Appendix B

STAFF REPORT

DRAFT STAFF REPORT ON PROPOSED SITE-SPECIFIC WATER QUALITY OBJECTIVES FOR CYANIDE FOR SAN FRANCISCO BAY

DRAFT FOR PUBLIC REVIEW

California Regional Water Quality Control Board
San Francisco Bay Region

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1 Introduction

This Staff Report supports a proposed Basin Plan amendment to replace existing marine water quality objectives for cyanide, a toxic pollutant, with site-specific objectives and proposes dilution credits for some San Francisco Bay wastewater dischargers to be used in the calculation of permit effluent limits. To implement the proposed water quality objectives, the Basin Plan amendment proposes requiring cyanide effluent limits in the permits of all San Francisco Bay municipal and industrial wastewater dischargers.

Water quality objectives for cyanide in the San Francisco Bay Region are currently based on the federal water quality standards adopted under the National Toxics Rule (NTR) in December 1992. The goal of this Basin Plan amendment effort is to incorporate into the Basin Plan, site-specific objectives for San Francisco Bay that reflect new information regarding the current understanding of cyanide toxicity. Cyanide water quality objectives that currently apply were driven by toxicity data for the eastern rock crab (*Cancer irroratus),* a species not found on the West Coast. The new cyanide water quality objectives will reflect the most recent toxicity data for several species of crabs common to San Francisco Bay. Adoption of these site-specific objectives is important to NPDES wastewater dischargers that discharge to San Francisco Bay, as it is currently infeasible for many of these dischargers to meet water-quality based effluent limits based on the NTR criteria.

The proposed action is consistent with state and federal law and regulations for adoption of water quality objectives. Site-specific objectives adjust water quality objectives to account for their over- and under-protectiveness using EPA published procedures. One of those procedures is the Recalculation Procedure. The goal of the Recalculation Procedure is to recalculate water quality objectives using data that is representative of the sensitivities of species found in the waterbody. Recalculation of the U.S. EPA cyanide criteria, incorporating recent, peer-reviewed toxicity data, suggests that the cyanide criteria should be made less stringent. This recalculation was recently used to adopt modified water quality objectives for cyanide by the State of Washington for Puget Sound, which the U.S. EPA approved, and the same approach is proposed for San Francisco Bay.

Evidence exists that beneficial uses are currently protected with respect to cyanide, in that ambient concentrations of cyanide in the main body of San Francisco Bay do not exceed the existing more stringent chronic water quality objective. Cyanide is a pollutant that chemically degrades to harmless by-products in natural waters over time, as opposed to pollutants like elemental metals. This is supported by observations that have been made of a relatively rapid decline in cyanide concentrations in the Bay away from points of discharge, due to the effects of tidal mixing, dilution and degradation (this decline is termed “attenuation” in this Report). These observations support the adoption of less stringent site-specific objectives for cyanide. The source of cyanide in municipal wastewater discharges is in part due to the fact that small amounts of cyanide are formed in municipal wastewater treatment plants as a by-product of disinfection processes, such as chlorination. Disinfection occurs at the end of the treatment process, prior to discharge to the Bay. Some of the potential compliance issues for wastewater dischargers are related to the need for disinfection.

This Staff Report demonstrates why the site-specific objectives are necessary and protective of the most sensitive beneficial uses of San Francisco Bay. Section 2 of the Staff Report presents the project's description. Sections 3 and 4 provide the background and basis of the proposed Basin Plan amendment. Cyanide sources and pretreatment programs are described in Section 5.

The scientific basis for establishing dilution credits is discussed in Section 6. The Basin Plan prohibits wastewater discharges into nontidal water, dead-end slough or at any point that wastewater does not receive dilution of at least 10:1. The Water Board can and has granted exceptions to the Basin Plan. Those wastewater dischargers that the Water Board has currently granted an exception to are hereinafter referred to as "shallow water dischargers" in this Staff Report. The Water Board has rarely allowed shallow water dischargers to apply dilution credits in the calculation of water-quality based effluent limits. This Basin Plan amendment proposes dilution credits for shallow water dischargers based on the available information regarding the attenuation, i.e., tidal mixing, dilution and degradation of cyanide from the point of discharge. The granting of dilution credits in the calculation of cyanide effluent limits does not authorize discharges into shallow waters; each shallow water discharger must continue to satisfy all requirements for an exception to Basin Plan Prohibition 1.

Derivation of dilution credits specific to each shallow water discharger that would be used to compute effluent limits is described in the Staff Report. Appendix J of the Staff Report specifically describes how the requirements in the Basin Plan and the State Water Board's "Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California" (the State Implementation Policy or "SIP") have been addressed in the derivation of dilution credits.

Section 7 provides a discussion of the cost of providing alternative cyanide treatment technologies and the cost of converting from chlorination as a disinfectant to ultraviolet disinfection. The implementation plan in Section 8 describes targeted surveillance and monitoring and a regional cyanide action plan that will be required to ensure that water quality and beneficial uses of the Bay are protected. Regulatory analyses are presented in Section 9 that include an overview of the Project's compliance with California Water Code (CWC) requirements; peer review requirements of Health and Safety Code §57004; California Environmental Quality Act (CEQA); and federal and state antidegradation policies. The Staff Report in its entirety serves as a substitute CEQA environmental document. Language for the proposed Basin Plan amendment is included as Appendix A.

2 Project Description

2.1 Project Necessity and Definition

The Project is a proposed Basin Plan amendment that will do the following:

1) Establish site-specific marine water quality objectives (SSOs) for cyanide in all San Francisco Bay segments;
2) Establish shallow water discharger dilution credits for cyanide;
3) Require cyanide effluent limits for all municipal and industrial wastewater dischargers to protect against degradation;
4) Define the implementation plan, maintain ambient concentrations of cyanide, and comply with state and federal antidegradation policies. The implementation plan requires development of the following:
   a) Numeric effluent limits for cyanide that are protective of water quality in San Francisco Bay now and in the future;
   b) An influent monitoring program conducted by dischargers with industrial sources of cyanide to maintain surveillance of periodic influent spikes attributable to illegal discharges;
   c) An ambient water quality monitoring program to detect changes in ambient concentrations of cyanide in San Francisco Bay; and
   d) Cyanide Action Plan, consisting of standard permit provisions for all wastewater dischargers to periodically update their source identification studies, develop and implement source reduction plans if warranted, and commit resources to fully implement the source control and reduction plan, at every permit reissuance (i.e., once per five years), and report to the Water Board.
5) Reiterate that effluent limits for copper and nickel are required in NPDES permits for municipal shallow water dischargers to South San Francisco Bay, south of Dumbarton Bridge.

This Staff Report describes why it is necessary to adopt a Basin Plan amendment to establish site-specific water quality objectives for cyanide in San Francisco Bay and to require numeric effluent limits for wastewater dischargers that provide reasonable protection of those beneficial uses involving aquatic life and reflect attenuation of cyanide in ambient waters.

The proposed Basin Plan language, included in Appendix A, describes the implementation of the cyanide SSOs in NPDES permits for industrial and municipal wastewater dischargers, the latter of which are also referred to as publicly owned treatment works (POTWs).

For consistency, effluent limit implementation for the only other SSOs adopted for this region in 2002, copper and nickel for Lower south San Francisco Bay, are clarified in the proposed Basin Plan language in Appendix A. The Basin Plan language associated with the 2002 Basin Plan amendment states that copper and nickel "effluent limits will be calculated" for the three shallow water dischargers south of Dumbarton Bridge, Palo Alto, Sunnyvale, and San Jose/Santa Clara. In the subsequent permitting process of 2003, two of the three dischargers argued that effluent limits were not necessarily "required." These dischargers' interpretation conflicts with the applicable Staff Report of the Basin Plan amendment of May 2002 which states on page 33:

> "The IP [implementation plan] for maintaining the proposed SSOs [site-specific objectives for copper and nickel] includes continuation of provisions in the dischargers' NPDES permits that ensure that the treatment facilities continue to perform at highest efficiency. These provisions must also ensure that continuing efforts are being made to control all copper and nickel sources entering the treatment facilities, and that reasonable and cost-effective opportunities to reclaim wastewater are pursued. New concentration-based effluent limits for the three Lower South SF Bay POTWs will be calculated from the proposed chronic copper and nickel SSOs *and incorporated into their NPDES permits when those permits are re-issued*" (emphasis added).

Throughout the 2002 Basin Plan amendment documents, justification for less stringent water quality objectives is predicated on both the attainability and maintenance of copper and nickel effluent limits for Palo Alto, Sunnyvale and San Jose/Santa Clara, for instance on page 34 of the Staff Report:

> "After the proposed SSOs are adopted, the Regional Board intends to incorporate the water quality-based effluent limits into the NPDES permits during the next permit reissuance for the three Lower South SF Bay POTWs. Considering current performance, it is clear that all three Lower South SF Bay POTWs are in compliance with the effluent limits calculated from the proposed SSOs."

Clarifying language for copper and nickel proposed in Appendix A is not a regulatory change. Instead, it reflects and clarifies what the Board actually adopted in 2002 and prevents future misinterpretation of the adopted amendment. Effluent limits have always been needed to hold dischargers to current levels of performance to prevent accumulation of these pollutants in the sediments and waters of the San Francisco Bay Estuary, and Appendix A includes language that reaffirms this clearly. Because effluent limits derived from the site-specific objectives for copper and nickel are attainable (see Staff Report language above), there are no economic or environmental impacts of mandatory limits. There would be a potential environmental impact of removing effluent limits for copper and nickel, since it would erode the regulatory basis for copper and nickel local limits for industries discharging to these POTWs, and would potentially compromise the dischargers' abilities to meet the Basin Plan requirements to fully commit resources to ensure there is no degradation associated with adopting site-specific objectives.

2.2 Objectives of the Project

The objectives of the project are as follows:

1) Establish SSOs for cyanide and update the Basin Plan to incorporate the best available scientific information on aquatic toxicity specific to San Francisco Bay that;
   a) Fully protect aquatic beneficial uses in the Bay;

   b) Are calculated using the best and most relevant set of data and are based on sound scientific rationale;
   c) Are no more or less stringent than necessary; and
   d) Are at a level allowing municipal and industrial wastewater dischargers to comply with water quality-based effluent limits, provided they maintain high levels of performance and carry out intensive source control and prevention programs

2) Avoid unnecessary compliance problems for municipal and industrial wastewater dischargers authorized to discharge into the Bay.

3) Determine dilution credits for shallow water dischargers and provide details of an implementation plan for achieving water quality objectives

4) Comply with the antidegradation requirements of State Board Resolution No. 68-16 and federal antidegradation regulations.

3 Background and Existing Conditions

3.1 Description of San Francisco Bay

The proposed site-specific objectives (SSOs) for cyanide would apply to marine waters of the San Francisco Bay and excludes the Pacific Ocean. Water quality objectives for the ocean are established in the California Ocean Plan. The proposed marine SSOs would apply to all segments of the San Francisco Bay:

"San Francisco Bay" - for the purposes of this Report, refers to the following water bodies, as shown in Figure 1 and Figure 2:

- A portion of the Sacramento/San Joaquin River Delta (within San Francisco Bay)
- Suisun Bay
- Carquinez Strait
- San Pablo Bay
- Central San Francisco Bay
- Lower San Francisco Bay
- South San Francisco Bay

San Francisco Bay is a natural embayment in the Central Coast of California. With an average depth of six meters, the bay is broad, shallow, and turbid, which makes sediment an important factor in the fate and transport of particulate-bound pollutants such as copper and nickel. The movement of sediment within the bay is driven by daily tides, the spring-neap tide cycle, and seasonally variable wind patterns.

The Bay is divided into two major hydrographic units, which are connected by the Central Bay to the Pacific Ocean. The northern reach is relatively well flushed because more than half of the California's freshwater flows into the bay through the Sacramento and San Joaquin Rivers. In contrast, the southern reach receives more limited fresh water inflow from local watersheds and is less well flushed.

3.2 Project Background

A new marine site-specific objective for San Francisco Bay and an associated implementation plan are needed for two main reasons: to reflect best available scientific information regarding cyanide toxicity to aquatic organisms and to implement more appropriate NPDES effluent limits. Specifically, (1) the basis of the federal criteria can be updated by adding species which are common to San Francisco Bay and to make it consistent with the objectives already adopted by the State of Washington in Puget Sound; and (2) effluent limits for cyanide based on the currently applicable federal criteria, developed in 1985, are not attainable and will cause non-compliance for a majority of NPDES dischargers beginning in 2006. Scientifically-defensible effluent limits are proposed that will provide protection of sensitive beneficial uses in accordance with procedures contained in the Basin Plan and SIP.

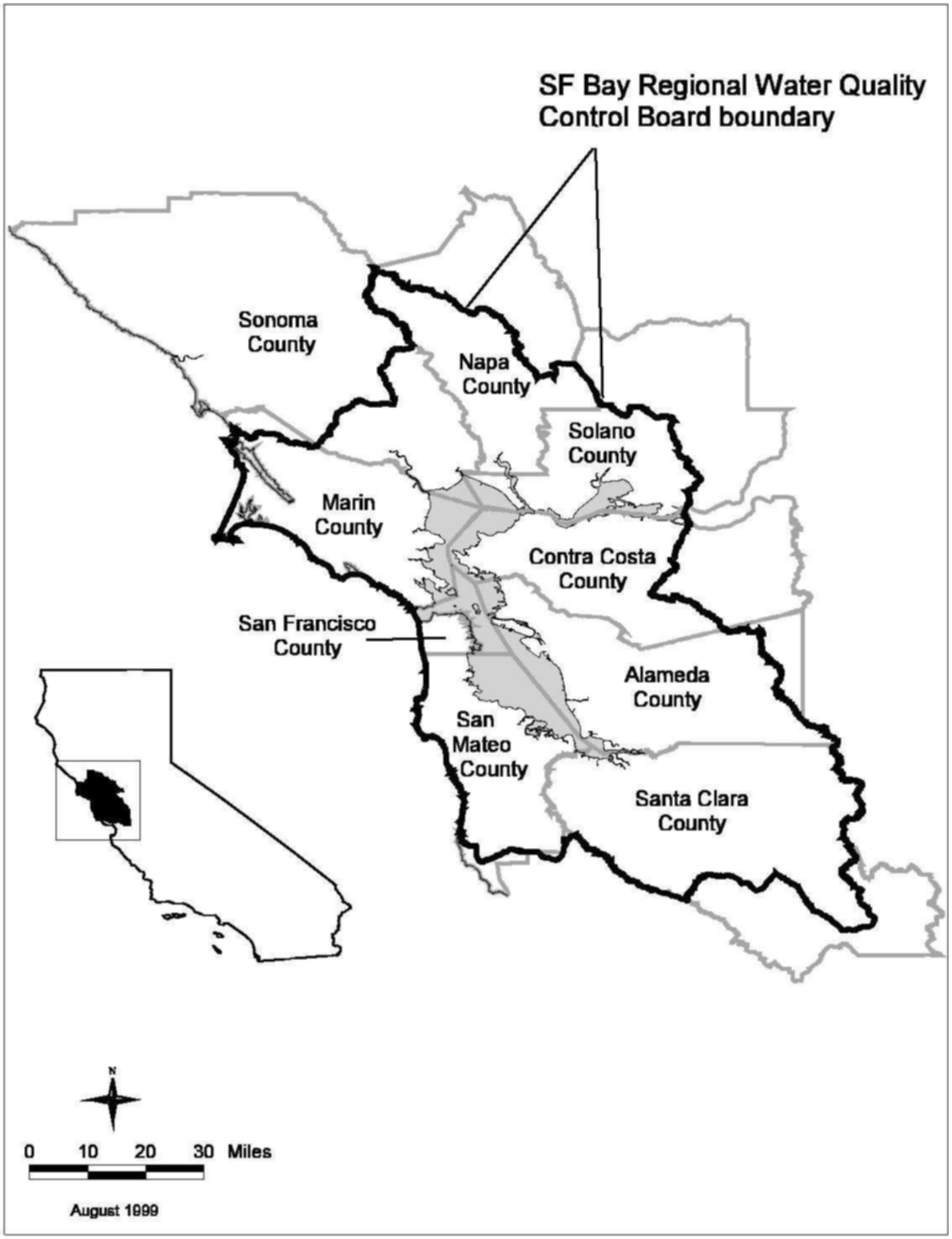

Figure 1: Map of San Francisco Bay

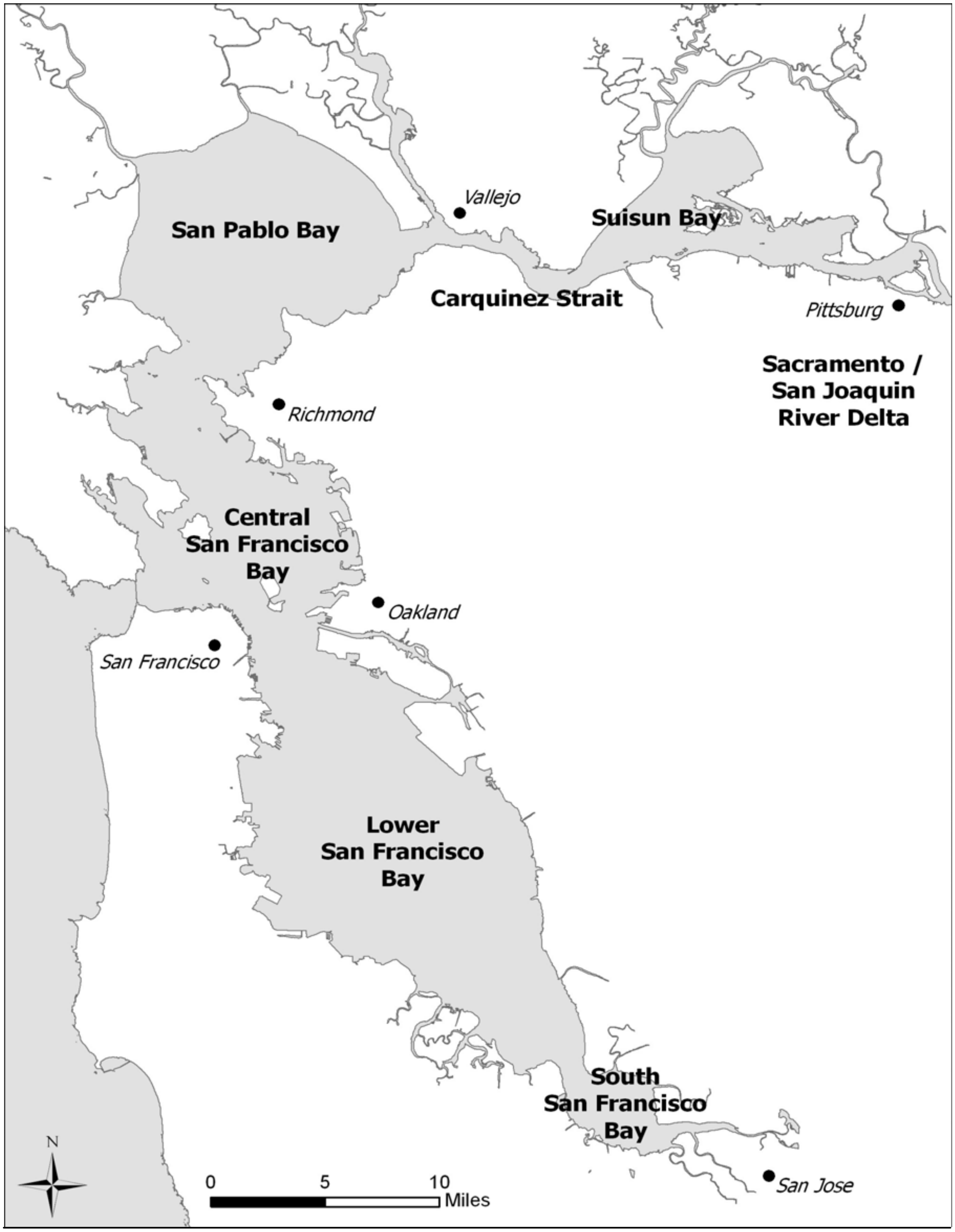

Figure 2: Segments of the San Francisco Bay

Table 1 summarizes the existing and proposed marine water quality objectives for cyanide. An objective of 1.0 µg/L (4-day average) was adopted for San Francisco Bay by U.S. EPA under the National Toxics Rule (NTR) in 1992. The NTR objective was based on the 1985 U.S. EPA ambient criterion for aquatic life protection (USEPA 1985b). It superseded the 1986 Basin Plan objective of 5.0 µg/L because it was more stringent and was based on U.S. EPA Section 304(a) criteria.

Table 1: Existing and Proposed Cyanide Objectives for Marine Waters

	Existing	Proposed
Acute	1 µg/L (NTR)	9.4 µg/L
Chronic	1 µg/L (NTR)	2.9 µg/L

The existing U.S. EPA cyanide marine criteria are heavily influenced by the toxicological data for one species (eastern rock crab – *Cancer irroratus*). Toxicity tests found *C. irroratus* to be six times more sensitive than the next most sensitive *Cancer* species tested. Work performed in Puget Sound using species native to San Francisco Bay made available new scientific information that provides a basis for updating the U.S. EPA criteria. Moreover the results demonstrated that the NTR objective might be unnecessarily stringent dependent on site-specific conditions. Data developed for the Puget Sound study for four other west coast crab species (*Cancer* spp.) indicate that the sensitivity of these species is 24 times less than indicated by the 1981 *C. irroratus* data (Brix et al., 2000). Like Puget Sound, these four species are known to be present in marine and estuarine waters of San Francisco Bay (Morris et al., 1980). Adding the four west coast crab species to the national data set and removing the *Cancer irroratus* data results in a recalculation of the cyanide marine chronic water quality criterion from 1 µg/L to 2.9 µg/L. Similar updated criteria have already been adopted by the State of Washington for parts of Puget Sound. The proposal is to adopt 2.9 µg/L as a 4-day average chronic objective and 9.4 µg /L as a 1-hour average acute objective, for the marine waters of San Francisco Bay

Cyanide has become a NPDES permit compliance issue for municipal and industrial wastewater dischargers to the San Francisco Bay. At each permit adoption the Water Board determines that dischargers could not comply with final effluent limits based on the NTR objective. Therefore, all San Francisco Bay wastewater NPDES permits contain interim performance-based numeric effluent limits for cyanide (see Table 22). The interim limits have prevented immediate compliance problems beginning in 2005, but those interim limits may be replaced overly stringent final limits in the next round of NPDES permits.

3.3 Cyanide Chemical Composition, Sources, and Environmental Fate

Cyanide is a chemical compound with a carbon atom triple bonded to a nitrogen atom (CN). Inorganic cyanides contain the cyanide ion (CN^-) and are the salts of the acid hydrogen cyanide (HCN). These forms of cyanide, known as “free cyanide” are the most toxic to aquatic organisms. In natural waters in the pH range from 6.5 to 8.5, free cyanide is typically present in the hydrogen cyanide form (HCN).

The mechanism of cyanide toxicity occurs at the cellular level. The cyanide ion is toxic to aerobic organisms by shutting down respiration in cells, acting as an asphyxiant. Cyanide interrupts the electron transport chain in the inner membrane of the mitochondrion, thereby preventing proper combination of cytochromes with oxygen, interrupting the pathway energy is transmitted to living cells.

