EVALUATION OF A MIXING ZONE POLICY FOR HUMAN HEALTH RELATED CONSTITUENTS

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SUMMARY

Complying with water quality objectives and drinking water standards, and effluent limitations based on these objectives and standards may be costly or infeasible for some dischargers. Regulatory relief for discharges may be provided, under certain conditions, by allowing limited dilution of the discharged effluent with the receiving water to occur (a mixing zone) either before attainment with water quality criteria/objectives is required or in the determination of effluent limitations, (40 CFR 131.13, 40 CFR 122.44(d)(1)(ii)). Mixing zones are recognized in the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP) for constituents with California Toxics Rule (CTR) criteria (see Appendix A for a list of CTR criteria). However, no provision is made either by the State or the Water Quality Control Plan for the North Coast Region ("Basin Plan") for mixing zones for non-CTR constituents. This document evaluates a potential amendment to the North Coast Basin Plan to allow mixing zones for discharge to surface freshwater of non-CTR constituents with human health objective by Publically Owned Treatment Works (POTWs) in the North Coast region (see Appendix A for a list of constituents with maximum contaminant levels (MCL) or secondary contaminant levels (SMCL) for drinking water as listed in Title 22 of the California Code of Regulations Division 4 – Environmental Health).

Federal guidelines for mixing zones are primarily contained in three documents

- Technical Support Document for Water Quality-Based Toxics Control (TSD) (USEPA 1991)
- Water Quality Standards Handbook (USEPA 1994)
- Allocated Impact Zones for Areas of Non-Compliance (USEPA 1995)
- NPDES Permit Writer's Manual (USEPA 1996)

Provisions for mixing zones are contained in the Basin Plans of the San Francisco Bay Region, the Los Angeles Region, the Central Valley Region and the San Diego Region. The Basin Plans of several Regions, including the North Coast Region allow mixing zones for turbidity. The Central Coast, Lahontan, Colorado River and Santa Ana basin plans do not have mixing zone provisions (other than turbidity for the Central Coast).

The North Coast Region has twenty-one POTWs that discharge or are permitted to discharge directly to surface freshwater – eight to the Eel River or its tributaries, nine to the Russian River or its tributaries, two to Humboldt Bay or its tributaries (salinity in Humboldt Bay is occasionally low enough that one of its beneficial uses is Municipal and Domestic Supply), one to the Mad River, and one to a drain tributary to the Tulelake-Lower Klamath Lake reach of the Lost River Basin. Available data characterizing the quality of effluent discharged in the North Coast region, primarily Self-Monitoring Reports (SMRs), were evaluated to identify constituents for which a discharger could reasonably be expected to seek credit for a mixing zone in the event that the Basin Plan is amended to permit such credit. Six of the seventeen POTWs with nitrate data in their SMRs reported maximum nitrate concentrations that exceeded the human health criterion indicating that these dischargers could reasonably be expected to seek credit for a mixing zone in

the event that the Basin Plan is amended to permit such credit. Other than nitrate, non-CTR drinking water constituents are rarely and not systematically measured in North Coast dischargers' effluent. The SMRs examined for dischargers other than Santa Rosa revealed only one non-CTR drinking water constituent, carbon tetrachloride, with concentrations that exceeded its respective primary or secondary MCLs. Santa Rosa has measured most Title 22 constituents on four occasions and non-CTR disinfection by-products on one occasion. In these samples, the only non-CTR constituents that exceeded their primary MCLs were aluminum, nitrite and nitrate. The only non-CTR constituents that exceeded their secondary MCLs were aluminum, manganese, color and turbidity.

Eight mixing zone alternatives for an amendment to the Basin Plan are presented in this document. They include a "No Action" alternative for no Basin Plan amendment and seven alternatives which vary by allowable constituents and the size of the mixing zone. In addition to the size and constituent limitations, mixing zone alternatives containing conditions that would lessen or eliminate environmental impacts are recommended.

For the No Action alternative, methods by which a POTW can comply with future effluent limitations for non-CTR human health constituents include treatment plant improvements, wetlands, and source control. Costs for these improvements range from minimal for source control to $14.7 million for extensive treatment plant upgrades. Methods by which a POTW can comply with requirements associated with Basin Plan amendment alternatives for a mixing zone include diffusers and/or increased storage to allow modulation of discharge to achieve a particular stream to wastewater flow ratio. Costs for these improvements can be zero if neither a diffuser nor increased storage is required. Costs for a diffuser and/or storage are very site and project specific but are approximately $100,000 to $1 million for a diffuser and approximately $200,000 per million gallons for storage.

A basic evaluation was conducted to determine the length of a mixing zone that would be required to meet an effluent limitation for nitrate based on available information for several POTWs. Nitrate was chosen as an example because a number of North Coast POTWs have or will likely have in the future effluent limitations for nitrate in their NPDES permits. A range of potentially allowable mixing zones was determined for a subset of North Coast POTWs which were classified according to the size of their receiving water. In general, for discharge concentrations less than 20 mg-N/L (which is double the 10 mg-N/L regulatory requirement), the mixing zone length is less than one channel width. For higher discharge concentrations of nitrate, the mixing zone length increases. At the highest discharge concentration evaluated (40 mg-N/L), the mixing zone length was about twice the channel width (1.75W to 2.00W) in the very small, small, and medium receiving water groups and about one and a quarter times the width for large receiving water group (1.25W).

Each of the eight Basin Plan amendment alternatives was examined for potential impacts (both positive and negative) on the environment. The adverse impacts were identified as follows:

Alternative 1 – No Action:

- Aesthetics
- Agricultural and Forestry Resources

- Biological Resources
- Cultural Resources
- Greenhouse Gas Emissions
- Noise

Alternative 2– All human health constituents and small mixing zone size; Alternative 3 – All human health constituents and medium mixing zone size; Alternative 5 – Nitrate and non-CTR Disinfection-by-Products (DBPs or chemicals resulting from the inactivation of pathogens by chlorination or other means) and small mixing zone size; and Alternative 6 – Nitrate and non-CTR DBPs and medium mixing zone size:

- Aesthetics
- Agricultural and Forestry Resources
- Biological Resources
- Cultural Resources
- Greenhouse Gas Emissions.
- Hydrology and Water Quality
- Noise

Alternative 4 – All human health constituents and large mixing zone size and Alternative 7 – Nitrate and non-CTR DBPs and large mixing zone size (For these alternatives, the size of the mixing zone is assumed sufficient to make storage unnecessary):

- Hydrology and Water Quality

Beneficial impacts from Alternative 1 include:

- Biological Resources
- Recreation

Beneficial Impacts of Alternative 2, 3, 5, and 6:

- Hydrology and Water Quality.

Beneficial Impacts of Alternatives 4 and 7:

- Hydrology and Water Quality

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INTRODUCTION

Complying with water quality objectives and drinking water standards and effluent limitations based on these objectives and standards may be costly or infeasible for some dischargers. Federal regulations (40 CFR 131.13, 40 CFR 122.44(d)(1)(ii)) allow limited dilution of the discharged effluent with the receiving water to occur (a mixing zone), under certain conditions, either before attainment with water quality criteria/objectives is required or in the determination of effluent limitations. A mixing zone is "an area where an effluent discharge undergoes initial dilution and is extended to cover the secondary mixing in the ambient waterbody. A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented." (USEPA, 1991) Water quality criteria must be met at the edge of a mixing zone. Mixing zones that are allocated to a discharge are considered both in calculating effluent limitations and in determining compliance with water quality objectives and drinking water objectives in the receiving water body. If a mixing zone is allowed for particular constituents, an effluent limitation greater than the objective may be established for those constituents. If a mixing zone is not allowed, the effluent limitation is set equal to the objective. Mixing zones are recognized in the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP) for constituents with California Toxics Rule (CTR) criteria (see Appendix A for a list of CTR criteria). The current Water Quality Control Plan for the North Coast Region ("Basin Plan") does not contain a provision for mixing zones with the exception of a provision for a zone of dilution for the water quality objective for turbidity (see Regulatory Setting section below). With the promulgation of the CTR, the North Coast Regional Water Quality Control Board (NCRWQCB) was not required to amend its Basin Plan for mixing zones to be used by dischargers for compliance with effluent limitations based on CTR constituents. However, many dischargers in the North Coast Region have or will have effluent limits imposed for constituents that are driven by non-CTR criteria or objectives (see Appendix A for a list of constituents with State maximum contaminant levels (MCL) or secondary contaminant levels (SMCL) for drinking water). Modification of treatment facilities to comply with these limits could cost utilities and their ratepayers millions of dollars. A Basin Plan Amendment (BPA) is required before a mixing zone for non-CTR constituents can be incorporated into a National Pollutant Discharge Elimination System (NPDES) permit issued by the NCRWQCB.

EXISTING REGULATIONS AND POLICIES

MIXING ZONE AUTHORITY

The federal authority to allow states to use mixing zones in the application and implementation of state standards is contained in the following sections of the Code of Federal Regulations:

- 40 CFR 131.13 General policies. States may, at their discretion, include in their State standards, policies generally affecting their application and implementation, such as mixing zones, low flows and variances. Such policies are subject to EPA review and approval.

- 40 CFR 122.44(d)(1)(ii). When determining whether a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above a narrative or numeric criteria within a State water quality standard, the permitting authority shall use procedures which account for existing controls on point and nonpoint sources of pollution, the variability of the pollutant or pollutant parameter in the effluent, the sensitivity of the species to toxicity testing (when evaluating whole effluent toxicity), and where appropriate, the dilution of the effluent in the receiving water.

The California Water Code gives authority to the Regional Water Boards for basin planning, setting water quality objectives, and imposing waste discharge requirements to meet those water quality objectives which could include allowing mixing zones. This authority is granted in the following sections:

- Section 13240. Each regional board shall formulate and adopt water quality control plans for all areas within the region.

