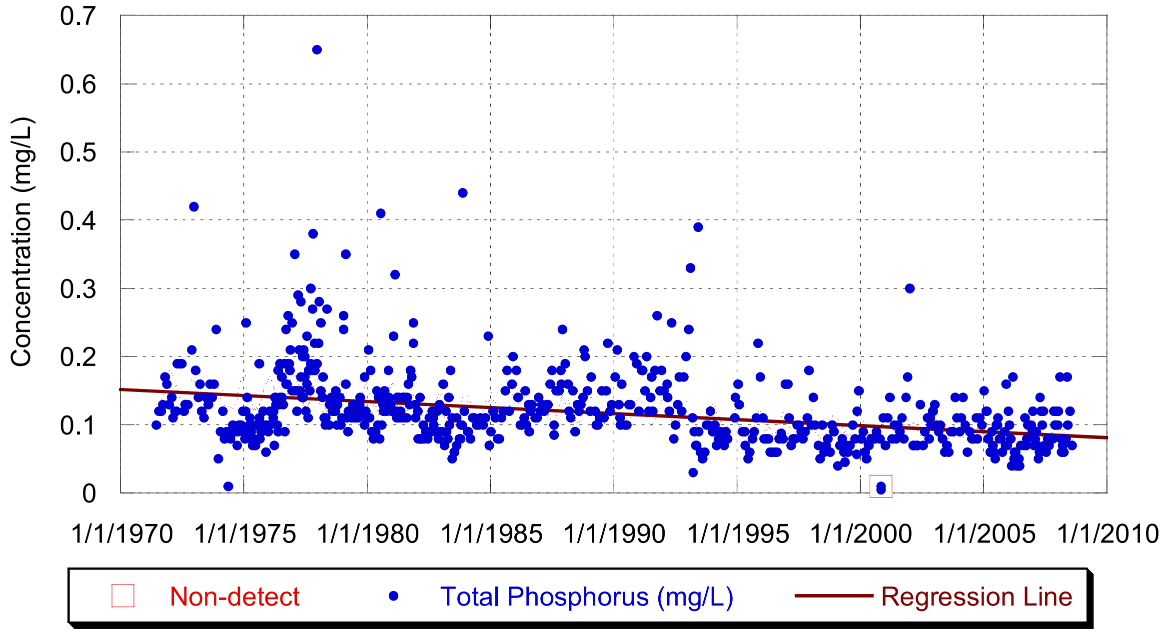

Figure 5-59: Historic Data and Regression Analysis Trend Line for Total Phosphorus in the Sacramento River at Greene's Landing / Hood.

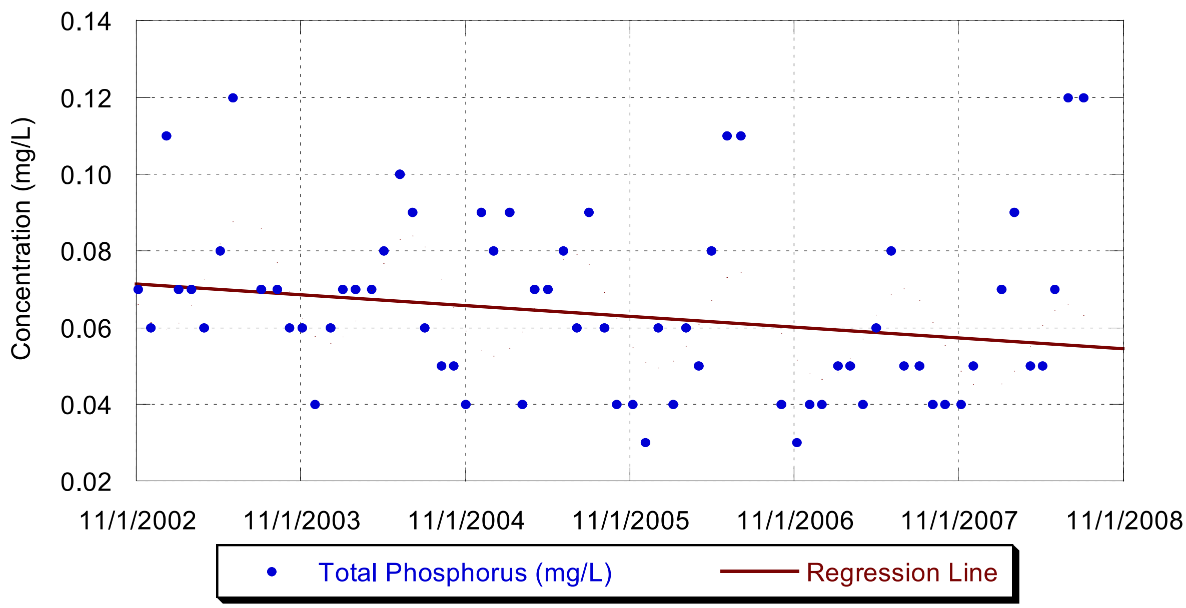

Figure 5-60: Historic Data and Regression Analysis Trend Line for Total Phosphorus at Contra Costa Water District Pumping Plant #1.

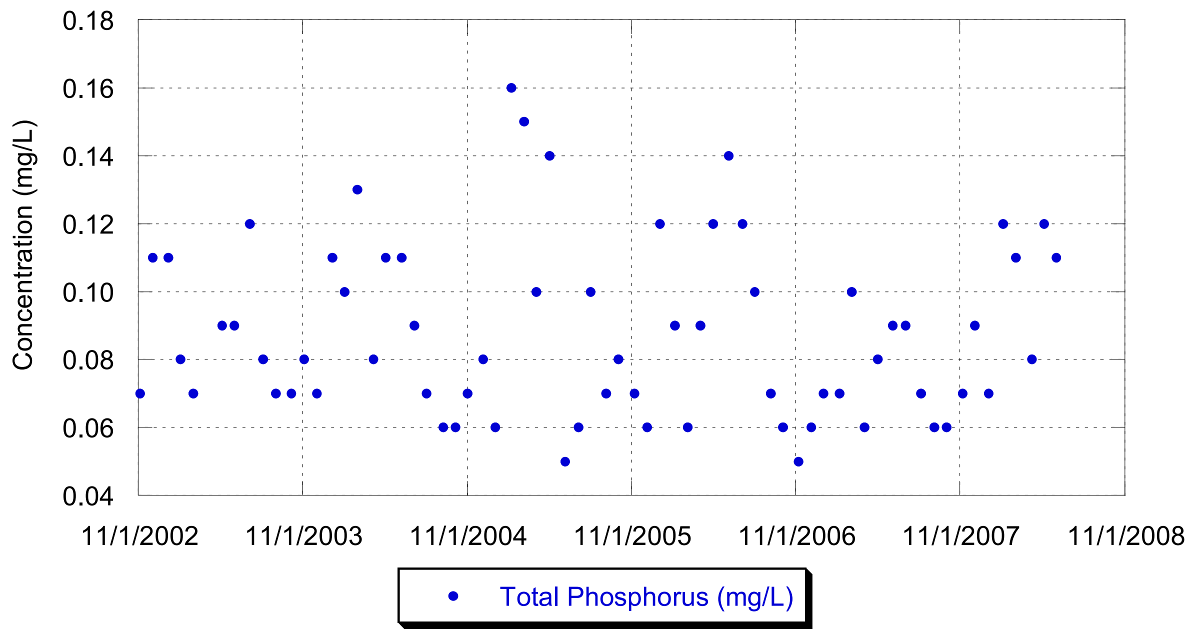

Figure 5-61: Historic Data for Total Phosphorus at the Contra Costa Water District Los Vaqueros Intake.

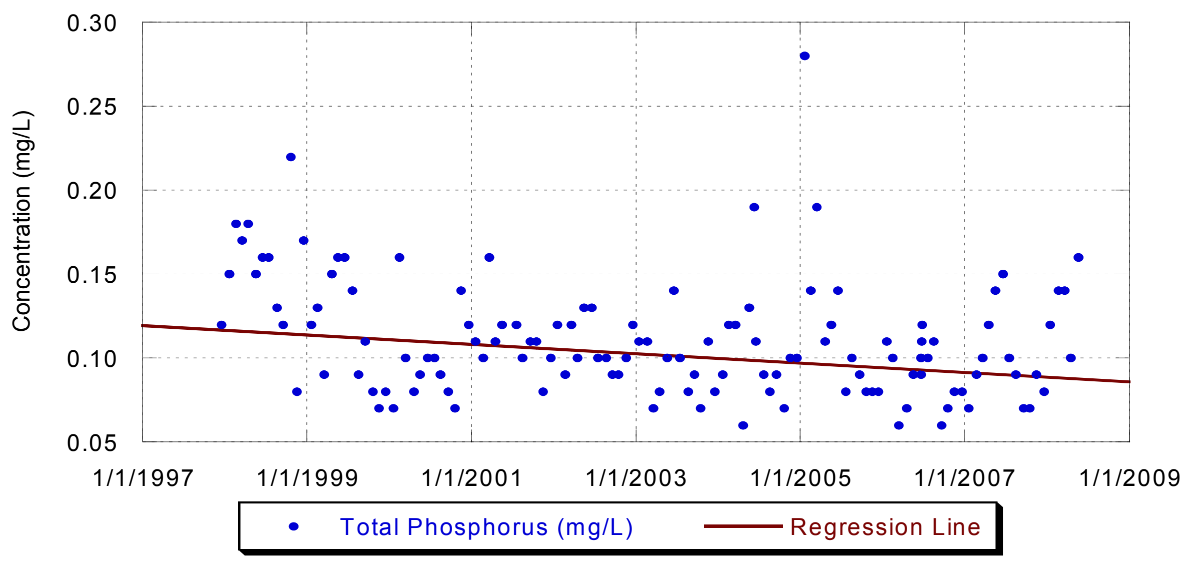

Figure 5-62: Historic Data and Regression Analysis Trend Line for Total Phosphorus at the Harvey O. Banks Delta Pumping Plant Headworks.

5.4.10.7 Trend Analysis Evaluation

The trend analyses performed on ambient TP data collected upstream (Sacramento River at Freeport) and downstream (all other far-field Delta locations) of the SRWTP discharge resulted in the determination of a generalized downward trend in TP concentrations. While the trend analysis for TP at the Contra Costa Water District Los Vaqueros Intake showed no observable temporal trend, downward trends were observed at each of the other locations considered. Ambient TP concentrations upstream and downstream of the SRWTP discharge have decreased slightly to moderately over the past forty years. The slight increases in ambient downstream TP concentrations projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-47**) are anticipated to have negligible effects on the long-term TP concentration trends in the project area and downstream into the Delta.

5.4.10.8 Overall Total Phosphorus Evaluation

The results from the near and far-field modeling, in combination with power analysis and trend analysis for TP at various locations in the Delta indicate that the proposed project would have no significant or substantial effect on TP concentrations. The magnitude of incremental change associated with the proposed discharge of 218 mgd is very small and immeasurable under any normal sampling frequency.

5.4.11 Electrical Conductivity

5.4.11.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for electrical conductivity (EC) at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from EC measured in the Sacramento River at Freeport. Effluent quality model inputs were derived from EC measured in SRWTP effluent. The modeled in-plume EC concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-49**. Modeled in-plume EC concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-50**.

Table 5-49: Modeled In-Plume Electrical Conductivity Concentration (µmhos/cm) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	302	251	221	202	187	182
Median	295	243	213	194	178	173
95%-ile	466	386	337	311	293	289
99.91%-ile	601	530	493	477	466	464
5%-ile	161	146	132	120	109	104

Table 5-50: Modeled In-Plume Electrical Conductivity Concentration (µmhos/cm) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	327	266	230	208	190	185
Median	326	259	223	200	182	176
95 %-ile	492	405	349	317	297	291
99.91 %-ile	615	543	499	481	468	465
5 %-ile	160	148	136	123	111	106

The incremental differences in modeled in-plume EC concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-51**. The median incremental increase in EC concentrations would range from 31 µmhos/cm at a distance of 30 feet downstream from the diffuser to 3 µmhos/cm at a distance of 700 feet downstream from the diffuser.

Table 5-51: Modeled In-Plume Electrical Conductivity Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (μmhos/cm)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	24	15	10	6	3	3
Median	31	16	10	6	4	3
95%-ile	26	19	12	6	4	2
99.91%-ile	14	13	6	4	2	1
5%-ile	-1	2	4	3	2	2

The probability distributions of modeled EC concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-63**. The median EC concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-64**.

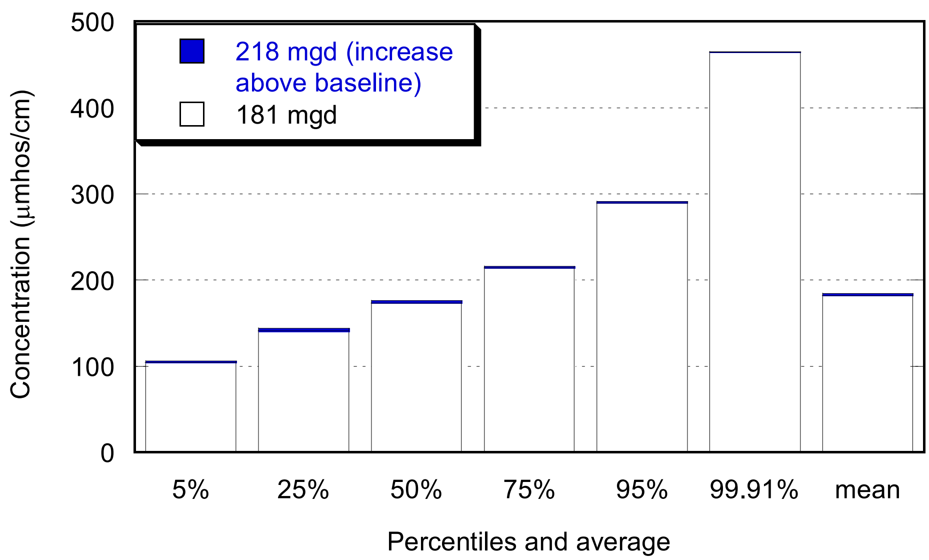

Figure 5-63: Distribution of Modeled Electrical Conductivity Concentrations 700 feet Downstream of SRWTP Diffuser.

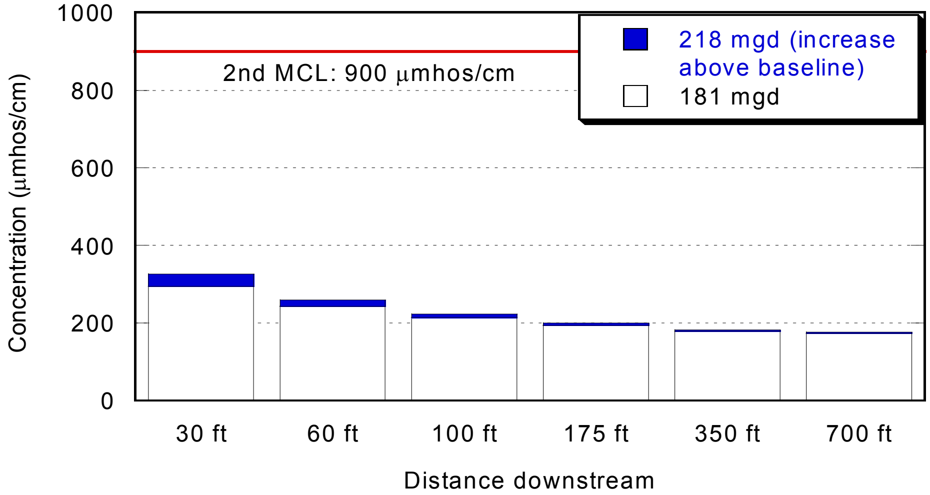

Figure 5-64: Median Modeled Electrical Conductivity Concentration Downstream of SRWTP Diffuser.

5.4.11.2 Comparison to Water Quality Objectives

The most stringent water quality objective for EC in the Sacramento River is the California Code of Regulations Title 22 Secondary MCL of 900 µmhos/cm, incorporated into the Basin Plan by reference. The Secondary MCL exists to support consumer acceptance of finished drinking water. The percent exceedances of the Title 22 Secondary MCL for EC at various distances downstream from the SRWTP diffuser are listed in Table 5-52. As the table indicates, the Secondary MCL for EC was not exceeded in the dynamic model simulations at any point within the modeled plume.

Table 5-52: DYNTOX Modeled Percent Exceedance Frequency for Electrical Conductivity at Various Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Secondary MCL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the Title 22 Secondary MCL for EC. To this end, the 900 µmhos/cm objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-49**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-50**). These modeled results are graphically represented in **Figure 5-63** at a distance of 700 foot downstream from the diffuser. These findings are consistent with the modeled results indicating no exceedances of the Secondary MCL as listed in **Table 5-52**.

5.4.11.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-49**) and proposed discharge (see **Table 5-50**) have similar characteristics. For the 5th percentile through the 95th percentile distributions, EC concentrations in the plume are greater near the outfall, corresponding to the scenario where the effluent concentration is generally greater than the receiving water concentration. As listed in **Table 5-51**, the proposed increase in SRWTP effluent discharge would slightly increase EC concentrations in the Sacramento River throughout the modeled plume, with the greatest incremental increases occurring near the discharge and then gradually tapering off with downstream distance.

The dynamic model results presented in **Table 5-52** are used to demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the EC objective. The incremental change in EC concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight. Both the modeled EC distributions at 700 feet downstream from the diffuser (see **Figure 5-63**) and the modeled, median EC concentration within the plume (see **Figure 5-64**) show a slight incremental increase in EC concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in EC concentrations in the Sacramento River.

5.4.11.4 Far-Field Model Analysis Results

Far-field modeling was also performed to determine incremental contributions of EC resulting from an increase in SRWTP discharge from 181 mgd to 218 mgd at seven far-field locations. The far-field modeled results are shown graphically in **Figure 5-65** and **Figure 5-66**. **Figure 5-65** shows percentile modeled incremental change in EC concentrations associated with the proposed 218 mgd discharge placed on top of the median ambient concentration estimated to occur at the current permitted 181 mgd discharge in the Sacramento River at Greene's Landing/Hood. There were sufficient ambient EC data at six of the seven primary far-field locations to confidently present the median incremental EC concentration differences between the modeled existing condition (181 mgd) and proposed permitted condition (218 mgd), as shown in **Table 5-53**. Modeled, median incremental change in EC concentration on top of ambient median (50th percentile) and 95th percentile concentrations estimated to occur at the current permitted 181 mgd discharge at four Delta locations are displayed in **Table 5-53**.

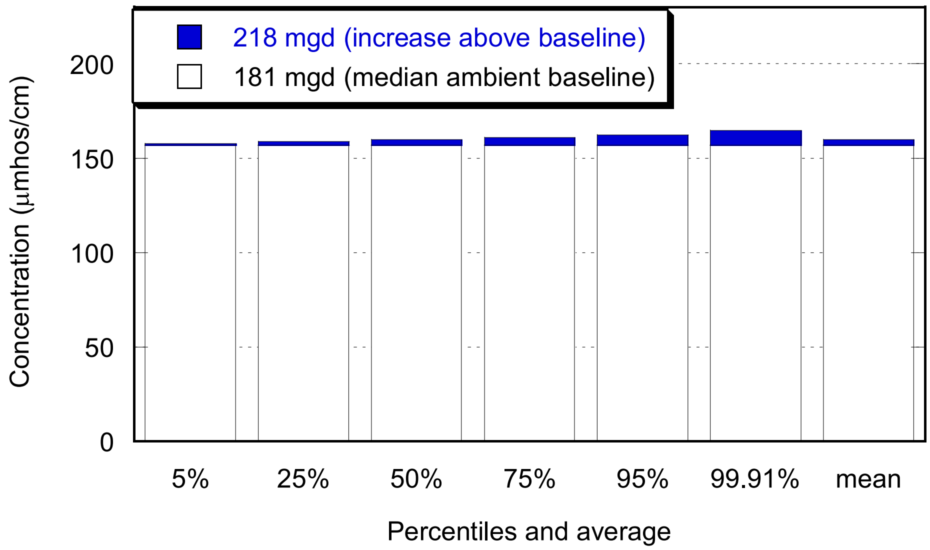

Figure 5-65: Percentiles of Modeled Incremental Change in Electrical Conductivity Concentration in the Sacramento River at Greene's Landing/Hood.

Table 5-53: Modeled Electrical Conductivity (µmhos/cm) Downstream of the SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95th Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	157.0	221.6	2.8
Emmaton	365.8	1548.5	2.5
CCWD PP#1	449.6	1064.3	2.2
CCWD Los Vaqueros Intake	363.4	717.3	2.1
Banks Delta Pumping Plant	365.5	717.2	1.9

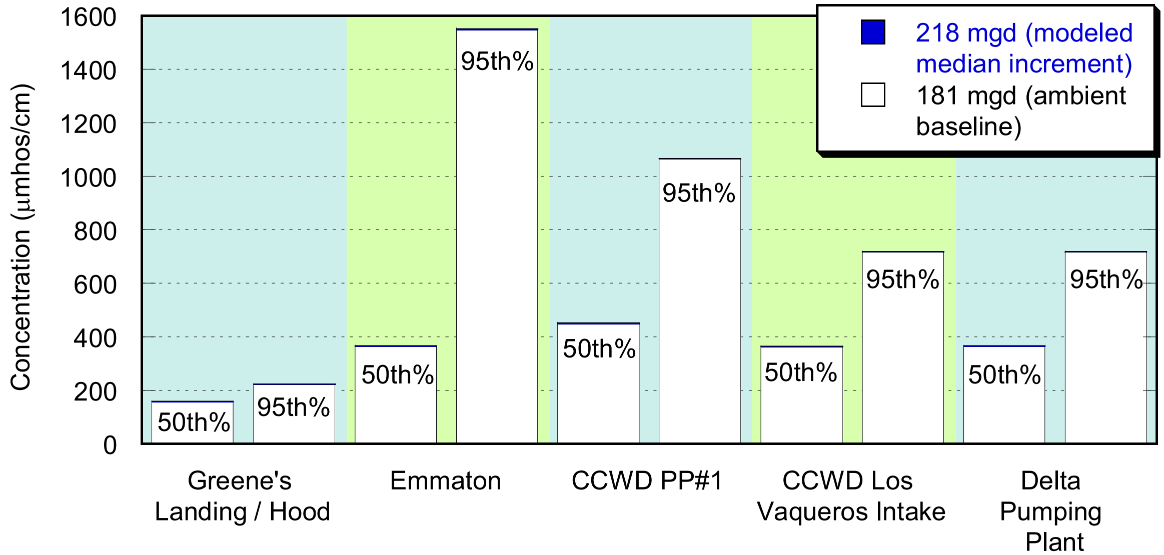

Figure 5-66: Median and 95th Percentile Modeled Incremental Electrical Conductivity Concentration at Far-Field Downstream Locations.

5.4.11.5 Far-Field Evaluation

Fischer Delta Model (FDM) far-field modeling results for the Sacramento River at Greene's Landing/Hood are presented in **Figure 5-65**. This figure graphically displays all modeled distributions of ambient, median EC concentrations at the existing permitted condition (181 mgd) on top of which are placed modeled, median EC concentration increments estimated for the proposed permitted condition (218 mgd). **Table 5-53** provides median (50th percentile) and 95th percentile EC concentrations at the existing permitted condition (181 mgd) at four far-field Delta locations for which sufficient ambient data were available. Additionally, **Table 5-53** presents the modeled, median EC concentration increment at the proposed permitted condition (218 mgd) for the Delta locations considered. **Table 5-53** modeled results are graphically represented in **Figure 5-66**. This figure shows the range in ambient EC concentrations for modeled Delta far-field locations under the existing permitted (181 mgd) and proposed permitted conditions (218 mgd). While ambient concentrations vary widely, it should be noted that the modeled, median EC increment under the proposed permitted condition (218 mgd) is remarkably small compared to ambient concentrations, as shown in **Table 5-53**. A statistical power analysis ($\alpha = 0.05$, $\beta = 0.1$) was performed to determine how many water quality samples would need to be collected and analyzed in order to detect the modeled EC increment and the results ranged from 5,151 samples at Greene's Landing/Hood to 3,155,422 samples at Emmaton. The power analysis results indicate that the modeled far-field increments in EC concentration due to the proposed permitted discharge of 218 mgd are immeasureable under typical monitoring frequencies at far-field Delta locations.

5.4.11.6 Trend Analysis Results

The results of the near- and far-field trend analyses are presented below in the form of a summary table and time series graphs. These graphs were developed showing actual ambient concentrations beside the concentrations provided by the regression equations. A best-fit line through the predicted concentrations visually shows the direction of the trend, where a trend with time was determined to exist. There were sufficient detected EC data at five locations to employ a parametric regression analysis to determine whether trends exist between ambient EC concentrations and time. The results of the trend analyses are shown in **Table 5-54**, and the historic EC data with applicable trend lines (regression lines) are shown in **Figure 5-67** through **Figure 5-72**.

Table 5-54: Trend Analysis Results for Electrical Conductivity.

Location	Count	% Detected	Start Date	End Date	Trend Result with Time	R^2 (adj)	Regression Fit
Freeport	1156	100%	11/7/58	7/28/08	No trend	41.8%	Good
Greene/Hood	1486	100%	6/16/71	8/4/08	Upward	49.0%	Excellent
Emmaton	3227	100%	10/1/88	9/30/00	Downward	47.0%	Excellent
CCWD PP #1	398	100%	10/2/90	8/13/08	No trend	23.4%	Good
CCWD Los Vaqueros Intake	547	100%	3/2/89	9/2/08	Downward	15.4%	Fair
Delta PP	611	100%	3/30/82	9/17/08	Downward	16.5%	Fair

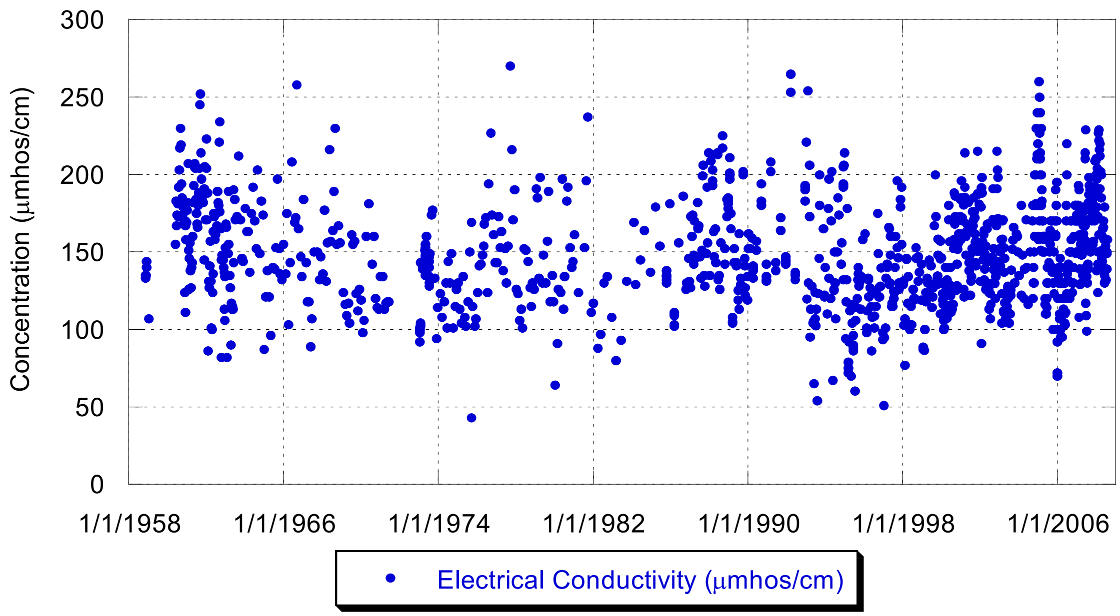

Figure 5-67: Historic Data for Electrical Conductivity in the Sacramento River at Freeport.

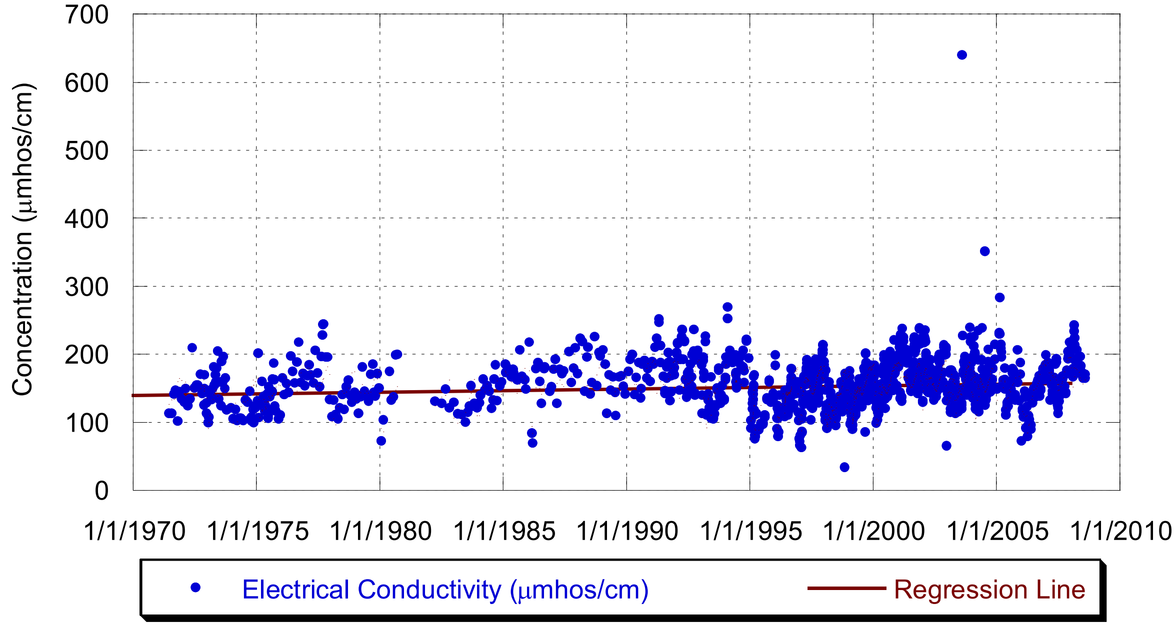

Figure 5-68: Historic Data and Regression Analysis Trend Line for Electrical Conductivity in the Sacramento River at Greene's Landing / Hood.

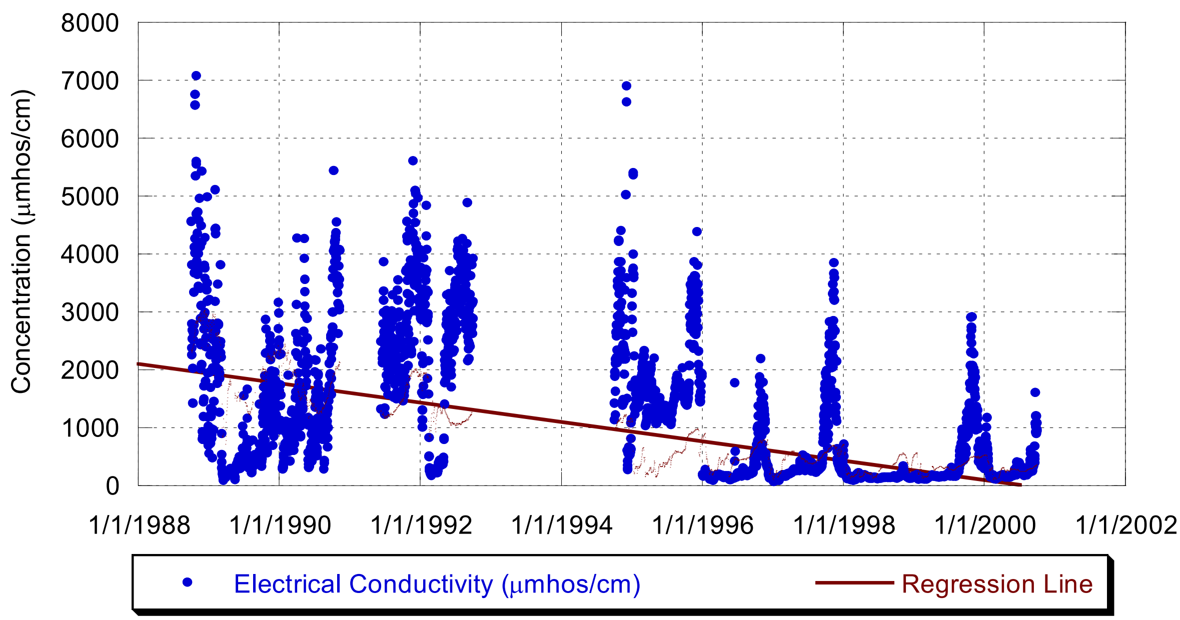

Figure 5-69: Historic Data and Regression Analysis Trend Line for Electrical Conductivity in the Sacramento River at Emmaton.

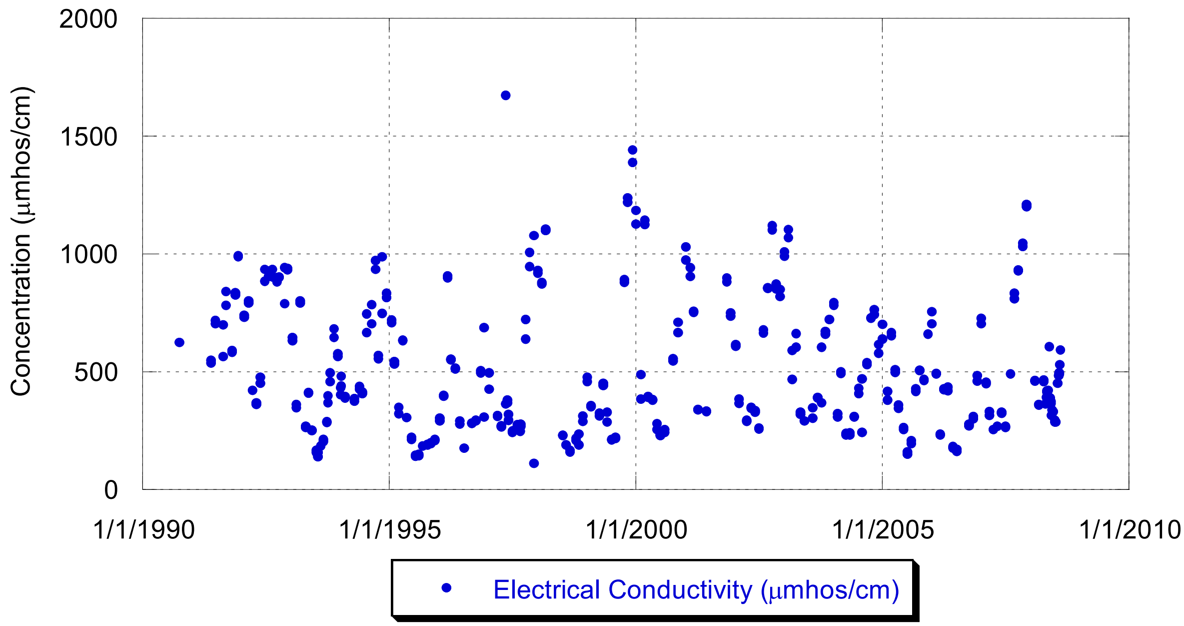

Figure 5-70: Historic Data for Electrical Conductivity at Contra Costa Water District Pumping Plant #1.

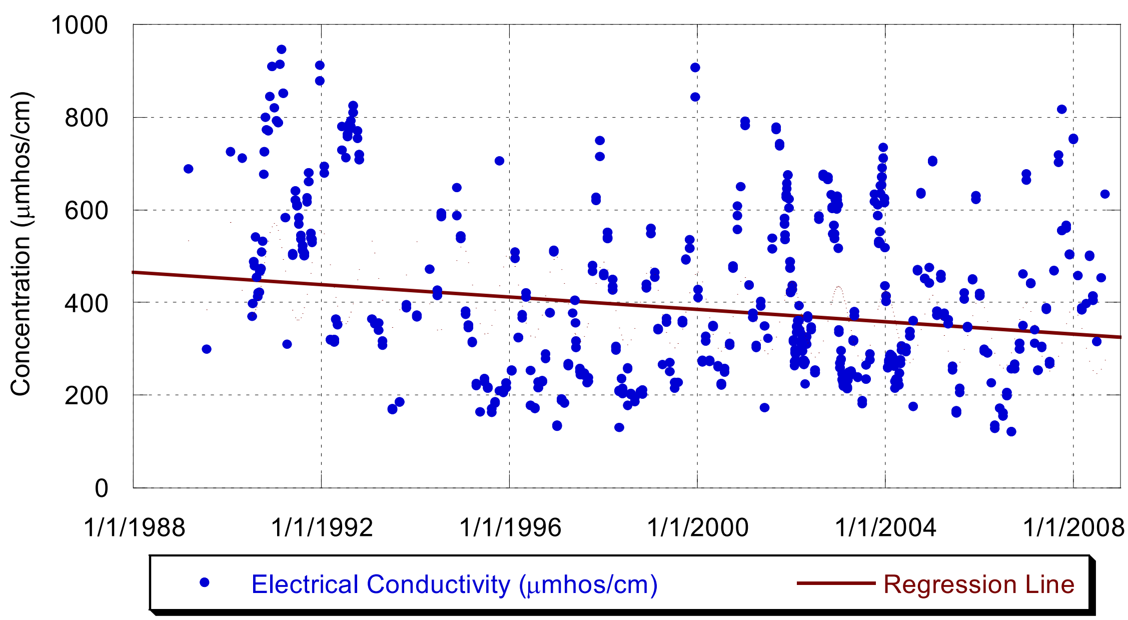

Figure 5-71: Historic Data and Regression Analysis Trend Line for Electrical Conductivity at the Contra Costa Water District Los Vaqueros Intake.

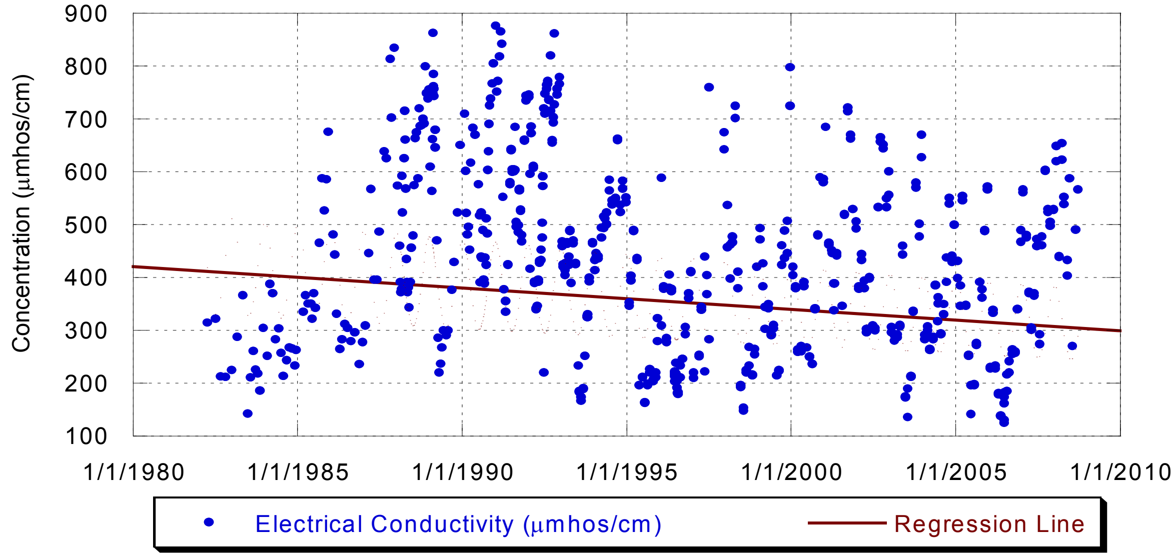

Figure 5-72: Historic Data and Regression Analysis Trend Line for Electrical Conductivity at the Harvey O. Banks Delta Pumping Plant Headworks.

5.4.11.7 Trend Analysis Evaluation

The trend analyses performed on ambient EC data collected upstream (Sacramento River at Freeport) and downstream (all other far-field Delta locations) of the SRWTP discharge resulted in the determination of a downward EC trend with time at three of the four locations at which a trend with time was observed. The trend analysis conducted on EC data collected in the Sacramento River at Greene's Landing/ Hood showed a slight upward trend with time. The trend analysis conducted on EC data collected in the Sacramento River at Freeport and at the Contra Costa Pumping Plant #1 showed no observable trend in EC concentrations with time. At the other three stations, ambient EC concentrations downstream of the SRWTP discharge have decreased slightly to moderately over the past twenty or more years. The slight increase in ambient downstream EC concentrations projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-53**) is anticipated to have a negligible effect on the long-term EC concentration trends identified in the project area as part of the current trend analysis evaluation.

5.4.11.8 Overall Electrical Conductivity Evaluation

Electrical conductivity is a measure of salinity. High salinity levels may adversely impact industrial process water uses such as for cooling towers, water recycling activities, groundwater replenishment, agriculture, and domestic water supply. Water agencies in particular express concerns about salinity because high levels of salinity (exceeding MCL threshold values) can impart an unpleasant taste to drinking water and can increase the amount of detergent or soap needed for clothes washing and personal hygiene. Elevated salinity in water supplied to households that exceeds MCL levels can also affect plumbing, water heaters and other appliances.

In the near-field, the increase in SRWTP discharge to 218 mgd would cause slight increases in EC (see **Table 5-51**). Moreover, relative to the current near-field ambient conditions these increases are very small (see **Figure 5-63** and **Figure 5-64**). The proposed discharge of 218 mgd would not cause any exceedances of the Secondary MCL, which is intended to minimize economic and aesthetic impacts, in particular to protect public water system uses (see **Table 5-52**).

In the far-field, median ambient water EC levels in some locations are already close to the Secondary MCL. The increase in EC caused by the proposed discharge at these locations, however, is negligible (see **Table 5-53** and **Figure 5-66**). At the far-field location closest to the SRWTP, Greene's Landing / Hood, even the 99.91 percentile ambient concentration is in compliance with the Secondary MCL (see **Figure 5-65**). It is only closer to the inlet to the Delta that the Secondary MCL is exceeded in some cases (see **Table 5-53**), reflecting the influence of mixing with saline waters of San Francisco Bay during tidal excursions into the Delta.

5.4.12 Total Dissolved Solids

5.4.12.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for total dissolved solids (TDS) at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from TDS concentrations in the Sacramento River at Freeport. Effluent quality model inputs were derived from TDS concentrations measured in SRWTP effluent. The modeled in-plume TDS concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-55**. Modeled in-plume TDS concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-56**.

Table 5-55: Modeled In-Plume Total Dissolved Solids Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	170	144	128	118	110	108
Median	167	140	125	115	107	105
95 %-ile	252	207	180	164	154	151
99.91 %-ile	319	274	238	221	212	210
5 %-ile	100	94	87	81	75	73

Table 5-56: Modeled In-Plume Total Dissolved Solids Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	183	151	133	121	112	109
Median	182	149	130	118	109	106
95 %-ile	267	219	187	168	156	153
99.91 %-ile	328	281	243	224	214	211
5 %-ile	99	94	89	83	77	74

The incremental differences in modeled in-plume TDS concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-57**. The median incremental increase in TDS concentrations would range from 13 mg/L at a distance of 30 feet downstream from the diffuser 1 mg/L at a distance of 700 feet downstream from the diffuser.

Table 5-57: Modeled In-Plume Total Dissolved Solids Concentration Increment (mg/L) at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences between 181 and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L)					
	30 ft	**60 ft**	**100 ft**	**175 ft**	**350 ft**	**700 ft**
Mean	13	8	5	3	2	1
Median	15	9	5	3	2	1
95 %-ile	15	12	7	4	2	2
99.91 %-ile	9	7	5	3	2	1
5 %-ile	-1	1	2	2	1	1

The probability distributions of modeled TDS concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-73**. The median dissolved copper concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-74**.

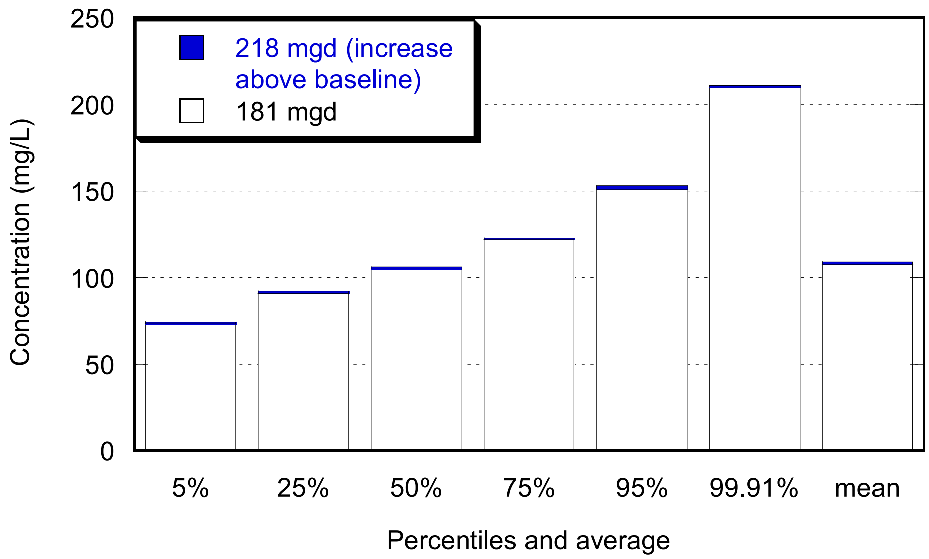

Figure 5-73: Distribution of Modeled Total Dissolved Solids Concentrations 700 Feet Downstream of SRWTP Diffuser.

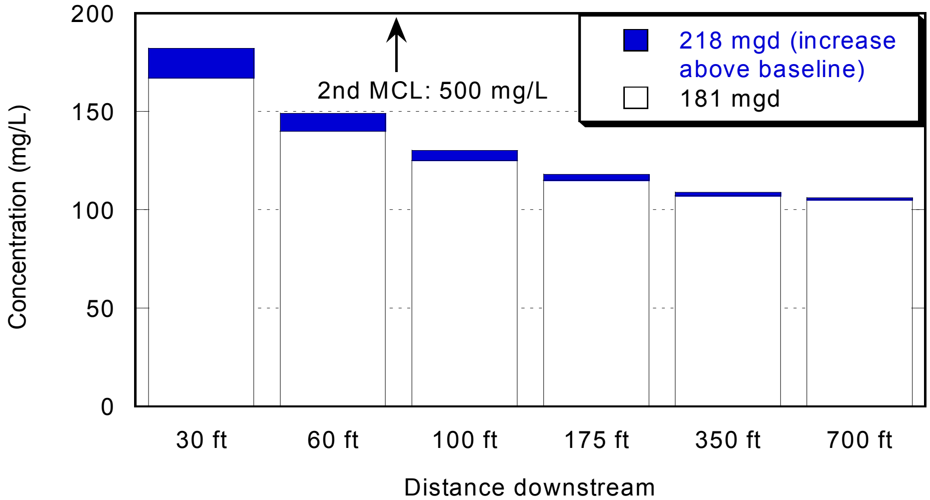

Figure 5-74: Median Modeled Total Dissolved Solids Concentration Downstream of SRWTP Diffuser. Secondary MCL of 500 mg/L for Drinking Water.

5.4.12.2 Comparison to Water Quality Objectives

The most stringent water quality objective for TDS in the Sacramento River is the 500 mg/L MCL for the protection of public water system use (e.g. for drinking water). The MCL is a long-term average value, best compared to mean or median values for compliance determination. The percent exceedances of this TDS criterion at various distances downstream from the SRWTP diffuser are listed in **Table 5-58**. This table shows that Secondary MCL is never exceeded in these locations downstream of the diffuser at the proposed 218 mgd discharge.

Table 5-58: DYNTOX Modeled Percent Exceedance Frequency for Total Dissolved Solids at Various Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Secondary MCL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

5.4.12.3 Near-Field Evaluation

Most of the TDS in natural waters are comprised of inorganic compounds - mineral as opposed to the organic compounds derived from organisms. Although there are at least traces of many elements, the great majority of the TDS load is from four negative ions (bicarbonate, carbonate, chloride, and sulfate) and four positive ions (calcium, magnesium, sodium and potassium). EC estimates the total amount of dissolved ions in water, so there is a close correlation between TDS and EC. Accordingly, TDS has the same impacts to water quality as discussed in the section on EC (see Section 5.4.11). TDS is of concern to water agencies because of potential impacts on plumbing, appliances, and drinking water quality. It also may, depending on the concentration, affect agricultural uses, industrial process uses, and downstream water recycling. As discussed earlier in the section discussing EC, the Secondary MCL of 500 mg/L is intended to minimize these economic and aesthetic impacts.

The dynamic modeling results for the current discharge (see **Table 5-55**) and proposed discharge (see **Table 5-56**) have similar characteristics. TDS concentrations are greater near the outfall because effluent concentration is generally greater than the receiving water concentration. Concentrations near the diffuser are generally greater for the proposed 218 mgd discharge (see **Table 5-57**). At 175 feet and further downstream of the diffuser, the current and proposed discharges are almost identical.

Figure 5-73 and **Figure 5-74** reflect the same conclusions as **Table 5-57**: at 175 feet and further downstream of the diffuser, the increase in TDS is negligible. Exceedance frequencies (see **Table 5-58**) demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the Secondary MCL.

5.4.12.4 Far-Field Evaluation and Trend Analysis

Far-field water quality impacts analyses and trend analyses were not performed for TDS due to the extensive far-field assessments performed for EC (Section 5.4.11) and chloride (Section 5.4.13). Because TDS correlates strongly with EC, it would be expected that far-field impacts would be similar for these two constituents.

5.4.13 Chloride

5.4.13.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for chloride at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from chloride measured in the Sacramento River at Freeport. Effluent quality model inputs were derived from chloride measured in SRWTP effluent. The modeled in-plume chloride concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-59**. Modeled in-plume chloride concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-60**.

Table 5-59: Modeled In-Plume Chloride Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	25.0	17.6	13.3	10.6	8.46	7.81
Median	23.9	16.6	12.4	10.0	8.00	7.38
95%-ile	46.3	33.0	23.8	18.0	13.8	12.7
99.91%-ile	59.0	47.0	35.6	28.1	21.8	20.0
5%-ile	7.10	7.02	6.57	5.81	4.93	4.49

Table 5-60: Modeled In-Plume Chloride Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	28.5	19.8	14.7	11.5	8.94	8.19
Median	28.3	18.9	13.9	10.9	8.52	7.80
95 %-ile	49.7	36.5	26.4	19.7	14.5	13.2
99.91 %-ile	60.2	48.1	36.4	28.4	22.0	20.3
5 %-ile	5.99	5.99	5.97	5.69	5.01	4.58

The incremental differences in modeled in-plume chloride concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-61**. The median incremental increase in chloride concentrations would range from 4.4 mg/L at a distance of 30 feet downstream from the diffuser to 0.42 mg/L at a distance of 700 feet downstream from the diffuser.

Table 5-61: Modeled In-Plume Chloride Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	3.5	2.1	1.4	0.9	0.47	0.37
Median	4.4	2.3	1.5	0.9	0.52	0.42
95%-ile	3.4	3.5	2.6	1.7	0.7	0.5
99.91%-ile	1.2	1.1	0.8	0.3	0.2	0.3
5%-ile	-1.11	-1.03	-0.60	-0.12	0.08	0.09

The probability distributions of modeled chloride concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-75**. The median chloride concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-76**.

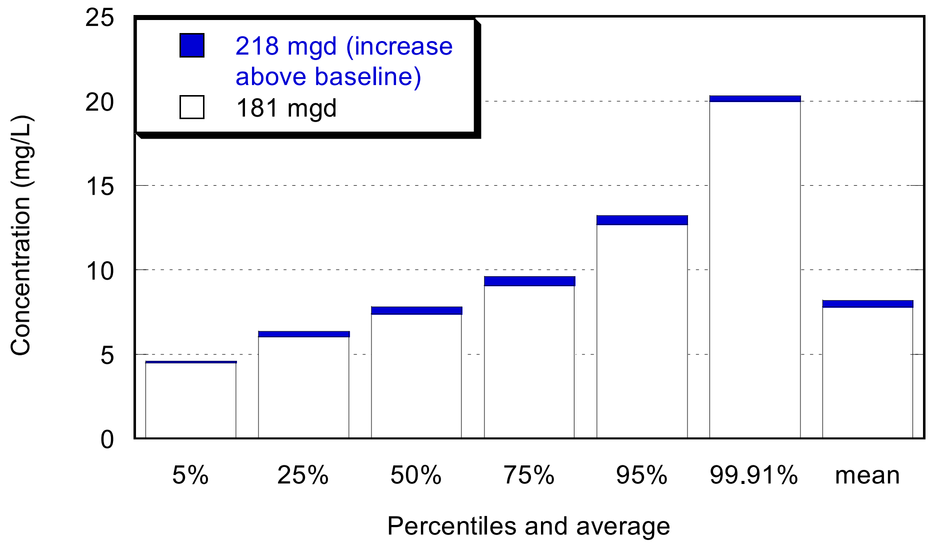

Figure 5-75: Distribution of Modeled Chloride Concentrations 700 feet Downstream of SRWTP Diffuser.

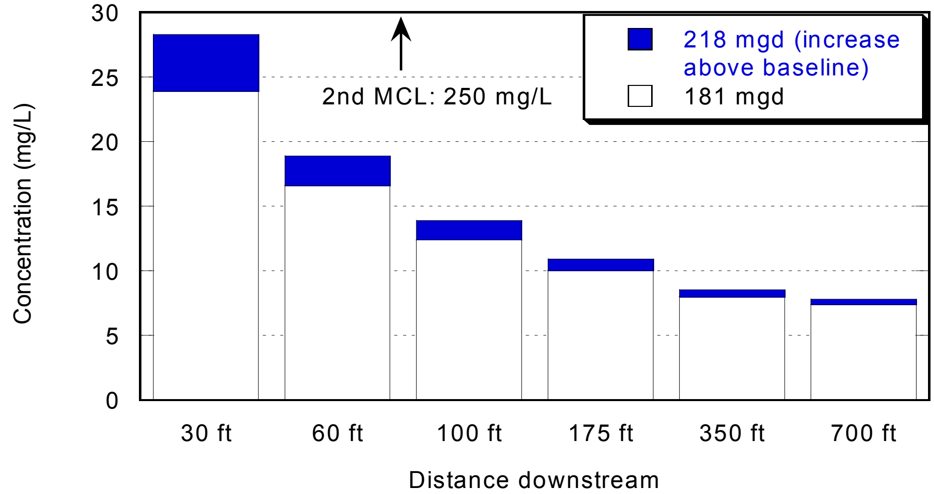

Figure 5-76: Median Modeled Chloride Concentration Downstream of SRWTP Diffuser.

5.4.13.2 Comparison to Water Quality Objectives

The most stringent water quality objective for chloride in the Sacramento River is the California Code of Regulations Title 22 Secondary MCL of 250 mg/L, incorporated into the Basin Plan by reference. The Secondary MCL exists to support consumer acceptance of finished drinking water and is based on long-term average concentrations. The percent exceedances of the Title 22 Secondary MCL for chloride at various distances downstream from the SRWTP diffuser are listed in **Table 5-62**. As shown in the table, the Secondary MCL for chloride was not exceeded in the dynamic model simulations at any point within the modeled plume.

Table 5-62: DYNTOX Modeled Percent Exceedance Frequency for Chloride at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Secondary MCL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the Title 22 Secondary MCL for chloride. To this end, the 250 mg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-59**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-60**). These modeled results are graphically represented in **Figure 5-75** at a distance of 700 foot downstream from the diffuser. These findings are consistent with the modeled results indicating no exceedances of the Secondary MCL as listed in **Table 5-62**.

5.4.13.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-59**) and proposed discharge (see **Table 5-60**) have similar characteristics. Chloride concentrations are greater near the outfall, corresponding to the scenario where the effluent concentration is generally greater than the receiving water concentration. All percentile concentrations show a curvilinear decrease in the modeled plume with highest concentrations near the diffuser, indicating that the receiving water concentrations are less than the effluent concentrations. Furthermore, as listed in **Table 5-61**, the proposed increase in SRWTP effluent discharge would slightly increase chloride concentrations in the Sacramento River throughout the modeled plume, with the greatest incremental increases occurring near the discharge and then gradually tapering off with downstream distance.

Exceedance frequencies are presented in **Table 5-62** for the Title 22 Secondary MCL chloride objective. The dynamic model results are used to demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the chloride objective for taste and odor of finished water evaluated as an annual average concentration. The percent exceedance frequency results provided in **Table 5-62** show that the chloride objective was not exceeded in the dynamic model simulations. The incremental change in chloride concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight. The modeled near-field results project in-plume median chloride concentrations that are substantially below the most stringent applicable water quality criterion, the Title 22 Secondary MCL that exists to support consumer acceptance of finished drinking water. Both the modeled chloride distributions at 700 feet downstream from the diffuser (see **Figure 5-75**) and the modeled, median chloride concentration within the plume (see **Figure 5-76**) show a slight incremental increase in chloride concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in chloride concentrations in the Sacramento River.

It should be noted that, because chloride is a drinking water issue, it is of concern in the far-field rather than vicinity of the SRWTP discharge. The above analysis is included primarily to demonstrate the rapid dilution of the SRWTP effluent into the Sacramento River.

5.4.13.4 Far-Field Model Analysis Results

Far-field modeling was also performed to determine incremental contributions of chloride resulting from an increase in SRWTP discharge from 181 mgd to 218 mgd at seven far-field locations. The far-field modeled results are shown graphically in **Figure 5-77** and **Figure 5-78**. **Figure 5-77** shows percentile modeled incremental change in chloride concentrations associated with the proposed 218 mgd discharge placed on top of the median ambient concentration estimated to occur at the current permitted 181 mgd discharge in the Sacramento River at Greene's Landing/Hood. There were sufficient ambient chloride data at four of the seven primary far-field locations to confidently present the median incremental chloride concentration differences between the modeled existing condition (181 mgd) and proposed permitted condition (218 mgd), as shown in **Table 5-63**. Modeled, median incremental change in chloride concentration on top of ambient median (50th percentile) and 95th percentile concentrations estimated to occur at the current permitted 181 mgd discharge at four Delta locations are displayed in **Figure 5-78**.

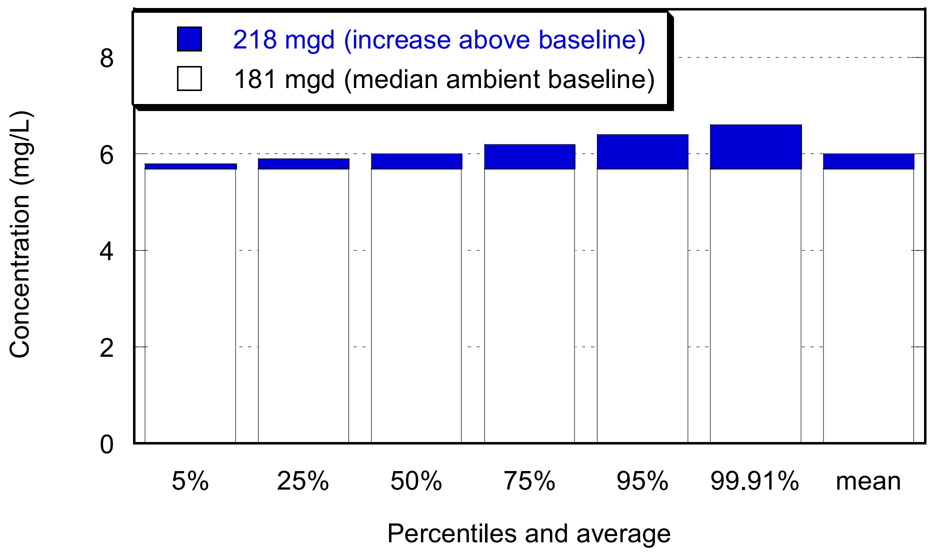

Figure 5-77: Percentiles of Modeled Incremental Change in Chloride Concentration in the Sacramento River at Greene's Landing/Hood.

Table 5-63: Incremental Difference in Modeled Chloride Concentrations (mg/L) Downstream of SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95th Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	5.7	10.4	0.3
CCWD PP#1	60.0	230.6	0.3
CCWD Los Vaqueros Intake	48.0	157.2	0.2
Banks Delta Pumping Plant	47.8	138.3	0.2

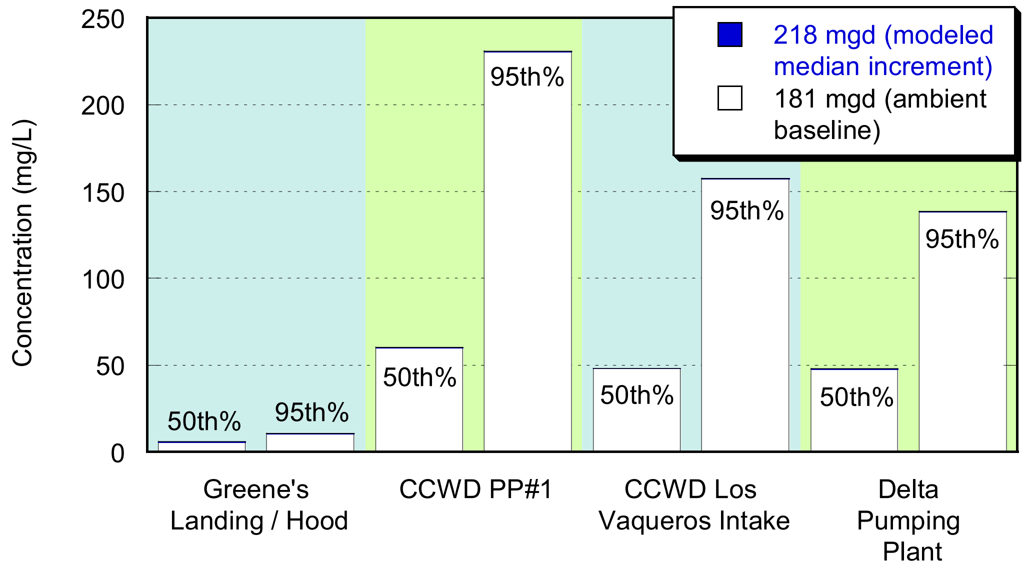

Figure 5-78: Median Modeled Incremental Chloride Concentration at Downstream Far-Field Locations.