Cyanide compounds are typically classified as either simple or complex cyanides. Simple cyanides are those compounds that are readily converted to free cyanides (e.g. KCN, NaCN, NH_4CN). Complex cyanides are formed through the action of the cyanide ion as a ligand and its complexation with either metals (e.g. copper, iron, nickel, zinc) or with organics. Most cyanide complexes are much less toxic than cyanide, but weak acid dissociable complexes such as those of copper and zinc are relatively unstable and dissociate depending on a number of factors. Organic cyanides contain a carbon atom bonded to the CN group (also known as nitriles).

An important concern is the amount of free cyanide that is present in treated effluent, since free cyanide is the most toxic form to aquatic organisms. This is important since pollutants in treatment plant effluent are sometimes highly complexed (Bedsworth and Sedlak, 1999). Currently, best available analytical protocols and detection limits do not allow for direct measurement of free cyanide levels in treated effluent at levels that would provide answers to this question, so the Water Board exercises a conservative assumption that all measured cyanide in effluent and in ambient waters is free cyanide.

As with any toxicant, cyanide effects are dependent on the concentration and duration of exposure. Toxicological tests have been performed which establish the knowledge base regarding cyanide toxicity to sensitive aquatic species at given concentrations and exposure durations. As a rule, the toxicity tests performed to date have exposed aquatic organisms to free cyanide concentrations in clean laboratory water.

Available scientific evidence indicates that cyanide is not teratogenic (causing structural abnormalities), mutagenic (causing mutations) or carcinogenic (causing cancer) to aquatic organisms. Additionally, available information indicates that cyanide is not bioaccumulated by aquatic organisms, ostensibly due to the fact that cyanide is highly reactive and readily metabolized (Eisler 1991; USEPA 1985b; WERF 2003).

Cyanide is commonly employed as an industrial reagent due to its many uses in chemical extraction processes. Hydrogen cyanide gas (HCN) is commonly used in the manufacture of plastics, for fumigation and pesticide use, and in the synthesis of other compounds such as nitriles. Sodium and potassium cyanide are used in gold mining, metallurgy, electroplating, and animal control.

Thiocyanate (SCN^-) is one of the major constituents of wastewater from facilities that gasify coal, where various by-products are formed during the production of gas for fuel, coke, and substances for chemical industries. Cyanide is usually converted to thiocyanate by the addition reaction with sulfur since thiocyanate is less toxic than free cyanide. The resultant thiocyanate is then treated in an activated sludge process, where microbes degrade this substance.

Under normal conditions in natural surface waters, cyanide does not persist. Cyanide degrades in natural waters due to processes of microbial utilization, volatilization, and photolysis (WERF, 2003, Chapter 8). The combined effect of these processes lowers cyanide concentrations in surface waters and is often referred to as natural degradation or attenuation. In fact such attenuation is recognized as a treatment method. Cyanide solutions are placed in shallow ponds with large surface area or impoundments to maximize the rate of cyanide attenuation through volatilization and oxidation (Botz, 2001).

In receiving waters along the periphery of San Francisco Bay, cyanide discharged in wastewater effluents is also diluted through tidal mixing and turbulent diffusion in Bay waters. The combined effects of dilution and degradation lead to rapid reduction of cyanide concentrations with distance from the point of input to the Bay.

3.4 Discharger Descriptions and Performance

A total of 46 public agencies and industries discharge treated wastewater directly to San Francisco Bay and its tributaries. Each of these discharges is permitted under the federal NPDES permit program, which is administered by the Water Board under a delegation agreement with the U.S. EPA.

A summary of cyanide effluent concentration data for individual NPDES dischargers is provided in Appendix C. Implementation of the default NTR objective through the SIP would lead to unattainable effluent limits, presenting compliance problems for the majority of San Francisco Bay municipal and industrial wastewater dischargers. Resultant water quality-based effluent limits (WQBELs) would be less than 6 µg/L for deep water dischargers, and less than 1.0 µg/L for many shallow water dischargers. Neither of these limits would be consistently achieved in most effluents despite source control and treatment technologies. Table 2 and Table 3 summarize projected final effluent limits for cyanide for Bay area POTWs and industries based on effluent limitation derivation procedures contained in Section 1.4 of the SIP and the existing NTR-based water quality objectives.

For shallow water dischargers to the Bay, no dilution credit is currently granted. As a consequence, the average monthly cyanide effluent limits for a given shallow water discharger would be 1.0 µg/L or less, depending on the variability of cyanide in the effluent in question. Available data indicate that none of the thirteen shallow water dischargers examined can achieve the projected NTR-based cyanide effluent limits.

For deep water dischargers to San Francisco Bay, a dilution credit of 10:1 (the maximum allowable dilution) has been used in the calculation of estimated effluent limits. Recent ambient monitoring data collected in 2002 and 2003, relevant to deep water dischargers indicates that the maximum observed cyanide concentration at the three ambient, deep water sites tested was 0.5 µg /L total cyanide. Using the existing NTR cyanide standard of 1.0 µg/L and effluent limit derivation equations contained in Section 1.4 of the SIP, the monthly average cyanide effluent limits for a given deep water discharger would be 5.5 µg /L, or less, depending on the variability of cyanide in the effluent in question.

Table 2: Shallow Water Discharger Compliance Evaluation – Comparison of Existing Cyanide Concentrations to Projected NTR-Based Effluent Limits

NPDES Permittee	Cyanide Effluent Concentrations (µg/L)		Coefficient of Variation (CV)	Projected Final Cyanide Effluent Limits (µg/L)		Projected Compliance Problem?	Interim CN effluent limits in current permit?
	mean	***max***		***AMEL***[b]	***MDEL***[c]		
American Canyon	1.4	5.0	0.5	0.5	1.0	Yes	No [a]
Fairfield-Suisun Sewer District	3.9	28.0	1.0	0.4	1.0	Yes	Yes
Hayward Marsh	2.9	11.3	0.8	0.4	1.0	Yes	Yes
Las Gallinas Valley SD	3.0	10.0	0.8	0.4	1.0	Yes	Yes
Mt. View Sanitary District	0.5	3.0	0.6	0.5	1.0	Yes	Yes
Napa SD	2.6	20.0	1.2	0.4	1.0	Yes	Yes
Novato SD	1.8	4.4	0.7	0.5	1.0	Yes	Yes
Palo Alto, City of	3.3	4.8	0.3	0.7	1.0	Yes	Yes
Petaluma, City of	2.9	10.0	0.9	0.4	1.0	Yes	Yes
San Jose Santa Clara WPCP	2.8	5.2	0.4	0.6	1.0	Yes	No[d]
Sonoma County Water Agency	3.2	8.6	0.9	0.4	1.0	Yes	Yes
Sunnyvale, City of	4.4	29.0	0.9	0.4	1.0	Yes	Yes
USS - Posco	8.8	10.0	0.6	0.5	1.0	Yes	Yes

Note: Projected effluent limits based on existing NTR objective for cyanide = 1 µg/L (chronic).
The mean and coefficient of variation were estimated using the probability regression method

[a] No interim limits granted to a new discharge. Final limit of 5 µg/l exists.

[b] AMEL= Average Monthly Effluent Limit.. The highest allowable average of daily pollutant discharges over a calendar month, calculated as the sum of all daily discharges measured during a calendar month divided by the number of measurements.

[c] MDEL=Maximum Daily Effluent Limitation. The highest allowable daily discharge of a pollutant, over a calendar day (or 24-hour period). For pollutants with limits expressed in units of mass, the daily discharge is calculated as the total mass of the pollutant discharged over the day. For pollutants with limits expressed in other units of measurement, the daily discharge is calculated as the arithmetic mean measurement of the pollutant over the day.

[d] No permit limits in existing permit due to an artifactual finding of no reasonable potential to cause or contribute to violation of the cyanide objective, due to review of effluent data limited to a certain time period. San Jose Santa Clara had three discharge events in 2004 that caused significant violations of the cyanide objective in San Francisco Bay waters (see Figure 3 of Appendix K). This example shows why the SIP reasonable potential calculation method can be misrepresentative of actual reasonable potential, and why the SIP grants the Water Board authority to make an independent finding of reasonable potential.

Of the 25 deep water dischargers with adequate detected data, 14 (56%) will not comply with final effluent limits based on the NTR, 8 (32%) may not comply and 3 (12%) will likely comply. The eight deep water dischargers for which compliance uncertainty exists, do not have adequate detected cyanide concentration values to determine compliance based on the NTR. The data indicate that 12% of deep water dischargers can comply with projected final effluent limits, and none of the 13 shallow water dischargers can comply with NTR standard-based final effluent limits for cyanide. A summary of effluent limits and compliance dates adopted in NPDES permits in the Bay is provided in Table 22. The significance of these compliance dates is that the five-year compliance schedule allowed under the SIP will have expired resulting in immediate non-compliance for Bay area POTWs.

Table 3: Deep Water Discharger Compliance Evaluation – Comparison of Existing Cyanide Concentrations to Projected NTR-Based Effluent Limits

NPDES Permittee	Cyanide Effluent Concentrations (μg/L)		Coefficient of Variation (CV)	Projected Final Cyanide Effluent Limits (μg/L)		Projected Compliance Problem?	Interim CN Effluent Limits in Current Permit?
	mean	***max***		***AMEL***	***MDEL***		
Benicia, City of	5.6	26.0	0.9	4.1	9.9	Yes	Yes
Burlingame, City of	3.3	13.0	0.6	4.5	9	Possible	Yes
Central Contra Costa Sanitary Dist.	3.8	9.9	0.4	4.8	8	No	Yes
Central Marin Sanitation Agency	4.3	16.0	0.7	4.4	9.4	Possible	Yes
Chevron Richmond Refinery	7.3	14.9	0.5	4.7	8.6	Yes	Yes
ConocoPhillips (at Rodeo)	6.1	14.0	0.4	4.8	8	Yes	Yes
Delta Diablo Sanitation District	7.1	13.0	0.6	4.5	9	Yes	Yes
Dow Chemical Company	3.3	5.7	0.6	4.5	9	No [a]	Yes
Dublin San Ramon Services District	7.0	8.8	ND	ND	ND	ND	Yes
EBDA	5.1	68.0	1	3.4	10	Yes	Yes
EBMUD	5.7	25.0	1.6	4.2	9.7	Yes	Yes
GWF E 3rd St (Site I)	7.5	10.0	0.6	4.5	9	Yes	Yes
GWF Nichols Rd (Site V)	7.4	10.0	ND	ND	ND	ND	Yes
Livermore, City of	14.9	25.0	ND	ND	ND	ND	Yes
Marin Co SD No. 5 (Tiburon)	5.0	5.0	0.6	4.5	9	Possible [b]	Yes
Martinez Refining Company	13.2	29.0	0.4	4.8	8	Yes	Yes
Millbrae, City of	3.7	18.0	0.7	4.4	9.4	Possible	Yes
Morton	7.5	10.0	ND	ND	ND	ND	Yes
Pinole-Hercules	3.5	10.0	0.5	4.7	8.6	Possible	Yes
Rhodia Basic Chemicals	10.0	10.0	ND	ND	ND	ND	Yes
Rodeo Sanitary District	3.7	7.0	0.3	5	7.5	No [a]	Yes
S.F. Airport Water Quality Control Plant	9.8	16.5	0.6	4.5	9	Yes	Yes
S.F. Airport, Industrial	9.8	10.0	ND	ND	ND	ND	Yes
S.F. City & County Southeast, North Point & Bayside	7.8	10.0	0.5	4.7	8.6	Possible	Yes
San Mateo, City of	4.3	15.0	0.5	4.7	8.6	Possible	Yes
Sausalito-Marin Sanitary District	9.6	20.0	0.5	4.7	8.6	Yes	Yes
South Bayside System Authority	7.8	14.7	0.4	4.8	8	Yes	Yes
South San Francisco & San Bruno	18.3	430.0	2.5	2.8	9	Yes	Yes
Tesoro Golden Eagle Refinery	8.6	28.0	3.6	4.7	8.6	Yes	Yes
US Navy Treasure Island	10.0	10.0	ND	ND	ND	ND	Yes
Valero Benicia Refinery	10.0	15.0	ND	ND	ND	ND	Yes
Vallejo San. & Flood Control District	4.8	22.8	1.0	4	10	Yes	Yes
West County/Richmond	3.6	8.0	0.6	4.5	9	Possible [b]	Yes

Note: Projected effluent limits based on existing NTR objective for cyanide = 1 μg/L (chronic). The mean and coefficient of variation were estimated using the half-detection method

[a] Limited number of detected values. [b] Limited data set.

3.5 Cyanide Levels in Influent and Effluent

In almost all cases, effluent cyanide concentrations at a given treatment facility are higher than influent cyanide concentrations. This in-plant increase is attributed to disinfection processes that protect recreational users of the San Francisco Bay waters (i.e., the designated beneficial use of water - contact recreation or REC1). Figure 3 shows the relationship between plant influent, within-plant concentrations (i.e., nitrification effluent), and plant effluent at the San Jose/Santa Clara Water Pollution Control Plant (WPCP), that is typical of the relationship in the Bay area.

Consistent with the influent/effluent relationship cited above, and as shown in Table 4, effluent cyanide concentrations were above detection limits more often than influent cyanide for most of the POTWs providing data. Detection limits using U.S. EPA-approved Standard Methods for total cyanide and/or weak acid dissociable cyanide range from 3 to 10 µg/l for the POTWs).

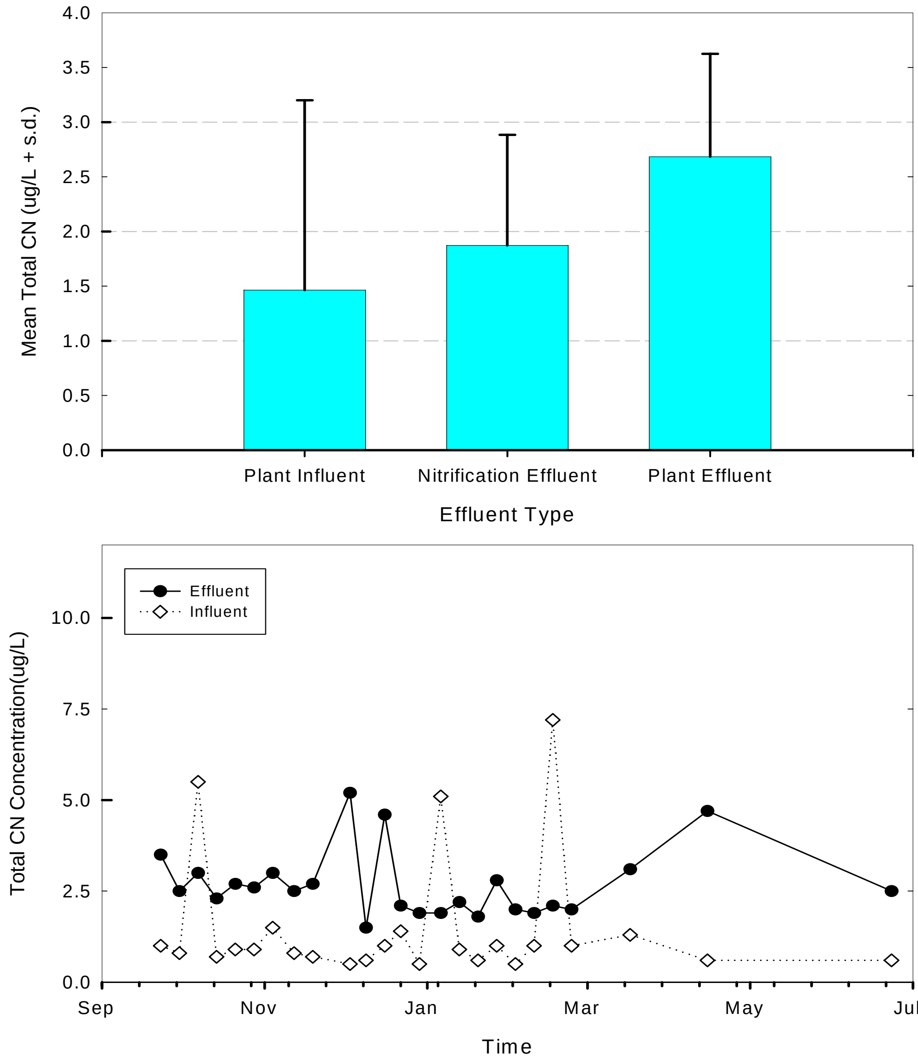

Figure 3: San Jose/Santa Clara WPCP In-Plant Cyanide Measurements (Sept. 2003 - June 2004 [1])

[1] High cyanide episode measured in May 2004 is not included in the data above; n=25

Table 4: Effluent Cyanide Levels above Detection Limits for Bay Area POTWs[2]

Data Source	Sample Type	Data Points	Percent Detected	Maximum Detection Limit (µg/L)
American Canyon, City of	Effluent	15	46.7%	5
Benicia, City of	Influent	14	35.7%	3
	Effluent	46	89.1%	3
Delta Diablo Sanitary District (DDSD)	Influent	65	15.4%	10
	Effluent	66	16.7%	10
Fairfield-Suisun Sewer District	Influent	65	13.8%	4
	Effluent	131	66.4%	3
Millbrae, City of	Influent	31	100%	---
	Effluent	42	100%	---
Napa Sanitation District	Influent	64	28.1%	3
	Effluent	91	25.3%	3
Palo Alto RWQCP	Influent	77	32.5%	3
	Effluent	273	37.4%	3
Petaluma, City of	Influent	36	25%	3
	Effluent	38	57.9%	3
San Francisco Southeast WPCP	Influent	265	11.3%	10
	Effluent	259	23.9%	10
San Jose/Santa Clara WPCP	Influent	70	4.3%	5
	Effluent	71	5.6%	5
San Mateo WWTP	Influent	43	11.6%	5
	Effluent	79	31.6%	6.8
Sonoma Valley County Sanitation District	Influent	53	64.2%	5
	Effluent	52	34.6%	5
South Bayside System Authority (SBSA)	Influent	47	97.9%	3
	Effluent	48	100.0%	---
Sunnyvale, City of	Influent	134	1.5%	5
	Effluent	137	19.7%	5
Union Sanitary District (USD)	Influent	22	27.3%	3
	Effluent	66	31.8%	3
Vallejo Sanitation & Flood Control District	Influent	66	37.9%	3
	Effluent	66	47.0%	3

[2] Effluent Data from 2000 - 2003

3.6 Ambient Conditions

Knowledge of the ambient levels of cyanide in the water column of San Francisco Bay is important to the understanding of potential impacts of cyanide on aquatic life beneficial uses. Available information indicates that cyanide concentrations in the main body of San Francisco Bay are typically not detectable using standard analytical methods, and that ambient concentrations are below the existing 1.0 µg/L water quality objective. Recent data collected near shallow water dischargers indicate detectable levels in the receiving waters, sometimes above the current chronic and acute NTR objective of 1.0 µg/L, which decrease with distance from the discharge points.

Open Bay Conditions

Ambient concentrations of cyanide in deep water portions of the San Francisco Bay have been measured on several occasions since 1990. S.R. Hansen and Associates made the first measurements in a study performed for several Bay area oil refineries in 1989-1990. A second set of measurements were gathered in 1993 under the first year of the Regional Monitoring Program for Trace Substances (RMP), after which cyanide monitoring was discontinued due to lack of detectable values using a detection limit of 1.0 µg/L (SFEI, 1993). The Water Board issued a Water Code Section 13267 information request to all NPDES dischargers which lead to a third set of measurements being collected as part of the Regional Monitoring Program by the San Francisco Estuary Institute (SFEI) in 2002-2003. Bay Area Clean Water Agencies (BACWA) and other Bay area NPDES dischargers funded this effort.

A description of the three cyanide ambient data sets is provided below.

Data collected by S.R. Hansen and Associates

This work was performed in 1989 and 1990. Data results are shown below in Table 5. The four monitoring stations for this work were located in San Pablo Bay (SP1) and (SP2), Carquinez Strait (CS) and Suisun Bay (SB). Each of these sampling sites are located in the deeper channels of the Bay. Samples were taken at flood tide at stations SP1 and CS and at ebb tide at stations SP2 and SB. QA/QC consisted of spikes on three occasions during the monitoring effort (January 1989, April 1989 and January 1990). Detection limits for the analytical work were 0.5 µg/L. A modification of cyanide test methods prescribed in American Society of Testing and Materials (ASTM) 1986 and American Public Health Administration (APHA) 1985 EPA were used to achieve the selected detection limits. Modifications included increasing the volume of sample distilled and decreasing the volume of NaOH scrubber solution (SR Hansen & Associates, 1990).

Table 5: Summary of Data Collected by SR Hansen and Associates (1989-1990)

Date	San Pablo Bay No. 1 (SP1)	San Pablo Bay No. 2 (SP2)	Carquinez Strait (CS)	Suisun Bay (SB)
April 1989	<0.5	<0.5	<0.5	<0.5
May 1989	<0.5	<0.5	<0.5	<0.5
June 1989	<0.5	<0.5	<0.5	<0.5
July 1989	<0.5	<0.5	<0.5	<0.5
August 1989*	8	6.5	6.8	<0.5
August 1989	<0.5	<0.5	<0.5	<0.5
September 1989	0.54	<0.5	<0.5	<0.5
October 1989	<0.5	<0.5	<0.5	<0.5
December 1989	<0.5	<0.5	<0.5	<0.5
December 1989	<0.5	<0.5	<0.5	<0.5
January 1990	<0.5	<0.5	<0.5	<0.5

Notes: The extremely elevated detected values in August 1989 stand out as anomalies in the data set and in subsequent data sets. A re-sampling one week later on August 26, 1989 indicated no detectable levels at any of the four stations. These high concentrations were not explained in the technical report. Absence of event specific QA/QC procedures precluded rigorous investigation of these results.

Data collected under the first year of the Regional Monitoring Program

This work was performed in March, May and September 1993. Results are shown below in Table 6. The sixteen monitoring stations for this work were located throughout the Bay, from the Sacramento River (BG20) and San Joaquin River (BG30) stations in the north to an extreme South Bay station (BA20) below the Dumbarton Bridge. Each of these sampling sites was located in the deeper channels of the Bay. Samples were taken at a depth of one meter at various tidal conditions. QA/QC followed protocols established for the RMP. Detection limits for the analytical work were 1.0 µg/L (SFEI online database at www.sfei.org).

Table 6: Summary of Data Collected by SFEI for RMP (March, May and September, 1993)

RMP Station No:	RMP Station Name	Cyanide Concentration - total (µg/L)	Cyanide Concentration - dissolved (µg/L)
BA20	Extreme South Bay	<1.0	<1.0
BA30	Dumbarton Bridge	<1.0	<1.0
BA40	Redwood Creek	<1.0	<1.0
BB30	Oyster Point	<1.0	<1.0
BC10	Yerba Buena Island	<1.0	<1.0
BC20	Golden Gate	<1.0	<1.0

RMP Station No:	RMP Station Name	Cyanide Concentration - total (µg/L)	Cyanide Concentration - dissolved (µg/L)
BC30	Richardson Bay	<1.0	<1.0
BC41	Point Isabel	<1.0	<1.0
BD20	San Pablo Bay	<1.0	<1.0
BD30	Pinole Point	<1.0	<1.0
BD40	Davis Point	<1.0	<1.0
BD50	Napa River	<1.0	<1.0
BF10	Pacheco Creek	<1.0	<1.0
BF20	Grizzly Bay	<1.0	<1.0
BG20	Sacramento River	<1.0	<1.0
BG30	San Joaquin River	<1.0	<1.0

Notes: Based on the above results, the decision was made to remove cyanide from the parameter list for subsequent RMP analyses.