- Section 13241. Each regional board shall establish such water quality objectives in water quality control plans as in its judgment will ensure the reasonable protection of beneficial uses and the prevention of nuisance; however, it is recognized that it may be possible for the quality of water to be changed to some degree without unreasonably affecting beneficial uses.

- Section 13263.6. (a) The regional board shall prescribe effluent limitations as part of the waste discharge requirements of a POTW for all substances that the most recent toxic chemical release data reported to the state emergency response commission pursuant to Section 313 of the Emergency Planning and Community Right to Know Act of 1986 (42 U.S.C. Sec. 11023) indicate as discharged into the POTW, for which the state board or the regional board has established numeric water quality objectives, and has determined that the discharge is or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to, an excursion above any numeric water quality objective.

APPLICABLE CONSTITUENTS

Compilation of EPA Mixing Zone Documents (USEPA 2006) lists three classes of pollutants addressed by mixing zone documents:

- "Toxic pollutants: sometimes referred to as "priority pollutants." EPA identified 126 pollutants from the 65 families of pollutants specified in Section 307(a) of the Clean Water Act. These pollutants are listed at 40 CFR Part 423, Appendix A." These are essentially equivalent to the CTR constituents addressed by the mixing zone policy in the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP) (SWRCB 2005)"
- "Conventional pollutants: the five pollutants as defined by Section 304(a)(4) of the Clean Water Act and listed at 40 CFR 401.16. Those are biochemical oxygen demand (BOD), total suspended solids (non-filterable) (TSS), pH, fecal coliform, and oil and grease."

- "Nonconventional pollutants: any pollutant not already defined as a toxic or conventional pollutant."

FEDERAL GUIDANCE

HISTORY

This section (adapted from MSC 2006) contains an overview of the USEPA's guidance on mixing zones.

Mixing zones have been applied in the water quality standards program since its inception (USEPA 1994, p. 5-1). Mixing zones and dilution were discussed in federal water quality control policies and guidelines dating back to the 1968 Water Quality Criteria (Green Book) developed by the United States National Technical Advisory Committee. This federal guidance introduced the concept that water quality standards protect the water body as a whole, rather than to protect the entirety of the water body; meaning that overall the quality of the water body was protected, but that in some instances minimum water quality standards could be violated in very localized areas. The Green Book criteria specifically authorized the inclusion of mixing zones in standards designed to protect both freshwater and marine fish populations (USEPA 1973). Mixing zones were to be considered places where waste and water mixed and not as places where effluent were treated.

The Green Book's mixing zone recommendations included provisions to protect migrating or drifting aquatic species. Although concentrations of a pollutant were allowed to exceed the criteria in a portion of the waterbody, the Green Book recommended 75 percent of the cross-sectional area and/or volume of flow of the stream or estuary be reserved for a "zone of passage". In these passageways, concentrations of pollutants met the water quality standards for the receiving water. The Green Book also recommended that if several discharges were close together, the discharges should be on the same side of a waterbody to allow the passageway to be continuous. It also recommended "mixing should be accomplished as quickly as possible through devices which insure that the waste is mixed with the allocated dilution water in the smallest possible area" (USEPA 1995).

When USEPA was created in 1971 to oversee federal environmental protection efforts, it continued using the Green Book. By this time, most States had adopted water quality standards, as required by the Federal Water Pollution Control Act (FWPCA) of 1965.

The 1972 Amendments to the FWPCA, known as the Clean Water Act (CWA) did not mention mixing zones. Section 303(a) of the 1972 CWA specifically directed existing state water standards to remain in effect and USEPA's review of state standards to be based on the requirements of the FWPCA prior to 1972 Amendments. Major amendments to the CWA occurred in 1977, 1981 and 1987.

The 1973 Water Quality Criteria (Blue Book) developed by the National Academy of Sciences/National Academy of Engineering contained a significant discussion of mixing zones. The Blue Book concluded that since all life stages, such as spawning and larval development, are necessary functions of aquatic organisms and are not protected in mixing zone, it was essential to insure that adequate portions of every waterbody were free from mixing zones (USEPA 1995). The Blue Book was updated again in 1976 (Red Book).

In 1983, USEPA simultaneously released Water Quality Standards (WQSs) regulations and the first Water Quality Standards Handbook (updated in 1994). The WQSs regulations included 40 CFR §131.13 cited above. The Water Quality Standards Handbook provided guidance on the interpretation and implementation of the WQSs regulation, including a discussion of mixing zones. This guidance with regard to mixing zones is discussed in the Mixing Zone Guidance section below. The Water Quality Standards Handbook also contained information on scientific and technical analyses that were used in making decisions that would impact WQSs.

In 1985, USEPA developed the Technical Support Document for Water Quality-Based Toxics Control (TSD), which was updated in 1991 (USEPA 1991). Mixing zones were discussed in the context of the whole effluent characterization process and the total maximum daily load (TMDL) and waste load allocations procedures. The document included several mixing and wasteload allocation models for rivers, lakes, and estuaries and descriptions of studies to identify isopleth concentrations (bands of similar concentrations) within a mixing zone. Guidance contained in the TSD with regard to mixing zones is discussed in the Mixing Zone Guidance Documents section below.

USEPA's (1979) longstanding interpretation of the CWA is that mixing zones are authorized. USEPA (1999, Response CTR-004-009) has stated it will continue to support the State's establishment of technically defensible mixing zones and dilution policies and implementation procedures, consistent with USEPA's water quality standards regulations and guidance, and their application in setting TMDLs and water quality based effluent limitations for acute, chronic, and human health criteria.

Several courts have considered the application of a mixing zone in a discharge permit and confirmed mixing zones are permissible under the CWA and upheld USEPA's use of a limited mixing zone (See Hercules v. EPA, 598 F.2d 91 (D.C. Cir. 1978); P.R. Sun Oil Co. v. EPA, *F.3d. 73, 75 (1st Cir. 1993); Marathon Oil Co. v. EPA, 830F. 2d 1346 (1987); and American Wildlands v. Browner, 00-1244 (10th Cir. 2001).

MIXING ZONE GUIDANCE DOCUMENTS

Compilation of EPA Mixing Zone Documents (USEPA 2006) was designed as a source of information for states, authorized tribes, and territories to use when developing and refining their mixing zone policies. According USEPA (2006), federal guidance for development of mixing zone policy is primarily contained in the following documents:

- Technical Support Document for Water Quality-Based Toxics Control (TSD) (USEPA 1991)
- Water Quality Standards Handbook (USEPA 1994)
- Allocated Impact Zones for Areas of Non-Compliance (USEPA 1995)
- NPDES Permit Writer's Manual (USEPA 1996)

This section describes guidance for mixing zones contained in these documents. Much of the guidance relates to the protection of aquatic organisms and applying mixing zones to constituents with acute and chronic criteria for the protection of aquatic life. Some guidance is general in nature and can be applied to mixing zones for constituents with only human health standards. Since this Basin Plan Amendment is restricted to constituents of concern only to human health, the discussion below is restricted to general guidance that is applicable to mixing zones for non-CTR human health constituents. In many cases, constituents with human health criteria do not adversely affect aquatic species. However, there can be a nexus between human health and aquatic life criteria. Implicit in the discussion of guidance for mixing zones for human health constituents is the concept that a mixing zone for human health should not adversely affect aquatic species. This is explicitly discussed in the Other Conditions for a Mixing Zone section below.

Technical Support Document for Water Quality-Based Toxics Control (TSD). The TSD discusses mixing zones with respect to water quality criteria and standards and to exposure and wasteload allocations. Chapter 2.2.2 discusses mixing zones as a means to meet water quality criteria and contains the following guidance for non-aquatic life criteria mixing zones:

- To ensure mixing zones do not impair the integrity of the waterbody, the mixing zone should not cause lethality to passing organisms.
- For protection of human health, the presence of mixing zones should not result in significant health risks, when evaluated using reasonable assumptions about exposure pathways. Thus, where drinking water contaminants are a concern, mixing zones should not encroach on drinking water intakes.
- Where fish tissue residues are a concern mixing zones should not result in significant health risks to average consumers of fish and shellfish, after considering exposure duration of the affected aquatic organisms in the mixing zone, and the patterns of fisheries use in the area.
- The size of the mixing zone and the area within certain concentration isopleths should be evaluated for their effect on the overall biological integrity of the waterbody. If the total area affected by elevated concentrations within all mixing zones combined is small compared to the total area of a waterbody (such as a river segment), then mixing zones are likely to have little effect on the integrity of the waterbody as a whole, provided that they do not impinge on unique or critical habitats.

Chapter 4.3 in the TSD discusses mixing zones provides background information on mixing zones and discusses EPA's mixing zone policy and how this policy affects the allowable toxic load that can be discharged from a point source. State mixing zone dimensions and the determination of mixing zone boundaries are also discussed.. It states that mixing zones can be allowed as long as the following conditions are met:

- Freedom from materials in concentrations that settle to form objectionable deposits.
- Freedom from floating debris, oil, scum, and other matter in concentrations that form nuisances

- Freedom from substances in concentrations that produce objectionable color, odor, taste, or turbidity
- Freedom from substances in concentrations that produce undesirable aquatic life or result in a dominance of nuisance species.

In addition, allowable mixing zone characteristics should be established to ensure the following:

- No impairment of the integrity of the waterbody as a whole
- No lethality to organisms passing through the mixing zone.
- No significant health risks, considering likely pathways of exposure.

The TSD recommends that mixing zone characteristics be defined on a case-by-case basis after a determination that the assimilative capacity of the receiving system can safely accommodate the discharge. This assessment should take into consideration the physical, chemical, and biological characteristics of the discharge and the receiving system; the life history and behavior of organisms in the receiving system; and the desired uses of the waters.

The TSD also recommends that, for incompletely-mixed discharges, a mixing zone analysis would be needed to determine if dilution is available, and if a mixing zone and dilution credit are appropriate. Such mixing zone studies include, but are not limited to: tracer studies, dye studies, modeling studies, and monitoring upstream and downstream of the discharge that characterizes the extent of actual dilution.