5.4.13.5 Far-Field Evaluation

Fischer Delta Model (FDM) far-field modeling results for the Sacramento River at Greene's Landing/Hood are presented in **Figure 5-77**. This figure graphically displays all modeled distributions of ambient, median chloride concentrations at the existing permitted condition (181 mgd) on top of which are placed modeled, median chloride concentration increments estimated for the proposed permitted condition (218 mgd). **Table 5-63** provides median (50th percentile) and 95th percentile chloride concentrations at the existing permitted condition (181 mgd) at four far-field Delta locations for which sufficient ambient data were available. Additionally, **Table 5-63** presents the modeled, median chloride concentration increment at the proposed permitted condition (218 mgd) for the Delta locations considered. **Table 5-63** modeled results are graphically represented in **Figure 5-78**. This figure shows the range in ambient chloride concentrations for modeled Delta far-field locations under the existing permitted (181 mgd) and proposed permitted conditions (218 mgd). While ambient concentrations vary widely, it should be noted that the modeled, median chloride increment under the proposed permitted condition (218 mgd) is remarkably small compared to ambient concentrations, as shown in **Table 5-63**. A statistical power analysis ($\alpha = 0.05$, $\beta = 0.1$) was performed to determine how many water quality samples would need to be collected and analyzed in order to detect the modeled chloride increment and the results ranged from 1,053 samples at Greene's Landing/Hood to 1,777,806 samples at Contra Costa Pumping Plant #1. The power analysis results indicate that the modeled far-field increment in chloride concentration due to the proposed permitted discharge of 218 mgd are immeasureable under typical monitoring frequencies at far-field Delta locations.

5.4.13.6 Trend Analysis Results

The results of the near- and far-field trend analyses are presented below in the form of a summary table and time series graphs. These graphs were developed showing actual ambient concentrations beside the concentrations provided by the regression equations. A best-fit line through the predicted concentrations visually shows the direction of the trend, where a trend with time was determined to exist. There were sufficient detected chloride data at five locations to employ a parametric regression analysis to determine whether trends exist between ambient chloride concentrations and time. The results of the trend analyses are shown in **Table 5-64**, and the historic chloride data with applicable trend lines (regression lines) are shown in **Figure 5-79** through **Figure 5-83**.

Table 5-64: Trend Analysis Results for Chloride

Location	Count	% Detected	Start Date	End Date	Trend Result with Time	R^2 (adj)	Regression Fit
Freeport	637	99%	11/7/58	4/24/08	Downward	47.2%	Excellent
Greene/Hood	940	100%	6/16/71	8/4/08	Downward	49.7%	Excellent
CCWD PP #1	207	100%	10/2/90	8/13/08	No trend	21.6%	Good
CCWD Los Vaqueros Intake	232	100%	3/2/89	6/2/08	Downward	14.7%	Fair
Delta PP	379	100%	3/30/82	5/21/08	Downward	11.2%	Fair

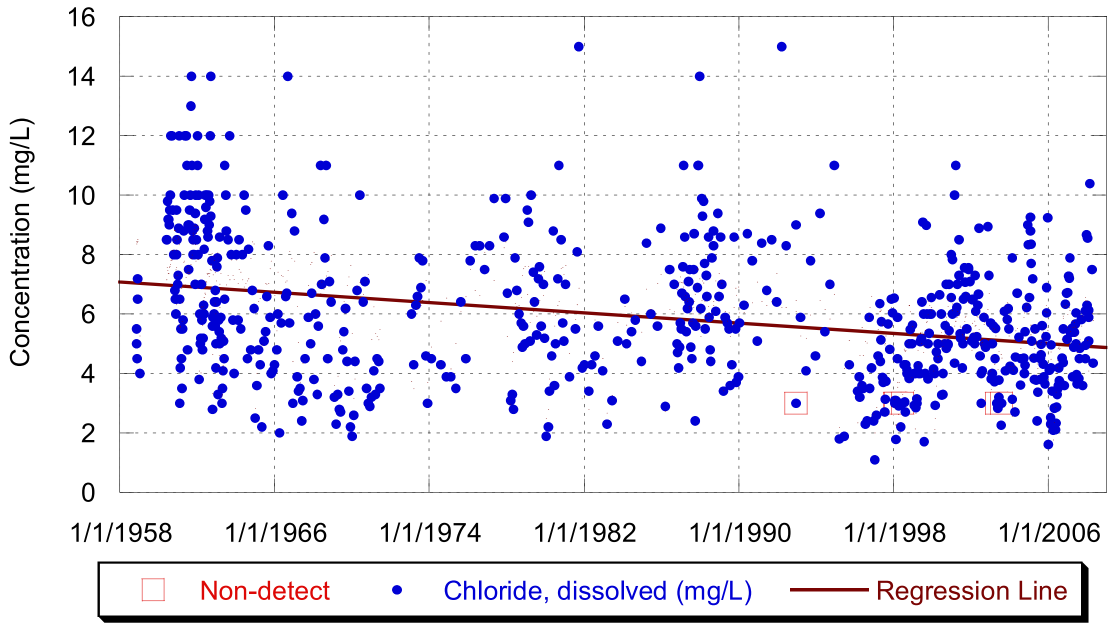

Figure 5-79: Historic Data and Regression Analysis Trend Line for Chloride in the Sacramento River at Freeport.

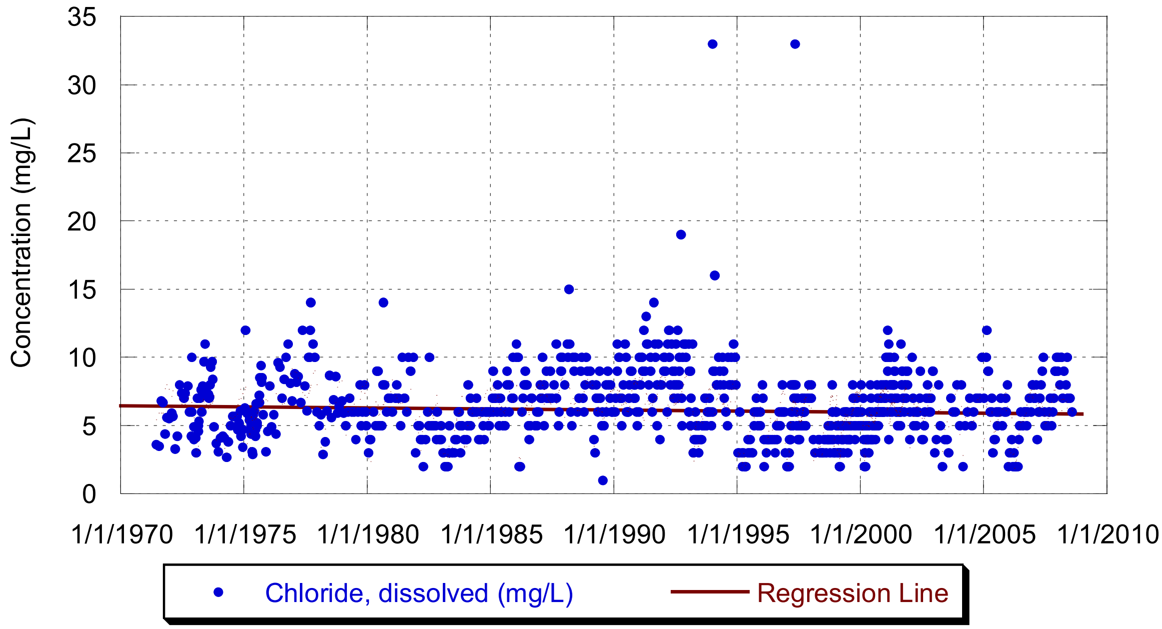

Figure 5-80: Historic Data and Regression Analysis Trend Line for Chloride in the Sacramento River at Greene's Landing/Hood.

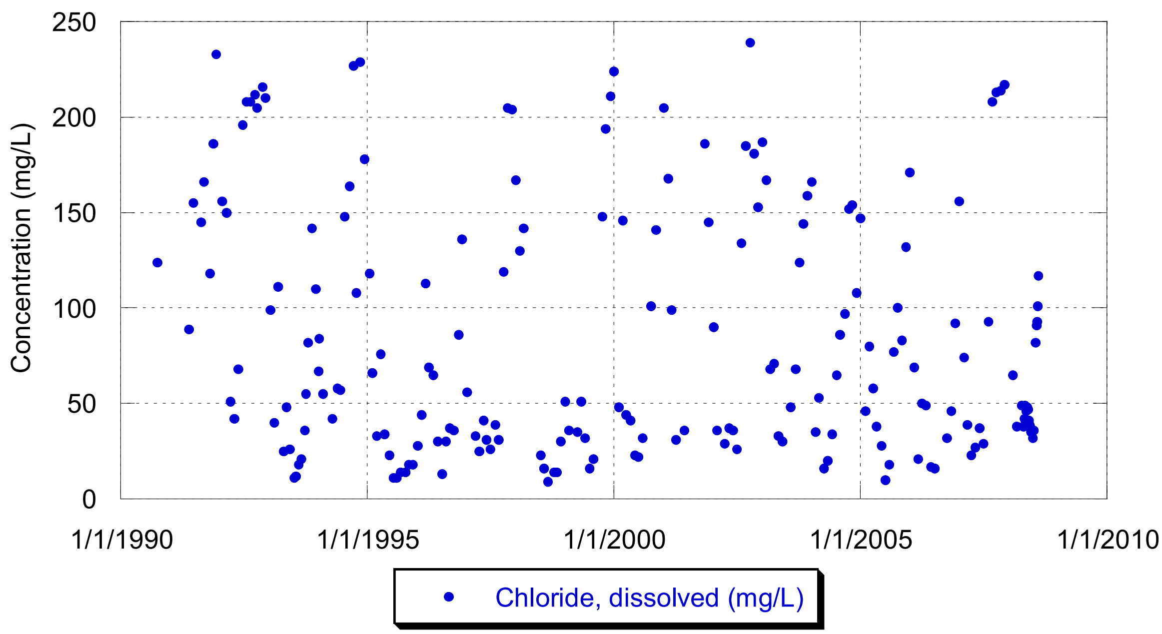

Figure 5-81: Historic Data for Chloride at Contra Costa Water District Pumping Plant #1.

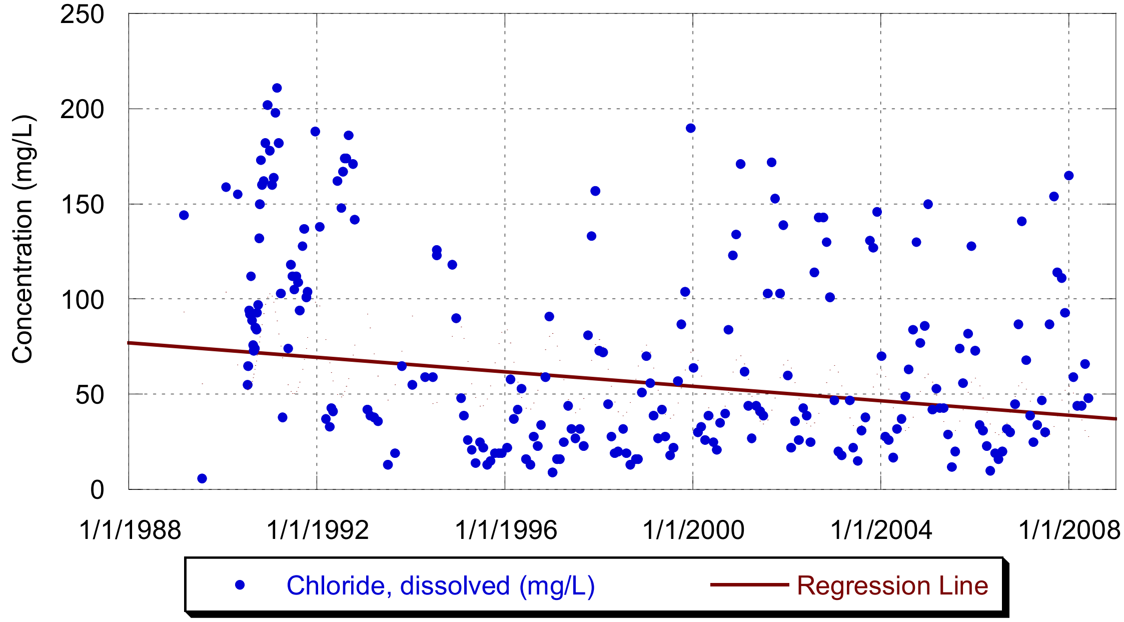

Figure 5-82: Historic Data and Regression Analysis Trend Line for Chloride at the Contra Costa Water District Los Vaqueros Intake.

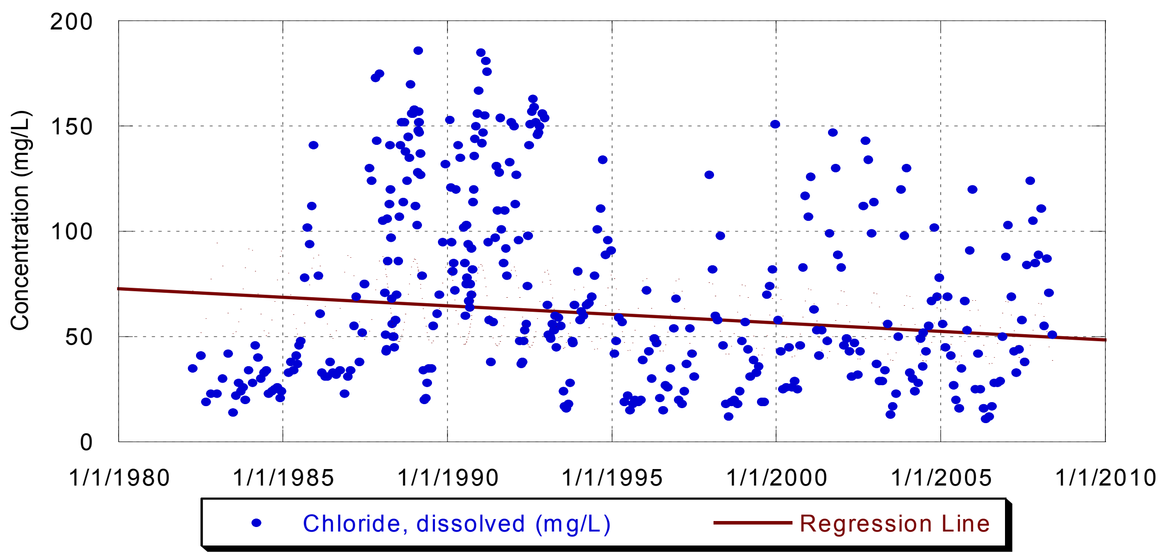

Figure 5-83: Historic Data and Regression Analysis Trend Line for Chloride at the Harvey O. Banks Delta Pumping Plant Headworks.

5.4.13.7 Trend Analysis Evaluation

The trend analyses performed on ambient chloride data collected upstream (Sacramento River at Freeport) and downstream (all other far-field Delta locations) of the SRWTP discharge resulted in the determination of a downward chloride trend with time at all but one location. The trend analysis conducted on chloride data collected at the Contra Costa Pumping Plant #1 showed no observable trend in chloride concentrations with time. Generally speaking, ambient chloride concentrations upstream and downstream of the SRWTP discharge have decreased slightly to moderately over the past twenty or more years. The slight increase in ambient downstream chloride concentrations projected as a result of the proposed permitted discharge (218 mgd) (see **Table 5-63**) is anticipated to have a negligible effect on the long-term chloride concentration trends identified in the project area as part of the current trend analysis evaluation.

5.4.13.8 Overall Chloride Evaluation

The U.S. EPA has established a Title 22 Secondary MCL for chloride of 250 mg/L. This is the most stringent water quality objective in the Sacramento River and serves as a non-enforceable guideline for water systems for aesthetic considerations, such as taste, color and odor. The Contra Costa Water District (CCWD) uses an operational goal of 65 mg/L for chloride for the purpose of determining levels of treatment required for its drinking water. The 65 mg/L goal is substantially lower than any other recommended chloride objective (additional information regarding the CCWD operational goal is included in Appendix I). As a result of the near-field evaluation described above, the incremental changes in chloride concentrations associated with the proposed 218 mgd discharge have been quantified. The near-field model analysis results show that modeled in-plume chloride concentrations in the Sacramento River resulting from the proposed permitted condition (218 mgd) are estimated to be well below the Secondary MCL for chloride of 250 mg/L, and would not impact drinking water uses and would not otherwise adversely impact any other beneficial uses.

In the far-field, the question is whether incremental changes in long-term average chloride concentrations are sufficient in magnitude to cause changes in either the design or operation of water treatment plants using Delta water as a supply. The median chloride concentration at the CCWD Pumping Plant #1 is projected to be approximately 60 mg/L under the proposed 218 mgd discharge, which is below CCWD’s operational goal for the parameter. Additionally, the power analysis performed as part of the current water quality impacts analysis revealed that the modeled median chloride increment at CCWD Pumping Plant #1 (0.3 mg/L) under the proposed 218 mgd discharge is so small that it would never be observed at the monitoring frequency employed by a typical ambient water quality monitoring program. In fact, the power analysis determined that 1,777,806 samples would need to be collected at CCWD Pumping Plant #1 in order to resolve the projected chloride increment due to the proposed permitted condition (218 mgd). This implies that the historic variability in chloride concentrations is of sufficient magnitude that the incremental changes associated with the proposed discharge would fall within the range of chloride values normally encountered at the intakes to existing water treatment plants. To this end, no changes in operations are anticipated since ambient Delta chloride concentrations observed prior to the proposed project would be indistinguishable from those projected under the proposed permitted condition (218 mgd). In summary, the slight increases in far-field chloride concentrations projected as a result of the proposed discharge increase are anticipated to have a negligible effect on the long-term chloride concentrations in the Delta.

5.4.14 Total Organic Carbon

5.4.14.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for total organic carbon (TOC) at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from TOC measured in the Sacramento River at Freeport. Effluent quality model inputs were derived from TOC measured in SRWTP effluent. The modeled in-plume TOC concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-65**. Modeled in-plume TOC concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-66**.

Table 5-65: Modeled In-Plume Total Organic Carbon Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	5.85	4.56	3.79	3.32	2.93	2.82
Median	5.44	4.24	3.54	3.09	2.71	2.59
95%-ile	10.6	8.07	6.59	5.75	5.18	5.03
99.91%-ile	18.7	14.4	11.4	10.0	9.37	9.25
5%-ile	2.38	2.12	1.88	1.66	1.45	1.36

Table 5-66: Modeled In-Plume Total Organic Carbon Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	6.46	4.93	4.04	3.47	3.02	2.88
Median	6.10	4.62	3.79	3.25	2.80	2.67
95 %-ile	11.7	8.78	7.00	5.98	5.28	5.11
99.91 %-ile	19.9	15.1	11.8	10.1	9.44	9.32
5 %-ile	2.29	2.12	1.92	1.71	1.49	1.40

The incremental differences in modeled in-plume TOC concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-67**. The median incremental increase in TOC concentrations would range from 0.66 mg/L at a distance of 30 feet downstream from the diffuser to 0.08 mg/L at a distance of 700 feet downstream from the diffuser.

Table 5-67: Modeled In-Plume Total Organic Carbon Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.62	0.38	0.24	0.15	0.08	0.07
Median	0.66	0.38	0.25	0.16	0.09	0.08
95%-ile	1.1	0.71	0.41	0.23	0.10	0.08
99.91%-ile	1.2	0.7	0.4	0.1	0.07	0.07
5%-ile	-0.09	<0.01	0.04	0.05	0.04	0.04

The probability distributions of modeled TOC concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-84**. The median TOC concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-85**.

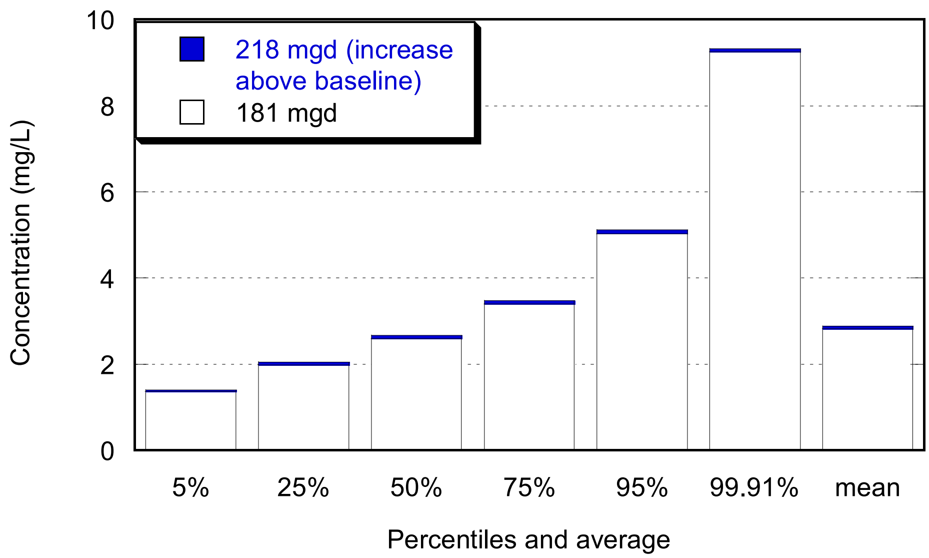

Figure 5-84: Distribution of Modeled Total Organic Carbon Concentrations 700 feet Downstream of SRWTP Diffuser.

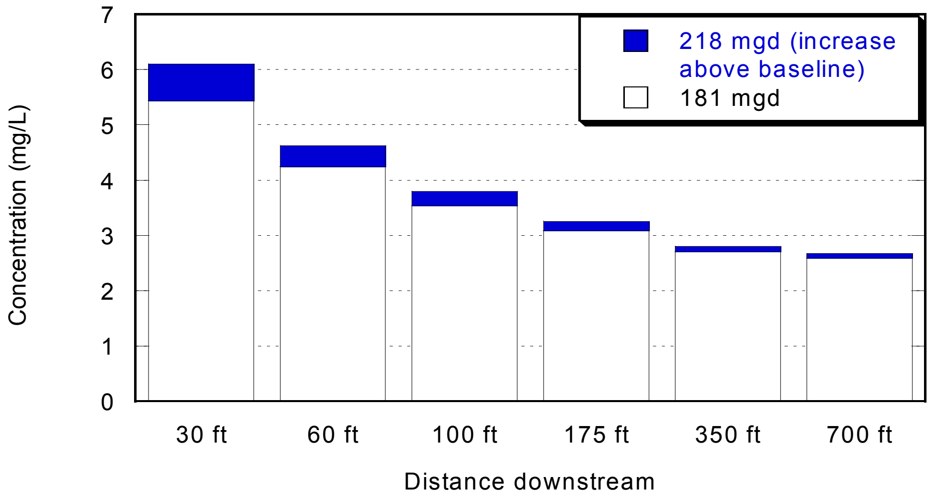

Figure 5-85: Median Modeled Total Organic Carbon Concentration Downstream of SRWTP Diffuser.

5.4.14.2 Comparison to Water Quality Objectives

Currently, there are no water quality standards for TOC or DOC applicable to the Sacramento River or Delta. The concern with TOC/DOC is that some forms of organic carbon are a precursor of trihalomethanes (THMs) which are formed as a result of chlorine disinfection in some water treatment plants. Therefore, the concentration of TOC is not a concern in the near-field vicinity of the SRCSD discharge. Concerns with TOC as related to the proposed project are focused on the changes in ambient levels in the far-field, in general, and at the intakes to water treatment plants, specifically.

A TOC goal of 3.0 mg/l was adopted in the CALFED Record of Decision (ROD) in 2000 based on an analysis that assumed future more stringent Safe Drinking Water Act regulations and projections regarding the future cost impacts of those regulations on agencies that use the Delta as a water supply. It is commonly acknowledged that this goal exists as a planning value and is neither an adopted, enforceable water quality objective nor a proposed water quality objective.

A more recent analysis of the impacts of ambient TOC levels in the Delta on water treatment agencies has been undertaken by the Central Valley Drinking Water Policy Work Group. The scope of that analysis is included as Appendix D. Results from that analysis would provide information regarding the benefit or cost impact of marginal changes in Delta water quality on water treatment operations, including changes in TOC levels. The near and far-field results derived in this evaluation can be used to assess this question for the proposed project.

5.4.14.3 Near-Field Evaluation

The dynamic modeling results for the current permitted 181 mgd discharge (see **Table 5-65**) and proposed 218 mgd discharge (see **Table 5-66**) have similar concentration characteristics in the near field. For the 5th percentile through the 95th percentile distributions, TOC concentrations are greater near the outfall, since the effluent concentration is generally greater than the receiving water concentration. Furthermore, as listed **Table 5-67**, the proposed increase in SRWTP effluent discharge would slightly increase TOC concentrations in the Sacramento River throughout the modeled plume, with the greatest incremental increases occurring near the discharge.

The incremental increase in TOC concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight. Both the modeled TOC distributions at 700 feet downstream from the diffuser (see **Figure 5-84**) and the modeled, median TOC concentration within the plume (see **Figure 5-85**) show a slight incremental increase in TOC concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in TOC concentrations in the Sacramento River.

5.4.14.4 Far-Field Model Analysis Results

FSI performed a far-field modeling analysis to determine the percent of SRWTP effluent that is estimated to reach twelve far-field Delta locations under the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd). Far-field modeling was also performed to determine incremental contributions of TOC resulting from an increase in SRWTP discharge from 181 mgd to 218 mgd at seven of the twelve far-field locations. The far-field modeled results are shown graphically in **Figure 5-86** and **Figure 5-87**. **Figure 5-86** shows percentile modeled incremental changes in TOC concentrations associated with the proposed 218 mgd discharge added to the median ambient concentration estimated to occur at the current permitted 181 mgd discharge in the Sacramento River at Greene's Landing/Hood. There were sufficient ambient TOC data at four of the seven primary far-field locations to meaningfully present the median incremental TOC concentration differences between the modeled existing condition (181 mgd) and proposed permitted condition (218 mgd), as shown in **Table 5-68**. Modeled, median incremental changes in TOC concentration on top of ambient median (50th percentile) and 95th percentile concentrations estimated to occur at the current permitted 181 mgd discharge at four Delta locations are displayed in **Figure 5-87**.

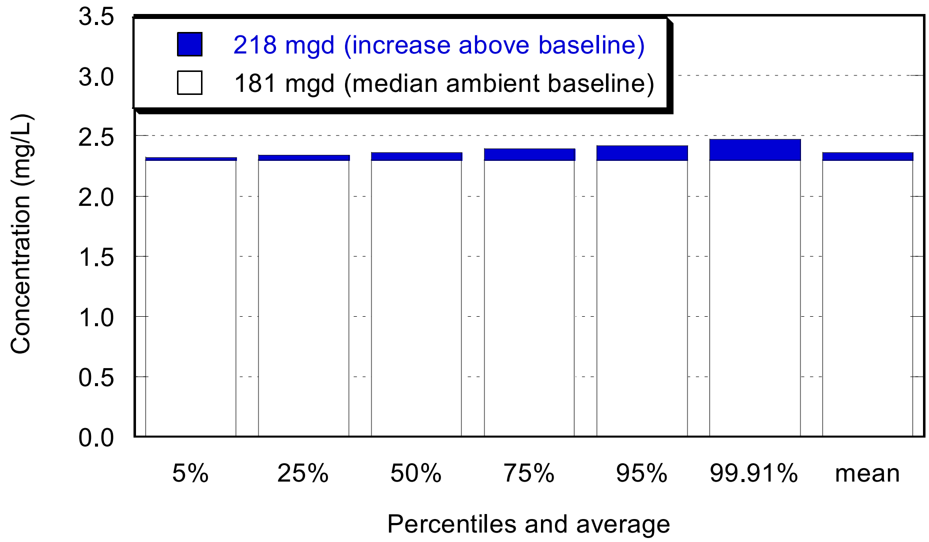

Figure 5-86: Percentiles of Modeled Incremental Change in Total Organic Carbon Concentration in the Sacramento River at Greene's Landing/Hood.

Table 5-68: Incremental Difference in Modeled Total Organic Carbon Concentrations (mg/L) Downstream of SRWTP Discharge at 181 mgd and 218 mgd.

	Median Ambient Concentration at 181 mgd	95th Percentile Ambient Concentration at 181 mgd	Median Concentration Increment
Greene's Landing / Hood	2.30	4.21	0.06
CCWD PP#1	3.62	6.02	0.05
CCWD Los Vaqueros Intake	3.74	6.63	0.05
Banks Delta Pumping Plant	3.96	6.93	0.04

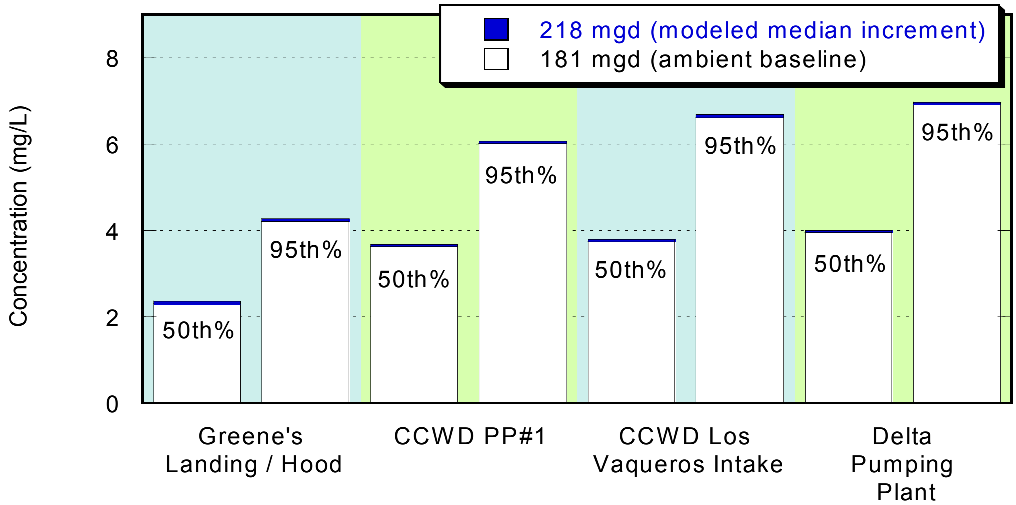

Figure 5-87: Median Modeled Incremental Total Organic Carbon Concentration at Downstream Far-Field Locations.

5.4.14.5 Far-Field Evaluation

Fischer Delta Model (FDM) far-field modeling results for the Sacramento River at Greene's Landing/Hood are presented in **Figure 5-86**. This figure graphically displays all modeled distributions of ambient, median TOC concentrations at the existing permitted condition (181 mgd) on top of which are placed modeled, median TOC concentration increments estimated for the proposed permitted condition (218 mgd). The 50 percentile concentration increment at Greene's Landing/Hood is of primary importance in the assessment of impacts on drinking water agencies, since SDWA regulations regarding TOC levels are focused on long term (running annual average) concentrations. Note that TOC levels at Green's Landing/Hood for the proposed 218 mgd discharge are less than 2.5 mg/l TOC at all percentile values. **Table 5-68** provides median (50th percentile) and 95th percentile TOC concentrations at the existing permitted condition (181 mgd) at four far-field Delta locations for which sufficient ambient data were available. As noted above, the 50 percentile values are most relevant to the assessment of potential impacts on drinking water treatment operations, given the long term averaging period for TOC in the regulatory driver under the SDWA. **Table 5-68** also presents the modeled, median TOC concentration increment at the proposed permitted condition (218 mgd) for the Delta locations considered. **Table 5-68** modeled results are graphically represented in **Figure 5-87**. This figure shows the range in ambient TOC concentrations for modeled Delta far-field locations under the existing permitted (181 mgd) and proposed permitted conditions (218 mgd). While ambient concentrations vary, it should be noted that the modeled, median TOC increment under the proposed permitted condition (218 mgd) is very small compared to ambient concentrations, as shown in **Table 5-68**. A statistical power analysis ($\alpha = 0.05$, $\beta = 0.1$) was performed to determine how many water quality samples would need to be collected and analyzed in order to detect the modeled TOC increment and the results ranged from 16,535 samples at Greene's Landing/Hood to 68,093 samples at the Banks Delta Pumping Plant Headworks. The power analysis results indicate that the modeled far-field incremental changes in TOC concentration at the proposed permitted discharge of 218 mgd are immeasurable at any reasonable monitoring frequency.

5.4.14.6 Trend Analysis Results

The results of the near- and far-field TOC concentration trend analyses are presented below in a summary table and time series graphs. The graphs show actual ambient concentrations next to the concentrations provided by the regression equations. A best-fit line through the predicted concentrations visually shows the direction of the trend, where a trend with time was determined to exist. There were sufficient detected TOC data at five locations to employ a parametric regression analysis to determine whether trends exist between ambient TOC concentrations and time. The results of the trend analyses are shown in **Table 5-69**, and the historic TOC data with applicable trend lines (regression lines) are shown in **Figure 5-88** through **Figure 5-92**.

Table 5-69: Trend Analysis Results for Ambient Total Organic Carbon Concentrations.

Location	Count	% Detected	Start Date	End Date	Trend Result with Time	R^2 (adj)	Regression Fit
Freeport	266	89%	2/1/73	4/2/08	Downward	24.9%	Fair
Greene/Hood	752	100%	7/21/83	8/4/08	Upward	19.8%	Fair
CCWD PP #1	132	100%	2/8/96	8/5/08	No trend	7.1%	Fair
CCWD Los Vaqueros Intake	249	100%	2/14/96	6/2/08	No trend	15.5%	Fair
Delta PP	288	100%	11/12/86	5/21/08	No trend	10.0%	Fair

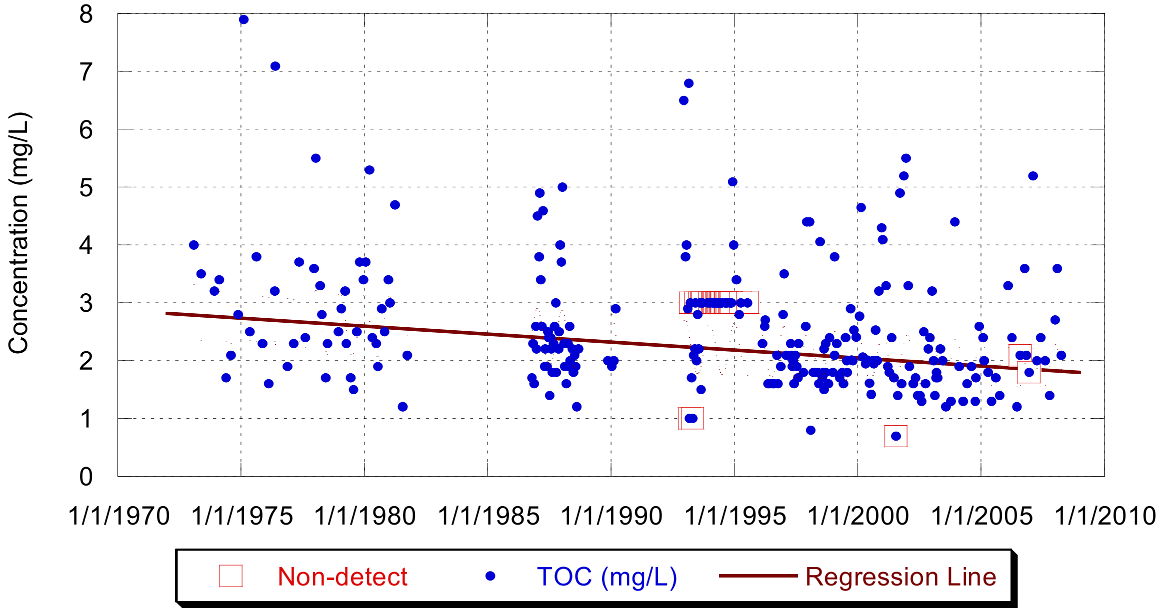

Figure 5-88: Historic Data and Regression Analysis Trend Life for Total Organic Carbon in the Sacramento River at Freeport.

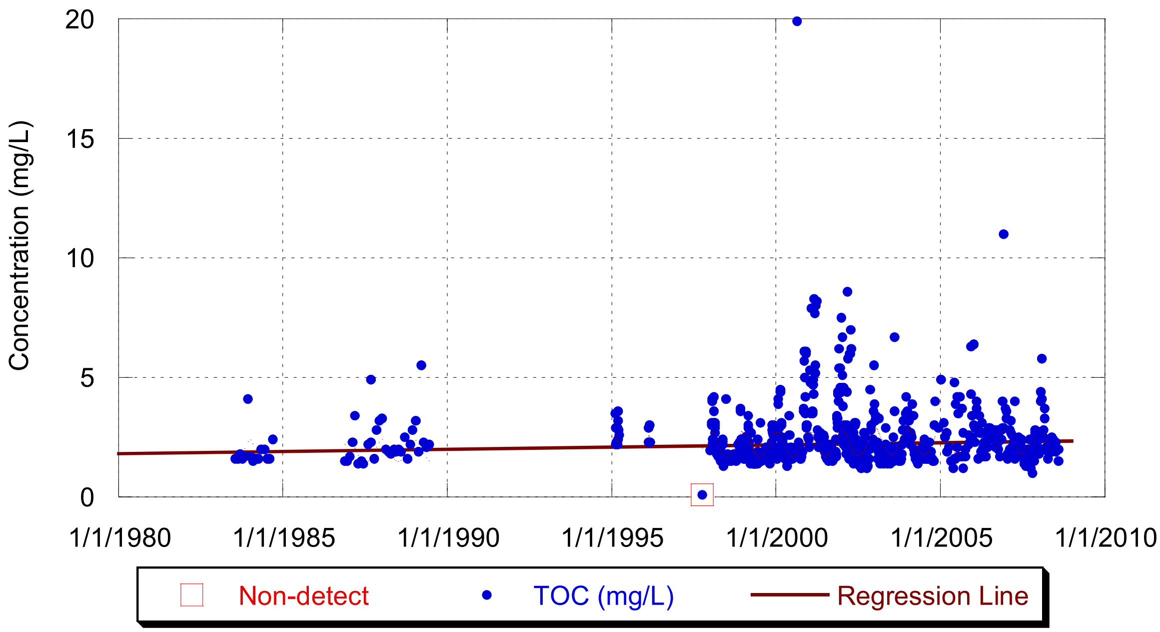

Figure 5-89: Historic Data and Regression Analysis Trend Line for Total Organic Carbon in the Sacramento River at Greene's Landing/Hood.

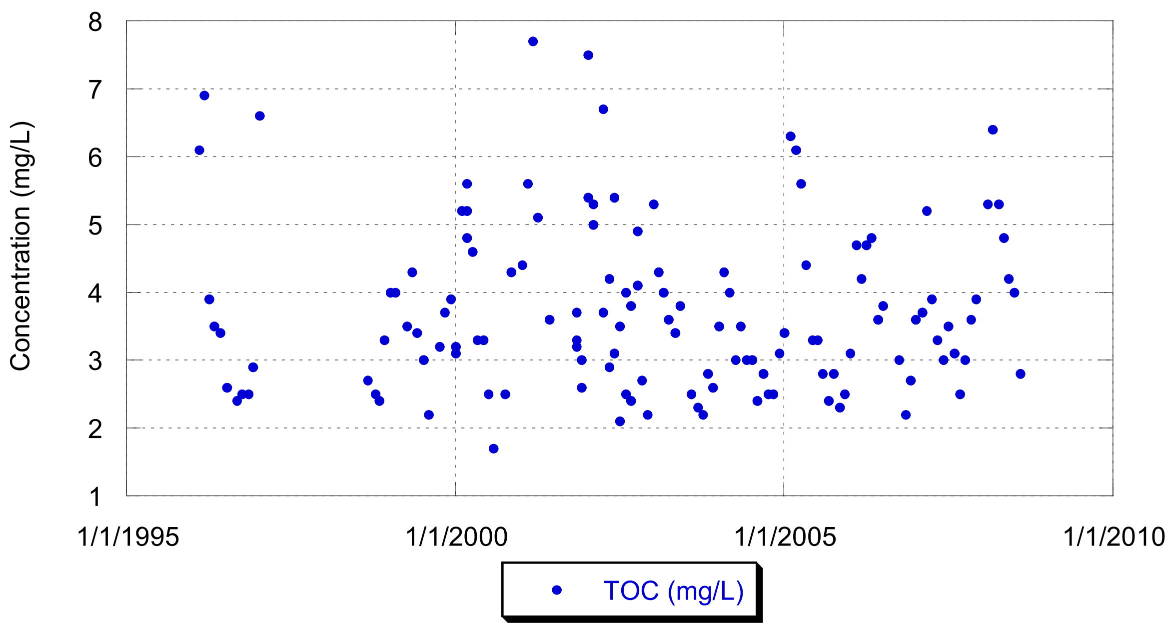

Figure 5-90: Historic Data for Total Organic Carbon at Contra Costa Water District Pumping Plant #1.

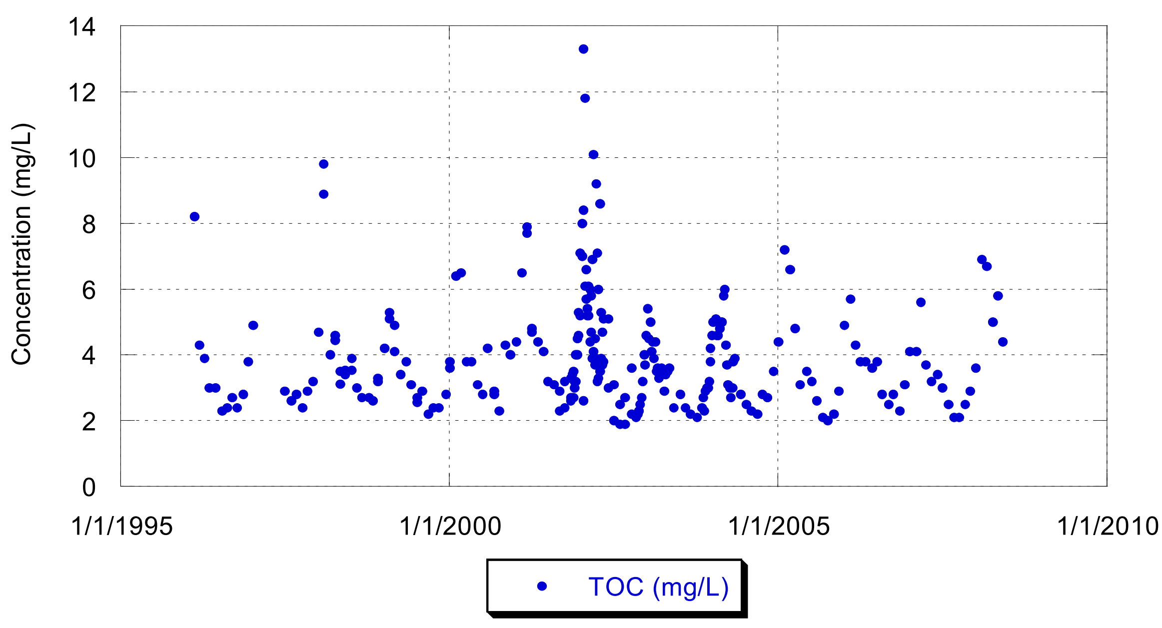

Figure 5-91: Historic Data for Total Organic Carbon at the Contra Costa Water District Los Vaqueros Intake.

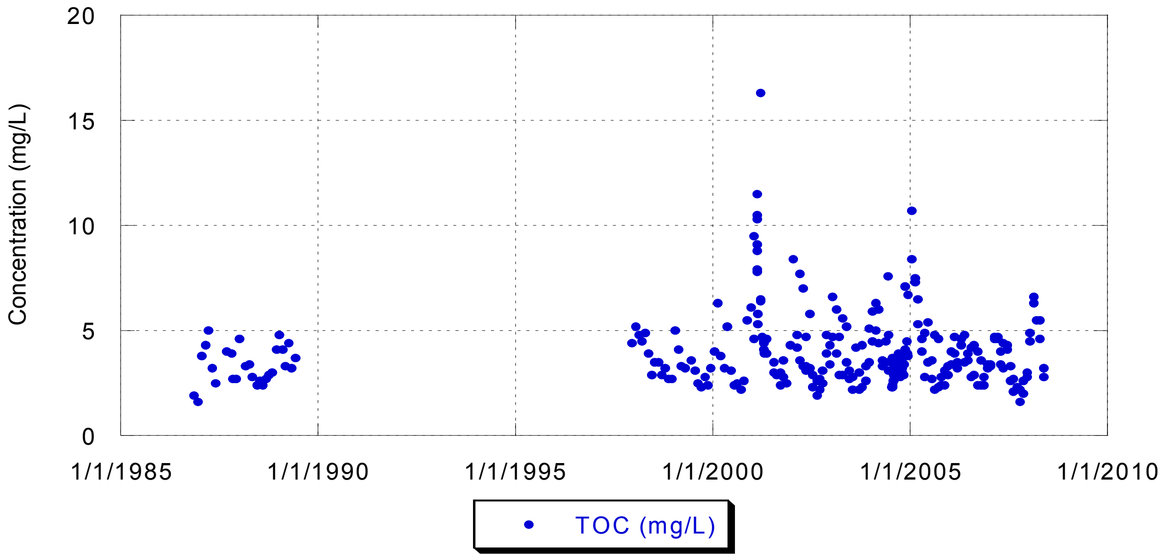

Figure 5-92: Historic Data for Total Organic Carbon at the Harvey O. Banks Delta Pumping Plant Headworks.

5.4.14.7 Trend Analysis Evaluation

The trend analyses performed on ambient TOC data collected upstream (Sacramento River at Freeport) and downstream (all other far-field Delta locations) of the SRWTP discharge resulted in the determination of a downward TOC trend upstream of the SRWTP discharge, an upward TOC trend at Greene's Landing/Hood and no temporal trend at all other far-field locations downstream of the discharge with sufficient data to perform the analysis. With the exception of Greene's Landing/Hood, ambient TOC concentrations upstream and downstream of the SRWTP discharge have not increased over the past fifteen or more years. The upward TOC trend identified at Greene's Landing/Hood is attributable to TOC concentration increases in the SRCSD effluent and is small in magnitude as evidenced by the slight slope of the trend line. The slight incremental increases in ambient downstream TOC concentrations resulting from the proposed permitted discharge (218 mgd) (see **Table 5-68**) are immeasurable and would have negligible effects on downstream TOC concentration levels.

5.4.14.8 Overall TOC Evaluation

As a result of the near and far-field evaluations described above, the incremental changes in TOC concentrations associated with the proposed 218 mgd discharge have been quantified. In the near-field, the proposed discharge would not impact drinking water uses and would not otherwise adversely impact any other beneficial uses.

In the far-field, the question is whether incremental changes in long-term average TOC concentrations are of sufficient magnitude to cause changes in either the design or operation of water treatment plants using Delta water as a supply. A key determination is that the projected TOC concentration increments associated with the 218 mgd discharge would not be measurable. This implies that the historic variability of TOC concentrations is of sufficient magnitude that the incremental changes associated with the proposed discharge would fall within the range of TOC values normally encountered at the intakes to existing water treatment plants. As shown in **Table 5-68** and **Figure 5-86**, projected median ambient TOC concentrations at downstream locations in the Delta under the current permitted condition (181 mgd) range from 3.6 to just under 4.0 mg/l, while 95th percentile ambient levels range from 6 to 7 mg/l. Some of the agencies treating this supply have switched to ozonation to avoid treatment requirements associated with these levels of TOC. Other treatment plants with chlorine disinfection systems are designed and operated to accommodate TOC concentrations in this range. Since existing water treatment plants that employ chlorine disinfection were designed based on the existing TOC concentrations at their intakes, the design of those plants and associated capital costs would not be affected by the proposed discharge. Since changes in TOC levels are immeasurable, changes in plant operations would be indistinguishable from current operations and would, therefore, not be significant.

5.4.15 Mercury

5.4.15.1 Near-Field Model Analysis Results

Although mercury bioaccumulation is primarily a far-field, regional scale issue, results of near-field analysis are presented here. FSI performed a near-field analysis for total mercury at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. The modeled in-plume total mercury concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-70**. Modeled in-plume total mercury concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-71**.

Table 5-70: Modeled In-Plume Total Mercury Concentration (ng/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	5.25	5.37	5.45	5.50	5.53	5.54
Median	4.09	4.08	4.07	4.07	4.07	4.07
95 %-ile	12.6	13.5	14.0	14.4	14.7	14.7
99.91 %-ile	39.3	42.3	44.3	45.6	46.6	47.0
5 %-ile	1.68	1.48	1.36	1.27	1.20	1.18

Table 5-71: Modeled In-Plume Total Mercury Concentration (ng/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	5.19	5.34	5.42	5.48	5.52	5.54
Median	4.10	4.08	4.07	4.07	4.07	4.07
95 %-ile	12.1	13.2	13.9	14.3	14.6	14.7
99.91 %-ile	37.8	41.4	43.7	45.3	46.3	46.8
5 %-ile	1.76	1.54	1.40	1.30	1.22	1.19

The incremental differences in modeled in-plume total mercury concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-72**. The median incremental increase in total mercury concentrations are negligible, ranging from 0.01 ng/L at a distance of 30 feet downstream from the diffuser to <0.01 ng/L at a distance of 700 feet downstream from the diffuser.

Table 5-72: Modeled In-Plume Total Mercury Concentration Increment (ng/L) at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd					
	30 ft	**60 ft**	**100 ft**	**175 ft**	**350 ft**	**700 ft**
Mean	-0.06	-0.04	-0.02	-0.02	-0.01	-0.01
Median	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
95 %-ile	-0.5	-0.3	-0.1	-0.1	-0.1	<0.1
99.91 %-ile	-1.5	-0.9	-0.6	-0.3	-0.3	-0.2
5 %-ile	0.08	0.06	0.04	0.03	0.02	0.01

The probability distributions of modeled total mercury concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-93**. The median total mercury concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-94**.

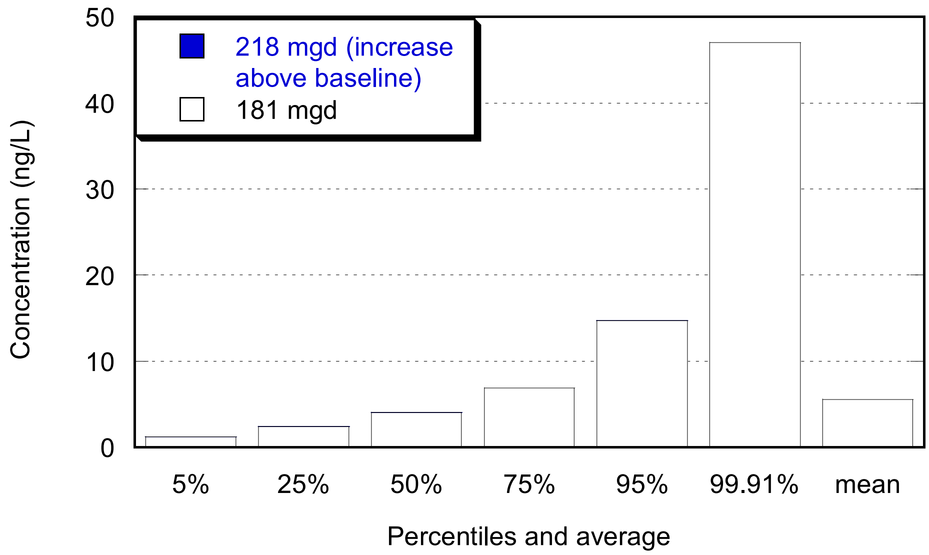

Figure 5-93: Distribution of Modeled Total Mercury Concentrations 700 feet Downstream of SRWTP Diffuser.

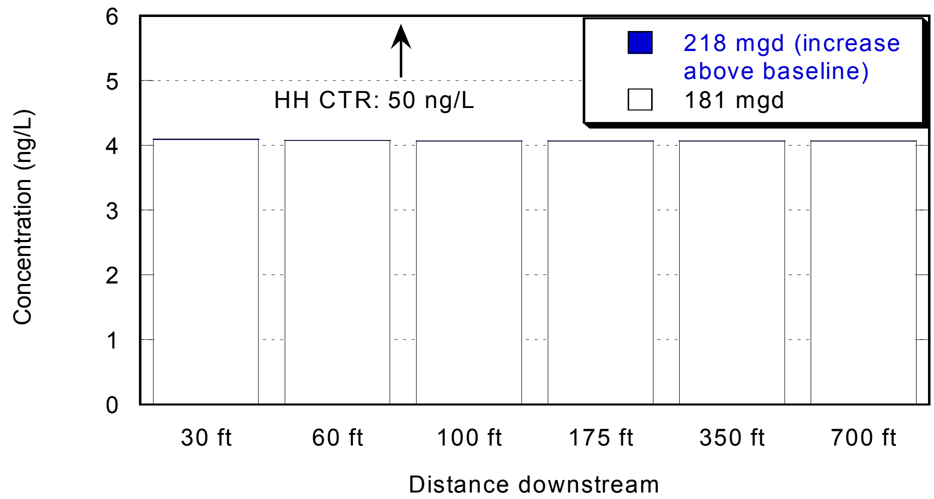

Figure 5-94: Median Modeled Total Mercury Concentration Downstream of SRWTP Diffuser.

5.4.15.2 Comparison to Water Quality Objectives

The applicable numerical objective for mercury in the Sacramento River is the CTR criterion of 50 ng/L for total mercury in the water column. The CTR criterion is applicable to freshwater systems and addresses potential mercury accumulation through the ingestion of fish and consumption of drinking water. All modeled concentrations are well below the applicable water quality objective.

The percent exceedances of total mercury criteria at various distances downstream from the SRWTP diffuser are listed in **Table 5-73**. Each calculated total mercury concentration in the water column was compared to the CTR criterion of 50 ng/L. As indicated in **Table 5-73**, the DYNTOX results show that, at the proposed 218 mgd SRWTP discharge rate, there are no exceedances of the total mercury criterion.

A TMDL for mercury is under development which will likely include fish tissue objectives for mercury and wasteload allocations for methylmercury. It is anticipated that those wasteload allocations will require some reduction in methylmercury mass discharges from the SRWTP. It is premature at this time to approximate the magnitude of those wasteload allocations. The future NPDES permit governing the SRWTP discharge will be required to be consistent with those allocations over a specified time frame. Additional information regarding the future Delta mercury TMDL is included in Section 5.4.15.5.2 below.

Table 5-73: DYNTOX Modeled Percent Exceedance Frequency for Total Mercury at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Human Health	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

5.4.15.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-70**) and proposed discharge (see **Table 5-71**) have similar characteristics. Total mercury concentrations are lowest near the outfall, since the effluent concentration is generally lower than the receiving water concentration. Typically, the total mercury in the SRCSD discharge is not contributing to higher total mercury concentrations in the Sacramento River.

Mean concentrations throughout the modeled plume are slightly lower for the proposed discharge (218 mgd) case, and median concentrations show a negligible increase throughout the modeled plume. Furthermore, as listed in **Table 5-72**, the proposed increase in SRWTP effluent discharge would differ negligibly at all distances downstream from the discharge.

Exceedance frequencies are presented in **Table 5-73** for the total mercury criterion. The dynamic model results are used to demonstrate that the proposed discharge rate of 218 mgd would not result in any exceedances of the total mercury criterion. The incremental change in total mercury concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results indicate in-plume median total mercury concentrations that are substantially below the most stringent applicable water quality criteria, the CTR objectives for the protection of human health. Both the modeled total mercury distributions at 700 feet downstream from the diffuser (see **Figure 5-93**) and the modeled, median total mercury concentration within the plume (see **Figure 5-94**) show a negligible change in total mercury concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible increase in total mercury concentrations in the Sacramento River.

5.4.15.4 Far-Field Evaluation and Trend Analysis

Insufficient ambient surface water data were available to conduct a far-field water quality impacts analysis or trend analysis for mercury. Research regarding the impacts of mercury and methylmercury is ongoing and is described below.

5.4.15.5 Additional Mercury Considerations

5.4.15.5.1 Bioaccumulation and Toxicity

Mercury is primarily a concern because of the potential adverse effects and bioaccumulative nature of methylmercury. Once mercury is released in the environment, local environmental conditions determine its transformations. Bacteria that process sulfate in the environment can take up mercury in its inorganic form, and through metabolic processes convert it to methylmercury. Factors such as dissolved oxygen, pH, nutrient, sulfide and sulfate concentrations, and others affect methylation rates (U.S. EPA, 1997). Concentrations of methylmercury typically increase in the food web, from primary producers to higher trophic level fish to wildlife and humans, thereby causing a greater risk to consumers at the highest trophic level. Methylmercury is a neurotoxin that affects the brain and central nervous system.

In the past decade, a number of studies have focused on the bioaccumulative effects of mercury concentration in fish in Delta waterways. A 1998 study examined fish tissue concentrations of mercury in the Delta region, identifying elevated tissue mercury concentrations in sport fish along with regional variation in mercury concentrations – with higher concentrations in tributaries (including the Feather, Sacramento, American, and San Joaquin Rivers) and lower concentrations in the Central Delta (Davis et al., 2000). A recently published study systematically evaluated mercury concentrations in Delta sport fish, to determine baseline levels of mercury in fish and evaluate spatial patterns of mercury accumulation (Davis et al., 2008). The report underscored the complexity of mercury dynamics in the Delta, reporting variations in methylmercury levels among fish species, along with correlations between fish tissue and water column methylmercury but no relationship between fish tissue and sediment methylmercury.

5.4.15.5.2 Draft Mercury TMDL

The Central Valley Regional Water Board has proposed an amendment to the Sacramento River and San Joaquin River Basin Plan to address the regulation of methylmercury and total mercury in the Delta. The draft Sacramento-San Joaquin Delta Estuary TMDL for Methylmercury (TMDL) (Wood et al. 2008) aims to reduce methylmercury concentrations in fish by implementing waste load allocations for total and methylmercury. The proposed fish tissue objectives in the Draft TMDL are presented in **Table 5-74**.

Table 5-74: Proposed Fish Tissue Concentrations included in Draft Sacramento-San Joaquin Delta Estuary TMDL for Methylmercury.

Matrix	MeHg Objective
Trophic level 3 fish tissue (150-500 mm length)	0.08 mg MeHg/kg
Trophic level 4 fish tissue (150-500 mm length)	0.24 mg MeHg/kg
Small fish (<50 mm length)	0.03 mg MeHg/kg

The draft TMDL specifies methylmercury waste load allocations which apply to dischargers to the Sacramento River and San Joaquin River Basins, and includes reductions in total mercury loads to enable water and fish methylmercury reductions and seek to comply with the CTR criterion for human health protection.

Wastewater dischargers in the Delta that are assigned methylmercury waste load allocations would be required monitor total mercury and methylmercury in their effluent and receiving water and submit monitoring reports and annual average concentrations of total mercury and methylmercury to the Central Valley Regional Water Board. In addition, certain wastewater treatment facilities, including SRWTP, would be required to conduct methylmercury characterization and control studies and implement a total mercury minimization program.

The Central Valley Regional Water Board is using a facilitated, stakeholder-based approach to address issues that exist with the current draft TMDL. A revised draft TMDL is scheduled to be presented at a late 2009 hearing of the Regional Water Board. Waste load allocations, Phase 1 study requirements and additional implementation elements of the TMDL will be finalized upon adoption of the TMDL in 2010 or thereafter.

5.4.16 Dissolved Oxygen

Generally, aquatic organisms require dissolved oxygen at sufficient levels for respiration; furthermore, species such as Salmonids require relatively high levels of dissolved oxygen in the water column. Oxygen dissolves into the water column from the atmosphere to achieve an equilibrium between the water column and the overlying atmosphere. The rate at which dissolved oxygen dissolves in the water column of a river is generally a function of the water depth and velocity; and is driven by the difference between the water column dissolved oxygen concentration and the saturation concentration of dissolved oxygen which is largely a function of water temperature for freshwater. Carbon compounds and ammonia present in receiving waters are oxidized by microorganisms (bacteria, algae, etc.) resulting in the consumption of oxygen from the water column. If sufficient quantities of carbon compounds and ammonia are present in the water column, the rate of oxygen consumption may be greater than the reaeration rate of oxygen from the atmosphere resulting in the dissolved oxygen levels dropping. As the carbon compounds and ammonia are oxidized, the rate of oxygen consumption falls and the reaeration acts to increase the dissolved oxygen levels in the water column. Because the typical response of the dissolved oxygen downstream from a discharge is to first decrease and then increase some distance downstream the concentrations plotted as distance downstream, or as float time, from the point of discharge forms a characteristic sag curve.

A detailed analysis of dissolved oxygen upstream and downstream of the SRWTP follows, including the results of a near-field modeling analysis, and a far-field modeling analysis. In plume concentrations of dissolved oxygen are modeled with DYNTOX as the near-field mixing occurs much faster than the rates of oxygen consumption or reaeration. The effect of the discharge on downstream dissolved oxygen concentrations is by definition a result of several reactions, so the far-field analysis of DO does not follow the near field DYNTOX modeling or the far field modeling with the Fischer Delta Model. The method of Streeter-Phelps is utilized to model the DO downstream of the SRWTP. The model utilized for the analysis is an expanded version of the classic Streeter-Phelps equation which includes separate terms for both carbonaceous and nitrogenous oxygen demand and simulates the discharge/diversion of the effluent in response to tidal effects. The model development is detailed in the *Low Dissolved Oxygen Prevention Assessment* (SRCSD, 2009b). Furthermore, the SRCSD has used the Streeter-Phelps model as an assessment tool and completed an analysis for the load of oxygen demanding substances in the SRWTP effluent and the effect on downstream dissolved oxygen in relation to the Basin Plan objective (SRCSD 2009b). The assessment for the need of limiting the mass load of oxygen demanding substances concluded that for future increases in SRWTP flow rates, the discharged loads should be limited during May through September to ensure that excursions of the Basin Plan dissolved oxygen objective do not occur. For current concentrations of oxygen demanding substances in the effluent, limitations were not necessary from October through April to comply with the Basin Plan objective at discharge flow rates of 181 mgd or 218 mgd.

5.4.16.1 Near-Field Model Analysis Results

Flow Science International (FSI) performed a near-field analysis for dissolved oxygen at locations downstream of the SRWTP diffuser. The existing condition (181 mgd) modeled concentrations are shown in **Table 5-75**. The future with project (218 mgd) modeled concentrations are shown in **Table 5-76**. Note that there are no direct measurements of the dissolved oxygen concentrations in the SRWTP effluent, and for modeling purposes, the effluent concentrations were assumed to average 2.0 mg/L and range from 0.1 mg/L to 4.0 mg/L. These levels of dissolved oxygen in the SRWTP effluent are consistent with the District's assessment (SRCSD, 2009b) and mass balance comparisons between upstream and downstream measured dissolved oxygen. The concentration difference between existing and future modeled concentrations are shown in **Table 5-77**.