Data collected by SFEI

This work was performed in 2002 and 2003 at three RMP monitoring stations: Sacramento River (BG20), Yerba Buena Island (BC10), and Dumbarton Bridge (BA30). Results are shown below in Table 7. The sampling sites are located in the deeper channels of the Bay. Samples were taken at a depth of one meter at various tidal conditions. Extensive QA/QC procedures were utilized during the sample collection and laboratory analysis performed, mirroring procedures employed by the RMP. Detection limits for the analytical work were 0.4 µg/L. Cyanide analyses were performed by Central Contra Costa Sanitary District's laboratory (SFEI, 2003).

Table 7: Summary of Data Collected by SFEI (2002-2003)

RMP Station Number	RMP Station Name	Dates	Cyanide Concentration - total (µg/L)
BA30	Dumbarton Bridge	January 2002	<0.4
		July 2002	<0.4
		January 2003	<0.4
BC10	Yerba Buena Island	January 2002	<0.4
		July 2002	<0.4
		January 2003	<0.4
BG20	Sacramento River	January 2002	<0.4
		July 2002	<0.4
		January 2003	0.5

Notes: These data were collected using current clean methods for sampling and analysis.

Summary tables of the available ambient cyanide data for San Francisco Bay measured in samples taken from 1989 through 2003 are presented below in Table 8. The data in Table 5 to

Table 7 show that ambient levels of cyanide at various deep water locations in the San Francisco Bay are consistently less than the existing NTR acute and chronic objectives for protection of aquatic life uses.

Table 8: Consolidated Summary of Data Collected at Overlapping Stations (1989-2003)

RMP Station No:	RMP Station Name	Mar-93	May-93	Sep-93	Jan-02	Jul -02	Jan-03
BA30	Dumbarton Bridge	<1.0	<1.0	<1.0	<0.4	<0.4	<0.4
BC10	Yerba Buena Island	<1.0	<1.0	<1.0	<0.4	<0.4	<0.4
BG20	Sacramento River	<1.0	<1.0	<1.0	<0.4	<0.4	0.5

Notes: Ambient levels are also important to the determination of effluent limits for NPDES dischargers to San Francisco Bay. Ambient levels are used in the determination of whether a specific discharge has reasonable potential to cause or contribute to a violation of a water quality objective, and thus whether an effluent limit is required to be adopted in accordance with U.S. EPA regulations (40 CFR 122.44), and Section 1.3 of the SIP. Ambient levels are also used in the calculation of water quality-based effluent limits (WQBELs) for dischargers that receive credit for dilution, according to procedures in Section 1.4 of the SIP.

Conditions near Shallow Water Discharges

Recent data for the period 2003-2005 indicate that ambient levels in the immediate vicinity of shallow water discharger outfalls are detectable at levels ranging from 0.3 µg/L to 6.7 µg/L. Figures in Appendix B show the results of ambient monitoring of cyanide concentrations at various locations along individual discharge gradients for the following shallow water dischargers: American Canyon, Fairfield-Suisun, Las Gallinas, Napa, Mountain View Sanitary District (Martinez), Petaluma, Sonoma County Water Agency, Palo Alto, Sunnyvale and San Jose/Santa Clara. These dischargers collected a total of 225 local receiving water samples between 2003 and 2005 to inform the empirical derivation of an attenuation factor (Appendices B and D; Section 6) in the proposed calculation of numeric effluent limits. The average cyanide concentration in the vicinity of shallow water discharges was 0.9 µg/L, and the 90^{th} percentile value was 2.2 µg/L.

As shown in Appendix B and D, especially for San Jose/Santa Clara for which there are more data, the ambient data collected near shallow water discharges demonstrates a pattern of rapid decline in cyanide concentrations with distance away from the point of discharge. As described previously, this “attenuation” caused by a combination of dilution due to tidal mixing, dispersion and naturally occurring degradation processes causes ambient cyanide levels to exist at levels that are protective of aquatic life beneficial uses in the open Bay and in the Bay margins near shallow water discharges.

Ambient monitoring of cyanide levels in San Francisco Bay indicates no evidence that cyanide concentrations pose a toxicity problem to aquatic species. The monitoring done to date has measured total cyanide levels, rather than free cyanide, the toxic form. Therefore, while the ambient data set is not as robust as that for trace metals, the ambient cyanide evaluation has an inherent factor of safety, since it is likely that a portion of the cyanide present in the Bay is complexed cyanide. Such complexed forms are not toxic to aquatic organisms at the levels of the existing or proposed cyanide objectives. Additionally, a biological study of one receiving water area conducted by a shallow water discharger is described in Section 6.1.4 and Appendix M, suggests that current cyanide levels near discharge points are not adversely affecting aquatic life.

4 Derivation of Existing and Proposed Cyanide Criteria

4.1 Water Quality Standards, Criteria and Objectives

Before describing the details of the proposed cyanide water quality objective Basin Plan amendment, it is helpful to revisit the concept of a water quality standard since it is the basis of how water quality is regulated. A water quality standard defines the water quality goals of a water body by designating the beneficial uses to be made of the water, by setting the numeric or narrative criteria necessary to protect the uses, and by preventing degradation of water quality through antidegradation provisions. Under the California Water Code, the numeric or narrative criteria of the water quality standard are known as the "water quality objectives." States adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the federal Clean Water Act. Numeric water quality criteria and objectives that are designed to protect aquatic organisms are generally of two types – the Criteria Continuous Concentration (CCC) or the Criteria Maximum Concentration (CMC).

The CCCs are the U.S. EPA national water quality criteria recommendations for the highest in-stream concentrations of a toxic pollutant to which organisms can be exposed on a long-term average basis without causing unacceptable effect (USEPA 2000). When adopted into California standards, the CCC becomes the chronic water quality objective for a given toxic pollutant. The CMCs are the U.S. EPA national water quality criteria recommendations for the highest in-stream concentrations of a toxic pollutant to which organisms can be exposed for a short-term average period of time without causing an acute effect. When adopted into California standards, the CMC becomes the acute water quality objective for a given toxic pollutant.

4.2 Existing Cyanide Water Quality Objectives

For the San Francisco Bay, existing cyanide objectives have been established through federal action under the National Toxics Rule 1992 (NTR), which superseded previous cyanide objectives from the 1986 Basin Plan, which were based on the level of detection of 5 µg/L. Existing water quality objectives for cyanide in San Francisco Bay are summarized in Table 9.

Table 9: Current Water Quality Objectives for Cyanide in San Francisco Bay

Source	Date	Description	Acute Objective	Chronic Objective
National Toxics Rule (NTR), (40 CFR 131.36)	December 22, 1992; amended May 4, 1995	**Marine water**[a] - waters with salinity greater than 10 ppt 95% of the time	1 µg/L (1-hour average)	1 µg/L (4-day average)
NTR	December 22, 1992; amended May 4, 1995	**Freshwater** - waters with salinity less than 1 ppt 95% of the time	22 µg/L (1-hour average)	5.2 µg/L (4-day average)

[a] Because marine objectives are more stringent than freshwater objectives the Basin Plan specifies that the marine objective applies for estuarine waters, where 95% of the time salinity is less than 10 ppt and greater than 1 ppt.

4.3 Proposed Cyanide Regulatory Changes

Of the above water quality objectives, Water Board staff is proposing changes to only the marine objective, based on a more complete data set for crabs of the *Cancer* genus. Only the marine objective poses significant compliance challenges for municipal and industrial NPDES dischargers to San Francisco Bay. To Water Board staff's knowledge there is no compelling scientific information available at this time that suggests the freshwater objectives should be changed.

The Water Board staff has determined through best professional judgment and consideration of the fate and transport of cyanide in San Francisco Bay, that a regional approach to implementation of cyanide objectives for shallow water discharges to the Bay is appropriate. Therefore, the Water Board staff is proposing that effluent limits which implement the proposed cyanide objectives for shallow water dischargers be based on an evaluation of cyanide attenuation in the Bay as a component of the program of implementation for San Francisco Bay cyanide objectives. The Water Board finds that attenuation, a combination of dilution, tidal mixing and natural degradation, is effectively equivalent to dilution since, in both cases, the cyanide concentration in the receiving water diminishes with distance from the discharge location. Therefore the proposed plan would grant dilution credits for individual shallow water dischargers. Section 6 describes the approach to determine the extent of dilution and degradation of cyanide in shallow incompletely mixed discharges.

4.4 Developing Site-Specific Objectives

California can choose to base state water quality objectives on the federal water quality criteria published by U.S. EPA (i.e., the basis of standards contained in the NTR and CTR) or can adopt site-specific water quality objectives provided they are based on an appropriate scientific justification.

Site-specific objectives may be developed where appropriate site-specific conditions warrant more or less stringent objectives, without compromising the beneficial uses of the receiving water. The SIP provides in Section 5.2 that a Water Board may consider site-specific objectives where an existing objective cannot be met through reasonable treatment, source control, and pollution prevention measures. The current applicable standards for cyanide are set forth in the NTR. As shown in this Report, NPDES wastewater dischargers that discharge into San Francisco Bay are unable to comply with effluent limits based on the NTR criteria.

Section 131.11(b)(ii) of the water quality standards regulation (40 CFR Part 131) provides the regulatory mechanism for states to develop site-specific criteria for use in water quality standards. There are several U.S. EPA-approved procedures (USEPA 1994) that can be used to modify national criteria so that they more accurately reflect ambient conditions and bioavailability. For this proposal, three procedures discussed below were evaluated and one was chosen as the basis for the site-specific objectives.

4.4.1 Recalculation Procedure

The proposed cyanide objectives are based on the recalculation procedure. It allows for modification to the national criterion by correcting, adding or removing data from the national toxicity database. Toxicity databases are collections of laboratory-measured toxicity values for different species and form the basis of water quality criteria promulgated by U.S. EPA. The goal of the recalculation procedure is to create a data set that is appropriate for deriving a site-specific criterion by modifying the national data set in some or all of three ways:

a) Correction of data that are in the national database;
b) Addition of data to the national database; and/or
c) Deletion of data that are in the national database (e.g. elimination of data for species that are not residents).

The proposed objectives rely on (b) and (c) above. The proposal includes addition of data for four species of the *Cancer* genus and deletion of data from *Cancer irroratus*, a species that exists only on the east coast of the United States.

4.4.2 Indicator Species Procedure

This procedure allows for modifications to the national criterion by using a site-specific multiplier called a water effects ratio (WER). Under the WER approach, the toxic substance of interest is added to clean laboratory water (to mimic the testing approach used in development of U.S. EPA criteria) and site water samples (to reflect local conditions) and toxicity tests are performed using sensitive organisms. The WER is the numeric ratio between the toxicity value (typically lethality to 50% of the organisms [LC50] or adverse effects to 50% of the organisms [EC50]) in local site water versus the toxicity value in clean laboratory water. The WER is then used as a multiplier in the following equation to produce a site-specific objective:

U.S. EPA national criteria X WER = Site-specific water quality objective

U.S. EPA (1994) guidelines specify that WERs may be developed for either acute or chronic criteria and that the test endpoint used to derive the WER should be near to but above the criterion that it is intended to modify**.** Laboratory studies conducted by dischargers in the region could not generate a consistent WER value for cyanide, so this alternative was abandoned early in the process.

4.4.3 Resident Species Approach

This procedure is intended to account for differences in both resident species sensitivity and differences in toxicity due to local water quality characteristics. Under the Resident Species procedure, data for species which are either resident or known to be present in the Bay are assembled or developed for use in criteria calculations. The minimum data requirements for development of national criteria must be met. Data used in the resident species procedure must pass the strict quality assurance and data quality requirements required for national criteria development.

For the marine cyanide objectives there were not enough data available for resident species to meet the minimum data requirements for a national criteria, so this alternative was abandoned early in the process.

4.5 Calculation of Proposed Cyanide Site-Specific Objectives

The proposed marine site-specific objectives for cyanide were developed based on the recalculation procedure. The recalculation was performed by adding recent toxicity data for four *Cancer* species to the existing U.S. EPA data set, deleting data from an east coast *Cancer* species, and recalculating the criteria values.

The calculation of water quality criteria for cyanide using the recalculation procedures includes several steps. The first step is using LC50 (lethal concentration to 50% of test organisms) toxicity data to arrive at a final acute value (FAV), and then the FAV becomes the basis for both the chronic criterion and the acute criterion. The FAV is derived from LC50 or EC50 values and is divided by two to calculate an acute criterion. Division by two is an approximation intended to estimate a concentration that will not adversely affect organisms (i.e. as a means to estimate the LC0 or EC0 value). The FAV is divided by an acute-to-chronic ratio (ACR) to produce a chronic criterion.

These calculations can be summarized as follows:

Acute Criterion = (FAV/2)
Chronic Criterion = (FAV/ACR)

4.5.1 Basis for Current U.S. EPA Marine Criteria for Cyanide

The Section 304(a) water quality criteria for cyanide were developed by the Environmental Research Laboratory of the U.S. EPA and published as national criteria in January 1985 (USEPA 1985b). These criteria were adopted into California water quality standards through the NTR. The cyanide marine criteria were derived using the minimum data set allowed by the U.S. EPA Guidelines (acute toxicity data for eight genera, chronic toxicity data for 5 freshwater and two saltwater species). The species and associated data used in the marine acute toxicity analysis are summarized in Table 10. The species used in this analysis include 3 fish families in the phylum Chordata, 4 families in the phylum Arthropoda (one mysid shrimp, one crab, one amphipod and one copepod) and one family in the phylum Mollusca (a gastropod). This assemblage of representative genera fulfilled the *minimum* allowed by U.S. EPA criteria guidelines.

Chronic toxicity data was available for a marine mysid, *Americamysis bahia* (formerly *Mysidopsis bahia*) and a marine fish (*Cyprinodon variegatus*) and five freshwater species (three fish, an amphipod and an isopod). The chronic values for these species were used to calculate acute-to-chronic ratios for each of these species. According to the U.S. EPA (1985c) guidelines, a final chronic value may be determined by one of eight different methods, which are summarized in the U.S. EPA 1995 Saltwater Copper Addendum. The acute-to-chronic ratio values for four freshwater species were used in the derivation of the final freshwater chronic value (FCV) by dividing the FAV by the ACR (USEPA 1985b). However, Method 4 (USEPA 1995) was used to derive a marine chronic value. Method 4 assumes that the ACR is 2 (CMC=CCC) because the acute tests used to derive the FAV were from embryo larval tests with molluscs, and a limited number of other taxa (*Cancer* sp. crabs in the case of cyanide). This assumption appears to be correct since the saltwater CMC of 1.015 ppb is 8-fold lower than the lowest observed "acceptable" freshwater chronic result (*Salvelinus fontinalus*), and 36-fold lower than the lowest observed "acceptable" saltwater chronic result (*Cyprinodon variegatus*) shown in the U.S. EPA cyanide criteria document (see Table 11).

Table 10: Data Used in Calculation of Current Cyanide Marine Criterion (USEPA 1985b)*

Rank	Species	Genus Mean Acute Value (μg/L)
8	Common Atlantic slippershell, *Crepidula fornicata*	>10,000
7	Amphipod, *Ampelisca abdita*	995.9
6	Winter flounder, *Pseudopleuronectes americanus*	372
5	Sheepshead minnow, *Cyprinodon variegatus*	300
4	Mysid, *Americamysis bahia/bigelowi*	118.4
3	Atlantic silverside, *Menidia menidia*	59
2	Copepod, *Acartia clausi*	30
1	Eastern rock crab, *Cancer irroratus*	4.893

* U.S. EPA criteria calculations are based on GMAVs for organisms ranked 1 through 4. The FAV is calculated based on a regression equation using the GMAVs for the four most sensitive genera. Refer to Table 11 and Table 12 for the specific calculations used in the U.S. EPA criteria derivation.

No saltwater studies have been reported which show significant bioaccumulation or biomagnification in the aquatic food chain. Studies indicate that while cyanide may penetrate aquatic organisms, it readily metabolizes (USEPA 1985b).

Table 11: Calculations for Existing Cyanide Marine Criteria for San Francisco Bay

Rank	Genus species	Common Name	Phylum/Class/Family	GMAV	ln(GMAV)	ln(GMAV)2	P	(P)0.5	
1	Cancer irroratus	Eastern rock crab	Arthropoda/Crustacea/Cancridae	4.89	1.5872	2.5192	0.1111	0.3333	
2	Acartia clausi	Copepod	Arthropoda/Crustacea/Acartiidae	30	3.4012	11.5681	0.2222	0.4714	
3	Menidia menidia	Atlantic silverside	Chordata/Osteichthyes/Atherinidae	59	4.0775	16.6263	0.3333	0.5774	
4	Mysidopsis bahia/bigelowi	Mysid	Arthropoda/Crustacea/Mysidae	118.4	4.7741	22.7917	0.4444	0.6667	
5	Cyprinodon variegatus	Sheepshead minnow	Chordata/Osteichthyes/Cyprinodontidae	300					
6	Pseudopleuronectes americanus	Winter flounder	Chordata/Osteichthyes/Pleuronectidae	372					
7	Ampelisca abdita	Amphipod	Arthropoda/Crustacea/Ampeliscidae	995.6					
8	Credipula fornicata	Common Atlantic slippershell	Mollusca/Gastropoda/Calyptraeidae	10000					
		Count (n)	8						
		Sums			13.8400	53.5054	1.1111	2.0488	
		S2	= [Ln(GMAV)2 - Ln(GMAV)*Ln(GMAV)/4]/[P-P(0.5)*P(0.5)/4]						90.9781
		S	= SQRT (S2)						9.5382
		L	= [Ln(GMAV)-S/(P)0.05]/4						-1.4254
		A	= SQRT(0.05)*S+L						0.7074
		FAV	= Exp (A)						2.0288
		CMC	= FAV/2						1.0144
		FCV	Based on U.S. EPA judgment, FCV = CMC = CCC						1.0144

4.5.2 Basis for Current U.S. EPA Freshwater Criteria for Cyanide

The freshwater cyanide objectives are not proposed to be changed, but the basis of these objectives is discussed in this section, as they are considered in discharges to estuarine regions where freshwater and marine species overlap in occurrence. The 1985 U.S. EPA aquatic life criteria document (USEPA 1985b) describes the basis for calculation of the freshwater criteria for cyanide, which is currently a water quality objective for the San Francisco Bay Region as established under the NTR.

Data on the acute toxicity of free cyanide to 17 aquatic species of fish and invertebrates in 15 genera were used to derive the U.S. EPA freshwater acute criterion. The range in acute toxicity for the 17 species was from 44.73 μg/L to 2490 μg/L. The freshwater chronic criterion was calculated using acute and chronic data for four freshwater species. The species and associated data used in the acute and chronic freshwater criteria development are summarized in Table 13. The species used in this analysis include fish families in the phylum Chordata, families in the phylum Arthropoda and families in the phylum Mollusca. This assemblage of representative genera fulfilled the U.S. EPA criteria guidelines.

In the final freshwater criteria calculation, the species mean acute value (SMAV) for juvenile rainbow trout (previously referred to as *Salmo gairdneri,* now *Oncorhynchus mykiss)* (44.73 μg/L) derived from six separate study results performed between 1978 and 1984 was found to be more sensitive than the final acute value (FAV) calculated from the four most sensitive genera [rainbow trout and Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), yellow perch (*Perca flavescens*) and bluegill (*Lepomis macrochirus*), all fish families in the phylum Chordata]. In accordance with U.S. EPA water quality criteria guidance, the rainbow trout SMAV replaced the calculated FAV. The most sensitive invertebrate (*Daphnia*) was more than two-fold less sensitive than rainbow trout.

The freshwater acute criterion (CMC) of 22.4 μg/L was derived by dividing the rainbow trout SMAV-based FAV of 44.73 μg/L by 2 (to approximate a "no effect" value from the EC50 value [effects concentration affecting 50% of organisms] for rainbow trout). The freshwater chronic value (CCC) of 5.2 μg/L was derived by dividing the FAV (44.73 μg/L) by an acute to chronic ratio of 8.57 (geometric mean of values from four freshwater species). The most sensitive chronic toxicity value used in criteria derivation in 1985 was 7.85 μg/L for brook trout (*Salvelinus fontinalis*), a sensitive species to cyanide.

No freshwater studies have been reported which show significant bioaccumulation or biomagnification of cyanide in the aquatic food chain (USEPA 1985).

Table 12: Calculations for U.S. EPA Existing Cyanide Freshwater Criteria (USEPA 1985)

Rank	Genus species	Common Name	SMAV	GMAV	ln(GMAV)	ln(GMAV)2	P	(P)0.5	
1	Oncorhynchus mykiss	Rainbow trout	44.73	63.45	4.1503	17.2246	0.0625	0.2500	
	Salmo salar	Atlantic salmon	90						
2	Salmo salvelinus	Brook trout	85.8	85.8	4.4520	19.8205	0.1250	0.3536	
3	Perca flavescens	Yellow perch	92.64	92.64	4.5287	20.5093	0.1875	0.4330	
4	Lepomis macrochirus	Bluegill	99.28	99.28	4.5979	21.1411	0.2500	0.5000	
5	Pomoxis nigromaculatus	Black crappie	102	102					
6	Micropterus salmoides	Largemouth bass	102	102					
7	Daphnia magna	Cladoceran	160	123.6					
	Daphnia pulex		95.55						
8	Pimephales promelas	Fathead minnow	125.1	125.1					
9	Poecillia reticulata	Guppy	147	147					
10	Gammarus pseudolimnaeus	Amphipod	167	167					
11	Carassius auratus	Goldfish	318	318					
12	Pteronarcys dorsata	Stonefly	426	426					
13	Physa heterostropha	Snail	432	432					
14	Asellus communis	Isopod	2326	2326					
15	Tanytarsus dissimilis	Midge	2490	2490					
	Count (n)	15							
	Sum				17.7289	78.6955	0.6250	1.5366	
	S2	= [Ln(GMAV)2 - Ln(GMAV)*Ln(GMAV)/4]/[P-P(0.5)*P(0.5)/4]							3.3584
	S	= SQRT (S2)							1.8326
	L	= [Ln(GMAV)-S/(P)0.05]/4							3.7283
	A	= SQRT(0.05)*S+L							4.1380
	FAV	= Exp (A)							62.6798
	Calculated CMC	= FAV/2							31.3399
	Sensitive Species-based CMC (based on species mean acute value for rainbow trout)					= 44.73/2			22.3650
	FCV (based on Rainbow trout SMAV divided by ACR for four freshwater species)					=44.73/8.57			5.2194

Table 13: Data Used in U.S. EPA (1985) Cyanide Chronic Freshwater Criteria Derivation

FW[a] or SW[b]	Rank[c]	SMAV[d]	SMACR[e]	SMCV[f]	Species	Common name
SW	5	300	8.306	36.12	*Cyprinodon variegatus*	Sheepshead minnow
SW	4	113	1.621	69.71	*Americamysis bahia*[g]	Mysid
FW	14	2326	68.29	34.06	*Asellus communis*	Isopod
FW	10	167	9.111	18.33	*Gammarus pseudolimnaeus*	Amphipod
FW	8	125.1	7.633	16.39	*Pimephales promelas*	Fathead minnow
FW	4	99.28	7.316	13.57	*Lepomis macrochirus*	Bluegill
FW	2	83.14	10.59	7.849	*Salvelinus fontinalus*	Brook trout
			1.621	7.849	Minimum	
			68.29	34.06	Maximum	
			8.306		Median ACR (all)	
			9.05		Geometric Mean ACR (all)	
			8.37		Median ACR (Freshwater only minus Asellus)	
			8.57		Geometric Mean ACR (Freshwater only minus Asellus)	

[a] Fresh Water
[b] Salt Water
[c] Rank is based on sensitivity to cyanide, with the most sensitive genus ranked no. 1
[d] SMAV= species mean acute value
[e] SMACR = species mean acute to chronic ratio
[f] SMCV= species mean chronic value
[g] formerly Mysidopsis bahia

4.5.3 Proposed Cyanide Marine Site-Specific Objectives for San Francisco Bay

The SIP requires that site-specific water quality objectives "be developed in a manner consistent with State and federal law and regulations." In accordance with the State's Porter-Cologne Water Quality Control Act (Division 7 of the Water Code), objectives must provide for the reasonable protection of beneficial uses based on consideration of the factors listed in Water Code Section 13241. In accordance with federal law (CWA) and regulations (40 CFR 131.11, revised as of July 1, 1997), the objectives must be "based on sound scientific rationale and protect the designated beneficial uses of the receiving water." The SIP further requires that the "RWQCB shall use scientifically defensible methods appropriate to the situation to derive the objectives. Such methods may include U.S. EPA-approved methods (e.g. Water Effects Ratio (WER) procedure, recalculation procedure, a combination of recalculation and WER procedures, Resident Species Procedure), and/or other methods…"

Section 6.1.5 describes the different U.S. EPA-approved methods reviewed to address the cyanide compliance issue for dischargers to San Francisco Bay.