The TSD provides guidance for determining receiving water is available to dilute the discharge in a mixing zone. The receiving water flow should be based on the critical low flow of the receiving water because the priority pollutant criteria are established to protect uses at or above critical low flow conditions (i.e., these flows approximate a worst case condition). The TSD identifies two methods for calculating acceptable critical low flows: (1) the hydrologically-based method developed by the U.S. Geological Survey; and (2) the biologically-based method developed by the U.S. EPA. The hydrologically-based method (which has been used traditionally) establishes critical low flows of 1Q10, 7Q10, 30Q5, and harmonic mean that correspond to acute aquatic life criteria, chronic aquatic life criteria, human health criteria for carcinogens, and human health criteria for non-carcinogens, respectively. The biologically-based critical flow method requires more data than the hydrologic method but considers specific toxicological effects of a pollutant and biological recovery times in determining the flow. The effluent flow could be based on the facility's design flow, or the facility's maximum or mean flows over a specified period of time (e.g., maximum daily mean flow, mean daily mean flow). The selection of the effluent flow is based on a consideration of worst case conditions and the type of criterion.

Water Quality Standards Handbook. Chapter 5.1 of the Water Quality Standards Handbook discusses mixing zones. Mixing zone characteristics are recommended to be defined on a case-by-case basis after determining that the assimilative capacity of the receiving water can safely accommodate the discharge. This assessment should take into consideration the following:

- Physical, chemical, and biological characteristics of the discharge and receiving water;

- Life history and behavior of organisms in the receiving water;

- Desired uses of the waters.

Chapter 5.1 further states that mixing zones should not be permitted where they may endanger critical areas such as drinking water supplies, recreational areas, breeding grounds, or areas with sensitive biota. For human health protection, the presence of mixing zones should not result in significant human health risk when evaluated using reasonable assumptions about exposure pathways. Thus mixing zones should not encroach on drinking water intakes and should be restricted for bioaccumulative pollutants. Careful consideration should be given to the appropriateness of a mixing zone where a substance discharged is bioaccumulative, persistent, carcinogenic, mutagenic, or teratogenic.

The Water Quality Standards Handbook recommends that State water quality standards should describe the methodology for determining the location, size, shape, outfall design, and in-zone quality of mixing zones.

Allocated Impact Zones for Areas of Non-Compliance. The document Allocated Impact Zones for Areas of Non-Compliance (USEPA 1995) provides a holistic approach for development of mixing zones to prevent adverse impacts on the environment. The method considers all the impacts to the water body and all the impacts that the drop in water quality will have on the surrounding ecosystem and water body uses. It is a multistep data collection and analysis procedure that is particularly sensitive to overlapping mixing zones. This method includes the following:

- Identification of all upstream and downstream water bodies and the ecological and cultural data pertaining to them;
- Collection of data on all present and future discharges to the water body
- Assessment of relative environmental value and level of protection needed for the water body;
- Allocation of environmental impact for a discharge applicant.

The Allocated Impact Zones document recognizes that because of the difficulty in collecting the data necessary for this procedure and the general lack of agreement concerning relative values, this method will be difficult to implement in full. However, it serves as a guide on how to proceed in allocating a mixing zone.

NPDES Permit Writer's Manual. The NPDES Permit Writer's Manual refers to the Water Quality Standards Handbook and Chapter 4 of the TSD for guidance on mixing zones and how to conduct a mixing zone analysis.

STATE POLICIES

In 1952, the State Water Pollution Control Board (SWPCB), the predecessor to the State Board, published Water Quality Criteria (SWPCB 1952), which is a compilation of water quality criteria literature and its impacts on beneficial uses. Water Quality Criteria describes the concept of mixing zones. The publication devotes nearly a chapter to describe mixing and dilution and their role in determining if a pollutant in a waterbody is likely to cause adverse or unreasonable impacts on beneficial uses. In describing the advantages and disadvantages of water quality based standards versus effluent standards, the document states (SWPCB 1952, p. 57) "the principal advantage of standards of stream quality over effluent standards lies in the fact that they take into account dilution and the assimilative capacity of the receiving water and consequently lead generally to an economy of treatment works for pollution abatement."

Subsequent to SWPCB (1952), statewide plans and policies include the Water Quality Control Plan for Control of Temperature in Coastal and Interstate Water, and Enclosed Bays and Estuaries of California (California Thermal Plan), California's Ocean Plan, California Inland Surface Waters Plan (ISWP) and the California Enclosed Bays and Estuaries Plan (EBEP). The ISWP and EBEP were replaced by the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP) in 2005.

REGIONAL BOARD POLICIES

BASIN PLANS

The San Francisco Bay Region. The Water Quality Control Plan for the San Francisco Bay Region (SF Bay Basin Plan) provides for zones of initial dilution. The SF Bay Basin Plan classifies dischargers into two categories, deep and shallow. The deep-water submerged outfalls, which received an initial dilution of 10 through momentum and buoyancy, were given a dilution ratio of 10:1. The initial dilution from submerged outfalls in shallow water was determined either by 1) the dilution obtained through the momentum of discharge through turbulent mixing or 2) the dilution plume reaching a fixed distance from the discharge, whichever results in the lower estimate for initial dilution.

In general, the SF Bay Basin Plan anticipates limited to no dilution for shallow water discharges. However, the SF Bay Basin Plan provides dilution credits on a pollutant-by-pollutant basis based on provisions in the SIP. Although the current SF Bay Basin Plan contains water quality objectives for Title 22 constituents and effluent limitations for conventional pollutants, it does not say whether or not dilution credits for either deep or shallow water discharges are applicable to non-CTR constituents. However, a Basin Plan amendment for bacteria objectives for marine and estuarine waters currently under development supports the use of mixing zones for non-CTR constituents (specifically bacteria). The staff report states:

> "The approach taken in the proposed amendment is to establish the enterococcus geometric mean bacteriological criteria as the default "end-of-pipe" effluent limitation and to provide the Board the flexibility to adjust this limitation as well as other water quality-based default bacteria limitations to account for dilution in a manner consistent with procedures in the SIP. Establishing the allowable dilution credit through the permitting process generally requires the permitted entity to conduct a detailed dilution study for their specific discharge environment. "

The Basin Plan amendment proposes to add the following language with regard to bacteria:

"The water quality-based effluent limitations in Table 4-2A may be adjusted to account for dilution in a manner consistent with procedures in the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California…"

Los Angeles Region. The Water Quality Control Plan: Los Angeles Plan, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (LA Basin Plan) provides that mixing zones can be allowed for compliance with receiving water objectives on a case-by-case basis (page 4-30). The plan does not specify for which receiving water objectives mixing zones are allowed. Since the Chapter 3 (Water Quality Objectives) incorporates by reference Title 22 MCLs, it can be presumed that the allowance for mixing zones refers to constituents with MCLs as well as CTR constituents. The LA Basin Plan contains limitations on the size of a mixing zone.· For rivers and streams a mixing zone cannot extend more than 250 feet from the point of discharge or be located less than 500 feet from an adjacent mixing zone. The LA Basin Plan notes that due to minimal upstream flows, mixing zones are not appropriate for many of the streams in the region. For lakes and reservoirs: the mixing zone may not extend 25 feet in any direction from the discharge point. The sum of mixing zones in lakes and reservoirs may not be more that 5 percent of the volume of the water body.

Central Valley Region. Both the Sacramento and San Joaquin River Basin Water Quality Control Plan and the Tulare Lake Basin Water Quality Control Plan (Central Valley Basin Plans) contain mixing zone provisions. The Central Valley Regional Board may grant mixing zones in waste discharge requirements for acute, chronic and human health objectives provided the discharger has demonstrated to the satisfaction of the Regional Board that the mixing zone will not adversely impact beneficial uses. If allowed, different mixing zones may be designated for different types of objectives, including, but not limited to, acute aquatic life objectives, chronic aquatic life objectives, human health objectives, and acute and chronic whole effluent toxicity objectives, depending in part on the averaging period over which the objectives apply. The Central Valley Basin Plans dictate that USEPA guidance (TSD and Water Quality Standards Handbook) for mixing zones are used in determining the appropriate dimensions.

San Diego Region. The San Diego Basin Plan states that the Regional Board will consider the establishment of mixing zones for inland surface waters and enclosed bays and estuaries on a case-by-case basis.

Other Regions. Several basin plans, including the North Coast Region, include a provision for a zone of dilution for the water quality objective for turbidity, which is not considered a toxic substance. The North Coast Basin Plan states:

"Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof."

The Central Coast, Lahontan, Colorado River and Santa Ana basin plans do not have mixing zone provisions (other than turbidity for the Central Coast).

TOTAL MAXIMUM DAILY LOADS

Section 303(d) of the federal Clean Water Act and 40 CFR §130.7 require states to identify waterbodies that do not meet water quality standards and are not supporting their beneficial uses. These waters are placed on the Section 303(d) List of Water Quality Limited Segments (List), also known as the 303(d) List of Impaired Waterbodies. The List identifies the pollutant or stressor causing impairment and establishes a schedule for developing a control plan to address the impairment. Placement on this list generally triggers development of a pollution control plan called a Total Maximum Daily Load (TMDL) for each waterbody and associated pollutant/stressor on the list. The TMDL process leads to a "pollution budget" designed to restore the health of a polluted body of water. The TMDL process provides a quantitative assessment of water quality problems, contributing sources of pollution, and the pollutant load reductions or control actions needed to restore and protect the beneficial uses of an individual waterbody impaired from loading of a particular pollutant. More specifically, a TMDL is defined as the sum of the individual waste load allocations for point sources, load allocations for non-point sources, and natural background such that the capacity of the water body to assimilate pollutant loading (the loading capacity) is not exceeded (40 CFR §130.2). In other words, a TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards which will insure the protection of beneficial uses. This calculation also includes a margin of safety and consideration of seasonal variations. In addition, the TMDL contains the reductions needed to meet water quality standards and allocates those reductions among the pollutant sources in the watershed. The Clean Water Act of 1972 gave the State Water Resources Control Board and the US Environmental Protection Agency (EPA) the authority to establish TMDLs under Section 303(d).