Table 5-75: Modeled Baseline In-Plume Dissolved Oxygen Concentration (mg/L) Downstream of the SRWTP Diffuser at 181 mgd.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	8.2	8.9	9.3	9.6	9.8	9.9
Median	8.1	8.8	9.2	9.4	9.6	9.7
95 %-ile	10.7	11.2	11.5	11.7	11.9	12.0
99.91 %-ile	12.5	12.6	12.7	12.9	13.1	13.2
5 %-ile	5.6	6.8	7.5	7.9	8.2	8.2

Table 5-76: Modeled Future with Project In-Plume Dissolved Oxygen Concentration (mg/L) Downstream of SRWTP Diffuser at 218 mgd.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	7.8	8.7	9.2	9.5	9.8	9.8
Median	7.7	8.6	9.0	9.3	9.6	9.6
95 %-ile	10.5	11.0	11.4	11.6	11.9	12.0
99.91 %-ile	12.6	12.6	12.7	12.9	13.1	13.2
5 %-ile	5.2	6.5	7.3	7.8	8.1	8.2

The incremental differences in modeled in-plume dissolved oxygen concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-77**. The median incremental decrease in dissolved oxygen concentrations would range from 0.4 mg/L at a distance of 30 feet downstream from the diffuser to 0.0 mg/L at a distance of 700 feet downstream from the diffuser.

Table 5-77: Modeled Future with Project In-Plume Dissolved Oxygen Increment (mg/L) Downstream of SRWTP Diffuser at 218 mgd.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	-0.4	-0.2	-0.1	-0.1	-0.0	-0.0
Median	-0.4	-0.2	-0.1	-0.1	-0.0	-0.0
95 %-ile	-0.2	-0.2	-0.1	-0.1	0.0	0.0
99.91 %-ile	0.1	0.0	0.0	0.0	0.0	0.0
5 %-ile	-0.4	-0.3	-0.2	-0.1	-0.0	-0.0

5.4.16.2 Comparison to Water Quality Objectives

The applicable water quality objective for dissolved oxygen in the Sacramento River below the I Street Bridge and in all Delta waters west of the Antioch Bridge is specified in the Basin Plan as to not fall below 7.0 mg/L. The Basin Plan objective is set based on a CDFG goal, and is not directly a level that is reflective of acute or chronic affects on aquatic life. However, the Basin Plan objective is the applicable water quality receiving water objective downstream of the SRWTP discharge.

The dissolved oxygen criteria pertaining to the viability of aquatic life have generally lower levels than the Basin Plan objective. The historic USEPA criterion is as follows:

> Freshwater aquatic life: A minimum concentration of dissolved oxygen to maintain good fish populations is 5.0 mg/L. The criterion for salmonid spawning beds is a minimum of 5.0 mg/L in the interstitial water of the gravel[9].

The USEPA has developed ambient water quality criteria for dissolved oxygen[10]. If the period of exposure to low dissolved oxygen concentrations is limited to less than 3.5 days, concentrations of dissolved oxygen of 3 mg/L or higher should produce no direct mortality of salmonids (USEPA, 1986).

The criteria in USEPA 1986 are developed to represent annual worst-case dissolved oxygen concentrations believed to protect the more sensitive populations of organisms against potentially damaging production impairment. The recommended criteria for coldwater species as developed by the USEPA are listed in **Table 5-78**. As is evidenced by the criteria listed in **Table 5-78**, the Basin Plan objective is considerably greater than the levels needed to provide protection to all lifestages of sensitive aquatic life species.

Table 5-78: USEPA Criteria for the Ambient Dissolved Oxygen Concentrations (USEPA 1986).

	Coldwater Dissolved Oxygen Criteria (mg/L)	
Criteria	**Early Life Stages[(1)]**	**Other Life Stages**
30 day mean	---	6.5
7 day mean	6.5	---
7 day mean of minimums	---	5.0
1 day minimum[(2)]	5.0	4.0

(1) Includes all embryonic and larval stages and all juvenile forms to 30-days following hatching. For embryonic stages criteria applied to the intergravel water.

(2) Should be considered as instantaneous concentrations to be achieved at all times.

The percent exceedances of the dissolved oxygen Basin Plan objective are listed in **Table 5-79**, for various distances downstream of the diffuser. As the effluent mixes through the plume the frequency of exceedance falls, to a point where there is less than 10 instances of hourly time

[9] USEPA (1976), Quality Criteria for Water (the Red Book), Stock No. 055-001-01049-4, July 1976.

[10] USEPA (1986), Ambient Water Quality Criteria for Dissolved Oxygen, EPA 440/5-86-003, April 1986.

steps in the 70 year period of record where the Basin Plan objective is not met 700 feet from the diffuser. From the Streeter-Phelps analysis, there are no exceedances of the dissolved oxygen Basin-Plan objective at the point where the river and effluent are completely mixed.

Table 5-79: Distribution of Modeled Dissolved Oxygen Concentrations 700 feet Downstream from SRWTP Diffuser.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Basin Plan	35%	11%	2.7%	0.33%	0.007%	0.001%

5.4.16.3 Near-Field Evaluation

Increasing the SRWTP discharge from 181 mgd to 218 mgd would have a negligible effect on the near field dissolved oxygen concentrations, as is evidenced by the increments presented in **Figure 5-95**. Additionally, a minor reduction of in-plume concentrations in the immediate vicinity of the diffuser is calculated to occur with the increased discharge, but there is a negligible difference in concentrations after 350 feet from the diffuser, as displayed on **Figure 5-96**.

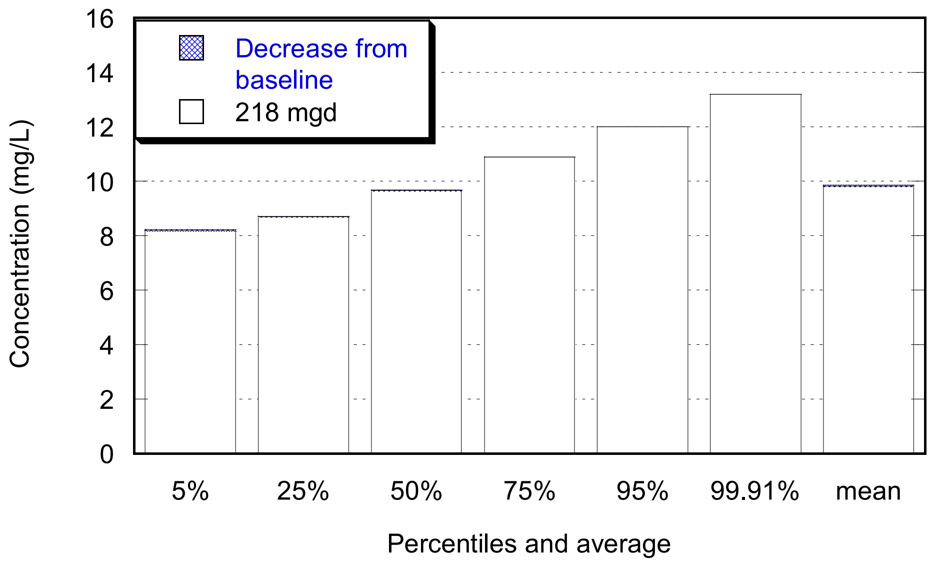

Figure 5-95: Distribution of Modeled Dissolved Oxygen Concentrations 700 feet Downstream from SRWTP Diffuser.

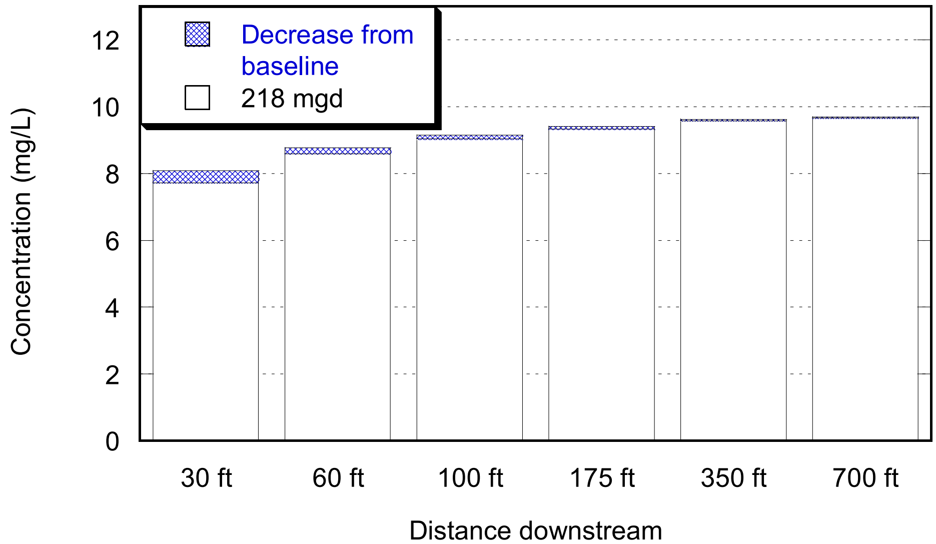

Figure 5-96: Median Modeled Dissolved Oxygen Concentration Downstream of SRWTP Diffuser.

5.4.16.4 Far-Field Model Analysis Results

For summer operating conditions, the Streeter-Phelps modeling results for the Sacramento River at Rio Vista[11] are presented in **Figure 5-97**, where the distribution of modeled dissolved oxygen corresponding to the existing permitted condition (181 mgd) are shown with the corresponding incremental decrease in dissolved oxygen concentration for the proposed permitted condition (218 mgd). As discussed in the *Low Dissolved Oxygen Prevention Assessment* (SRCSD, 2009), an alternative to implement the oxygen demanding substances load reductions would be to control ammonia concentrations in the SRWTP effluent. For the period May through September, during summer operating conditions, limiting the effluent concentration of ammonia to 17 mg/L as N for a discharge rate of 181 mgd and 14 mg/L as N for a discharge rate of 218 mgd would satisfy the calculated load reductions. In October through April, effluent ammonia concentrations in excess of 30 mg/L as N would not result in excursions of the dissolved oxygen Basin Plan objective at discharge rates over 218 mgd. For winter operations, an effluent ammonia concentration of 25 mg/L as N was simulated for both 181 and 218 mgd. The corresponding results for winter operations are presented in **Figure 5-98**. Because low dissolved oxygen is the critical number, the 0.09% concentrations are displayed instead of the 99.91% concentrations.

[11] Rio Vista was determined to be the critical location for dissolved oxygen downstream of the SRWTP discharge (SRCSD, 2009b).

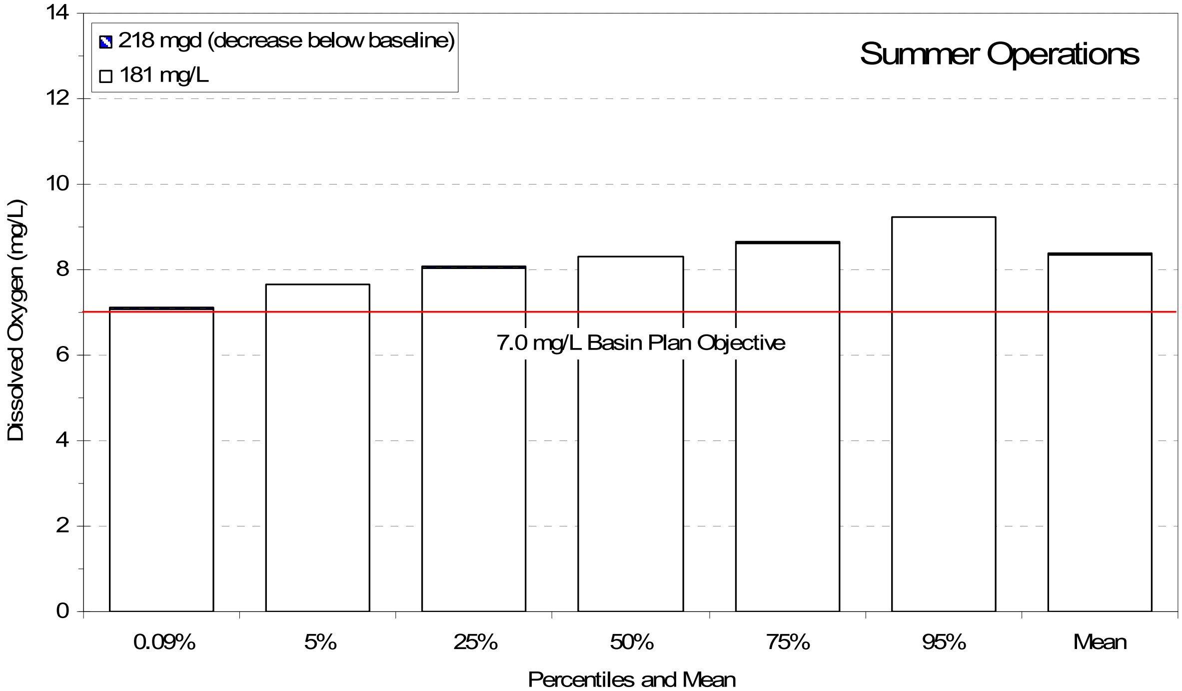

Figure 5-97: Summer Operations Distribution of Dissolved Oxygen at Rio Vista.

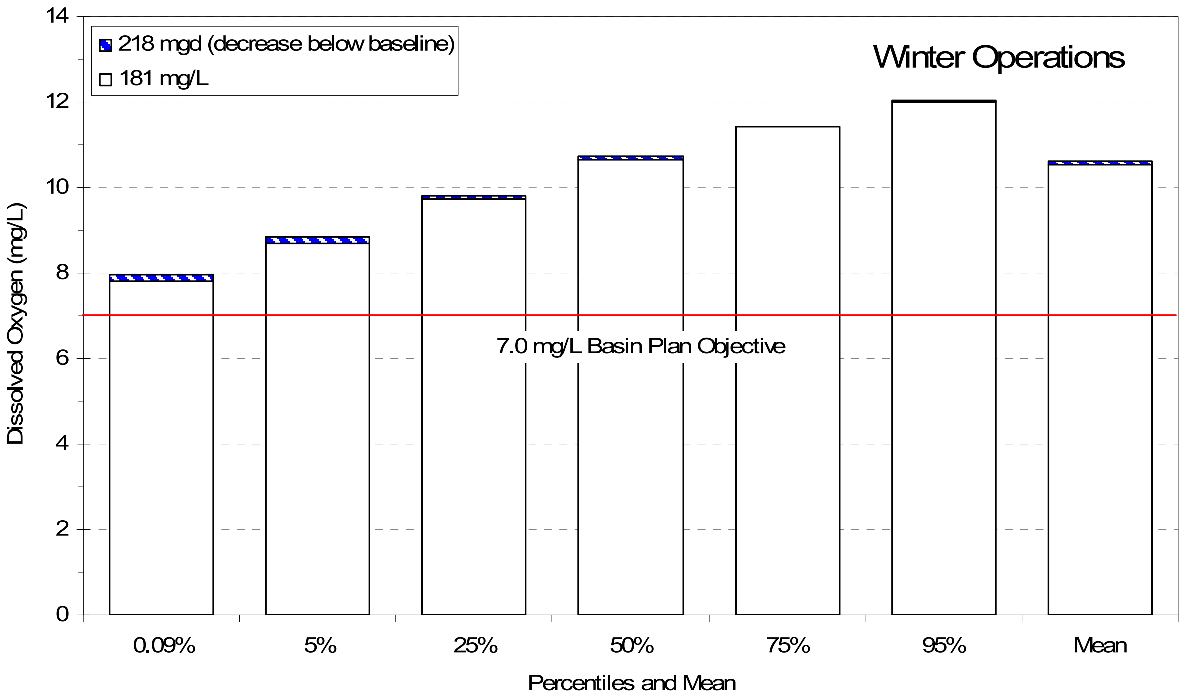

Figure 5-98: Winter Operations Distribution of Dissolved Oxygen at Rio Vista.

5.4.16.5 Far-Field Evaluation

The combined condition of low river flow rates and high water temperature results is the critical condition for low dissolved oxygen. When the water temperature is elevated less oxygen can be dissolved in the water, and respiration rates increase. As the river flow rate decreases there is less available dilution resulting in increased concentrations of oxygen demanding substances, and the water velocity decreases resulting in lower reaeration rates. The summer operations include limitation of oxygen demanding mass load to control potential excursions of the Basin Plan objective for dissolved oxygen. The summer operations result in an effective cap to oxygen demanding mass load, thereby the increments in dissolved oxygen in the far-field are negligible.

For winter operations, where the river temperatures are sufficiently low and the flow rates are sufficiently high so that without a cap on the oxygen demanding substances, there would be no excursions of the Basin Plan objective. Under winter operating conditions there would be minor decreases in the dissolved oxygen at Rio Vista.

5.4.16.6 Overall Dissolved Oxygen Evaluation

Analyses have been performed to quantify the changes in ambient dissolved oxygen levels in the near and far-field associated with a proposed increase in discharge from the SRWTP from 181 to 218 mgd. Additionally, oxygen demanding substances load reductions per the District's assessment could be implemented as a summer operating condition utilizing controlled effluent ammonia concentrations, and a winter operating condition without additional controls on the effluent ammonia concentration. The near field increment in dissolved oxygen would be negligible for the proposed permit condition and is not affected by the implementation of the oxygen demanding substances load reductions. Limitation of the discharged mass of ammonia by the SRWTP is the current means being pursued by the District to prevent excursions of the Basin Plan objective for dissolved oxygen. Seasonal ammonia mass load limitations are sufficient to satisfy the Basin Plan objective, as the evaluation has established that potential excursions of the Basin Plan objective for dissolved oxygen of 7.0 mg/L may occur in downstream waters in warm summer months when dissolved oxygen saturation levels are low and nitrification of ammonia to nitrate is most pronounced. However, it is the limitation of oxygen demanding substances that ensures the dissolved oxygen Basin Plan objective is met downstream of the discharge, not necessarily ammonia limitations.

While seasonal ammonia mass emission limits would be necessary to preclude exceedance of the Basin Plan objective, the modeled dissolved oxygen concentrations without limitation would remain well above the U.S. EPA ambient water quality criteria developed to provide protection to sensitive populations of aquatic organisms at discharge flow rates exceeding 218 mgd.

With respect to the Antidegradation policies, the proposed permitted condition with ammonia limitations as per the District's assessment (SRCSD, 2009b) would result in slightly lower loading of oxygen demanding substances than would occur if the existing effluent were to be discharged at 181 mgd. With these controls on ammonia in place incremental increases in ammonia would be negligible resulting in negligible increments of dissolved oxygen and the proposed discharge would satisfy all concerns related to Antidegradation, from the standpoint of ammonia, and dissolved oxygen levels.

5.5 ASSESSMENT OF CATEGORY 2 CONSTITUENTS

Category 2 constituents are those of concern with respect to localized impacts and were evaluated only in terms of their potential near-field water quality impacts. The six constituents assigned to this category are listed below.

Aluminum	**Copper**	**Temperature**
Cadmium	**Zinc**	**Total Coliform**

Category 2 constituents were evaluated with respect to potential receiving water impacts resulting from an increase in permitted SRWTP discharge from the current permitted condition (181 mgd (ADWF)) to the proposed permitted condition (218 mgd (ADWF)) using the following water quality assessments:

- Near-Field Impacts Analysis
- Comparison to Water Quality Objectives
- Near-Field Evaluation and Consideration of Issues of Concern

General descriptions of these assessments and their presentation within individual pollutant evaluations are described below in more detail.

5.5.1 Near-Field Impacts Analysis

Near-field pollutant impact analyses include the presentation of modeled in-plume concentration results for a pollutant at varying distances downstream of the SRWTP diffuser: 30, 60, 100, 175, 350, and 700 feet. Modeled concentration results are presented in tabular form for both the current permitted condition (181 mgd (ADWF)) and the proposed permitted condition (218 mgd (ADWF)). These modeled data presentations are followed by the tabular presentation of the in-plume concentration increment due to the proposed 37 mgd (ADWF) increase in permitted SRWTP discharge. The concentration increment is calculated by subtracting the modeled in-plume concentration for a pollutant at the discharge flow rate of 181 mgd (ADWF) from the modeled in-plume concentration of the pollutant at the discharge flow rate of 218 mgd (ADWF). For example, to determine the 99.91 percentile concentration increment, the 99.91 percentile modeled concentration at 181 mgd is subtracted from the 99.91 percentile modeled concentration at 218 mgd.

These tabular data presentations are followed by graphical presentations showing various percentile distributions (5%, 25%, 50%, 75%, 95%, 99.91%, and a mean) of the modeled in-plume concentration of a pollutant at 700 feet downstream of the SRWTP diffuser at both the 181 mgd (ADWF) "baseline" discharge flow rate and the 218 mgd (ADWF) proposed flow rate. In instances where the modeled pollutant concentration at 218 mgd (ADWF) results in an increase in receiving water concentration above the 181 mgd (ADWF) condition, the modeled pollutant concentration at 218 mgd (ADWF) appears as a blue-colored increment stacked on top of the baseline concentration. In instances where the modeled pollutant concentration at 218 mgd (ADWF) results in a decrease in receiving water concentration below that modeled for the 181 mgd (ADWF) condition, no such blue-colored increment is visible in the graph.

The next graphical data presentation included in all near-field impacts analyses is a graph showing the median modeled concentration of a pollutant at six distances downstream of the SRWTP diffuser at both the 181 mgd (ADWF) baseline discharge flow rate and the 218 mgd (ADWF) proposed flow rate. Similar to the explanation provided for the previous graph, increases in modeled in-plume pollutant concentrations at 218 mgd (ADWF) appear as blue-colored increments stacked on top of 181 mgd (ADWF) modeled concentrations. In instances where the modeled pollutant concentration at 218 mgd (ADWF) results in a decrease in receiving water concentration below that modeled for the 181 mgd (ADWF) condition, no such blue-colored increment is visible in the graph.

5.5.2 Comparison to Water Quality Objectives

Where a water quality objective or criterion exists for a constituent, the DYNTOX model was used to evaluate in-plume compliance with the objective or criterion downstream of the SRWTP diffuser. Where applicable, pollutant evaluations include the tabular presentation of DYNTOX modeled in-plume percent exceedance frequency for a constituent at 30, 60, 100, 175, 350, and 700 feet downstream of the SRWTP diffuser under the proposed permitted condition (218 mgd (ADWF)). Where a constituent has more than one criterion, for example CTR freshwater acute and chronic water quality criteria, compliance frequencies for all relevant criteria were evaluated using the DYNTOX model and presented for the pollutant.

The frequency of exceedance is determined by comparing the pollutant concentration generated by DYNTOX for each hour time-step in the 70-year period to the applicable criteria. For the acute criteria, exceedance percentages are calculated as the number of hourly values that exceed the criteria out of 613,420 (*i.e.*, 70 x 365 x 24 + 17.5 leap days x 24). For 30-day criteria, a 30-day average is generated for each hourly time step after the first 30 days (720 values) and the percent exceedance is based on the number of 30-day averages exceeding the criteria out of 612,900 values. Four day (4-day) average criteria exceedances are determined based on the number of 4-day averages exceeding the criteria out of 612,324 values.

5.5.3 Near-Field Evaluation and Consideration of Issues of Concern

Where relevant, Category 2 pollutant evaluations are concluded with a consideration of the salient issues surrounding a constituent in terms of concerns related to aquatic toxicity, bioaccumulation in aquatic organisms, habitat and ecosystem integrity, drinking water supply, agricultural water supply, and/or contact recreation. The results of near-field water quality impacts analyses and evaluations of DYNTOX modeled in-plume water quality objective compliance frequencies at the proposed permitted condition (218 mgd (ADWF)) are discussed in the context of relevant issues of concern surrounding a given constituent. These elements are used to provide an evaluation of the potential near-field water quality impacts for a pollutant due to the proposed 37 mgd (ADWF) increase in permitted SRWTP discharge.

The Category 2 pollutant evaluations that follow are organized in a similar manner and, where necessary, changes in the organization of individual pollutant evaluations are noted.

5.5.4 Aluminum

5.5.4.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for total aluminum at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from total aluminum monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from total aluminum measured in SRWTP effluent. The modeled in-plume total aluminum concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-80**. Modeled in-plume aluminum concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-81**.

Table 5-80: Modeled In-Plume Total Aluminum Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	264.5	291.3	307.0	317.0	324.9	327.3
Median	220.0	244.0	257.0	266.0	272.0	274.0
95 %-ile	595.0	649.0	683.0	705.0	722.0	728.0
99.91 %-ile	1450	1560	1630	1670	1720	1730
5 %-ile	83.8	92.9	97.9	100.0	103.0	103.0

Table 5-81: Modeled In-Plume Total Aluminum Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	251.7	283.5	302.0	313.8	323.2	325.9
Median	208.0	237.0	253.0	263.0	271.0	273.0
95 %-ile	569.0	633.0	672.0	697.0	719.0	725.0
99.91 %-ile	1410	1530	1600	1660	1710	1720
5 %-ile	79.6	90.5	96.4	99.9	102.0	103.0

An increase in SRWTP effluent discharge would slightly decrease total aluminum concentration in the Sacramento River downstream of the discharge as shown in **Table 5-82**. The median decrease in aluminum concentrations would range from 12.8 µg/L at a distance of 30 feet downstream from the diffuser to 1.4 µg/L at a distance of 700 feet downstream from the diffuser.

Table 5-82: Modeled In-Plume Total Aluminum Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	-12.8	-7.8	-5.0	-3.2	-1.7	-1.4
Median	-12.0	-7.0	-4.0	-3.0	-1.0	-1.0
95 %-ile	-26.0	-16.0	-11.0	-8.0	-3.0	-3.0
99.91 %-ile	-40	-30	-30	-10	-10	-10
5 %-ile	-4.2	-2.4	-1.5	-0.1	-1.0	<0.1

The probability distributions of modeled total aluminum concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-99**. The median total aluminum concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-100**.

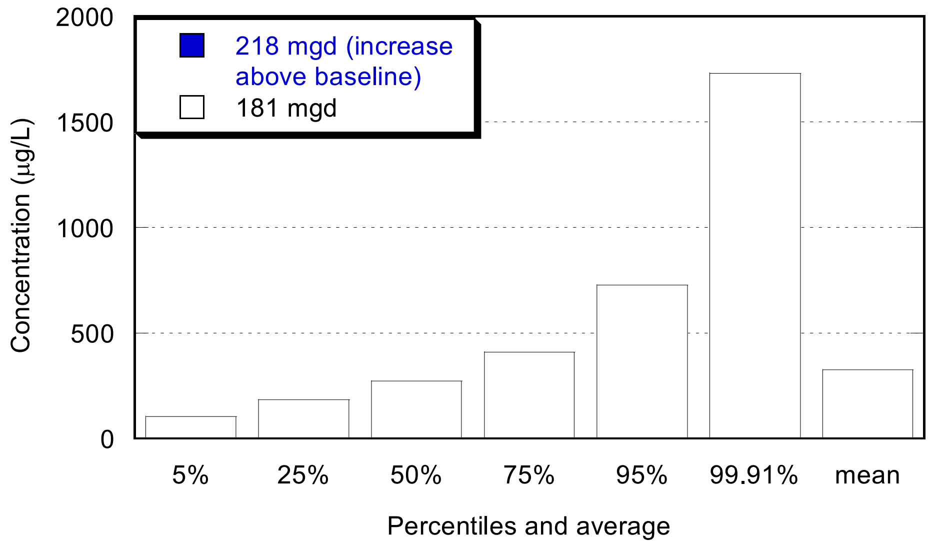

Figure 5-99: Distribution of Modeled Total Aluminum Concentrations 700 feet Downstream of SRWTP Diffuser.

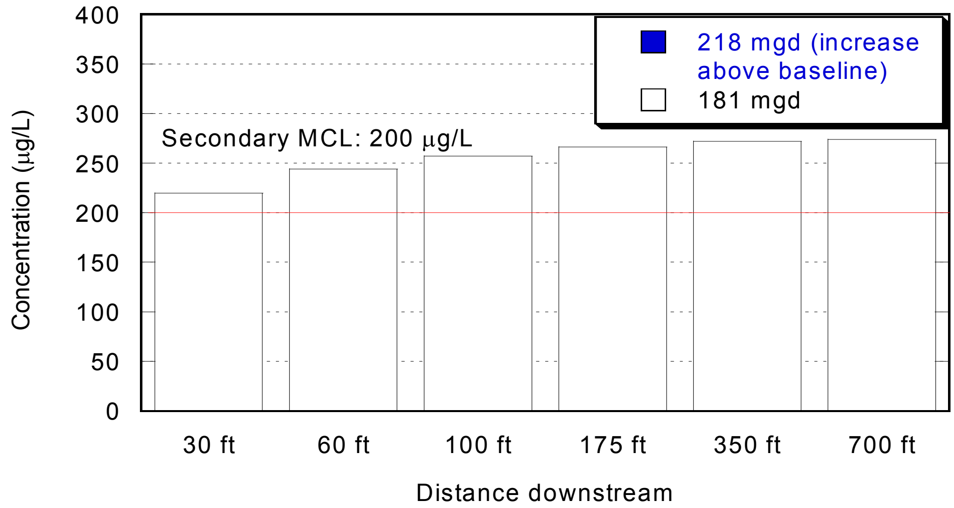

Figure 5-100: Median Modeled Total Aluminum Concentration Downstream of SRWTP Diffuser.

5.5.4.2 Comparison to Water Quality Objectives

The Title 22 Secondary Maximum Contaminant Level (MCL) for aluminum has been determined to be the controlling water quality objective for the discharge to the Sacramento River. The determination is made through evaluation of available aluminum toxicity bioassay results performed in the Central Valley (e.g., City of Manteca, City of Yuba City, and City of Modesto) which resulted in adjusted chronic criteria more than an order of magnitude greater than the 1988 U.S. EPA ambient water quality chronic criterion of 87 µg/L (U.S. EPA, 1986) and greatly exceeding the next lowest water quality standard for aluminum, the Title 22 Secondary MCL of 200 µg/L. Considering the available information regarding the low aluminum toxicity in Central Valley waters provided by the bioassays, the fact that the Secondary MCL concentration is an order of magnitude less than the bioassay effects levels, and the fact that the U.S. EPA criteria document acknowledges many high quality waters with aluminum concentrations exceeding 87 µg/L and recommends consideration of the site specific waters in determining the appropriate aquatic life criterion, the use of the 200 µg/L Secondary MCL value is deemed appropriate.

Title 22 Secondary MCLs are set to evaluate potable water that has received treatment, including filtration that generally removes the particulate materials from the water, leaving essentially only the dissolved fraction. However, Title 22 standards do not directly specify whether the total or dissolved phase should be considered. Applying Secondary MCLs directly to surface water warrants consideration in that only the dissolved fraction would ultimately pass through a drinking water treatment plant. The Regional Water Board has requested an opinion from the California Department of Public Health (CDPH) as to whether Secondary MCLs should be applied to the total or dissolved fraction in receiving waters. CDPH responded[12] stating that

[12] Letter from Carl Lischeske, CDPH Region Chief, to Kenneth Landau, Region 5 Assistant Executive Officer, regarding Yuba City Wastewater Treatment Plant, dated April 10, 2007.

application of Secondary MCLs as dissolved is sufficient to protect municipal and drinking water users. The Regional Water Board has indicated that only the numbers from the Tables of Title 22 Secondary MCLs are incorporated into the Basin Plan by reference, and will continue to apply the value of the Secondary MCL standard to the total concentration of the constituent in the receiving water to provide protection for persons directly using the river as their water source.

The percent exceedances of the Secondary MCL for aluminum at various distances downstream from the SRWTP diffuser are listed in **Table 5-83**. Since CDPH assesses compliance with Title 22 Secondary MCLs on an annual average basis and the Regional Water Board has also incorporated this standard in recently adopted permits, running one-year averages of aluminum concentrations in the Sacramento River were modeled to determine projected exceedance of the MCL in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the total aluminum annual average concentrations are expected to exceed the Secondary MCL at all times. It should be noted that throughout the year, the Sacramento River concentrations would be below the 200 µg/L level 25% of the time 700 feet downstream of the diffuser (see **Figure 5-99**) and even more frequently at distances closer to the diffuser. However, taken as an annual average, the concentrations are expected to exceed the Secondary MCL 100% of the time

Table 5-83: DYNTOX Modeled Percent Exceedance Frequency for Total Aluminum at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Secondary MCL	100%	100%	100%	100%	100%	100%

The mean and median values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) exceed the aluminum Secondary MCL under both discharging conditions. The probability distribution of the modeled in-plume total aluminum concentrations indicates that the Secondary MCL of 200 µg/L would only be met 25% of the time at a distance of 700 foot downstream of the diffuser, as graphically represented in **Figure 5-99**. These findings are consistent with the modeled frequency of exceedances listed in **Table 5-83** which indicate 100% probability of exceeding the Secondary MCL applied as an annual average.

It should be stressed that the exceedance frequencies noted in **Table 5-83** are not in fact caused by the proposed discharge rate of 218 mgd, but are an artifact of preexisting elevated aluminum concentrations in the Sacramento River. The median total aluminum concentration for SRWTP effluent is 25 µg/L, significantly lower than the 200 µg/L MCL. At the same time, the median aluminum concentration in the Sacramento River is double the MCL value at 401 µg/L. As such, an increase in the effluent discharge rate from the current condition (181 mgd) to the proposed condition (218 mgd) would reduce in-plume total aluminum concentrations. The modeled incremental decreases listed in **Table 5-82** are expected with elevated aluminum levels in the receiving water being diluted by the SRWTP effluent.

5.5.4.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-80**) and proposed discharge (see **Table 5-81**) have similar characteristics. For the 5th percentile through the 99.91 percentile distributions, total aluminum concentrations are lower near the outfall, corresponding to the fact that the effluent concentration is generally lower than the receiving water concentration. All percentile concentrations show a curvilinear increase in the modeled plume with the lowest concentrations near the diffuser, also indicating that the receiving water concentrations are higher than the effluent concentrations. Concentrations near the diffuser are lower for the proposed discharge (218 mgd) case; however, the concentrations towards the end of the modeled plume are similar for both discharge rates as they even back out towards the preexistent river conditions upstream of the discharge. Furthermore, as listed in **Table 5-82**, the proposed increase in SRWTP effluent discharge would decrease total aluminum concentrations in the Sacramento River in the vicinity of the SRWTP diffuser, with the decrease becoming less significant at locations further downstream from the diffuser.

Exceedance frequencies are presented in **Table 5-83** for the aluminum Secondary MCL, applied as an annual average standard. It should be noted that the exceedance frequencies noted in **Table 5-83** are not in fact caused by the proposed discharge rate of 218 mgd, but are an artifact of pre-existing elevated aluminum concentrations in the Sacramento River. The increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd would, in fact, cause less frequent exceedances in the Sacramento River downstream of the SRWTP diffuser. Regardless of the high exceedance frequencies under both current and proposed conditions, an increase in permitted discharge from 181 mgd to 218 mgd does not negatively impact the Sacramento River, and in fact would decrease total aluminum concentrations in the receiving water.

5.5.5 Cadmium

FSI performed a near-field analysis for cadmium at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured dissolved fraction of cadmium in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total recoverable fraction of cadmium measured in SRWTP effluent. Therefore, the modeling conservatively estimated the frequency at which cadmium concentrations would exceed the applicable water quality objectives, which are expressed as dissolved. The modeled in-plume dissolved cadmium concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-84**. Modeled in-plume dissolved cadmium concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-85**.

Table 5-84: Modeled In-Plume Dissolved Cadmium Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.012	0.010	0.010	0.009	0.009	0.009
Median	0.010	0.009	0.008	0.008	0.007	0.007
95 %-ile	0.025	0.022	0.020	0.019	0.019	0.018
99.91 %-ile	0.076	0.056	0.047	0.044	0.043	0.043
5 %-ile	0.004	0.004	0.003	0.003	0.003	0.003

Table 5-85: Modeled In-Plume Dissolved Cadmium Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.012	0.011	0.010	0.009	0.009	0.009
Median	0.010	0.009	0.008	0.008	0.008	0.007
95 %-ile	0.027	0.023	0.020	0.019	0.019	0.018
99.91 %-ile	0.085	0.061	0.049	0.044	0.043	0.043
5 %-ile	0.004	0.004	0.004	0.003	0.003	0.003

The incremental differences in modeled in-plume dissolved cadmium concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-86**. The median incremental increase in dissolved cadmium concentrations is negligible, less than 0.001 µg/L at all points within the plume from 30 feet to 700 feet downstream of the SRWTP diffuser.

Table 5-86: Modeled In-Plume Dissolved Cadmium Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Median	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
95 %-ile	0.002	0.001	<0.001	<0.001	<0.001	<0.001
99.91 %-ile	0.009	0.005	0.002	<0.001	<0.001	<0.001
5 %-ile	<0.001	<0.001	0.001	<0.001	<0.001	<0.001

The probability distributions of modeled dissolved cadmium concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-101**. The median dissolved cadmium concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-102**.

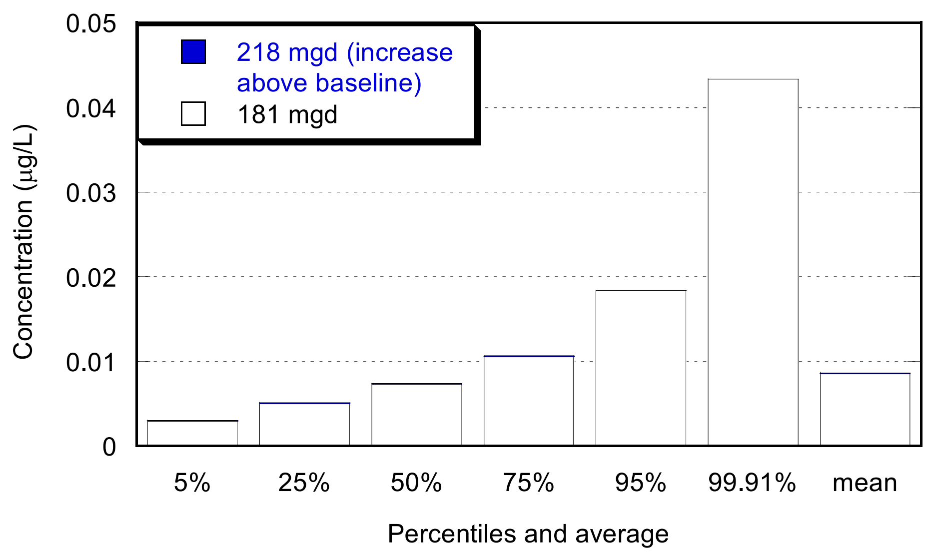

Figure 5-101: Distribution of Modeled Dissolved Cadmium Concentrations 700 feet Downstream from SRWTP Diffuser.

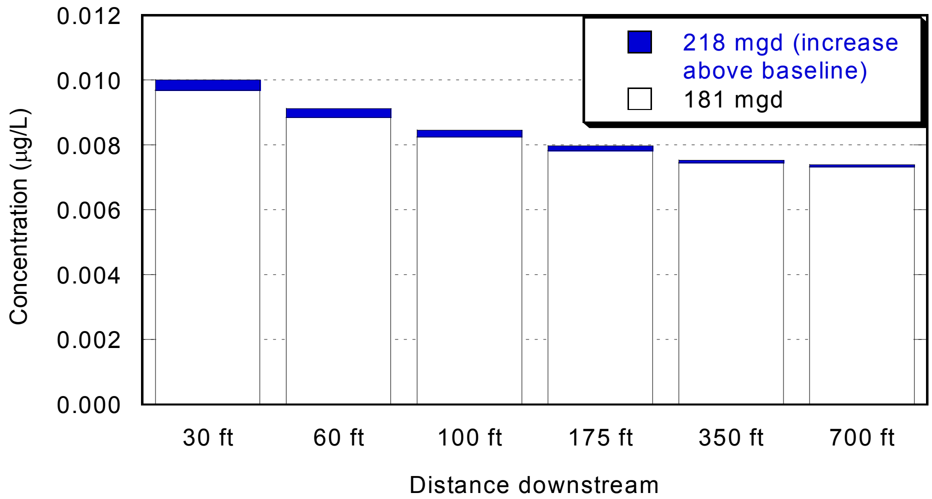

Figure 5-102: Median Modeled Dissolved Cadmium Concentration Downstream of SRWTP Diffuser.

5.5.5.1 Comparison to Water Quality Objectives

The most stringent water quality objectives for dissolved cadmium in the Sacramento River are the hardness-based CTR standards for the protection of freshwater aquatic life. The modeled hardness in the plume, corresponding to the mixed effluent and river hardness levels, is used to evaluate the compliance of the in-plume dissolved cadmium concentrations. . The modeled, dissolved cadmium concentrations in the plume are compared with the calculated hardness-based criteria for both acute (1-hour) and chronic (4-day) toxicity criteria.

In addition to being hardness-based, the CTR criterion equation also includes a water-effect ratio (WER). The WER is a measure of the complexation of the toxic free cadmium ions in the site-specific water body, thereby making them biologically unavailable and non-toxic to aquatic life, in relation to the complexation of cadmium ion in the laboratory water used by U.S. EPA to derive the criterion. Without an additional study, the default WER of 1.0 is specified in the CTR for criteria development. An upward adjustment of the presumed WER of 1.0 in the zone of initial mixing, due to the cadmium binding capability of treated effluent, would result in higher objectives.

The percent exceedances of dissolved cadmium criteria over a three-year interval at various distances downstream from the SRWTP diffuser are listed in **Table 5-87**. As noted above, the modeled in-plume hardness level at each epoch of the model is used to calculate the criteria throughout the plume for that epoch. For the acute toxicity objective, each calculated dissolved cadmium concentration in the plume was compared to the 1-hour acute criterion calculated from the hardness for the individual epoch. For the chronic toxicity objective, intended as protection for an organism under continuous 4-day exposure to a certain water quality condition, a running 4-day average of the ratios was evaluated at each time step that compared calculated dissolved cadmium concentrations to the chronic criteria calculated with the hardness value for the time step. If the running 4-day average of the ratio was greater than 1.0, the criterion was exceeded. As listed in **Table 5-87**, the modeled results indicate that exceedances of either the acute or the chronic dissolved cadmium objectives are not expected at any of the modeled in-plume locations with an increased in discharge rate.

Table 5-87: DYNTOX Modeled Percent Exceedance Frequency for Dissolved Cadmium at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

5.5.5.2 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-84**) and proposed discharge (see **Table 5-85**) have similar characteristics. For the 5th percentile through the 99.91 percentile distributions, dissolved cadmium concentrations are greater near the outfall, corresponding to the scenario where the effluent concentration is generally greater than the receiving water concentration. Concentrations in the immediate vicinity of the diffuser are very slightly higher for the proposed discharge (218 mgd) case; however, the concentrations in the middle and end of the modeled plume are similar for both discharge rates. Furthermore, as listed in **Table 5-86**, cadmium concentrations change negligibly for the proposed discharge (218 mgd) case; with median incremental changes less than 0.001 µg/L at all modeled in-plume locations.

Exceedance frequencies of the most stringent applicable water quality criteria, the CTR acute and chronic objectives for the protection of freshwater aquatic life, are presented in **Table 5-87**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the dissolved cadmium criteria. The incremental change in dissolved cadmium concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median dissolved cadmium concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled dissolved cadmium distributions at 700 feet downstream from the diffuser (see **Figure 5-101**) and the modeled, median dissolved cadmium concentration within the plume (see **Figure 5-102**) show a negligible change in dissolved cadmium concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in dissolved cadmium concentrations in the Sacramento River.

5.5.6 Copper

5.5.6.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for copper at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured dissolved fraction of copper in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total recoverable fraction of copper measured in SRWTP effluent. Therefore, the modeling conservatively estimated the frequency at which copper concentrations would exceed the applicable water quality objectives, which are expressed as dissolved. The modeled in-plume dissolved copper concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-88**. Modeled in-plume dissolved copper concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-89**.

Table 5-88: Modeled In-Plume Dissolved Copper Concentration (μg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	2.13	1.89	1.74	1.65	1.58	1.56
Median	2.08	1.81	1.65	1.56	1.48	1.46
95 %-ile	3.23	2.95	2.81	2.74	2.69	2.67
99.91 %-ile	4.71	4.70	4.70	4.71	4.72	4.72
5 %-ile	1.19	1.07	0.97	0.90	0.83	0.81

Table 5-89: Modeled In-Plume Dissolved Copper Concentration (μg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	2.24	1.96	1.79	1.68	1.60	1.57
Median	2.22	1.89	1.71	1.59	1.50	1.47
95 %-ile	3.35	3.02	2.84	2.76	2.70	2.68
99.91 %-ile	4.72	4.69	4.70	4.71	4.72	4.72
5 %-ile	1.22	1.10	1.00	0.92	0.84	0.82

The incremental differences in modeled in-plume dissolved copper concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-90**. The median incremental increase in dissolved copper concentrations would range from 0.14 µg/L at a distance of 30 feet downstream from the diffuser to 0.01 µg/L at a distance of 700 feet downstream from the diffuser.

Table 5-90: Modeled In-Plume Dissolved Copper Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.11	0.07	0.05	0.03	0.02	0.01
Median	0.14	0.08	0.06	0.03	0.02	0.01
95 %-ile	0.12	0.07	0.03	0.02	0.01	0.01
99.91 %-ile	0.01	-0.01	<0.01	<0.01	<0.01	<0.01
5 %-ile	0.03	0.03	0.03	0.02	0.02	0.01

The probability distributions of modeled dissolved copper concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-103**. The median dissolved copper concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-104**.

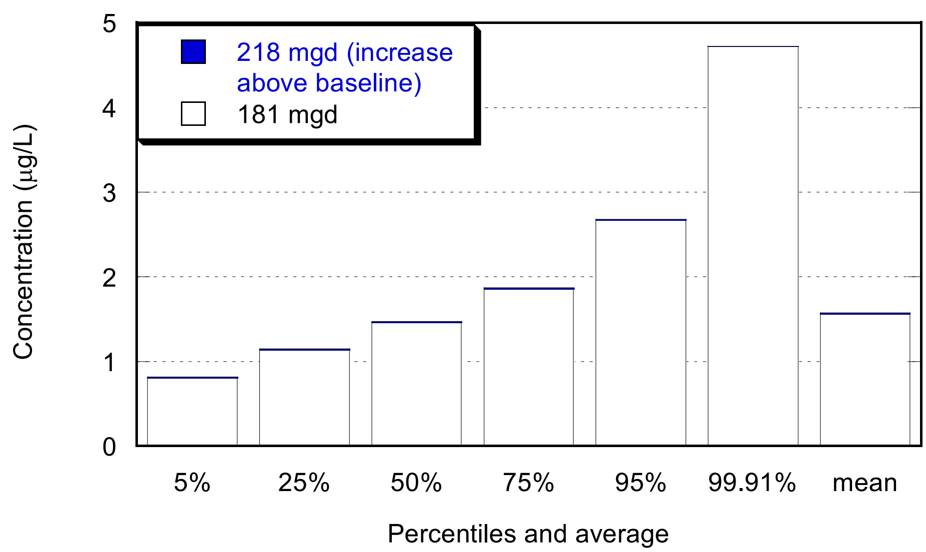

Figure 5-103: Distribution of Modeled Dissolved Copper Concentrations 700 feet Downstream from SRWTP Diffuser.

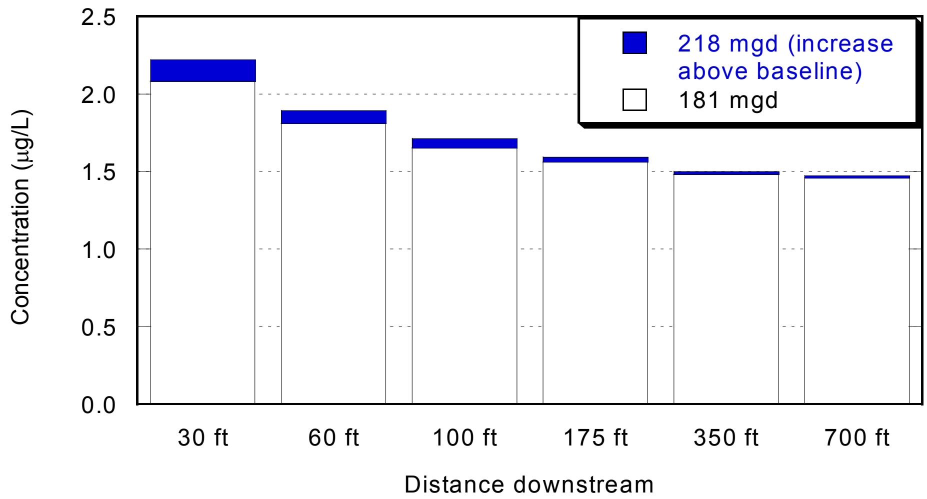

Figure 5-104: Median Modeled Dissolved Copper Concentration Downstream of SRWTP Diffuser.

5.5.6.2 Comparison to Water Quality Objectives

The most stringent water quality objectives for dissolved copper in the Sacramento River are the hardness-based CTR standards for the protection of freshwater aquatic life. The modeled hardness levels in the plume, corresponding to the mixed effluent and river hardness levels, is used to evaluate the compliance of the in-plume dissolved copper concentrations. The modeled, dissolved copper concentrations in the plume are compared with the calculated hardness-based criteria for both acute (1-hour) and chronic (4-day) toxicity criteria.

In addition to being hardness-based, the CTR criterion equation also includes a water-effect ratio (WER). The WER is a measure of the complexation of the toxic free copper ions in the site-specific water body, thereby making them biologically unavailable and non-toxic to aquatic life, in relation to the complexation of copper ion in the laboratory water used by U.S. EPA to derive the criterion. Without an additional study, the default WER of 1.0 is specified in the CTR for criteria development. However, it should be noted that the scientific literature has thoroughly demonstrated that where receiving waters contain treated municipal effluent, the WERs for copper are in excess of 1.0 and are frequently well above this number in water bodies containing substantial amounts of treated municipal effluent (Hall et al., 1997). An upward adjustment of the presumed WER of 1.0 in the zone of initial mixing, due to the copper binding capability of treated effluent, would result in higher objectives and reduced frequency of exceedance near the point of discharge.

The percent exceedances of dissolved copper criteria over a three-year interval at various distances downstream from the SRWTP diffuser are listed in **Table 5-91**. As noted above, the modeled in-plume hardness level at each epoch of the model is used to calculate the criteria throughout the plume for that epoch. For the acute toxicity objective, each calculated dissolved copper concentration in the plume was compared to the 1-hour acute criterion calculated from the hardness for each epoch. For the chronic toxicity objective, intended as protection for an organism under continuous 4-day exposure to a certain water quality condition, a running 4-day average of the ratios was evaluated at each time step that compared calculated dissolved copper concentrations to the chronic criteria calculated with the hardness value for the time step. If the running 4-day average of the ratio was greater than 1.0, the criterion was exceeded.

Table 5-91: DYNTOX Modeled Percent Exceedance Frequency for Dissolved Copper at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.0007%	0.0011%	0.0013%	0.0018%	0.0021%	0.0024%
Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

For the acute objective, the permissible frequency of exceedance is 1-hour in a 3-year interval, or 0.0038% of time. As indicated by the DYNTOX results presented **Table 5-91**, the percent exceedance frequencies are less than this threshold at all in-plume locations at the proposed discharge condition (218 mgd). The model results in **Table 5-91** also indicate that the chronic objective would be met at all times at all the modeled in-plume locations at the proposed discharge condition (218 mgd).

5.5.6.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-88**) and proposed discharge (see **Table 5-89**) have similar characteristics. Dissolved copper concentrations are greater near the outfall, corresponding to the scenario where the effluent concentration is generally greater than the receiving water concentration. As listed in **Table 5-90**, the proposed increase in SRWTP effluent discharge would slightly increase dissolved copper concentrations in the Sacramento River up to 175 feet downstream from the discharge, but would differ negligibly at distances 350 feet and greater downstream from the discharge.

Exceedance frequencies presented in **Table 5-91** indicate that the acute dissolved copper criterion would be exceeded less than once in a three-year interval at all modeled in-plume locations at the proposed discharge condition (218 mgd). The chronic criterion would also be met at all times, at all modeled in-plume locations at the proposed discharge condition (218 mgd). The incremental change in dissolved copper concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. Both the modeled dissolved copper distributions at 700 feet downstream from the diffuser (see **Figure 5-103**) and the modeled, median dissolved copper concentration within the plume (see **Figure 5-104**) show a slight incremental increase in dissolved copper concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in dissolved copper concentrations in the Sacramento River.

5.5.7 Zinc

5.5.7.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for zinc at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured dissolved fraction of zinc in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total recoverable fraction of zinc measured in SRWTP effluent. Therefore, the modeling conservatively estimated the frequency at which zinc concentrations would exceed the applicable water quality objectives, which are expressed as dissolved. The modeled in-plume dissolved zinc concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-92**. Modeled in-plume dissolved zinc concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-93**.

Table 5-92: Modeled In-Plume Dissolved Zinc Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	5.34	3.59	2.55	1.90	1.38	1.22
Median	4.91	3.23	2.30	1.72	1.24	1.09
95 %-ile	11.0	7.46	5.17	3.74	2.67	2.41
99.91 %-ile	17.1	13.0	9.47	7.04	5.12	4.58
5 %-ile	0.99	0.95	0.88	0.75	0.60	0.52

Table 5-93: Modeled In-Plume Dissolved Zinc Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	6.18	4.10	2.88	2.11	1.49	1.31
Median	5.88	3.77	2.63	1.93	1.36	1.19
95 %-ile	12.2	8.44	5.84	4.15	2.87	2.54
99.91 %-ile	17.8	13.6	9.78	7.13	5.14	4.66
5 %-ile	0.73	0.73	0.72	0.69	0.59	0.52

The incremental differences in modeled in-plume dissolved zinc concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-94**. The median incremental increase in dissolved zinc concentrations would range from 0.97 µg/L at a distance of 30 feet downstream from the SRWTP diffuser to 0.10 µg/L at a distance of 700 feet downstream from the diffuser.

Table 5-94: Modeled In-Plume Dissolved Zinc Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.84	0.51	0.33	0.21	0.11	0.09
Median	0.97	0.54	0.33	0.21	0.12	0.10
95 %-ile	1.2	0.98	0.67	0.41	0.20	0.13
99.91 %-ile	0.7	0.6	0.31	0.09	0.02	0.08
5 %-ile	-0.26	-0.22	-0.16	-0.06	-0.01	<0.01

The probability distributions of modeled dissolved zinc concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-105**. The median dissolved zinc concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-106**.

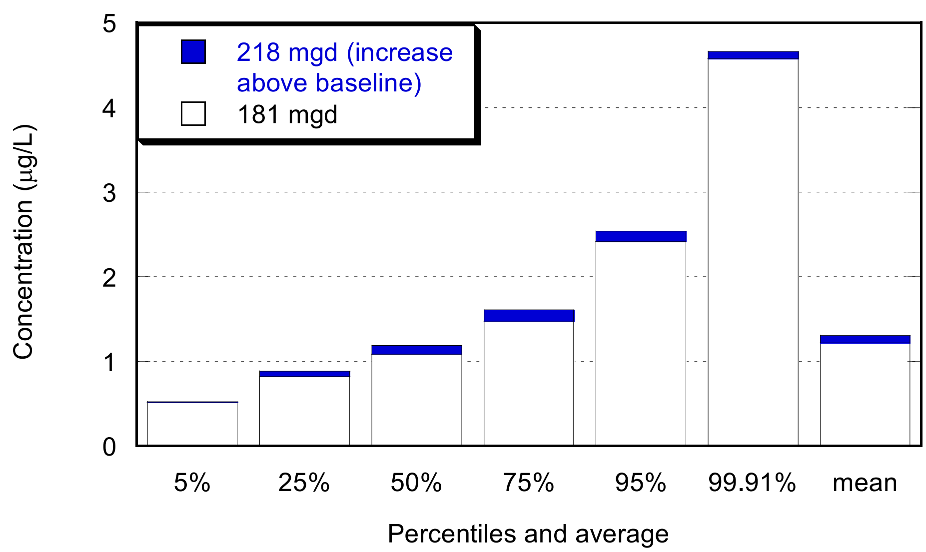

Figure 5-105: Distribution of Modeled Dissolved Zinc Concentrations 700 feet Downstream from SRWTP Diffuser.

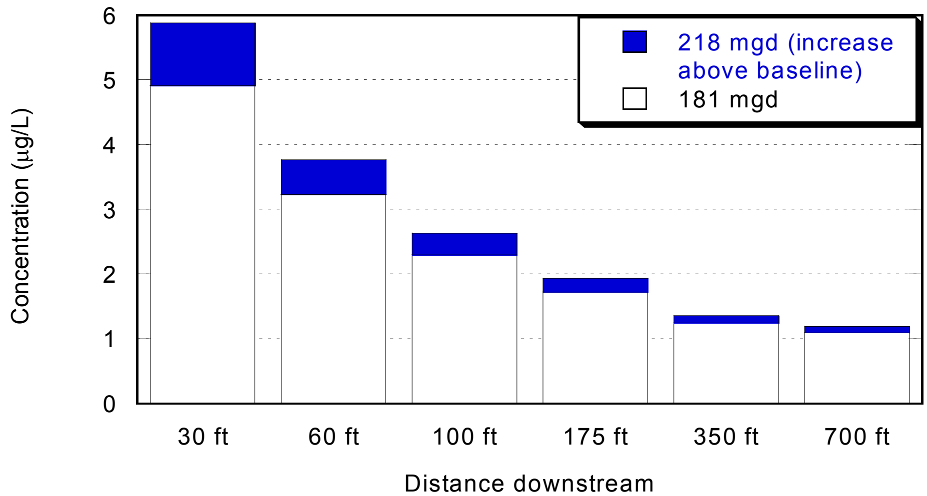

Figure 5-106: Median Modeled Dissolved Zinc Concentration Downstream of SRWTP Diffuser.

5.5.7.2 Comparison to Water Quality Objectives

The most stringent water quality objectives for dissolved zinc in the Sacramento River are the hardness-based CTR standards for the protection of freshwater aquatic life. The modeled hardness in the plume, corresponding to the mixed effluent and river hardness levels, is used to evaluate the compliance of the in-plume dissolved zinc concentrations. The modeled, dissolved zinc concentrations in the plume are compared with the calculated hardness-based criteria for both acute (1-hour) and chronic (4-day) toxicity criteria.

In addition to being hardness-based, the CTR criterion equation also includes a water-effect ratio (WER). The WER is a measure of the complexation of the toxic free zinc ions in the site-specific water body, thereby making them biologically unavailable and non-toxic to aquatic life, in relation to the complexation of zinc ion in the laboratory water used by U.S. EPA to derive the criterion. Without an additional study, the default WER of 1.0 is specified in the CTR for criteria development. An upward adjustment of the presumed WER of 1.0 in the zone of initial mixing, due to the zinc binding capability of treated effluent, would result in higher objectives.

The percent exceedances of dissolved zinc criteria at various distances downstream from the SRWTP diffuser are listed in **Table 5-95**. As noted above, the modeled in-plume hardness level at each epoch of the model is used to calculate the criteria throughout the plume for that epoch. For the acute toxicity objective, each calculated dissolved zinc concentration in the plume was compared to the 1-hour acute criterion calculated from the hardness for each epoch. For the chronic toxicity objective, intended as protection for an organism under continuous 4-day exposure to a certain water quality condition, a running 4-day average of the ratios was evaluated at each time step that compared calculated dissolved zinc concentrations to the chronic criteria calculated with the hardness value for the time step. If the running 4-day average of the ratio was greater than 1.0, the criterion was exceeded. As listed in **Table 5-95**, the modeled results indicate that exceedances of either the acute or the chronic dissolved zinc objectives are not expected at any of the modeled in-plume locations with an increased in discharge rate.

Table 5-95: DYNTOX Modeled Percent Exceedance Frequency for Dissolved Zinc at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

5.5.7.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-92**) and proposed discharge (see **Table 5-93**) have similar characteristics. Dissolved zinc concentrations are greater near the outfall, corresponding to the scenario where the effluent concentration is generally greater than the receiving water concentration. Concentrations near the diffuser are generally greater for the proposed discharge (218 mgd) case; however, they are similar for both discharge rates toward the end of the plume. As listed in **Table 5-94**, the proposed increase in SRWTP effluent discharge would slightly increase dissolved zinc concentrations within the plume, with slightly higher increments in areas closer to the diffuser.

Exceedance frequencies of the most stringent applicable water quality criteria, the CTR acute and chronic objectives for the protection of freshwater aquatic life, are presented in **Table 5-95**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the dissolved zinc criteria. The incremental change in dissolved zinc concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median dissolved zinc concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled dissolved zinc distributions at 700 feet downstream from the diffuser (see **Figure 5-105**) and the modeled, median dissolved zinc concentration within the plume (see **Figure 5-106**) show a slight incremental increase in dissolved zinc concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in dissolved zinc concentrations in the Sacramento River.

5.5.8 Temperature

A thermal assessment of the SRWTP discharge to the Sacramento River was conducted to determine the potential effects on fishes migrating past and through the thermal plume (RBI et al., 2005). The approach, findings, and conclusions of this assessment are presented below.

The current SRWTP NPDES permit contains effluent and receiving water limitations for temperature. These limitations are based, in part, on effluent and receiving water objectives in the Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California, commonly referred to as the Thermal Plan (SWRCB, 1988a). Specifically, these requirements are that:

- *The discharge temperature shall not exceed the receiving water by more than 25 ºF from October 1 through April 30 or by more than 20 ºF from May 1 through September 30.*
- *The discharge shall not cause the river temperature to increase by more 4 ºF above the ambient temperature of the river outside the zone of initial dilution.*
- *The discharge shall not create an area outside the zone of initial dilution which exceeds 25% of the cross-sectional area of the river where the water temperature is 2 ºF greater than the ambient river temperature.*
- *When the river temperature is greater than 65 °F, the discharge shall not create an area outside the zone of initial dilution which exceeds 25% of the cross-sectional area of the river where the water temperature is 1 ºF greater than the ambient river temperature.*

Extensive modeling was conducted to characterize the temperature conditions within the Sacramento River downstream of the SRWTP diffuser under "worst-case" and "typical" conditions (i.e., 50% of expected conditions) to determine what, if any, effect the future 218 mgd (ADWF) SRWTP discharges would have on temperatures in the receiving water and on fishes migrating past the diffuser.

5.5.8.1 Thermal Assessment Methodology

Both the thermal plume within the vicinity of the diffuser and the resultant, fully-mixed temperature farther downstream of the diffuser were characterized. This was accomplished through the use of hydrologic, temperature, and near-field dilution models as described below.