The 1985 cyanide marine criteria values are significantly affected by the acute toxicity value (LC50) for one species (*Cancer irroratus*, the Eastern rock crab). This acute value has been scrutinized by researchers (Brix et al., 2000) and has been found to be significantly different from the acute values for other *Cancer* species.

The cyanide marine site-specific objectives are derived through application of the U.S. EPA recalculation approach by using acute toxicity test results for four crab species (*Cancer magister, Cancer productus, Cancer gracilis, and Cancer oregonensis*) to replace the existing data for *Cancer irroratus* used in the 1985 U.S. EPA cyanide criteria. A slight variation of this approach was performed and approved in the adoption of cyanide standards in Puget Sound, located in U.S. EPA Region 10. The resulting Genus Mean Acute Value (GMAV) derived from the consideration of crab data for four species is then used in the recalculation of the cyanide water quality objectives. Acute to Chronic Ratio (ACR) value of 6.46 is used in the derivation of the cyanide chronic criterion. The ACR value of 6.46 was calculated using all ACR values in the 1985 U.S. EPA criteria document except the ACR value for *Asellus communis*. The ACR value for *Asellus communis* was excluded from the 1985 U.S. EPA freshwater criteria calculations by U.S. EPA criteria experts in accordance with U.S. EPA guidance because its magnitude was significantly different from the other available ACR values.

The four additional acute toxicity values for *Cancer* spp. were developed by Parametrix, Inc. and EcoTox in 1995 using West Coast species as part of a study to derive site-specific cyanide marine objectives for Puget Sound in Washington (Parametrix, 1995; Brix et al., 2000). The four additional values are presented in Table 14, below *Cancer irroratus*. The results indicated significantly higher LC50 values for each of the *Cancer* species tested than the LC50 value stated for the Eastern rock crab (*Cancer irroratus*) in the U.S. EPA cyanide criteria document. The net effect of adding the data for these four crab species into the data set was to increase the GMAV for *Cancer* from 4.9 μg/L to 62.6 μg/L. The GMAV without the *Cancer irroratus* SMAV is 118.4 μg/l. In the recalculation for the proposed cyanide SSOs, it is proposed that the GMAV without *Cancer irroratus* be used.

Table 14: Summary of Available Acute Toxicity Saltwater Data for Five Crab Species (*Cancer* spp.)[a] After Brix et al., 2000)

Species	Species Mean Acute Value (µg/L)	Genus Mean Acute Value (µg/L)
Cancer irroratus[b]	4.9	
Cancer magister	68.5	
Cancer productus	153.1	
Cancer gracilis	143.7	
Cancer oregonesis	130.7	
Cancer spp (with *Cancer irroratus)*		62.6
Cancer spp (without *Cancer irroratus)*		118.4

[a] Three additional West Coast Cancer species are known to exist in San Francisco Bay (C. anthonyi, C. antennarius, and C. jordani). No data are available for these species to assess sensitivity to cyanide.
[b] This species (Eastern rock crab) is not present in San Francisco Bay.

The recalculated site-specific objectives are based on the revised Cancer GMAV and the ACR value. See Table 15 for the values used to derive the recalculated cyanide marine criteria. See Table 1 for the existing and proposed site-specific objectives for cyanide.

U.S. EPA criteria documents and the Technical Support Document for Water Quality-Based Toxics Control (USEPA 1991, Appendix D) state that beneficial uses will be protected if the 304(a) criteria values are not exceeded more than one time in three years, particularly acute criteria. The same allowable exceedance frequency is presumed to apply to these recalculated cyanide objectives.

4.6 Justification of the Site-Specific Objectives Required by SIP

Significant compliance problems will occur throughout the San Francisco Bay for the majority of NPDES dischargers if effluent limits based on the existing water quality NTR standard of 1.0 µg/L are adopted in NPDES permits. This is despite the fact that evidence exists that current ambient concentrations of cyanide are not impacting beneficial uses in the waters of San Francisco Bay. NPDES permittees are currently subject to interim limits, which are scheduled to sunset in 2010. This proposed Basin Plan amendment presents site-specific marine objectives for cyanide for San Francisco Bay, using procedures detailed in the SIP for recalculation of a water quality objective based on utilizing data from resident aquatic species. The site-specific objectives are justified under the SIP as dischargers cannot comply with the NTR-based limits even though they have implemented and will continue to do so, all reasonable treatment, source control and pollution prevention activities. Beneficial uses will continue to be protected after the adoption of the site-specific objectives.

Table 15: Calculations for Proposed Cyanide Marine Site-Specific Objectives for San Francisco Bay

	Rank	Genus	Common Name	GMAV	ln(GMAV)	ln(GMAV)2	P	(P)0.5	
	1	*Acartia clausi*	*Copepod*	30	3.4012	11.5681	0.1111	0.3333	
	2	*Menidia menidia*	*Atlantic silverside*	59	4.0775	16.6263	0.2222	0.4714	
	3	*Cancer spp*	*Crabs (*excludes *Cancer irroratus* at 4.89 µg/l*)*	118.4	4.7741	22.7917	0.3333	0.5774	
	4	*Mysidopsis bahia/bigelowi*	*Mysid*	118.4	4.7741	22.7917	0.4444	0.6667	
	5	*Cyprinodon variegatus*	*Sheepshead minnow*	300					
	6	*Pseudopleuronectes americanus*	*Winter flounder*	372					
	7	*Ampelisca abdita*	*Amphipod*	995.6					
	8	*Credipula fornicata*	*Common Atlantic slippershell*	10000					
Count (n)									8
Sum					17.0269	73.7779	1.1111	2.0488	
S2									21.0376
S									4.5867
L									1.9075
A									2.9331
FAV									18.7855
CMC									**9.3928**
ACR									6.4600
FCV CCC									**2.9080**

5 Cyanide Source Characterization

Cyanide sources are limited to municipal and industrial wastewater dischargers. Several Bay area POTWs have completed cyanide source identification studies, some as a condition of having interim effluent limits, to determine the origins of the cyanide in their effluent. Results show that the predominant source of effluent cyanide is typically generated in-plant through municipal and industrial wastewater treatment processes (disinfection or biosolids incineration). In some cases, cyanide that enters municipal treatment plants from industrial, commercial and residential sources may influence effluent concentrations of cyanide (see Appendix K).

5.1 Cyanide in Municipal Influent

Available data from POTW facilities show that influent concentrations of cyanide are often not detected, or are present at levels below effluent cyanide concentrations. Recent and historic (over ten years old) data both indicate that higher influent values are an episodic occurrence, sometimes traceable to illicit discharges in the collection system.

Where observed in municipal wastewater influent, cyanide may originate from industrial activities, such as metal plating, steel production, mining operations, or photographic finishing facilities (WERF 2003). Other commercial or industrial operations that may utilize or discharge cyanide include metal finishing, electroplating, hospitals, manufacturing, chemical laboratories, and chemical manufacturing facilities. In several Bay area studies completed to date, these sources have been considered insignificant based on mass balance calculations that demonstrate their relative contributions to wastewater treatment plant influent. A study performed for Sacramento Regional County Sanitation District detected cyanide in 5% of residential wastewater samples taken, suggesting that residential wastewater is a minor source of cyanide loading (Malcolm Pirnie 2003). Formation of cyanide in the collection system as a result of chemical treatments or maintenance activities is also a possible source of cyanide in influent.

Thiocyanate (SCN^-) in influent is a potential precursor of cyanide in effluent. Little is currently known about the amount of thiocyanate in POTW influent, as it is currently an unmonitored and unregulated constituent. There is a question as to whether thiocyanate may be a significant and controllable precursor for cyanide formation in wastewater treatment. WERF (2003) researchers have found that chlorination of thiocyanate seems to be an important mechanism for the formation of cyanide in wastewater treatment. In 2005 Los Angeles County Sanitation District (LACSD) tested thiocyanate levels at various points in the wastewater treatment process and found that elevated levels of thiocyanate in raw wastewater and primary effluent were reduced significantly in the secondary (biological) process, indicating that thiocyanate is biodegradable. This result is generally consistent with the WERF findings. However, the LACSD investigators found that use of an ion chromatography analytical method, that avoided interferences inherent in the colorimetric methods used in the WERF study, yielded much lower thiocyanate measurements in effluent. This result raises doubt whether levels of thiocyanate in effluent are capable of causing cyanide formation at previously reported levels. Since thiocyanate is not measured in the total cyanide test, a question exists whether influent levels of thiocyanate may explain observed cyanide levels in effluent. A more detailed discussion of thiocyanate is presented in Section 5.2.1.

5.2 Cyanide Formation in Wastewater Treatment

Cyanide, cyanide precursors, and cyanide complexes can undergo various transformations during the wastewater treatment process for municipal and industrial dischargers. Chlorination, UV disinfection, and incinerator scrubber return flows have been implicated as sources of cyanide formation during wastewater treatment and sources of cyanide detected in effluent (Zheng et al., 2004a; Zheng et al., 2004b; Malcolm Pirnie 2003). In-plant cyanide formation is not limited to POTWs; any discharger that disinfects or incinerates may produce cyanide in their effluent.

Investigations of cyanide formation in wastewater treatment can be confounded by the presence of interferences that produce false negatives or false positives introduced as a result of sample handling, preservation or analytical methods. Additionally, limitations on the detection levels of total cyanide, free cyanide and thiocyanate have hampered our understanding of cyanide formation (see Section 5). As also described in Section 5, other compounds that can affect the formation or measurement of cyanide in wastewater effluent include nitrate, nitrite, sulfide, aldehydes, and uncharacterized organic matter.

5.2.1 Chlorination

Chlorination was the first process to be identified as causing formation of cyanide within treatment plants. Oxidative decomposition of thiocyanate using chlorine can produce free cyanide. Thiocyanate is known to be used or generated in various industrial processes, including photofinishing, coke gasification, herbicide and insecticide production, ore mining process, and dyeing and electroplating (Zheng et al., 2004a; WERF 2003). Zheng et al., 2004a and 2004c showed cyanide formation from thiocyanate to be dependant on chlorination levels. Treatment plant influent from two plants was used in the study. None of the treatment plant influent samples had detectable levels of thiocyanate. When spiked with thiocyanate, approximately 1-6% of the thiocyanate was converted to cyanide during chlorination of the effluent. The cyanide was formed as a result of non-stoichiometric amounts of chlorine being applied.

The above case study can be applied to a hypothetical example, which suggests that thiocyanate probably does not explain the majority of cyanide formed in chlorination processes in treatment plants. Extrapolating the study results above, if an industrial facility discharges 100,000 gal/day containing 5 mg/L thiocyanate to the collection system of a 10 MGD plant, the approximate thiocyanate concentration in the POTW influent would be 0.05 mg/L. If 6% of the thiocyanate were converted to cyanide, it would add approximately 0.3 μg/L of cyanide to the effluent, which is below the levels of concern (i.e., 1 to 3 μg/L). Therefore, unless an industry is identified that discharges large amounts of thiocyanate, influent thiocyanate levels are unlikely to significantly impact cyanide levels in POTW effluents.

Thiocyanate concentrations measured in POTW influent have been observed to decrease in secondary influent by 60% (WERF 2003; Zheng et al., 2004b), suggesting significant removal in primary treatment. However, a positive correlation between thiocyanate decrease and cyanide increase could not be established, suggesting multiple factors contributing to the cyanide formation.

Other organocyanide compounds also have the potential to elevate cyanide concentrations in post-chlorinated effluent, although these effects are not well understood. Compounds studied include acetonitrile, D-Amygdalin, 2-acetoxy-3-butenenitrile, and cyanobalamin.

5.2.2 UV Disinfection

Available information on cyanide formation by UV disinfection is very limited at this time. The information hints that switching from chlorination to UV could reduce cyanide effluent levels, but much more investigation and full scale evaluation using very low detection limits would be needed to verify this preliminary hypothesis.

One study has shown that UV irradiation has the capability to decompose thiocyanate and create cyanide. Zheng et al. (2004a) conducted studies with thiocyanate-spiked wastewater treatment plant effluents and confirmed that cyanide does have the potential to form (12.3% conversion for irradiation time of 10 min at pH 6.9) when precursors are present. Emerging information indicates that UV disinfection may not create cyanide at the same concentrations created by chlorine disinfection.

While the above research has indicated that exposure to high intensity ultraviolet light creates cyanide in wastewater effluent, recent pilot study work using collimated beam tests performed by the Los Angeles County Sanitation District on secondary effluents indicates that, at lower design intensities used in newer UV installations (e.g. 500 millilJoules per square centimeter), effluent cyanide concentrations may be relatively low (i.e. less than an analytical reporting limit of 5 µg/l). Full scale testing of UV disinfection to further assess cyanide formation is scheduled to occur at the Whittier Narrows Water Reclamation Plant in 2006.

Limited full scale data from two advanced San Francisco Bay secondary plants that utilize UV disinfection (Mountain View Sanitary District of Martinez [MVSD] and American Canyon) tend to support the finding that effluent cyanide concentrations less than 5 µg/l can be produced by plants utilizing UV disinfection. Mean and maximum total cyanide effluent concentrations from these facilities ranged from 0.5 to 1.4 µg/l and 3.0 to 5.0 µg/l, respectively (see Table 16). These results indicate that MVSD and American Canyon, both shallow water dischargers, could not comply with effluent limits derived from the NTR marine objectives of 1.0 µg/l (see Table 2), and may marginally comply with the effluent limits derived from the proposed saltwater site specific objectives of 2.9 µg/l chronic and 9.4 µg/l acute, without consideration for cyanide attenuation.

The above results suggest that a conversion from chlorination disinfection to UV disinfection provides a treatment technology option to reduce cyanide concentrations in effluent. However, the ability to provide reliable projections of effluent cyanide concentrations from UV disinfection is still uncertain, given the lack of full scale operating experience over a range of treatment facilities. Given the effluent quality observed for American Canyon and MVSD, the viability of this option to comply with effluent limits in the range from 2 to 4 µg/l for a broad spectrum of treatment facilities is uncertain.

5.2.3 Biosolids Incineration Operations

The practice of biosolids incineration is practiced in the San Francisco Bay Region by Central Contra Costa Sanitary District and the Palo Alto Regional Water Quality Control Plant. It has been determined that cyanide compounds are formed as a byproduct during the combustion of biosolids. These cyanide compounds have been shown to accumulate in scrubber water. When this water is discharged to the headworks of the treatment plant, an increase in influent cyanide is possible. Optimization of hearth furnace operations, specifically furnace oxygen levels and hearth exit temperatures have been shown to be able to reduce cyanide concentrations in scrubber water (Schmidt et al., 2000).

5.2.4 Nitrosation

Nitrosation of organic compounds, which involves the reaction with nitrite, NO_2^-, has been shown to produce CN^- under some conditions. The protonated form, HNO_2, has been shown to be the primary reactive species, with NO_2^- being almost non-reactive. This suggests that the potential for nitrosation to form cyanide in neutral to high pH wastewater effluent is negligible.

While nitrosation may not occur in the treatment process due to pH, the most commonly used total cyanide analytical method utilizes strong acidic conditions and high temperature, which greatly favors the nitrosation process. Procedures specified in the 20th edition of *Standard Methods* accounts for this potential through the addition of sulfamic acid in the sample preparation to remove nitrite. (Zheng et al., 2004d). Reaction of nitrite species with organics to form cyanide may also occur during the distillation step of cyanide analyses. Sample pretreatment with sulfamic acid at the time of sampling, not at the time of analysis, has been recommended by Zheng et al. (2004d).

5.2.5 Nitrification

Incomplete nitrification (conversion of ammonia to nitrate) can result in excess nitrite in the wastewater effluent, leaving the potential for nitrosation to occur. It has been observed that cyanide formation occurs the most during the summer months when a plant is fully nitrifying (Zheng et al., 2004b). Nitrate can also act as an oxidizing agent on thiocyanate, forming free cyanide.

5.2.6 Other Potential Mechanisms of Cyanide Formation

There is a possibility that ozonation can convert thiocyanate to cyanide under some conditions. Ozonation is not practiced by Bay area POTWs for disinfection of treated effluent.

5.3 Cyanide Analytical Methods

Cyanide measurements for San Francisco Bay NPDES wastewater permit compliance are based on either total cyanide or weak acid-dissociable (WAD) cyanide measurements using Standard Methods 4500-CN or USEPA Method 335. The total cyanide analytical method attempts to measure all cyanide species that may dissociate in the environment over time due to varying conditions of heat, light, hardness and pH. These species include the toxic free cyanide species (CN- and HCN), weak and moderately strong metal-cyanide complexes of silver, cadmium, copper, mercury, nickel and zinc, and the strong metal-cyanide complexes of iron. The WAD method attempts to measure theoretically "available cyanide" (i.e. cyanide that dissociates in the presence of acid), again seeking to measure either free cyanide or the weak or moderately strong metal-cyanide complexes that may become free over time in the environment. Free cyanide test methods (ASTM D4282-02) measure free cyanide in water and wastewater by microdiffusion. Neither total cyanide nor WAD analytical methods provide specific information regarding the cyanide forms (e.g. free cyanide or metal-cyanide complexes) present in a sample. Both methods therefore overestimate, to an unknown degree, the toxic forms of cyanide by including relatively non-toxic iron-cyanide complexes and other less toxic metal-cyanide complexes.

For the purpose of the compliance analyses described in this Report, reported data from NPDES dischargers for the period 2000 to 2004 has been utilized. This data has been developed using Standard Methods 4500-CN, typically with reporting limits in the 3 to 5 µg/l range. It is appropriate to use this data for the compliance analysis since NPDES dischargers must use analytical methods approved by U.S. EPA under 40 CFR Part 136 in monitoring for compliance with effluent limits. Future monitoring for cyanide will continue to use these methods unless U.S. EPA approval for another method is granted.

The City of San Jose developed a modified version of Standard Method 4500-CN to obtain reduced detection limits for cyanide in effluent and receiving waters. The analytical method developed by San Jose was used in the analysis of effluent and receiving water data collected by shallow water dischargers that is summarized in Appendices B and D. A brief description of the modified method developed and used by San Jose is included in Appendix L.

Use of the San Jose analytical method provided improved insight into the actual levels of cyanide in effluents and in ambient waters near shallow water discharges and was essential in the determination and evaluation of cyanide attenuation in the immediate vicinity of these discharges. The reporting limits for the San Jose analytical method were 1.0 µg/l in effluent and 0.3 µg/l in ambient waters. The use of these research methods for characterizing ambient concentrations and evaluating options for determining effluent limits is appropriate. However, a distinction must be made regarding the use of this data in the NPDES permit compliance assessments. In that case, data resulting from U.S. EPA-approved analytical methods must be used to reflect future compliance capabilities. Therefore, effluent data from the special effluent and receiving water studies performed by the City of San Jose and other shallow water dischargers were not used in the compliance assessments described in this Report.

Some uncertainties have been identified regarding interferences that may affect the cyanide concentration data that is generated by NPDES dischargers using Standard Methods. In its special study, the City of San Jose reported that the addition of NaOH as a preservative to bring de-chlorinated tertiary effluent samples up to pH 12 prior to cyanide analysis (in accordance with Standard Method 4500-CN-E) resulted in increased total cyanide measurements. In a controlled experiment by San Jose where flasks were sealed to prevent the loss of cyanide, samples with NaOH preservative added to pH 12 exhibited a 75 percent increase in measured cyanide concentration (2.1 µg/l versus 1.2 µg/l) as compared to unpreserved samples (City of San Jose, 2004). Similar results were observed by the County Sanitation Districts of Los Angeles County (Khoury et al, 2005), who found that unpreserved sample concentrations were less than a reporting limit of 5 µg/l in all samples, whereas samples preserved to pH 12 were above 5 µg/l in 18 percent of the samples where thiosulfate was used as a de-chlorinating agent and in 97 percent of the samples where arsenite was used to as the de-chlorinating agent. Others have found that use of ascorbic acid as a dechlorination compound has caused an upward bias in cyanide measurements. WERF researchers (Zheng et al, 2004) have found that (a) thiocyanate in combination with nitrate and (b) nitrite in combination with specific trace organic compounds (aromatics such as phenol and benzoic acid) can produce cyanide during total cyanide analysis that biases cyanide measurements upward. These researchers recommended sufficient addition of sulfamic acid at the time of sampling to avoid upward-biased cyanide results due to nitrite/organics reactions (known as nitrosation).

Various compounds are also known to interfere with cyanide measurements, as follows:

- Oxidizing Agents – Presence of residual oxidizing agents in samples, such as free chlorine, can negatively bias results due to decomposition.
- Sulfide – Sulfides are known interferents of cyanide measurement as they can distill over with cyanide when performing an analysis and interfere with colorimetric measurements or react with cyanide to form thiocyanate.
- Aldehydes – Aldehydes can convert cyanide into cyanohydrin, thus negatively biasing results.

The above findings indicate that consideration of refinements to U.S. EPA approved sampling and analytical methods should be made to ensure that cyanide measurements reported for NPDES compliance are accurate.

The uncertainties associated with varying methodologies, the potential for interference introduced during sample handling or analysis, and the fact that many reported historical results are at or near the reporting limit, all combine to make it difficult to confidently compare influent/effluent data from different treatment plants across the country. Historically POTWs have measured total cyanide, which, as described above, includes free cyanide, weak metal-cyanide complexes, and strong metal-cyanide complexes. Furthermore, detection limits have historically been at or above 5 µg/L, in the range of typical effluent values, and above ambient levels. Adoption of uniform methods for sampling and analysis of total cyanide in Bay area effluents will be evaluated as part of the Cyanide Action Plan.