LOCAL REGULATIONS

No regulations promulgated by local agencies in the North Coast region have been identified.

BASIN PLAN AMENDMENT ALTERNATIVES

ALTERNATIVES FOR A MIXING ZONE

This section describes alternatives to address a mixing zone policy for effluent limitations for non-CTR constituents with human health MCLS in the North Coast Basin Plan. The first alternative proposes no change to the Basin Plan. The seven other alternatives propose amending the Basin Plan in some fashion to allow for a mixing zone when calculating effluent limitations.

Alternative 1. No Action – Under the No Action alternative, the Basin Plan would not be revised to allow mixing zones and dilution credits for the calculation of effluent limitations for non- CTR constituents.

ALTERNATIVES TO AMEND THE BASIN PLAN TO ALLOW MIXING ZONES

Alternatives to amend the Basin Plan to allow mixing zones for non-CTR constituents differ on the basis of allowable constituent and the size of the mixing zone. Table 1 presents the matrix of alternative components.

Table 1. Mixing Zone Alternative Components

Allowable Constituents	**Mixing Zone Size**		
	Small	**Medium**	**Large**
All constituents with Primary and Secondary MCLs	Alternative 2	Alternative 3	Alternative 4
Nitrate and Non-CTR DBPs	Alternative 5	Alternative 6	Alternative 7

Alternative 2. Under this Alternative, a Basin Plan policy is established that allows mixing zones for effluent limitations for all constituents with Title 22 primary and secondary Maximum Contaminant Levels (MCLs) and limits the mixing zone to a small area of the stream relative to Alternatives 3 and 4.

Alternative 3. Under this Alternative, a Basin Plan policy is established that allows mixing zones for effluent limitations for all constituents with Title 22 primary and secondary Maximum Contaminant Levels (MCLs) and limits the mixing zone to an intermediate area of the stream relative to Alternatives 2 and 4.

Alternative 4. Under this Alternative, a Basin Plan policy is established that allows mixing zones for effluent limitations for all constituents with Title 22 primary and secondary Maximum Contaminant Levels (MCLs) and limits the mixing zone to a relatively large area of the stream as compared to Alternatives 2 and 4.

Alternative 5. Under this Alternative, a Basin Plan policy is established that allows small mixing zones for nitrate and non-CTR chlorine breakdown products (non-CTR DPBs). This alternative would be similar to Alternative 2, but applied only for the specified constituents.

Alternative 6. Under this Alternative, a Basin Plan policy is established that allows mixing zones for effluent limitations for nitrate and non-CTR DBPs and limits the mixing zone to an intermediate area of the stream relative to Alternatives 5 and 7.

Alternative 7. Under this Alternative, a Basin Plan policy is established that allows mixing zones for effluent limitations for nitrate and non-CTR DBPs and limits the mixing zone to a relatively large area of the stream as compared to Alternatives 6 and 7.

OTHER CONDITIONS FOR A MIXING ZONE

In addition to the size and constituent limitations described above, it is recommended that the Mixing Zone Alternatives 2 through 7 contain conditions that would lessen or eliminate environmental impacts.

These conditions include the following:

1. A mixing zone shall not result in the exceedence of any primary or secondary MCL within any known drinking water intake.

2. A mixing zone shall not:

   a. result in acute toxicity or bioaccumulation to aquatic life passing through the mixing zone

   b. restrict the passage of aquatic life

   c. adversely impact biologically sensitive or critical habitats, including, but not limited to, habitat of species listed under federal or State endangered species laws.

3. For human health constituents with CTR criteria for the protection of aquatic life, the smaller of the mixing zone as determined by this policy and the mixing zone as determined by the SIP shall apply.

4. A mixing zone shall not produce color, odor, taste, suspended material, or turbidity that causes a nuisance or adversely affects beneficial uses.

5. A mixing zone shall not result in floating material, oil or grease in concentrations that cause a nuisance or adversely affects beneficial uses.

6. A mixing zone shall not result in an increase in plant growth that causes a nuisance or adversely affects beneficial uses.

7. A mixing zone shall not result in bottom deposits that causes a nuisance or adversely affects beneficial uses.

8. A mixing zone shall not dominate the receiving water body or overlap a mixing zone from different outfalls.

9. A mixing zone shall not result in the exceedence of an established TMDL

METHODS OF COMPLIANCE TO A MIXING ZONE POLICY

Potential environmental impacts associated with the Basin Plan Amendment depend, in part, upon the specific compliance methods selected by the POTWs which, as public agencies, are subject to their own CEQA obligations. (See Pub. Res. Code section 21159.2). The Regional Water Board does not specify the means by which permittees must comply with the requirements of the Basin Plan, including any provisions of the proposed BPA

Mixing zones potentially involves many constituents. A full evaluation of methods of compliance for each constituent is infeasible. Therefore, the analysis of reasonably foreseeable methods of compliance and the analysis of potential environmental impacts associated with these methods of compliance in this document focuses on one constituent – nitrate. Nitrate was chosen because it is the constituent for which the most information is available.

The following are reasonably foreseeable methods of compliance for mixing zones and for the No Action alternative.

No Action (Alternative 1)

- Treatment plant improvements. Appendix B describes in detail potential methods of nitrogen removal and treatment plant improvements for POTWs in the North Coast Region. Treatment plant improvements include:

    - addition of a Membrane Bioreactor (MBR) system
    - extended aeration package plant
    - addition of activated sludge capacity
    - addition of capacity to solids contact basin

  Appendix B also describes estimated costs for treatment plant improvements. Depending on the facility and upgrades needed for improved nitrogen removal, capital costs range from $1.7 million to $5.8 million with operating costs ranging from $26,000 to $840,000 annually. Assuming a twenty year lifecycle, this translates to a total cost for treatment plant improvements of $2.1 to $14.7 million.

- Wetlands constructed for nitrogen removal. Wetlands for nitrogen removal could also be constructed for purposes of habitat enhancement and could include marsh or open water as well as riparian or upland habitat that could support a variety of plant species valuable to wildlife and ecosystem functions. The wetlands could be of a variety of sizes and types, and interpretive trails and viewing points could also be provided at the wetlands.

  Kadlec and Wallace (2009) estimate the median capital cost for a free water surface constructed wetland is approximately $100,000 per hectare. These costs include land, site investigation and system design, earthwork, liners, media, plants, water control structures and piping, site work, and human use facilities. Costs for wetlands in Northern California may be higher due to high land costs in some areas. The median cost for operations and maintenance of a free water surface wetland is estimated by Kadlec and Wallace (2009) to be approximately $2,000 per hectare. The size of wetland necessary to remove nutrients depends on the concentration in the effluent, the desired ending concentration and the season. Treatment wetland sizes in Southern California range from 4 to 13 hectares per mgd of effluent (Reilly, et al. 2000; Fleming-Singer and Horne, 2006).

- Source control. Source Control focuses on the reduction or elimination of contaminants before they enter the sewer system rather than treating them after they have been mixed with other wastes. In typical collection systems, source control for nitrate is infeasible because of the diffuse source (human waste). Individual treatment plant operators should consider any possible concentrated source of nitrate from industries or businesses. Source control measures would depend on the businesses and industries that discharge to the discharge's treatment plant.

Mixing Zone (Alternatives 2 through 7)

- Diffusers. Diffusers could be used to reduce the size of a mixing necessary to achieve compliance with effluent limitations. These could include an in-bank or an in-stream type diffuser. The diffuser could extend into the waterway and could include and encasement and riprap for streambed stability. On-bank structures might also be part of a diffuser facility. The cost for a diffuser is very site specific and would range from about $100,000 to about $1.0 million.

- Increased storage to allow modulation of discharge to achieve a particular receiving water to wastewater flow ratio. Storage facilities could be constructed either by berming on level sites, or, in hillside areas, by damming a natural drainage or valley by means of an earth filled embankment dam. Storage facilities may require lining and for storage facilities in hillside areas, smaller back dams or drainage diversion structures around the storage area may be required. Designs for overflow facilities could include pipelines and spillways, with appurtenant energy dissipation facilities such as riprap and other and bank protection facilities as needed so that the velocity of water in downstream reaches would be approximately that which normally occurs in the channel in the absence of a reservoir. Acquisition of property may be required for the reservoirs and appurtenant facilities, including inlet and outlet pipelines and access roads. In addition, pump stations and conveyance pipelines may be required to convey recycled water to the discharge sites. For the purposes of this analysis, storage is assumed to be unnecessary to meet the conditions for the mixing zone for Alternatives 4 and 7 since these alternatives are defined to allow for a relatively large mixing zone that could result from an unmodulated discharge that would occur in the absence of storage. Costs for engineering and construction of storage ponds are typically approximately $200,000 per million gallons of storage (Winzler & Kelly, 2007).

RANGE OF POTENTIALLY ALLOWABLE MIXING ZONES

A mixing zone is dynamic, depending on flow, physical conditions in the waterway, and the chemical properties of both the waters being mixed. Mixing zones can be characterized in many ways. Tracer or dye studies and mixing models can be used for that purpose. Tracer studies use a physical or chemical constituent in the discharge that is distinct from the receiving waters to characterize dilution where dye studies use a dye as a tracer. Mixing models can range from simple models, which use a few equations to estimate the extent of mixing, to very complex computer models, which account for numerous factors and require a high level of expertise in order to apply properly. Choice of model will depend upon the complexity of the system including the dominant type of flow in the system, geomorphology, and type of diffuser system chosen.

Mixing zones are applicable in a discharge situation where the discharge concentration of the constituent in question is greater than the ambient concentration of the same constituent. To assess the potential application of mixing zones in the North Coast region, the extent (i.e., length) of potential mixing zones, necessary information, and examples are described below. For the purpose of this report, discharge outfall and receiving water characteristics based on available data, which are listed in Table 2 below, were examined to assess the length of potential mixing zones.