The computational fluid dynamics model, FLOWMOD, developed by FSI was used to simulate three-dimensional (i.e., vertical, lateral, and longitudinal) mixing of SRWTP effluent with river water downstream of the diffuser. Effluent dilution and resultant thermal plume temperatures were simulated for distances downstream of the diffuser at 30 ft, 60 ft, 100 ft, 175 ft, 350 ft, and 700 ft, the latter distance being the downstream boundary of the model. The thermal plume scenarios modeled were selected to depict the "worst-case" and "typical" conditions that would occur during each month of the year. These conditions were defined as follows:

- **Worst-case** is based on the minimum instantaneous 14:1 (river:effluent) flow ratio and the maximum permitted temperature difference of 25 °F (or the 99th percentile of the temperature differential, if a temperature differential of 25 °F was never reached over the 70-year (1922-1991) period considered in the simulation).

- **Typical** is based on the median (50th percentile) or near-median flow ratio, which is 40:1 or 50:1 depending on the month, and the median temperature differential from the 70-year simulation.

The "worst-case" and "typical" scenarios modeled essentially bracket the worst-case half of all conditions that would occur in the thermal plume under 2020 conditions. The rest of the time, flow ratios would be greater than 40:1 or 50:1 and the temperature differential between river and effluent would be smaller than the median differentials modeled for the "typical" scenario. Under these conditions, the thermal plume would be even smaller and less severe than the "typical" scenarios. **Table 5-96** summarizes the dilution ratios and temperature conditions modeled.

Table 5-96: Thermal Plume Modeling Scenarios.

Month	Worst-case Condition		Typical (Median) Condition	
	Dilution Ratio (river:effluent)	Temperature Differential (°F)	Dilution Ratio (river:effluent)	Temperature Differential (°F)
January	14:1	25	50:1	21.9
February		25		17.6
March		20		14
April		17.4		10.4
May		16		8
June		13		6.8
July		11		6.3
August		13	40:1	7.9
September		16		10.5
October		21.8		15.5
November		25		19.9
December		25	50:1	22.9

5.5.8.2 Fully-Mixed Temperature Modeling

Complete mixing of the effluent and Sacramento River water is projected to occur between 1 and 2 miles downstream from the diffuser. The fully-mixed downstream temperature was determined from a mass-balance of the effluent discharge and river flow rates and temperatures. To capture the range of river flows, including low-flow conditions, a 70-year (1922-1991) time-series of hourly river flows was derived from the U.S. Bureau of Reclamation's PROSIM model output post-processed using the Fischer Delta Model. Hourly effluent flow rates were applied accounting for the seasonal and diurnal patterns of the SRWTP discharge. To capture the range of temperature conditions, including extreme events, the effluent and river temperatures were sampled from probability distributions developed for each month of the year. The effluent temperature distribution was derived from historical effluent data. The river temperature distribution was derived from historical data and temperature modeling of the Sacramento River using the U.S. Bureau of Reclamation's Sacramento River Temperature Model for the 70-year (1992-1991) period of record.

The fully-mixed thermal assessment considered the resultant temperature downstream of the diffuser after complete mixing of the effluent with Sacramento River water. The assessment determined the fully-mixed temperature resulting from effluent discharges of 154 mgd and 218 mgd.

The resultant fully-mixed temperatures for these two discharge rates were plotted by month as cumulative probability distributions for a 70-year hydrologic period of record. In the context of this assessment, a cumulative probability distribution defines the probability, or frequency, with which a specified temperature would be expected to occur, based on the range of possible river and effluent flow rates and temperatures during the period in question.

5.5.8.3 Assessment Results

The modeling and associated fisheries assessment found that migrations of adult fishes past the diffuser would not be affected by the thermal plume created by the discharge because: (1) the plume minimally affects temperatures in the upper half of the water column; (2) a 100 feet wide zone of passage thermally unaffected by the discharge exists along both river banks at the diffuser; and (3) adult fish will maneuver around the plume to find more favorable temperatures within the zones of passage provided. Therefore, the SRWTP discharge at 218 mgd ADWF is not expected to increase the frequency with which potentially adverse temperatures to adult salmonid immigration would occur in the Sacramento River just below Freeport Bridge.

Fish species such as Chinook salmon, steelhead, splittail, Delta smelt, and striped bass are believed to move through the upper half of the water column (see **Figure 5-107**) when immigrating to upstream spawning grounds, and thus typically do not move along the river bottom in deep rivers like the Sacramento River at Freeport. Moreover, for the adult upstream migration life stage, coldwater species such as Chinook salmon and steelhead prefer temperatures below those that often exist in the Sacramento River at Freeport during the summer months (Cherry et al., 1977) and, therefore, would seek the coldest water temperatures available along their migration route. Numerous studies have shown that fish, when presented with a range of temperatures, will seek a temperature that is preferred, and will not submit themselves to temperatures sufficiently high to cause adverse physiological effects when given options to experience lower ambient temperatures (Cherry et al., 1975; Gray et al., 1977; Biro, 1998).

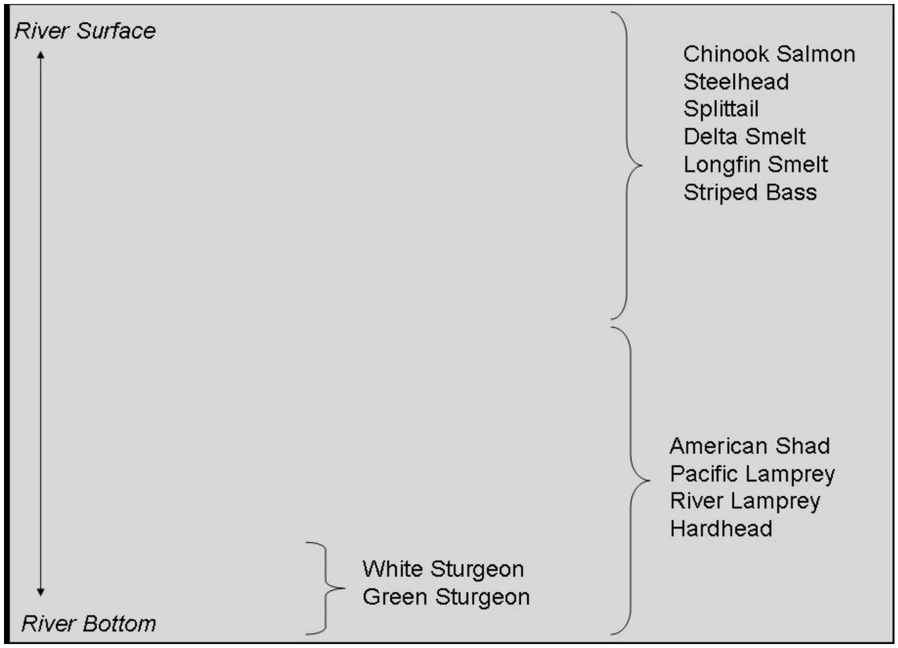

Figure 5-107: Vertical Distribution of Immigrating Adult Anadromous Fish Species in the Water Column.

It should be noted that longfin smelt are rarely found upstream of Rio Vista, and Delta smelt occur in the Delta primarily below Isleton on the Sacramento River (Moyle, 2002). These towns are located 20 to 30 miles downstream of Freeport.

At 700 feet downstream of the diffuser (the lower boundary of the model used), a substantial portion of the river cross-section along the river margins and in the upper one-third of the water column is either unaffected or negligibly affected (i.e., < 2.5 °F increase from background) by the effluent plume. As such, a substantial zone of passage exists for the fish species that migrate in the upper half of the water column (see **Figure 5-107**). As the fish move closer to the diffuser, the portion (cross-section) of the water column affected by the effluent plume decreases. Within 175 feet of the diffuser, the plume exists along the bottom and center of the river and minimally affects the upper one-third of the water column. At 60 feet downstream of the diffuser, where internal plume temperatures can show substantial differences from river background, particularly under the "worst-case" scenario (RBI et al., 2005), both the margins of the river and the upper half of the water column are essentially unaffected by the plume.

Based on the plume dynamics simulated within the river channel under the broad range of conditions, adult fish that primarily utilize the upper half of the water column undertaking upstream spawning migrations past the SRWTP diffuser would be presented with an adequate zone of passage during all months of the year under future 218 mgd (ADWF) discharge conditions.

Downstream migrations of actively swimming and passively drifting young-of-the-year fishes, and drifting fish eggs, would not be affected by the thermal discharge, because: (1) these life-stages are typically transported along the river margins, where a 100 feet wide zone of the river is thermally unaffected, or within the upper half of the water column which is minimally affected by the plume; and (2) any exposure to substantial temperature differentials would be for a matter of minutes given the typical river velocity. The short duration of exposure to the plume's gradient of temperatures for any fish species that emigrates through the plume would not be lethal, nor would such exposure be expected to adversely affect those fishes or their Sacramento River/Delta populations.

Future incremental changes in temperature due to higher, future discharge rates (i.e., from 181 mgd to 218 mgd (ADWF)) would be negligible (i.e., 0.2 °F), with simulated changes existing as both slight increases and slight decreases in downstream temperatures, and the highest temperatures that currently occur (i.e., 0.09% and 5% exceedance temperatures) would not occur more often. Therefore, the proposed 218 mgd (ADWF) discharge of effluent from the SRWTP to the Sacramento River through the diffuser would not pose a barrier to migrating fishes or result in population- or community-level effects to fish downstream of the diffuser.

In addition to evaluating thermal impacts immediately downstream of the SRWTP diffuser, this assessment evaluated the increase in the fully-mixed Sacramento River water temperatures that relate to background and existing downstream conditions. Monthly cumulative probability distribution plots of the fully-mixed Sacramento River water temperature at the point where effluent mixes completely with river water (i.e., several miles downstream of the diffuser) were developed and analyzed. For all months, the median downstream fully-mixed temperature (i.e., 50% exceedance value) for a discharge of 218 mgd was essentially equivalent to the median temperature resulting from a 154 mgd discharge. The median temperatures differed by no more than 0.2 °F between the 218 mgd and 154 mgd discharge scenarios during all months of the year. Similarly, the highest temperatures (i.e., 5% and 0.09% exceedance values) are equivalent for both discharge scenarios for all months, indicating that the project would impart no significant additional warming of the river downstream of the diffuser.

The antidegradation analysis is based on the SRCSD seeking an increase its permitted discharge from 181 mgd (ADWF) to 218 mgd (ADWF). Because the proposed discharge increase (37 mgd) is a smaller incremental increase in discharge relative to that evaluated above (i.e., 218 mgd – 154 mgd = 64 mgd), the effects of the proposed increment would be less than or equal to those previously described and would impart no significant additional warming of the river downstream of the diffuser. Based on their independent review and evaluation of the modeling approach and fisheries assessment performed from modeling results, NOAA Fisheries water quality and fisheries staff concur with the thermal effects findings reported herein, which they stated at a September 26, 2003 meeting with CDFG and RWQCB staff.

5.5.9 Total Coliform

5.5.9.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for total coliform at locations downstream of the SRWTP diffuser. The modeled concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-97**. The proposed permitted condition (218 mgd) modeled concentrations are shown in **Table 5-98**.

Table 5-97: Modeled In-Plume Total Coliform Concentration (MPN/100mL) at varying distances Downstream of SRWTP Diffuser at 181 mgd SRWTP discharge rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	1,532	1,701	1,800	1,863	1,913	1,928
Median	666	746	792	820	842	849
95 %-ile	5,540	6,130	6,490	6,710	6,890	6,940
99.91 %-ile	37,700	41,300	43,700	45,300	46,600	46,900
5 %-ile	81	91	97	100	102	103

Table 5-98: Modeled In-Plume Total Coliform Concentration (MPN/100mL) at varying distances Downstream of SRWTP Diffuser at 218 mgd SRWTP discharge rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	1,451	1,652	1,769	1,843	1,902	1,919
Median	628	723	777	811	837	845
95 %-ile	5,250	5,950	6,370	6,640	6,850	6,910
99.91 %-ile	35,500	40,000	42,700	44,700	46,200	46,700
5 %-ile	76	88	95	99	101	102

The incremental differences in modeled in-plume total coliform concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-99**. For all locations, the modeled change in discharge rate resulted in an incremental decrease in total coliform concentration. The median incremental change in total coliform concentrations would range from a decrease of 38 MPN/100 mL at a distance of 30 feet downstream from the diffuser to a decrease of 4 MPN/100 mL at a distance of 700 feet downstream from the diffuser.

Table 5-99: Modeled In-Plume Total Coliform Concentration Increment (MPN/100mL) at varying distances Downstream of SRWTP Diffuser reflecting differences between 181 and 218 mgd discharge rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (MPN/100 mL)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	-81	-49	-31	-20	-11	-9
Median	-38	-23	-15	-9	-5	-4
95 %-ile	-290	-180	-120	-70	-40	-30
99.91 %-ile	-2,200	-1,300	-1,000	-600	-400	-200
5 %-ile	-5	-3	-2	-1	-1	-1

The probability distributions of modeled total coliform concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-108**. The median total coliform concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-109**. Again, the proposed 218 mgd discharge had lower modeled total coliform concentrations at all locations compared with the current 181 mgd discharge, with the largest incremental decrease closest to the diffuser.

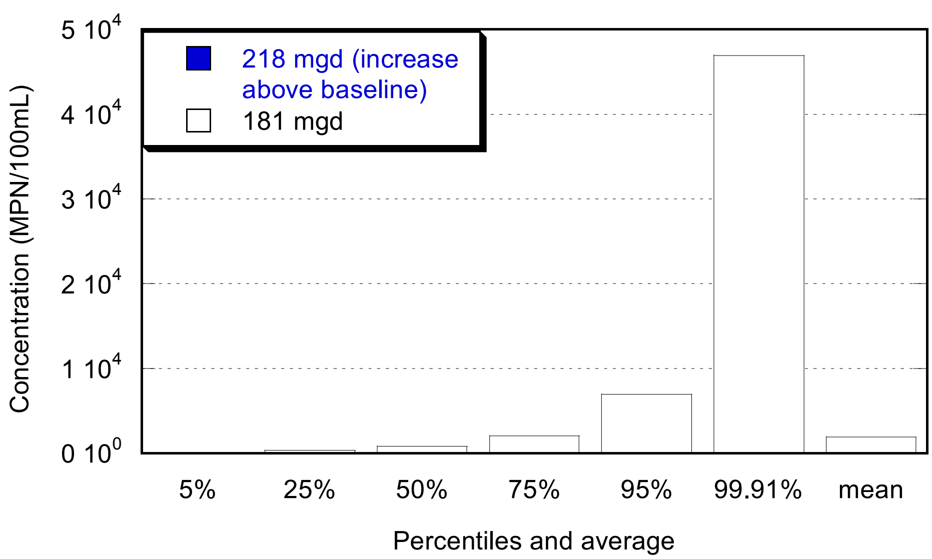

Figure 5-108: Distribution of Modeled Total Coliform Concentrations 700 feet Downstream from SRWTP Diffuser.

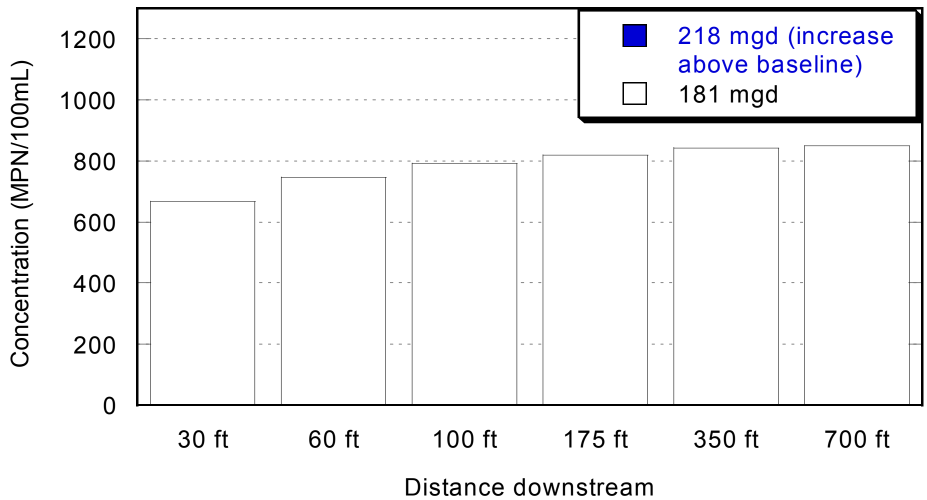

Figure 5-109: Median Modeled Total Coliform Concentration Downstream of SRWTP Diffuser.

5.5.9.2 Comparison to Water Quality Objectives

There are no applicable water quality objectives for total coliform. According to SRWTP's current NPDES permit No. CA0077682, Order No. 5-00-188, coliform limits are imposed to protect beneficial uses of the receiving water, which include contact recreation and drinking water. The permit states that the weekly median effluent limit of 23 MPN/100 mL is applicable to discharges with river/effluent dilution ratios greater than or equal to 20:1 under California Department of Health Services (since renamed California Department of Public Health) guidelines.

Public water systems are required under the EPA Total Coliform Rule (TCR) provisions under the Safe Drinking Water Act (SDWA) to monitor for the presence of total coliform in their distribution systems. The TCR requires public water systems to monitor for total coliform at a frequency proportional to the number of people served, and requires additional tests for fecal coliform or *E. coli* if total coliforms are detected. Disinfection by chlorination is effective in killing bacteria. Chlorination at doses as low as 8 mg/L have been shown to decrease levels of indicator bacteria by 4-log units (Tree et al., 2002). Since the efficacy of chlorination will remain the same, there are no anticipated increases in the concentration of indicator bacteria in SRWTP effluent. The increase in SRWTP permitted discharge from 181 mgd to 218 mgd is, in fact, expected to decrease fecal coliform and *E. coli* concentrations in the Sacramento River, since their concentrations in SRWTP effluent are lower than in the receiving water.

EPA considers total coliform to be a useful indicator for pathogens, which may react to environmental stresses and water treatment in a similar manner, and therefore considers the absence of total coliform in distribution systems to minimize the likelihood that pathogens are present. As previously discussed in Section 4.6.5, a 2006 survey reported that protozoan pathogens (*Giardia* and *Cryptosporidium*) are not detected frequently in SWP waters, despite being detected in treated wastewater. The pathogen levels in the source waters for all the drinking water treatment plants surveyed were classified as needing no additional treatment based on SDWA provisions (see **Table 4-5**). Thereby, increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd would not necessitate that water purveyors expand or otherwise modify their treatment processes.

5.5.9.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-97**) and proposed discharge (see **Table 5-98**) have similar characteristics. For the 5th percentile through the 99.91th percentile distributions, total coliform concentrations increase with distance from the outfall, indicating that effluent concentrations are lower than the receiving water concentration. Concentrations at all locations are lower for the proposed discharge (218 mgd) case. Furthermore, as listed in **Table 5-99**, the proposed increase in SRWTP effluent discharge would result in the greatest decrease in total coliform concentration closest to the diffuser, with negligible decreases further downstream.

Both the modeled total coliform distributions at 700 feet downstream from the diffuser (see **Figure 5-108**) and the modeled, median total coliform concentration within the plume (see **Figure 5-109**) show a slight decrease in total coliform concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight decrease in total coliform concentrations in the Sacramento River.

The SRWTP has historically achieved a high degree of compliance with its total coliform effluent limits, and will continue to be in compliance based on modeled results of total coliform concentrations in the 218 mgd discharge.

5.6 ASSESSMENT OF CATEGORY 3 CONSTITUENTS

Category 3 constituents are those generally having no history of contributing to adverse impacts in the Sacramento River, and were evaluated only in terms of their potential near-field water quality impacts. The 27 constituents assigned to this category are listed below.

Antimony	**Bromide***	**Diethyl Phthalate**
Arsenic	**Chlorine Residual***	**Di-n-butyl Phthalate**
Chromium	**Cyanide**	**Methyl Chloride**
Lead	**Total Suspended Solids**	**Methylene Chloride**
Molybdenum	**1,4-Dichlorobenzene**	**Tetrachloroethylene**
Nickel	**Bis(2-ethylhexyl)phthalate**	**Toluene**
Selenium	**Bromodichloromethane**	**Chlorpyrifos***
Silver	**Chloroethane**	**Dibromochloromethane***
Biochemical Oxygen Demand**	**Chloroform**	**N-Nitrosodimethylamine***

Category 3 constituents were evaluated with respect to potential receiving water impacts resulting from an increase in permitted SRWTP discharge from the current permitted condition (181 mgd (ADWF)) to the proposed permitted condition (218 mgd (ADWF)) using the following water quality assessments:

- Near-Field Impacts Analysis
- Comparison to Water Quality Objectives
- Near-Field Evaluation

General descriptions of these assessments and their presentation within individual pollutant evaluations are described below in more detail. Constituents labeled with an asterisk (*) in the above list include those for which an adequate statistical distribution could not be developed due to the following reasons: insufficient data (bromide), insufficient detected data (chlorine residual, chlorpyrifos, dibromochloromethane), or an analytical detection limit that far exceeds a water quality objective (n-nitrosodimethylamine). The influence of the SRWTP's BOD(**) input is most strongly expressed as an oxygen demand downstream of the SRWTP discharge, and therefore the impacts of SRWTP effluent BOD levels on downstream receiving waters are addressed in the dissolved oxygen evaluation (see Section 5.4.16). For these reasons, these constituents were not modeled in the quantitative manner used to evaluate the majority of the pollutants considered in this antidegradation analysis. Rather the potential water quality impacts attributable to these constituents were assessed in a qualitative manner.

5.6.1 Near-Field Impacts Analysis

Near-field pollutant impact analyses include the presentation of modeled in-plume concentration results for a pollutant at varying distances downstream of the SRWTP diffuser: 30, 60, 100, 175, 350, and 700 feet. Modeled concentration results are presented in tabular form for both the current permitted condition (181 mgd (ADWF)) and the proposed permitted condition (218 mgd (ADWF)). These modeled data presentations are followed by the tabular presentation of the in-plume concentration increment due to the proposed 37 mgd (ADWF) increase in permitted SRWTP discharge. The concentration increment is calculated by subtracting the modeled in-plume concentration for a pollutant at the discharge flow rate of 181 mgd (ADWF) from the modeled in-plume concentration of the pollutant at the discharge flow rate of 218 mgd (ADWF). For example, to determine the 99.91 percentile concentration increment, the 99.91 percentile modeled concentration at 181 mgd is subtracted from the 99.91 percentile modeled concentration at 218 mgd.

These tabular data presentations are followed by graphical presentations showing various percentile distributions (5%, 25%, 50%, 75%, 95%, 99.91%, and a mean) of the modeled in-plume concentration of a pollutant at 700 feet downstream of the SRWTP diffuser at both the 181 mgd (ADWF) "baseline" discharge flow rate and the 218 mgd (ADWF) proposed flow rate. In instances where the modeled pollutant concentration at 218 mgd (ADWF) results in an increase in receiving water concentration above the 181 mgd (ADWF) condition, the modeled pollutant concentration at 218 mgd (ADWF) appears as a blue-colored increment stacked on top of the baseline concentration. In instances where the modeled pollutant concentration at 218 mgd (ADWF) results in a decrease in receiving water concentration below that modeled for the 181 mgd (ADWF) condition, no such blue-colored increment is visible in the graph.

The next graphical data presentation included in all near-field impacts analyses is a graph showing the median modeled concentration of a pollutant at six distances downstream of the SRWTP diffuser at both the 181 mgd (ADWF) baseline discharge flow rate and the 218 mgd (ADWF) proposed flow rate. Similar to the explanation provided for the previous graph, increases in modeled in-plume pollutant concentrations at 218 mgd (ADWF) appear as blue-colored increments stacked on top of 181 mgd (ADWF) modeled concentrations. In instances where the modeled pollutant concentration at 218 mgd (ADWF) results in a decrease in receiving water concentration below that modeled for the 181 mgd (ADWF) condition, no such blue-colored increment is visible in the graph.

5.6.2 Comparison to Water Quality Objectives

Where a water quality objective or criterion exists for a constituent, the DYNTOX model was used to evaluate in-plume compliance with the objective or criterion downstream of the SRWTP diffuser. Where applicable, pollutant evaluations include the tabular presentation of DYNTOX modeled in-plume percent exceedance frequency for a constituent at 30, 60, 100, 175, 350, and 700 feet downstream of the SRWTP diffuser under the proposed permitted condition (218 mgd (ADWF)). Where a constituent has more than one criterion, for example CTR freshwater acute and chronic water quality criteria, compliance frequencies for all relevant criteria were evaluated using the DYNTOX model and presented for the pollutant.

The frequency of exceedance is determined by comparing the pollutant concentration generated by DYNTOX for each hour time-step in the 70-year period to the applicable criteria. For the acute criteria, exceedance percentages are calculated as the number of hourly values that exceed the criteria out of 613,420 (*i.e.*, 70 x 365 x 24 + 17.5 leap days x 24). For 30-day criteria, a 30-day average is generated for each hourly time step after the first 30 days (720 values) and the percent exceedance is based on the number of 30-day averages exceeding the criteria out of

612,900 values. Four day (4-day) average criteria exceedances are determined based on the number of 4-day averages exceeding the criteria out of 612,324 values.

5.6.3 Near-Field Evaluation

Category 3 pollutant evaluations are concluded with a consideration of the results of near-field water quality impacts analyses and evaluations of DYNTOX modeled in-plume water quality objective compliance frequencies at the proposed permitted condition (218 mgd (ADWF)). These elements are used to provide an evaluation of the potential near-field water quality impacts for a pollutant due to the proposed 37 mgd (ADWF) increase in permitted SRWTP discharge.

The Category 3 pollutant evaluations that follow are organized in a similar manner and, where necessary, changes in the organization of individual pollutant evaluations are noted.

5.6.4 Antimony

5.6.4.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for antimony at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured total antimony in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total antimony measured in SRWTP effluent. The modeled in-plume total antimony concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-100**. Modeled in-plume total antimony concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-101**.

Table 5-100: Modeled In-Plume Total Antimony Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.12	0.10	0.090	0.082	0.076	0.074
Median	0.12	0.10	0.088	0.081	0.075	0.073
95 %-ile	0.19	0.15	0.13	0.11	0.10	0.10
99.91 %-ile	0.26	0.22	0.18	0.15	0.14	0.13
5 %-ile	0.071	0.067	0.062	0.058	0.054	0.053

Table 5-101: Modeled In-Plume Total Antimony Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.14	0.11	0.094	0.085	0.077	0.075
Median	0.13	0.11	0.092	0.083	0.076	0.074
95 %-ile	0.21	0.16	0.13	0.12	0.10	0.10
99.91 %-ile	0.27	0.22	0.18	0.15	0.14	0.14
5 %-ile	0.069	0.066	0.063	0.059	0.055	0.053

The incremental differences in modeled in-plume total antimony concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-102**. The median incremental increase in total antimony concentrations would range from 0.01 µg/L at a distance of 30 feet downstream from the diffuser to 0.001 µg/L at any distances 350 feet or farther downstream from the diffuser.

Table 5-102: Modeled In-Plume Total Antimony Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.02	0.01	0.004	0.003	0.001	0.001
Median	0.01	0.01	0.004	0.002	0.001	0.001
95 %-ile	0.02	0.01	<0.01	<0.01	<0.01	<0.01
99.91 %-ile	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5 %-ile	-0.002	-0.001	0.001	0.001	0.001	<0.001

The probability distributions of modeled total antimony concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-110**. The median total antimony concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-111**.

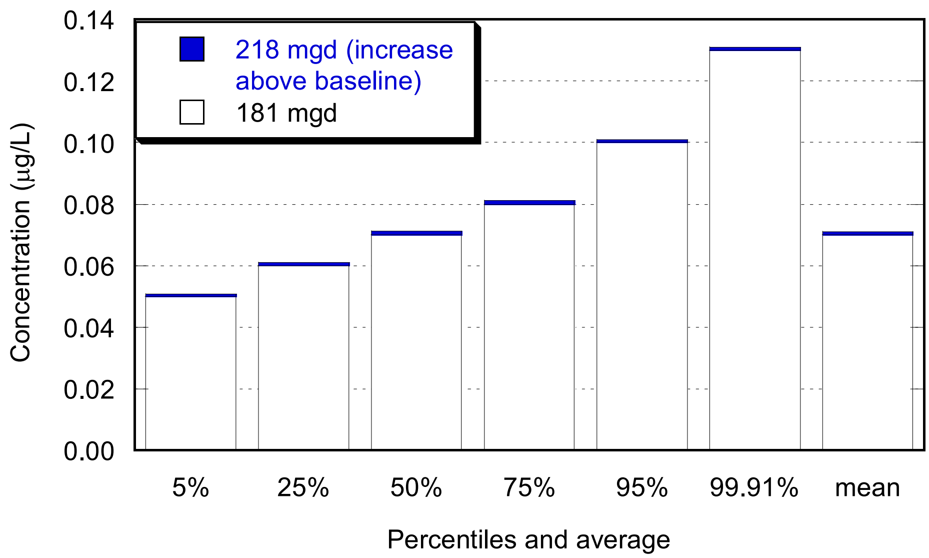

Figure 5-110 Distribution of Modeled Total Antimony Concentrations 700 feet Downstream of SRWTP Diffuser.

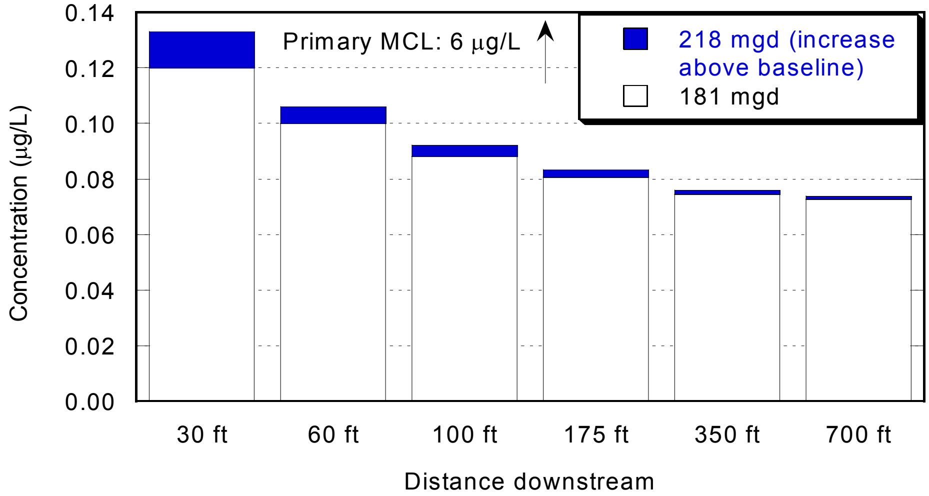

Figure 5-111: Median Modeled Total Antimony Concentration Downstream of SRWTP Diffuser.

5.6.4.2 Comparison to Water Quality Objectives

The most stringent water quality objective for antimony in the Sacramento River is the California Code of Regulations Title 22 Primary MCL of 6 µg/L, incorporated into the Basin Plan by reference. The percent exceedances of the antimony MCL at various distances downstream from the SRWTP diffuser are listed in **Table 5-103**. Running 30-day averages for concentrations in the Sacramento River were modeled to determine projected exceedance of the MCL in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the antimony concentrations are not expected to approach or exceed the applicable MCL at any point within the modeled plume.

Table 5-103: DYNTOX Modeled Percent Exceedance Frequency for Total Antimony at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the MCL Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Primary MCL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are substantially lower than the Title 22 Primary MCL for antimony. To this end, the 6 µg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-100**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-101**). These modeled results are graphically represented in **Figure 5-110** at a distance of 700 foot downstream from the diffuser. These findings are consistent with the modeled results indicating no exceedances of the antimony MCL as listed in **Table 5-103**.

5.6.4.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-100**) and proposed discharge (see **Table 5-101**) have similar characteristics. For the 5th percentile through the 99.91 percentile distributions, antimony concentrations are greater near the outfall, corresponding to the most expected scenario where the effluent concentration is greater than the receiving water concentration. As listed in **Table 5-102**, the proposed increase in SRWTP effluent discharge would slightly increase total antimony concentrations in the Sacramento River within the modeled plume.

Exceedance frequencies of the most stringent applicable water quality criteria, Title 22 Primary MCL, are presented in **Table 5-103**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd will not result in MCL exceedances. The incremental change in total antimony concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median concentrations of total antimony that are substantially below the most stringent applicable water quality criteria. Both the modeled antimony distributions at 700 feet downstream from the diffuser (see **Figure 5-110**) and the modeled, median concentration of total antimony within the plume (see **Figure 5-111**) show a slight incremental increase in antimony concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in total antimony concentrations in the Sacramento River.

5.6.5 Arsenic

5.6.5.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for arsenic at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured dissolved fraction of arsenic in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total recoverable fraction of arsenic measured in SRWTP effluent. Therefore, the modeling conservatively estimated the frequency at which arsenic concentrations would exceed the applicable water quality objectives, which are expressed as dissolved. The modeled in-plume dissolved arsenic concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-104**. Modeled in-plume dissolved arsenic concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-105**.

Table 5-104: Modeled In-Plume Dissolved Arsenic Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	1.42	1.39	1.38	1.37	1.36	1.36
Median	1.39	1.37	1.35	1.34	1.33	1.33
95 %-ile	1.89	1.88	1.89	1.90	1.90	1.90
99.91 %-ile	2.50	2.55	2.59	2.61	2.64	2.65
5 %-ile	1.03	0.99	0.97	0.95	0.93	0.93

Table 5-105: Modeled In-Plume Dissolved Arsenic Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	1.43	1.40	1.38	1.37	1.36	1.36
Median	1.41	1.37	1.35	1.34	1.33	1.33
95 %-ile	1.89	1.88	1.89	1.89	1.90	1.90
99.91 %-ile	2.49	2.53	2.57	2.60	2.63	2.64
5 %-ile	1.04	1.00	0.98	0.96	0.94	0.93

The incremental differences in modeled in-plume dissolved arsenic concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-106**. The median incremental increase in dissolved arsenic concentrations would range from 0.02 µg/L at a distance of 30 feet downstream from the diffuser to less than 0.01 µg/L at distances farther downstream from the diffuser.

Table 5-106: Modeled In-Plume Dissolved Arsenic Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.01	0.01	<0.01	<0.01	<0.01	<0.01
Median	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
95 %-ile	<0.01	<0.01	<0.01	-0.01	<0.01	<0.01
99.91 %-ile	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01
5 %-ile	0.01	0.01	0.01	0.01	0.01	<0.01

The probability distributions of modeled dissolved arsenic concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-112**. The median dissolved arsenic concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-113**.

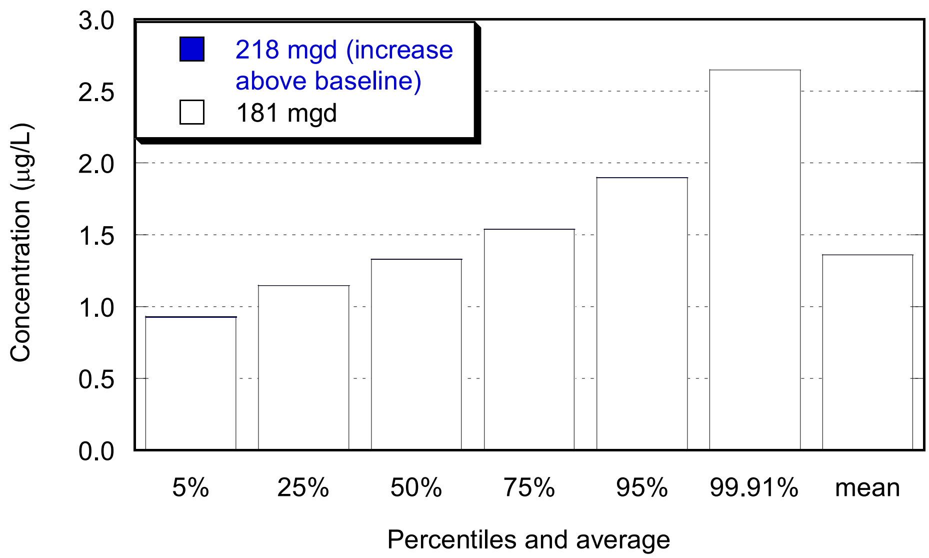

Figure 5-112: Distribution of Modeled Dissolved Arsenic Concentrations 700 feet Downstream of SRWTP Diffuser.

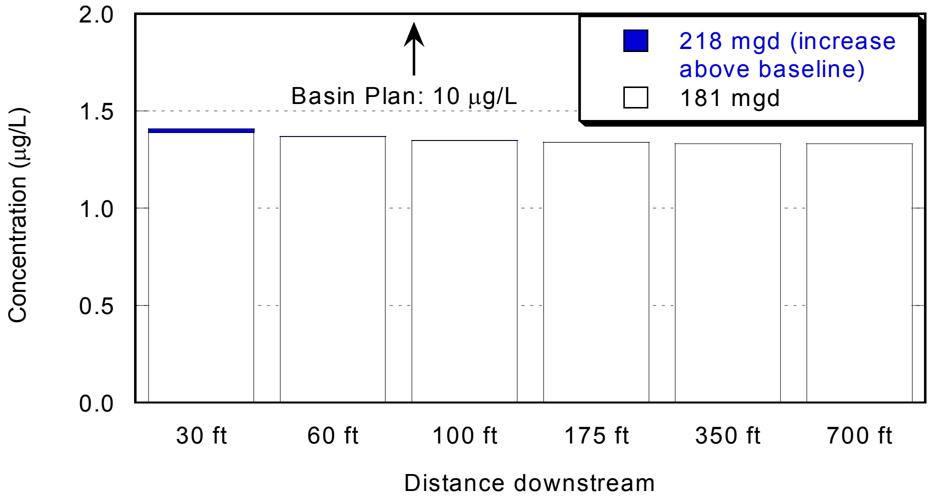

Figure 5-113: Median Modeled Dissolved Arsenic Concentration Downstream of SRWTP Diffuser.

5.6.5.2 Comparison to Water Quality Objectives

The most stringent water quality objective for dissolved arsenic in the Sacramento River is the Basin Plan objective of 10 µg/L. The percent exceedances of the Basin Plan dissolved arsenic objective at various distances downstream from the SRWTP diffuser are listed in **Table 5-107**. Running 30-day averages for in-plume dissolved arsenic concentrations were modeled to determine projected exceedance frequencies of the objective in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that dissolved arsenic concentrations are not expected to approach or exceed the Basin Plan standard at any point within the modeled plume.

Table 5-107: DYNTOX Modeled Percent Exceedance Frequency for Dissolved Arsenic at Various Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Basin Plan Objective Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Basin Plan	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the Basin Plan objective for dissolved arsenic. To this end, the 10 µg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-104**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-105**). These modeled results are graphically represented in **Figure 5-112** at a distance of 700 foot downstream from the diffuser. The findings are consistent with the modeled results indicating no exceedances of the dissolved arsenic objective as listed in **Table 5-107**.

5.6.5.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-104**) and proposed discharge (see **Table 5-105**) have similar characteristics. The 5th percentile and the 50th percentile (median) modeled distributions, indicate dissolved arsenic concentrations are generally greater near the outfall, corresponding to the more frequent scenario where the effluent concentration is greater than the receiving water concentration. The 95th percentile modeled distribution denotes nearly constant dissolved arsenic concentrations within the plume, indicating that the receiving water concentrations are equal to the effluent concentrations at this end of the probability distributions for effluent and receiving water. For the 99.91 percentile distribution, dissolved arsenic concentrations are slightly lower near the diffuser, indicating that the maximum receiving water concentrations are greater than the maximum effluent concentrations. Concentrations in the immediate vicinity of the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the concentrations in the middle and end of the modeled plume are similar for both discharge rates. Furthermore, as noted in **Table 5-106**, the proposed increase in SRWTP effluent discharge would produce a negligible change in dissolved arsenic concentrations within the plume, with no noticeable incremental change at downstream distances past 60 feet or farther from the effluent diffuser.

Exceedance frequencies of the Basin Plan dissolved arsenic objective are presented in **Table 5-107**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the Basin Plan standard. The incremental change in dissolved arsenic concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median dissolved arsenic concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled dissolved arsenic distributions at 700 feet downstream from the diffuser (see **Figure 5-112**) and the modeled, median dissolved arsenic concentration within the plume (see **Figure 5-113**) show a negligible change in dissolved arsenic concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in dissolved arsenic concentrations in the Sacramento River.

5.6.6 Chromium

5.6.6.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for chromium at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured dissolved fraction of chromium in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total recoverable fraction of chromium measured in SRWTP effluent. The modeled in-plume dissolved chromium concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-108**. Modeled in-plume dissolved chromium concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-109**.

Table 5-108: Modeled In-Plume Dissolved Chromium Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.282	0.237	0.210	0.193	0.180	0.176
Median	0.276	0.232	0.206	0.190	0.176	0.172
95 %-ile	0.463	0.388	0.350	0.330	0.316	0.312
99.91 %-ile	0.662	0.556	0.485	0.458	0.445	0.442
5 %-ile	0.121	0.100	0.082	0.069	0.056	0.052

Table 5-109: Modeled In-Plume Dissolved Chromium Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.303	0.250	0.218	0.199	0.183	0.178
Median	0.299	0.246	0.215	0.195	0.179	0.175
95 %-ile	0.495	0.407	0.360	0.335	0.319	0.314
99.91 %-ile	0.684	0.573	0.496	0.462	0.446	0.443
5 %-ile	0.127	0.105	0.088	0.073	0.059	0.054

The incremental differences in modeled in-plume dissolved chromium concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-110**. The median incremental increase of in-plume dissolved chromium concentrations would range from 0.023 µg/L at a distance of 30 feet downstream from the SRWTP diffuser to 0.003 µg/L at distances 350 feet or farther downstream from the diffuser.

Table 5-110: Modeled In-Plume Dissolved Chromium Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.021	0.013	0.008	0.006	0.003	0.002
Median	0.023	0.014	0.009	0.005	0.003	0.003
95 %-ile	0.032	0.019	0.010	0.005	0.003	0.002
99.91 %-ile	0.022	0.017	0.011	0.004	0.001	0.001
5 %-ile	0.006	0.005	0.006	0.005	0.003	0.002

The probability distributions of modeled dissolved chromium concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-114**. The median dissolved chromium concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-115**.

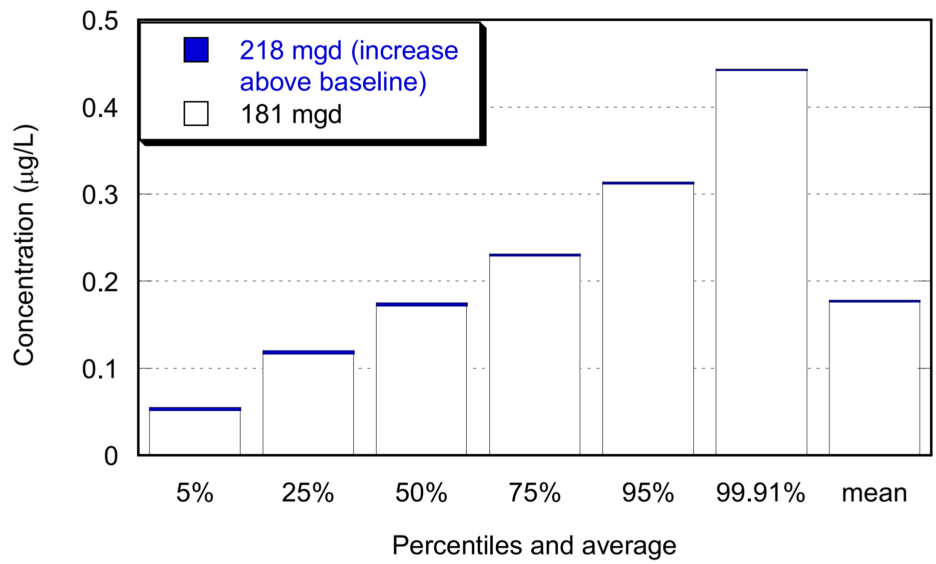

Figure 5-114: Distribution of Modeled Dissolved Chromium Concentrations 700 feet Downstream of SRWTP Diffuser.

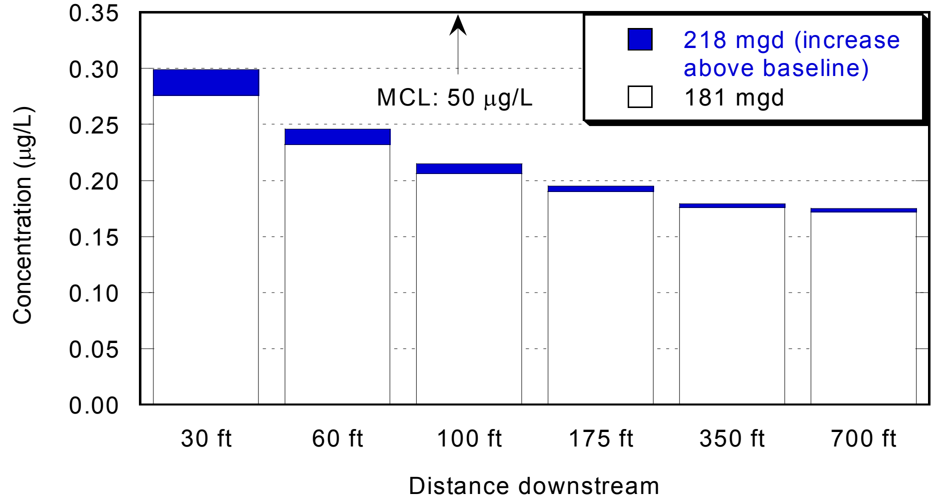

Figure 5-115: Median Modeled Dissolved Chromium Concentration Downstream of SRWTP Diffuser. Title 22 MCL of 50 µg/L, Intended for the Protection of Drinking Water Users, Is the Most Stringent Chromium Chronic Objective Applicable to Delta Waters. The Next Lowest Objectives Are the CTR Chronic Criteria for the Protection of Aquatic Organisms. The Basin Plan Objective of 50 µg/L Ensures Protection for this Beneficial Use.

5.6.6.2 Comparison to Water Quality Objectives

The most stringent water quality objective for total chromium in the Sacramento River is the California Code of Regulations Title 22 Primary MCL of 50 µg/L, incorporated into the Basin Plan by reference. The next lowest objectives are the CTR hardness-dependent chronic and acute criteria for the protection of aquatic life. The modeled hardness in the plume, corresponding to the mixed effluent and river hardness levels, is used to evaluate the compliance of the in-plume dissolved lead concentrations. The modeled, dissolved chromium concentrations in the plume are compared with the Title 22 MCL, and with the calculated hardness-based criteria for both acute (1-hour) and chronic (4-day) toxicity criteria.

The percent exceedances of the chromium criteria over a three-year interval at various distances downstream from the SRWTP diffuser at a discharge rate of 218 mgd are listed in **Table 5-111**. Running 30-day averages for in-plume dissolved chromium concentrations were modeled to determine projected MCL exceedance frequencies in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that dissolved chromium concentrations are not expected to exceed the chromium MCL at any point within the modeled plume. The MCL for total chromium is 50 µg/L, total chromium effluent concentrations are over an order of magnitude lower than the MCL, and modeled in-plume dissolved chromium concentrations are less than 1 µg/L, therefore no exceedances of the MCL are expected and no compliance problems are anticipated.

For the acute toxicity objective, each calculated dissolved chromium concentration in the plume was also compared to the acute criterion calculated from the hardness for each epoch. For the chronic objective, intended as protection for an organism under continuous 4-day exposure to a certain water quality condition, a running 4-day average of the ratios was evaluated at each time step that compared calculated dissolved chromium concentrations to the chronic criteria calculated with the hardness value for the time step. If the running 4-day average of the ratio was greater than 1.0, then the criterion was exceeded. As listed in **Table 5-111**, the modeled results indicate that exceedances of either the Title 22 Primary MCL for total chromium or the toxicity objectives for dissolved chromium are not expected at any of the modeled in-plume locations with an increased in discharge rate.

Table 5-111: DYNTOX Modeled Percent Exceedance Frequency for Dissolved Chromium at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Primary MCL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

5.6.6.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-108**) and proposed discharge (see **Table 5-109**) have similar characteristics. For the 5th percentile through the 99.91 percentile distributions, dissolved chromium concentrations are generally greater near the outfall, corresponding to the most frequent scenario where the effluent concentration is greater than the receiving water concentration. All percentile concentrations show a curvilinear decrease in the modeled plume with highest concentrations near the diffuser, also indicating that the receiving water concentrations are less than the effluent concentrations. Concentrations near the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the concentrations towards the end of the modeled plume are similar for both discharge rates. As noted in **Table 5-110**, the proposed increase in SRWTP effluent discharge would produce a slight increase of dissolved chromium concentrations within the plume, with minimal incremental change at distances of 350 feet downstream or farther from the effluent diffuser.

Exceedance frequencies of Title 22 chromium MCL and the CTR criteria for acute and chronic toxicity are presented in **Table 5-111**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of these objectives. The incremental change in dissolved chromium concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median dissolved chromium concentrations that are substantially below the most stringent applicable water quality objectives. Both the modeled dissolved chromium distributions at 700 feet downstream from the diffuser (see **Figure 5-114**) and the modeled, median dissolved chromium concentration within the plume (see **Figure 5-115**) show a slight incremental increase in dissolved chromium concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in dissolved chromium concentrations in the Sacramento River.

5.6.7 Lead

5.6.7.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for lead at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured dissolved fraction of lead in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total recoverable fraction of lead measured in SRWTP effluent. Therefore, the modeling conservatively estimated the frequency at which lead concentrations would exceed the applicable water quality objectives, which are expressed as dissolved. The modeled in-plume dissolved lead concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-112**. Modeled in-plume dissolved lead concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-113**.

Table 5-112: Modeled In-Plume Dissolved Lead Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.081	0.062	0.051	0.044	0.039	0.037
Median	0.069	0.054	0.045	0.039	0.033	0.032
95 %-ile	0.176	0.130	0.104	0.091	0.082	0.079
99.91 %-ile	0.431	0.309	0.237	0.204	0.193	0.192
5 %-ile	0.025	0.022	0.019	0.016	0.014	0.013

Table 5-113: Modeled In-Plume Dissolved Lead Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.090	0.068	0.055	0.046	0.040	0.038
Median	0.077	0.059	0.048	0.041	0.034	0.033
95 %-ile	0.198	0.143	0.112	0.095	0.083	0.081
99.91 %-ile	0.473	0.337	0.251	0.208	0.194	0.193
5 %-ile	0.025	0.022	0.019	0.017	0.014	0.013

The incremental differences in modeled in-plume dissolved lead concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-114**. The median incremental increase in dissolved lead concentrations within the plume range from 0.008 µg/L at a distance of 30 feet downstream from the SRWTP diffuser to 0.001 µg/L at distances of 350 feet or farther downstream from the diffuser.

Table 5-114: Modeled In-Plume Dissolved Lead Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.009	0.006	0.004	0.002	0.001	0.001
Median	0.008	0.005	0.003	0.002	0.001	0.001
95 %-ile	0.022	0.013	0.008	0.004	0.001	0.002
99.91 %-ile	0.042	0.028	0.014	0.004	0.001	0.001
5 %-ile	<0.001	<0.001	<0.001	0.001	<0.001	<0.001

The probability distributions of modeled dissolved lead concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-116**. The median dissolved lead concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-117**.

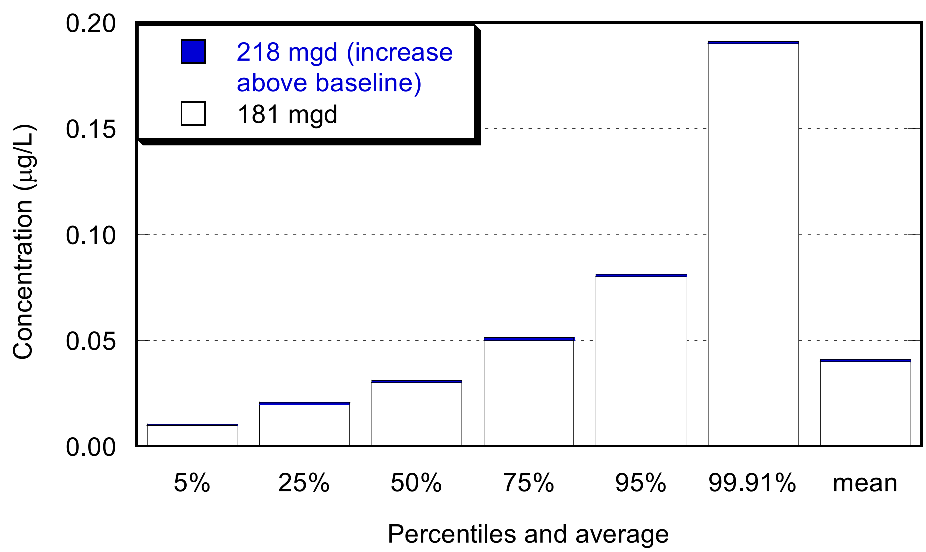

Figure 5-116: Distribution of Modeled Dissolved Lead Concentrations 700 feet Downstream of SRWTP Diffuser.

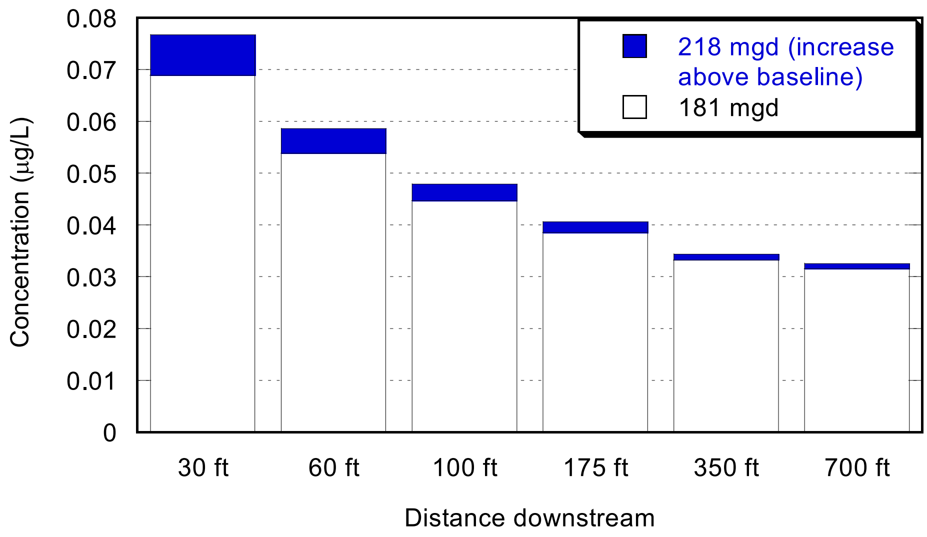

Figure 5-117: Median Modeled Dissolved Lead Concentration Downstream of SRWTP Diffuser.

5.6.7.2 Comparison to Water Quality Objectives

The most stringent water quality objectives for dissolved lead in the Sacramento River are the hardness-based CTR standards for the protection of freshwater aquatic life. The modeled hardness in the plume, corresponding to the mixed effluent and river hardness levels, is used to evaluate the compliance of the in-plume dissolved lead concentrations. The modeled dissolved lead concentrations in the plume are compared with the calculated hardness-based criteria for both acute (1-hour) and chronic (4-day) toxicity criteria.

In addition to being hardness-based, the CTR criterion equation also includes a water-effect ratio (WER). The WER is a measure of the complexation of the toxic free lead ions in the site-specific water body, thereby making them biologically unavailable and non-toxic to aquatic life, in relation to the complexation of lead ion in the laboratory water used by U.S. EPA to derive the criterion. Without an additional study, the default WER of 1.0 is specified in the CTR for criteria development. An upward adjustment of the presumed WER of 1.0 in the zone of initial mixing, due to the lead binding capability of treated effluent, would result in higher objectives.

The percent exceedances of dissolved lead criteria over a three-year period at various distances downstream from the SRWTP diffuser are listed in **Table 5-115**. As noted above, the modeled in-plume hardness level at each epoch of the model is used to calculate the criteria throughout the plume for that epoch. For the acute toxicity objective, each calculated dissolved lead concentration in the plume was compared to the acute criterion calculated from the hardness for each epoch. For the chronic objective, , a running 4-day average of the ratios was evaluated at each time step that compared calculated dissolved lead concentrations to the chronic criteria calculated with the hardness value for the time step. If the running 4-day average of the ratio was greater than 1.0, then the criterion was exceeded. As listed in **Table 5-115**, the modeled results indicate that exceedances of either the acute or chronic toxicity objectives for dissolved lead are not expected at any of the modeled in-plume locations with an increased in discharge rate.

Table 5-115: DYNTOX Modeled Percent Exceedance Frequency for Dissolved Lead at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

5.6.7.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-112**) and proposed discharge (see **Table 5-113**) have similar characteristics. For the 5th percentile through the 99.91 percentile distributions, dissolved lead concentrations are greater near the outfall, corresponding to the scenario where the effluent concentration is generally greater than the receiving water concentration. All percentile concentrations show a curvilinear decrease in the modeled plume with highest concentrations near the diffuser, indicating that the receiving water concentrations are less than the effluent concentrations. Concentrations near the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the concentrations in the middle and end of the modeled plume are similar for both discharge rates. Furthermore, as listed in **Table 5-114**, the proposed increase in SRWTP effluent discharge would slightly increase dissolved lead concentrations in the plume up to 350 feet from the SRWTP diffuser, but the in-plume increment is minimal at distances any farther downstream from the diffuser.

Exceedance frequencies of the most stringent applicable water quality criteria for dissolved lead, the CTR acute and chronic objectives for the protection of freshwater aquatic life, are presented in **Table 5-115**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the dissolved lead criteria. The incremental change in dissolved lead concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median dissolved lead concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled dissolved lead distributions at 700 feet downstream from the diffuser (see **Figure 5-116**) and the modeled, median dissolved lead concentration within the plume (see **Figure 5-117**) show a slight increase in dissolved lead concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in dissolved lead concentrations in the Sacramento River.

5.6.8 Molybdenum

5.6.8.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for molybdenum at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the total molybdenum in the Sacramento River at Freeport. Effluent quality model inputs were derived from total molybdenum measured in SRWTP effluent. The modeled in-plume total molybdenum concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-116**. Modeled in-plume total molybdenum concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-117**.

Table 5-116: Modeled In-Plume Total Molybdenum Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	1.048	0.850	0.733	0.660	0.602	0.584
Median	0.996	0.812	0.706	0.638	0.581	0.564
95 %-ile	1.730	1.340	1.110	0.981	0.892	0.869
99.91 %-ile	2.760	2.170	1.710	1.450	1.310	1.280
5 %-ile	0.533	0.492	0.453	0.417	0.380	0.367

Table 5-117: Modeled In-Plume Total Molybdenum Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	1.142	0.908	0.771	0.683	0.614	0.594
Median	1.100	0.870	0.743	0.662	0.595	0.575
95 %-ile	1.890	1.450	1.170	1.020	0.907	0.881
99.91 %-ile	2.900	2.270	1.770	1.480	1.330	1.300
5 %-ile	0.519	0.493	0.460	0.425	0.388	0.373

The incremental differences in modeled in-plume molybdenum concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-118**. The median incremental increase in molybdenum concentrations would range from 0.095 µg/L at a distance of 30 feet downstream from the SRWTP diffuser to 0.010 µg/L at a distance of 700 feet downstream from the diffuser.

Table 5-118: Modeled In-Plume Total Molybdenum Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.096	0.058	0.037	0.023	0.012	0.010
Median	0.104	0.058	0.037	0.024	0.014	0.011
95 %-ile	0.160	0.110	0.060	0.039	0.015	0.012
99.91 %-ile	0.140	0.100	0.060	0.030	0.020	0.020
5 %-ile	-0.014	0.001	0.007	0.008	0.008	0.006

The probability distributions of modeled total molybdenum concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-118**. The median total molybdenum concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-119**.

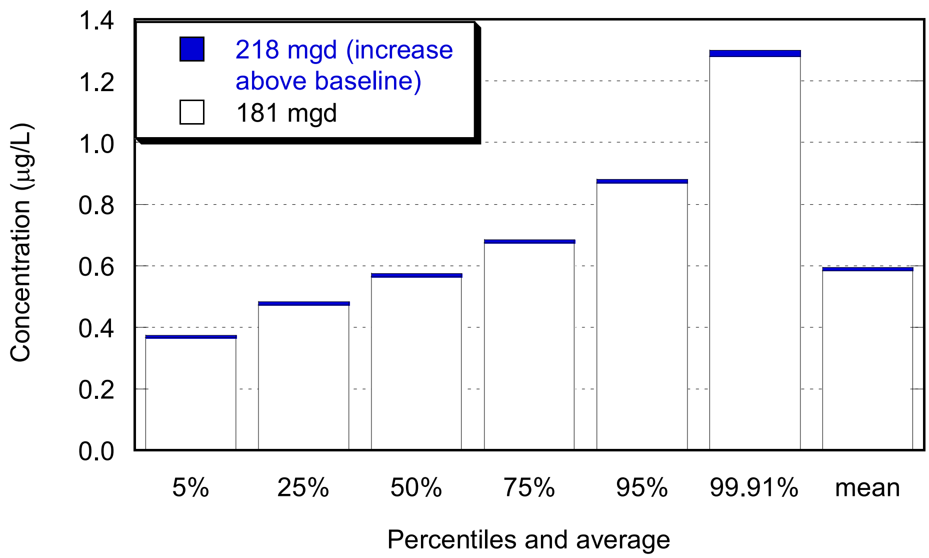

Figure 5-118: Distribution of Modeled Total Molybdenum Concentrations 700 feet Downstream of SRWTP Diffuser.

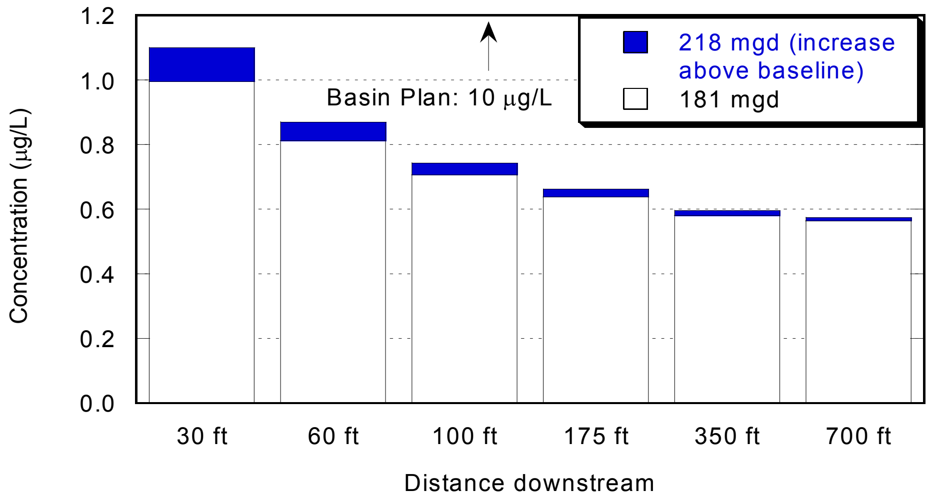

Figure 5-119: Median Modeled Total Molybdenum Concentration Downstream of SRWTP Diffuser.