5.4 Cyanide Pretreatment and Pollution Prevention Activities in San Francisco Bay

According to the Basin Plan, site-specific objectives may be appropriate for pollutants of concern on a case-by-case basis, after it has been demonstrated that all other reasonable treatment, source control and pollution prevention measures have been exhausted. It also requires that NPDES permits for shallow water dischargers "shall include provisions requiring continuing efforts at source control, targeting the substances to which the exceptions apply." This section of the Staff Report describes efforts at source identification and control that shall continue as part of the Cyanide Action Plan that accompanies the adoption of the site-specific marine water quality objectives for cyanide in San Francisco Bay.

Bay Area POTWs, particularly shallow water dischargers, have conducted cyanide source identification and control efforts, some as a condition of having interim effluent limits. These activities have included source identification studies, industrial discharge assessments and evaluation of POTW treatment processes.

Source identification studies are conducted through collection system monitoring and business inspections. Sonoma County Water Agency (SCWA) provided an exemplary effort to identify cyanide influent sources. As required by its current NPDES permit for the Sonoma Valley County POTW, SCWA conducted a cyanide source identification study (SCWA 2002). Commercial and residential collection system sites were monitored over a 6-month period in 1999. During that study, cyanide was never detected in the collection system above detection limits (i.e., 5 μg/L). Additional monitoring of residential collection system sites in 2001 also resulted in no detected values of cyanide. With no sources being identified through collection system monitoring, SCWA conducted a review of businesses to determine if there were any potential discharges of cyanide. As a result, four businesses were identified with cyanide levels above detection limits (a winery, two spas and a hospital). While none of these were determined to have significant mass discharges of cyanide, source control actions were implemented as appropriate. Specifically, the hospital was using a 1% cyanide solution in its laboratory that was being discharged to the sewer. SCWA staff worked with the hospital to identify a suitable non-cyanide replacement solution. The spas and winery each use chlorine for disinfection but, because of public health codes, there were no suitable replacement disinfectants.

Novato Sanitary District also conducted a Cyanide Source Reduction Study that included source identification and investigation of potential control strategies. Collection system monitoring and review of District records for industrial and commercial dischargers did not reveal any cyanide sources. Novato's service area is comprised entirely of residential and commercial users. Because no cyanide sources were identified, no source control actions were taken (Selfridge 2002).

Cyanide discharges to sanitary sewer systems have been regulated at industrial facilities, primarily metal finishers, through Pretreatment Programs. Activities in San Jose and Palo Alto provide examples of industrial cyanide source control. In the late 1990s, the San Jose/Santa Clara Water Pollution Control Plant reduced its local discharge limit for cyanide. A fact sheet was developed and distributed to metal finishers and electroplaters in an effort to assist them with meeting the local limit. (San Jose 1999). The Palo Alto Regional Water Quality Control Plant's Pretreatment Program regularly monitors electroplaters that utilize cyanide-containing plating baths. Palo Alto has worked with its industries to modify their processes to reduce discharges of both metals and cyanide to the sanitary sewer. This effort has included encouraging industries to install cyanide destruction treatment units, modification of rinse operations, and/or collection of concentrated cyanide wastes for offsite treatment (Palo Alto 1996a; Palo Alto 1996b). The cyanide destruction units use a two-stage alkaline chlorination treatment process. The first stage of treatment uses sodium hypochlorite to oxidize cyanide to cyanate, and the second stage further oxidizes the resulting cyanate to carbon dioxide and nitrogen (Cushnie 1994). Palo Alto also identified a cyanide discharge from a solvent recycler and hazardous waste management facility. The facility had been accepting, processing and discharging a waste containing cyanide strongly complexed with iron (ferrocyanide). The discharge had led to violations of Palo Alto's cyanide effluent limits. Palo Alto worked with the facility to modify its procedures to prevent a recurrence of the discharge (Palo Alto 1997).

Central Contra Costa Sanitary District (CCCSD), a deep water discharger, did not identify influent sources of cyanide but reviewed its treatment processes and determined that cyanide was being discharged in scrubber water from its sludge incineration process. CCCSD modified the air inlet configuration to reduce cyanide formation and evaluated redirecting the scrubber water. (CCCSD 2002).

All shallow water dischargers have been issued interim cyanide effluent limits and compliance schedules were established in their permits. Under the SIP requirements, before a compliance schedule is authorized, the dischargers are required to document that diligent efforts are undertaken to quantify pollutant levels in the discharge and to control pollutant sources. In addition, a plan to implement measures to control future sources and to minimize pollutant levels is also required. Therefore, in advance of this proposed Basin Plan amendment, shallow water dischargers with interim limits in their permits were required to conduct source identification studies and to develop and implement specific source reduction plans.

They also committed resources to implement the source control and reduction plans. These efforts have been successful at identifying and reducing cyanide sources in the collection system and within the treatment plant processes. Continuation of these programs under the proposed Cyanide Action Plan will effectively minimize cyanide discharges to receiving waters.

6 Cyanide Effluent Limits for Shallow Water Discharges

6.1 Need for Dilution Credits

Analysis of effluent data for the past several years indicates that shallow water dischargers will not be assured of achieving water quality-based effluent limits through reasonable treatment, source control and pollution prevention measures (Table 2) without dilution credits. The locations of these discharges are shown in Figure 4. The resulting permit non-compliance would lead to a presumption that aquatic life uses are being impacted by the existing shallow water discharges. In fact, available toxicity and biological information indicates that aquatic uses are not adversely affected by these discharges (see discussion below and Appendix M). This information and the fact that cyanide undergoes natural degradation in the receiving waters create the need for considering dilution credits for cyanide in shallow water discharges, described below.

Unlike metals and selenium, cyanide does not persist and ambient water quality data from the RMP indicate it does not accumulate to levels of concern in the waters and sediment of the Bay. Cyanide attenuates in the receiving waters due to degradation as well as dilution. Wastewater discharges are the only significant source of cyanide to the Bay; urban runoff is not known to contain detectable levels of cyanide.

Before this project, limited data existed in shallow water receiving waters (i.e., where discharges receive less than 10:1 dilution) relative to ambient levels of cyanide. In the last three years, information was collected by shallow water dischargers to better define dilution and degradation of cyanide in areas near their discharges and analyzed using a modified analytical method that lowered the detection limit. A body of low-level detection limit cyanide data was developed that exists nowhere else in the world. This information was used to determine dilution credits, as authorized by the SIP, for shallow water dischargers that reflect attenuation of cyanide (dilution and degradation) in receiving waters.

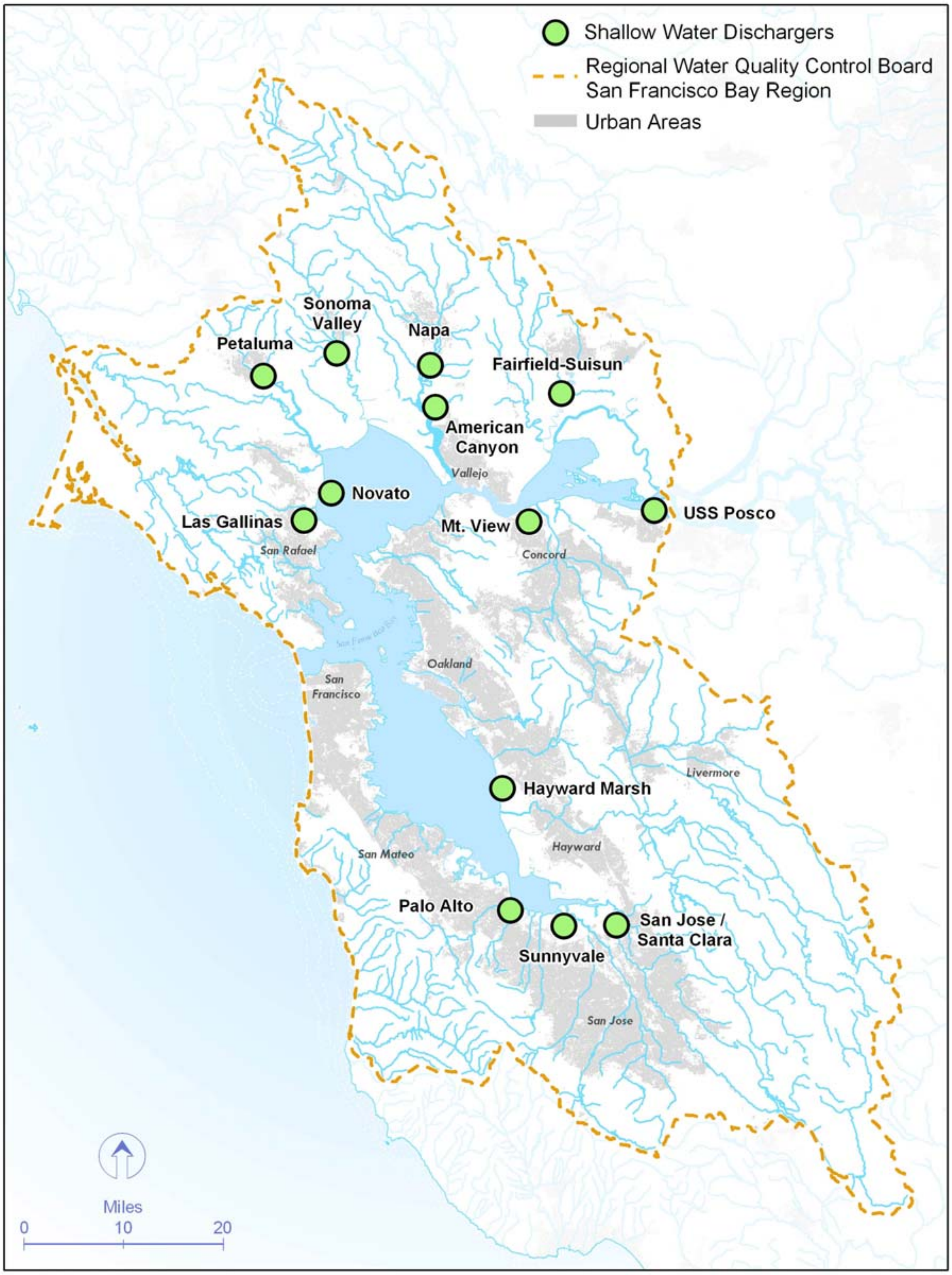

Figure 4: Location of Shallow Water Dischargers

6.1.1 Methodology for Selection of Dilution Credits and Derivation of Effluent Limits

The methodology employed to determine dilution credits from attenuation studies is summarized below and is detailed in Appendix K. For incompletely mixed discharges the SIP provides an option to establish dilution credits and mixing zones by a number of methods including, for example, dye studies, modeling studies and monitoring upstream and downstream of the discharge. If the latter approach is used, it would not be known what caused the concentrations to diminish and in the case of cyanide, the observed reduction would be partly attributed to dilution and partly to natural degradation. Similarly, in the approach applied in this Project, cyanide concentrations were measured in receiving waters to determine attenuation that results from combination of dilution and degradation.

In 2003, City of San Jose initiated a study to determine the rate of cyanide attenuation in the receiving waters (City of San Jose 2004). Cyanide concentrations were measured upstream and downstream of the effluent discharge and along the discharge gradients from the San Jose/Santa Clara Water Pollution Control Plant. This was done to evaluate cyanide degradation in addition to dilution and to test selection of alternative, protective attenuation levels that would aid NPDES permit compliance while minimizing the areal extent of mixing zones associated with varying cyanide concentrations. The potential for acute toxicity to passing organisms within mixing zones was also evaluated.

A number of shallow water dischargers have performed water quality modeling studies to assess the patterns and time scales of dilution of treated effluent in the San Francisco Bay Estuary. These studies have typically been calibrated using dyes or tracers. Information derived from those modeling studies provides important insight for estimation of cyanide attenuation near a given discharge. A summary of these modeling studies is provided in Appendix E. Other shallow water dischargers performed monitoring of cyanide levels along a gradient from the discharge location to determine dilution. Low detection limit analytical methods tested by the City of San Jose were used to measure cyanide concentrations in the effluent and receiving waters. A brief description of the modified Standard Method 4500-CN developed and used by the City of San Jose is included in Appendix L.

The use of measured concentrations in the Bay provides information for direct calculation of attenuation, and thereafter water quality-based effluent limits. Using ambient data, attenuation is calculated as the reciprocal of the total cyanide observed at a given sampling station measured as a fraction of the total cyanide discharged by a treatment facility at the upper end of a discharge gradient. Available modeling results can be used to give a conservative estimate of attenuation at a given location, based on the dilution of effluent at that location without account for natural degradation of total cyanide in the Bay. The conceptual formula for attenuation is as follows:

***Attenuation* = [*(Degradation in ambient waters)* + *(Effluent Dilution)*]**

When using empirical cyanide data, the calculation of an attenuation factor inherently takes both degradation and dilution into account. Given the log normal distribution of such empirical data, median values are used in this calculation. The attenuation factor (AF) derived from empirical cyanide data is calculated as follows:

***AF* = [*1/ (Ratio of total cyanide at a given location to the total cyanide in the effluent discharge)*]**

When using modeling results that provide information on the percent of effluent at given locations, the calculation of an attenuation factor does not take degradation into account. The attenuation factor derived from modeling results is calculated as follows and reflects dilution only:

AF = [1/ (Percent effluent at a given location)]

Assessment of empirical data along discharge gradients and available mathematical modeling

One year of monthly data collected by the City of San Jose along its discharge gradient in Artesian Slough and Coyote Creek were first used to indicate that cyanide dissipated rapidly in the vicinity of shallow water discharges. Empirical data and mathematical modeling results from other shallow water discharges were used to confirm that the attenuation of cyanide observed by the City of San Jose was exhibited in other situations around the Bay. Based on the combination of empirical measurements and modeling data the attenuation curves were developed for all 13 shallow water discharges to determine attenuation levels and the associated locations along each gradient where those levels are likely to occur (see Appendix D).

Initially the empirically determined attenuation levels of 2.25 and 4.5, corresponding to successive receiving water monitoring locations along the San Jose gradient at Drawbridge and the mouth of Alviso Slough, were selected as upper and lower boundaries for further evaluation. These stations were selected because no exceedances of the proposed water quality objectives occurred in this portion of the receiving waters during the year-long study, therefore these values were considered protective. In addition, these attenuation thresholds were indicative of dilution ratios that, when implemented, would likely lead to effluent limits that could be complied with by municipal dischargers, based on effluent values attributable to disinfection processes.

Cyanide thresholds of concern in shallow water discharges; mixing zone issues

Not all available effluent data from 2000-2003 are considered to be acceptably protective. Effluent values above the U.S. EPA freshwater CMC (22 μg /L), equivalent to the LC0 for rainbow trout, and the marine site-specific final acute value (18.8 μg /L) derived from toxicity information for a copepod species, were considered too high to be reasonably in compliance or attributable to only disinfection. The analysis for attainability did not use compliance of all shallow water discharger data from 2000-2003 as the only criterion, but considered the freshwater CMC and recalculated marine site-specific FAV as well to prevent acute toxicity in the receiving waters of shallow water dischargers. Use of these values is considered appropriate because shallow water discharges are known to stratify in tidal sloughs for some periods of the day, and not mix immediately because of difference in salinity (1 part per thousand in effluent) from receiving waters (anywhere from 0 to 34 ppt). Also, many shallow water discharges comprise most of the waters in certain sloughs at lower low tide and receive limited dilution over a short timescale exceeding one hour. This might occur at, for example, Novato discharge on the San Pablo Bay mudflat and Palo Alto discharge in a constructed dead-end slough and South San Francisco Bay mudflat.

Analysis of projected NPDES permits compliance for alternative attenuation levels

Effluent concentration data collected between 2000 and 2003 were used to conduct an iterative evaluation of potential dilution credits corresponding to attenuation levels established from empirical and modeling studies to evaluate the preferred dilution credits. These evaluations included attenuation values of 2.25, 3.0, 3.5, and 4.5.

The selected attenuation values were evaluated to determine the projected compliance of each shallow water discharger with final cyanide effluent limits derived from the proposed cyanide marine SSOs for San Francisco Bay, based on the procedure described above and in Appendix F. The results of this analysis are summarized in Table 16. At an attenuation value of 2.25, Fairfield Suisun, Hayward Marsh, Las Gallinas Valley SD, Napa, Petaluma, Sonoma County Water Agency and Sunnyvale would be anticipated to have compliance difficulties with projected effluent limits. At an attenuation value of 4.5, no shallow water dischargers would have attainability issues. Fairfield-Suisun and Sunnyvale detected concentrations of cyanide above potential effluent limits based on an attenuation value of 4.5, but those effluent values exceed the freshwater CMC and marine FAV and therefore would not be protective of receiving waters in a shallow water discharge situation where stratification of effluent may occur. Attenuation values of 3.0 and 3.5 were also investigated for potential compliance difficulties. Aside from Fairfield-Suisun and Sunnyvale, Napa, Petaluma, and Sonoma could all have some compliance difficulties with a value of 3.0, however, this value could provide attainable effluent limits for cyanide concentrations in discharges attributable to in-plant formation of cyanide.

Analysis of the areal extent of mixing zones associated with different attenuation levels

Using the attenuation curves developed in the first step, the distance from the point of discharge was determined for each discharge for the two boundary attenuation values (2.25 and 4.5). Subsequently, areal estimates of the surface water between the point of discharge and the point where a given attenuation value would occur were determined. These distances and areal estimates are summarized in Appendices D and L.

Evaluation of potential for acute toxicity in mixing zones

A review of available toxicity data for sensitive aquatic organisms was performed to evaluate whether acutely toxic conditions to mobile organisms would occur within either of the mixing zones within the boundaries defined by the selected attenuation thresholds of 2.25 and 4.5. The review indicated that acute toxicity would not significantly impact the determination of dilution credits within that range. A detailed discussion is provided below in Sections 6.1.3 and 6.1.4.

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Table 16: Attainability Analysis of Cyanide Attenuation

		1	2	3	4	5	6	7	8	9	10	11	12	13
Discharger		**American Canyon**	**Fairfield-Suisun**	**Hayward Marsh Effluent**	**Las Gallinas**	**Mt. View**	**Napa**	**Novato**	**Palo Alto**	**Petaluma**	**San Jose/ Santa Clara**	**Sonoma**	**Sunnyvale**	**USS Posco**
Coefficient of Variation (CV)	**CV-regression**	1.216	1.002	0.794	0.776	0.600	1.227	0.665	0.300	0.868	1.190	0.858	0.944	0.600
	CV-half detection limit	0.600	0.979	0.764	0.730	0.600	1.095	0.568	0.564	0.731	1.190	0.822	0.903	0.600
Summary Statistics	**MEC**	8	28	11.3	10	1.6	20	4.43	5	10	5.2	13	29	4.6
	Mean	2.2	3.9	2.9	3.0	0.5	2.6	1.8	3.3	2.9	2.8	3.2	4.4	4.4
	95th	4.1	11.7	7.3	7.8	1.3	8.3	4.6	5.1	9.1	5.0	8.7	12.3	NA
	99th	5.4	21.1	11.8	12.9	2.2	16.4	7.6	6.3	17.1	6.6	14.9	21.4	NA
	99.87th	7.3	38.0	19.1	21.3	3.7	32.3	12.3	7.6	32.1	8.6	25.4	37.1	NA
No Dilution	LTA	1.1	1.3	0.8	1.4	1.5	1.0	1.6	1.6	1.4	0.9	1.3	1.2	1.5
	AMEL	2.4	2.1	2.3	2.3	2.4	2.0	2.4	2.4	2.3	2.0	2.2	2.2	2.4
	MDEL	4.8	5.3	5.1	5.0	4.8	5.3	4.7	4.7	5.0	5.4	5.1	5.2	4.8
	Compliance	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**Yes**	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** MEC> AMEL
Attenuation =2.25	LTA	5.2	3.2	3.8	3.8	4.5	2.8	4.2	6.3	3.5	5.5	3.6	3.4	4.4
	AMEL	7.6	6.2	6.6	6.6	7.0	6.1	6.8	7.9	6.4	7.6	6.4	6.4	6.8
	MDEL	13.9	15.6	15.0	14.9	14.0	16.6	14.4	11.9	15.3	13.0	15.2	15.9	13.6
	Compliance	**Yes**	**No** Mean>LTA 95th>AMEL 99th>MDEL	**No** Mean>LTA	**No** 95th>AMEL	**Yes**	**No** 95th>AMEL	**Yes**	**Yes**	**No** 95th>AMEL, 99th>MDEL	**Yes**	**No** 95th>AMEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**Yes**
Attenuation =3.0	LTA	6.4	3.9	4.6	4.7	5.5	3.5	5.2	7.6	4.3	6.7	4.4	4.2	5.3
	AMEL	9.3	7.5	8.0	8.1	8.5	7.5	8.3	9.7	7.8	9.3	7.9	7.9	8.3
	MDEL	17.0	19.0	18.3	18.2	17.1	20.3	17.6	14.5	18.6	15.9	18.6	19.4	16.6
	Compliance	**Yes**	**No** 95th>AMEL 99th>MDEL	**Yes**	**Yes**	**Yes**	**No** 95th>AMEL	**Yes**	**Yes**	**No** 95th>AMEL	**Yes**	**No** 95th>AMEL	**No** Mean>LTA 95th>AMEL 99th>MDEL	**Yes**

Discharger		American Canyon	Fairfield-Suisun	Hayward Marsh Effluent	Las Gallinas	Mt. View	Napa	Novato	Palo Alto	Petaluma	San Jose/ Santa Clara	Sonoma	Sunnyvale	USS Posco
Attenuation =3.5	LTA	7.2	4.3	5.1	5.2	6.1	3.9	5.8	8.6	4.8	7.5	4.9	4.7	6.0
	AMEL	10.4	8.4	9.0	9.0	9.5	8.4	9.3	10.8	8.8	10.4	8.8	8.8	9.3
	MDEL	19.1	21.3	20.5	20.4	19.1	22.8	19.7	16.3	20.9	17.8	20.8	21.8	18.6
	Compliance	**Yes**	**No** 95th>AMEL	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No** 95th>AMEL	**Yes**	**Yes**	**No** 95th>AMEL	**Yes**
Attenuation =4.5	LTA	8.8	5.3	6.3	6.4	7.5	4.7	7.0	10.4	5.9	9.2	5.9	5.7	7.2
	AMEL	12.7	10.3	10.9	11.0	11.6	10.2	11.3	13.2	10.7	12.7	10.7	10.8	11.2
	MDEL	23.3	25.9	24.9	24.8	23.2	27.8	23.9	19.8	25.3	21.7	25.3	26.5	22.5
	Compliance	**Yes**	**No** 95th>AMEL	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No** 95th>AMEL	**Yes**

Note:
LTA :long term average limitation
MEC: maximum effluent concentration
AMEL: monthly average effluent limitation
MDEL: daily maximum effluent limition
Coefficient of variation (CV) were calculated using both half detection limit method and probability regression method, and are listed in the first two rows of the table for comparison.
The AMELs and MDELs were calculated using the CVs from the probability regression method. In general, the higher the CV, the higher the MDEL, but the lower the AMEL.

Dilution credits for shallow water discharges based on attenuation analysis

The conclusions from the above multi-step analysis were used as a basis for selection of attenuation values reflecting dilution and natural degradation of cyanide in proximity to shallow water effluent discharges. Attenuation and modeling studies conducted for the purpose of this analysis helped determine the extent of cyanide reduction due to mixing with waters of the Bay. Therefore they could be used to establish dilution credits for individual dischargers following the procedures set in the SIP for incompletely mixed discharges. The proposed attenuation values between 2.25 and 3.0 correspond to dilution credits of 3.25:1 and 4.0:1 respectively.