Table 2. North California Discharge Facilities

Municipality, NPDES Permit # and Adoption Date	Outfall Location	Water body	Outfall Type[1]	Treatment Type	Permitted Average Dry Weather Flow (ADWF), mgd	Discharge Restrictions (when allowed)	Storage Conditions	Receiving Water (RW) Flow
Arcata NPDES Permit No. CA0022713 June 22, 2004	Outfall 001: 40º 51' 16"N, 124º 05' 54"W Outfall 002: location is located approximately 5 feet from outfall 1	Outfall 001 Humboldt Bay Outfall 002 AMWS(Arcata Marsh & Wildlife Sanctuary)	24" pipe to marsh, 26" pipe from marsh to Bay[2]	Chlorinated secondary	5 [3]	Discharge to Humboldt Bay must be in conjunction with discharge to AMWS		Unknown, not applicable to Humboldt Bay/Marsh
Cloverdale NPDES No. CA0022977 June 29, 2006	38° 47' 47"N 123° 0' 18"W	Russian River (RR)	12-18" pipe with no diffuser	Chlorinated secondary	1.0, 8.25 peak wet weather flow(PWWF)	Discharge restricted to October 1 through May 14 (seasonal discharge prohibition) 1% of the receiving water flow[5]	Has storage to limit/manage discharge	Measured in the RR near Cloverdale at USGS gage 11463000
College of the Redwoods NPDES No. CA0006700 June 10, 2010	40º 41' 56.20"N 124º 12' 11.77"W	White Slough - an estuarine tributary of Humboldt Bay	Unknown	Chlorinated secondary	0.1 [6]	No seasonal prohibition	No appreciable storage	Unknown, not applicable to Humboldt Bay
Covelo NPDES No. CA00235'74 March 8, 2006	39°47'2"N 123°14'37"W	Grist Creek (trib. of Mill Creek - trib. of Middle Fork of Eel River)	6" pipe[7]	Chlorinated secondary	0.08, 0.384 PWWF	Seasonal discharge prohibition, 1% of flow to Grist Creek during discharge season	Has storage to limit/manage discharge	n/a[8]
Ferndale NPDES No. CA0022721 July 23, 2009	40º35' 40"N 124º15' 44"W	Francis Creek/Salt River tributary to Eel River.	One 12" and one 6"[9]	Secondary[10]	0.576 [11]	Seasonal discharge prohibition, 1% of upstream receiving water flow during discharge season[12]		n/a[13]
Forestville NPDES Permit No. CA0023043 October 6, 2004	38° 27' 58"N 122° 53' 18"W	Jones Creek trib. to Green Valley Creek trib. to RR	12" pipe (est.)[14]	Chlorinated tertiary for discharge	0.13 [16]	Seasonal discharge prohibition, 1% of Green Valley Creek flow during discharge season	Limited Storage	n/a[17]
Fortuna NPDES No. CA0022730 Sept. 13, 2007	40º 35' 34"N 124º 09' 30"W	Strongs Creek, trib. of Eel River	18" pipe[18]	Chlorinated secondary	1.5, 7 PWWF	Seasonal discharge prohibition, 1% of flow of Eel R. during discharge season.	Has storage to limit/manage discharge	USGS 11477000 + USGS 11478500 [19]
Graton NPDES PERMIT No. CA0023639 October 6, 2004	38° 26' 48"N 122° 52' 46"W	Atascadero trib. to Green Valley Creek	8"(est.) pipe[20]	Chlorinated secondary[15]	0.14, 0.85 PWWF	Seasonal discharge prohibition, 1% of flow of Atascadero during discharge season.	Has storage to limit/manage discharge	n/a[21]

Table 2. North California Discharge Facilities								
Municipality, NPDES Permit # and Adoption Date	**Outfall Location**	**Water body**	**Outfall Type[1]**	**Treatment Type**	**Permitted Average Dry Weather Flow (ADWF), mgd**	**Discharge Restrictions (when allowed)**	**Storage Conditions**	**Receiving Water (RW) Flow**
Healdsburg NPDES No. CA0025135 October 28, 2010	38°34'48"N 122°51'48"W	Basalt Pond	a straight CMP culvert outlet that is usually just above the water line	Tertiary with UV	1.4	Seasonal discharge prohibition, 1% of flow of RR during discharge season		USGS 11464000 + USGS 11465350 [45]
Loleta NPDES No. CA0023671 March 6, 2008	40° 38' 23"N 124° 13' 37"W	Wetland tributary to the Eel River	12" pipe[22]	Chlorinated secondary	0.081, 0.143 (avg. wet)	Seasonal discharge prohibition, 1% of flow of Eel R. during discharge season.		USGS 11477000 + USGS 11478500 [23]
McKinleyville CSD NPDES No. CA0024490 June 12, 2008	40° 55' 28"N 124° 7' 13"W	Mad River	12" pipe[24]	Chlorinated secondary[25]	1.61, 3.3 [26]	Seasonal discharge prohibition, during discharge season, only when flow > 200 cfs and 1% of Mad River flow	Has storage to limit/manage discharge	USGS 11481000 [27]
Occidental CSD NPDES No. CA0023051 May 27, 1993	38° 24'46"N 122°56'31"W	Graham's Pond to Dutch Bill Creek trib. of RR	No pipe[28]	Chlorinated secondary	0.02 (as of 1993)	Seasonal discharge prohibition, during discharge season, 1% of flow of Dutch Bill Creek	Has storage to limit/manage discharge	n/a[29]
Redway CSD NPDES No. CA00229781 May 17,2006	40° 7'48.22"N 123°49'20.23"W	Eel River	4" pipe[30]	Chlorinated secondary	0.19, 0.58 PWWF	Seasonal discharge prohibition, during discharge season, 1% of Eel R. flow		USGS 11476500 [31]
Rio Dell NPDES No. CA0022748 February 8, 2007	40° 29' 45"N 124° 5' 30"W	Eel River	14" pipe[32]	Chlorinated secondary	0.3, 0.7 PWWF[33]	Seasonal discharge prohibition, during discharge season, 1% of Eel R. flow		USGS 11477000
Russian River CSD NPDES No. CA002405 January 29, 2009	38° 28' 54"N 123° 0' 3.2"W	Russian River	4" pipe[34]	Tertiary, upgrading to UV	0.71, 3.5 PWWF	Seasonal discharge prohibition, during discharge season, 1% of RR flow		USGS 11467000
Santa Rosa Subregional System NPDES No. CA0022764 Sept. 20, 2006 amended July 24, 2008	Primary discharge. location 38 º 26' 54" N 122 º 49' 27" W	Laguna de Santa Rosa, tributary of RR	48" pipe with diffuser	Tertiary with UV	21.34 64 peak weekly 47.3 peak monthly	Seasonal discharge prohibition, during discharge season, 5% of RR flow	Has storage to limit/manage discharge	USGS 11467000

Table 2. North California Discharge Facilities								
Municipality, NPDES Permit # and Adoption Date	**Outfall Location**	**Water body**	**Outfall Type[1]**	**Treatment Type**	**Permitted Average Dry Weather Flow (ADWF), mgd**	**Discharge Restrictions (when allowed)**	**Storage Conditions**	**Receiving Water (RW) Flow**
Town of Scotia NPDES No. CA0006017 June 29, 2006	40°29'7"N 124°6'9"W	Eel River	12" pipe[35]	Chlorinated secondary	0.77 PWWF[36]	Seasonal discharge prohibition, during discharge season, 1% of Eel R. flow		USGS 11477000
Tulelake NPDES No. CA0023272 October 6,2004	41°56'55"N 121°28'15"W	Lower Lost River and Tule Lake		Chlorinated secondary	0.16	No seasonal prohibition		n/a[37]
Ukiah NPDES No. CA0022888 Sept. 20, 2006	39°07'05.98"N 123°11'32.00"W	Russian River	Pipe[38]	Chlorinated tertiary / secondary	3.01, 8.0 PWWF[39]	Seasonal discharge prohibition, during discharge season, 1% of RR flow	Has storage to limit/manage discharge	USGS 11462500
Willits NPDES No. CA0023060 July 15, 2010	Discharge point 001 39° 25' 14" N 123° 20' 24" W Discharge Point 003 (after construction of new WWTP) 39°25'38"N 123°20'38"W	Outlet Cr., trib. to Eel River	001 - 24" horizontal pipe[40] 003 will be after a treatment wetland	Secondary[41]	1.3, 3.0 PWWF	Seasonal discharge prohibition, during discharge season, 1% of Broaddus Cr. Flow		USGS 11472160 [42]
Windsor NPDES No. CA0023345 June 14, 2007	38° 29' 39"N 122° 51' 05"W	Mark West Creek, trib. to RR	18" (est.) pipe[43]	Tertiary UV	2.25, 7.2 PWWF	Seasonal discharge prohibition, during discharge season, 1% of MWC flow minus Santa Rosa's discharge	Has storage to limit/manage discharge	measured at Trenton-Healdsburg Bridge[44]

Table 2. North California Discharge Facilities

Municipality, NPDES Permit # and Adoption Date	Outfall Location	Water body	Outfall Type[1]	Treatment Type	Permitted Average Dry Weather Flow (ADWF), mgd	Discharge Restrictions (when allowed)	Storage Conditions	Receiving Water (RW) Flow