5.6.8.2 Comparison to Water Quality Objectives

The most stringent water quality objective for total molybdenum in the Sacramento River is the Basin Plan objective of 10 µg/L. The percent exceedance frequencies of the Basin Plan total molybdenum objective at various in-plume distances downstream from the SRWTP diffuser are listed in **Table 5-119**. Running 30-day averages for concentrations in the Sacramento River were modeled to determine projected exceedance of the objective for in-plume distances downstream of the SRWTP diffuser. The DYNTOX results indicate that molybdenum concentrations are not expected to approach or exceed the Basin Plan standard at any point within the modeled plume.

Table 5-119: DYNTOX Modeled Percent Exceedance Frequency for Total Molybdenum at Various Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Basin Plan Objective Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Basin Plan	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the Basin Plan objective for total molybdenum. To this end, the 10 µg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-116**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-117**). These modeled results are graphically represented in **Figure 5-118** at a distance of 700 feet downstream from the diffuser. These findings are consistent with the modeled results indicating no exceedances of the molybdenum objective as listed in **Table 5-119**.

5.6.8.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-116**) and proposed discharge (see **Table 5-117**) have similar characteristics. For the 5th percentile through the 99.91 percentile distributions, molybdenum concentrations are generally greater near the outfall, corresponding to the most frequent scenario where the effluent concentration is greater than the receiving water concentration. Concentrations near the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the concentrations toward the end of the modeled plume are similar for both discharge rates. As noted in **Table 5-118**, the proposed increase in SRWTP effluent discharge would produce a slight increase of molybdenum concentrations in the Sacramento River throughout the modeled plume, with the greatest incremental increases occurring near the discharge and then gradually tapering off with downstream distance.

Exceedance frequencies of the Basin Plan molybdenum objective are presented in **Table 5-119**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the Basin Plan standard. The incremental change in total molybdenum concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median molybdenum concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled total molybdenum distributions at 700 feet downstream from the diffuser (see **Figure 5-118**) and the modeled, median concentration of total molybdenum within the plume (see **Figure 5-119**) show a slight incremental increase in total molybdenum concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible increase in total molybdenum concentrations in the Sacramento River.

5.6.9 Nickel

5.6.9.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for nickel at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured dissolved fraction of nickel in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total recoverable fraction of nickel measured in SRWTP effluent. Therefore, the modeling conservatively estimated the frequency at which nickel concentrations would exceed the applicable water quality objectives, which are expressed as dissolved. The modeled in-plume dissolved nickel concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-120**. Modeled in-plume dissolved nickel concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-121**.

Table 5-120: Modeled In-Plume Dissolved Nickel Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	1.06	0.92	0.83	0.78	0.74	0.72
Median	1.02	0.86	0.77	0.71	0.67	0.65
95 %-ile	1.74	1.55	1.46	1.41	1.38	1.37
99.91 %-ile	2.72	2.73	2.74	2.74	2.75	2.75
5 %-ile	0.523	0.461	0.412	0.372	0.335	0.322

Table 5-121: Modeled In-Plume Dissolved Nickel Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	1.13	0.96	0.86	0.80	0.75	0.73
Median	1.10	0.91	0.80	0.73	0.68	0.66
95 %-ile	1.82	1.60	1.48	1.42	1.39	1.37
99.91 %-ile	2.73	2.72	2.73	2.74	2.75	2.75
5 %-ile	0.536	0.476	0.427	0.384	0.343	0.329

The incremental differences in modeled in-plume dissolved nickel concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-122**. The median incremental increase in dissolved nickel concentrations within the plume ranges from 0.08 µg/L at a distance of 30 feet downstream from the diffuser to 0.01 µg/L at distances of 350 feet downstream or farther from the diffuser.

Table 5-122: Modeled In-Plume Dissolved Nickel Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.07	0.04	0.03	0.02	0.01	0.01
Median	0.08	0.05	0.03	0.02	0.01	0.01
95 %-ile	0.08	0.05	0.02	0.01	0.01	<0.01
99.91 %-ile	0.01	-0.01	-0.01	<0.01	<0.01	<0.01
5 %-ile	0.013	0.015	0.015	0.012	0.008	0.007

The probability distributions of modeled dissolved nickel concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-120**. The median dissolved nickel concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-121**.

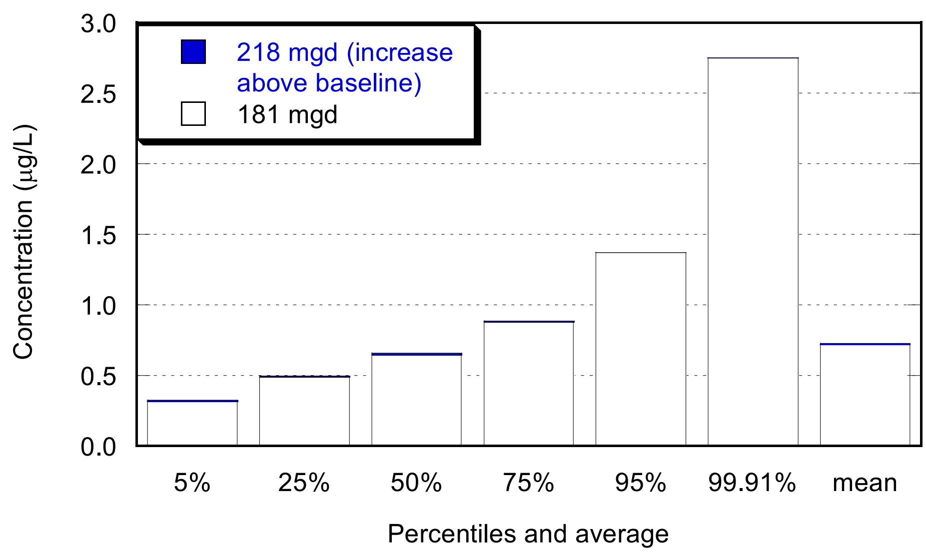

Figure 5-120: Distribution of Modeled Dissolved Nickel Concentrations 700 feet Downstream of SRWTP Diffuser.

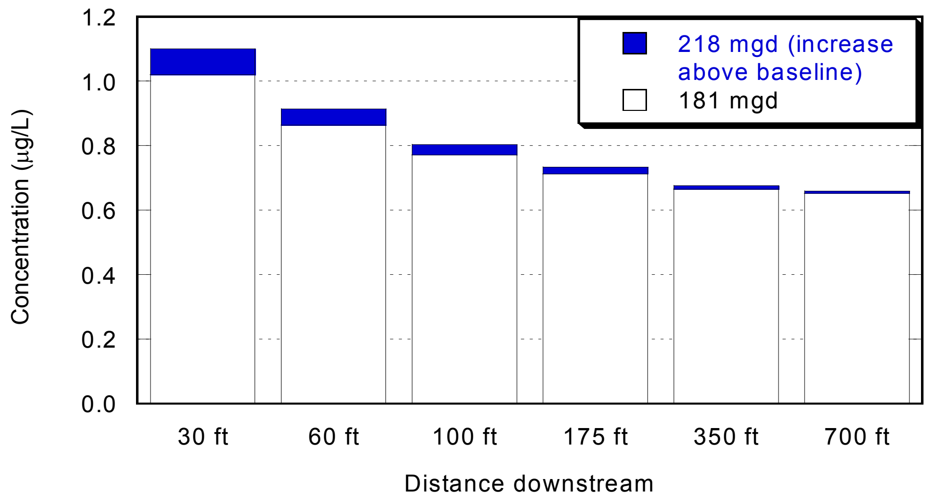

Figure 5-121: Median Dissolved Nickel Concentration Downstream of SRWTP Diffuser.

5.6.9.2 Comparison to Water Quality Objectives

The most stringent water quality objectives for dissolved nickel in the Sacramento River are the hardness-based CTR standards for the protection of freshwater aquatic life. The modeled hardness in the plume, corresponding to the mixed effluent and river hardness levels, is used to evaluate the compliance of the in-plume dissolved nickel concentrations. The modeled dissolved nickel concentrations in the plume are compared with the calculated hardness-based criteria for both acute (1-hour) and chronic (4-day) toxicity criteria.

In addition to being hardness-based, the CTR criterion equation also includes a water-effect ratio (WER). The WER is a measure of the complexation of the toxic free nickel ions in the site-specific water body, thereby making them biologically unavailable and non-toxic to aquatic life, in relation to the complexation of nickel ion in the laboratory water used by U.S. EPA to derive the criterion. Without an additional study, the default WER of 1.0 is specified in the CTR for criteria development. An upward adjustment of the presumed WER of 1.0 in the zone of initial mixing, due to the nickel binding capability of treated effluent, would result in higher objectives.

The percent exceedances of dissolved nickel criteria at various distances downstream from the SRWTP diffuser are listed in **Table 5-123**. As noted above, the modeled in-plume hardness level at each epoch of the model is used to calculate the criteria throughout the plume for that epoch. For the acute toxicity objective, each calculated dissolved nickel concentration in the plume was compared to the acute criterion calculated from the hardness for each epoch. For the chronic objective, intended as protection for an organism under continuous 4-day exposure to a certain water quality condition, a running 4-day average of the ratios was evaluated at each time step that compared calculated dissolved nickel concentrations to the chronic criteria calculated with the hardness value for the time step. If the running 4-day average of the ratio was greater than 1.0, the criterion was exceeded. As listed in **Table 5-123**, the modeled results indicate that exceedances of either the acute or chronic toxicity objectives for dissolved nickel are not expected at any of the modeled in-plume locations with an increased in discharge rate.

Table 5-123: DYNTOX Percent Exceedance Frequency for Dissolved Nickel at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

5.6.9.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-120**) and proposed discharge (see **Table 5-121**) have similar characteristics. For the 5th percentile through the 95th percentile distributions, dissolved nickel concentrations are greater near the outfall, corresponding to the scenario where the effluent concentration is generally greater than the receiving water concentration. The 99.91 percentile concentrations remain relatively constant throughout the modeled plume with negligibly lower concentrations near the diffuser, accounting for the unlikely scenarios when the receiving water concentrations are equal to or greater than the effluent concentrations. Concentrations near the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the concentrations in the middle and end of the modeled plume are similar for both discharge rates. As listed in **Table 5-122**, the proposed increase in SRWTP effluent discharge would slightly increase dissolved nickel concentrations in the Sacramento River up to 350 feet from the SRWTP diffuser, but the increment is minimal at distances any farther downstream from the diffuser.

Exceedance frequencies of the most stringent applicable water quality criteria for dissolved nickel, the CTR acute and chronic objectives for the protection of freshwater aquatic life, are presented in **Table 5-123**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of these criteria. The incremental change in dissolved nickel concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median dissolved nickel concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled dissolved nickel distributions at 700 feet downstream from the diffuser (see **Figure 5-120**) and the modeled, median dissolved nickel concentration within the plume (see **Figure 5-121**) show a slight increase in dissolved nickel concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in dissolved nickel concentrations in the Sacramento River.

5.6.10 Selenium

5.6.10.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for selenium at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured total selenium in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total recoverable fraction of selenium measured in SRWTP effluent. The modeled in-plume total selenium concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-124**. Modeled in-plume total selenium concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-125**.

Table 5-124: Modeled In-Plume Total Selenium Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.34	0.29	0.27	0.25	0.23	0.23
Median	0.31	0.25	0.22	0.19	0.18	0.17
95 %-ile	0.65	0.62	0.61	0.60	0.59	0.59
99.91 %-ile	1.73	1.83	1.88	1.92	1.95	1.96
5 %-ile	0.13	0.11	0.090	0.076	0.063	0.058

Table 5-125: Modeled In-Plume Total Selenium Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.37	0.31	0.27	0.25	0.24	0.23
Median	0.35	0.27	0.23	0.20	0.18	0.17
95 %-ile	0.66	0.63	0.61	0.60	0.59	0.59
99.91 %-ile	1.68	1.80	1.87	1.91	1.94	1.95
5 %-ile	0.13	0.11	0.095	0.080	0.066	0.060

The incremental differences in modeled in-plume total selenium concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-126**. The median incremental increase in selenium concentrations within the plume range from 0.03 µg/L at a distance of 30 feet downstream from the diffuser to 0.01 µg/L or less at a distance of 100 feet downstream and farther from the diffuser.

Table 5-126: Modeled In-Plume Total Selenium Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mg to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.03	0.02	<0.01	<0.01	0.01	0.01
Median	0.04	0.02	0.01	0.01	<0.01	<0.01
95 %-ile	0.01	0.01	<0.01	<0.01	<0.01	<0.01
99.91 %-ile	-0.05	-0.03	-0.01	-0.01	-0.01	-0.01
5 %-ile	<0.01	<0.01	0.005	0.004	0.003	0.002

The probability distributions of modeled total selenium concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-122**. The median total selenium concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-123**.

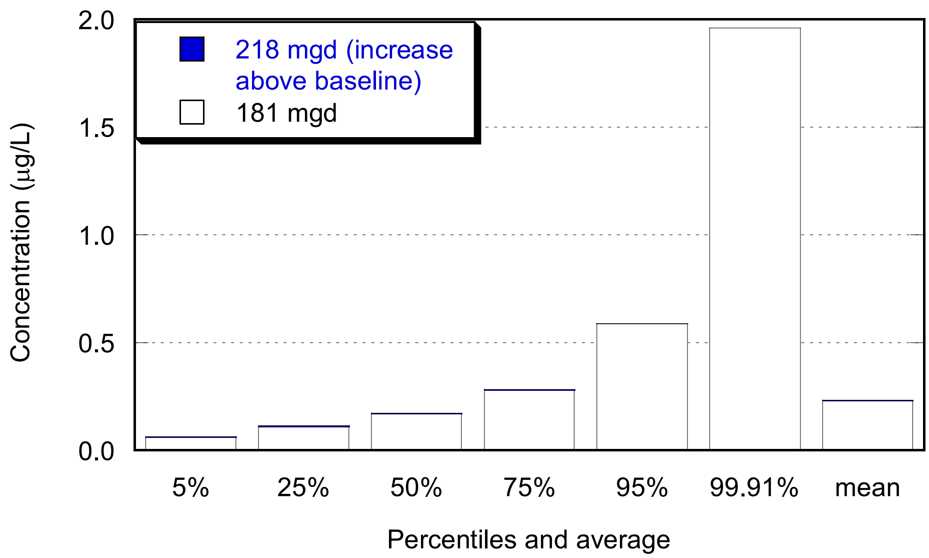

Figure 5-122: Distribution of Modeled Total Selenium Concentrations 700 feet Downstream of SRWTP Diffuser.

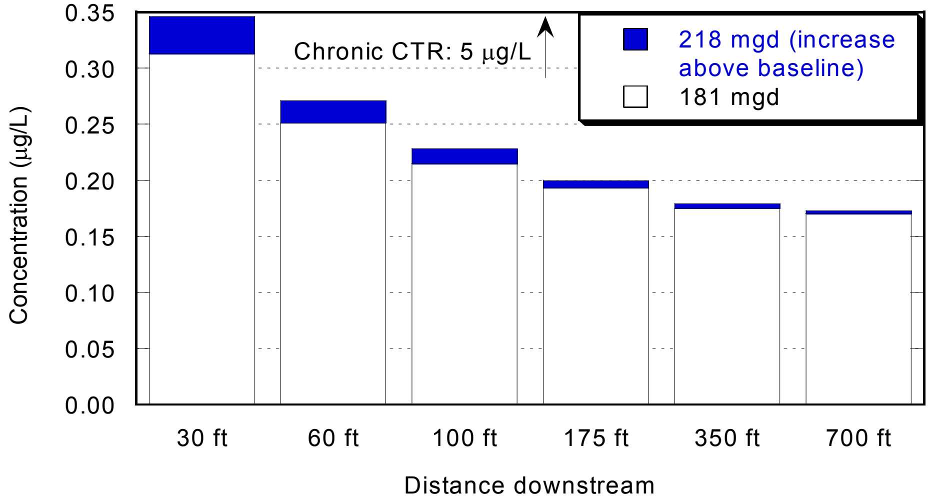

Figure 5-123: Median Modeled Total Selenium Concentration Downstream of SRWTP Diffuser.

5.6.10.2 Comparison to Water Quality Objectives

The CTR criterion of 5 µg/L for the protection of human health for the consumption of water and aquatic organisms is the most stringent water quality objective applicable for selenium in the Sacramento River. The percent exceedance frequencies of total selenium criteria at various distances downstream from the SRWTP diffuser are listed in **Table 5-127**. By definition, the chronic objective is intended as protection for an organism under continuous 4-day exposure to a certain water quality condition. As such, to determine the percent exceedances of the chronic total selenium objective, a running 4-day average calculated total selenium concentration in the plume was compared to the chronic criterion. As indicated in **Table 5-127**, the total selenium criterion is projected to be met at all modeled distances within the plume.

Table 5-127: DYNTOX Modeled Percent Exceedance Frequency for Total Selenium at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate. Exceedances of the Chronic Criterion Are Based on Running 4-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the chronic CTR criteria for total selenium. To this end, the 5 µg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-124**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-125**). These modeled results are graphically represented in **Figure 5-122** at a distance of 700 feet downstream from the diffuser. The findings are consistent with the modeled results indicating that no exceedances of the selenium CTR objective are expected with an increased in discharge rate, as listed in **Table 5-127**.

5.6.10.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-124**) and proposed discharge (see **Table 5-125**) have similar characteristics. For the 5th percentile through the 95th percentile distributions, total selenium concentrations are greater near the outfall, corresponding to the scenario where the effluent concentration is generally greater than the receiving water concentration. The 99.91 percentile distributions display slightly lower concentrations near the diffuser, accounting for the infrequent times when the receiving water concentrations are equal to or greater than the effluent concentrations. Concentrations near the diffuser are slightly higher for the proposed discharge (218 mgd) case; however, the concentrations in the middle and end of the modeled plume are similar for both discharge rates. Furthermore, as listed in **Table 5-126**, the proposed increase in SRWTP effluent discharge would slightly increase total selenium concentrations in the Sacramento River in the immediate vicinity of the SRWTP diffuser, but the change is negligible at distances beyond the initial 100 feet downstream from the diffuser.

Exceedance frequencies of the most stringent applicable water quality objective, the CTR chronic criterion for the protection of freshwater aquatic life, are presented in **Table 5-127**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the total selenium objective. The incremental change in total selenium concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median total selenium concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled total selenium distributions at 700 feet downstream from the diffuser (see **Figure 5-122**) and the modeled, median total selenium concentration within the plume (see **Figure 5-123**) show a negligible change in total selenium concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in total selenium concentrations in the Sacramento River.

5.6.11 Silver

5.6.11.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for silver at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured dissolved fraction of silver in the Sacramento River at Freeport. Effluent quality model inputs were derived from the total recoverable fraction of silver measured in SRWTP effluent. Therefore, the modeling conservatively estimated the frequency at which silver concentrations would exceed the applicable water quality objectives, which are expressed as dissolved. The modeled in-plume dissolved silver concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-128**. Modeled in-plume dissolved silver concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-129**.

Table 5-128: Modeled In-Plume Dissolved Silver Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.026	0.021	0.019	0.017	0.016	0.016
Median	0.024	0.020	0.017	0.016	0.014	0.014
95 %-ile	0.049	0.040	0.035	0.033	0.032	0.031
99.91 %-ile	0.081	0.071	0.067	0.067	0.067	0.067
5 %-ile	0.0095	0.0087	0.0080	0.0073	0.0065	0.0062

Table 5-129: Modeled In-Plume Dissolved Silver Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.028	0.023	0.020	0.018	0.016	0.016
Median	0.026	0.021	0.018	0.016	0.015	0.014
95 %-ile	0.053	0.043	0.037	0.034	0.032	0.031
99.91 %-ile	0.085	0.072	0.068	0.067	0.067	0.067
5 %-ile	0.0095	0.0089	0.0082	0.0075	0.0067	0.0064

The incremental differences in modeled in-plume dissolved silver concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-130**. The median incremental increase in dissolved silver concentrations within the plume range from 0.002 µg/L at a distance of 30 feet downstream from the diffuser to 0.001 µg/L or less at a distance of 60 feet downstream and farther from the diffuser.

Table 5-130: Modeled In-Plume Dissolved Silver Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.002	0.002	0.001	0.001	<0.001	<0.001
Median	0.002	0.001	0.001	<0.001	0.001	<0.001
95 %-ile	0.004	0.002	0.001	0.001	<0.001	<0.001
99.91 %-ile	0.004	0.001	0.001	<0.001	<0.001	<0.001
5 %-ile	<0.0001	0.0002	0.0002	0.0002	0.0002	0.0002

The probability distributions of modeled dissolved silver concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-124**. The median dissolved silver concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-125**.

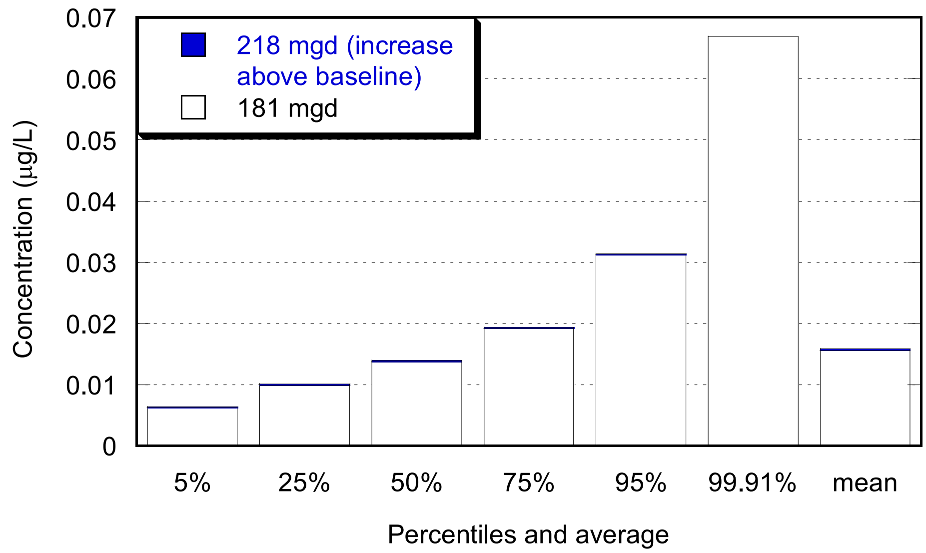

Figure 5-124: Distribution of Modeled Dissolved Silver Concentrations 700 feet Downstream of SRWTP Diffuser.

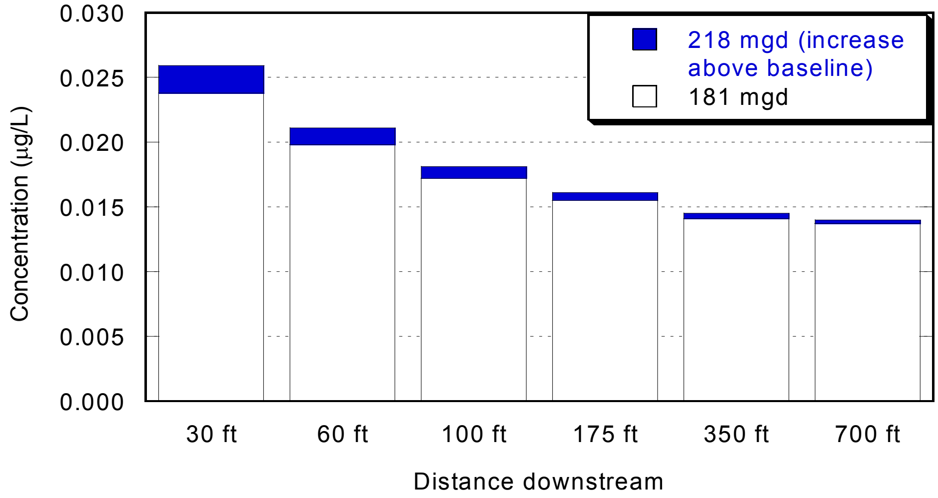

Figure 5-125: Median Modeled Dissolved Silver Concentration Downstream of SRWTP Diffuser.

5.6.11.2 Comparison to Water Quality Objectives

The most stringent water quality objective for dissolved silver in the Sacramento River is the hardness-based CTR acute criterion for the protection of freshwater aquatic life. There is no CTR chronic objective for silver. The modeled hardness in the plume, corresponding to the mixed effluent and river hardness levels, is used to evaluate the compliance of the in-plume dissolved silver concentrations.

In addition to being hardness-based, the CTR criterion equation also includes a water-effect ratio (WER). The WER is a measure of the complexation of the toxic free silver ions in the site-specific water body, thereby making them biologically unavailable and non-toxic to aquatic life, in relation to the complexation of silver ion in the laboratory water used by U.S. EPA to derive the criterion. Without an additional study, the default WER of 1.0 is specified in the CTR for criteria development. An upward adjustment of the presumed WER of 1.0 in the zone of initial mixing, due to the silver binding capability of treated effluent, would result in higher objectives.

The percent exceedances of the acute (1-hour) criterion for dissolved silver at various distances downstream from the SRWTP diffuser are listed in **Table 5-131**. As noted above, the modeled hardness level in the upstream river at an epoch of the model is used to calculate the criterion throughout the plume for that epoch. Each calculated dissolved silver concentration in the plume was compared to the acute objective calculated from the hardness for the individual epoch. . As listed in **Table 5-131**, the modeled results indicate that exceedances of the toxicity objective for dissolved silver are not expected at any of the modeled in-plume locations with an increase in discharge rate.

Table 5-131: DYNTOX Modeled Percent Exceedance Frequency for Dissolved Silver at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

5.6.11.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-128**) and proposed discharge (see **Table 5-129**) have similar characteristics. For the 5th percentile through the 99.91 percentile distributions, dissolved silver concentrations are greater near the outfall, corresponding to the scenario where the effluent concentration is generally greater than the receiving water concentration. All percentile concentrations show a curvilinear decrease in the modeled plume with highest concentrations near the diffuser, indicating that the receiving water concentrations are less than the effluent concentrations. Concentrations near the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the concentrations beyond 100 feet from the SRWTP diffuser are similar for both discharge rates. As indicated in **Table 5-130**, the proposed increase in SRWTP effluent discharge would slightly increase dissolved silver concentrations in the Sacramento River up to 60 feet from the SRWTP diffuser, but the in-plume increment is negligible at distances farther downstream from the diffuser.

Exceedance frequencies of the most stringent applicable water quality objective, the CTR acute criterion for the protection of freshwater aquatic life, are presented in **Table 5-131**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the dissolved silver objective. The incremental change in dissolved silver concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median dissolved silver concentrations that are substantially below the most stringent applicable water quality objective. Both the modeled dissolved silver distributions at 700 feet downstream from the diffuser (see **Figure 5-124**) and the modeled, median dissolved silver concentration within the plume (see **Figure 5-125**) show a negligible change in dissolved silver concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible increase in dissolved silver concentrations in the Sacramento River.

5.6.12 Biochemical Oxygen Demand

5.6.12.1 Near-Field Evaluation

Ambient biochemical oxygen demand (BOD) concentrations upstream of the SRWTP discharge in the Sacramento River at Freeport are very low and tend to be below detection limits (< 2 mg/L). There are no ambient water quality criteria for BOD in the Sacramento River or downstream receiving waters. BOD concentrations in SRWTP effluent are currently regulated by the RWQCB through the NPDES permit process for the purpose of maintaining DO concentrations in receiving waters at levels meeting the DO water quality objective for the Delta (7 mg/L) specified in the Basin Plan. The SRWTP's NPDES permit contains monthly average (30 mg/l), weekly average (45 mg/l), and daily average (60 mg/l) effluent limits for BOD. Of the 1,157 BOD effluent samples taken between 2005 and 2008, the SRWTP's mean BOD concentration was 7.6 mg/L and the 99.91 percentile concentration was 18.0 mg/L. These results show that even the highest BOD concentrations measured in SRWTP effluent are well below all of the treatment plant's NPDES effluents limits for BOD. SRWTP BOD effluent concentrations are projected to remain at similar levels with the proposed increase in SRWTP discharge.

5.6.12.2 Far-Field Evaluation

The effect of an increased BOD load in receiving waters due to the proposed increase in SRWTP discharge is appropriately addressed in the well-mixed conditions downstream of the discharge. This is because the consumptive oxygen demand of BOD is evidenced in decreased ambient DO levels downstream of the discharge. Accordingly, the far-field impacts of BOD in SRWTP discharge are addressed in the dissolved oxygen section of the current antidegradation analysis (see Section 5.4.16).

5.6.13 Bromide

Use of chlorine or ozone to disinfect water containing bromide can result in the formation of disinfection byproducts, which pose potential carcinogen risks to humans above threshold concentrations. As a result, bromide is undesirable in raw drinking water supplies. The major source of bromide to Delta waters is seawater intrusion (CALFED, 2000). CALFED concluded that the Sacramento River and east side streams are not significant sources of bromide in the water diverted from the Delta (CALFED, 2000). The California Department of Water Resources concluded that Delta island drainage, the San Joaquin River, and seawater intrusion are significant sources of bromide to the Delta, and found that wastewater treatment facilities (including the SRWTP) are not significant sources of bromide (DWR, 2000). There are no water quality standards or U.S. EPA recommended criteria for bromide to compare to ambient water quality data. However, the concentration of bromide in SRWTP influent would not change with the proposed increased discharge, so given the cited studies it is not expected that the increase in the SRWTP discharge rate would cause an increase in bromide concentrations in the Sacramento River or the Delta.

5.6.14 Chlorine Residual

As a means of assessing the potential for the SRWTP discharge flow rate increase from 181 mgd to 218 mgd to cause excursions of chlorine levels in the Sacramento River and downstream receiving waters, a review of the total residual chlorine levels in the SRWTP effluent was performed.

The SRWTP is required by its NPDES permit to monitor its effluent on a continuous basis for total residual chlorine. Based on current permit requirements, chlorine residual in the SRWTP effluent is not to exceed a monthly average limit of 0.011 mg/L and a daily average limit of 0.018 mg/L. Additionally, SRCSD is required to report any detected chlorine discharges, regardless of how they compare to the specified limits. A summary of chlorine discharges over a period from January 2004 to July 2008 is presented in **Table 5-132** below.

Table 5-132: SRWTP Chlorine Discharge Events and SRWTP Summary of Compliance with Total Residual Chlorine NPDES Permit Limits, January 2004 through July 2008.

Year	Total No. of Chlorine Discharge Events	Discharge Events Causing Exceedance of NPDES Limits		Percent of Time in Compliance with NPDES Limits	
		Monthly Average	Daily Average	Monthly Average	Daily Average
2004	4	0	0	100%	100%
2005	13	0	4	100%	98.90%
2006	4	0	0	100%	100%
2007	5	0	1	100%	99.73%
2008(1)	1	0	0	100%	100%
Total	27	0	5	100%	99.70%

(1) Based on January – July data.

As **Table 5-132** indicates, the SRWTP has been in compliance with the monthly average total chlorine residual limit 100% of the time for the period under review. The plant has also been in compliance with its daily average limit 99.70% of the time, with only 5 isolated incidents of exceedance – 4 in 2005 and 1 in 2007.

Historically, chlorine discharge events and exceedances of the SRWTP chlorine residual limits had been more frequent. Chlorine discharge events had been caused by various difficulties including power disruptions, maintenance activities, and frequent equipment malfunctions. However, in an effort to minimize these incidents, SRCSD has made considerable modifications to SRWTP chlorination/dechlorination facilities. Enhancements made to improve the process control and reliability of the disinfection system have resulted in a reduced number of chlorine discharge events in recent years. As such, the plant is now operating at the high compliance levels summarized in **Table 5-132**. Plant performance is expected to continue at these levels under the proposed discharge condition (218 mgd). Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is not anticipated to negatively impact receiving waters due to residual chlorine in the effluent discharge to the Sacramento River.

5.6.15 Cyanide

5.6.15.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for cyanide at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from the measured cyanide in the Sacramento River at Freeport. Effluent quality model inputs were derived from cyanide measured in SRWTP effluent. The modeled in-plume cyanide concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-133**. Modeled in-plume cyanide concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-134**.

Table 5-133: Modeled In-Plume Cyanide Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	4.20	4.09	4.03	3.99	3.96	3.95
Median	3.84	3.65	3.55	3.48	3.43	3.42
95 %-ile	7.68	7.91	8.05	8.15	8.23	8.26
99.91 %-ile	16.2	17.1	17.8	18.2	18.4	18.5
5 %-ile	1.91	1.76	1.65	1.56	1.48	1.46

Table 5-134: Modeled In-Plume Cyanide Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	4.25	4.13	4.05	4.01	3.97	3.96
Median	3.93	3.71	3.58	3.50	3.44	3.43
95 %-ile	7.58	7.83	8.00	8.12	8.22	8.24
99.91 %-ile	15.7	16.8	17.6	18.0	18.4	18.5
5 %-ile	1.97	1.81	1.69	1.59	1.50	1.47

The incremental differences in modeled in-plume cyanide concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-135**. The median incremental increase in cyanide concentrations would range from 0.09 µg/L at a distance of 30 feet downstream from the diffuser to 0.01 µg/L distances of 350 feet and farther downstream from the diffuser.

Table 5-135: Modeled In-Plume Cyanide Concentration Increments at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	**60 ft**	**100 ft**	**175 ft**	**350 ft**	**700 ft**
Mean	0.05	0.04	0.02	0.02	0.01	0.01
Median	0.09	0.06	0.03	0.02	0.01	0.01
95 %-ile	-0.10	-0.08	-0.05	-0.03	-0.01	-0.02
99.91 %-ile	-0.5	-0.3	-0.2	-0.2	<0.1	<0.1
5 %-ile	0.06	0.05	0.04	0.03	0.02	0.01

The probability distributions of modeled dissolved cyanide concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-126**. The median cyanide concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-127**.

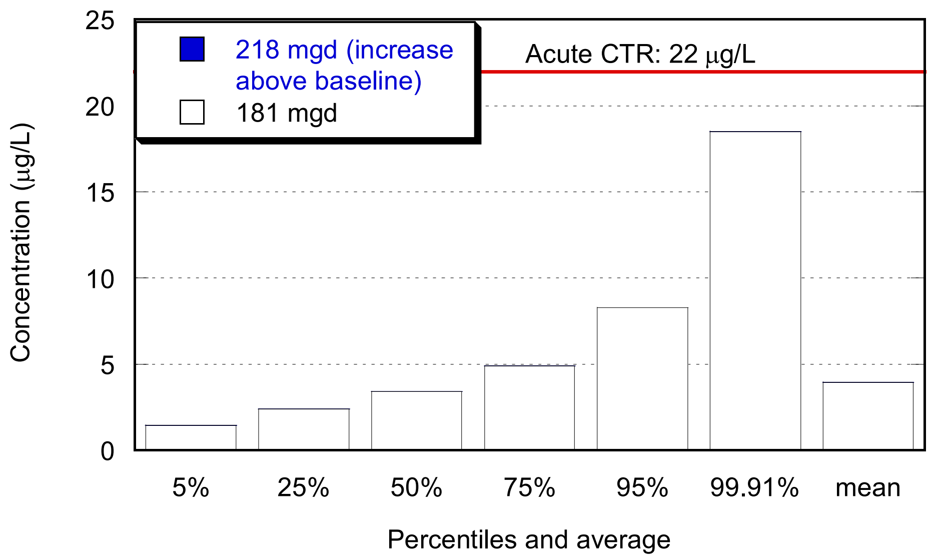

Figure 5-126: Distribution of Modeled Cyanide Concentrations 700 feet Downstream of SRWTP Diffuser.

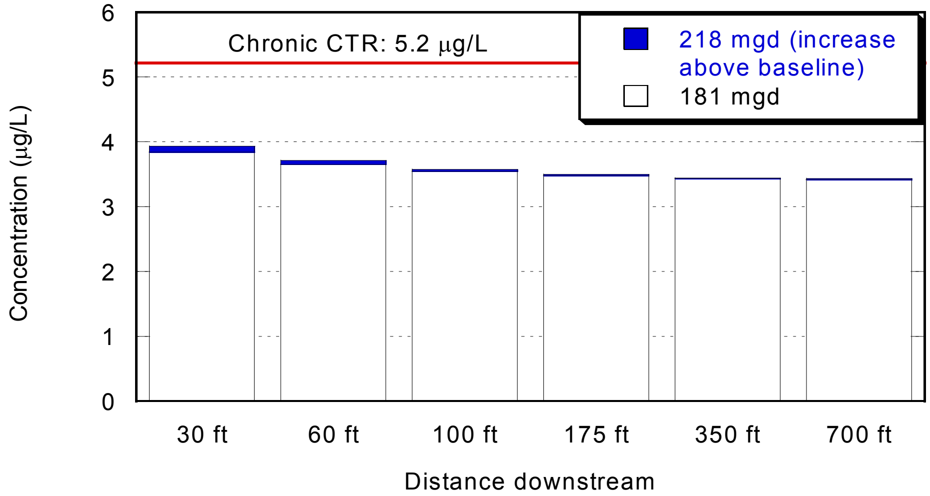

Figure 5-127: Median Modeled Cyanide Concentration Downstream of SRWTP Diffuser.

5.6.15.2 Comparison to Water Quality Objectives

The most stringent water quality objectives for cyanide in the Sacramento River are the acute and chronic CTR standards for the protection of freshwater aquatic life, 22 µg/L and 5.2 µg/L, respectively. The mean and median values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the acute and chronic CTR criteria for cyanide (see **Table 5-133** and **Table 5-134**). The percent exceedance frequencies of cyanide criteria at various in-plume distances downstream of the SRWTP diffuser are listed in **Table 5-136** and **Table 5-137** for two modeling scenarios regarding receiving water data sets, as explained below.

Table 5-136: DYNTOX Modeled Percent Exceedance Frequency for Cyanide at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Modeled Non-detect Receiving Water Values Set to the Value of the Method Detection Limit.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.01%	0.02%	0.02%	0.03%	0.03%	0.03%
Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 5-137: DYNTOX Modeled Percent Exceedance Frequency for Cyanide at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Modeled Non-detect Receiving Water Values Set to Zero.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Acute	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chronic	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

To determine the percent exceedances of the acute objective, each calculated cyanide concentration in the plume was compared to the acute criterion. In the case of cyanide, due to high frequency of non-detected values (more than 80%) of the receiving water data set, two scenarios were run: first, non-detected receiving water values were equated to the method detection limit (with results presented in **Table 5-136**), and second, non-detected receiving water values were equated to zero (with results presented in **Error! Reference source not found.**). In the first scenario, the acute criterion is projected to be met at a high frequency at all modeled distances within the plume, with the frequency of exceedance projected to be increasing with increasing disctance downstream of the diffuser. The modeled percent exceedance frequencies are very low and would be caused by elevated cyanide concentrations in the receiving water, not the SRWTP effluent. In this case, the modeling projects such exceedances would occur in rare instances when the receiving water cyanide concentration is greater than the effluent cyanide concentration and also higher than the acute criterion of 22 µg/L. These instances, even though projected to occur by the modeled distributions, are truly unrealistic – the maximum detected cyanide value in the receiving water is 5 µg/L, much lower than the acute criterion value of 22 µg/L. In the second scenario, where for modeling purposes, the non-detected receiving water values are equated with zero (0), the modeling results project that the acute criterion would be met at all times and at modeled distances in the plume (see Error! Reference source not found.).

The percent exceedance frequencies in **Table 5-136** also indicate that the chronic objective would not be exceeded at the proposed discharge condition (218 mgd). By definition, the chronic objective is intended as protection for an organism under continuous 4-day exposure to a certain water quality condition. As such, to determine the percent exceedances of the chronic objective, a running 4-day average calculated cyanide concentration in the plume was compared to the chronic criterion. The DYNTOX results show that there are no exceedances of the rolling 4-day average as presented in **Table 5-136**. As such, even though results listed in **Table 5-134** show that the cyanide concentration in the Sacramento River may at times be greater than the chronic objective, aquatic life would not be affected due to an organism's actual exposure time. Moreover, as noted in **Table 5-133** and **Table 5-134**, concentrations at the 95th percentile and higher (i.e., those same concentrations which are greater than the chronic objective) are lower near the diffuser and increase with increasing downstream distance, an indication that the receiving water concentrations are greater than the effluent concentrations in these instances.

5.6.15.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-133**) and proposed discharge (see **Table 5-134**) have similar characteristics. For the 5th and 50th percentile (median) distributions, cyanide concentrations are greater near the outfall, corresponding to the frequent scenario where the effluent concentration is generally greater than the receiving water concentration. The 95th and 99.91 percentile distributions point to lower concentrations near the diffuser, an indication that there are times when the receiving water concentrations are equal to or greater than the effluent concentrations. Concentrations near the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the concentrations in the middle and end of the modeled plume are similar for both discharge rates. As listed in **Table 5-135**, the proposed increase in SRWTP effluent discharge would slightly increase cyanide concentrations in the Sacramento River up to 350 feet downstream from the discharge, but would differ negligibly at farther distances downstream from the discharge.

Exceedance frequencies are presented in **Table 5-136** for the acute and chronic cyanide criteria. The dynamic model results are used to demonstrate that modeled in-plume cyanide levels at the proposed discharge rate of 218 mgd would exceed the cyanide acute criterion less than 0.03% of the time, and even then the exceedances are attributed to instances of high cyanide levels in the receiving water. Additionally, the cyanide chronic criterion was not exceeded in the dynamic model simulations. The incremental change in cyanide concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median cyanide concentrations that are below the most stringent applicable water quality criteria, the CTR acute and chronic objectives for the protection of freshwater aquatic life. Both the modeled cyanide distributions at 700 feet downstream from the diffuser (see **Figure 5-126**) and the modeled, median cyanide concentration within the plume (see **Figure 5-127**) show a slight incremental increase in cyanide concentration in the receiving water with an increased in SRWTP discharge. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in cyanide concentrations in the Sacramento River.

5.6.16 Total Suspended Solids

5.6.16.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for total suspended solids (TSS) at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from TSS measured in the Sacramento River at Freeport. Effluent quality model inputs were derived from TSS measured in SRWTP effluent. The modeled in-plume TSS concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-138**. Modeled in-plume TSS concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-139**.

Table 5-138: Modeled In-Plume Total Suspended Solids Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	24.1	26.1	27.2	27.9	28.5	28.6
Median	18.7	20.2	21.0	21.6	22.0	22.1
95%-ile	59.4	64.6	67.9	69.9	71.6	72.1
99.91%-ile	175	190	199	205	210	211
5%-ile	6.73	6.79	6.82	6.83	6.83	6.83

Table 5-139: Modeled In-Plume Total Suspended Solids Concentration (mg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	23.2	25.5	26.8	27.7	28.3	28.5
Median	18.0	19.8	20.8	21.4	21.9	22.0
95 %-ile	56.9	63.0	66.8	69.3	71.2	71.8
99.91 %-ile	169	186	197	204	209	211
5 %-ile	6.70	6.78	6.81	6.82	6.83	6.83

The incremental differences in modeled in-plume TSS concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-140**. The median incremental increase in TSS concentrations would range from -0.7 mg/L at a distance of 30 feet downstream from the diffuser to -0.1 mg/L at a distance of 700 feet downstream from the diffuser.

Table 5-140: Modeled In-Plume Total Suspended Solids Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (mg/L)					
	30 ft	**60 ft**	**100 ft**	**175 ft**	**350 ft**	**700 ft**
Mean	-0.9	-0.6	-0.4	-0.2	-0.1	-0.1
Median	-0.7	-0.4	-0.2	-0.2	-0.1	-0.1
95%-ile	-2.5	-1.6	-1.1	-0.6	-0.4	-0.3
99.91%-ile	-6	-4	-2	-1	-1	<1
5%-ile	-0.03	-0.01	-0.01	-0.01	<0.01	<0.01

The probability distributions of modeled TSS concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-128**. The median TSS concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-129**.

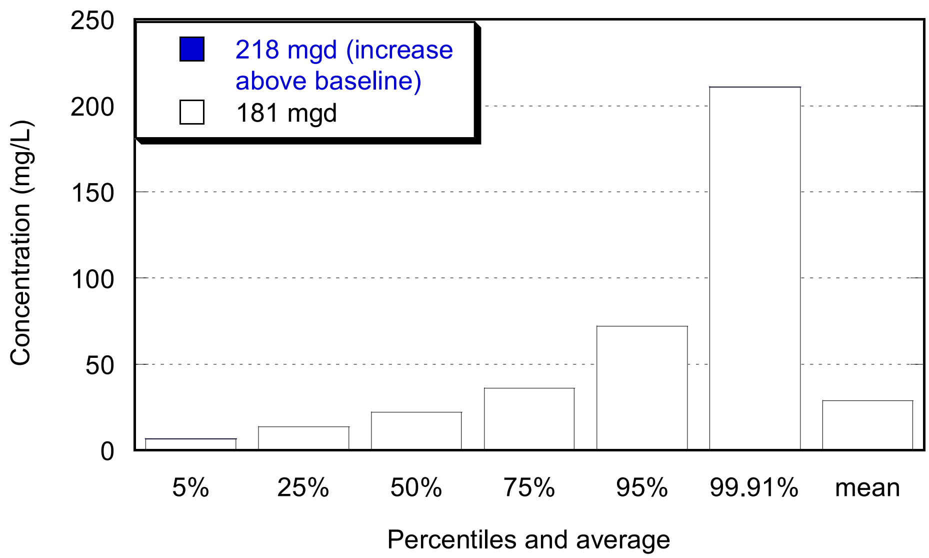

Figure 5-128: Distribution of Modeled Total Suspended Solids Concentrations 700 feet Downstream of SRWTP Diffuser.

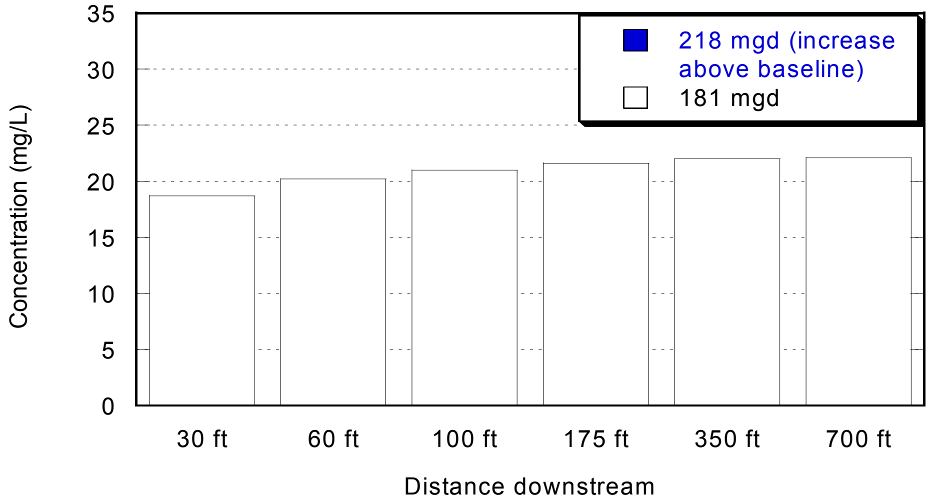

Figure 5-129: Median Modeled Total Suspended Solids Concentration Downstream of SRWTP Diffuser.

5.6.16.2 Comparison to Water Quality Objectives

There are no applicable numeric water quality objectives for TSS in the Sacramento River.

5.6.16.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-138**) and proposed discharge (see **Table 5-139**) have similar characteristics. For the 5th percentile through the 99.91th percentile distributions, TSS concentrations are smaller near the outfall, and increase with distance downstream. All percentile concentrations show a curvilinear increase in the modeled plume with lowest concentrations near the diffuser, indicating that the receiving water concentrations are greater than the effluent concentrations. Furthermore, as listed in **Table 5-140**, the proposed increase in SRWTP effluent discharge would slightly decrease TSS concentrations in the Sacramento River throughout the modeled plume, with the greatest incremental decreases occurring near the discharge and then gradually tapering off with downstream distance.

The incremental change in TSS concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and beneficial to river concentrations. Both the modeled TSS distributions at 700 feet downstream from the diffuser (see **Figure 5-128**) and the modeled, median TSS concentration within the plume (see **Figure 5-129**) show a slight reduction in TSS concentrations in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight decrease in TSS concentrations in the Sacramento River.

5.6.17 1,4-Dichlorobenzene

FSI performed a near-field analysis for 1,4-dichlorobenzene at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from 1,4 dichlorobenzene monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from 1,4 dichlorobenzene measured in SRWTP effluent. The modeled in-plume 1,4-dichlorobenzene concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-141**. Modeled in-plume 1,4-dichlorobenzene concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-142**.

Table 5-141: Modeled In-Plume 1,4-Dichlorobenzene Concentration (μg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.37	0.34	0.31	0.30	0.29	0.28
Median	0.35	0.31	0.28	0.27	0.25	0.25
95 %-ile	0.68	0.62	0.60	0.59	0.58	0.58
99.91 %-ile	1.21	1.22	1.24	1.26	1.28	1.28
5 %-ile	0.15	0.14	0.13	0.12	0.11	0.11

Table 5-142: Modeled In-Plume 1,4-Dichlorobenzene Concentration (μg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.39	0.35	0.32	0.30	0.29	0.29
Median	0.37	0.32	0.29	0.27	0.26	0.25
95 %-ile	0.72	0.64	0.60	0.59	0.58	0.58
99.91 %-ile	1.20	1.22	1.24	1.26	1.27	1.28
5 %-ile	0.15	0.15	0.14	0.13	0.12	0.11

The incremental differences in modeled in-plume 1,4-dichlorobenzene concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-143**. The median incremental increase in 1,4-dichlorobenzene concentrations would range from 0.02 μg/L at a distance of 30 feet downstream from the diffuser to less than 0.01 μg/L at a distance of 175 feet or farther from the diffuser.

Table 5-143: Modeled In-Plume 1,4-Dichlorobenzene Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.02	0.01	0.01	<0.01	<0.01	0.01
Median	0.02	0.01	0.01	0.01	0.01	<0.01
95 %-ile	0.03	0.02	<0.01	<0.01	<0.01	<0.01
99.91 %-ile	-0.01	<0.01	<0.01	<0.01	-0.01	<0.01
5 %-ile	<0.01	0.01	0.01	0.01	0.01	<0.01

The probability distributions of modeled 1,4-dichlorobenzene concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-130**. The median 1,4 dichlorobenzene concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-131**.

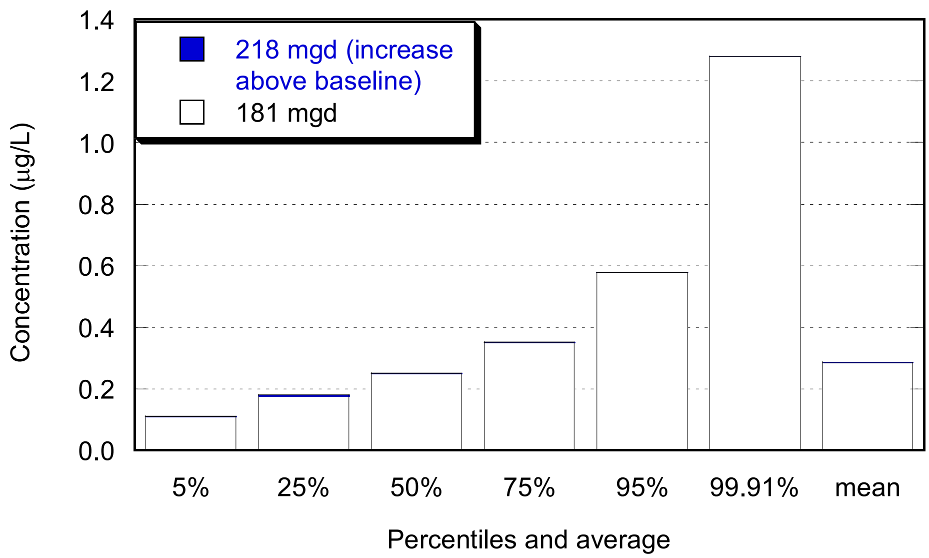

Figure 5-130: Distribution of Modeled 1,4-Dichlorobenzene Concentrations 700 feet Downstream of SRWTP Diffuser.

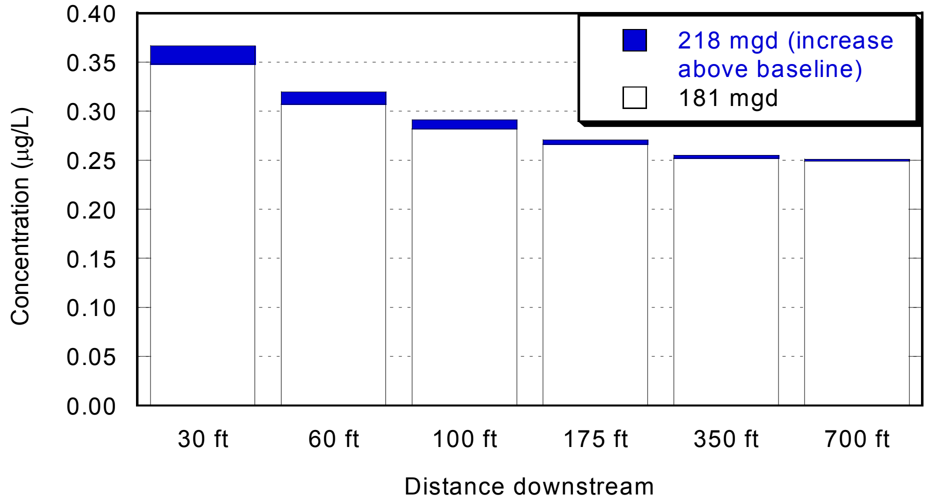

Figure 5-131: Median Modeled 1,4-Dichlorobenzene Concentration Downstream of SRWTP Diffuser.

5.6.17.1 Comparison to Water Quality Objectives

The most stringent water quality objective for 1,4-dichlorobenzene in the Sacramento River is the California Code of Regulations Title 22 Primary MCL of 5 µg/L, incorporated into the Basin Plan by reference. The percent exceedances of the 1,4-dichlorobenzene MCL at various distances downstream from the SRWTP diffuser are listed in **Table 5-144**. Running 30-day averages for concentrations in the Sacramento River were modeled to determine projected exceedance of the MCL in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the 1,4-dichlorobenzene concentrations are not expected to exceed the applicable MCL at any point within the modeled plume.

Table 5-144: DYNTOX Modeled Percent Exceedance Frequency for 1,4-Dichlorobenzene at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Primary MCL Based on Running 30-Day In-Plume concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Primary MCL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the Title 22 Primary MCL for 1,4-dichlorobenzene. To this end, the 5 µg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-141**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-142**). These modeled results are graphically represented in **Figure** 5-130 at a distance of 700 foot downstream from the diffuser. The findings are consistent with the modeled results indicating no exceedances of the 1,4-dichlorobenzene MCL as listed in **Table 5-144**.

5.6.17.2 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-141**) and proposed discharge (see **Table 5-142**) have similar characteristics. Of 62 upstream receiving water samples, none had detectable levels of 1,4-dichlorobenzene (see **Table 5-2**), so the model input used for the evaluation is an estimate heavily biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. In-plume concentrations in the immediate vicinity of the diffuser are generally greater for the proposed discharge (218 mgd) case; however, they are similar for both discharge rates at distances beyond 175 feet downstream of the SRWTP diffuser. As listed in **Table 5-143**, the proposed increase in SRWTP effluent discharge would produce a negligible change of 1,4-dichlorobenzene concentrations within the plume, with no noticeable incremental change beyond 350 feet from the effluent diffuser.

Exceedance frequencies of the most stringent applicable water quality criteria for 1,4-dichlorobenzene, Title 22 Primary MCL, are presented in **Table 5-144**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in MCL exceedances. The incremental change in 1,4-dichlorobenzene concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median 1,4 dichlorobenzene concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled 1,4-dichlorobenzene distributions at 700 feet downstream from the diffuser (see **Figure 5-130**) and the modeled, median 1,4-dichlorobenzene concentration within the plume (see **Figure 5-131**) show a negligible change in 1,4-dichlorobenzene concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in 1,4-dichlorobenzene concentrations in the Sacramento River.

5.6.18 Bis(2-ethylhexyl)phthalate

FSI performed a near-field analysis for bis(2-ethylhexyl)phthalate at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from bis(2-ethylhexyl)phthalate monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from bis(2-ethylhexyl)phthalate measured in SRWTP effluent. The modeled in-plume bis(2-ethylhexyl)phthalate concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-145**. Modeled in-plume bis(2-ethylhexyl)phthalate concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-146**.

Table 5-145: Modeled In-Plume Bis(2-ethylhexyl)phthalate Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.69	0.47	0.35	0.27	0.21	0.19
Median	0.57	0.40	0.29	0.23	0.17	0.15
95 %-ile	1.62	1.09	0.79	0.61	0.47	0.44
99.91 %-ile	3.97	2.79	2.00	1.56	1.30	1.25
5 %-ile	0.14	0.12	0.10	0.082	0.064	0.056

Table 5-146: Modeled In-Plume Bis(2-ethylhexyl)phthalate Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.79	0.54	0.39	0.30	0.22	0.20
Median	0.67	0.45	0.33	0.25	0.18	0.16
95 %-ile	1.85	1.24	0.88	0.66	0.50	0.46
99.91 %-ile	4.31	3.05	2.15	1.63	1.32	1.27
5 %-ile	0.11	0.11	0.096	0.082	0.066	0.058

The incremental differences in modeled in-plume bis(2-ethylhexyl)phthalate concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-147**. The median incremental increase in bis(2-ethylhexyl)phthalate concentrations would range from 0.10 µg/L at a distance of 30 feet downstream from the diffuser to less than 0.01 µg/L at a distance of 350 feet or farther from the diffuser.

Table 5-147: Modeled In-Plume Bis(2-ethylhexyl)phthalate Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.10	0.07	0.04	0.03	0.01	0.01
Median	0.10	0.05	0.04	0.02	0.01	0.01
95 %-ile	0.23	0.15	0.09	0.05	0.03	0.02
99.91 %-ile	0.34	0.26	0.15	0.07	0.02	0.02
5 %-ile	-0.03	-0.01	-0.004	<0.001	0.002	0.002

The probability distributions of modeled bis(2-ethylhexyl)phthalate concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-132**. The median bis(2-ethylhexyl)phthalate concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-133**.

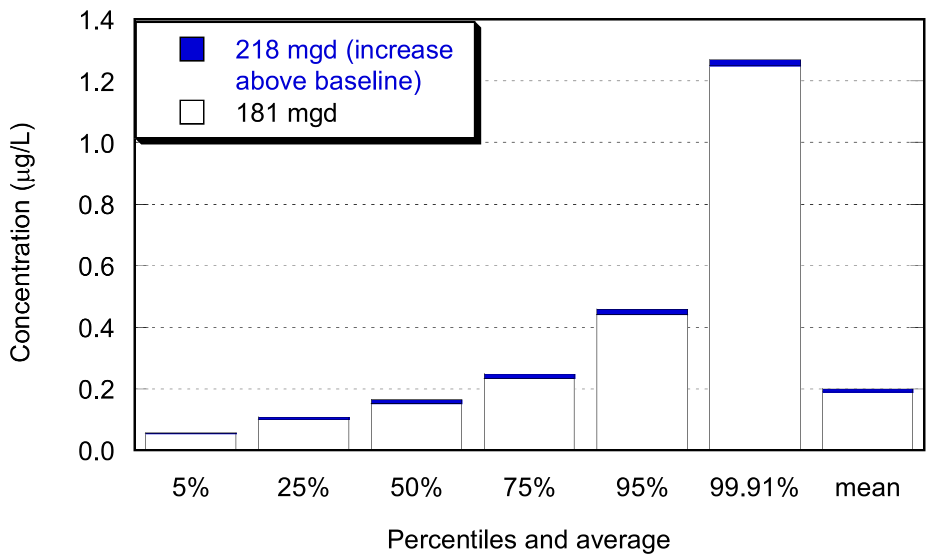

Figure 5-132: Distribution of Modeled Bis(2-ethylhexyl)phthalate Concentrations 700 feet Downstream of SRWTP Diffuser.

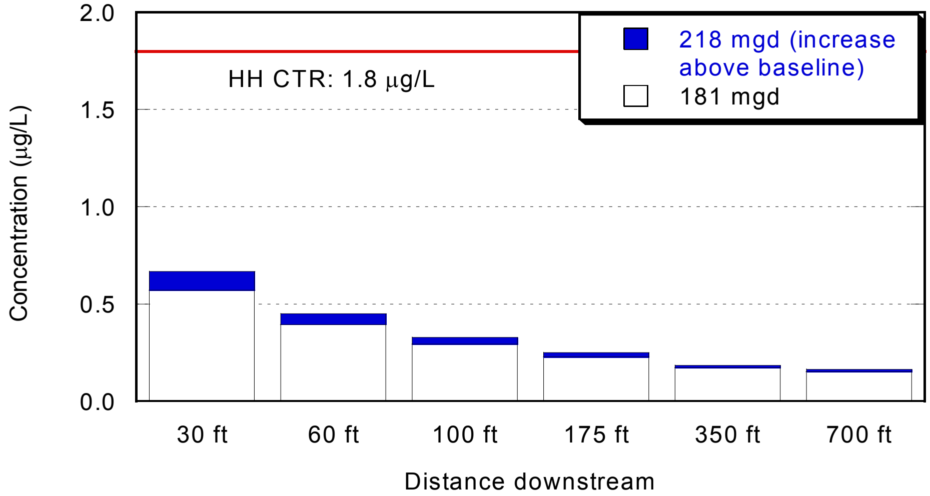

Figure 5-133: Median Modeled Bis(2-ethylhexyl)phthalate Concentration Downstream of SRWTP Diffuser.

5.6.18.1 Comparison to Water Quality Objectives

The CTR criterion of 1.8 µg/L for the protection of human health for the consumption of water and aquatic organisms is the most stringent water quality objective applicable for bis(2-ethylhexyl)phthalate in the Sacramento River. The percent exceedances of the criterion at various distances downstream from the SRWTP diffuser are listed in **Table 5-148**. Running 30-day averages for concentrations in the Sacramento River were modeled to determine projected exceedance of the CTR human health criterion in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the bis(2-ethylhexyl)phthalate concentrations are not expected to exceed the criterion at any point within the modeled plume.