They were selected to ensure that the extent of the mixing zone associated with each effluent outfall is minimized and that the computed compliance thresholds such as Maximum Daily Effluent Limit (MDEL) and Average Monthly Effluent Limit (AMEL) are protective of aquatic life. The maximum computed MDEL for all 13 dischargers will only slightly exceed 19.0 µg/L expressed as total cyanide, which is significantly lower than the conservative estimate of LC0 for rainbow trout of 22.4 µg/L expressed as free cyanide. The maximum computed AMEL will not exceed 8.4 µg total cyanide /L, well below the LC0 for saltwater copepod of 15 µg free cyanide/L. This ensures that no lethality to aquatic organisms would result from temporary passage through the mixing zone. Selection of the above values and the implementation of the resulting effluent limits would not have a significant impact on the ambient cyanide concentrations in the Bay, which currently comply with the proposed cyanide SSOs.

6.1.2 Spatial Extent of Mixing Zones

The provision of dilution credits for the determination of water quality-based effluent limits involves the establishment of a mixing zone as described in the SIP. Compliance with cyanide water quality objectives occurs at the edge of the cyanide mixing zone. In this project the extent of the mixing zone is defined as the location in the receiving water where the ratio of effluent concentrations to receiving water concentrations of cyanide equals the attenuation value.

The areal extent of the cyanide mixing zone for each shallow water discharger is site-specific and, in part, a function of the assigned dilution credit. Estimates of the distance from the point of discharge to the edge of the cyanide mixing zone and the surface area of the cyanide mixing zone for each shallow water discharger is provided in Appendix D. The upper and lower bounds of potential attenuation values of 2.25 and 4.5 are indicated to demonstrate the minimum and maximum dimensions of potential cyanide mixing zones. The edges of the zones were determined using measured cyanide concentrations along individual discharge gradients and the results from mathematical water quality modeling studies, where available. The proposed dilution credits were assigned to ensure that the surface area of the mixing zone is no larger than necessary to provide intended compliance relief as required by the SIP.

Appendix J provides an assessment of the compliance with additional Basin Plan and SIP requirements for the establishment of a mixing zone and dilution credit for shallow water dischargers to San Francisco Bay. This assessment and Section 5.4 are provided to document the fulfillment of these requirements.

6.1.3 Consideration of Acute Toxicity to Sensitive Organisms in Mixing Zone

In the establishment of mixing zones, the SIP prohibits acutely toxic conditions, i.e. lethality to mobile organisms that move or drift through the mixing zone.

Concentrations of free cyanide that have been observed to exhibit acute toxicity to sensitive saltwater and freshwater species are shown below. The values shown as LC50 are the free cyanide concentrations that were observed to be lethal to 50 percent of the most sensitive test organisms, in the freshwater and recalculated saltwater databases. The LC0 values are concentrations estimated to produce no acute toxicity to any test organisms.

Acartia clausi copepod (saltwater) LC50 = 30 μg/L (unmeasured)

LC0 = 15 μg/L (estimated)

Rainbow trout (juvenile) (freshwater) LC50 = 44.7 μg/L (measured)

LC0 = 22.4 μg/L (estimated)

Depending on the specific discharge, these or similarly sensitive species could pass through the cyanide attenuation zones of the shallow water dischargers to San Francisco Bay waters. Some of the shallow water discharges occur in dead end sloughs as described in Table 17 where occurrence of sensitive aquatic species may be scarce. Downstream movement of mobile aquatic organisms may occur in Coyote Creek, Guadalupe Slough, Sonoma Creek (connected to Schell Slough), Petaluma and Napa Rivers, and Miller Creek, regionally important steelhead-supporting streams. Exposure of organisms on the mudflat near the Novato mixing zone will be very short duration and will not produce concentrations that would produce acute toxicity to sensitive organisms.

Free cyanide concentrations in the estimated range from 15 to 22 μg/L establish the upper bound of cyanide concentrations that would cause acute toxicity within a cyanide attenuation zone. In the U.S. EPA criteria, total cyanide concentrations are used as a conservative estimate of free cyanide levels. Therefore, maximum daily total cyanide concentrations ranging from 15 to 22 μg/L would ensure (with a significant margin of safety) that acute toxicity to sensitive organisms would not occur within any of the cyanide attenuation zones of shallow water dischargers.

Table 17: Effluent Discharge Areas for Shallow Water Dischargers

Shallow Water Discharger	Receiving Water	Description
San Jose	Artesian Slough	Dead-end slough
	Coyote Creek	Major tributary
Sunnyvale	Guadalupe Slough	Minor tributary
Palo Alto	Unnamed channel	Dead-end slough
Las Gallinas	Miller Creek	Minor tributary
Mt. View	Pacheco Slough	Dead-end slough
Novato	San Pablo Bay	Mud flat
Sonoma County Water Agency	Schell Slough	Dead-end slough
Petaluma	Petaluma River	Minor tributary
Napa	Napa River	Major tributary
American Canyon	North Slough	Wetlands
Hayward Marsh	Hayward Shoreline Regional Park marsh basin	Dead-end slough
Fairfield Suisun	Boynton Slough	Dead-end slough
USS Posco	New York Slough	Major tributary

6.1.4 Evaluation of Biological Community along a Representative Shallow Water Discharge Gradient

Available information suggests that cyanide concentrations in existing shallow water discharges are not measurably affecting biota in the receiving waters, and therefore the proposed effluent limits would be protective of the potentially affected beneficial uses. A case in point is the Palo Alto Regional Water Quality Control Plant (Palo Alto), which represents an arguably "worst-case" source scenario of documented industrial sources of cyanide in the influent and associated historic effluent violations, as well as in-plant sources of both biosolids incinerator scrubber water and disinfection by chlorination.

Palo Alto commissioned a biological study of its effluent discharge channel in August 1997. A November 1997 technical report summarizes the results of the study, titled *Benthos and Fisheries Assessment, Palo Alto Wastewater Treatment Plant Discharge Channel*. The study also examined biological conditions in San Francisquito Creek, an urban creek with a fairly large, undeveloped watershed located 1000 feet northwest of the discharge channel. The results of the August 1997 biological assessment of benthic community and fish in the Palo Alto effluent channel indicated that it supported a diverse assemblage of aquatic fauna. The types and abundances of organisms present in the channel were representative of typical South Bay slough species and not indicative of highly stressed benthic communities, and not degraded relative to the tidal channel of San Francisquito Creek. These conditions exist despite levels of cyanide in the Palo Alto effluent channel that are elevated, at times, in comparison to the NTR cyanide objective of 1.0 µg/l and the proposed chronic site specific objective of 2.9 µg/l. A description of the Palo Alto study and its results is presented in Appendix M.

6.1.5 Options Explored to Resolve Shallow Water Discharger Compliance Issues

Several alternatives were evaluated to seek resolution of shallow water discharger permit compliance issues for cyanide. These alternatives included the following:

- Water Effect Ratio (WER)
- Toxicity testing of effluent
- Toxicity testing of ambient waters
- Use of a "translator" approach based on measurements of free cyanide and total cyanide

The WER approach was evaluated by the City of San Jose in a pilot-testing program performed in 2002 using larvae of a sensitive fish species, *Menidia beryllina* (Inland silversides), as the test organism. The City conducted acute toxicity tests in accordance with U.S. EPA guidance for performing water effect ratio studies but found that the sensitivity of the test organism (LC50 of 87 µg/L in laboratory water) was not sufficient to derive a WER value that was (a) applicable to the cyanide concentrations measured in effluent (typically in the range from 1 to 10 µg/L) and (b) a value significantly different from 1.0 (observed WER was 0.92)(City of San Jose 2002). Therefore, the WER approach was determined not to be a useful approach to address the shallow water discharger compliance issues.

Direct measurement of cyanide toxicity in effluent and receiving waters was considered as a potential method to address the shallow water discharger cyanide compliance issues. Upon examination of sensitive aquatic organisms, it was determined that even the most sensitive saltwater test organism, a copepod (*Acartia clausi*), was not adequately sensitive (LC50 = 30 µg/L) to confirm or deny cyanide toxicity in either effluent (cyanide concentrations of 1 to 10 µg/L), shallow discharge receiving waters (cyanide concentrations of 0.3 µg/L in background waters to less than 3 µg/L in sloughs near outfalls). Similar evaluation of the use of the most sensitive freshwater test organism, rainbow trout (*Oncorhynchus mykiss*) with an LC50 of 44.7 µg/L produced a similar finding.

A "translator" approach was considered which would use measured concentrations of free cyanide and total cyanide in effluent and/or ambient waters to determine the ratio in each water. This approach is similar to trace metal translators in which dissolved metal measurements and total recoverable metals measurements are used to develop ratios used in the derivation of effluent limits. The challenge in the derivation of the free to total cyanide ratios is in the availability of analytical methods to measure these cyanide fractions at the levels present in effluent or ambient waters. Analytical methods for total cyanide were researched and methods were found that would lower the detection limit from the levels obtained using U.S. EPA standard methods (3 to 5 µg/L) to 0.1 to 0.3 µg/L in ambient waters and 1 µg/L in effluent (Exygen Research 2002; City of San Jose 2004). However, similar analytical methods do not exist for the determination of free cyanide concentrations (Exygen Research 2002). Therefore, the inability to measure free cyanide concentrations at levels that total cyanide is present in ambient waters (i.e. in the range from zero to 0.4 µg/L) prevents the derivation of the desired translator values and precludes the use of this approach in the derivation of effluent limits for cyanide.

The above approaches are consistent with the evaluation of permit relief options as stipulated in Step 6 of the decision tree of Appendix 5 of the SIP. Appendix 5 of the SIP outlines a decision-making approach for performance and approval of a variety of special studies by the State and Regional Boards, including the development of site-specific objectives.

7 Alternative Cyanide Treatment Technologies and Costs

7.1 Cost of Treatment to Meet NTR Objective for Cyanide

In March 2002, C.L. Meyer of Shell Global Solutions, Inc. prepared a technical memorandum for the Bay area cyanide working group to evaluate available treatment technologies to assess the ability to achieve a 1 µg/L effluent limit for cyanide (Meyer 2002). The memorandum addressed the following treatment technologies: alkaline chlorination, ozone or ozone/UV, hydrogen peroxide, wet air oxidation, catalytic oxidation with GAC/PAC, ion exchange, SO_2/air oxidation, polysulfide, biological treatment, precipitation, electrolytic decomposition, reverse osmosis and air stripping.

The analysis by Meyer included (1) a description of each technology, (2) available process data, (3) available cost information, (4) applicability to the Shell refinery, and (5) a summary comment on each process. A key finding from the analysis by Meyer is that no record exists to confirm that any of the above technologies can achieve an effluent concentration of less than 10 µg/L. Many of the alternative technologies are applicable to treatment of waste streams with influents exceeding 50 to 100 µg/L. Of the technologies examined, the most likely to be able to approach or equal an effluent cyanide concentration in the range from 1 to 5 µg/L are reverse osmosis, ozonation with UV radiation and wet air oxidation. Unit cost estimates for these three treatment technologies are summarized below in Table 18. These estimates confirm that reverse osmosis would be the most economical of the three alternative technologies by a comparative percentage ranging from 73 to 465 percent.

Table 18: Cyanide Treatment Alternatives and Estimated Unit Costs

Treatment Alternative	Capital ($ million/mgd)	Annual ($ million/mgd)	Annualized Capital Annual ($ million/mgd)
Ozonation plus UV	9.2	2.0	2.8
Wet air oxidation	76		6.6
Reverse Osmosis			1.34
Reverse Osmosis plus filtration			1.58

Assumptions: ENR Construction Cost Index used to adjust costs to 2005 (ENRCCI = 8290). Capital costs for Ozonation plus UV based on 1974 estimate (ENR = 2020). Capital costs for Wet Air Oxidation based on 1987 estimate (ENR = 4406). Annual costs for Reverse Osmosis and Filtration based on 1991 costs (ENR = 4835). Interest rate = 6%. 20 year planning period. Capital recovery factor = (A/P,6%, 20) = 0.08718. Refs: Meyer 2002; NRC 1993.

Unit costs for the ozonation with UV radiation and wet air oxidation options were derived from cost information provided in Meyer, C.L., 2002, "Evaluation of the Treatment Technologies to achieve a 1 µg/L Effluent Limit for Cyanide". Unit costs for reverse osmosis (and prerequisite filtration) were derived from cost estimates contained in 1993 National Research Council publication titled *Managing Wastewater in Coastal Urban Areas* (NRC 1993). The following annual unit costs (expressed as $ million per year per mgd) were derived from the information provided in the NRC publication and are used to estimate costs in this analysis:

- Filtration: $0.24 million per year per mgd
- Reverse osmosis (RO): $1.34 million per year per mgd
- Filtration plus RO: $1.58 million per year per mgd

These estimated costs are derived from annualized capital and annual operation and maintenance costs and are indexed to a 2005 construction cost index of 8290. The source document for these costs included costs with an estimated 1991 construction cost index of 4835 (Meyer 2002).

The estimated costs of implementing reverse osmosis (i.e. constructing and operating facilities) for the dischargers that could not comply with the projected final cyanide effluent limits derived from the NTR cyanide acute and chronic objective of 1.0 µg/l is summarized in Table 19. These costs are based on application of the unit costs for either RO or filtration plus RO at the average dry weather flow capacity for each permittee, depending on the existence of filtration at a given facility.

As shown in Table 19, the total discharge that would require reverse osmosis treatment would be approximately 601 mgd. This would require an estimated annualized capital and operational costs of $887 million. In addition, an estimated 115 mgd of concentrated brine from the reverse osmosis would be generated and would require further treatment and disposal. Costs for brine treatment and disposal are not included in the above estimated costs, but need to be acknowledged as part of potential environmental impacts of no action.

Table 19: Cost Estimate – Reverse Osmosis Treatment as Alternative to Achieve Projected Cyanide Effluent Limits

NPDES Permittee	Type of Discharge	Projected Compliance Problem with Effluent Limits derived from NTR objectives?	Design Flow Rate (mgd)	Annualized Cost ($ million)(ENR 8290)
American Canyon	Shallow	Yes	2.5	3.4
Benicia, City of	Deep	Yes	4.5	7.1
Burlingame, City of	Deep	Possible		
Central Contra Costa Sanitary District	Deep	No		
Central Marin Sanitation Agency	Deep	Possible		
Delta Diablo Sanitation District	Deep	Yes	16.5	26.1
Dow Chemical Company	Deep	No (1)		
Dublin San Ramon Services District	Deep	ND		
EBDA	Deep	Yes	97.1	153.4
EBMUD	Deep	Yes	120	189.6

NPDES Permittee	Type of Discharge	Projected Compliance Problem with Effluent Limits derived from NTR objectives?	Design Flow Rate (mgd)	Annualized Cost ($ million)(ENR 8290)
Fairfield-Suisun Sewer District	Shallow	Yes	17.5	23.5
GWF Nichols Rd (Site V)	Deep	ND		
Livermore, City of	Deep	ND		
Las Gallinas Valley SD	Shallow	Yes	2.9	4.6
Marin Co SD No. 5 (Tiburon)	Deep	Possible (2)		
Millbrae, City of	Deep	Possible		
Morton	Deep	ND		
Mt. View Sanitary District	Shallow	Yes	2.4	3.2
Napa SD	Shallow	Possible		
Novato SD	Shallow	Yes	6.5	10.3
Palo Alto, City of	Shallow	Yes	39	52.3
Petaluma, City of	Shallow	Yes	5.2	8.2
Pinole-Hercules	Deep	Possible		
Rhodia Basic Chemicals	Deep	ND		
Rodeo Sanitary District	Deep	No (1)		
S.F.Airport, Industrial	Deep	ND		
S.F.City & County Southeast, North Point & Bayside	Deep	Possible		
San Jose Santa Clara WPCP	Shallow	Yes	167	223.8
San Mateo, City of	Deep	Possible		
Sausalito-Marin Sanitary District	Deep	Yes	1.8	2.8
Sonoma County Water Agency	Shallow	Yes	3.0	4.7
South Bayside System Authority	Deep	Yes	29	45.8
South San Francisco & San Bruno	Deep	Yes	13	20.5
Sunnyvale, City of	Shallow	Yes	29.5	39.5
US Navy Treasure Island	Deep	ND		
USS - Posco	Shallow	Yes	28	44
Valero Benicia Refinery	Deep	ND		
Vallejo San & Flood Control District	Deep	Yes	15.5	24.5
West County/Richmond	Deep	Possible (2)		
			601	887

Reverse osmosis treatment facilities are energy intensive and would place a significant new energy demand on the San Francisco Bay Region. The adverse environmental and social impact of brine disposal and power demand associated operation of large reverse osmosis facilities would likely outweigh other environmental benefits of such facilities (Malcolm Pirnie 2003). Therefore, the use of such facilities to achieve cyanide final effluent limits derived from existing NTR water quality objectives would not represent a reasonable compliance option.

7.2 Costs of Conversion from Chlorination to UV Disinfection

As noted previously, a conversion from chlorination disinfection to UV disinfection provides a treatment technology alternative to reduce cyanide concentrations in effluent. However, the ability to provide reliable projections of effluent cyanide concentrations from UV disinfection is still uncertain, given the lack of full scale operating experience over a range of treatment facilities.

For evaluation purposes, as a hypothetical, it is valuable to examine the estimated costs and projected benefits of conversion to UV disinfection as a means to comply with stringent cyanide effluent limits for shallow water dischargers (i.e. limits derived without consideration for cyanide attenuation in the receiving water). The following cost analysis for the installation of UV disinfection as a replacement for chlorination facilities provides perspective on this topic.

Implementation of UV disinfection on a broad scale in the Bay area would require the following steps:

- Install either granular media filters or membrane filters ahead of UV disinfection where such facilities do not presently exist
- Remove existing chlorination equipment
- Install UV disinfection equipment, typically in new contact structures.

A breakdown showing the estimated costs for each shallow water discharger is provided in Table 20. The estimated annual costs to add facilities to provide UV disinfection for all shallow water dischargers would be $29.3 million (ENR 8290). The projected benefits of UV disinfection would include incremental reductions in the concentrations of cyanide in the effluents from eleven shallow water dischargers. The average magnitude of these reductions would be estimated to range from 1 to 4 µg/l (see Table 16). As demonstrated by the effluent quality data for American Canyon and Mt. View Sanitary District, the use of UV disinfection will reduce but not eliminate cyanide in the effluent.

The ambient water quality benefits of such reductions in effluent concentrations are limited from a spatial perspective, since such reductions would only occur in the immediate vicinity of the shallow water discharges at the upper end of each discharge gradient. As noted elsewhere in this Report, cyanide concentrations in these areas are not presently at levels that produce toxicity to sensitive aquatic organisms. Therefore, no significant benefit to aquatic life uses in these areas would be projected.

Table 20: Cost Analysis - UV Disinfection for Shallow Water Dischargers

Discharger	Existing Design ADWF	Existing Filtration	Existing UV disinfection	Annual cost filtration	Annual cost UV	Total annual cost
	(mgd)			($ million)	($ million)	($ million)
American Canyon	2.5	yes	yes	0.0	0.0	0.0
Fairfield-Suisun SD	17.5	yes	no	0.0	0.7	0.7
Las Gallinas Valley SD	2.9	no	no	0.7	0.1	0.8
Mt. View SD	2.4	yes	yes	0.0	0.0	0.0
Napa SD	15.4	yes	no	0.0	0.6	0.6
Novato SD	6.5	no	no	1.5	0.3	1.8
Palo Alto	39	yes	no	0.0	1.6	1.6
Petaluma	5.2	no	no	1.2	0.2	1.4
San Jose Santa Clara	167	yes	no	0.0	6.9	6.9
Sonoma County Water Agency	3.0	no	no	0.7	0.1	0.8
Sunnyvale	29.5	yes	no	0.0	1.2	1.2
Union SD - Hayward Marsh	20	no	no	4.7	0.8	5.5
USS Posco	28	no	no	6.7	1.1	7.8
Totals				15.5	13.8	29.3

Assumptions:
All costs in table are adjusted to ENR = 8290 (July, 2005); Annual cost recovery factor for 6%, 20 years = 0.08718. Unit costs for filtration and UV disinfection were derived from the following sources: Unit annual cost for filtration ($ million/mgd) = 0.24; Based on 1993 National Research Council publication Managing Wastewater in Coastal Urban Areas (based on ENR 4835 costs); Unit annual cost for UV disinfection ($ million/mgd) = 0.04; Based on West Yost and Associates, August 2001 report Easterly WWTP NPDES Permit Compliance Analysis (based on ENR = 6400 costs)

Conversion to UV disinfection would significantly reduce or eliminate chlorine usage for disinfection at the treatment facilities in question. Chlorine use for other in-plant purposes may continue. Electrical power consumption associated with operation of the UV process would be increased at these facilities. These costs are accounted for in the cost estimate summarized in Table 20 .

Given the lack of demonstrable benefits to aquatic life uses and the significant costs associated with implementation of UV disinfection for all shallow water dischargers in San Francisco Bay, this approach is not warranted on the basis of cyanide concentration reduction benefits alone.

8 Implementation Plan

The Basin Plan amendment implementation plan was developed to serve as a non-degradation plan to ensure that existing water quality is maintained, beneficial uses are protected, and exceedances of the site-specific water quality objectives do not occur in waters of San Francisco Bay.

8.1 Effluent Limits Justification

Mandatory effluent limits are proposed for most dischargers, to fulfill antidegradation requirements and ensure full commitment of resources from dischargers to maintain current performance and pollution prevention, as required by the Basin Plan and SIP (see Appendix J). Cyanide has been detected in effluents of most of the dischargers in the region. For some dischargers that have not detected cyanide in the effluent, the method detection limit might be too high (e.g., 10 µg/L) to make a determination that cyanide is not present. Most of the detected values are thought to be a by-product of disinfection processes, including industrial dischargers to San Francisco Bay that disinfect their effluent or sewage inputs to their wastewater. Cyanide levels in effluent appear fairly consistent region-wide, with 90% of 2,349 concentration measurements ranging from 1 to 10 µg/L. The remaining higher concentrations of cyanide detected in effluent could not be explained by the disinfection processes alone. Infrequent short-lasted spikes in cyanide levels exceeding 10 µg/L are usually attributed to dumping events in collection systems or accidental spills and other seasonal anomalies.

The SIP specifies a methodology for determining which priority pollutants require effluent limits. Step 7 of Section 1.3 of the SIP provides that Water Boards may find that numeric effluent limits are required for pollutants even if Steps 1 through 6 do not trigger the requirement for the water-quality based limits. Most dischargers monitor effluent cyanide as grab samples once per month, and are hardly able to detect every potential pulse of cyanide that could enter the collection system. Therefore, using Steps 1 through 6 of the SIP on snapshots of effluent quality data is not a sufficient means to determine the need for effluent limits. Given the episodic nature of cyanide in effluent, and the receiving waters' vulnerability to illicit discharges to the collection system, more accountability is needed to ensure that water quality standards for a pollutant such as cyanide are not violated once per three years.