[1] No outfalls had diffusers unless noted. All the outfalls were assumed as side discharge to the receiving water body.
[2] Discharge to the bay is near the edge of the bay. They only rarely bypass the marsh and discharge directly to the bay.
[3] WWTF plant designed for a dry weather flow of 2.3 mgd and a maximum hydraulic capacity through the primary system of 5.0 mgd. Flows in excess of 5.0 mgd bypass the primary system and are routed directly to the oxidation ponds for treatment.
[5] Current permit allows discharge during the discharge season (October 1 - May 14) at 1% of the flow of the Russian River if WWTP upgraded to tertiary.
[6] Mean dry weather flow not to exceed 0.1 mgd averaged over a calendar month
[7] Discharge pipe doesn't reach stream. Discharge would flow along bank.
[8] Measured manually at point of discharge. Little data available (estimated 10 observations). Receiving water body is dry majority (est. 2/3) of the year, but winter flows can be notable with depths at the discharge location of up to 6 ft deep. No gauge. No records provided.
[9] Current pipes are one 12" and one 6". They don't run both at the same time. Proposed is 8". Outfall is on the riverbank. Riprap will be put in for new facility.
[10] Upgrade will be tertiary, UV disinfection, denitrification
[11] With plans for upgrade with 0.55 mgd ADWF and 0.95 peak wet weather flow
[12] They got an 1:1 exemption so can discharge at 100% of the flow for new facility
[13] When measured, measured at Van Ness Bridge on Francis Creek. Unknown who operates or keeps data. No records provided
[14] It discharges under a bridge above the water line in all but high flows.
[15] Highly polished, approximately equivalent to tertiary
[16] 0.357 maximum monthly. 0.58 maximum daily
[17] Measured at Iron Horse Bridge, no records provided.
[18] Pipe is on the bank above the creek. It goes down a rock passage way with riprap 12" boulders. About 10' to creek depending on depth of creek.
[19] Scotia gauging station (USGS Station 11477000) combined with the flow as measured at the Grizzly Creek gauging station (USGS Station 11478500)
[20] Discharge to a pond to commingle with local watershed runoff. When discharge occurs from pond, water is released through an 8 inch (est.) pipe to a pasture, after which flows diffuse into a tributary of Dutch Bill Creek.
[21] Atascadero monitored at Green Valley Road Bridge. No records provided
[22] Pipe goes 1/4 mile through pasture land/wetland with combined sanitary sand storm water. It discharges into wetland. From there, it runs to an oxbow seasonal water body tributary to the Eel R.
[23] Scotia gauging station (USGS Station 11477000) combined with the flow as measured at the Grizzly Creek gauging station (USGS Station 11478500)
[24] 15' long flexible rubber pipe anchored in concrete lays along the bottom. Downstream of old railway trestle. The pipe is in the hole that has been dug by an eddy around the trestle.
[25] With two finishing treatment wetlands so nitrate is usually ND.
[26] Plant design flow =1.61 (presumably ADWF). Permitted to discharge up to 3.3 mgd
[27] Highway 299 overpass (USGS Gage No. 11481000)
[28] It discharges from the storage pond to a ditch that runs 500 yds before it reaches Dutch Bill Creek
[29] Measured at Camp Meeker which is considerably downstream of actual discharge. Flow in creek where discharge enters is fairly low. No records provided.
[30] 25 ft above Eel R. Usually when discharging, the river is high enough so that it goes directly into the river.
[31] Closest gauge. DWR Miranda (MRD) station
[32] Although flow is much less. It ends up about 50 yds from the river, exits out of a wall onto the ground. Riprap where it spills out. Then, it goes across land to the river.
[33] Plant capacity = 0.9 mgd
[34] Underground pipe discharges off the bank; underwater most of the time. It extends above the bed out a short distance into the river
[35] With screen on end. It is on bank but, when discharging, it is nearly always underwater, extending several feet into the river channel.
[36] Facility design flow will be determined by a special study (from NPDES permit)
[37] Discharges to a drain that is tributary to Tule Lake Refuge
[38] No additional details.
[39] With upgrade, 3.01 mgd, 6.89 mgd PWWF and 24.5 mgd secondary PWWF
[40] About 2 ft off bottom of creek. Out of water at lower flows.
[41] In process of upgrading tertiary with UV
[42] Flow is measured at concrete flow-control structure in the creek at the point of discharge.
[43] On bank and can be underwater in high flow. A grate surrounded by riprap- about 2 ft boulders
[44] Few data in the time period between 1991 -1996.
[45] New NPDES permit will measure the 1% discharge compliance as the combined Russian River flow at the Dry Creek confluent.

ESTIMATING MIXING ZONE LENGTH

The estimation of mixing zones was completed using formulations developed by Fischer et al (1979) because limited site specific information was available and the approach provides a useful initial screening approach. Mixing zone length can be calculated based on the velocity of the receiving water, the width of the stream, a transverse mixing coefficient that incorporates depth and is evaluated at the discharge location (i.e., center or bank discharge) (see Appendix C for details on calculations). Transverse mixing is mixing that occurs perpendicular to the flow of the water body. The effects that different variables generally have on the mixing zone length are presented in Table 3, but local conditions and combinations of factors can play an important role. In general, while both increased channel width and increased water velocity increase the mixing zone length, increased transverse mixing decreased the mixing zone length.

Table 3. Variables and Their Effects on a Mixing Zone Length.

Variable	**Variable Type**	**Effect on Mixing Zone Length**
Transverse Mixing	More Transverse Mixing	Shorter
Velocity	Faster Water	Longer
Width	Wider Water Body	Longer
Depth	Deeper	Shorter

In this simplified representation, transverse mixing in a water body can be affected by several variables, including shear velocity, water depth, bed slope, sinuosity, flow variability and complexity, discharge flow (including orientation and momentum), of the water body (Table 4).

Table 4. Variables and Their Effects on Transverse Mixing.		
Variable	**Variable Type**	**Effect on Transverse Mixing**
Bed Slope	Steeper Slope	More
Channel Direction Variability	Straighter Channel	Less
Channel Shape Variability	More Irregular Channel Shape	More
Flow Type Variability	Higher Flow Type Variability	More
Discharge Momentum	Higher Discharge Momentum	More
Discharge to Receiving Water Ratio	Higher Discharge to Flow Ratio	More
Other Inflows	More Inflows	More
Shear Velocity	Higher Shear Velocity	More
Water Depth	Deeper Water	More

Using the equations and methodology presented in Appendix C, a range of mixing zone lengths can be estimated for different channel forms and receiving water flows. For these analyses, the momentum associated with the discharge is assumed negligible.

ASSUMPTIONS IN DETERMINING MIXING ZONE LENGTH

The mixing zone length can be estimated based on the receiving water flow and ambient concentration, channel configuration (e.g., depth. width, slope) at the discharge location, discharge flow and concentration, discharge location, and transverse mixing coefficient. For this analysis, such variables were based on available information and are considered general estimations and not specific to a particular discharge environment. In this analysis bed slope, water depth, and shear velocity are used to estimate transverse mixing.

Parameters used to determine the mixing zone length include the average channel width, slope, and curve radius (if applicable), discharge flow rate and concentration, receiving water flow rate and concentration, discharge location, transverse mixing constant, either Manning's roughness coefficient or depth, and the regulatory concentration. . Nitrate was chosen as a representative pollutant, and 0.2 mg/L was used as the background concentration within the receiving water. A regulatory concentration for nitrate of 10 mg-N/L was used to estimate mixing zone length. The regulatory concentration in the receiving water was used in this analysis as a target or goal to allow mixing zone size to be estimated for the various POTWs examined.

MIXING ZONES IN THE NORTH COAST REGION

Eleven municipalities within the North Coast Region were examined to describe the range of mixing zone size. The municipalities, presented in Table 5, were selected because they represent the range of receiving water flow and concentration, depth and channel width, and discharge flow and concentration that is considered representative of the region. The permitted Average Dry Weather Flow (ADWF) discharge and mean receiving water flows for each municipality is presented in Figure 1. Monthly average flow and gage height (used for depth) from the nearest gage in the receiving water for each municipality were calculated (the average for all January data available was calculated, then the average for all February data available was calculated, etc.) to determine the discharge season average flow and depth for each receiving water location (discharge season was estimated to be from October 1 through May 14). Aerial imagery from Google Earth was used to estimate the channel width for each location.

Table 5. North Coast Region Example Municipalities.							
Municipality	**Receiving Water Location**	**Gage Nearest Discharge Location**	**Gage Record (Water Years)**	**Estimated Width, ft**	**Receiving Water Size Group**	**Discharge Season Average Receiving Water Flow, cfs**	**Permitted Average Dry Weather Discharge Flow, cfs**
Willits[1]	Broaddus Creek (Eel River Tributary in Willits, CA	11472160	2004-2009	25	Very small	11	2.01
Ukiah[2]	Russian River near Hopland, CA	11462500	1940-2009	70	Small	955	1.55
Cloverdale	Russian River near Cloverdale, CA	11463000	1952-2009	80	Small	1,322	4.66
Healdsburg[3]	Russian River near Healdsburg, CA	11464000	1940-2008	115	Medium	2,033	2.17
Santa Rosa[4]	Santa Rosa Creek/Laguna de Santa Rosa	11466320 11465750	1999-2009	-	-	-	-
McKinleyville CSD	Mad River near Arcata, CA	11481000	1963-2009	200	Medium	2,000	2.49
Russian River CSD	Russian River near Guerneville, CA	11467000	1940-2009	140	Medium	3,316	1.10
Redway CSD	South Fork of the Eel River near Miranda, CA	11476500	1940-2008	120	Medium	2,718	0.29
Fortuna[5]	Eel River above Scotia, CA	11477000	1911-2008	150	Large	10,813	2.32
Loleta[5]	Eel River above Scotia, CA	11477000	1911-2008	150	Large	10,813	0.13
Rio Dell	Eel River above Scotia, CA	11477000	1911-2008	150	Large	10,813	0.49
Town of Scotia	Eel River above Scotia, CA	11477000	1911-2008	150	Large	10,813	1.19

[1] Willits discharge determination uses flow data from Willits Creek above Lake Emily near Willits, CA (USGS 11472160)

[2] Due to the irregular nature of the Ukiah stage and flow relationships, Ukiah data was not used to calculate the small receiving water size group information in the example calculations presented within this document.