Table 5-148: DYNTOX Modeled Percent Exceedance Frequency for Bis(2-ethylhexyl)phthalate at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Human Health Criterion Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
CTR Human Health	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The mean and median values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the CTR criterion for bis(2-ethylhexyl)phthalate. The 1.8 µg/L objective is met more than 95% of times at distances 60 feet or greater from SRWTP diffuser under the existing discharge condition (181 mgd), see **Table 5-145**, and would continue to be met with the proposed discharge increase (218 mgd), see **Table 5-146**. The objective, however, is applied as a 30-day average and, as indicated in **Table 5-148**, therefore no exceedances are expected at any modeled distance within the initial mixing zone. These modeled results are graphically represented in **Figure 5-132** at a distance of 700 foot downstream from the diffuser.

5.6.18.2 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-145**) and proposed discharge (see **Table 5-146**) have similar characteristics. For the 5th percentile through the 99.91th percentile distributions, bis(2-ethylhexyl)phthalate concentrations are greater near the outfall. All percentile concentrations show a curvilinear decrease in the modeled plume with highest concentrations near the diffuser, also indicating that the receiving water concentrations are less than the effluent concentrations. Concentrations in the immediate vicinity of the diffuser are generally greater for the proposed discharge (218 mgd) case; however, little difference can be discerned beyond 350 feet downstream of the diffuser. As listed in **Table 5-147**, the proposed increase in SRWTP effluent discharge would result in slight increase of bis(2-ethylhexyl)phthalate concentrations within the plume, with the greatest incremental increases occurring near the discharge and then gradually tapering off with downstream distance.

Exceedance frequencies of the most stringent applicable water quality objective, the CTR criterion of 1.8 µg/L for the protection of human health for the consumption of water and aquatic organisms, are presented in **Table 5-148**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in objective exceedances. The incremental change in bis(2-ethylhexyl)phthalate concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median bis(2-ethylhexyl)phthalate concentrations that are below the most stringent applicable water quality criteria. Both the modeled bis(2-ethylhexyl)phthalate distributions at 700 feet downstream from the diffuser (see **Figure 5-132**) and the modeled, median bis(2-ethylhexyl)phthalate concentration within the plume (see **Figure 5-133**) show a slight incremental change in bis(2-ethylhexyl)phthalate concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in bis(2-ethylhexyl)phthalate concentrations in the Sacramento River.

5.6.19 Bromodichloromethane

FSI performed a near-field analysis for bromodichloromethane at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from bromodichloromethane monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from bromodichloromethane measured in SRWTP effluent. The modeled in-plume bromodichloromethane concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-149**. Modeled in-plume bromodichloromethane concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-150**.

Table 5-149: Modeled In-Plume Bromodichloromethane Concentration (µg/L) at Varying Distances Downstream of the SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.51	0.46	0.43	0.41	0.39	0.39
Median	0.48	0.42	0.39	0.36	0.35	0.34
95 %-ile	0.92	0.85	0.82	0.80	0.80	0.79
99.91 %-ile	1.64	1.68	1.71	1.74	1.75	1.76
5 %-ile	0.22	0.20	0.18	0.17	0.16	0.15

Table 5-150: Modeled In-Plume Bromodichloromethane Concentration (µg/L) at Varying Distances Downstream of the SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.53	0.47	0.44	0.42	0.40	0.39
Median	0.50	0.44	0.40	0.37	0.35	0.34
95 %-ile	0.95	0.86	0.82	0.81	0.80	0.80
99.91 %-ile	1.62	1.67	1.70	1.73	1.75	1.75
5 %-ile	0.22	0.20	0.19	0.17	0.16	0.15

The incremental differences in modeled in-plume bromodichloromethane concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-151**. The median incremental increase in bromodichloromethane concentrations would range from 0.03 µg/L at a distance of 30 feet downstream from the diffuser to 0.01 µg/L and lower at distances of 100 feet and farther downstream from the diffuser.

Table 5-151: Modeled In-Plume Bromodichloromethane Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.02	0.01	0.01	0.01	0.01	<0.01
Median	0.02	0.02	0.01	0.01	<0.01	<0.01
95 %-ile	0.03	0.01	<0.01	0.01	<0.01	0.01
99.91 %-ile	-0.02	-0.01	-0.01	-0.01	<0.01	-0.01
5 %-ile	<0.01	<0.01	0.01	<0.01	<0.01	<0.01

The probability distributions of modeled bromodichloromethane concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-134**. The median bromodichloromethane concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-135**.

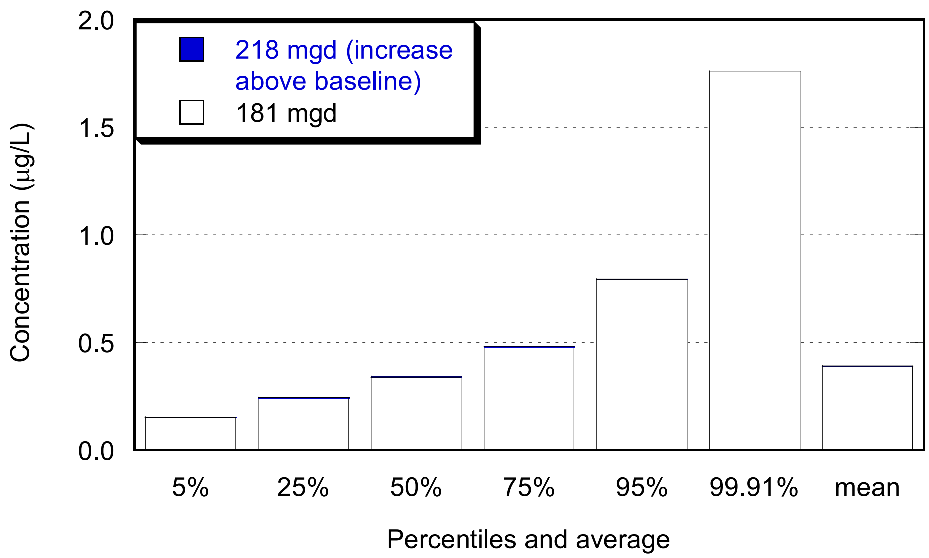

Figure 5-134: Distribution of Modeled Bromodichloromethane Concentrations 700 feet Downstream of SRWTP Diffuser.

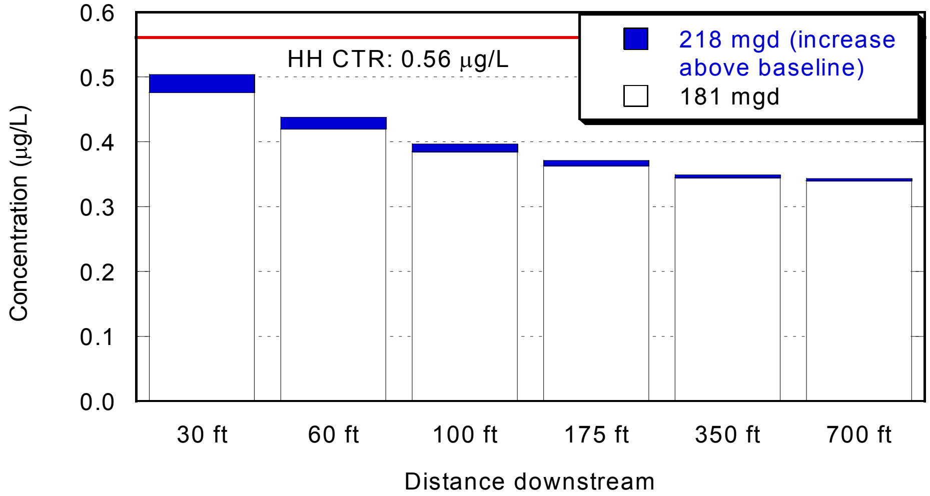

Figure 5-135: Median Modeled Bromodichloromethane Concentration Downstream of SRWTP Diffuser.

5.6.19.1 Comparison to Water Quality Objectives

The CTR criterion of 0.56 µg/L for the protection of human health for the consumption of water and aquatic organisms is the most stringent water quality objective applicable for bromodichloromethane in the Sacramento River. The percent exceedances of the bromodichloromethane criterion at various distances downstream from the SRWTP diffuser are listed in **Table 5-152**. Running 30-day averages for concentrations in the Sacramento River were modeled to determine projected exceedance of the criterion in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the bromodichloromethane 30-day average concentrations are not expected to exceed the applicable objective at distances of 60 feet or greater from the SRWTP diffuser.

Table 5-152: DYNTOX Modeled Percent Exceedance Frequency for Bromodichloromethane at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge with Exceedances of the Human Health Criterion Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
CTR Human Health	31.4%	0.00%	0.00%	0.00%	0.00%	0.00%

The mean and median values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the most stringent bromodichloromethane criteria at all modeled distances within the plume. Results for the 95th percentile probability distribution of the modeled in-plume concentrations indicate that there are times when the objective would be exceeded within the plume, under both the existing discharge condition (181 mgd) and the proposed discharge increase (218 mgd) (see **Table 5-149** and **Table 5-150**, respectively). The objective, however, is applied as a 30-day average, and as indicated in **Table 5-152**, infrequent exceedances would only be encountered in the immediate vicinity of the SRWTP diffuser. These modeled results are graphically represented in **Figure 5-134** at a distance of 700 foot downstream from the diffuser.

5.6.19.2 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-149**) and proposed discharge (see **Table 5-150**) have similar characteristics. Of 43 upstream receiving water samples, none had detectable levels of bromodichloromethane (see **Table 5-2**), so the model input used for the evaluation is an estimate heavily biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. Concentrations in the immediate vicinity of the diffuser are generally greater for the proposed discharge (218 mgd) case; however, they are similar for both discharge rates at distances beyond 350 feet downstream of the discharge. As listed in **Table 5-151**, the proposed increase in SRWTP effluent discharge would slightly increase bromodichloromethane concentrations in the vicinity of the SRWTP diffuser, but the difference in concentrations is negligible at distances farther than 100 feet from the diffuser.

Exceedance frequencies of the most stringent applicable water quality criteria, the CTR criterion of 0.56 µg/L for the protection of human health for the consumption of water and aquatic organisms, are presented in **Table 5-152**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in criterion exceedances at distances of 60 feet or greater downstream of the SRWTP diffuser. The incremental change in bromodichloromethane concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project the median bromodichloromethane concentrations to be below the most stringent applicable water quality criteria at all modeled distances within the plume. Both the modeled bromodichloromethane distributions at 700 feet downstream from the diffuser (see **Figure 5-134**) and the modeled, median bromodichloromethane concentration within the plume (see **Figure 5-135**) show a negligible incremental change in bromodichloromethane concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in bromodichloromethane concentrations in the Sacramento River.

5.6.20 Chloroethane

5.6.20.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for chloroethane at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from chloroethane monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from chloroethane measured in SRWTP effluent. The modeled in-plume chloroethane concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-153**. Modeled in-plume chloroethane concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-154**.

Table 5-153: Modeled In-Plume Chloroethane Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	**60 ft**	**100 ft**	**175 ft**	**350 ft**	**700 ft**
Mean	0.39	0.40	0.41	0.41	0.41	0.42
Median	0.34	0.35	0.35	0.36	0.36	0.36
95 %-ile	0.77	0.81	0.84	0.86	0.87	0.88
99.91 %-ile	1.69	1.79	1.86	1.90	1.94	1.95
5 %-ile	0.16	0.16	0.16	0.15	0.15	0.15

Table 5-154: Modeled In-Plume Chloroethane Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	**60 ft**	**100 ft**	**175 ft**	**350 ft**	**700 ft**
Mean	0.38	0.40	0.40	0.41	0.41	0.42
Median	0.34	0.35	0.35	0.36	0.36	0.36
95 %-ile	0.75	0.80	0.83	0.85	0.87	0.87
99.91 %-ile	1.64	1.75	1.84	1.89	1.93	1.95
5 %-ile	0.16	0.16	0.16	0.15	0.15	0.15

The incremental differences in modeled in-plume chloroethane concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-155**. The median incremental increase in chloroethane concentrations are less than 0.01 µg/L at all modeled distances within the initial mixing zone.

Table 5-155: Modeled In-Plume Chloroethane Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	-0.01	<0.01	0.01	<0.01	<0.01	<0.01
Median	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
95 %-ile	-0.02	-0.01	-0.01	-0.01	<0.01	<0.01
99.91 %-ile	-0.05	-0.04	-0.02	-0.01	-0.01	<0.01
5 %-ile	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

The probability distributions of modeled chloroethane concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-136**. The median chloroethane concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-137**.

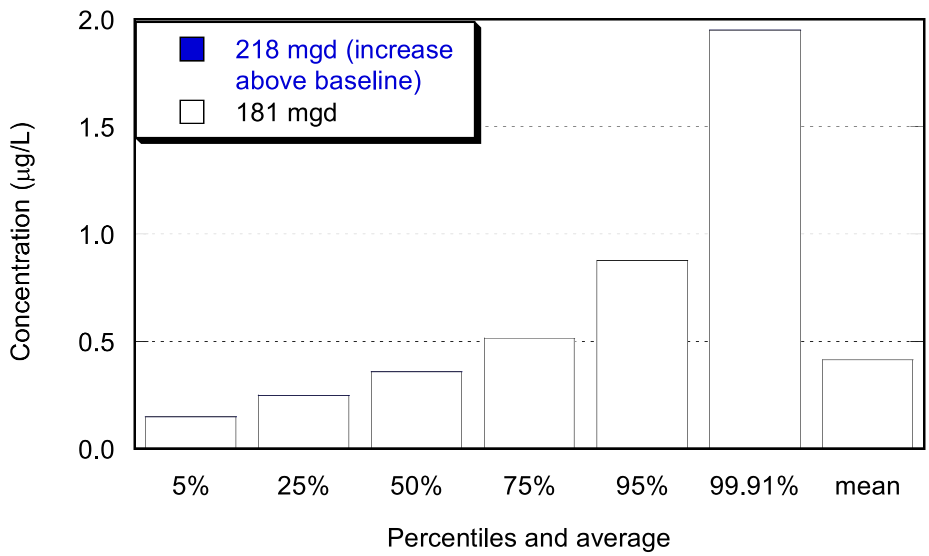

Figure 5-136: Distribution of Modeled Chloroethane Concentrations 700 feet Downstream of SRWTP Diffuser.

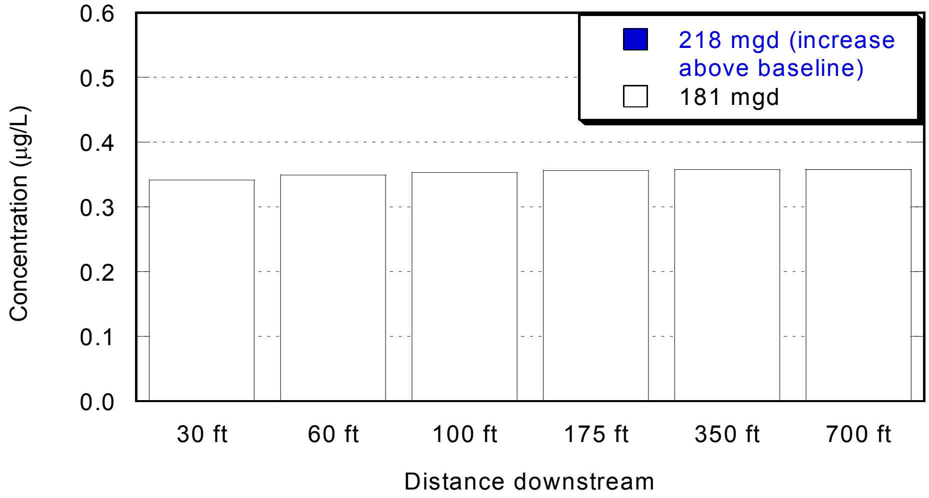

Figure 5-137: Median Modeled Chloroethane Concentration Downstream of SRWTP Diffuser.

5.6.20.2 Comparison to Water Quality Objectives

There are no applicable water quality objectives for chloroethane. At the time of the development of the national ambient water quality criteria for chlorinated ethanes, there was insufficient information available to develop chloroethane objectives. However, the criteria document notes that chloroethane is considered one of the least toxic chlorinated ethanes (U.S. EPA, 1980).

5.6.20.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-153**) and proposed discharge (see **Table 5-154**) have similar characteristics. Of 44 upstream receiving water samples, none had detectable levels of chloroethane (see **Table 5-2**), so the model input used for the evaluation is an estimate heavily biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. As listed in **Table 5-155**, concentrations are lower for the proposed discharge (218 mgd) case; however, little difference can be discerned; the median decrease is less than 0.01 µg/L at all modeled in-plume locations.

There is no water quality objective for chloroethane, but SRWTP effluent concentrations do show approximately 30% detection out of the 73 effluent samples considered in the analysis (see **Table 5-2**). The increase in SRWTP discharge from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is not expected to increase in-plume chloroethane concentrations. Both the modeled chloroethane distributions at 700 feet downstream of the diffuser (see **Figure 5-136**) and the modeled, in-plume median concentration (see **Figure 5-137**) indicate there are no noticeable changes in chloroethane concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change of chloroethane concentrations in the Sacramento River.

5.6.21 Chloroform

5.6.21.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for chloroform at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from chloroform monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from chloroform measured in SRWTP effluent. The modeled in-plume chloroform concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-156**. Modeled in-plume chloroform concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-157**.

Table 5-156: Modeled In-Plume Chloroform Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	4.19	2.99	2.28	1.84	1.48	1.38
Median	3.78	2.69	2.07	1.67	1.34	1.24
95 %-ile	8.50	5.93	4.36	3.43	2.78	2.62
99.91 %-ile	16.0	11.9	8.65	6.67	5.34	5.07
5 %-ile	1.18	1.07	0.94	0.81	0.67	0.60

Table 5-157: Modeled In-Plume Chloroform Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	4.76	3.34	2.51	1.98	1.56	1.44
Median	4.39	3.03	2.29	1.81	1.42	1.31
95 %-ile	9.52	6.65	4.83	3.70	2.90	2.70
99.91 %-ile	17.2	12.7	9.18	6.89	5.43	5.16
5 %-ile	1.02	1.00	0.93	0.82	0.68	0.62

The incremental differences in modeled in-plume chloroform concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-158**. The median incremental increase in chloroform concentrations would range from 0.61 µg/L at a distance of 30 feet downstream from the diffuser to 0.07 µg/L at a distance of 700 feet from the diffuser.

Table 5-158: Modeled In-Plume Chloroform Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.57	0.35	0.23	0.14	0.08	0.06
Median	0.61	0.34	0.22	0.14	0.08	0.07
95 %-ile	1.02	0.72	0.47	0.27	0.12	0.08
99.91 %-ile	1.2	0.8	0.53	0.22	0.09	0.09
5 %-ile	-0.16	-0.07	-0.01	0.01	0.02	0.02

The probability distributions of modeled chloroform concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-138**. The median chloroform concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-139**.

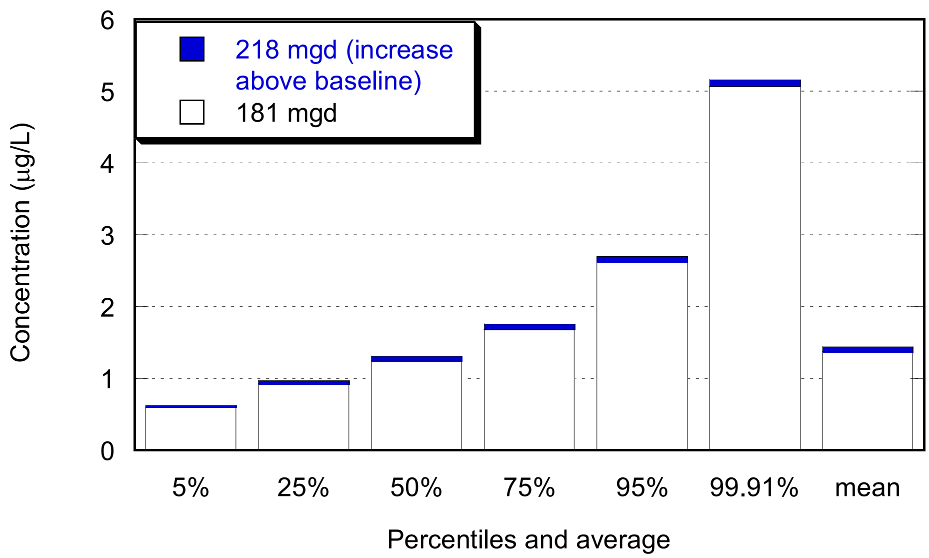

Figure 5-138: Distribution of Modeled Chloroform Concentrations 700 feet Downstream of SRWTP Diffuser.

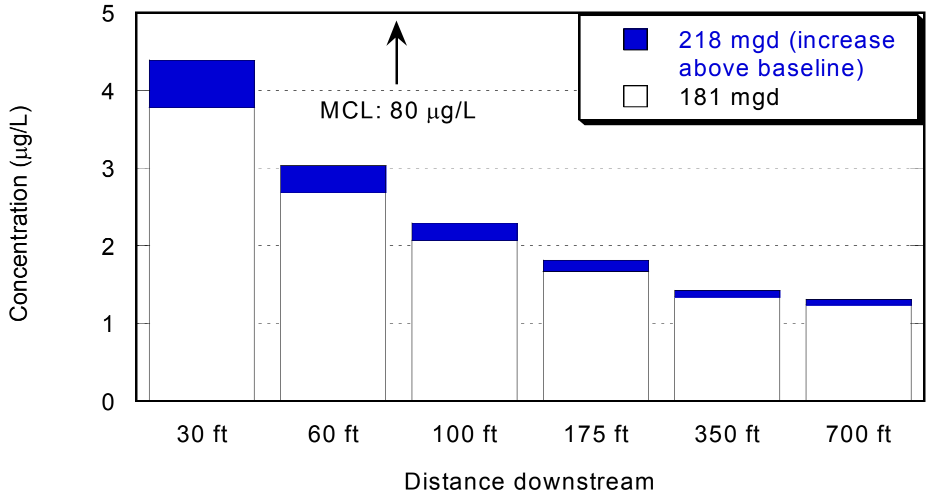

Figure 5-139: Median Modeled Chloroform Concentration Downstream of SRWTP Diffuser.

5.6.21.2 Comparison to Water Quality Objectives

The most stringent water quality objective for chloroform in the Sacramento River is the California Code of Regulations Title 22 Primary MCL of 80 µg/L for the purpose of reporting disinfection byproducts, incorporated into the Basin Plan by reference. The percent exceedances of the chloroform MCL at various distances downstream from the SRWTP diffuser are listed in **Table 5-159**. Running 30-day averages for concentrations in the Sacramento River were modeled to determine projected exceedance of the MCL in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the chloroform concentrations are not expected to exceed the applicable MCL at any point within the modeled plume.

Table 5-159: DYNTOX Modeled Percent Exceedance Frequency for Chloroform at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Primary MCL Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Primary MCL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are substantially lower than the Title 22 Primary MCL for chloroform. To this end, the 80 µg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-156**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-157**). These modeled results are graphically represented in **Figure 5-138** at a distance of 700 foot downstream from the diffuser. The findings are consistent with the modeled results indicating no exceedances of the chloroform MCL as listed in **Table 5-159**.

5.6.21.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-156**) and proposed discharge (see **Table 5-157**) have similar characteristics. Of 46 upstream receiving water samples, 9% had detectable levels of chloroform (see **Table 5-2**), so the model input used for the evaluation is an estimate heavily biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. Concentrations in the immediate vicinity of the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the incremental difference between the two conditions gradually decreases with downstream distance. As listed in **Table 5-158**, the proposed increase in SRWTP effluent discharge would produce a slight increase in chloroform concentrations within the plume, with the greatest incremental increases occurring near the discharge and then gradually tapering off with downstream distance.

Exceedance frequencies of the most stringent applicable water quality criteria for chloroform, Title 22 Primary MCL, are presented in **Table 5-159**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in MCL exceedances. The incremental change in chloroform concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is slight and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median chloroform concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled chloroform distributions at 700 feet downstream from the diffuser (see **Figure 5-138**) and the modeled, median chloroform concentration within the plume (see **Figure 5-139**) show a slight incremental increase in chloroform concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a slight increase in chloroform concentrations in the Sacramento River.

5.6.22 Diethyl Phthalate

5.6.22.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for diethyl phthalate at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from diethyl phthalate monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from diethyl phthalate measured in SRWTP effluent. The modeled in-plume diethyl phthalate concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-160**. Modeled in-plume diethyl phthalate concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-161**.

Table 5-160: Modeled In-Plume Diethyl Phthalate Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.38	0.26	0.19	0.14	0.11	0.095
Median	0.15	0.12	0.10	0.083	0.069	0.065
95 %-ile	1.36	0.87	0.59	0.42	0.28	0.25
99.91 %-ile	10.9	7.1	4.69	3.17	2.00	1.67
5 %-ile	0.033	0.030	0.027	0.025	0.022	0.021

Table 5-161: Modeled In-Plume Diethyl Phthalate Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.43	0.29	0.21	0.16	0.11	0.101
Median	0.17	0.13	0.10	0.087	0.072	0.067
95 %-ile	1.59	1.02	0.68	0.47	0.31	0.27
99.91 %-ile	12.8	8.2	5.44	3.65	2.26	1.86
5 %-ile	0.033	0.030	0.027	0.025	0.022	0.021

The incremental differences in modeled in-plume diethyl phthalate concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-162**. The median incremental increase in diethyl phthalate concentrations would range from 0.02 µg/L at a distance of 30 feet downstream from the diffuser to less than 0.01 µg/L at a distance of 175 feet or farther from the diffuser.

Table 5-162: Modeled In-Plume Diethyl Phthalate Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rates from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.05	0.03	0.02	0.02	<0.01	<0.01
Median	0.02	0.01	0.01	<0.01	<0.01	<0.01
95 %-ile	0.23	0.15	0.09	0.05	0.03	0.02
99.91 %-ile	1.9	1.1	0.75	0.48	0.26	0.19
5 %-ile	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

The probability distributions of modeled diethyl phthalate concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-140**. The median diethyl phthalate concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-141**.

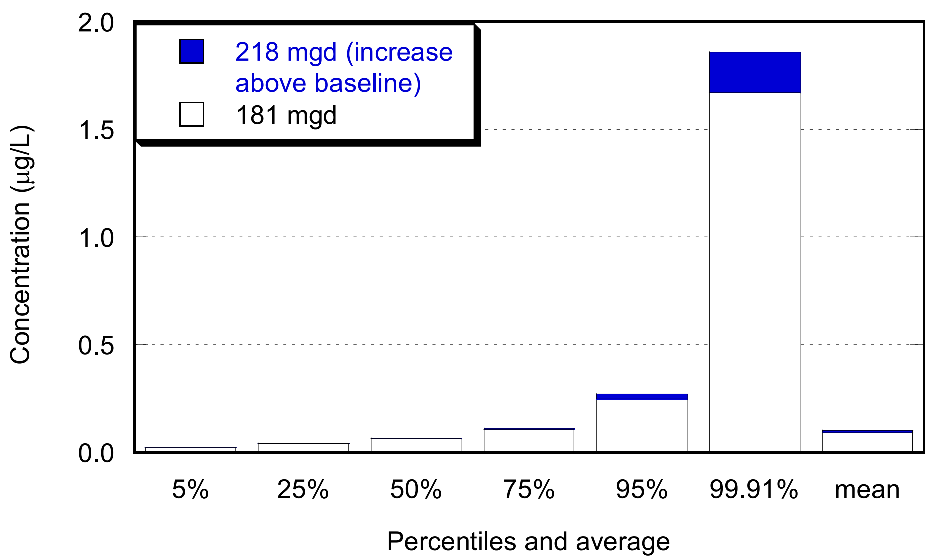

Figure 5-140: Distribution of Modeled Diethyl Phthalate Concentrations 700 feet Downstream of SRWTP Diffuser.

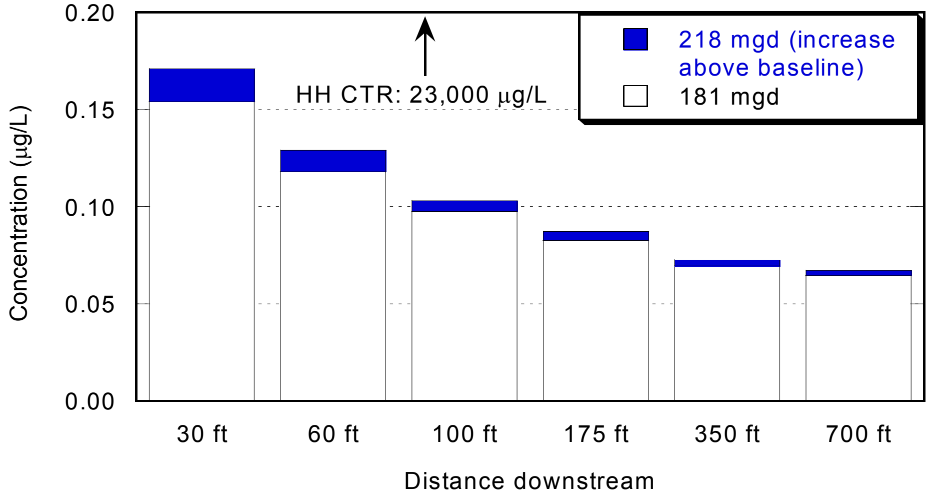

Figure 5-141: Median Modeled Diethyl Phthalate Concentration Downstream of SRWTP Diffuser.

5.6.22.2 Comparison to Water Quality Objectives

The CTR criterion of 23,000 µg/L for the protection of human health for the consumption of water and aquatic organisms is the most stringent water quality objective applicable for diethyl phthalate in the Sacramento River. The percent exceedances of the criterion at various distances downstream from the SRWTP diffuser are listed in **Table 5-163**. Running 30-day averages for diethyl phthalate concentrations in the Sacramento River were modeled to determine projected exceedance of the CTR human health criterion in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the diethyl phthalate concentrations are not expected to exceed the criterion at any point within the modeled plume.

Table 5-163: DYNTOX Modeled Percent Exceedance Frequency of Diethyl Phthalate at Various Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Human Health Criterion Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
CTR Human Health	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are substantially lower than the CTR human health criterion for diethyl phthalate. To this end, the 23,000 µg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-160**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-161**). These modeled results are graphically represented in **Figure 5-140** at a distance of 700 feet downstream from the diffuser. The findings are consistent with the modeled results listed in **Table 5-163** indicating no exceedances of the diethyl phthalate criterion.

5.6.22.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-160**) and proposed discharge (see **Table 5-161**) have similar characteristics. Of 53 upstream receiving water samples, 32% had detectable levels of diethyl phthalate (see **Table 5-2**), so the model input used for the evaluation is an estimate biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. Concentrations in the immediate vicinity of the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the concentrations in the middle and end of the modeled plume are similar for both discharge rates. As listed in **Table 5-162**, the proposed increase in SRWTP effluent discharge would slightly increase diethyl phthalate concentrations within the plume, with the greatest incremental increases occurring near the discharge and then gradually tapering off with downstream distance.

Exceedance frequencies of the most stringent applicable water quality objective for diethyl phthalate, the CTR criterion of 23,000 µg/L for the protection of human health for the consumption of water and aquatic organisms, are presented in **Table 5-163**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in objective exceedances. The incremental change in diethyl phthalate concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median diethyl phthalate concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled diethyl phthalate distributions at 700 feet downstream from the diffuser (see **Figure 5-140**) and the modeled, median diethyl phthalate concentration within the plume (see **Figure 5-141**) show a negligible change in diethyl phthalate concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in diethyl phthalate concentrations in the Sacramento River.

5.6.23 Di-n-butyl Phthalate

5.6.23.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for di-n-butyl phthalate at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from di-n-butyl phthalate monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from di-n-butyl phthalate measured in SRWTP effluent. The modeled in-plume di-n-butyl phthalate concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-164**. Modeled in-plume di-n-butyl phthalate concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-165**.

Table 5-164: Modeled In-Plume Di-n-Butyl Phthalate Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.44	0.34	0.29	0.25	0.22	0.21
Median	0.32	0.27	0.24	0.22	0.19	0.19
95 %-ile	1.20	0.84	0.64	0.54	0.47	0.46
99.91 %-ile	5.27	3.51	2.40	1.70	1.16	1.01
5 %-ile	0.086	0.071	0.060	0.051	0.041	0.037

Table 5-165: Modeled In-Plume Di-n-Butyl Phthalate Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.49	0.37	0.30	0.26	0.22	0.21
Median	0.34	0.29	0.25	0.23	0.20	0.19
95 %-ile	1.38	0.94	0.70	0.57	0.48	0.47
99.91 %-ile	6.08	4.00	2.71	1.89	1.24	1.08
5 %-ile	0.088	0.074	0.063	0.053	0.043	0.039

The incremental differences in modeled in-plume di-n-butyl phthalate concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-166**. The median incremental increase in di-n-butyl phthalate concentrations would range from 0.02 µg/L at a distance of 30 feet downstream from the diffuser to 0.01 µg/L or less at a distance of 100 feet or farther from the diffuser.

Table 5-166: Modeled In-Plume Di-n-Butyl Phthalate Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.05	0.03	0.01	0.01	<0.01	<0.01
Median	0.02	0.02	0.01	0.01	0.01	<0.01
95 %-ile	0.18	0.10	0.06	0.03	0.01	0.01
99.91 %-ile	0.81	0.49	0.31	0.19	0.08	0.07
5 %-ile	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

The probability distributions of modeled di-n-butyl phthalate concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-142**. The median di-n-butyl phthalate concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-143**.

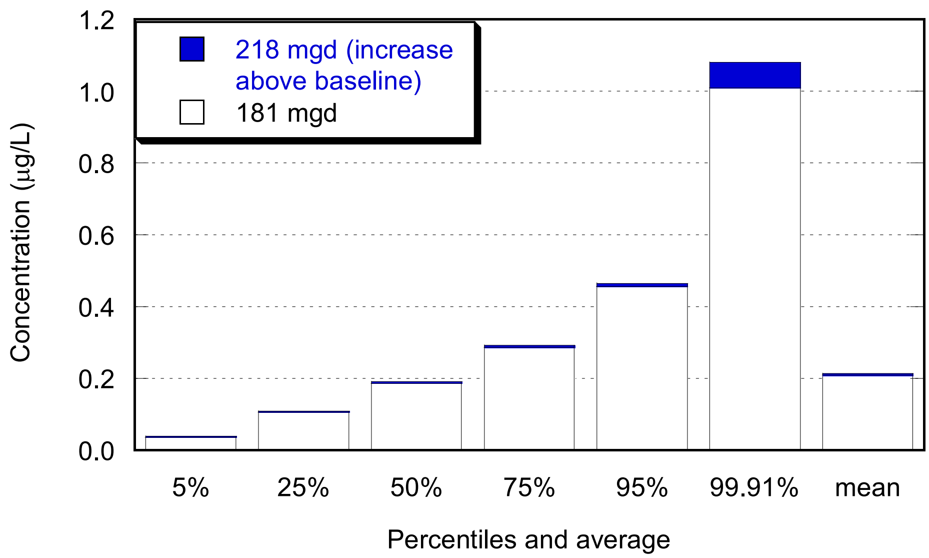

Figure 5-142: Distribution of Modeled Di-n-Butyl Phthalate Concentrations 700 feet Downstream of SRWTP Diffuser.

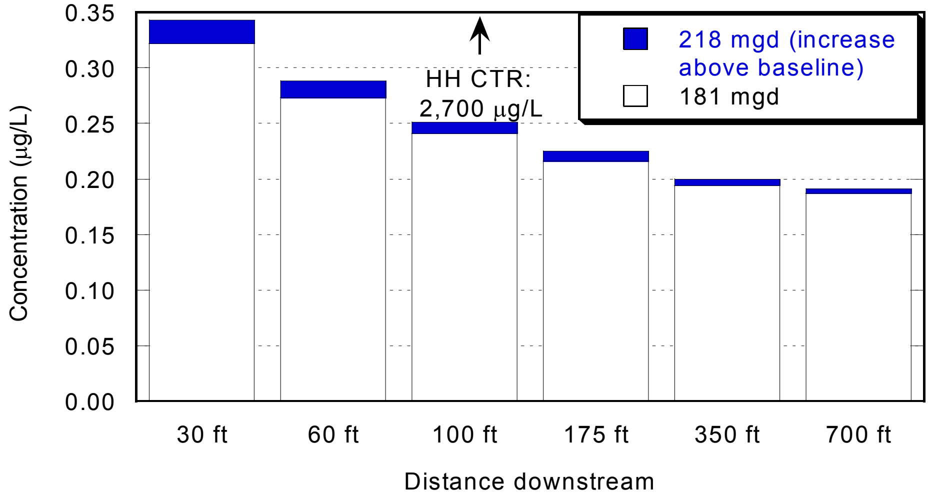

Figure 5-143: Median Modeled Di-n-Butyl Phthalate Concentration Downstream of SRWTP Diffuser.

5.6.23.2 Comparison to Water Quality Objectives

The CTR criterion of 2,700 µg/L for the protection of human health for the consumption of water and aquatic organisms is the most stringent water quality objective applicable for di-n-butyl phthalate in the Sacramento River. The percent exceedances of the criterion at various distances downstream from the SRWTP diffuser are listed in **Table 5-167**. Running 30-day averages for concentrations of di-n-butyl phthalate in the Sacramento River were modeled to determine projected exceedance of the CTR criterion in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the di-n-butyl phthalate concentrations are not expected to exceed the criterion at any point within the modeled plume.

Table 5-167: DYNTOX Modeled Percent Exceedance Frequency for Di-n-Butyl Phthalate at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Human Health Criterion Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
CTR Human Health	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are substantially lower than the CTR human health criterion for di-n-butyl phthalate. To this end, the 2,700 µg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-164**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-165**). These modeled results are graphically represented in **Figure 5-142** at a distance of 700 feet downstream from the diffuser. The findings are consistent with the modeled results listed in **Table 5-167** indicating no exceedances of the di-n-butyl phthalate criterion.

5.6.23.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-164**) and proposed discharge (see **Table 5-165**) have similar characteristics. Of 53 upstream receiving water samples, 32% had detectable levels of di-n-butyl phthalate (see **Table 5-2**), so the model input used for the evaluation is an estimate biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. Concentrations in the immediate vicinity of the diffuser are generally greater for the proposed discharge (218 mgd) case; however, little difference can be discerned beyond 175 feet downstream of the diffuser. As listed in **Table 5-166**, the proposed increase in SRWTP effluent discharge would produce negligible increases of di-n-butyl phthalate concentrations within the plume, with the greatest incremental increases occurring near the discharge and then gradually tapering off with downstream distance.

Exceedance frequencies of the most stringent applicable water quality objective, the CTR criterion of 2,700 µg/L for the protection of human health for the consumption of water and aquatic organisms, are presented in **Table 5-167**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in objective exceedances. The incremental change in di-n-butyl phthalate concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median di-n-butyl phthalate concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled di-n-butyl phthalate distributions at 700 feet downstream from the diffuser (see **Figure 5-142**) and the modeled, median di-n-butyl phthalate concentration within the plume (see **Figure 5-143**) show a negligible incremental change in di-n-butyl phthalate concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in di-n-butyl phthalate concentrations in the Sacramento River.

5.6.24 Methyl Chloride

5.6.24.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for methyl chloride at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from methyl chloride monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from methyl chloride measured in SRWTP effluent. The modeled in-plume methyl chloride concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-168**. Modeled in-plume methyl chloride concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-169**.

Table 5-168: Modeled In-Plume Methyl Chloride Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.53	0.51	0.50	0.49	0.48	0.48
Median	0.48	0.45	0.44	0.43	0.42	0.42
95 %-ile	1.01	0.99	0.98	0.99	0.99	0.99
99.91 %-ile	2.06	2.07	2.11	2.15	2.19	2.20
5 %-ile	0.23	0.21	0.20	0.19	0.18	0.18

Table 5-169: Modeled In-Plume Methyl Chloride Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.54	0.51	0.50	0.49	0.48	0.48
Median	0.49	0.46	0.44	0.43	0.42	0.42
95 %-ile	1.03	0.99	0.98	0.99	0.99	0.99
99.91 %-ile	2.09	2.05	2.09	2.14	2.18	2.20
5 %-ile	0.23	0.22	0.21	0.19	0.18	0.18

The incremental differences in modeled in-plume methyl chloride concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-170**. The median incremental increase in methyl chloride concentrations are equal to or less than 0.01 µg/L at all modeled distances within the initial mixing zone.

Table 5-170: Modeled In-Plume Methyl Chloride Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Median	0.01	0.01	<0.01	<0.01	<0.01	<0.01
95 %-ile	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
99.91 %-ile	0.03	-0.02	-0.02	-0.01	-0.01	<0.01
5 %-ile	<0.01	0.01	0.01	<0.01	<0.01	<0.01

The probability distributions of modeled methyl chloride concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-144**. The median methyl chloride concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-145**.

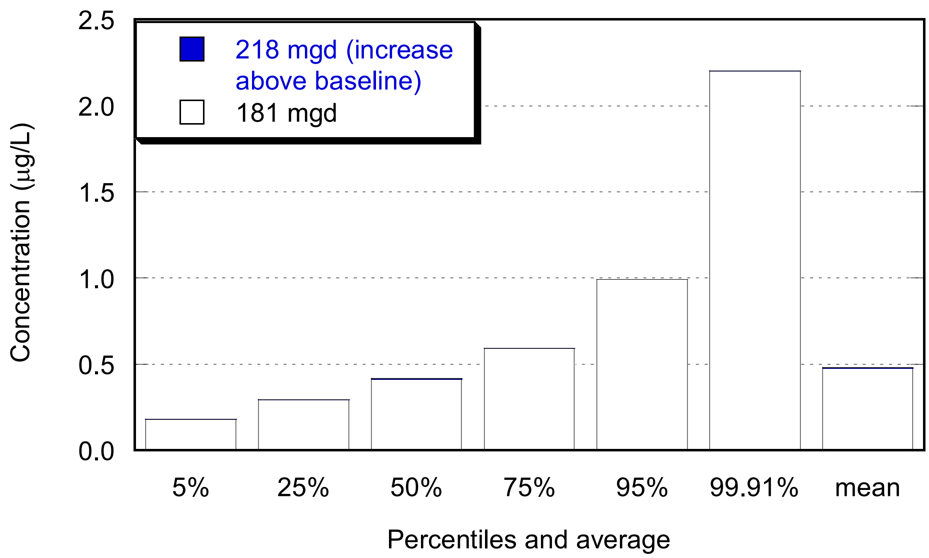

Figure 5-144: Distribution of Modeled Methyl Chloride Concentrations 700 feet Downstream of SRWTP Diffuser.

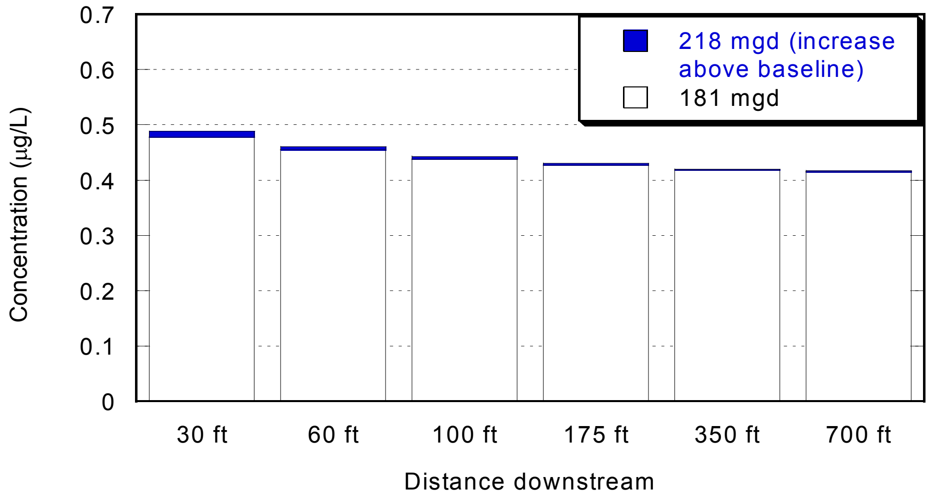

Figure 5-145: Median Modeled Methyl Chloride Concentration Downstream of SRWTP Diffuser.

5.6.24.2 Comparison to Water Quality Objectives

There are no applicable water quality objectives for methyl chloride. From the little information available on this constituent, it is understood that human exposure and uptake of methyl chloride from fluids is minor and uptake from other sources, mostly air, is more significant (U.S. EPA, 1980).

5.6.24.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-168**) and proposed discharge (see **Table 5-169**) have similar characteristics. Of 44 upstream receiving water samples, 5% had detectable levels of methyl chloride (see **Table 5-2**), so the model input used for the evaluation is an estimate heavily biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. As listed in **Table 5-170**, concentrations show a negligible increase for the proposed discharge (218 mgd) case; with median incremental changes of 0.01 µg/L or less at all modeled in-plume locations.

The incremental change in methyl chloride concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. Both the modeled methyl chloride distributions at 700 feet downstream of the diffuser (see **Figure 5-144**) and the modeled, in-plume median concentration (see **Figure 5-145**) indicate negligible increases to methyl chloride concentrations in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change of methyl chloride concentrations in the Sacramento River.

5.6.25 Methylene Chloride

5.6.25.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for methylene chloride at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from methylene chloride monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from methylene chloride measured in SRWTP effluent. The modeled in-plume methylene chloride concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-171**. Modeled in-plume methylene chloride concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-172**.

Table 5-171: Modeled In-Plume Methylene Chloride Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.76	0.74	0.72	0.71	0.70	0.70
Median	0.68	0.65	0.63	0.62	0.61	0.61
95 %-ile	1.47	1.44	1.44	1.44	1.45	1.45
99.91 %-ile	3.08	3.03	3.09	3.15	3.20	3.22
5 %-ile	0.32	0.30	0.29	0.28	0.27	0.26

Table 5-172: Modeled In-Plume Methylene Chloride Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.77	0.74	0.72	0.71	0.70	0.70
Median	0.69	0.66	0.64	0.63	0.61	0.61
95 %-ile	1.49	1.45	1.44	1.44	1.45	1.45
99.91 %-ile	3.14	3.01	3.05	3.12	3.19	3.21
5 %-ile	0.33	0.31	0.29	0.28	0.27	0.26

The incremental differences in modeled in-plume methylene chloride concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-173**. The median incremental increase in methylene chloride concentrations is equal to or less than 0.01 µg/L at all in-plume modeled distances downstream from the SRWTP diffuser.

Table 5-173: Modeled In-Plume Methylene Chloride Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Median	0.01	0.01	0.01	0.01	<0.01	<0.01
95 %-ile	0.02	0.01	<0.01	<0.01	<0.01	<0.01
99.91 %-ile	0.06	-0.02	-0.04	-0.03	-0.01	-0.01
5 %-ile	0.01	0.01	-0.01	-0.01	-0.01	-0.01

The probability distributions of modeled methylene chloride concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-146**. The median methylene chloride concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-147**.

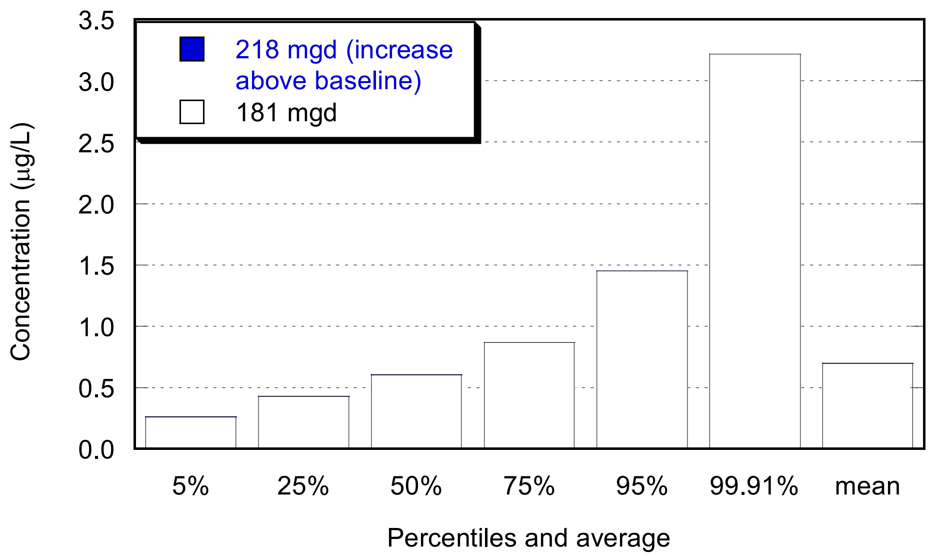

Figure 5-146: Distribution of Modeled Methylene Chloride Concentrations 700 feet Downstream of SRWTP Diffuser.

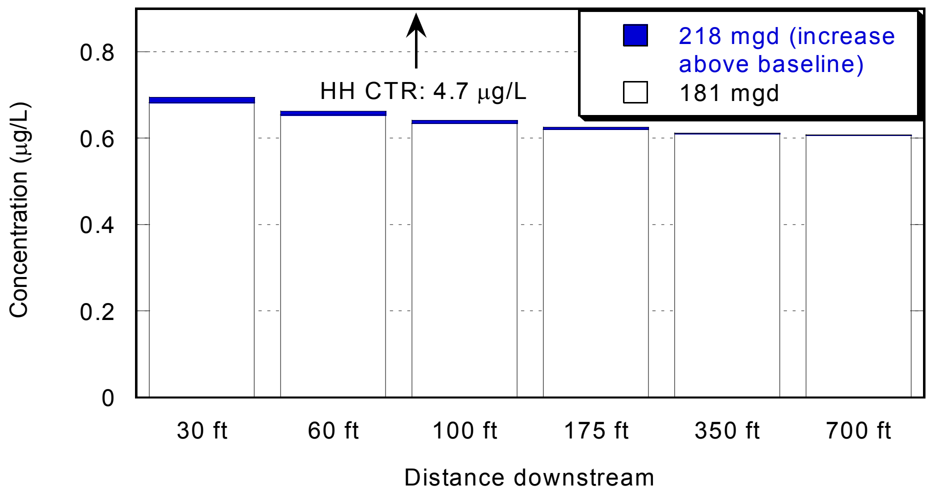

Figure 5-147: Median Modeled Methylene Chloride Concentration Downstream of SRWTP Diffuser.

5.6.25.2 Comparison to Water Quality Objectives

The CTR criterion of 4.7 µg/L for the protection of human health for the consumption of water and aquatic organisms is the most stringent water quality objective applicable for methylene chloride in the Sacramento River. The percent exceedances of the criterion at various distances downstream from the SRWTP diffuser are listed in **Figure 5-88**. Running 30-day averages for methylene chloride concentrations in the Sacramento River were modeled to determine projected exceedance of the CTR criterion in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the methylene chloride concentrations are not expected to exceed the criterion at any point within the modeled plume.

Table 5-174: DYNTOX Modeled Percent Exceedance Frequency for Methylene Chloride at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Human Health Criterion Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
CTR Human Health	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the CTR criterion for methylene chloride. To this end, the 4.7 µg/L objective is met at all times under the existing discharge condition (181 mgd) at all modeled in-plume distances (see **Table 5-171**), and would continue to be met with the proposed discharge increase (218 mgd) (see **Table 5-172**). These modeled results are graphically represented in **Figure 5-146** at a distance of 700 foot downstream from the diffuser. The findings are consistent with the modeled results listed in **Table 5-174** indicating no exceedances of the methylene chloride criterion.

5.6.25.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-171**) and proposed discharge (see **Table 5-172**) have similar characteristics. Of 44 upstream receiving water samples, none had detectable levels of methylene chloride (see **Table 5-2**), so the model input used for the evaluation is an estimate heavily biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. Concentrations in the immediate vicinity of the diffuser are generally greater for the proposed discharge (218 mgd) case; however, the concentrations in the middle and end of the modeled plume are similar for both discharge rates. As listed in **Table 5-173**, the proposed increase in SRWTP effluent discharge would produce a negligible increase of methylene chloride concentrations within the plume, with no noticeable incremental change at downstream distances beyond 175 feet downstream from the diffuser.

Exceedance frequencies of the most stringent applicable water quality objective, the CTR criterion of 4.7 µg/L for the protection of human health for the consumption of water and aquatic organisms, are presented in **Table 5-174**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in objective exceedances. The incremental change in methylene chloride concentration in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd is negligible and below the magnitude of change that could be reliably measured in the field. The modeled near-field results project in-plume median methylene chloride concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled methylene chloride distributions at 700 feet downstream from the diffuser (see **Figure 5-146**) and the modeled, median methylene chloride concentration within the plume (see **Figure 5-147**) show a negligible incremental change in methylene chloride concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in methylene chloride concentrations in the Sacramento River.

5.6.26 Tetrachloroethylene

5.6.26.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for tetrachloroethylene at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from tetrachloroethylene monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from tetrachloroethylene measured in SRWTP effluent. The modeled in-plume tetrachloroethylene concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-175**. Modeled in-plume tetrachloroethylene concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-176**.

Table 5-175: Modeled In-Plume Tetrachloroethylene Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.32	0.34	0.36	0.36	0.37	0.37
Median	0.28	0.30	0.31	0.31	0.32	0.32
95 %-ile	0.67	0.72	0.75	0.77	0.79	0.79
99.91 %-ile	1.52	1.63	1.70	1.75	1.79	1.80
5 %-ile	0.12	0.13	0.13	0.13	0.13	0.13

Table 5-176: Modeled In-Plume Tetrachloroethylene Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.31	0.34	0.35	0.36	0.37	0.37
Median	0.27	0.29	0.30	0.31	0.32	0.32
95 %-ile	0.65	0.71	0.74	0.77	0.79	0.79
99.91 %-ile	1.47	1.60	1.67	1.73	1.78	1.80
5 %-ile	0.12	0.13	0.13	0.13	0.13	0.13

The incremental differences in modeled in-plume tetrachloroethylene concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-177**. For the first 60 feet downstream of the SRWTP discharger, there is a projected minimal decrease of 0.01 µg/L in median tetrachloroethylene concentrations. Beyond this immediate vicinity of the diffuser, the model projects negligible increases of less than 0.01 µg/L.

Table 5-177: Modeled In-Plume Tetrachloroethylene Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	-0.01	<0.01	-0.01	<0.01	<0.01	<0.01
Median	-0.01	-0.01	-0.01	<0.01	<0.01	<0.01
95 %-ile	-0.02	-0.01	-0.01	<0.01	-0.01	<0.01
99.91 %-ile	-0.05	-0.03	-0.03	-0.02	-0.01	<0.01
5 %-ile	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

The probability distributions of modeled tetrachloroethylene concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-148**. The median tetrachloroethylene concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-149**.

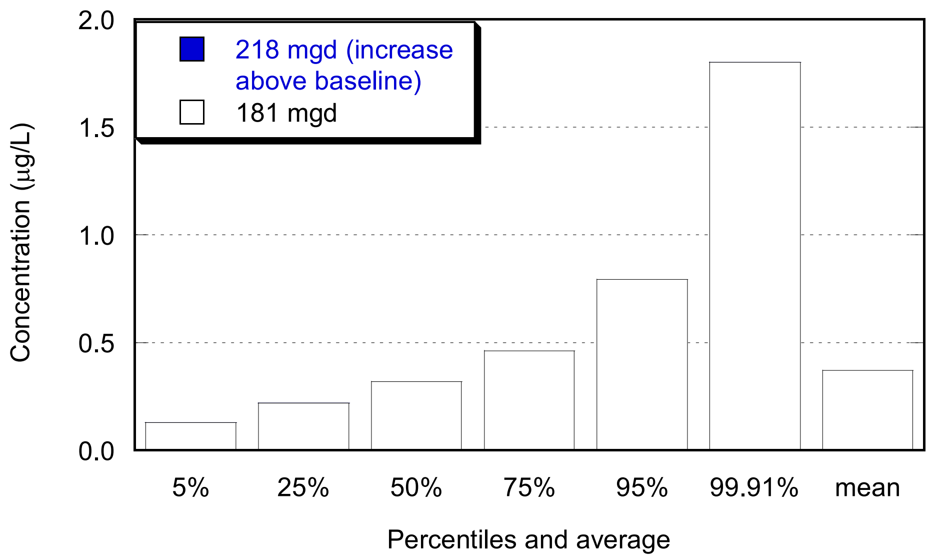

Figure 5-148: Distribution of Modeled Tetrachloroethylene Concentrations 700 feet Downstream of SRWTP Diffuser.

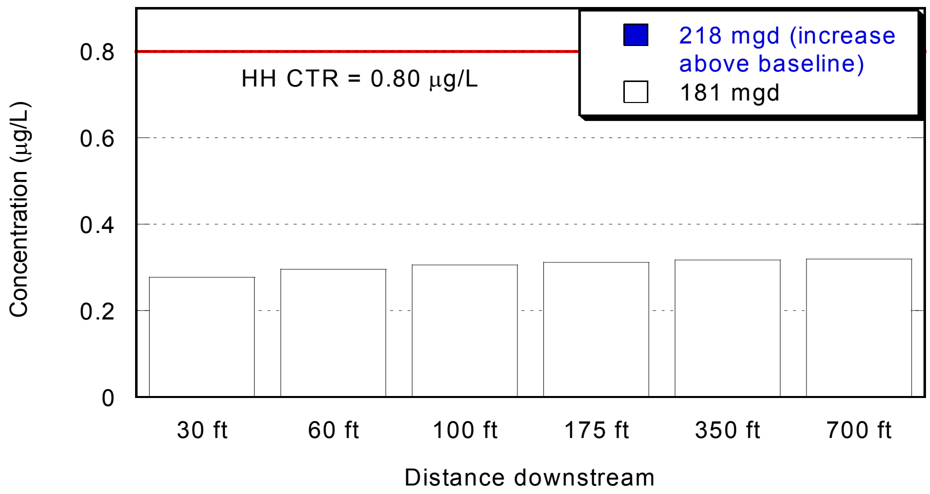

Figure 5-149: Median Modeled Tetrachloroethylene Concentration Downstream of SRWTP Diffuser.

5.6.26.2 Comparison to Water Quality Objectives

The CTR criterion of 0.80 µg/L for the protection of human health for the consumption of water and aquatic organisms is the most stringent water quality objective applicable for tetrachloroethylene in the Sacramento River. The percent exceedances of the tetrachloroethylene criterion at various distances downstream from the SRWTP diffuser are listed in **Table 5-178**. Running 30-day averages for tetrachloroethylene concentrations in the Sacramento River were modeled to determine projected exceedance frequencies of the criterion in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the tetrachloroethylene concentrations are not expected to exceed the applicable human health objective at any point within the modeled plume.

Table 5-178: DYNTOX Modeled Percent Exceedance Frequency for Tetrachloroethylene at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Human Health Criterion Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
CTR Human Health	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are lower than the CTR criterion for tetrachloroethylene. The 0.8 µg/L objective is met more than 95% of the time at all modeled in-plume distances under the existing discharge condition (181 mgd), see **Table 5-175**, and would continue to be met with the proposed discharge increase (218 mgd), see **Table 5-176**. The objective, however, is applied as a 30-day average, and as indicated in **Table 5-178**, no exceedances are expected at any modeled distance within the initial mixing zone. These modeled results are graphically represented in **Figure 5-148** at a distance of 700 feet downstream from the diffuser.

5.6.26.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-175**) and proposed discharge (see **Table 5-176**) have similar characteristics. Of 43 upstream receiving water samples, 2% had detectable levels of tetrachloroethylene (see **Table 5-2**), so the model input used for the evaluation is an estimate heavily biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. As listed in **Table 5-177**, in-plume tetrachloroethylene concentrations are projected to remain virtually unchanged with the increase in discharge rate. Furthermore, the proposed modeled increase in SRWTP effluent discharge would produce a slight modeled decrease of tetrachloroethylene concentrations within the plume. However, such a decrease would be difficult to detect beyond 30 feet downstream from the diffuser.

Exceedance frequencies of the most stringent applicable water quality objective, the CTR criterion of 0.80 µg/L for the protection of human health for the consumption of water and aquatic organisms, are presented in **Table 5-178**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the CTR objective. Modeled results show a negligible change in tetrachloroethylene concentrations in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd. The modeled near-field results project in-plume median tetrachloroethylene concentrations that are substantially below the most stringent applicable water quality criterion. Both the modeled tetrachloroethylene distributions at 700 feet downstream from the diffuser (see **Figure 5-148**) and the modeled, median tetrachloroethylene concentration within the plume (see **Figure 5-149**) show a negligible change in tetrachloroethylene concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in tetrachloroethylene concentrations in the Sacramento River.

5.6.27 Toluene

5.6.27.1 Near-Field Model Analysis Results

FSI performed a near-field analysis for toluene at six locations within the plume downstream of the SRWTP diffuser as part of the DYNTOX modeling. Model inputs for receiving water quality upstream of the SRWTP discharge were derived from toluene monitoring in the Sacramento River at Freeport. Effluent quality model inputs were derived from toluene measured in SRWTP effluent. The modeled in-plume toluene concentrations for the existing permitted condition (181 mgd) are shown in **Table 5-179**. Modeled in-plume toluene concentrations at the proposed permitted condition (218 mgd) are shown in **Table 5-180**.

Table 5-179: Modeled In-Plume Toluene Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 181 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.33	0.34	0.35	0.35	0.36	0.36
Median	0.30	0.30	0.30	0.30	0.31	0.31
95 %-ile	0.67	0.70	0.73	0.74	0.76	0.76
99.91 %-ile	1.47	1.56	1.62	1.66	1.69	1.70
5 %-ile	0.14	0.14	0.13	0.13	0.13	0.13

Table 5-180: Modeled In-Plume Toluene Concentration (µg/L) at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate.

	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	0.33	0.34	0.35	0.35	0.36	0.36
Median	0.29	0.30	0.30	0.30	0.31	0.31
95 %-ile	0.65	0.69	0.72	0.74	0.75	0.76
99.91 %-ile	1.44	1.54	1.60	1.65	1.69	1.70
5 %-ile	0.14	0.14	0.13	0.13	0.13	0.13

The incremental differences in modeled in-plume toluene concentrations between the existing permitted condition (181 mgd) and the proposed permitted condition (218 mgd) are presented in **Table 5-181**. The median decrease in toluene concentrations is less than 0.01 µg/L at all modeled in-plume distances downstream of the SRWTP diffuser.

Table 5-181: Modeled In-Plume Toluene Concentration Increment at Varying Distances Downstream of SRWTP Diffuser Reflecting Differences Between 181 mgd and 218 mgd Discharge Rate from SRWTP.