Recent experience has demonstrated how any municipal discharger in the region with cyanide sources to its influent has a reasonable potential to contribute to exceedance of the water quality standard (objective), whether it is 1.0 or 2.9 µg/L. In 2004, while the City of San Jose was performing its study of cyanide attenuation in the Bay, pulses of high concentrations of cyanide were tracked through the treatment plant and into the Bay on three separate occasions (in the months of May, November and December). In the case of May 2004, concentrations of cyanide in Artesian Slough, where the standard is currently 1.0 µg/L and proposed to be 2.9 µg/L, were measured at 62 µg/L near the outfall to under 10 µg/L at Coyote Creek, almost 4 miles from the outfall (see Figure 3 of Appendix Kfor graphic description). With the LC50 for rainbow trout at 44 µg of cyanide per liter, adverse effects to aquatic life during these dumping events were likely. Eventually, San Jose source control staff identified a single industrial source of these cyanide-dumping events. This case study shows that a single entity in the collection system of a large advanced secondary treatment plant can cause serious water quality standard violations that could go undetected under the routine sampling strategy.

Before work began on this proposed Basin Plan amendment, very little was known about cyanide levels in the areas of San Francisco Bay near discharge points or in the deeper channels. It was assumed, because of non-detect data, that cyanide did not approach chronic water quality thresholds of concern. Lower detection limits, advanced by the San Jose laboratory (explained in Appendix L), have shed light on ambient cyanide characteristics, particularly near shallow outfalls. While typically protective of aquatic life, levels very close to shallow water discharge outfalls have been shown to exceed thresholds of concern, forcing the consideration of mixing zones (i.e. cyanide attenuation zones) described in Appendices B, D, and L, and in Section 6.

To help protect against degradation of waters associated with adopting a less stringent standard, and recognizing that the only areas of San Francisco Bay with ambient values approaching the proposed SSOs are those located near discharge outfalls, it is proposed that effluent limits for cyanide be required for all shallow and deep water municipal wastewater dischargers and most deep water industrial wastewater dischargers. The proposed cyanide marine site-specific objective will be implemented through required effluent limits. This is because cyanide in deep water and shallow water dischargers' effluents, attributable to disinfection processes, incineration processes, or contributions to the collection systems, have a reasonable potential to cause or contribute to an exceedance of the numeric level of 2.9 µg/L cyanide in San Francisco Bay. Levels in the main estuary have been measured at 0.5 µg/L cyanide. The 99^{th} percentile value of effluent concentration from all the effluent data from all dischargers in this Region (from 2000-2003, n=2,349) is 26 µg/L. Discharges at this level would lead to measurable receiving water cyanide levels above 2.9 µg/L in most instances, and therefore an equitable, attainable, and enforceable effluent limits are proposed to keep all dischargers vigilant and maintaining effluent cyanide levels at current performance or better. This approach will also ensure adherence to applicable state and federal antidegradation policies.

8.2 Effluent Limits for Deep Water Dischargers

Deep Water Municipal Wastewater Dischargers

Water quality-based effluent limits for cyanide will be required for all deep water municipal wastewater dischargers. Numeric effluent limits will be derived in accordance with procedures described in Section 1.4 of the SIP.

Deep Water Industrial Wastewater Dischargers

Water quality-based effluent limits for cyanide will be required for most deep water industrial wastewater dischargers. Numeric effluent limits will be derived in accordance with procedures described in Section 1.4 of the SIP. Numeric effluent limits will not be required for those deep water industrial dischargers that do not detect cyanide in their effluent with a method detection limit of 1.0 μg/L or less, document that they do not use cyanide in their industrial processes and do not disinfect.

8.3 Effluent Limits for Shallow Water Dischargers

Possibly only one of the 13 shallow water dischargers to San Francisco Bay will be able to comply with effluent limits derived from the proposed site-specific objectives unless some recognition of the attenuation of cyanide is incorporated into the derivation of numeric effluent limits. Available effluent data, summarized in Table 2 indicate that none of these dischargers could reliably meet 2.9 μg/L as an average monthly limit.

Ambient cyanide levels near discharges meet the proposed site-specific objectives, which are considered protective of aquatic life beneficial uses. Moreover, rapid attenuation of cyanide takes place in Bay waters due to dilution and natural degradation. As such it is appropriate to consider dilution credits in the determination of cyanide effluent limits for shallow water dischargers. Table 21 shows the dilution credits assigned for each shallow water discharger that also serve as the basis for NPDES permit limit determinations. Attenuation values that formed the basis for dilution credits and a spatial extent of the mixing zone for each discharger are also provided in Table 21. An evaluation of attainability of hypothetical limits, described in Appendix F, suggests that those dilution credits are appropriate to ensure compliance attributed to disinfection-related cyanide levels, while being conservatively protective of beneficial uses. Water quality-based effluent limits will be derived for individual shallow water dischargers using dilution credits given in Table 21 and the effluent limit derivation procedures described in the SIP[1].

[1] Cyanide is often not detected in effluent using U.S. EPA-approved methods; In evaluating attainability with respect to effluent limits, various methods are used to quantify non-detect results. The Half-Detection Method used in the SIP substitutes every non-detect value with a value that is one-half the detection limit. The probability regression method was also used to evaluate attainability with respect to effluent limits, and final values were not significantly different to that of the SIP method .

Table 21: Dilution Credits and Projected Water Quality-Based Effluent Limits for Shallow Water Dischargers

Discharger	Discharge Location	Attenuation	Dilution Credit	Mixing Zone (surface area ha)	AMEL (µg/L)	MDEL (µg/L)
American Canyon	North Slough	2.25	3.25:1	0.6	7.6	13.9
Fairfield-Suisun	Boynton Slough/Suisun Slough	3.0	4.0:1	9.2	7.5	19.0
Hayward Marsh	Hayward Shoreline Regional Park Marsh Basin	2.25	3.25:1	16.7	6.6	15.0
Las Gallinas	Miller Creek	2.25	3.25:1	0.4	6.6	14.9
Mt. View SD	Pacheco Slough	2.25	3.25:1	<0.1	7.0	14.0
Napa SD	Napa River	2.25	3.25:1	6.9	6.1	16.6
Novato SD	San Pablo Bay	2.25	3.25:1	0.1	6.8	14.4
City of Palo Alto	Unnamed channel/South San Francisco Bay	2.25	3.25:1	1.7	7.9	11.9
City of Petaluma	Petaluma River	2.25	3.25:1	0.6	6.4	15.3
City of San Jose	Artesian Slough/Coyote Creek	2.25	3.25:1	16.2	7.6	13.0
Sonoma County Water Agency	Shell Slough	2.25	3.25:1	11.7	6.4	15.2
City of Sunnyvale	Guadalupe Slough	3.0	4:1	2.3	7.9	19.4
USS Posco	New York Slough	2.25	3.25:1	0.1	6.8	13.6

8.4 Cyanide Action Plan

The following describes the proposed plan for actions to ensure that current discharger performance is maintained and to ensure compliance with state and federal antidegradation policies. Additionally, continuing source control efforts targeting pollutants of concern, such as cyanide, is a key part of approving exceptions to the Basin Plan prohibition for shallow water dischargers. Because dilution credit is proposed for calculation of shallow water discharger effluent limits to be required in their NPDES permits, commitment to continuing efforts at cyanide source control by these dischargers is mandatory.

Required Effluent Limits for Cyanide

With the exception of deep water industrial dischargers that do not use cyanide in their processes, do not disinfect, and have no detectable cyanide in their effluent, all wastewater dischargers to San Francisco Bay will have water quality-based effluent limits in their permits to implement the site-specific objective. An attainability analysis, included as Appendix F, demonstrates that shallow water dischargers could comply with limits based on an attenuation of 2.25 or 3.0 corresponding to dilution ratios of 3.25:1 and 4:1 respectively, and deep water dischargers are expected to be able to comply with limits computed under derivation procedures described in the SIP. The mechanism of required effluent limits will ensure that current performance is maintained, and sources of cyanide to the influent are tracked and regulated by the dischargers.

Monitoring and Surveillance requirements

An additional element of the implementation plan supporting the proposed site-specific cyanide objectives and shallow water discharger effluent limits is a program of monitoring and surveillance to prevent unnecessary or excessive discharges of cyanide from wastewater discharges to the Bay. This program is described below:

- *Influent and Effluent*

  Monitor total cyanide monthly in influents and effluents using low detection level cyanide analytical methods. As noted in Appendix F, cyanide attainability analysis, some dischargers with higher effluent cyanide values in the past few years will likely sample effluent more than once per month for compliance purposes.

- *Service Area*

  At least once per 5-year permit cycle, assess whether potential contributors of cyanide exist in each service area. Where potential contributors exist, implement a local program aimed at the prevention of illicit discharges to the sewer system, as have occurred in 2004 in the City of San Jose (Figure 3 of Appendix K). The local program shall consist of the following elements:

  a) Identify sources of cyanide. Discuss how estimates and sources are identified in the annual Pollutant Minimization Plan report. Maintain list of potential contributors (e.g., metal plating operations, hazardous waste recycling, etc.).
  b) Monitor total cyanide monthly in influents and effluents using low detection level cyanide analytical methods.
  c) Within a year of permit adoption, perform a site inspection of each potential contributor to assess the need to include the facility in an ongoing program.
  d) For facilities in the ongoing program or those covered by the pretreatment program, follow U.S. EPA Guidance such as Industrial User Inspection and Sampling Manual for POTWs (EPA 831-B-94-01) that provides inspection and wastewater sampling procedures such as:
     i. Perform routine inspections of facilities.

ii. Develop and distribute educational materials regarding the need to prevent illicit discharges to the sewer system.

e) Prepare an emergency monitoring and response plan to be implemented in the event that a significant cyanide discharge event occurs. The plan should include procedures to verify the delivery, use and shipment of cyanide from a facility suspected of illicit discharges. (i.e. verify that State Hazardous Waste Manifests are consistent with the facility's permit application and self-monitoring report information and comparable to other disposal practices of similar local facilities).

- *Ambient*

  Include cyanide monitoring in the ongoing ambient monitoring in San Francisco Bay. Use analytical methods with detection limits of 1 μg/L or less. Implement an ambient trigger concentration of 1.0 μg/L in the main body of the Bay as the basis for initiation of a localized review of effluent limit compliance for wastewater discharges within the vicinity of the Bay where the trigger was exceeded and require dischargers to take appropriate actions to determine and abate any identified sources of cyanide.

Model permit language to implement this action plan for cyanide control by municipal wastewater dischargers, as an NPDES permit provision, has been developed and is included as Appendix I.

9 Regulatory Analyses

This section provides the regulatory analyses required for adoption of new site-specific water quality objectives, for establishing dilution credits to be used in the calculation of numeric effluent limits for wastewater dischargers to shallow waters and the implementation plan. Subsections below include an overview of the Project's compliance with California Water Code requirements; peer review requirements of Health and Safety Code §57004; CEQA; and federal and state antidegradation policies.

9.1 California Water Code §13241

CWC Section 13241 identifies six factors that must be considered when establishing a water quality objective.

- Past, present and probable beneficial uses of water;
- Environmental characteristics of the hydrographic unit under consideration; including the quality of water available thereto;
- Water quality conditions that could reasonably be achieved through the coordinated control of all factors that affect water quality in the area;
- Economic considerations;
- The need for developing housing within the region; and
- The need to develop and use recycled water

Each of these six factors is discussed below.

Beneficial Uses

The past, present and probably beneficial uses of San Francisco Bay are commercial and sport fishing, estuarine habitat, industrial service supply, marine habitat, fish migration, navigation, industrial process supply, preservation of rare and endangered species, water contact recreation, non-contact water recreation, shellfish harvesting, fish spawning, and wildlife habitat. Beneficial uses of the Bay are currently not impaired by cyanide. The proposed new site-specific objectives are based on the latest science pertaining to the toxicity of cyanide to aquatic organisms and, by definition, are fully protective of the most sensitive beneficial uses, those relevant to aquatic life and are thus protective of all beneficial uses listed above.

Environmental Characteristics of the Hydrographic Unit

The hydrographic unit is San Francisco Bay. San Francisco Bay includes a number of water bodies that are shown in Figure 2. The environmental characteristics and existing conditions in the Bay are discussed in Sections 3.1 and 3.3 of this Report.

Water Quality Conditions that Could Reasonably be Achieved

The goals of the proposed water quality objectives are to sustain current low levels of cyanide in the Bay waters while recognizing that existing marine water quality objectives for cyanide do not reflect site-specific conditions of San Francisco Bay for protecting beneficial uses. Although the recommended SSOs are higher than the National Toxics Rule marine cyanide criteria that currently apply, they better reflect existing scientific knowledge of cyanide toxicity and its effects on aquatic organisms specific to the Bay. The new cyanide objectives are based on the most recent toxicity data for several species of crabs common to San Francisco Bay and Puget Sound, where the new criterion has already been adopted by the State of Washington. The derivation of new objectives is conducted using calculation procedures established by the U.S. EPA, which, in turn, result in scientifically-defensible objectives for cyanide. The methods used to derive existing and proposed cyanide criteria are described in Section 4 of this Report. Less stringent cyanide objectives are appropriate and still protective of water quality and all beneficial uses. However, it is important to note that maintaining ambient cyanide concentrations at current levels is further assured by imposing numeric effluent limits for all industrial and municipal wastewater dischargers with cyanide in their effluent and a rigorous control plan.

A water quality attainment strategy developed to support the SSOs (Section 8.4, Appendix H) proposes coordinated efforts to control factors that may affect water quality. The strategy includes surveillance to ensure that these efforts are being sustained and that water quality is maintained. The ambient monitoring program is in place to detect an increase in cyanide ambient concentrations. According to the implementation plan, more aggressive pollution prevention actions, beyond the current baseline activities, would be triggered when that ambient level is exceeded.

The proposed site-specific objectives relax the current applicable water quality objectives for cyanide. However, current ambient cyanide concentrations in San Francisco Bay are well below the existing and proposed water quality objectives. Cyanide degrades rapidly in receiving waters and does not accumulate in sediment or biota in the Bay. A potential increase in cyanide loading of 15 kg per day is predicted applying theoretical effluent limits calculated using the maximum allowable dilution credits. The assimilative capacity of San Francisco Bay based on the existing NTR water quality objective is 200 kg. This potential loading increase is not expected to have a measurable impact on ambient cyanide levels in the Bay.

Economic considerations

There are no economic impacts that would result from this Basin Plan amendment. The proposed site-specific water quality objectives for cyanide are currently being met in the receiving water so no additional treatment measures are necessary to achieve compliance with the proposed objectives. Also, as shown in this Report, effluent limits that are calculated using the SIP methodology, and the site-specific objectives and proposed dilution credits, are attainable by the wastewater dischargers and therefore no additional treatment is required to meet such objectives. By contrast, the '*No Action*' alternative would constitute a compliance challenge for most shallow water dischargers and require substantial expenditures to ensure compliance (Section 7).

Need for Housing

The proposed water quality objectives would not restrict the development of housing in the San Francisco Bay Region because they do not result in discharge requirements that affect housing or any economic costs related to housing development.

Need to Develop and Use Recycled Water

There are no present restrictions on recycling of water due to cyanide. The intent of the proposed water quality objectives is to sustain low cyanide levels in the Bay and to maintain good water quality. Therefore, the proposed objectives are consistent with the need to develop and use recycled water. Adopting the recommended site-specific objectives for cyanide will have no impact on the quality and no impact on the quantity of wastewater available for recycling or reclamation in the region and none of the alternatives considered would restrict the development or use of recycled water.

9.2 Peer Review

Basin Plan amendments establishing new water quality objectives and related requirements necessitate scientific peer review. Health and Safety Code, Sect. 57004 requires an external peer review for work products that constitute the scientific basis for a rule "…establishing a regulatory level, standard, or other requirement for the protection of public health or the environment." State law (SB 1320) defines "scientific basis" as "the foundations of a rule that are premised upon, or derived from empirical data or other scientific findings, conclusions, or assumptions establishing a regulatory level, standard or other requirement for the protection of public health or the environment." Under SB 1320, "rule" includes any policy adopted by the State Water Resources Control Board under the Porter-Cologne Water Quality Control Act (Division 7, commencing with Section 13000 of the Water Code) that has the effect of a regulation.

This amendment establishes new site-specific water quality objectives for cyanide that replace the existing NTR criteria in the Basin Plan. The scientific basis of the amendment was subjected to external scientific peer review.

9.3 Environmental Analysis

CEQA requires agencies to review potential for their actions to result in adverse environmental impacts. The water quality planning process is a certified regulatory program approved by the Secretary of Resources as exempt from CEQA's requirements for preparation of an environmental impact report or negative declaration. As part of the regulatory program, the State Board's regulations at 23 Cal. Code of Regs. §3720 et seq require any standard, rule, regulation or plan proposed for board approval to be accompanied by a completed Environmental Checklist and a written report containing (1) a brief description of the proposed activity; (2) reasonable alternatives to the proposed activity and (3) mitigation measures to minimize any significant environmental impacts of the proposed activity. Upon completion of the written report, the Water Board is required to provide a Notice of Filing of the report to the public.

This Staff Report including Appendix H, Environmental Checklist, meets the requirements of CEQA for adopting Basin Plan amendments.

9.3.1 Brief Description of the Proposed Activity

The proposed Project is an amendment to the Basin Plan that establishes site-specific marine water quality objectives for cyanide in San Francisco Bay and an implementation plan to meet the objectives and sustain current good discharger performance. It also requires the imposition of effluent limits under the "Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California" (SIP) in wastewater NPDES permits and sets forth calculated dilution credits for specific dischargers, currently authorized to discharge into shallow waters, which will be used to calculate effluent limits. A detailed project description outlining the project objectives is provided in Section 2. The amendment described in Appendix A, proposes replacing the existing acute cyanide objective of 1 μg/L to 9.4 μg/L and the chronic objective of 1 μg/L to 2.9 μg/L and setting the dilution credits for individual shallow water dischargers. The proposed dilution credits will result in numeric effluent limits that provide reasonable protection for sensitive aquatic life uses in the vicinity of each discharge.

In addition to site-specific objectives for cyanide, the amendment also includes clarifying language regarding the site-specific objectives for copper and nickel for Lower South San Francisco Bay adopted by the Water Board in 2002. The record for that action clearly indicated that effluent limits for Lower South San Francisco Bay municipal wastewater dischargers would be both calculated and imposed. The language in the Water Quality Attainment Strategy portion of the Basin Plan stated only that the effluent limits would be "calculated," which some dischargers have been interpreting erroneously to mean that limits would be calculated but not included in their NPDES permits. Therefore, the clarifying language states that effluent limits for dischargers will be calculated and included in NPDES permits. This language clarification will not have economic or environmental effects, as it continues the current regulatory requirements.

Sections 2, 3, 4, 6, and 9 of this Report satisfy the foregoing analysis requirements for the proposed Basin Plan amendment. Appendix H contains the Environmental Checklist for the proposed activity. An explanation follows the Environmental Checklist and provides details concerning the environmental impact assessment. The analysis concludes that adopting the proposed amendment will not have any significant adverse environmental effects and no mitigation measures are proposed.

9.3.2 Consideration of Alternatives for the Proposed Amendment

Two alternatives to the proposed amendment are considered: (1) no Basin Plan amendment (*No Action*) and (2) Site-specific objectives only.

No Action

Under this alternative, the Water Board would not amend the Basin Plan to adopt the proposed cyanide site-specific objectives or the related implementation activities. The effluent limits based on the existing NTR objective and the SIP procedures would continue to present compliance problems for the majority of municipal and industrial wastewater discharges where compliance has thus far been determined to be infeasible. This issue would not be resolved under the '*No Action'* alternative.

The No Action alternative would not have less environmental impacts than the proposed project. Compliance issues may require wastewater dischargers to implement additional measures to reduce cyanide concentrations in their effluent that may include construction of additional treatment facilities, which, in turn, could adversely impact the environment. A '*No Action*' alternative would allow unnecessarily stringent effluent limits for San Francisco Bay wastewater dischargers, thereby possibly requiring the dischargers to consider implementing economically infeasible measures to comply as the only alternative to mandatory penalties (see Section 7). The more stringent effluent limits are not necessary to protect beneficial uses.

Site-Specific Objectives Only

Under this alternative, the Water Board would amend the Basin Plan to adopt the proposed marine cyanide site-specific objectives of 2.9 µg/L (chronic) and 9.4 µg/L (acute). No new implementation activities would be initiated and dilution credits would not be used in the calculation of effluent limits. Instead, the site-specific objectives would be implemented through NPDES permits without the additional requirements to ensure dischargers maintain their current good performance through cyanide source review, monitoring and control. This may result in missed opportunities to minimize cyanide loadings in wastewater resulting from wastewater disinfection.

Similar to the "*No Action*" alternative discussed above, compliance issues will arise that may require wastewater dischargers to implement additional measures to reduce cyanide concentrations in their effluent. This may require construction of additional treatment facilities, which, in turn, could adversely impact the environment. Dischargers could also be required to consider implementing mitigation measures that are economically infeasible. Thus, some of the objectives of the proposed Project, discussed in Section 2, will not be met if this alternative is adopted.

9.3.3 Preferred Alternative

Because the proposed Basin Plan amendment will not pose any significant adverse environmental impacts, any of the alternatives would not avoid or lessen any significant impacts. '*No Action*' would result in the moderate economic impacts of unnecessary enforcement and the significant economic impacts of capital projects to produce unnecessarily low effluent concentrations of cyanide. The analysis provided in this Report, including the ambient data collected near shallow water discharge points throughout the San Francisco Bay Estuary, show that current practices protect beneficial uses with respect to (a) discharges of cyanide and (b) current and desired cyanide concentrations at ambient levels. The proposed Basin Plan amendment is the preferred alternative.

9.3.4 Reasonably Foreseeable Methods of Compliance

CEQA additionally requires that whenever a Water Board adopts a rule that requires the installation of pollution control equipment or establishes a performance standard or treatment requirement, it must conduct an environmental analysis of reasonably foreseeable methods of compliance. This analysis must take into account a reasonable range of factors, including economics. The proposed project includes performance standards (i.e., water quality objectives) and therefore requires an environmental analysis of the reasonably foreseeable methods of compliance with these standards.

Compliance with the proposed water quality objectives will occur through the attainable and enforceable water-quality based effluent limits for the NPDES wastewater discharges. The Staff Report demonstrates that industrial and municipal wastewater dischargers will be able to comply with the effluent limits based on the proposed water quality objectives for cyanide, calculated using dilution credits. Thus, no additional measures need to be undertaken, there are no associated environmental impacts, and no mitigation measures are required.

9.4 Antidegradation

Before a water quality objective can be changed, careful consideration must be given to state and federal antidegradation requirements. The proposed Basin Plan amendment is consistent with the guidance concerning those requirements.

9.4.1 The Implementation Plan Protects Against Degradation

The assessment of consistency with anti-degradation policies include: a) analysis of the potential degradation to water quality resulting from the adoption and implementation of site-specific objectives for cyanide, and b) evaluation of the spatial extent of any potential water quality degradation.

The anti-degradation policies allow minor changes in both mass loadings and ambient concentrations, but do not allow significant adverse changes in ambient water quality. Concerns that concentrations of cyanide in San Francisco Bay may undergo significant adverse change with the adoption and implementation of cyanide site-specific objectives that are less stringent than the current cyanide objectives in the NTR is derived from the following hypotheses:

1. Effluent concentrations of cyanide from NPDES dischargers will increase as a result of less stringent effluent limits, with concentrations reaching the effluent limits,
2. Cyanide loadings to the Bay will increase as a result of increased concentrations, and
3. Increased cyanide loadings will lead to increased concentrations of cyanide in the Bay.