[3] Healdsburg discharge is not a direct discharge, but is included because these waters reach the Russian River. Healdsburg discharge determination uses flow data from Russian River near Healdsburg, CA (USGS 11464000) and Dry Creek near mouth near Healdsburg, CA (USGS 11465350)

[4] Santa Rosa discharge currently incorporates a mixing zone approach that addresses variable flow conditions in Santa Rosa Creek (USGS 11466320) and the Laguna de Santa Rosa (USGS 11465750) and is not assessed herein, but is included in this table for completeness.

[5] Fortuna and Loleta discharge determinations are based on flow data from Eel River above Scotia, CA (USGS 11477000) plus Van Duzen River near Bridgeville, CA (USGS 11478500). For the purposes of this table, the Discharge Season Average Receiving Water Flow column refers to only the Eel River above Scotia.

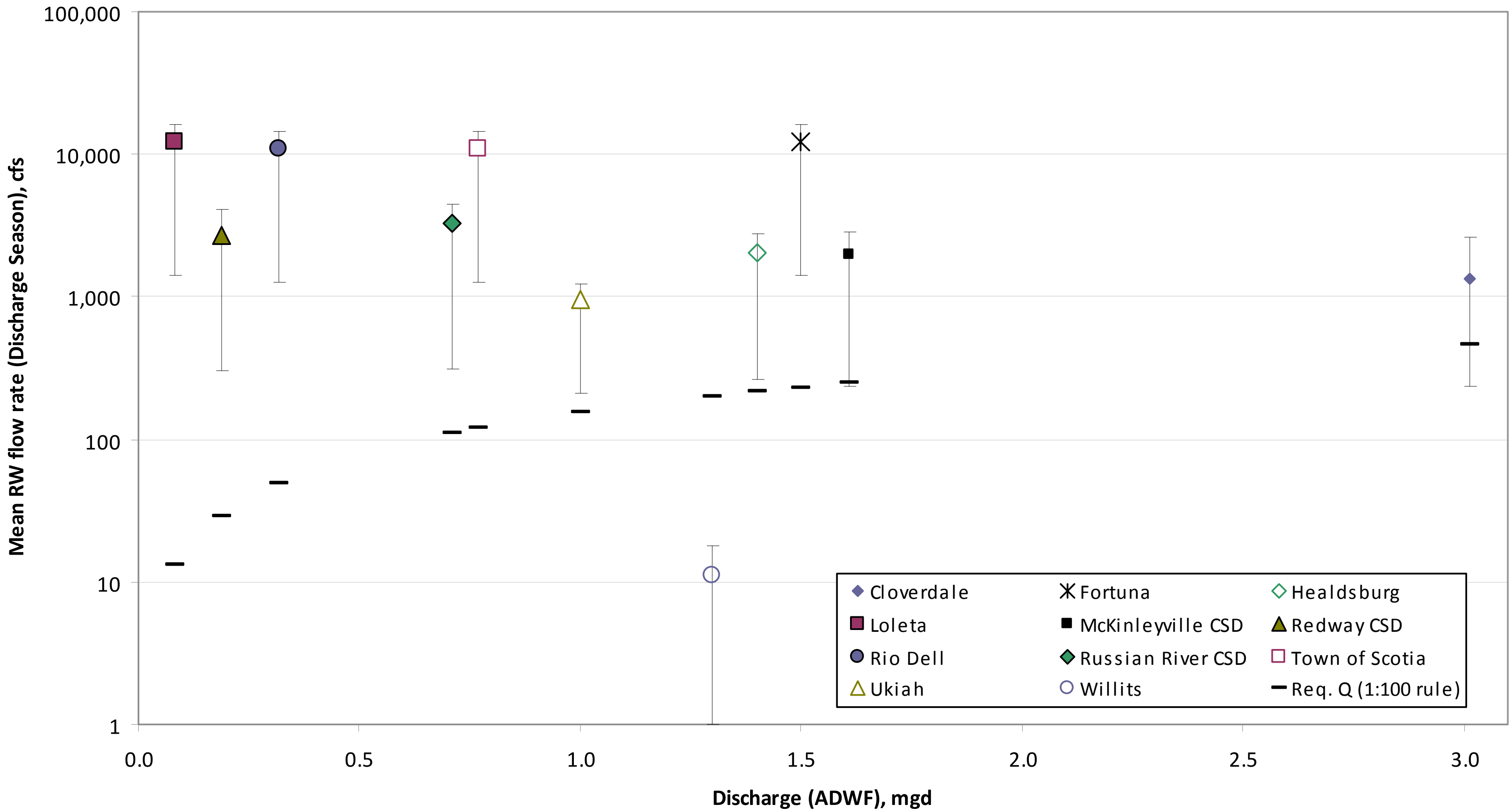

Figure 1. ADWF discharge and mean receiving water (RW) flow rates for selected municipalities in the North Coast Region. Data points show the mean discharge season flow, error bars show the minimum and maximum mean discharge season flows. Horizontal bars depict necessary receiving water flow rate for discharge to occur at the 1 percent (1:100) dilution level. All calculations were based on length of record for each location, except for Willits which was based on a six year record.

The municipalities were grouped into four receiving water flow size categories: very small, small, medium, and large. For each grouping, the monthly average flows, gage heights, and channel widths examined. The very small and small groups had one municipality per group and therefore used the actual data from the respective receiving waters. The data from the Ukiah discharge location contained extremely irregular relationships between flow and gage height and was therefore discarded. The medium size group contained four municipalities, and the flows, gage heights and channel widths were averaged to create an average data set for the medium size group. For the large receiving waters, all four of the discharge locations shared the same gage, so the monthly average flow and gage height, as well as the channel width, were estimated from USGS gage data in the Eel River above Scotia, California. The four receiving water size groups' flow and gage height were graphed and a power regression relationship was fitted to each receiving water size (see Appendix C for details). The relationship was used to estimate water depths for the range of flows represented in each receiving water size group. A power regression relationship was selected to ensure the flow and depth relationship did not curve downwards (indicating a drop of water depth) at high flow volumes. The flow ranges and the associated estimated water depth is presented in Table 6 for each of the four receiving water size groups.

Table 6. Range of Flows and the Associated Estimated Depths for Each Receiving Water Size Group.

Very small (n=1)		Small (n=1)		Medium (n=4)		Large (n=1)	
Width = 25 ft		Width = 75 ft		Width = 144 ft		Width = 150 ft	
Flow, cfs	Depth, ft	Flow, cfs	Depth, ft	Flow, cfs	Depth, ft	Flow, cfs	Depth, ft
1	0.31	197	2.36	101	3.41	158	9.6
2	0.41	198	2.37	105	3.45	162	9.6
5	0.57	217	2.45	131	3.64	328	9.9
10	0.74	226	2.49	149	3.76	437	10.1
15	0.86	210	2.42	313	4.54	3,495	12.4
20	0.95	575	3.55	908	5.94	5,029	13.1
25	1.03	345	2.92	1,423	6.65	8,353	14.1
30	1.11	1,022	4.43	2,096	7.33	13,117	14.8
35	1.17	2,675	6.40	4,529	8.91	30,282	20.3
40	1.23	4,093	7.53	8,614	10.5	52,047	24.9
45	1.28	3,879	7.38	8,660	10.5	57,283	25.9
58	1.41	3,814	7.33	10,536	11.0	70,551	28.0

Permitted ADWF varied considerably within each receiving water size group. Overall the ADWF range from 0.13 cfs to 4.66 cfs. The very small group only had one data point (2.01 cfs). The small group had one discharge of 4.66 cfs (the largest observed). The medium group ranged from 0.29 cfs to 2.49 cfs, while the large group ranged from 0.13 cfs to 2.32 cfs.

Data needs for this analysis included:

- Estimated channel parameters (width, depth, and slope),
- Receiving water conditions (flow and ambient concentration),
- Discharge conditions (flow, concentration, and location), and

- Criteria conditions (regulatory concentration and measurement location).
- Discharge flow and concentration

RESULTS

The approximate mixing zone length for each of the discharge groups (i.e., very small, small, medium, and large) was estimated for a variety of parameter values (Table 7). Twelve flows and depths calculated using the regression equation were used, along with three different channel width values (selected below, near and above the average channel width for each receiving water size group). The six different discharge concentrations were assessed and discharge flow was fixed at one percent of the ambient flow since this is the maximum discharge flow authorized in the Basin Plan for most discharge locations in the North Coast Region. Nitrate was chosen as a representative pollutant, and 0.2 mg/L was used as the background concentration within the receiving water. A regulatory concentration for nitrate of 10 mg-N/l was used to estimate mixing zone length.

Table 7. Summary of Parameter Values.

	Receiving Water				Discharge	
Group	**Channel Widths (ft)**	**Flow (cfs)**	**Depth (ft)**	**Background Nitrate Concentration (mg-N/L)**	**Flow[a]**	**Concentration (mg-N/L)**
Very small	12, 23, 35	1 – 58	0.29 – 1.11	0.2	1%	11, 15, 20, 30, 35, 40
Small	49, 82, 115	197 – 3,814	3.82 – 7.55	0.2	1%	11, 15, 20, 30, 35, 40
Medium	82, 164, 246	101 – 10,536	3.56 – 9.61	0.2	1%	11, 15, 20, 30, 35, 40
Large	82, 164, 246	158 – 70,551	7.92 – 20.30	0.2	1%	11, 15, 20, 30, 35, 40

[a] Discharge as a percent of the receiving water.

Overall, the very small receiving water group experienced the longest average distances to achieve the regulatory concentration, regardless of the discharge concentration. The small, medium, and larger receiving water groups had similar distance requirements, with the small receiving water group experiencing slightly shorter distances (Figure 2 and Table 8). For the very small receiving water group, the channel was relatively wide, with small, shallow flows. As a result, the distance required varied from less than the width to more than twice the width of the channel. For the other three receiving water groups, the channel was wider than for the very small, but transported more flow and were deeper, resulting in less distance (usually about one width) being needed, even for high concentration discharges. Also, as expected, as discharge concentration increases, so does the mixing zone length.