Comparison Percentile	Concentration Increment from 181 mgd to 218 mgd (µg/L)					
	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Mean	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Median	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
95 %-ile	-0.02	-0.01	-0.01	<0.01	-0.01	<0.01
99.91 %-ile	-0.03	-0.02	-0.02	-0.01	<0.01	<0.01
5 %-ile	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

The probability distributions of modeled toluene concentrations in the plume 700 feet downstream from the diffuser are presented in **Figure 5-150**. The median toluene concentrations in the discharge plume at 181 mgd and the incremental concentration changes associated with the proposed 218 mgd discharge at varying distances downstream of the SRWTP diffuser are shown in **Figure 5-151**.

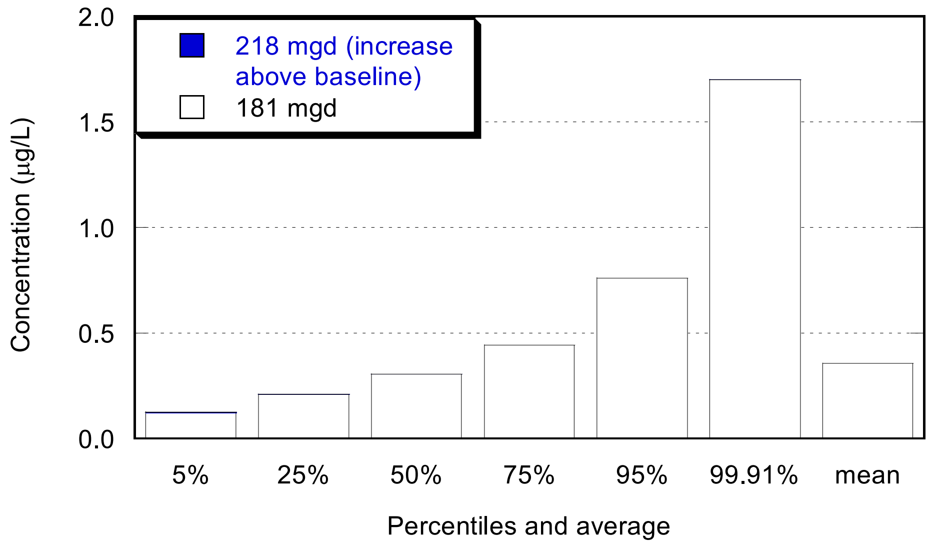

Figure 5-150: Distribution of Modeled Toluene Concentrations 700 feet Downstream of SRWTP Diffuser.

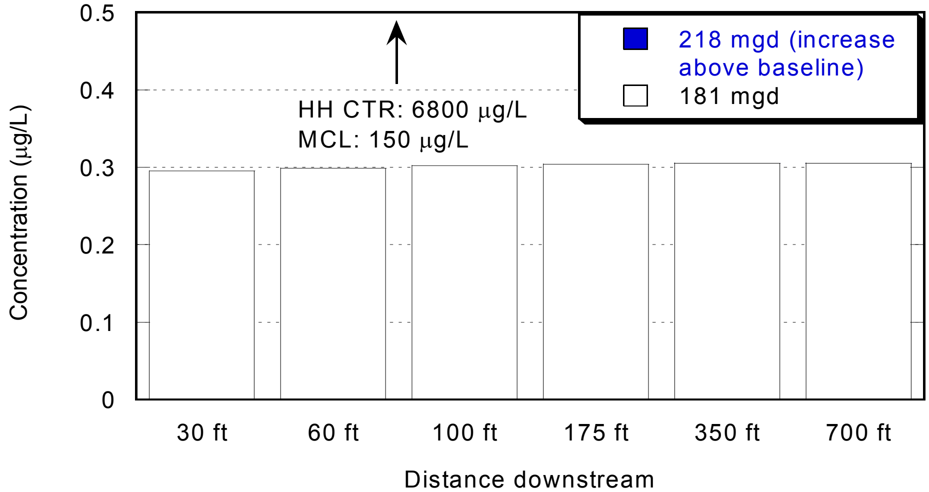

Figure 5-151: Median Modeled Toluene Concentration Downstream of SRWTP Diffuser.

5.6.27.2 Comparison to Water Quality Objectives

The most stringent water quality objective for toluene in the Sacramento River is the California Code of Regulations Title 22 Primary MCL of 150 µg/L, incorporated into the Basin Plan by reference. The percent exceedances of the toluene criterion at various distances downstream from the SRWTP diffuser are listed in **Table 5-182**. Running 30-day averages for toluene concentrations in the Sacramento River were modeled to determine projected exceedance of the MCL in the plume downstream of the SRWTP diffuser. The DYNTOX results indicate that the toluene concentrations are not expected to exceed the applicable objective at any point within the modeled plume.

Table 5-182: DYNTOX Modeled Percent Exceedance Frequency for Toluene at Varying Distances Downstream of SRWTP Diffuser at 218 mgd SRWTP Discharge Rate with Exceedances of the Primary MCL Based on Running 30-Day In-Plume Concentration Averages.

Criterion	30 ft	60 ft	100 ft	175 ft	350 ft	700 ft
Primary MCL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

The 99.91 percentile values of the modeled in-plume concentrations for both the existing permitted condition (181 mgd) and the proposed discharge increase (218 mgd) are substantially lower than the CTR criterion for toluene. The 150 µg/L objective is met at all times at all modeled in-plume distances under the existing discharge condition (181 mgd), see **Table 5-179**, and would continue to be met with the proposed discharge increase (218 mgd), see **Table 5-180**.

5.6.27.3 Near-Field Evaluation

The dynamic modeling results for the current discharge (see **Table 5-179**) and proposed discharge (see **Table 5-180**) have similar characteristics. Of 43 upstream receiving water samples, 5% had detectable levels of toluene (see **Table 5-2**), so the model input used for the evaluation is an estimate heavily biased by the detection levels used for analysis. Because of the lack of detected data, the model should be used strictly for comparisons between discharge rates, and not relative differences between upstream and effluent concentrations. As listed in **Table 5-181**, in-plume toluene concentrations are projected to remain virtually unchanged with the increase in discharge rate.

Exceedance frequencies of the most stringent applicable water quality objective for toluene, the Title 22 Primary MCL of 150 µg/L, are presented in **Table 5-182**. The dynamic model results demonstrate that the proposed discharge rate of 218 mgd would not result in exceedances of the Primary MCL. Modeled results show a negligible change in tetrachloroethylene concentrations in the Sacramento River due to an increase in SRWTP effluent discharged from the current permitted rate of 181 mgd to the proposed rate of 218 mgd. The modeled near-field results project in-plume median toluene concentrations that are substantially below the most stringent applicable water quality criteria. Both the modeled toluene distributions at 700 feet downstream from the diffuser (see **Figure 5-150**) and the modeled, median toluene concentration within the plume (see **Figure 5-151**) show a negligible change in toluene concentration in the receiving water. Increasing the SRWTP discharge flow rate from 181 mgd to 218 mgd is demonstrated to result in a negligible change in toluene concentrations in the Sacramento River.

5.6.28 Chlorpyrifos

A detailed analysis of chlorpyrifos concentrations was not possible due to limitations of the available data. For the Sacramento River at R-1, upstream of the SRWTP discharge, there were 108 chlorpyrifos analyses performed between February 1998 and June 2008. One hundred six (106) of these measurements were reported as non-detected at levels ranging from 0.0005 to 0.5 µg/L. Between June 2005 and June 2008, there were 73 chlorpyrifos analyses performed on SRWTP effluent; however, 68 of these measurements were reported as non-detected at levels between 0.003 and 0.006 µg/L. As chlorpyrifos is banned from residential use and has been restrictively relabeled to highly limit other uses, the effluent is not expected to contain detectable levels of chlorpyrifos in the future. The current detection levels for chlorpyrifos employed for both effluent and receiving water analyses are below the applicable water quality criteria. Chlorpyrifos levels in both the Sacramento River and SRWTP effluent are expected to remain below detectable levels for the current permitted condition (181 mgd) and the proposed permitted conditions (218 mgd), and are therefore thought to comply with Antidegradation policies.

5.6.29 Dibromochloromethane

A detailed analysis of dibromochloromethane concentrations was not possible due to limitations of the available data. For the Sacramento River at R-1, upstream of the SRWTP discharge, there were 44 dibromochloromethane analyses performed between February 1998 and June 2008, all of which were reported as non-detected levels between 0.18 and 0.5 µg/L. Between June 2005 and June 2008, there were 73 dibromochloromethane analyses performed on SRWTP effluent; however, 60 of these measurements were reported as non-detected at levels between 0.08 and 0.31 µg/L. The current detection levels for dibromochloromethane employed for both effluent and receiving water analyses are below the applicable water quality criteria. Dibromochloromethane concentrations in the Sacramento River are expected to remain below detectable levels in the future. The increment of dibromochloromethane in the ambient river below the discharge due to SRWTP effluent is expected to be negligible for the proposed permitted condition (218 mgd), and therefore thought to comply with Antidegradation policies.

5.6.30 N-Nitrosodimethylamine

5.6.30.1 Background

NDMA is one chemical in a group of compounds known as "nitrosamines", which belongs to a larger group of chemicals called "N-nitroso" compounds. At elevated concentrations in water, NDMA is a suspected carcinogen and may produce toxic effects to animals and humans (ATSDR, 1989; OEHHA, 2006; U.S. DHHS, 2005; U.S. EPA, 1980). Historically, NDMA was used to make rocket fuel until contamination was found in the air, soil and water near the manufacturing plants (ATSDR, 1989). Now, NDMA is produced in the United States as a research chemical only. NDMA is also a byproduct of both water and wastewater disinfection and has been found at detectable levels in groundwater and drinking water in California (SFDPH, 2007). In addition, studies have shown that agricultural activities may represent a source of NDMA precursors (Krasner et al., 2008).

The 1980 U.S. EPA criteria document for nitrosamines concluded that acute toxicity to aquatic life occurs at 5.85 mg/L in freshwater and 3,300 mg/L in saltwater[13]. Studies have shown that photolysis due to exposure to sunlight is a very important factor in reducing NDMA concentrations in surface waters. Therefore, receiving water concentrations at a given location are not necessarily indicative of ambient concentrations further downstream. The half-life of NDMA in surface water exposed to sunlight is approximately 3-24 hours, so it is not persistent in ambient waters. Biological degradation of NDMA also occurs in soils in the vadose zone and in groundwater (K/J/T, 2008; McCraven et al., 2008).

5.6.30.2 Human Health

The California Toxics Rule (CTR) contains human health criteria for NDMA for both "water & organisms" and "organisms only" based on a carcinogenicity risk level of 10^{-6} (U.S. EPA, 2000). The Office of Environmental Health Hazard Assessment (OEHHA) is required to perform risk assessments and adopt Public Health Goals (PHGs) for contaminants in drinking water based on public health considerations. PHGs adopted by OEHHA are for use by the California Department of Public Health (CDPH) in establishing primary drinking water standards (State Maximum Contaminant Levels, or MCLs). PHGs are to be based solely on scientific and public health considerations without regard to economic cost considerations or technical feasibility. Drinking water standards adopted by CDPH (MCLs), however, are to consider economic factors and technical feasibility. Each primary drinking water standard adopted by CDPH sets a level that is as close as feasible to the corresponding PHG, placing emphasis on the protection of public health. PHGs established by OEHHA are not regulatory in nature and represent only non-mandatory goals.

By state and federal law, MCLs established by CDPH must be at least as stringent as the federal MCL, if one exists (OEHHA, 2006). The CDPH establishes health-based advisory levels called notification levels for chemicals in drinking water that don't have established maximum contaminant levels (MCLs). When chemicals are found at concentrations greater than their notification levels, certain requirements and recommendations apply (CDPH, 2007). **Table 5-183** compares different criteria for NDMA.

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[13] The U.S. EPA has not developed chronic toxicity values due to a lack of available data (U.S. EPA, 1980).

Table 5-183: NDMA Numerical Limits and Goals

Limit/Goal (µg/L)	Source	Note
0.00069	CTR, 2000[1]	Human Health, Water and Organisms[2]
8.1	CTR, 2000[1]	Human Health, Organism Only[3]
0.003	OEHHA, 2006	Public Health Goal
0.01	CDPH, 2007	Notification Level[4]

(1) Criteria revised to reflect the Agency q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of October 1, 1996. The fish tissue bioconcentration factor (BCF) from the 1980 document was retained in each case. Criteria are based on carcinogenicity of 10^{-6} risk.

(2) Promulgated for specific waters in California. The waters of the Sacramento-San Joaquin Delta and waters of the State defined as inland that include MUN use designation.

(3) Promulgated for specific waters in California. The waters defined as bays and estuaries, Sacramento-San Joaquin Delta, and waters of the State defined as inland without a MUN use designation.

(4) Notification levels may eventually become MCLs.

Beginning in 1999, the CDPH conducted a study to determine the occurrence of NDMA in water systems, especially as a disinfection byproduct (CDPH, 2002). Almost twenty water agencies volunteered to participate, mostly in the Los Angeles and San Francisco Bay areas. Detection limits of 1 ng/L were used and concentrations of NDMA in drinking water distribution systems ranged from below 1 ng/L to 28 ng/L. NDMA may be present at levels of concern in drinking water systems resulting from disinfection practices. In fact disinfection of water supplies may have more impact on NDMA levels in tap water than NDMA present in wastewater effluents. NDMA in disinfected wastewater effluent that is subsequently discharged to surface waters is degraded by exposure to sunlight, which results in reduced levels of NDMA reaching drinking water intakes.

5.6.30.3 Fish and Wildlife

In studies conducted on a variety of species at different trophic levels, tumors resulted from exposure to extremely high levels of NDMA (5 – 50 mg/L) (ATSDR, 1989). A summary of specific adverse effects, and the concentrations at which effects were seen, is provided in **Table 5-184**. Toxicity tests have been conducted with *Gammarus limnaeus* (an amphipod commonly known as "scud") and 96-hr LC50 values ranged between 280 – 445 mg/L (Draper & Fisher, 1979; WHO, 2002). Toxicity testing performed on *Procambarus clarkii* (crayfish) found antennal gland degeneration at 200 mg/L and hyperplasia in the hepatopancreas at 100 mg/L (U.S. EPA, 1980).

Table 5-184: Effects of NDMA on Specific Aquatic Species

Species	Effect	Concentration	Reference
Fathead Minnow	96-hr LC50	940 mg/L	WHO, 2002
Flatworms	96-hr LC50	1,365 mg/L	WHO, 2002
Scud	96-hr LC50	280 – 445 mg/L	WHO, 2002
Mummichog	24-hr LC50	8,300 mg/L	WHO, 2002
Mummichog	120-hr LC50	2,700 mg/L	WHO, 2002
Crayfish	Adverse effects	100 – 200 mg/L	U.S. EPA, 1980

5.6.30.4 Quantitative Assessment of Water Quality Impacts

A detailed modeling analysis of NDMA was not possible due to limitations of the available data. For the Sacramento River at R-1, upstream of the SRWTP discharge, there were 47 NDMA analyses performed between February 1998 and June 2008, all of which were reported as non-detected at levels ranging from 0.01 μg/L to 10 μg/L. Between June 2005 and June 2008, there were 97 NDMA analyses performed on SRWTP effluent, of which 84 measurements were reported as non-detected at levels ranging from 0.002 μg/L to 5 μg/L. The 13 detected values ranged from 0.002 to 0.044 μg/L. The currently available detection levels for NDMA are an order of magnitude greater than the most stringent applicable water quality criterion. NDMA is not expected to exist in the upstream ambient waters of the Sacramento River, so that any infrequent, low-level discharge of the compound in SRWTP effluent would receive considerable dilution. There is no expected incremental change in the NDMA concentrations in the Sacramento River downstream of the SRWTP discharge, and therefore the proposed permitted condition (218 mgd) would comply with Antidegradation policies.

5.7 ADDITIONAL IMPACTS ANALYSES

In addition to the quantitative water quality analyses presented in the preceding sections, the current report also considers other potential impact areas where a proposed 37 mgd (ADWF) increase in permitted SRWTP discharge could affect receiving water quality, groundwater quality, and riverine benthic habitat. The following section presents qualitative discussions of SRWTP effluent toxicity testing, groundwater impacts at the SRWTP site, benthic impacts near the SRWTP discharge, and microconstituents in relation to potential impacts resulting from the proposed 37 mgd (ADWF) increase in permitted SRWTP discharge.

5.7.1 Toxicity Analysis

As a means of assessing the potential for the proposed SRWTP discharge flow rate increase from 181 mgd (ADWF) to 218 mgd (ADWF) to adversely impact toxicity in the Sacramento River and downstream receiving waters, a review of the SRWTP's whole effluent toxicity data was conducted. The SRWTP is required by its NPDES permit to test its effluent on a regular basis for acute and chronic toxicity.

Acute effluent toxicity is tested weekly on fathead minnows (*Pimephales promelas*) as percent survival in a 100% effluent stream over a 96-hr exposure period. The SRWTP permit establishes a limit of 70% survival for any single bioassay result and a median result of 90% survival for any three consecutive bioassays. It is important to note that these tests provide a very conservative assessment of the actual conditions in the discharge plume as the actual time of exposure for organisms passing through the plume in the immediate vicinity of the SRWTP diffuser is significantly shorter than the 96-hour exposure experienced under the test conditions.

For the period under review, January 2005 to December 2008, results for acute bioassay tests conducted in the SRWTP undiluted effluent have met or exceeded the required survival rates more than 98% of the time. Only three acute toxicity tests, performed during separate weeks in February and March 2008, showed less than 70% survival rates. Despite significant investigative efforts on the part of the District, no obvious cause was identified for these flow-through toxicity incidents. Monthly chronic toxicity effluent tests did not coincide with the weekly acute toxicity tests under investigation. Additionally, the chronic toxicity tests performed in 2008 in the periods preceding and following the investigation had consistently low chronic toxicity (ranging from 1 to 2 TUc NOEC for growth of fathead minnows). Moreover, chronic toxicity for downstream receiving water samples collected in the months preceding and following the effluent toxicity incidents indicated fathead minnow survival rates of above 98%, unchanged from their survival rates in receiving water upstream of the SRWTP discharge. These results, along with the fact that the February and March 2008 incidents were the sole such occurrences in a four-year period support the hypothesis that the observed acute toxicity events were episodic and uncharacteristic of SRWTP effluent quality.

Chronic whole effluent toxicity is determined through quarterly tests performed on three organisms. The tests include 4-day algal growth (*Selenastrum capricornutum*), 7-day water flea (*Ceriodaphnia dubia*) survival and reproduction, and 7-day fathead minnow survival and growth. The chronic toxicity tests involve serial dilutions of the effluent with river water and, therefore, are able to measure the aggregate toxicity of all constituents in effluent-river mixtures ranging from 6.25% to 100% effluent. The SRWTP permit requires that tests are performed more frequently (accelerated monitoring) for a period of six months following a test with a no observable effect concentration (NOEC) of 8 or more chronic toxicity units (TUc); that is, a test result where the NOEC was observed at 12.5% effluent, a mixture of 1 part effluent to 7 parts river water. As previously mentioned, it is important to note that the tests provide a conservative depiction of actual river conditions because the exposure time within the extent of the plume for drifting or otherwise mobile organisms is far less than the 7-day period over which the tests are conducted for invertebrate and fish species. **Table 5-185** summarizes SRWTP three-species chronic bioassays results for the four-year period 2005 through 2008.

5.7.1.1 Discussion of SRWTP Three-Species Chronic Bioassay Results

Algae: The SRWTP effluent has not been shown to have a toxicological effect on algae. None of the quarterly algal growth bioassay tests performed from 2005 through 2008 displayed NOEC values equal to or greater than the 8 TUc NPDES permit requirement.

Water flea: The SRWTP effluent has not been shown to have a toxicological effect on *C. dubia* survival or reproduction. For the period February 2007 through December 2008, none of the *C. dubia* survival tests recorded NOEC values higher than the 8 TUc NPDES permit requirement. Over the same period, *C. dubia* reproduction tests showed two occasions with recorded NOEC values of 8 TUc for the 7-day testing period. These incidents were episodic and non-indicative of typical SRWTP effluent water quality as revealed by follow-up tests which all showed a return to characteristic non-toxic results with NOECs of 2 TUc or less. Moreover, as previously mentioned, the exposure times for drifting organisms within the dilution zone immediately downstream of the diffuser is much less than the 7-day period over which tests are conducted. Hence, organisms passing through the plume would not experience an exposure scenario that would result in any toxic effect.

Fathead minnow: The SRWTP effluent has not been shown to have toxicological effects on fathead minnow survival or reproduction. For the period January 2005 through December 2008, there was only one incident, in October 2007, with recorded NOEC values of 8 TUc for both survival and reproduction effects. Investigation into the cause of this incident determined it to be associated with a first flush rain event. Accelerated monitoring confirmed this finding as high toxicity levels were not recorded in any follow-up tests.

As detailed above, the SRWTP discharges are not currently causing adverse effects on aquatic life in the Sacramento River. Considering SRWTP effluent will continue to maintain its high quality under future discharge conditions (218 mgd), and because there will be no significant change in dilution ratios within and downstream of the plume with the increased rate of discharge, increasing the SRWTP discharge flow rate from 181 mgd (ADWF) to 218 mgd (ADWF) is not expected to produce toxic effect on aquatic life in the Sacramento River.

Table 5-185: Results for Three Species Chronic Toxicity Tests Conducted for SRWTP Effluent between January 2005 and December 2008.

	Algae Growth	*Ceriodaphnia dubia*(1)						Fathead Minnow					
		Survival			Reproduction			Survival			Reproduction		
		Quarterly	Follow-up Tests(2)		Quarterly	Follow-up Tests(2)		Quarterly	Follow-up Tests(2)		Quarterly	Follow-up Tests(2)	
Test Date	NOEC (TUc)	NOEC (TUc)	Count	Avg. NOEC (TUc)	NOEC (TUc)	Count	Avg. NOEC (TUc)	NOEC (TUc)	Count	Avg. NOEC (TUc)	NOEC (TUc)	Count	Avg. NOEC (TUc)
Q1 2005	1	DSQ			DSQ			2			2		
Q2 2005	1	DSQ			DSQ			1			1		
Q3 2005	1	DSQ			DSQ			2			2		
Q4 2005	1	DSQ			DSQ			1(3)			3(3)		
Q1 2006	1	DSQ			DSQ			1			1		
Q2 2006	1	DSQ			DSQ			1			1		
Q3 2006	1	DSQ			DSQ			1			2		
Q4 2006	1	DSQ			DSQ			1			2		
Q1 2007	1	DSQ			DSQ			2			4		
Q2 2007	1	1	6	1	8	6	2	1			2		
Q3 2007	1	1			2			1			2		
Q4 2007	1	1			2			8	9	1.6	8	9	2.2
Q1 2008	4	1			4			1			2		
Q2 2008	1	4			4			2			2		
Q3 2008	1	2	7	1.1	8			1			2		
Q4 2008	1	2			2			1			2		
Total	16 Tests	18 Tests			18 Tests			23 Tests			24 Tests		

DSQ = Disqualified

(1) Results for *C. dubia* toxicity tests performed prior to February 2007 are not included in this analysis. Investigation of past sampling procedures revealed a problem with the sampling equipment; corrections were made to the equipment in February 2007. Results of pre-February 2007 tests are considered non-indicative of effluent characteristics.

(2) Follow-up tests include results of all tests performed within six months of accelerated monitoring triggered by an NOEC result equal to or greater than 8 TUc.

(3) Indicates average of results for 2 tests performed during this period.

5.7.2 Benthic Impacts Analysis

5.7.2.1 Background

In 2005, de Vlaming and Goding from the University of California Davis conducted a literature review of bioassessment studies of benthic communities in the Sacramento River (de Vlaming, 2005). The review identified and discussed variables that may impact benthic communities in riverine habitats, discussed challenges to benthic macroinvertebrate (BMI) sampling and discussed how this may be applied to the conditions in the Sacramento River near the SRWTP outfall.

The majority of studies surveyed throughout North America and Europe found that sampling methods have a strong influence on the results achieved. Bottom grab samples (e.g., Ponar) are characterized by low taxa abundance and high BMI variability between replicate samples. In contrast, artificial substrate sampling tends to be characterized by high abundance and low variability between sample replicates. Therefore, a majority of investigators concluded that artificial substrate sampling is preferable to bottom grab sampling. All artificial substrate samplers, however, present challenges. Retrieval of the samplers often results in loss of BMI, which can bias estimates of diversity and abundance. The fluctuating populations documented for various samplers (Simberloff, 1974) raise questions about when the samplers should be retrieved. Even if samplers have been in place for weeks, if BMI colonies on the samplers are relatively new they may not be indicative of water quality. Assuming some physical or biological event has not caused recent changes in BMI populations, artificial samplers are largely a reflection of ambient water quality rather than sediment quality. Furthermore, artificial substrate samplers are frequently colonized by BMI that are substantially different than those inhabiting the dominant substrate in the area; as such they may better reflect the capability of the ambient water quality to support aquatic life but may not represent the fauna adapted to survive on unstable riverbed (Slack et al., 1986).

Regardless of the sampling method used, several researchers have addressed the inability of bioassessment methods to establish a direct cause-and-effect relationship between stressors and biological communities (Barbour et al., 1996; Clements & Kiffney, 1996; Holdway, 1996; McCarty & Munkittrick, 1996; Wolfe, 1996; Power, 1997; Bart & Hartman, 2000; Adams, 2003). Without extensive sampling, it is difficult to account for natural temporal and spatial variations. Furthermore, the structure and composition of "healthy" BMI communities in deep/large rivers, such as the Sacramento River, has not been established. Standardization of BMI bioassessment protocols have also not been established for deep/large rivers in California or the U.S.

5.7.2.2 Local Benthic Community

The 2005 review by de Vlaming and Goding summarized studies that had been conducted on the Sacramento River. Few BMI studies have been conducted on the Sacramento River, so the review was limited to only five investigations. The locations for these studies and the sampling method used are shown in **Table 5-186**.

Table 5-186: BMI Studies in the Sacramento and San Joaquin Rivers.

Study Reference	Study Location	Sampling Method
Slack et al., 1986	Freeport Bridge Area	Artificial substrate & grab samples
CDFG, 1998	Sacramento and San Joaquin Rivers	Grab samples
Leland & Fend, 1998	Lower San Joaquin River	Artificial substrate
Brown & May, 2000	Lower Sacramento River and San Joaquin River	Other sampling methods
Griffith et al., 2003	Wadeable waterways in lower Sacramento River and San Joaquin River watersheds	Other sampling methods

These studies indicate that observed BMI taxa are primarily determined by habitat characteristics (e.g., substrate stability, depth, flow, velocity) and sampling method. These investigations found that taxa diversity (richness) is very low and consists of tolerant species adapted to live on unstable substrates such as silt, sand, and silty sand. The dominant tolerant taxa are Oligochaetes (annelid worms) and clams. Taxa richness tends to be greater on stable substrates (such as snags, pilings, rip-rap, etc.) with more taxa in these substrates that are generally more sensitive to contaminants and habitat quality. On these stable substrates, dominant taxa are larval dipterans (chironomids and black flies), larval caddisflies, some larval mayflies, and amphipods. Investigations on many other deep/large rivers provide similar BMI community results to those observed in the Sacramento River. However, while BMI diversity may be low in deep/large rivers with sand substrate, invertebrate productivity in that substrate is still important to the aquatic ecosystem food web as shifting sand areas constitute large portions of riverbeds (Benke et al., 1984; Soluk, 1985).

In 2006, SRCSD surveyed the concentrations of mercury in resident Asiatic clams near the SRCSD outfall in conjunction with the development of the San Francisco Bay-Delta mercury TMDL (SRCSD, 2008). To assess the possibilities for SRCSD to participate in an offsets program to meet future mercury effluent limits, the study investigated impacts to the local benthic community from SRWTP's current effluent discharge. As noted above, clams are one of the predominant BMI species in the sampled reach of the Sacramento River. Sampling was conducted monthly during low river flow conditions (July – December) at the sites shown in **Figure 5-152**. Two sites were sampled upstream of the SRCSD outfall at Garcia Bend (GB, approximately 1.5 miles upstream) and just upstream of the SRWTP outfall at R-1, one site was sampled approximately 700 ft downstream of the outfall (R-2b), and two additional sites were sampled further downstream of the outfall (R-3, approximately 1 mile downstream, and RM44, approximately 2 miles downstream). There was substantial spatial and temporal variation in the concentration of methylmercury measured in clam tissue. At site R-2-b, located within the SRWTP discharge plume, mean methylmercury concentrations were slightly higher than at other sites. However, looking at the other sites that were sampled, the mean concentrations of methylmercury in clam tissue upstream and downstream of the SRWTP outfall were similar, showing that the SRWTP discharge does not affect the benthic community outside of the initial mixing zone.

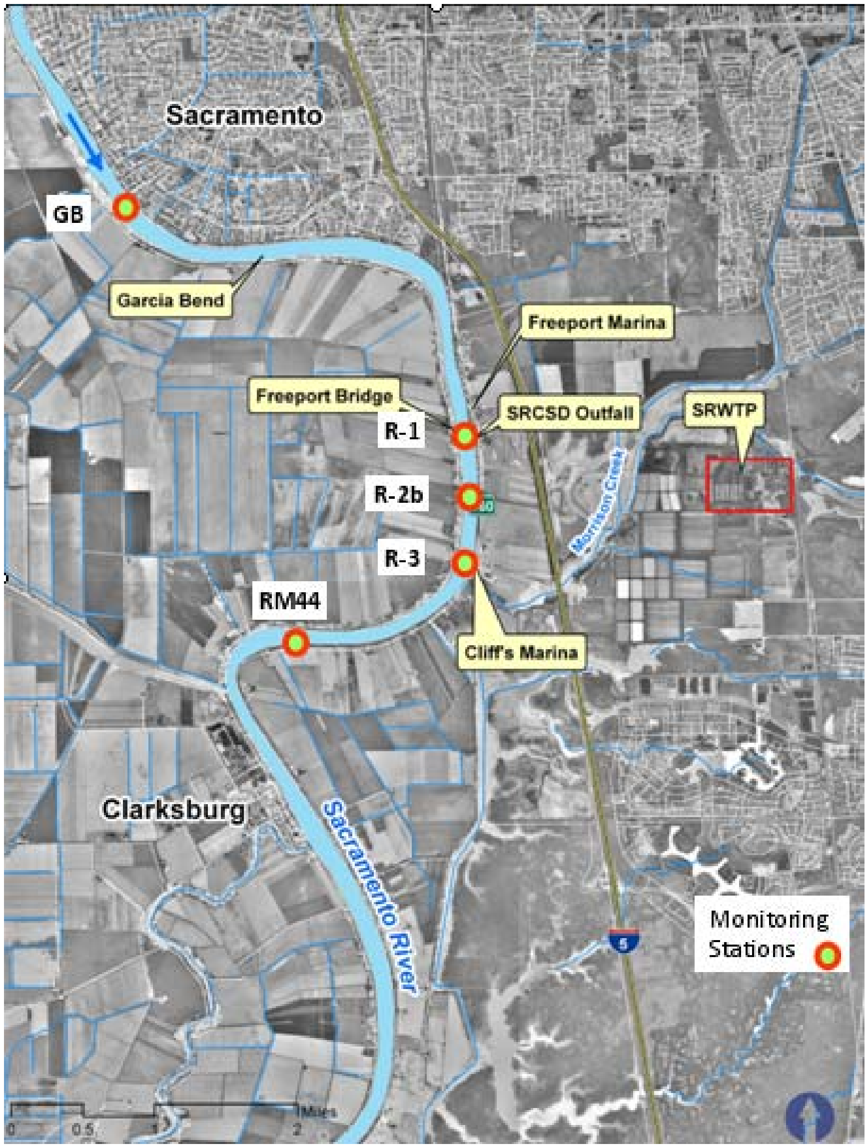

Figure 5-152: SRCSD 2006 Benthic Survey Locations (River Miles 40 and 50 are approximately located at the Bottom and Top of the Figure, Respectively).

Furthermore, as compared to other regional sites in the Sacramento River Watershed, mercury concentrations in clam tissue were relatively low as shown in **Figure 5-153**. This figure compares the SRCSD data collected in 2006 with data collected by the National Water Quality Assessment Program in 1995. SRCSD site R-1 is identified as Sacramento at Freeport by the National Water Quality Assessment Program, so the difference between mercury concentrations recorded by the two studies at the same site may show a decrease in mercury concentrations from 1995 to 2006 or more likely, may show variability in sampling conditions and methods. While the SRCSD study showed slightly higher methylmercury concentrations in the immediate vicinity of the SRWTP diffuser, they appear to be small compared to other rivers in the region. Additionally, these findings were reviewed by a panel of independent experts which concluded that mercury is a regional problem and that the levels of mercury observed in clams and small fish in the vicinity of the SRWTP do not represent a mercury “hot spot” (SRCSD, 2008).

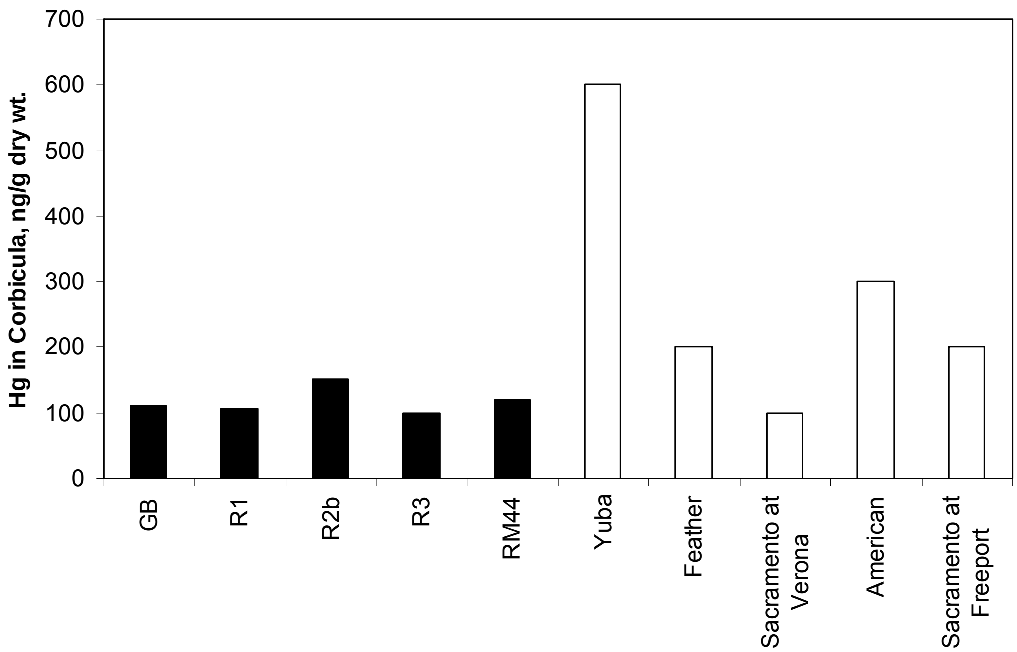

Figure 5-153: Comparison of Mean Mercury Concentrations in Resident Corbicula Tissues Measured by SRCSD in 2006 as Part of a Mercury TMDL Development Study (Black Bars) versus Mean Concentrations Measured by USGS in 1995 as Part of the National Water Quality Assessment Program (White Bars).

5.7.2.3 Regional Sediment Quality Survey

Benthic community analysis in the Delta was conducted in 2007 and 2008, but the final results of these evaluations are not yet available. The Southern California Coastal Water Research Project(SCCWRP), SFEI, and DWR initiated this analysis as part of the Delta sediment monitoring program in support of State Water Board efforts to develop sediment quality objectives for the Delta. Sediment quality samples were taken at locations throughout the Delta and analyzed for acute toxicity to the amphipod *Hyella azteca*. A subset of the locations were then selected for a full suite of sediment quality triad analyses including a second toxicity test, benthic community analysis, and chemistry analysis. Sampling was conducted in fall 2007 and spring 2008, and preliminary results are available for the fall 2007 chemical analyses. Sampling locations visited during the 2007 and 2008 benthic community evaluations are shown in **Figure 5-154**. Of the 100 locations sampled during the first round of analyses, only three were found to show toxicity. As shown in **Figure 5-154**, the three sites found to exhibit toxicity are located in the lower Delta. A second round of analyses was conducted at 50 of the original 100 sites, including the three sites identified as exhibiting toxicity. Samples from many of the “round two” sites were observed to contain legacy contaminants of concern as well as pesticides currently in use. Pyrethroid pesticides were detected in about 30% of samples, with bifenthrin, permethrin, and cyfluthrin detected most commonly. Piperonyl butoxide (PBO), which is a synergist added to pyrethroid pesticide mixtures, was detected in about 90% of samples. Forthcoming benthic analysis data from study locations on the Sacramento River will add to the current body of knowledge regarding regional benthic communities.

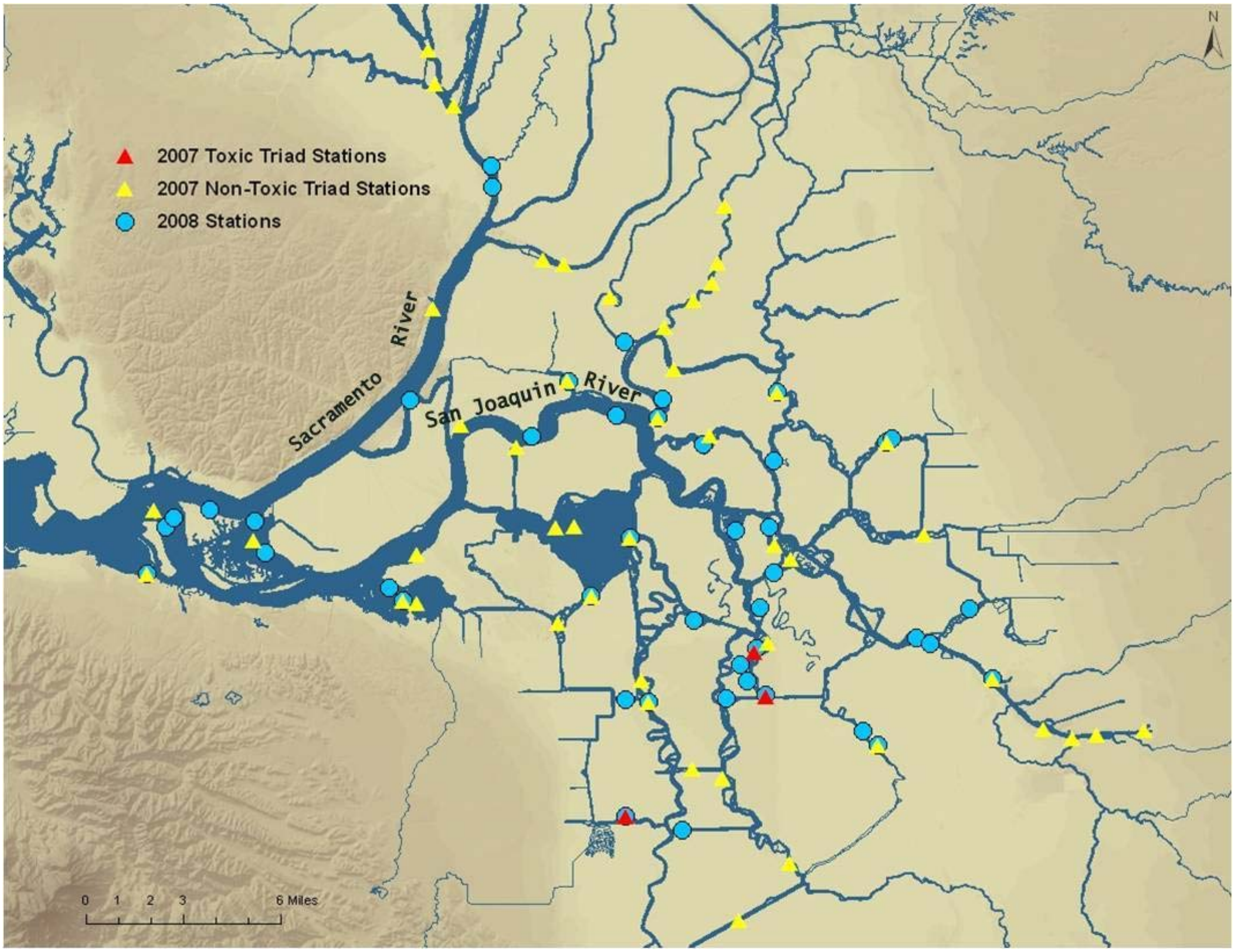

Figure 5-154: Delta Sediment Quality Objective Toxicity Survey Preliminary Results for Fall 2007 and Sampling Locations Associated with Spring 2008 Study.

5.7.3 Microconstituents

5.7.3.1 Background

Microconstituents are a class of anthropogenic substances which have recently raised concerns due to their possible ecotoxicological effects on humans and other living organisms. The term microconstituents is used because most of these substances are present in the environment at concentrations of parts per trillion (or nanograms per liter (ng/L)) or lower. Due to the low concentration in the environment, many of these constituents may have been present historically but are only now being detected because of improved analytical methods with lower detection limits.

The two subsets of microconstituents that have recently received the most public attention are personal care products and pharmaceuticals (PPCPs) and endocrine disrupting compounds (EDCs). PPCPs comprise a diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, antibacterial soaps, fragrances, and cosmetics. Some of these PPCPs are also categorized as EDCs. The U.S.EPA defines EDCs as exogenous agents that interfere with the "production, release, transport, metabolism, binding, action, or elimination of the natural hormones in the body responsible for the maintenance of homeostasis and the regulation of developmental processes" (National Center for Environmental Research, 2007). Some common products in which EDCs have been found are:

- Flame retardants (i.e., polybrominated diphenyl ether (PBDE)) found in many plastics and circuit boards in household electronic equipment, textiles, furniture, and carpets.
- Detergents, fragrances, and antimicrobial ingredients found in cleaning products.
- Fragrances and other chemicals found in personal care products.
- Both over-the-counter and prescription pharmaceuticals.

EDCs and PPCPs in many of the products mentioned may volatilize and be absorbed through the skin and/or be ingested by people and then excreted and discharged as waste into the sewer system. In some cases people may directly dispose of microconstituents by pouring them down the drain or into toilet (e.g., some people may flush unwanted pharmaceuticals down the toilet). It is reasonable to assume that most microconstituents have been present in the environment since the products containing them have been on the market.

Anthropogenic microconstituents are also present in the environment due to air emissions. EDCs have been detected in diesel exhaust and in emissions from uncontrolled domestic burning. They may also enter the atmosphere through cigarette smoke which contains several EDCs.

Some EDCs are also known or suspected to be naturally produced by animals and plants. Female sex hormones, for example, are excreted in urine and are present in wastewaters. These natural estrogenic steroid hormones, along with the synthetic birth control hormone, are some of the constituents of greatest concern due to their relative biological potency. Plants also produce phytoestrogens that can be introduced into the aquatic environment through runoff and may contribute to endocrine disrupting effects.

5.7.3.2 Presence and Impacts to Fish, Wildlife, and Humans

Various quantitative assessments have been performed to document the presence of microconstituents in wastewater treatment plant effluent and receiving waters. One of the most significant amongst the recent scientific studies that have looked at the presence of microconstituents in water bodies is "A National Reconnaissance" conducted by USGS (Kolpin et al., 2002). In this study, water samples from 139 surface water bodies were tested for the presence of 95 microconstituents. Water bodies that were susceptible to the presence of microconstituents due to contamination from human, agricultural, or industrial wastewater effluent were chosen for this study. One or more microconstituents were detected in 80% of the water bodies, indicating the widespread presence of microconstituents in surface water in the United States. The most widely occurring and persistent microconstituents detected in the USGS Study were the insect repellent, DEET, and the pesticide, atrazine.

Some studies have also reported the presence of microconstituents in drinking water and their persistence through drinking water treatment plants (Stackelberg et al., 2004; Westerhoff et al., 2005; Loraine & Pettigrove, 2006; Stackelberg et al., 2007). Such a study was performed on a conventional drinking water treatment plant located in a heavily populated area (Stackelberg et al., 2007). Treatment processes at the plant consisted of screening, clarification, disinfection, sand/granulated activated carbon (GAC) filtration, and secondary disinfection. Out of the 113 microconstituents studied, 32 were found in 25% of raw water samples and between 3 and 13 compounds were found in every finished water sample. These microconstituents included personal care products, pharmaceuticals, pesticides, flame retardants, and plasticizers.

There is evidence that some microconstituents can have detrimental effects on organisms at concentrations similar to those measured in the environment. Most microconstituents detected in the aquatic environment are measured at concentrations less than 100 parts per trillion (AWWARF, 2005). Adverse effects have been found in aquatic organisms downstream of wastewater treatment plants; however, these effects have not yet directly been linked to the presence of EDCs in the effluent. These effects include endocrine disruption and other effects (i.e., mortality and effects on body functions) (Newbold et al., 2007; Wiesner et al., 2006; Parks et al., 2001; Jobling et al., 1998). Some studies have shown that the presence of EDCs has caused masculinization or feminization of fish (Parks et al., 2001; Kidd, et al., 2007), but the effect of such changes on the sustainability of fish populations in water bodies is not clear (Kidd et al., 2007; Mills & Chichester, 2005). Adverse effects on aquatic organisms due to synergism have been documented when a mixture of EDCs was present at sufficiently elevated levels (Santos et al., 2006; Hayes, et al., 2006).

Indirect effects of microconstituents on the food chain due to bioaccumulation or decrease in population of other organisms have been postulated, but have not been verified. Because microconstituents occur in U.S drinking water supplies only at minute concentrations, it is unlikely that most of these chemicals will pose any credible threat to human health via drinking water exposure (Snyder et al., 2007). In the work conducted to date, effects in humans from EDCs have not been observed. However, research into the question of human health effects continues, with utilities and governmental agencies conducting comprehensive research programs.

5.7.3.3 Regulatory Status

For most microconstituents, no federal regulations have yet been developed to address possible health risks and ecological effects (WEF, 2007). The U.S. Food and Drug Administration (FDA) regulates the safety of food and drugs, which include pharmaceuticals and personal care products. The FDA does not generally pursue environmental assessments of chemicals when discharge concentrations are reasonably expected to be less than one part per billion, which is the case for most microconstituents found in wastewater effluents.

The U.S. EPA is the principal federal agency with regulatory authority over chemicals in water that may pose a human health or ecological risk. The U.S. EPA has regulatory authority through a variety of laws including the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA). Concentrations of microconstituents in drinking water or surface water are not currently regulated through any of these programs. Regulations have not been developed because of insufficient knowledge about the occurrence of microconstituents, the lack of full understanding of the toxicological significance of trace occurrence of various microconstituents, and the lack of standardized protocols and methods for the routine sampling and analysis for microconstituents. The EPA has begun the process of evaluating some microconstituents for which data are available as part of the Candidate Contaminants List (CCL) process under the SDWA, which is a first step in developing possible drinking water regulations for specific contaminants. The process of considering aquatic life criteria for microconstituents under the CWA has also begun (U.S. EPA, 2008). However, without final guidance or regulations on EDCs and other microconstituents in water, it is not possible to quantitatively evaluate the impacts of these constituents on fish, wildlife, and humans.

5.7.4 Groundwater Impacts Analysis at SRWTP Site

The main wastewater flow received at the SRWTP is contained at all times either in closed pipes or in concrete treatment process basins or tanks. The only possible exposure of wastewater constituents to groundwater associated with the current operation of the SRWTP could occur as a result of the following side-stream wastewater treatment operations and legacy facilities:

- Emergency Storage Basins (ESBs)
- Solids Storage Basins (SSBs)
- Dedicated Land Disposal Units (DLDs)
- Grit and Screenings Landfill (Closed)

These facilities and their associated operations are described in detail in Appendix J, along with their potential for impacts on groundwater quality and mitigation measures that have been implemented by SRCSD in recent years to minimize the potential for groundwater impacts.

No increase in the potential for impact to groundwater quality associated with these facilities is expected with expansion of discharge to 218 mgd (ADWF) for the following reasons:

<u>Emergency Storage Basins</u> (ESBs) – ESB-A and ESB-D are lined and, consequently, have no potential to impact groundwater quality as a result of percolation. Unlined basins, ESB-B, ESB-C, and ESB-E, are considered to have no significant impact on groundwater quality under current operating conditions because of their very low frequency of used and low rates of infiltration. The physical size or methods of operation of these basins All of the facilities at the SRWTP that could potentially impact groundwater quality – Emergency Storage Basins (ESBs), Solids Storage Basins (SSBs), and Dedicated Land Disposal units (DLDs) – would not change in terms of their physical size or methods of operation if the discharge from the SRWTP were expanded to 218 mgd. In addition, the period of time that water would be stored in unlined basins is not expected to increase significantly as a result of an increase in the treatment capacity to 218 mgd. Thus, no increase in the potential for impact to groundwater associated with these facilities would be expected with expansion of discharge to 218 mgd.

<u>Solids Storage Basins</u> (SSBs) – the size or operation of the SSBs would not change if the discharge from the SRWTP were expanded to 218 mgd.

<u>Dedicated Land Disposal Units</u> (DLDs) – the DLD units have been lined to prevent percolation of leachate to the underlying groundwater.

<u>Closed Grit and Screenings Landfill</u> – the impacts of the closed landfill and other legacy operations (seepage pits and dairy) at the SRWTP on groundwater quality are currently being mitigated through operation of the CAP system, which extracts impacted groundwater and discharges it with SRWTP effluent.

5.8 SUMMARY OF PROJECT-BASED WATER QUALITY IMPACTS

Existing SRWTP treatment processes, along with available measures to limit oxygen demanding substances in the effluent during summer operating conditions, would allow the facility to continue to discharge high quality secondary treated effluent to the Sacramento River below Freeport Bridge. The SRWTP proposes to discharge this high quality effluent to the Sacramento River at higher flow rates as the plant increases its discharge from the currently permitted rate of 181 mgd (ADWF) to the proposed rate of 218 mgd (ADWF). Since SRWTP effluent quality would remain unchanged for all parameters except for ammonia, total nitrogen, and TKN during summer operations, the anticipated increase in SRWTP effluent mass loadings is proportional to the increase in discharge from 181 mgd (ADWF) to 218 mgd (ADWF). Under summer operating conditions, the total mass loadings of oxygen demanding substances would essentially remain at current levels. The near-field and far-field water quality impact assessments presented earlier in this section show that the proposed increase in SRWTP discharge to the Sacramento River would generally have negligible to moderate impacts on the downstream water quality of the Sacramento River and Delta for those constituents evaluated (see **Table 5-187** and **Table 5-188**).

With regard to acute and chronic toxicity testing of SRWTP effluent, aquatic toxicity bioassays performed during the period January 2005 through December 2008 indicate that the SRWTP effluent has no adverse impacts on the receiving water. Considering that the SRWTP's effluent is not currently causing adverse effects on aquatic life in downstream receiving waters, and will continue to maintain its high water quality throughout and after implementation of the proposed project, it is projected that an increase in SRWTP flow rate from 181 mgd (ADWF) to 218 mgd (ADWF) will not produce adverse toxics effects in the Sacramento River and Delta.

The water quality parameters considered in this antidegradation analysis are generally expected to exhibit only negligible to moderate increases in concentration in the receiving water at well-mixed conditions downstream of the SRWTP discharge at the proposed 218 mgd (ADWF) discharge rate. None of these constituents are anticipated to exceed relevant water quality objectives, and, on average, are estimated to be present at concentrations well below objectives that will not unreasonably affect actual or potential beneficial uses, with increase in SRWTP discharge to 218 mgd (ADWF).

Table 5-187: Summary of Water Quality Impacts for Category 1 Constituents due to the Proposed SRWTP Discharge Increase from 181 mgd (ADWF) to 218 mgd (ADWF).

Category 1 Constituent (mg/L unless noted)	In-Plume Assessment at 700 ft Downstream of SRWTP Diffuser		Sacramento River at Greene's Landing/Hood		Characterization of Incremental Change in Downstream Receiving Water Concentration due to Proposed 218 mgd Discharge
	Modeled Median Concentration (181 mgd)	Modeled Median Concentration Increment (218 mgd)	Modeled Median Concentration (181 mgd)	Modeled Median Concentration Increment (218 mgd)	
Ammonia[1] (mg/L as N)					
Summer Operations	0.55	<0.01	0.25	<0.01	Negligible Increase
Winter Operations	0.72	0.11	0.31	0.09	Moderate Increase
Total Nitrogen[1]					
Summer Operations	0.84	<0.01	0.64	<0.01	Negligible Increase
Winter Operations	1.01	0.11	0.70	0.09	Moderate Increase
Nitrate + Nitrite (mg/L as N)	0.12	0.01	0.12	<0.01	Negligible Increase
Total Kjeldahl Nitrogen[1]					
Summer Operations	0.85	<0.01	0.51	0.01	Negligible Increase
Winter Operations	1.03	0.12	0.57	0.10	Moderate Increase
Total Phosphorus	0.11	0.01	0.08	0.01	Slight Increase
EC (µmhos/cm)	173	3	157	2.9	Slight Increase
Total Dissolved Solids	105	1	---[3]	---[3]	Slight Increase
Chloride	7.38	0.42	5.7	0.4	Slight Increase
Total Organic Carbon	2.59	0.08	2.30	0.06	Slight Increase
Total Mercury (ng/L)	4.07	<0.01	ISD	ISD	Negligible Increase
Dissolved Oxygen[1],[2]					
Summer Operations	8.73	-0.02	8.31[4]	-0.02[4]	Negligible Decrease
Winter Operations	10.91	-0.03	10.73[4]	-0.07[4]	Negligible Decrease

ISD = Insufficient data from 1998 to 2008 for determination of far-field ambient concentration increment resulting from the proposed project.

(1) Two scenarios (Summer Operations and Winter Operations) have been modeled for ammonia, total nitrogen, total Kjeldahl nitrogen, and dissolved oxygen due to the seasonal implementation of the District's assessment of controlling oxygen demanding substances in the summer months (May through September). The summer operations effluent concentrations for ammonia, TN, and TKN are expected to improve with the increase in discharge from 181 mgd to 218 mgd. As such, the increment of concentrations in the receiving water would be negligible during the summer months. On the other hand, winter operations effluent quality would stay the same at 181 and 218 mgd discharge capacities and as such, with the increase in discharge, the receiving water concentrations for ammonia, TN, and TKN are expected to moderately increase during winter time (SRCSD, 2009b).

(2) Dissolved oxygen levels in the receiving water remain virtually unchanged with the increase in discharge because of 1) Winter ambient conditions (i.e. Sacramento River flow and water temperature) act to prevent incidences of low dissolved oxygen in the receiving water during winter months and 2) implementation of seasonal controls act to prevent these incidents in the months (see also [a]) (SRCSD, 2009b). Difference between winter and summer dissolved oxygen concentrations reflective of seasonal difference in water temperature and corresponding difference in saturation concentration.

(3) Far-field water quality impacts analyses and trend analyses were not performed for TDS due to the extensive far-field assessments performed for EC (Section 5.4.11) and chloride (Section 5.4.13). Because TDS correlates strongly with EC, it would be expected that far-field impacts would be similar for these two constituents.

(4) Dissolved oxygen results presented at Rio Vista, the critical condition for dissolved oxygen (SRCSD, 2009b)

The water quality impacts assessed as part of the antidegradation analysis are evaluated in terms of the estimated incremental change in downstream receiving water quality due to the proposed project, and the effect that the incremental change is anticipated to have on beneficial uses identified for the receiving water. The incremental changes in near-field, downstream receiving water concentrations estimated for Category 1 pollutants (see **Table 5-187)** are expected to produce negligible to moderate reductions in water quality that will not significantly affect actual or potential beneficial uses. Additionally, far-field modeling results for Category 1 pollutants, combined with power and trend analyses, indicate that essentially immeasurable, incremental increases in far-field pollutant concentrations resulting from increasing SRWTP discharge to 218 mgd (ADWF) will not significantly impact Delta water quality. For Category 2 and Category 3 constituents, the incremental changes in near-field, downstream receiving water concentrations are expected to produce only negligible to slight reductions in water quality that will not significantly affect actual or potential beneficial uses (see **Table 5-188**). As such, these parameters are anticipated to have negligible impacts in far-field receiving waters.

Table 5-188: Summary of Water Quality Impacts for Category 2 and Category 3 Constituents due to the Proposed SRWTP Discharge Increase from 181 mgd (ADWF) to 218 mgd (ADWF).

Constituent	Modeled Median Concentration Increment at 700 feet Downstream of SRWTP Diffuser	Characterization of Incremental Change in Downstream Receiving Water Concentration due to Proposed 218 mgd Discharge
Category 2		
Aluminum – Total (µg/L)	-1	Slight Decrease
Cadmium – Dissolved (µg/L)	0.001	Negligible Increase
Copper – Dissolved (µg/L)	0.01	Slight Increase
Zinc – Dissolved (µg/L)	0.1	Slight Increase
Temperature (°F)	± 0.2	Negligible Increase or Decrease
Total Coliform (MPN/100 mL)	-4	Slight Decrease
Category 3		
Antimony – Total (µg/L)	0.001	Slight Increase
Arsenic – Dissolved (µg/L)	0.01	Negligible Increase
Chromium – Dissolved (µg/L)	0.003	Slight Increase
Lead – Dissolved (µg/L)	0.001	Slight Increase
Molybdenum – Total (µg/L)	0.01	Slight Increase
Nickel – Dissolved (µg/L)	0.01	Slight Increase
Selenium – Total (µg/L)	0.01	Negligible Increase
Silver – Dissolved (µg/L)	0.001	Negligible Increase
Cyanide – Total (µg/L)	0.01	Slight Increase
Total Suspended Solids (mg/L)	-0.1	Slight Decrease
1,4-Dichlorobenzene (µg/L)	0.01	Negligible Increase
Bis(2-ethylhexyl)phthalate (µg/L)	0.01	Slight Increase
Bromodichloromethane (µg/L)	0.01	Negligible Increase
Chloroethane (µg/L)	0.01	Negligible Increase
Chloroform (µg/L)	0.07	Slight Increase
Diethyl phthalate (µg/L)	0.002	Negligible Increase
Di-n-butyl phthalate (µg/L)	0.01	Negligible Increase
Methyl chloride (µg/L)	0.01	Negligible Increase
Methylene chloride (µg/L)	0.01	Negligible Increase
Tetrachloroethylene	0.01	Negligible Increase
Toluene	0.01	Negligible Increase

6 Assessment of Socioeconomic Considerations

The public benefit derived from an increase in SRWTP discharge that is necessary to accommodate growth in the SRCSD service area is an important consideration in this antidegradation analysis. In accordance with APU 90-004 guidance for a 'complete' antidegradation analysis, the following factors are considered in determining whether the lowering of water quality that is anticipated with the increase in the rate of discharge from the SRWTP is necessary to accommodate economic or social development and is consistent with maximum public benefit:

- A consideration of alternative control measures that might reduce, eliminate, or compensate for the water quality impacts of the proposed capacity increase;
- An evaluation of each alternative control measure for costs, impacts on water quality, and compliance with applicable laws, regulations, and policies;
- An assessment of the socioeconomic impacts of each alternative; and
- A balancing of the proposed SRWTP expansion and the alternatives based on environmental and socioeconomic considerations.

The U.S. EPA has provided *Interim Economic Guidance for Water Quality Standards* (U.S. EPA, 1995) in the form of a workbook designed to help States and EPA Regional Offices consider economic factors when setting, enforcing, or changing water quality standards. The guidance is presented to assist States and project proponents in understanding the economic factors that may be considered, and the types of tests that can be used to determine if a designated use cannot be attained, if a variance can be granted, or if degradation of high quality water is warranted. In order to remove a designated use or obtain a variance, the State or discharger must demonstrate that attaining the designated use would result in substantial and widespread economic and social impacts. Likewise, if degradation in high quality water is proposed, it must be shown that lower water quality is necessary to accommodate important social and economic development.

The guidance addresses antidegradation specifically and requires that a project proponent demonstrate that important economic or social development would be prevented unless lower water quality is allowed. The guidance also states that an economic analysis must demonstrate that (a) the discharger would face substantial financial impacts due to the costs of the necessary pollution controls (i.e., a demonstration of "substantial impacts"), and (b) the affected community will bear significant adverse impacts if the discharger is required to meet existing or proposed water quality standards (i.e., a demonstration of "widespread impacts"). The guidance provides a two-part test to demonstrate the occurrence of substantial and widespread impacts. The first test, called the Municipal Preliminary Screener, is an *affordability test* that looks to establish whether a community can pay for a project without incurring any substantial impacts. The second step in the analysis, the Secondary Test, looks at debt, socioeconomic, and financial management conditions in the community that would be required to pay for additional pollution controls.

The socioeconomic impacts analysis (SEIA) included in this report does not strictly follow the U.S. EPA's *Interim Economic Guidance for Water Quality Standards*, nor is it required to do so. The initial step in the socioeconomic analysis advanced in the guidance, an affordability test, is viewed as presumptuous in that additional pollution controls are appropriate if a community can afford them, and only secondarily tempers the affordability finding with an evaluation of other economic conditions present in the community. The SEIA included in this report demonstrates both substantial and widespread impacts using IMPLAN software – an economic impact assessment software that models community level impacts – and provides an evaluation of individual household impacts due to increased sewer treatment costs.

6.1 ALTERNATIVES TO AVOID INCREASED EFFLUENT LOADINGS ABOVE THOSE PERMITTED

Alternatives to maintain Sacramento River and downstream receiving water quality at pre-project conditions by eliminating any incremental increase in mass emissions above those allowed under the current permitted discharge rate of 181 mgd (ADWF) have been considered by the SRCSD and are described below. The "No Project" alternative will be described later in the current analysis (Section 6.4.1), but is not considered a viable alternative to avoiding increased effluent loadings above those permitted.

6.1.1 Regionalization

The formation of the SRCSD in 1973 was to provide a regional wastewater conveyance, treatment, and disposal system to serve the urbanized area of Sacramento, to eliminate wastewater discharges to the American River, minimize raw sewage overflows to the Sacramento River, and to replace 17 separate wastewater entities. To this end, the SRWTP has acted to regionalize wastewater treatment in Sacramento County. The City of West Sacramento was connected to the SRWTP in November 2007, the City of Courtland was just connected in April 2009, and the City of Walnut Grove is scheduled for connection in summer 2009. No other regional wastewater treatment plant exists that could accept the volume of influent currently treated by the SRWTP. Even if such a suitable, regional treatment plant existed, the cost of piping influent to a remote location and the environmental impacts of doing so would not warrant such a practice. For these reasons, regionalization was not considered a feasible, effective approach to avoiding the discharge of treated effluent to the Sacramento River above the current permitted discharge of 181 mgd (ADWF), and was not considered further in the current SEIA.