An evaluation of this “worst-case scenario” of the likelihood that adoption of site-specific cyanide objectives could result in increased concentrations of cyanide in the Bay is examined below.

Changes in Cyanide Effluent Limits and Concentrations

Wastewater discharges, controlled through NPDES permits, represent the major source of cyanide to the Bay. Twenty-two wastewater dischargers may receive increased effluent limits (Table 22) as a result of adoption of the new water quality objectives for cyanide and the proposed dilution credits for shallow water dischargers as compared to existing interim permit effluent limits.

However, an analysis of treatment plant operations and processes indicates that less stringent cyanide effluent limits are not expected to result in increased cyanide concentrations. Available data indicate that, for wastewater treatment plants discharging into San Francisco Bay, effluent cyanide concentrations are not a function of influent concentrations. As noted in Section 3.5, for many plants, influent cyanide concentrations are lower than effluent cyanide concentrations. For the remaining plants, no relationship exists between influent and effluent concentrations. Therefore, an argument that less stringent effluent limits would tend to encourage increased influent cyanide loadings that would result in higher effluent concentrations of cyanide is not tenable. Cyanide concentrations in effluent are not well explained, but are believed to be the complicated result of chlorination, dechlorination or UV disinfection. Operation of the physical and biological treatment processes used in wastewater treatment plants to achieve secondary treatment is required to meet technology-based federal requirements and will not be modified by plant operators. Further, no reliable information exists to suggest that changes in such operations will affect cyanide effluent concentrations. In other words, municipalities and industries have neither an incentive nor capability to "re-operate" their plants to "take advantage" of less stringent cyanide limits. For this reason, changes in cyanide concentrations resulting from changes in cyanide effluent limits are not likely. The more plausible expectation is that cyanide levels in effluent will remain at current levels, despite changes in effluent limits.

The potential for contributors to municipal facilities to take advantage of higher effluent limits through increased discharges to sanitary sewers is offset by 1) local limits derived from mandatory effluent limits and 2) a periodic review by every municipal wastewater discharger, in a permit provision, every 5 years (permit reissuance) of potential cyanide dischargers to the sanitary sewer and report to the Water Board. This higher level of cyanide surveillance will counter any potential efforts to increase discharges to sanitary sewers.

Table 22: Cyanide Effluent Limits- Existing and Projected Based on Proposed SSOs

				Existing Limits				Projected Effluent Limits	
Discharger	Type	NPDES Permit #	Permit Expiration Date	Interim Daily Avg (µg/L)	Interim Daily Max (µg/L)	Interim Monthly Average (µg/L)	No Limits	AMEL (µg/l)	MDEL (µg/l)
American Canyon, City of	POTW	CA0038768	1/19/2005	5				*7.6* *	*13.9*
Benicia, City of	POTW	CA0038091	7/31/2006			25		18.3**	44.1
Burlingame, City of	POTW	CA0037788	1/31/2007		10			20.1	40.2
Central Contra Costa Sanitary District	POTW	CA0037648	5/31/2006		18			21.4	35.9
Central Marin Sanitation Agency	POTW	CA0038628	8/31/2006		25			19.4	41.9
Delta Diablo Sanitation District	POTW	CA0038547	1/1/2009		25			20.1	40.2
Dublin San Ramon Services District	POTW	CA 0037613	8/16/2005		21			ND	ND
East Bay Dischargers Authority	POTW	CA 0037869	8/16/2005		21			15.2	44.5
East Bay Municipal Utilities District	POTW	CA0037702	5/31/2006 / 6/30/2006		10			18.8	43.2

				Existing Limits				Projected Effluent Limits	
Discharger	**Type**	**NPDES Permit #**	**Permit Expiration Date**	**Interim Daily Avg (µg/L)**	**Interim Daily Max (µg/L)**	**Interim Monthly Average (µg/L)**	**No Limits**	**AMEL (µg/l)**	**MDEL (µg/l)**
Fairfiend-Suisun Sewer District	POTW	CA0038024	9/30/2008		32			*8.0*	*18.3*
Hayward Marsh	POTW	CA0038636	5/25/2004	17.1				*6.6*	*15.0*
Las Gallinas Valley Sanitary District	POTW	CA0037851	11/30/2008		19			*6.6*	*14.9*
Livermore, City of	POTW	CA 0038008	8/16/2005		21			20.1	41.7
Marin County Sanitary District #5	POTW	CA0037753	10/31/2007	25				20.1	40.2
Millbrae, City of	POTW	CA0037532	10/31/2006			10		19.4	41.9
Mt. View Sanitary District	POTW	CA0037770	8/16/2005				No Limits	*7.0*	*17.0*
Napa Sanitation District	POTW	CA0037575	7/31/2005		25			*6.1*	*16.6*
Novato Sanitary District	POTW	CA0037958	5/25/2004					*6.8*	*14.4*
Palo Alto, City of	POTW	CA0037834	9/30/2008		32			*7.9*	*11.9*
Petaluma, City of	POTW	CA0037810	7/15/2003	14				*6.4*	*15.3*
Pinole-Hercules, Cities of	POTW	CA0037796	8/1/2006		12			20.7	38.2
Rodeo Sanitary District	POTW	CA0037826	8/31/2006		12			22.1	33.2
San Francisco International Airport	POTW	CA0038318	10/31/2006		10			20.1	40.2
San Francisco, City and County of, Southeast (Total)	POTW	CA0037664	5/31/2007				No RP	20.7	38.2
San Jose/Santa Clara WPCP	POTW	CA003784	9/30/2008				No RP	*7.6*	*13.0*
San Mateo, City of	POTW	CA0037541	5/31/2006		10			20.7	38.2
Sausalito-Marin City Sanitary District	POTW	CA0038067	7/19/2005		25			20.7	38.2
Sewerage Agency of Southern Marin	POTW	CA0037711	5/30/2006		25			15.2	45.5
Sonoma Valley County Sanitary District	POTW	CA0037800	2/28/2007			10.1		*6.4*	*15.2*
South Bayside System Authority	POTW	CA0038369	2/1/2006		18			21.4	35.9
South San Francisco /San Bruno WQCP	POTW	CA0038130	3/31/2008		10			12.7	40.3
Sunnyvale, City of	POTW	CA0037621	9/30/2008		32			*7.9*	*19.4*
Treasure Island WWTP	POTW	CA0110116	Tentative		10			20.8	41.7
Vallejo Sanitation & Flood Control District (Total)	POTW	CA0037699	4/19/2005		10			17.8	44.8
West County Agency	POTW	CA0038539	10/31/2006		25			20.1	40.2
Chevron Richmond Refinery	Refinery	CA0005134	5/31/2006					20.7	38.2
ConocoPhillips (Rodeo)	Refinery	CA0005053	3/15/2005					21.4	35.9
Martinez Refining Company	Refinery	CA0005789	10/31/2006		25			21.4	35.9
Tesoro Refinery	Refinery	CA0004961	2/16/2005		25			11.2	37.3
Valero Benicia Refinery	Refinery	CA0005550	11/30/2007		25			ND	ND
Crockett Cogeneration	Industrial	CA0029904	9/16/2003		265			20.8	41.7
Dow Chemical Company	Industrial	CA0004910	10/31/2006				No Limits	20.1	40.2

				Existing Limits				Projected Effluent Limits	
Discharger	Type	NPDES Permit #	Permit Expiration Date	Interim Daily Avg (µg/L)	Interim Daily Max (µg/L)	Interim Monthly Average (µg/L)	No Limits	AMEL (µg/l)	MDEL (µg/l)
General Chemical	Industrial	CA000497	5/31/2007				No Limits	12.1	39.5
GWF Power Systems (Site I)	Industrial	CA0029106	7/21/2004				No Limits	20.1	40.2
GWF Power Systems (Site V)	Industrial	CA0029122	7/21/2004				No Limits	ND	ND
Morton	Industrial	CA0005185	2/19/2002				No Limits	ND	ND
Pacific Gas & Electric (East Shell Pond)	Industrial	CA0030082	5/25/2004				No RP	ND	ND
Rhodia Basic Chemicals	Industrial	CA0006165	10/21/2003				No RP	ND	ND
S.F.Airport, Industrial (Total)	Industrial	CA0028070	2/28/2007				No RP	ND	ND
USS Posco	Industrial	CA0005002	11/29/2005		22			*6.8*	*13.6*

No RP Reasonable Potential analysis indicated that effluent limits were not required

ND Predominantly non-detected concentrations of cyanide and/or insufficient data to calculate effluent limits

* For shallow water dischargers (effluent limits indicated in *italics*) AMEL and MDEL limits were calculated using the dilution credits specified in Table 21

** For deep water dischargers a conservative dilution credit of 10:1 was used in computation of AMEL and MDEL. The site-specific dilution credit will be used in final effluent limits derivation on permit-by-permit basis.

Changes in Cyanide Loadings

In the unlikely event that effluent concentrations increase in response to less stringent effluent limits (contrary to the above analysis), cyanide loadings to the Bay would increase. Table 23 provides a summary of the maximum incremental changes in cyanide loadings to the Bay resulting from discharges at the maximum projected effluent limits reflecting the "worst-case scenario". The potential incremental increase in cyanide loadings over current loadings is less than 15 kilograms per day.

The magnitude of these incremental changes can be viewed in relation to (a) current mass of cyanide in the Bay and (b) allowable loadings of cyanide to the Bay, i.e. the assimilative capacity of the Bay for cyanide. The current mass of cyanide in the water column of the Bay is less than or equal to 2,700 kg. This is calculated based on an average cyanide concentration of less than 0.4 µg/L and modeled estimates of the estuary's mean volume of 6.66 billion cubic meters. Assimilative capacity of the Bay under the current NTR objectives and the proposed cyanide SSOs is calculated as follows:

Assimilative capacity under NTR = Current cyanide chronic objective per NTR X estimated water volume of the Bay X Multiplier to convert to kg = 6,700 kg

The total potential increase in cyanide loadings (presuming that all dischargers will increase from existing loadings to loadings allowed by new effluent limits) is estimated at less than 15 kilograms per day. This is approximately 0.6 percent of the current cyanide mass in the Bay water column, 0.2 percent of the cyanide mass allowed in the Bay under the NTR cyanide standard of 1.0 µg/L. Remembering that cyanide discharged to the Bay attenuates quickly, these minor incremental loading estimates would not be expected to have a measurable impact on ambient cyanide levels in the Bay.

Table 23: Hypothetical Cyanide Loadings at Projected Effluent Limits

NPDES Permittee	Average Annual Flow (mgd)	Projected Final Effluent Limit (AMEL) (µg/l)	Existing Mean Effluent Concentration (µg/l)	Loading at Projected AMEL (kg/day)	Existing Mean Loading (kg/day)	Hypothetical Increased Loading (kg/day)
American Canyon	1.3	10.4[a]	1.4	0.05	0.01	0.04
City of Burlingame	4.1	20.1	3.3	0.31	0.05	0.26
Central Contra Costa SD	43.1	21.4	3.8	3.50	0.61	2.88
Central Marin Sanitation Agency	7.4	19.4	4.3	0.54	0.12	0.42
Delta Diablo Sanitation District	13.1	20.1	7.1	1.00	0.35	0.65
East Bay Dischargers Authority	77.9	15.2	5.1	4.49	1.51	2.97
East Bay MUD	71.5	18.8	5.7	5.10	1.56	3.54
Las Gallinas Valley SD	1.3	9.0[a]	3.0	0.04	0.01	0.03
City of Livermore	6.3	20.1	14.9	0.48	0.36	0.12
Marin County SD No. 5	0.6	20.1	5.0	0.05	0.01	0.03
Martinez Refining Company	6.7	21.4	13.2	0.54	0.34	0.21
City of Millbrae	2.4	19.4	3.7	0.18	0.03	0.14
Novato SD	5.2	9.3[a]	1.8	0.18	0.04	0.15
City of Petaluma	3.3	8.8[a]	2.9	0.11	0.04	0.07
Cities of Pinole and Hercules	2.4	20.7	3.5	0.19	0.03	0.16
Rodeo SD	0.9	22.1	3.7	0.08	0.01	0.06
San Francisco International Airport	0.6	20.1	9.8	0.05	0.02	0.02
City of San Mateo	10	20.7	4.3	0.78	0.16	0.62
Sewerage Agency of Southern Marin	3.3	15.2	2.5	0.19	0.03	0.16
Sausalito-Marin City	1.7	20.7	9.6	0.13	0.06	0.07
South Bayside System Authority	15.5	21.4	7.8	1.26	0.46	0.80
South San Francisco/San Bruno	10.4	12.7	8.0[b]	0.50	0.32	0.19
Tesoro Golden Eagle Refinery	2.7	11.2	8.6	0.11	0.09	0.03
Treasure Island	0.4	20.8	2.6	0.03	0.00	0.03
Vallejo Sanitation and Flood Control District	11.4	17.8	4.8	0.77	0.21	0.56
West County Agency	13.1	20.1	3.6	1.00	0.18	0.82
Totals	**314**			**21.57**	**6.60**	**14.97**

Table shows loadings for discharges where projected final effluent limits exceed currently imposed interim limits.

[a] AMEL based on conservative dilution credit of 4.5:1 for shallow water dischargers; for the remaining deep water dischargers AMEL based on a dilution credit of 10:1.

[b] Median value used.

Changes in Ambient Cyanide Concentrations

In the unlikely event cyanide concentrations increase as a result of adoption of the proposed cyanide SSOs, ambient concentrations would change marginally in the vicinity of the affected shallow water discharges. Current ambient concentrations of cyanide at deep water sites in the Bay are typically less than 0.4 μg/L, while concentrations near shallow water discharges are usually less than 2.9 μg/L, sometimes as high as 4 or 6 μg/L. These ambient concentrations reflect the current source loading of cyanide to the Bay at existing effluent concentrations. Given the minor magnitude of the resulting potential increase in mass loadings as described above, significant changes in ambient cyanide concentrations would not be anticipated.

Overall Assessment

Based on the above analysis, it is not anticipated that adoption and implementation of the proposed cyanide SSOs will result in significant increased loadings or increased concentrations of cyanide in the Bay. Even if some lowering of water quality were to occur due to the relaxed SSOs, it is consistent with both state and federal antidegradation polices as discussed below.

9.4.2 State Requirements

New water quality objectives must conform to State Board Resolution 68-16, "Statement of Policy with Respect to Maintaining High Quality of Water in California." It must be demonstrated that the change in water quality owing to relaxing the water quality objective:

- Will be consistent with maximum benefits to the people of the State;
- Will not unreasonably affect present and anticipated beneficial use of such water;
- Will not result in water quality lower than that prescribed in the applicable policies; and
- Will ensure that dischargers will implement the best practicable treatment or control.

The proposed site-specific objectives for cyanide are based on the latest science pertaining to the toxicity of cyanide to aquatic organisms and are scientifically-defensible and protective of beneficial uses in San Francisco Bay. Proposing the water quality objectives is consistent with the maximum benefit to the people of the State because beneficial uses will be protected without requiring an unreasonable or unnecessary level of performance on the part of dischargers (see Section 7). Disinfection processes, identified as a contributing source of small measurable levels of cyanide in effluents, are required by the Water Board to protect beneficial uses of receiving waters for recreational users, such as swimmers, kayakers, fishers and board sailors. There is no evidence that precursors to cyanide formation contained in influents can be reasonably controlled to lower the effluent levels post-disinfection.

The original cyanide marine criterion was based on the minimum amount of data for a federal criterion and as most recent studies demonstrated, it has been overly conservative due to limited scientific information on crab species specific to San Francisco Bay. New scientific information (Brix et al., 2000) helps justify an increase in the threshold concentration of cyanide while protecting beneficial uses of the Bay. Moreover, the cities and industries are addressing potential sources of cyanide that contribute to increases in cyanide in effluents of the treatment plants (see Section 5.4). The proposed objectives are based on U.S. EPA marine cyanide criteria, which have been updated and adopted by the State of Washington. After evaluating current ambient cyanide concentrations and effects levels for the sensitive genera, impairment of beneficial uses due to current ambient concentrations of cyanide is considered unlikely.

A relaxation of the ambient water quality objectives for cyanide is unlikely to cause any increase in ambient cyanide concentrations due to increased cyanide loads if current performance by area dischargers is maintained as is expected. The analysis of adverse changes in cyanide concentrations provide strong evidence that the proposed site-specific objectives will not result in lower water quality.

The dischargers do not have the ability to manipulate their processes to adjust effluent cyanide levels, which are influenced by many factors within the disinfection process, including wastewater characteristics, and by the occasional illicit discharge into the sanitary sewer (see Section 5.4). The implementation plan in Section 8 requires effluent limits for all municipal dischargers and those industrial dischargers that have detectable levels of cyanide and/or use cyanide in their processes and describes the Cyanide Action Plan. The NPDES permit process will ensure that the sources of cyanide in the treatment plant influent and effluent are tracked and regulated by the dischargers and that the current high standard of performance is maintained. Dischargers would continue to comply with technology requirements under the Clean Water Act.

9.4.3 Federal Requirements

The federal regulations covering antidegradation (40 CFR 131.12) divide waters into three categories or tiers. Tier 1 waters[1] are those that are either not meeting the federal "fishable/swimmable" goals, or that meet "fishable/swimmable"[2] goals but lack assimilative capacity to accept any more of the specific pollutant proposed for discharge. Tier 2 waters are those where the water quality is better than the minimum necessary to maintain "fishable/swimmable" uses. Tier 3 waters are outstanding national resource waters such as National and State parks and wildlife refuges or waters of exceptional recreational or ecological significance.

Lowering of water quality (which could occur in the relaxation of a standard) may be done only after satisfying public participation requirements, and if the Water Board finds that (1) the relaxation of the standard is necessary to accommodate important economic or social development in the area in which the waters are located; (2) the revised water quality objective is fully protective of existing beneficial uses; and (3) the highest statutory and regulatory requirements will be imposed on all new and existing point sources and all cost-effective and reasonable best management practices will be required for nonpoint source control. Each of these three conditions will now be considered in turn.

1) *The relaxation of the standard is necessary to accommodate important economic or social development in the area in which the waters are located;*

[1] According to EPA guidance, Questions and Answers on Antidegradation, 1985, Tier 1 waters are those where there is any existing use, whether it is fishable/swimmable or not.

[2] A level of water quality that provides for the protection and propagation of fish, shellfish and wildlife, and recreation in and on the water (USEPA, 1994)

Relaxing water quality objectives for cyanide is consistent with the need to accommodate important economic or social development because beneficial uses will be protected without requiring an unreasonable level of performance on the part of dischargers that are already achieving high levels of performance. In the future, it is expected that ambient concentrations of cyanide in San Francisco Bay will remain similar to current levels or continue to decrease due to the actions required by the implementation plan. In an unlikely event that loadings of cyanide in fact increase due to imposed effluent limits, the analysis in Section 9.4.1 demonstrates that it would have a minimal effect on the ambient concentrations.

The combination of the proposed site-specific objectives and implementation plan will protect water quality and accommodate current and future economic activity and population growth. These two goals can be accomplished while ensuring that little or no actual lowering of water quality will occur despite relaxing the water quality objectives for cyanide.

2) *The water quality objective is fully protective of existing beneficial uses;*

This consideration is addressed in Section 9.1 and Appendix H.

3) *The highest statutory and regulatory requirements will be imposed on all new and existing point sources and all cost-effective and reasonable best management practices will be required for nonpoint source control.*

NPDES permits will require existing wastewater dischargers to maintain their current level of performance. The intent of the actions described in Section 8 (implementation plan) of this Report is to prevent degradation of water quality due to increases in concentrations of cyanide in San Francisco Bay despite the relaxation of the cyanide water quality objectives. This includes required effluent limits for all municipal dischargers and industrial dischargers and a cyanide action plan to control sources of cyanide. Municipal dischargers would continue to comply with all technology controls under the Clean Water Act. Nonpoint sources and stormwater-associated point sources are not considered to be sources of cyanide to San Francisco Bay.

10 Conclusions

The proposed site-specific objectives (SSOs) and implementation plan are needed and warranted as a Basin Plan amendment for numerous reasons. Specific reasons for adopting the proposed Basin Plan amendment are summarized below.

Proposed site-specific objectives are protective of beneficial uses

Given the current state of analytical cyanide detection capabilities, the proposed site-specific water quality objectives have an intrinsic margin of safety. The existing analytical methods for measuring cyanide in wastewater cannot effectively discern free cyanides from the less toxic complexed cyanides. Although the total or weak acid-dissociable cyanide in wastewater from POTWs is partially free cyanides, all detected cyanide (total cyanide) is assumed to be free cyanide. The NTR criteria, as well as the proposed SSOs, were formulated using controlled laboratory concentrations of free cyanide. Therefore the proposed objectives are inherently protective since they do not account for the less-toxic metal-cyanide complexes. Consequently, any given measurement of cyanide in ambient waters or POTW effluent will over-represent the actual concentration of the harmful cyanide constituent.

Proposed site-specific objectives are recalculated using resident species data

The proposed site-specific objectives reflect the inclusion of additional species resident to San Francisco Bay and therefore are an improvement of the original dataset used to derive water quality criteria and effluent limits. The existing national criteria were calculated in 1985 using only the minimum data set required per U.S. EPA guidelines. Also, *Cancer* specimens native to the east coast of the United States were used in the data set. The east coast species yielded sensitivity values six times that of the next-sensitive *Cancer* species. The revised data set for the proposed amendment substitutes the east-coast species with four species of *Cancer* native to the San Francisco Bay. Utilizing a more robust data set with native species yields new site-specific objectives that have more scientific and regional validity. The State of Washington used the same data set and proposed the same values for the site-specific objectives for Puget Sound in 1997.

Disinfection of wastewater contributes to increase of cyanide in effluent

Cyanide formation in wastewater effluent is a by-product of the disinfection process. The disinfection process is a mandatory procedure that dischargers must implement to protect the water recreation and other beneficial uses of the Bay. There is currently no procedure available that could practicably be instituted to entirely remove or eliminate the cyanide by-product (see Section 7). Ambient cyanide concentrations throughout the Bay demonstrate that the beneficial uses of the Bay are currently protected from cyanide impacts given the status quo of POTW facility operations. If these disinfection processes were eliminated to achieve the current national criteria objective for cyanide, then the water recreation beneficial uses of the Bay would no longer be protected.

Cyanide does not persist in the aquatic environment

Cyanide does not bioaccumulate and does not persist in the aquatic environment. It is appropriate to acknowledge not only dilution, but also natural degradation of cyanide in aquatic environments when formulating effluent limits for shallow water dischargers. The attenuation (tidal mixing, dilution and degradation degradation) of cyanide in shallow water environments has been documented thoroughly in Appendices D and L, and is recommended as a basis for derivation of required cyanide effluent limits for all shallow water dischargers.

Antidegradation is ensured through individual effluent limits and Cyanide Action Plan

All individual shallow and deep water municipal wastewater dischargers to the Bay will be subject to numeric cyanide effluent limits in their NPDES permit to enforce compliance with the proposed site-specific water quality objectives. All industrial wastewater dischargers that disinfect, use cyanide or have detectable cyanide in their effluents will have effluent limits as well. The establishment of required effluent limits is a part of the Cyanide Action Plan to assure discharger accountability and compliance with State and federal antidegradation requirements. The Action Plan also requires a source control program and surveillance and monitoring that could trigger further preventive measures.

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