6.1.2 Recycling/Reuse

The District has evaluated the feasibility of a number of water recycling/reuse opportunities in the context of its Water Recycling Opportunities Study (WROS) that would seek to deliver treated wastewater to various locations in Sacramento and Yolo counties for agricultural and urban irrigation uses (SRCSD, 2007). The WROS determined that a group of three to six individual water recycling projects would be required to achieve 30 – 40 mgd of recycled water use. Currently, the SRCSD has not identified a sufficient number of individual water recycling/reuse projects that would collectively require 30 – 40 mgd of treated wastewater. Furthermore, regional, year-round recycled water consumptive demand is insufficient to offset current and future SRWTP treated effluent flows produced during the wet season, and it would be too costly to store treated effluent when demand for reuse does not exist. For these reasons, water recycling/reuse was not considered a feasible, effective approach to avoiding the discharge of treated effluent to the Sacramento River above the current permitted discharge of 181 mgd (ADWF), and was not considered further in the current SEIA. While cost-effective water recycling projects have not been identified to date, SRCSD intends to continue its search for viable recycling projects.

6.1.3 Water Conservation

An aggressive water conservation program implemented by the SRCSD would not be able to achieve a 37 mgd reduction in influent flows. Any reduction in flows due to water conservation was not considered a feasible, effective approach to avoiding the discharge of treated effluent to the Sacramento River above the current permitted discharge of 181 mgd (ADWF), and was not considered further in the current SEIA.

6.1.4 Pollutant Source Minimization

An aggressive pollutant source reduction program implemented by the SRCSD might be able to achieve load reductions for a small number of pollutants of concern, but would not be able to achieve sufficient reductions for all pollutants of concern such that the pollutant loadings in SRWTP effluent at 181 mgd would remain constant as the District increases its discharge to 218 mgd. For this reason, pollutant source minimization was not considered a feasible, effective approach to avoiding increased loadings to the Sacramento River above those allowed at the current permitted discharge of 181 mgd (ADWF), and was not considered further in the current SEIA.

6.1.5 No Net Increase Treatment Alternative

Providing additional treatment to the SRWTP's existing secondary treated effluent would afford the ability to continue discharging effluent to the Sacramento River at a flow rate above 181 mgd while maintaining loadings to the receiving water at the levels allowed under the current permitted discharge of 181 mgd (ADWF). Under the No Net Increase treatment alternative, a separate treatment train consisting of microfiltration (MF), reverse osmosis (RO), and ozone/hydrogen peroxide (peroxone) would be used to treat a portion of the SRWTP's entire flow at 218 mgd, and this additionally treated flow would be blended with effluent not receiving such additional treatment to achieve "no net increase" in loadings to the Sacramento River (Carollo, 2009). This No Net Increase treatment alternative would be used to maintain existing water quality and mass loading in the receiving water from the SRWTP's current permitted discharge of 181 mgd (ADWF) through the proposed permitted condition of 218 mgd (ADWF). Of the five project alternatives considered, only the No Net Increase alternative will be considered further as a potential treatment option due to the infeasibility of the other alternatives discussed above to provide sufficient reductions in effluent loadings above those currently permitted.

6.2 COSTS AND BENEFITS OF ALTERNATIVES TO MAINTAIN EXISTING WATER QUALITY

The first component of the antidegradation analysis, the assessment of projected water quality impacts due to the proposed project, identified constituents that, to varying degrees, may impact water quality in the Sacramento River (downstream of the SRWTP discharge) and in the Delta due to an increase in SRWTP discharge. A second component of the antidegradation analysis is an assessment of the costs and benefits of maintaining existing water quality in receiving waters. Maintaining existing water quality (i.e., preventing any increase in mass loading above that allowed by the District's existing NPDES permit) in the Sacramento River and the Delta with an increase in SRWTP discharge may be approached through additional wastewater treatment by MF/RO/peroxone (Carollo, 2009). This No Net Increase alternative possesses unique abilities, liabilities, and costs that will be discussed throughout the remainder of this SEIA. In order to maintain existing water quality in the Sacramento River and Delta from the time the SRWTP reaches its current permitted discharge rate of 181 mgd (ADWF) through a discharge of 218 mgd (ADWF), it is estimated that a maximum of approximately 48 mgd (ADWF) would need to be treated by the advance treatment train and then blended with the remaining 170 mgd (ADWF) secondary treated effluent prior to discharge to the Sacramento River. The implementation of the No Net Increase alternative would maintain SRWTP effluent mass loading to the Sacramento River and Delta at the currently permitted 181 mgd (ADWF) level as SRWTP discharge increases to 218 mgd (ADWF). The cost of implementing the No Net Increase alternative control measure would be above and beyond the costs associated with increasing SRWTP discharge to 218 mgd (ADWF).

As a means of equitably dividing the costs of maintaining existing water quality in the Sacramento River and Delta among current and future sewer ratepayers to accommodate the No Net Increase treatment alternative, the SRCSD would look to current ratepayers to pay for 70 percent and future ratepayers to pay for 30 percent of the alternative's implementation costs. This percent allocation between current and future sewer ratepayers represents a partitioned cost sharing of advanced treatment for the SRWTP's proposed 218 mgd (ADWF) discharge increase, and is a cost-sharing allocation used by the District for some SRWTP improvements. Additionally, cost estimates and socioeconomic impacts are further divided into "residential" and "non-residential" ratepayer categories to reflect the fact that approximately 80 percent of SRWTP wastewater treatment capacity is allocated to residential customers. The remaining 20 percent of SRWTP wastewater treatment capacity is allocated to "non-residential" (commercial and industrial) customers. The proposed sharing of alternative control measure costs among current and future, residential and non-residential ratepayers is provided in **Table 6-1**.

Table 6-1: Alternative Control Measure Cost Sharing among SRWTP Ratepayer Groups.

	SRWTP Ratepayer Group by User History	
SRWTP Ratepayer Group by Sewage Type Contribution	**Current Users (*70%*)**	**Future Users (*30%*)**
Residential Users (*80% SRWTP capacity allocation*)	56%	24%
Non-Residential Users (*20% SRWTP capacity allocation*)	14%	6%

6.2.1 No Net Increase Alternative

As stated above, the No Net Increase treatment alternative would employ a treatment train consisting of MF/RO/peroxone to provide additional wastewater treatment to a portion of the

SRWTP's secondary treated effluent as a means to maintain existing water quality in receiving waters as the SRWTP discharges effluent to the Sacramento River above the facility's currently permitted 181 mgd (ADWF) discharge (Carollo, 2009).

Reverse osmosis (RO) is a membrane separation process that is used for the removal of dissolved constituents from wastewater after advance treatment with microfiltration or tertiary filtration (Metcalf and Eddy, 2003). RO treatment relies on applied pressure to force water through a semi-permeable membrane while restraining the passage of particulate and high molecular weight constituents. Membranes exclude ions, but require high pressures to produce deionized water (Metcalf and Eddy, 2003). Passage of water through the membrane produces a relatively ion free effluent stream and a concentrated brine. Microfiltration (MF) occurs prior to RO in order to remove larger organic and inorganic particles that foul the RO membrane and thus increase membrane resistance to water flow and reduce membrane service life. MF does not effectively remove trace organic compounds due to the large nominal pore size (typical range 0.1 – 1 μm) of the semi-permeable membranes employed. Snyder et al. (2007) observed percent removals with MF of less than 20 percent for trace organic compounds. The smaller nominal pore size (typically <0.001 μm) associated with RO membranes has been observed to remove greater than 80 percent of trace organic compounds when used in drinking water and reuse applications (Snyder et al., 2007). While RO membranes provide significant removal of trace organic compounds, RO is a very energy intensive process that produces toxic brine containing concentrated trace organics and metals that poses its own waste disposal issues.

Ozone/hydrogen peroxide (peroxone) is an advanced oxidation process that produces hydroxyl free radicals to break down organic pollutants into simpler products. Ozone removes contaminants by chemical reactions via molecular ozone or the formation of free radicals (primarily the hydroxyl radical). Peroxide addition to the ozonation process promotes hydroxyl radical formation. With the addition of peroxide, the dominant oxidant becomes the hydroxyl radical, which reacts more universally with organic compounds, but generally with slower reaction rates for the compounds that are oxidized well by ozone alone (Huber et al., 2003). Compounds that react slowly with ozone show slightly improved removals with the combination treatment of ozone and hydrogen peroxide (Ternes et al., 2003). Peroxone is used in conjunction with RO to provide multiple barrier protection for the removal of trace organic compounds. This combination of treatment processes is among the best available technologies to remove trace organics. In addition, ozone/hydrogen peroxide is easier to produce at SRWTP than other facilities since the plant already has a pure-oxygen generation system in place associated with its high-purity oxygen-activated sludge (HPOAS) treatment process. There is no waste stream or brine that requires further treatment or disposal due to the peroxone process; however, as stated above, the brine generated from the RO process will require disposal.

The capacities of the MF/RO/peroxone advanced treatment train are based on the limiting constituents among the pollutants targeted by the individual treatment processes (see **Table 6-2**). To achieve a "no net increase" in total dissolved solids, mercury, copper, and other mass loadings to the Sacramento River, approximately 48 mgd (ADWF) would need to be treated by the advanced treatment train and blended with the remaining 170 mgd (ADWF) of existing secondary effluent for discharge to the Sacramento River (Carollo, 2009). This analysis assumes that the blending of effluent streams of different qualities is permitted.

Table 6-2: Classes of Pollutants Treated by Individual Treatment Technologies associated with No Net Increase Advanced Treatment Train.

Pollutant Classes Treated by Particular Technology	Microfiltration	Reverse Osmosis	Ozone/Hydrogen Peroxide (peroxone)
Suspended particles	☑	☑	
Protozoa and bacteria	☑	☑	☑
Viruses	Limited removal	☑	☑
Dissolved inorganic material	☑	☑	
Insoluble organic material	☑	☑	
Dissolved organic material	☑	☑	
Trace organic compounds	Limited removal	☑	☑
Total organic carbon			☑

6.2.2 Costs

The MF/RO/peroxone costs provided in **Table 6-3** are planning level estimates (Class 4 and Class 5 estimates as presented in Association for the Advancement of Cost Engineering International Recommended Practice No. 18R-97 (AACEI, 2005)) and do not include the cost of the proposed SRWTP expansion to accommodate 218 mgd (ADWF). The SRWTP's secondary wastewater treatment processes would provide the requisite level of treatment for a portion of the flow that would undergo additional treatment via MF/RO/peroxone. The RO cost estimate assumes 90 percent recovery of flow. The remaining 10 percent brine flow is treated by on-site thermal brine concentration and crystallization, followed by off-site land disposal. Solids would require disposal in a Class II landfill, as a California designated waste. It is estimated that approximately 150,000 lbs/day of crystallized solids will require land disposal when the advanced treatment train is operated at its 48 mgd capacity. **Table 6-3** presents the various costs associated with the construction and operation of the No Net Increase advanced treatment train having a treatment capacity of 48 mgd (ADWF). Total costs include capital and operation and maintenance costs, and all cost estimates are presented as planning level estimates based on an Engineering News Record Construction Cost Index (ENRCCI) value of 9138[14] as of January 2009. Annualized costs are based on a 20-year period and a 5 percent discount rate (annualization factor = 0.08024). In addition to total project costs, the cost of this alternative are divided among current and future ratepayers, and further subdivided among residential and non-residential customers. Blended advanced treated effluent and secondary treated effluent would undergo chlorination prior to discharge to the Sacramento River. The cost of chlorination of the entire flow (218 mgd (ADWF)) is not included in the No Net Increase treatment costs presented in **Table 6-3** as chlorine disinfection is an existing element of the SRWTP treatment process.

[14] A January 2009 ENRCCI value of 9138 for Sacramento, CA was estimated by taking an average of the average ENRCCI for the U.S. 20 cities (i.e., 20-City Average) and the ENRCCI for San Francisco, CA.

Table 6-3: No Net Increase Advanced Treatment Train Cost Estimates by Ratepayer Group Allocations for 48 mgd (ADWF) Treatment Capacity.

Ratepayer Group	Capital Cost(1,2)	Annualized Capital Cost(1,2,4)	Annual Operation and Maintenance Cost(3)	Total Annual Cost(5)
Current Residential	$372,400,000	$29,700,000	$21,800,000	$51,500,000
Current Non-Residential	$93,100,000	$7,400,000	$5,500,000	$12,900,000
Future Residential	$159,600,000	$12,700,000	$9,400,000	$22,100,000
Future Non-Residential	$39,900,000	$3,200,000	$2,300,000	$5,500,000
Totals	**$665,000,000**	**$53,000,000**	**$39,000,000**	**$92,000,000**

(1) Project costs include engineering, administrative, legal and contingency. All costs in January 2009 dollars (ENRCCI 9138). The ENRCCI for Sacramento, CA (9138) was estimated by taking an average of the average ENRCCI for the U.S. 20 cities (i.e., 20-City Average) and the ENRCCI for San Francisco, CA.

(2) Project costs sized to treat associated ADMMF of 67 mgd.

(3) O&M costs sized to treat ADAF of 52 mgd.

(4) Annual capital cost developed using a 20 year amortization period and 5 percent interest.

(5) Reverse osmosis costs included in the No Net Increase advanced treatment train include brine treatment and disposal. The assumed brine flow requiring treatment is 10% of the ADMMF.

6.2.3 Benefits

MF/RO/peroxone treatment of a portion of SRWTP secondary treated effluent would provide sufficient removal of pollutants of concern from blended advanced treated effluent and secondary treated effluent to the Sacramento River so as to maintain existing water quality at pre-project levels (i.e., maintain mass loading at the currently permitted 181 mgd (ADWF) level). However, it should be noted that MF/RO/peroxone treatment would not significantly improve downstream water quality in the Sacramento River and Delta.

6.2.4 Potential Impacts

Advanced wastewater treatment employing MF/RO generates a significant level of concern due to energy demand and "cross media impacts" – this term refers to the interrelated impacts caused by removal of a pollutant from one medium and its transfer to one or more other media. In the case of MF/RO, the process removes a pollutant at a certain concentration from wastewater and partitions it at a significantly higher concentration in brine and/or residuals. Pollutants, such as metals, are not destroyed, but transferred from one medium to another. Organic pollutants can be destroyed or converted to other toxic or non-toxic forms and can also be transferred from one medium to another. It should be noted that in transferring from one medium to another, the bioavailability of the pollutant may be changed significantly. MF/RO treatment results in the transfer of pollutants from wastewater into biosolids, air, and/or concentrated waste streams. Depending on regulatory limits, additional treatment of the biosolids, air, or waste streams may be required (Carollo, 2005). In addition to these cross media pollutant transfer impacts, operation of MF/RO processes can generate additional pollutants and greatly elevate locale power demand as described by the potential MF/RO environmental impacts provided in **Table 6-4**.

Table 6-4: Potential Environmental Impacts associated with Microfiltration/Reverse Osmosis Treatment of Wastewater.

Potential MF/RO Environmental Impacts[1]
Substantial power requirements of MF/RO treatment and associated increases in greenhouse gas emissions from the power plants providing the electricity.
Potential need for additional treatment of brine waste to remove heavy metals and other contaminants from the aqueous phase prior to crystallization and disposal of waste.
Ultimate disposal of brine and residuals requiring the energy intensive processes of evaporation, crystallization, and off-site transport.
Increases in greenhouse gas emissions from truck and rail traffic to dispose of crystallized brine waste.

(1) Metcalf and Eddy, 2003.

Increased power consumption resulting from implementation of the No Net Increase treatment alternative would lead to increases in greenhouse gas emissions that would significantly expand the carbon footprint of the SRWTP. SRCSD has estimated the increase in electricity consumption and corresponding increase in emissions of CO_2 for the No Net Increase treatment alternative as compared o the SRWTP's existing secondary treatment process at the proposed discharge capacity of 218 mgd (ADWF), as shown in **Table 6-5**. Secondary treatment processes at the proposed 218 mgd (ADWF) discharge capacity would annually consume an estimated 168.4 million kilowatt hours (kWh) and produce an estimated 61,566 metric tons of CO_2. By comparison, the addition of the No Net Increase treatment alternative to secondary treatment would annually consume an estimated 352.2 million kWh and produce an estimated 128,755 metric tons of CO_2. The No Net Increase treatment alternative would increase the SRWTP's annual CO_2 emissions by 109%. This increase in greenhouse gas emissions runs contrary to Assembly Bill 32 (AB 32) – the California Global Warning Solutions Act of 2006 – that seeks to establish a statewide greenhouse gases emissions cap for 2020 based on California's 1990 emission levels.

Finally, temporary, construction-related impacts associated with the building of MF/RO/peroxone treatment facilities are anticipated for this alternative control measure. However, these temporary, construction-related impacts would be mitigated to the greatest extent practicable.

Table 6-5: Comparison of Greenhouse Gas Emissions at the SRWTP Resulting from Electricity Consumption by Secondary Treatment Processes and the No Net Increase Treatment Alternative Added to Secondary Treatment.

Treatment Level (218 mgd (ADWF))(1)	Estimated Total Annual Electricity Consumption (kWh)(2)(3)	Estimated Total Annual CO_2 Emissions(4)(5) (metric ton)	Percent Increase in Estimated Annual CO_2 Emissions above that Estimated for Secondary Treatment at 218 mgd (ADWF)
Secondary Treatment	168,434,486	61,566	0%
Secondary Treatment + MF/RO/peroxone	352,253,756	128,755	109%

(1) Electricity consumption and CO_2 emissions values provided in this table based on an average day annual flow (ADAF) of 237 mgd, which corresponds to an average dry weather flow (ADWF) of 218 mgd.

(2) Electricity consumption estimates for secondary treatment projected from actual 2005 SRWTP electricity consumption.

(3) Electricity consumption estimate for microfiltration based on personal communication with Carollo Engineers, Inc. (Carollo, 2007); electricity consumption estimate for reverse osmosis taken from Carollo (2002b); and electricity consumption estimate for peroxone treatment based on personal communication with Carollo Engineers, Inc. (Garvey, 2009).

(4) Total CO_2 emissions calculations based on California Climate Action Registry's General Reporting Protocol, Ver. 2.2, March 2007.

(5) Total CO2 emissions (direct emissions plus indirect emissions) data only captures greenhouse gas emissions due to electricity consumption at the SRWTP, and does not include electricity consumption at interceptor facilities.

– Direct emission is defined as those emissions from sources that are owned by an organization. Direct emissions may include mobile combustion sources and fugitive sources (e.g., methane leak from pipeline system).

– Indirect emission is defined as those emissions that occur because of an organization's actions, but are produced by sources owned or controlled by another entity. Indirect emissions may include purchased and consumed electricity, natural gas, and/or steam.

6.2.5 Compliance with Laws and Regulations

State and federal water quality laws require that discharges not result in an exceedance of water quality standards. The portion of SRWTP effluent that would undergo MF/RO/peroxone treatment is expected to meet all relevant water quality objectives and standards. The MF/RO/peroxone treatment alternative is not expected to result in far-field exceedances of applicable water quality objectives and standards.

6.3 SOCIOECONOMIC IMPACTS OF ALTERNATIVES FOR MAINTAINING EXISTING WATER QUALITY

As described in the previous section, the analysis of costs, benefits, and potential impacts of maintaining existing surface water quality in the Sacramento River and Delta by maintaining SRWTP effluent mass loading to the river at the currently permitted 181 mgd (ADWF) level as SRWTP discharge capacity increases to the proposed 218 mgd (ADWF) level is based on a combination of advanced treatment processes including MF, RO, and peroxone. This additional treatment will result in a substantial increase in monthly sewer rate fees paid by users of SRCSD's treatment facilities. Furthermore, the annual costs of additional treatment, and the monthly increases, can be translated into a set of economic indicators that describe revenue and employment losses in the SRCSD service area as a means of modeling the overall socioeconomic cost of implementing and operating the No Net Increase advanced treatment alternative. As a means of limiting the number of projections made in the course of estimating alternative control measure project costs and impacts to ratepayers in the SRCSD service area, a decision was made to estimate all costs and impacts in January 2009 dollars (using ENRCCI = 9138) and apply them to the SRCSD's estimate of current residential ratepayers (i.e., 477,804 ESDs[15]). Limiting the current discussion to increases in residential sewer fees follows the common practice of estimating the economic impact of a project on the *average household* with a potentially impacted community. This section discusses the impacts of the No Net Increase advanced treatment alternative in terms of monthly sewer rate increases and overall socioeconomic impacts to the SRCSD service area.

6.3.1 Impacts on Monthly Residential Sewer Rates

The current analysis of monthly sewer rate increases that would be associated with the construction and operation of the No Net Increase advanced treatment alternative is focused on increases to the current residential ratepayers. An analysis of fee increases to current non-residential ratepayers and all future ratepayers is outside of the scope of the current effort; however, socioeconomic impacts to all current and future ratepayer categories are considered in the Section 6.3.2.2, Modeling of Economic Impacts on the Community. The project costs for the No Net Increase advanced treatment alternative presented in **Table 6-3** can be used to estimate a monthly sewer rate increase that would be assessed to each existing residential ratepayer if the alternative control measure was implemented today, as shown in **Table 6-7**. A ratepayer's total monthly sewer fee is comprised of a fee for collection and conveyance and a fee for treatment and discharge of wastewater. As mentioned previously (see Section 4.3), contributing sewer agencies are responsible for collection and transport of wastewater from local jurisdictions and SRCSD provides treatment and discharge of wastewater at the SRWTP. Sewer fees assessed to single family residences with the SRCSD service area by contributing agencies for collection and conveyance of wastewater are shown in **Table 6-6**. Ratepayers pay the collection and conveyance fee corresponding to the contributing agency providing service to their residence, in addition to a SRCSD sewer fee.

Table 6-6: Monthly Residential Sewer Fees Charged by SRCSD Contributing Agencies for Collection and Conveyance of Wastewater to the SRWTP.

Contributing Agency	Monthly Residential Sewer Fee
Sacramento Area Sewer District (SASD)	$15.00
City of Sacramento	$11.10
City of West Sacramento	$5.19
City of Folsom	$16.15

Based on the current monthly SRCSD residential sewer fee of $19.75 (as of March 2009; paid in bimonthly installments of $39.50), customers in this rate category would pay SRCSD monthly fees of $35.80 (or $71.60 bimonthly) if the alternative control measure was implemented today. It is important to note that these estimated monthly fee increases represent only the portion of the alternative control measure's cost assessed to current residential ratepayers to pay for approximately 56 percent of the construction and operation/maintenance costs of the alternative control measure (see **Table 6-1**). This percentage is calculated based on the planning estimate

[15] ESDs = Equivalent single-family dwellings

that 70 percent of the project would be paid for by current ratepayers, and then multiplied by the 80 percent of SRWTP capacity allocated to residential users (70% x 80% = 56%).

Table 6-7: Estimated Monthly and Annual SRCSD Residential Sewer Rate Increases assessed to Current Residential Ratepayers to provide Debt Service for the No Net Increase Advanced Treatment Alternative.

Alternative Control Measure	Current Residential Ratepayer Share of Total Annual Project Cost	Estimated Current SRCSD Residential Ratepayer Increases	
		Monthly Increase	Annual Increase
MF/RO/peroxone	$51,500,000	$16.05	$192.55

The monthly SRCSD sewer rate increase shown in **Table 6-7** that would be assessed to current residential ratepayers would provide debt service for 56 percent of the total cost of the No Net Increase advanced treatment train alternative. The remaining 44 percent of the alternative's cost would be borne by existing non-residential and future residential and non-residential ratepayers as shown in **Table 6-8**. In the case of current non-residential ratepayers, their monthly sewer fees would also increase; however, a detailed accounting and projection of monthly rate increases for existing commercial and industrial users is outside of the scope of the current effort. Debt service for approximately 30 percent of the No Net Increase alternative's cost (see **Table 6-1**) would come from increased sewer connection fees assessed to future residential and non-residential customers. Once a future customer becomes a current ratepayer, he will pay the current monthly sewer rate assessed to all customers in a specific rate category at the time of his connection. A consolidated assessment of alternative control measure costs to all SRWTP ratepayers in terms of overall economic impact to the SRCSD service area is provided in Section 6.3.2.2, Modeling of Economic Impacts on the Community.

Table 6-8: Estimated Annual Debt Service for No Net Increase Advanced Treatment Train Alternative assessed to Current Non-Residential and All Future Ratepayers in SRCSD Service Area.

Ratepayer Group	Annual Debt Service	Debt Service Revenue Source
Current Non-Residential	$12,900,000	Increased monthly sewer fees
Future Residential	$22,100,000	Increased connection fees
Future Non-Residential	$5,500,000	Increased connection fees

(1) Debt amortized over a 20-year period with an annualization factor of 0.08024

6.3.2 Socioeconomic Impacts to the SRCSD Service Area

Socioeconomic impacts to the SRCSD service area as a result of implementing the No Net Increase treatment alternative are assessed at two levels: (1) impact on individual households due to sewer fee increases, and (2) impact on the community based on a modeling of key economic indicators. As stated earlier, the estimating of alternative control measure costs and impacts to ratepayers in the SRCSD service area was made in today's dollars (as of January 2009) and applied to the District's estimate of current residential ratepayers (477,804 ESDs).

This strategy avoids the uncertainties associated with an estimate based on future population growth within the SRCSD service area, future construction costs, and the precise timing of alternative control measure implementation. While it is true that the No Net Increase treatment alternative, if pursued, would not begin to be implemented until SRWTP flows approached 181 mgd (ADWF), and project costs would be greater at that time, household incomes and the total number of ratepayers asked to share the expense of the alternative control measure would also increase, thus maintaining the relative economic burden of the alternative control measure relatively constant over the next several years. The economic impact analysis software used to model economic impacts to the SRCSD service area due to the implementation of the No Net Increase treatment alternative relies on the distribution of wealth in the community and the spending habits of Sacramento County and City of West Sacramento residents in order to project changes in several key economic indicators. The current distribution of wealth, spending habits, and overall economic health of Sacramento County and the City of West Sacramento are not anticipated to significantly change in future years relative to the historic economic growth trends observed for these areas, thus supporting the use of 2009 project cost estimates to assess the general economic burden imposed by the implementation of the No Net Increase advanced treatment alternative. However, in light of the current U.S. economic recession and the uncertainty of its magnitude and length, the socioeconomic impacts projected for SRSCD ratepayers in the current analysis as a result of implementing the No Net Increase alternative may represent an underestimation of the actual socioeconomic impacts that would be observed in the SRCSD service area with implementation of the alternative control measure.

6.3.2.1 Projected Increases in SRCSD Residential Rates

SRCSD's current residential monthly sewer fee is $19.75. Monthly residential sewer rate increases estimated for the No Net Increase treatment alternative necessary to maintain SRWTP effluent mass loading to the Sacramento River at the current permitted 181 mgd (ADWF) level as the SRWTP discharge capacity increases to the proposed permitted discharge of 218 mgd (ADWF) will bring SRCSD monthly fees to $35.80 (see **Table 6-9**). Using SASD as an example contributing agency since it contributes the largest amount of wastewater flow to SRCSD, a single family residence serviced by the SASD would pay a total monthly sewer fee of $50.80 with implementation of the No Net Increase treatment alternative (see **Table 6-6**). As stated earlier, the estimated residential SRCSD monthly fee increase will only support repayment of approximately 56 percent of the total cost of the No Net Increase treatment alternative. The estimated $50.80 total monthly sewer fee (for providing additional MF/RO/peroxone treatment of a portion of SRWTP secondary treated effluent) only applies to existing residential ratepayers serviced by the SASD and does not consider the added economic hardship to future home buyers due to increased home prices associated with increased connection fees levied against new development. The estimated annual debt service that would be required to be supported by new development through the assessing of increased connection fees is shown in **Table 6-8**.

Table 6-9: Comparison of Current Monthly Residential Sewer Fees to those Estimated for the No Net Increase Advanced Treatment Alternative for a Household Serviced by SASD.

Treatment Level	SRCSD Monthly Residential Fee	SASD Monthly Residential Fee	Total Monthly Residential Fee	Total Annual Residential Fee	% Increase in Treatment Cost above Current Level
Current Treatment	$19.75	$15.00	$34.75	$417.00	---
MF/RO/peroxone	$35.80(1)	$15.00	$50.80(1)	$609.55(1)	46%

(1) Estimated fee.

6.3.2.2 Modeling of Economic Impacts on the Community

An economic impact analysis traces spending through an economy and measures the cumulative effects of that spending. The impact region can be an entire state, one or more counties, a single city, or any segment of the population representing a semi self-sufficient economic unit for which relevant economic information exists. The current economic impact analysis evaluates the potential impacts to a large portion of Sacramento County and the entirety of the City of West Sacramento (i.e., those areas comprising the SRCSD service area) due to an increase in annual sewer fees that would be needed to finance the No Net Increase advanced treatment alternative presented in this section. An economic impact modeling software package, IMPLAN® (IMpact Analysis for PLANing) Version 2, was used to estimate the socioeconomic impacts of increased sewer fees on SRCSD ratepayers from a broader perspective, beyond the single economic metric of an annual rate increase. IMPLAN® is a widely accepted model that has been used by the U.S. EPA, the California Department of Water Resources, USDA Forest Service, and USDI Bureau of Land Management. IMPLAN® is an economic impact assessment modeling system that allows the user to build models to estimate the impacts of economic changes at state, county, or community levels. For the current analysis, economic data specific to the SRCSD service area were obtained from the Minnesota IMPLAN® Group, Inc. (MIG), based on the following zip codes within Sacramento County and the City of West Sacramento that comprise the SRCSD service area:

95608, 95610, 95615, 95621, 95624, 95626, 95628, 95630, 95652, 95655, 95660, 95662, 95670, 95671, 95673, 95683, 95690, 95742, 95757, 95758, 95814, 95815, 95816, 95817, 95818, 95819, 95820, 95821, 95822, 95823, 95824, 95825, 95826, 95827, 95828, 95829, 95830, 95831, 95832, 95833, 95834, 95835, 95836, 95837, 95838, 95841, 95842, 95843, 95864, 95605, 95691, 95798, 95799

IMPLAN® is an input-output model that uses multipliers[16] to represent demand and flow of resources among sectors[17] and institutions in the economy. Input-output analysis is a means of examining relationships within an economy, both between businesses and between businesses and final consumers. It captures all monetary market transactions for consumption in a given

[16] Multipliers describe the response of an economy to a stimulus (a change in demand or production).

[17] A sector represents an economic activity that produces goods and/or services. Fruit farming, natural gas distribution, real estate, and medical practices, to name a few, all represent economic activities, and hence sectors in an economy.

time period. This type of analysis allows examination of the effects – or economic impacts – of a change in one or several economic activities on an entire community. Economic impacts are represented by changes in economic output and employment. The current analysis is based on the assumption that a sewer fee increase to households in the SRCSD service area will reduce discretionary spending of disposable income. A loss in discretionary spending will reduce demands for local goods and services, which in turn will reduce demands for local labor, resulting in loss of employment.

Unlike the ratepayer category effects presented in **Table 6-1** where alternative control measure costs are divided among four ratepayer groups, the economic impact analysis using IMPLAN® considers the impacts of the entirety of the No Net Increase advanced treatment alternative on the SRCSD service area as a whole. While it is true that the alternative control measure, if pursued, would not be implemented for several years and project costs would be greater at that time, household incomes and the total number of ratepayers asked to share the expense of an alternative would also increase, thus maintaining the relative economic burden of the alternative control measure comparatively constant over the next several years. The IMPLAN® model utilizes information regarding the distribution of wealth and spending habits in the SRCSD service area to estimate changes in several key economic indicators. The current distribution of wealth, spending habits, and overall economic health of the service area not anticipated to significantly change in future years relative to the historic economic growth trends observed for these areas, thus supporting the use of 2009 project cost estimates to assess the general economic burden on the SRCSD service area imposed by the implementation of additional advanced wastewater treatment. In short, the current economic impact analysis looks at present day economic effects of the entire cost of the No Net Increase advanced treatment alternative on all SRCSD ratepayers.

IMPLAN® data from 2007 were the most recent economic data available for the SRCSD service area, as compiled by MIG, and were used in the current analysis. As a means of equating 2007 model data to 2009 project costs, 2009 inflators were applied to model data to account for the change in the actual value of the dollar over the 24-month period. Basic 2007 economic information for the SRCSD service area used by the IMPLAN® model is shown in **Table 6-10**. The largest household (HH) income class in the community is the 50 – 75K group representing 20 percent of the total community. If one uses the U.S. Census Bureau's 2002 offering of "middle class" as the middle 20 percent (middle or third quintile) of the country having incomes ranging from $40,000 – $95,000, then approximately 50 percent of the residents in the SRCSD service area could be described as belonging to the "middle class". This middle class group includes members of the 25 – 35K, 35 – 50K, and 50 – 75K HH income classes, as presented in **Table 6-10**. In fact, the U.S. Census Bureau's $40,000 – $95,000 range was derived by stretching its own definition of middle class to include household incomes falling into the second through fourth quintiles. A 2007 Congressional Research Service report found that the use of the U.S. Census Bureau's three middle quintiles produces a middle class group that accounts for about 60 percent of all U.S. households and is generally in-line with the perception of what it means to belong to the "middle class" based on numerous surveys of the American public used to compare income distributions with self-reported class divisions (Cashell, 2007).

Table 6-10: Summary of Household Income Classes in Sacramento County and the City of West Sacramento and their Relative Contributions to the No Net Increase Alternative Annual Costs.

Household Income Class(1)	Average Annual Household Income(2,3,4)	Number of Households in Class(4)	Percent of Total Households under Consideration	Annual Contribution to No Net Increase Treatment Cost by HH Income Class
<10K	$8,498	44,292	8.5%	$7,832,436
10 – 15K	$21,221	31,417	6.0%	$5,555,668
15 – 25K	$33,949	63,279	12.2%	$11,190,028
25 – 35K	$50,876	67,363	12.9%	$11,912,228
35 – 50K	$72,075	88,946	17.1%	$15,728,887
50 – 75K	$118,688	105,559	20.3%	$18,666,669
75 – 100K	$152,633	56,291	10.8%	$9,954,295
100 – 150K	$212,070	43,987	8.8%	$7,778,501
150K+	$339,589	19,121	3.7%	$3,381,288

HH = Household

(1) Household income class is based on median monetary income (money income) data collected by the U.S. Census Bureau.

(2) Average annual household income is based on average personal income data collected by the U.S. Bureau of Economic Analysis.

(3) Due to the manner in which average annual household income is calculated, it commonly falls above the upper boundary of the household income class to which it is associated. The difference lies in the definition of personal versus monetary income.

(4) Data source IMPLAN® 2007.

The determination that 50 percent of all households in the SRCSD service area fall into the middle class leaves the remainder of the economic community with approximately 27 percent representation in the "lower class" and about 23 percent representation in the "upper class". As shown by **Table 6-10**, low and middle class households would contribute the vast majority (approximately 77 percent) of financing required for the No Net Increase advanced treatment alternative. The annual burden on lower income households of financing the alternative control measure (see **Table 6-9**) would result in proportionately less disposable person income (DPI; a percentage of total average income) available to these households as compared to middle class and upper class income classes as presented in **Table 6-11**. DPI represents "after tax" income and is considered as 82.5 percent of average annual income by the IMPLAN® model. A decrease in disposable income translates into fewer dollars available to spend on essential goods and services such as food, lodging, and healthcare. An increase in annual sewer fees due to the implementation of additional treatment would result in households in the <10K income class spending over 8.5 percent of their average annual DPI on sewer treatment (see **Table 6-11**). It is clear that increased monthly sewer fees due to the implementation of the No Net Increase advanced treatment alternative would result in proportionately larger financial burdens to lower household income classes as compared to middle and upper income classes. However, the estimated, total annual residential sewer fees provided in **Table 6-9** upon which the percentages provided in **Table 6-11** are based do not address fee increases to current non-residential or future residential and non-residential ratepayers. Financial impacts to these ratepayer groups in terms of projected sewer rate increases is beyond the scope of the current effort, but community level socioeconomic impacts to all ratepayer groups are considered in aggregate by the IMPLAN® model.

Table 6-11: Percent Household Income and Average Annual Disposable Personal Income by Household Income Class Required to Finance the No Net Increase Treatment Alternative for a Household Serviced by SASD.

Household Income Class	Average Annual Disposable Personal Income (DPI)[(1,2)]	Total Annual Sewer Fee[(3)] by Treatment Level as Percentage of Average Annual Household Income (HHI) and Annual Average Disposable Personal Income (DPI)			
		Current Treatment ($417.00)		No Net Increase Treatment ($609.55)	
		% of HHI	% of DPI	% of HHI	% of DPI
<10K	$7,011	4.91	5.96	7.17	8.69
10 – 15K	$17,507	1.97	2.38	2.87	3.48
15 – 25K	$28,008	1.23	1.49	1.80	2.18
25 – 35K	$41,973	0.82	0.99	1.20	1.45
35 – 50K	$59,462	0.58	0.70	0.85	1.03
50 – 75K	$97,901	0.35	0.43	0.51	0.62
75 – 100K	$125,922	0.27	0.33	0.40	0.48
100 – 150K	$174,958	0.20	0.24	0.29	0.35
150K+	$280,161	0.12	0.15	0.18	0.22

(1) Calculated as 82.5% of Average Annual Household Income provide in Table 6-8.

(2) Data source IMPLAN® 2007.

(3) Total annual sewer fee includes annual fee paid to contributing agency (SASD) for collection and conveyance of wastewater, as well as annual fee paid to SRCSD for treatment and discharge of wastewater.

Table 6-12 presents IMPLAN®-modeled economic impacts of the No Net Increase advanced treatment alternative in terms of labor income loss, indirect business tax loss, employment loss, and total output loss. Labor income constitutes the wages and benefits of employees and proprietors, and indirect business tax includes the excise and sales taxes paid by individuals and businesses. Total output is the sum of all the goods and services produced in a community's economy. The IMPLAN® model was run using the 50 – 75K income class as a surrogate for all income classes as the spending habits of the 50 – 75K income class have been found to be representative of the spending habits of all income classes within a community. The losses projected by the model, as presented in the model output, are the sum of all direct, indirect, and induced effects of the cost of the alternative control measure on the economy of the SRCSD service area. The model input is the estimated total annual cost for the No Net Increase alternative (see grand total of total annual costs presented in **Table 6-3**).

Table 6-12: Annualized Socioeconomic Impacts of Increased Sewer Fees Required to Finance the No Net Increase Advanced Treatment Alternative.

Alternative Control Measure	Estimated Annual Sewer Fee Increase(1)	Economic Indicators(2)			
		Labor Income Loss/Year	Indirect Business Tax Loss/Year	Employment Loss/Year	Total Output Loss/Year
No Net Increase	$192.55	$29,264,883	$5,808,739	671.6	$117,844,630

(1) Reflects only estimated increase in current SRCSD residential ratepayer annual fees (see Table 6-7).
(2) Considers annual losses to SRCSD service area due to the entire cost of the No Net Increase advanced treatment alternative.

As shown by the economic indicators provided in **Table 6-12**, the No Net Increase advanced treatment alternative is projected to have a significant negative impact on the local economies of Sacramento County and the City of West Sacramento. Because the economic indicators represent only a single year's impacts on the SRCSD service area's economy – they are, in fact, *annualized* economic indicators – these impacts would be repeated every year for the 20-year life cycle of the alternative. The losses, whether in dollars or jobs, are linked to a reduction in DPI due to increased sewer fees required to pay for the No Net Increase alternative. All communities possess somewhat unique spending habits as a whole, and a reduction in DPI has different consequences for some economic sectors as compared to others depending on the community in which the reduction in DPI occurs. The IMPLAN® model output also includes a listing of affected sectors for each economic indicator. The Top 10 sectors in the SRCSD service area projected to be affected by the implementation of the No Net Increase alternative in terms of both losses in employment and labor income as shown in **Table 6-13**. The sectors hit hardest by employment loss are not necessarily the same ones projected to have the greatest impact on loss of labor income because a smaller number of medium to high paying jobs (for example, health care industry jobs) will have a greater impact on a community's labor income than a larger number of low paying jobs (for example, food service jobs).

Table 6-13: Top 10 Sectors Projected to be Affected by Implementation of the No Net Increase Advanced Treatment Alternative.

Top 10 Affected Employment Sectors(1)	Top 10 Affected Labor Income Sectors(1)
Food Service and Drinking Places	Health Care Offices
Health Care Offices	Wholesale Trade
Wholesale Trade	Hospitals
General Merchandise Stores	Food Service and Drinking Places
Hospitals	Motor Vehicle and Parts Dealers
Real Estate	Food and Beverage Stores
Food and Beverage Stores	General Merchandise Stores
Nursing and Residential Care Facilities	Legal Services
Motor Vehicle and Parts Dealers	Real Estate
Private Households	Nursing and Residential Care Facilities

(1) Taken from IMPLAN® model output.

In terms of the impact to the current unemployment rate in Sacramento County (10.4 percent as of January 2009) and the City of West Sacramento (17.8 percent as of January 2009), implementation of additional treatment would increase the overall unemployment rate in the SRCSD service area (10.5 percent as of January 2009) to 10.6 percent once annual projected employment losses (an estimated annual loss of 672 jobs per year; see **Table 6-12**) due to the No Net Increase alternative were realized, if the alternative was implemented today. While the incremental increase in unemployment rate may appear small, the City of Sacramento, which accounts for approximately one third of the total labor force in Sacramento County, is currently experiencing levels of unemployment (12.2 percent as of January 2009) approximately 15 percent higher than the statewide average of 10.6 percent. The City of West Sacramento is currently experiencing almost 68 percent greater unemployment than that experienced statewide. Other areas of Sacramento County are currently experiencing unemployment rates above 15 percent: Rio Linda (15.2 percent), North Highlands (15.3), Florin (15.6 percent), and South Sacramento (17.5 percent). Even a small increase in the unemployment rates of those communities in the SRCSD service area that are being hardest hit by the current economic recession would have detrimental localized impacts. The projected losses to labor income and total output (similar to gross metropolitan output) for the SRCSD service area as a result of financing the No Net Increase alternative would be minor on a percent basis when compared to the total labor income and output of Sacramento County and the City of West Sacramento, yet the estimated job losses and reduction in local output (see **Table 6-12**) would produce economic hardship at the household level, with lower income households bearing a larger impact on an annual basis, in relative terms, than wealthier household in the community. Furthermore, the final economic impact of the No Net Increase alternative could increase significantly if (1) the brine produced by the RO process requires additional treatment to remove heavy metals and other contaminants, and/or (2) brine crystallized residuals require specialized disposal in some type of hazardous materials containment site. Contingencies of this sort were not considered from an economic perspective by the IMPLAN® model, but certainly could generate additional direct and indirect economic and environmental impacts to be borne by existing and future SRWTP ratepayers.

6.4 BALANCE OF ENVIRONMENTAL BENEFITS AND SOCIOECONOMIC CONSIDERATIONS

SWRCB guidance requires that a complete antidegradation analysis includes a balancing of the proposed action against the public interest. SRCSD’s approach for compliance with this requirement is to compare the environmental impacts of the proposed project (an increase in NPDES permitted discharge of 37 mgd (ADWF)) with the environmental and socioeconomic impacts of the No Net Increase advanced treatment alternative integrated with the proposed project as a means of essentially eliminating the incremental water quality impacts of the proposed discharge above the current permitted 181 mgd (ADWF) level. The socioeconomic impacts of the proposed project need not be estimated in the analysis because they form a baseline[18] common to the proposed project and the proposed project integrated with the No Net

[18] While the proposed project will result in an increase to monthly residential sewer fees and socioeconomic impacts as a result of constructing and operating/maintaining the proposed project, these costs represent a baseline effect common to the proposed project and the additional advanced treatment alternative, and therefore do not require quantification as a means of assessing the incremental socioeconomic effect due to additional treatment.

Increase alternative. The current comparison focuses on the socioeconomic impacts and environmental benefits and impacts of the No Net Increase alternative to the water quality impacts of the proposed project. Additionally, the no project alternative is also considered. Based on these comparisons, a project deemed to be consistent with best practicable treatment or control consistent with maximum benefit to the people of the State is identified.

The socioeconomic and water quality impacts of the proposed project and the No Net Increase advanced treatment alternative considered in this analysis are compared in **Table 6-14**. The proposed 218 mgd (ADWF) secondary treated discharge is projected to have favorable, negligible, and unfavorable effects on Sacramento River water quality downstream of the SRWTP discharge depending on parameter. The proposed permitted condition (218 mgd) is projected to have a slight diluting effect, albeit *de minimis*, on the following constituents: total aluminum, total coliform, and total suspended solids. A number of parameters evaluated in the current analysis are anticipated to have a negligible impact on downstream Sacramento River water quality due to their small projected increment above the existing, baseline ambient condition at the proposed permitted condition (218 mgd). The incremental change in concentration for these constituents is estimated to be of small enough magnitude that it will either lie within the existing variability observed among historic, ambient water quality measurements for these parameters, or exist below analytical detection levels. Constituents for which no measureable change in downstream Sacramento River water quality is projected due to the proposed discharge capacity increase include ammonia (summer operations, May through September), total nitrogen (summer operations), nitrate plus nitrite, TKN (summer operations), total mercury, dissolved oxygen, dissolved cadmium, temperature, dissolved arsenic, total selenium, dissolved silver, 1,4-dichlorobenzene, bromodichloromethane, chloroethane, diethyl phthalate, di-n-butyl phthalate, methyl chloride, methylene chloride, tetrachloroethylene, and toluene. A slight increase in downstream Sacramento River concentration and mass loading is anticipated for total phosphorus, EC, TDS, chloride, TOC, dissolved copper, dissolved zinc, total antimony, dissolved chromium, dissolved lead, total molybdenum, dissolved nickel, total cyanide, bis(2-ethylhexyl)phthalate, and chloroform. A moderate increase in downstream Sacramento River concentration and mass loading is anticipated during winter operating conditions (October through April) for ammonia, total nitrogen, and TKN.

Table 6-14: Comparison of the Socioeconomic Impacts and Environmental Benefits and Impacts of the Proposed Project and No Net Increase Advanced Treatment Alternative Control Measure

Treatment Level	Monthly Residential Fee Increase	Estimated Loss in Jobs	Treatment Process Environmental Impacts
Pure Oxygen Secondary Treatment and Chlorine Disinfection (proposed project)	Not estimated(1)	Not estimated(1)	Favorable Impact ● Slight decrease, albeit de minimis, in downstream Sacramento River concentration for total aluminum, total coliform, and TSS. Negligible Impact ● Immeasurable change in downstream Sacramento River concentration for ammonia (summer operations), total nitrogen (summer operations), nitrate plus nitrite, TKN (summer operations), total mercury, dissolved oxygen, dissolved cadmium, temperature, dissolved arsenic, total selenium, dissolved silver, 1,4-dichlorobenzene, bromodichloromethane, chloroethane, diethyl phthalate, di-n-butyl phthalate, methyl chloride, methylene chloride, tetrachloroethylene, and toluene. Unfavorable Impact ● Slight increase in downstream Sacramento River concentration and mass loading for total phosphorus, EC, TDS, chloride, TOC, dissolved copper, dissolved zinc, total antimony, dissolved chromium, dissolved lead, total molybdenum, dissolved nickel, total cyanide, bis(2-ethylhexyl)phthalate, and chloroform. ● Moderate increase in downstream Sacramento River concentration and mass loading during winter operations for ammonia, total nitrogen, and TKN.
Not Net Increase: MF/RO/ Peroxone (in addition to proposed project)	$16.05/month	672/year	Favorable Impact ● No net increase in downstream Sacramento River mass loading with the discharge of 218 mgd secondary treated effluent. Unfavorable Impact ● Increases in energy consumption and air emissions due to power requirements of MF/RO/peroxone treatment. ● Disposal of toxic substances and contaminated media resulting from the separation of unwanted pollutants from wastewater. ● Potential need for additional treatment of brine waste to remove heavy metals and other contaminants from the aqueous phase prior to crystallization and disposal of residuals. ● Off-site disposal of crystallized residuals. ● Increases in air emissions from truck and rail traffic to dispose of crystallized residuals.

(1) While the proposed project will result in an increase to monthly residential sewer fees and socioeconomic impacts as a result of financing and operating/maintaining the proposed project, these costs represent a baseline effect common to the proposed project and the No Net Increase advanced treatment alternative, and therefore do not require quantification as a means of assessing the incremental socioeconomic effect of the MF/RO/peroxone treatment.

The implementation of the No Net Increase advanced treatment alternative as an additional treatment process for secondary disinfected effluent is also projected to have both favorable and unfavorable environmental impacts. The favorable impact is the maintaining of mass loading to the Sacramento River downstream of the SRWTP discharge with an increase of 37 mgd (ADWF) secondary disinfected effluent discharged to the river. While the MF/RO/peroxone process would be operated to maintain total dissolved solids, mercury, copper, and other mass loadings to the receiving water at pre-project levels, it would have a favorable indirect impact on downstream water quality through the further reduction of metals, salts, nutrients, and trace organics from the portion (48 mgd) of secondary treated effluent that undergoes MF/RO/peroxone treatment. This ancillary reduction in secondary effluent pollutant loading would likewise act to maintain downstream Sacramento River water quality and mass loading to pre-project levels. However, it should be noted that the extent of MF/RO/peroxone treatment considered in this alternatives analysis will not produce demonstrable downstream water quality improvements in the receiving water. The modeled level of MF/RO/peroxone treatment is designed to maintain downstream total dissolved solids, mercury, copper, and other mass loadings to the Sacramento River at pre-project levels. Unfavorable impacts of the No Net Increase advanced treatment alternative stem from the concentration of brine, its potential toxic contaminants and their subsequent removal, ultimate disposal of crystallized residuals, and the substantial energy requirements inherent in this advanced treatment process. These increases in electricity consumption and associated greenhouse gas emissions would dramatically increase the SRWTP's carbon footprint. Apart from these direct and more obvious effects, MF/RO/peroxone treatment brings with it the potential to transfer environmental impacts outside of the project area when off-site transport and disposal of residuals create new environmental impacts in other areas of the State.

As directed by SWRCB guidelines, the costs of offsetting a proposed project's potential impacts must be estimated and compared to the expected environmental benefits to be gained by maintaining water quality. Within the context of this comparison, it is also appropriate to consider the environmental and socioeconomic implications of not going forward with the proposed project; a scenario commonly referred to as the no project alternative. Three scenarios emerge from the current analysis that warrant evaluation: the no project alternative, the No Net Increase advanced treatment alternative, and SRCSD's proposed project. As part of this antidegradation analysis, the balance of economic consideration and environmental benefits under each scenario are evaluated herein.

6.4.1 No Project Alternative

If the Central Valley Regional Water Board does not permit an increase in SRWTP discharge capacity, the decision would produce unfavorable socioeconomic impacts both locally and regionally. From a socioeconomic perspective, an increase in SRWTP discharge capacity is needed to accommodate continued growth in the SRCSD service area, including the cities of Sacramento, West Sacramento, Elk Grove, Citrus Heights, Rancho Cordova, Folsom, and smaller surrounding communities. Among cities in Sacramento County with populations greater than 50,000, Rancho Cordova, Folsom, Citrus Heights, Elk Grove, and the City of Sacramento have all experienced significant growth in recent years and become urban and economic focal points within the County. Growth within these cities and the County has produced social infrastructure demands that require some level of continued expansion in order to maintain economic growth and prosperity within the region. A restriction in the growth that can occur in the SRCSD service area due to insufficient wastewater treatment capacity will negatively affect residential development, retail markets, an already high local unemployment rate, and the economic prosperity of Sacramento County in general. In terms of housing affordability as measured by the Fourth Quarter 2008 HAI-FTB Index[19], the Sacramento region possesses more affordable housing than Alameda and Contra Costa counties, as well as more affordable housing than Northern California as a whole. In fact, the Fourth Quarter HAI-FTB of 74 for the Sacramento region makes it one of the most affordable housing markets in California. Restricting new development in the SRCSD service area will prompt prospective home buyers – as well as retail and commercial development – to look to other cities in neighboring counties for affordable housing and business development opportunities. For these reasons, not seeking to increase the SRWTP discharge capacity runs contrary to the enhancement of the economic health of the SRCSD service area.

6.4.2 No Net Increase Treatment Alternative

The environmental benefits of the No Net Increase advanced treatment alternative (utilizing a MF/RO/peroxone treatment train) are proportional to the incremental changes in Sacramento River water quality that will be offset by the alternative control measure. As stated earlier, the No Net Increase advanced treatment alternative would not improve downstream water quality in the Sacramento River, but merely maintain it at pre-project levels. The projected increases in downstream receiving water concentrations for a limited number of constituents attributable to the proposed 37 mgd (ADWF) increase in secondary disinfected effluent discharged to the Sacramento River are estimated to be moderate (from October through April for ammonia, total nitrogen, and TKN) or slight (for total phosphorus, EC, TDS, chloride, TOC, dissolved copper, dissolved zinc, total antimony, dissolved chromium, dissolved lead, total molybdenum, dissolved nickel, total cyanide, bis(2-ethylhexyl)phthalate, and chloroform) in terms of their impacts to downstream receiving water quality (see **Table 6-14**). The more striking effects of MF/RO/peroxone treatment are found in the unfavorable environmental impacts inherent in the process resulting from brine concentration, potential need for removal of toxic contaminants, cross-media contamination, crystallized residuals disposal, and the substantial energy requirements of the process with their associated natural resource and air quality impacts.

From a socioeconomic perspective, MF/RO/peroxone treatment is estimated to result in the loss of approximately 672 jobs per year during the 20-year life-cycle over which SRWTP ratepayers would provide debt service for this advanced treatment alternative. This level of employment loss is projected to result in an almost $29.3 million loss in annual labor income to the SRCSD service area. These losses would act to further impact a local job market that is currently experiencing its highest unemployment rate since 1990, and enduring its 17th straight month of economic decline as part of the current U.S. economic recession. In total, the cost of the No Net Increase advanced treatment alternative is estimated to result in an annual $117.8 million output loss from the local economy. This suite of impacts is the result of increased sewer fees (existing users) and connection fees (future users) levied against SRWTP ratepayers and the associated loss of disposal personal income that is no longer available to purchase local goods and services. Furthermore, the actual economic impact of MF/RO/peroxone treatment could increase

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[19] The First-Time Buyer Housing Affordability Index (HAI-FTB) describes the percentage of California households that can afford to purchase a median-priced home. Source: California Association of Realtors.

significantly above that estimated in this analysis if (1) the brine produced by the process requires additional treatment to remove heavy metals and other contaminants, and/or (2) crystallized residuals require specialized disposal in some type of hazardous materials containment site. To this end, the environmental and socioeconomic costs associated with the No Net Increase advanced treatment alternative are not commensurate with the water quality benefits that would be achieved through the implementation of this alternative as a means of offsetting the incremental water quality changes projected for an increase in permitted discharge. For these reasons, it is not believed to be in the public interest to require the SRCSD to implement MF/RO/peroxone treatment of its effluent to maintain existing water quality in the Sacramento River.

6.4.3 Proposed Project

The proposed project would increase the discharge of disinfected, secondary effluent to the Sacramento River from the currently permitted 181 mgd (ADWF) to 218 mgd (ADWF) by augmenting and enhancing existing capacity-limiting facilities. The water quality impacts analysis conducted earlier in this report shows that SRWTP effluent undergoing existing, pure oxygen secondary treatment and chlorine disinfection generally results in water of high quality being discharged by the SRWTP into the Sacramento River. As shown in **Table 6-14**, *de minimis* decreases in the downstream concentrations of total aluminum, total coliform, and TSS are projected. Moderate increases in downstream concentrations are expected during the winter months (October through April) for ammonia, total nitrogen, and TKN. Because of the implementation of effluent oxygen demanding substances load reductions during the summer months (May through September), these constituents are expected to display negligible changes in downstream concentrations during the summer period. Additionally, negligible changes in downstream concentrations are estimated for nitrate plus nitrite, total mercury, dissolved oxygen, dissolved cadmium, temperature, dissolved arsenic, total selenium, dissolved silver, 1,4-dichlorobenzene, bromodichloromethane, chloroethane, diethyl phthalate, di-n-butyl phthalate, methyl chloride, methylene chloride, tetrachloroethylene, and toluene. A slight increase in downstream Sacramento River concentration and mass loading is anticipated for total phosphorus, EC, TDS, chloride, TOC, dissolved copper, dissolved zinc, total antimony, dissolved chromium, dissolved lead, total molybdenum, dissolved nickel, total cyanide, bis(2-ethylhexyl)phthalate, and chloroform. None of the water quality parameters evaluated in this report are anticipated to exceed relevant water quality objectives as a result of the proposed project beyond a limited zone of initial mixing, and on average are estimated to be present at concentrations well below objectives. Additionally, the SRWTP would be required to operate in compliance with the NPDES regulatory program (i.e., future effluent limitations) which ensure that that the discharge does not cause or contribute to exceedances of water quality objectives in the receiving water outside of any allowed in an initial mixing zone. Furthermore, the small changes in water quality that would result from the proposed project will not unreasonably affect actual or potential beneficial uses.

6.4.4 Project Identified as Providing Maximum Benefit to the State

Considering the 37 MGD (ADWF) increase in permitted discharge that is sought relative to the range of year-round flows observed in the Sacramento River, the difference in downstream pollutant concentrations produced by effluent undergoing existing, pure oxygen secondary treatment with chlorine disinfection compared to effluent undergoing additional

MF/RO/peroxone advanced treatment is essentially *de minimis* for many constituents evaluated in the current water quality impacts analysis once SRWTP effluent and receiving water are well-mixed. Additionally, the difference in projected downstream receiving water quality when the SRWTP is discharging at its currently permitted rate of 181 mgd (ADWF) compared to the proposed rate of 218 mgd (ADWF) is generally slight, relative to water quality objectives, for most constituents once SRWTP effluent and receiving water are well-mixed. Therefore, the critical comparison to be made between the proposed project and the No Net Increase alternative is a balancing of the generally slight degradation in downstream receiving water quality for a limited number of parameters attributable to the discharge of 37 mgd (ADWF) disinfected secondary treated effluent against the environmental impacts of MF/RO/peroxone treatment, and the significant socioeconomic impacts of this No Net Increase advanced treatment alternative as estimated by the IMPLAN® model. Based on the balancing of environmental and socioeconomic impacts associated with the three scenarios described above, SRCSD has identified the proposed project as the project providing best practicable treatment or control consistent with maximum benefit to the people of the State.

7 Evaluation of Consistency with Antidegradation Policy

The SWRCB guidelines for the antidegradation analysis (APU 90-004) provide direction on evaluating SRCSD's proposed discharge increase into the Sacramento River by focusing on whether and the degree that water quality is lowered and by considering whether or not the assumed water quality change is consistent with the maximum benefit to the people of the State. In developing the antidegradation analysis, the Sacramento River beneficial uses and relevant water quality objectives and commonly used criteria were considered, as well as the environmental and socioeconomic costs of wastewater treatment alternatives that would maintain existing water quality in an effort to avoid any potential environmental impacts of the proposed project.

7.1 CONSISTENCY WITH ANTIDEGRADATION POLICIES

A 37 mgd (ADWF) discharge increase to the Sacramento River below Freeport Bridge, as described in this analysis, is believed to comprise best practicable treatment or control and to be consistent with federal and State antidegradation policies for the following reasons:

- The increase in permitted discharge is necessary to accommodate important economic and social development in Sacramento County and the City of West Sacramento. Failure to approve the increase, or alternatively requiring the SRCSD to implement control measures that would maintain existing water quality and mass emissions in the Sacramento River, would have significant adverse economic and social impacts on the citizens and businesses of Sacramento County and the City of West Sacramento.
- The increase will not adversely affect existing or probable beneficial uses of the Sacramento River, nor will it cause water quality to fall below applicable water quality objectives.
- While causing moderate increases during winter operating conditions (October through April) for ammonia, total nitrogen, and TKN, the increase in permitted discharge will impart negligible changes in downstream concentrations of these pollutants during the summer period (May through September). The increase will also produce slight increases in downstream water quality concentrations for total phosphorus, EC, TDS, chloride, TOC, dissolved copper, dissolved zinc, total antimony, dissolved chromium, dissolved lead, total molybdenum, dissolved nickel, total cyanide, bis(2-ethylhexyl)phthalate, and chloroform, but will produce slight decreases in downstream concentrations for total aluminum, total coliform, and TSS. Additionally, the increase is expected to produce negligible changes in downstream concentrations for nitrate plus nitrite, total mercury, dissolved oxygen, dissolved cadmium, temperature, dissolved arsenic, total selenium, dissolved silver, 1,4-dichlorobenzene, bromodichloromethane, chloroethane, diethyl phthalate, di-n-butyl phthalate, methyl chloride, methylene chloride, tetrachloroethylene, and toluene. The benefits of maintaining existing water quality and mass emissions for the constituents analyzed through a No Net Increase treatment scheme are not commensurate with the costs of additional advanced treatment processes. The small decrease in quality with respect to the constituents considered in the analysis is unlikely to affect beneficial uses of the Sacramento River and Delta.

- Based on the above, the requested increase in permitted discharge is consistent with federal and State antidegradation policies in that the lowering of water quality for a limited number of pollutants is necessary to accommodate important economic or social development, will not unreasonably affect beneficial uses, will not cause further exceedances of applicable water quality objectives, and is consistent with the maximum benefit to the people of the State.
- Based on the above, the requested increase in permitted discharge is consistent with the Porter-Cologne Act in that the resulting water quality will constitute the highest water quality that is reasonable, considering all demands placed on the waters, economic and social considerations, and other public interest factors.

8 Acronyms

Acronyms and Abbreviations

ADAF	Average Day Annual Flow
ADMMF	Average Daily Maximum Month Flow
ADWF	Average Dry Weather Flow
C	Celsius
CDFG	California Department of Fish and Game
CFS	Cubic Feet Per Second
CSD-1	County Sanitation District No. 1
CTR	California Toxics Rule
CVP	Central Valley Project
District	Sacramento Regional County Sanitation District
DWR	California Department of Water Resources
DPI	Disposable Personal Income
F	Fahrenheit
HH	Household
IEP	Interagency Ecological Program
kWh	Kilowatt Hour
MGD	Million Gallons Per Day
NDOI	Net Delta Outflow Index
NPDES	National Pollution Discharge Elimination System
SDWA	Safe Drinking Water Act
SEIA	Socioeconomic Impacts Analysis
SRCSD	Sacramento Regional County Sanitation District
SRWTP	Sacramento Regional Wastewater Treatment Plan
SWP	State Water Project
SWRCB	State Water Resources Control Board
T&O	Taste and Odor
TCR	Total Coliform Rule
THM	Trihalomethane
TMDL	Total Maximum Daily Load
VOC	Volatile Organic Compound

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