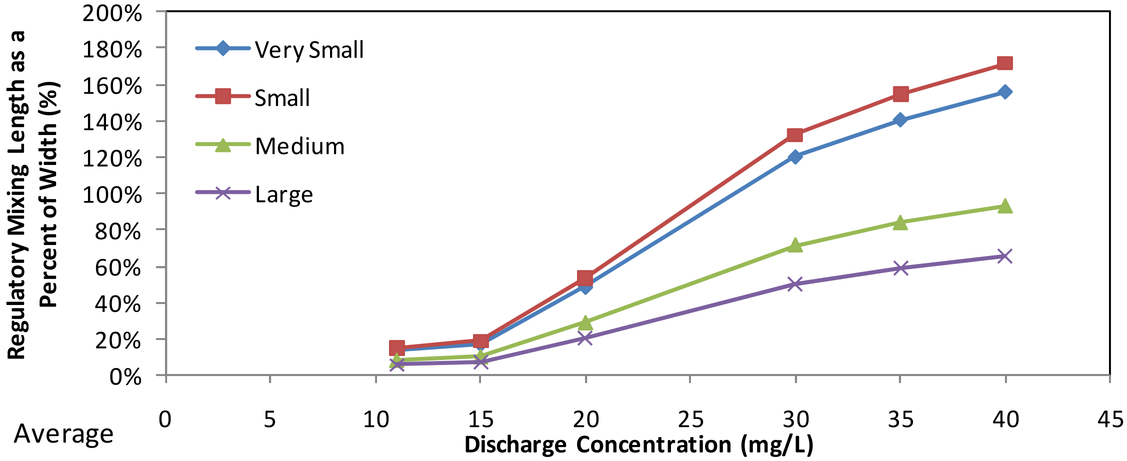

Figure 2.Average distance of mixing zone length (as a percent of the channel width) for different discharge concentrations.

Table 8. Mixing Zone Length to Achieve 10 mg-N/L as a Percentage of Channel Width for Each Receiving Water Group and Discharge Concentrations.				
	Mixing Zone (Min-Avg-Max) as a Percentage of Channel Width			
Discharge Concentration (mg-N/L)	**Very Small**	**Small**	**Medium**	**Large**
11	11%-14%-15%	15%-15%-17%	3%-8%-16%	0%-6%-11%
15	14%-17%-19%	18%-19%-20%	4%-10%-20%	0%-7%-13%
20	40%-49%-54%	51%-54%-58%	10%-29%-57%	1%-20%-37%
30	98%-120%-133%	125%-132%-143%	25%-72%-142%	3%-51%-92%
35	115%-141%-156%	146%-155%-167%	30%-84%-166%	4%-59%-108%
40	127%-156%-173%	162%-172%-185%	33%-93%-184%	4%-66%-120%

In general, for discharge concentrations less than the 20 mg-N/L (double the 10 mg-N/L regulatory requirement), the mixing zone length is less than one channel width for all size dischargers. For higher discharge concentrations, the mixing zone length increases (Table 9). At the highest discharge concentration evaluated (40 mg-N/L), the mixing zone length was about twice the channel width (1.75W to 2.00W) in the very small, small, and medium receiving water groups and about one and a quarter times the width for large receiving water group (1.25W). Overall mixing zone lengths may be smaller if outfalls were fitted with diffusers, but lacking site specific information such information was not determined.

Table 9. Mixing Zone Length as a Function of Channel Width for Various Discharger Groups and Discharge Concentrations. W = channel width.				
	Maximum Mixing Zone Length As A Function of Channel Width			
Discharge Concentration (mg/L)	Very Small	Small	Medium	Large
11	0.25W	0.25W	0.25W	0.25W
15	0.25W	0.25W	0.50W	0.50W
20	0.75W	0.75W	0.75W	0.50W
30	1.50W	1.50W	1.50W	1.00W
35	1.75W	1.75W	1.75W	1.25W
40	1.75W	2.00W	2.00W	1.25W

ENVIRONMENTAL ANALYSIS

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) REQUIREMENTS

The Regional Water Board is the lead agency for evaluating the environmental impacts of Basin Plan amendments pursuant to the CEQA. Although subject to CEQA, the Regional Water Board's basin planning process is certified by the Secretary for Resources as "functionally equivalent to" CEQA, and therefore exempt from the requirement for preparation of an environmental impact report or negative declaration and initial study (Cal. Code Regs., tit. 14, § 15251(g)). The State Water Resources Control Board (State Water Board) has promulgated guidelines for exempt regulatory programs that describe the documents required for the adoption or approval of standards, rules, regulations or plans (Cal. Code Regs., tit. 23, § 3777). These documents must at least contain the following:

1. A brief description of the proposed activity. In this case, the proposed activity is the adoption of a Basin Plan Amendment.

2. Reasonable alternatives to the proposed activity.

3. Mitigation measures to minimize any significant adverse environmental impacts of the proposed activity.

Additionally, for actions by the Regional Water Board that adopt a rule or regulation requiring the installation of pollution control equipment, establish a performance standard, or establish a treatment requirement, the CEQA (Cal. Pub. Resources Code, § 21159 (a)) and CEQA Guidelines (Cal. Code Regs., tit.14 § 15187 (c)) require an environmental analysis of the reasonably foreseeable methods by which compliance with that rule or regulation will be achieved. The substitute environmental documentation (SED) satisfies this requirement if it contains the following components, some of which are repetitive with the list above:

1. An analysis of the reasonably foreseeable environmental impacts of the methods of compliance. The reasonably foreseeable methods of compliance are the potential actions that individuals may employ to comply with the requirements in the proposed BPA.

2. An analysis of the reasonably foreseeable feasible mitigation measures relating to those impacts.

3. An analysis of reasonably foreseeable alternative means of compliance with the rule or regulation, which would avoid or eliminate any identified impacts.

The environmental analysis must take into account a reasonable range of the following (Cal. Code Regs., tit. 14 § 15187(d); Cal. Pub. Resources Code, § 21159 (c)):

- Environmental factors
- Technical factors
- Population
- Geographic areas
- Specific sites
- Economic factors

The regulations require consideration of a "reasonable range" of the factors listed above; however, an examination of every site is not required, only a reasonably representative sample of them. The statute specifically states that the agency shall not conduct a "project level analysis" (Public Resources Code section 21159(d)). Rather, in most circumstances, a project level analysis will be performed by the permittees as part of the permitting process.

Consistent with the CEQA, this document does not engage in speculation or conjecture, but rather considers the reasonably foreseeable environmental impacts of the reasonably foreseeable methods of compliance.

ENVIRONMENTAL SETTING

The North Coast Hydrologic Region encompasses a total area of approximately 19,390 square miles or 12.3 percent of California's land area. It includes all or large portions of Modoc, Siskiyou, Del Norte, Trinity, Humboldt, Mendocino, Lake, and Sonoma counties and also includes small areas of Shasta, Tehama, Glenn, Colusa, and Marin counties. Forest and rangeland represent about 98 percent of this region's land area. Much of the region is identified as national forests, state and national parks, under the jurisdiction of the federal Bureau of Land Management, and American Indian lands such as the Quartz Valley and Yurok and Hoopa reservations. The major land uses in the North Coast region consist of timber production, agriculture, fish and wildlife management, parks, recreational areas, and open space.

The North Coast Region is divided into two basins – the Klamath River Basin and the North Coast Basin. The Klamath River Basin covers an area of approximately 10,830 square miles within northern California tributary to the Klamath, Smith, Applegate, Illinois, and Winchuck Rivers, as well as the closed Lost River and Butte Valley hydrologic drainage areas. In the Klamath Basin point source discharge is prohibited to surface freshwater impoundments and their tributaries (with the exception of the lower Lost River system) and the Smith, Klamath, Applegate, Illinois, and Winchuck rivers and their tributaries. Discharge is also prohibited to Crescent City Harbor and estuaries. New point source discharges are prohibited to coastal streams and drainages. The North Coast Basin is dissected by six major river systems: Eel, Russian, Mad, Navarro, Gualala, and Noyo rivers and numerous smaller river systems. In the North Coast Basin, point source discharge is prohibited to surface freshwater impoundments and their tributaries and to bays and estuaries. Discharge to the Russian, Mad, and Eel rivers is prohibited during the period May 15 through September 30 and during all other periods when the waste discharge flow is greater than one percent of the receiving stream's flow. The Regional Water Board may consider exceptions for cause to these waste discharge rate limitations.

Twenty-one POTWs discharge are permitted to discharge directly to surface freshwater in the North Coast Region– eight to the Eel River or its tributaries, nine to the Russian River or its tributaries, two to Humboldt Bay or its tributaries, one to the Mad River, and one to a drain tributary to the Tulelake-Lower Klamath Lake reach of the Lost River Basin. These discharges are discussed in detail below.

Freshwater bodies with permitted POTW discharge are listed as impaired in Proposed 2010 Integrated Report (Clean Water Act Section 303(d) List / 305(b) Report) for the following constituents (including those requiring TMDLs, those being addressed by TMDLS, and those being addressed by other means):

- Eel River – aluminum, dissolved oxygen, sedimentation/siltation, water temperature,
- Humboldt Bay and White Slough – none
- Lost River – nutrients
- Russian River – sedimentation/siltation, water temperature, indicator bacteria, dissolved oxygen (Green Valley Creek and Laguna de Santa Rosa), specific conductivity (Sulphur Creek), nitrogen and phosphorus (Laguna de Santa Rosa)
- Mad River – sedimentation/siltation, water temperature, turbidity

POTWS PERMITTED TO DISCHARGE DIRECTLY TO SURFACE FRESHWATER IN THE NORTH COAST REGION

Russian River Basin. The Russian River drains an area of 1,485 square miles that is approximately 100 miles long and from 12 to 32 miles wide. From its source, about 16 miles north of Ukiah, the river flows southward for 90 miles through Redwood, Ukiah, Hopland, and Alexander Valleys, and through the northwestern part of the Santa Rosa Plains. The river then turns abruptly westward at Mirabel Park and flows for 22 miles through a canyon in the mountains before entering the Pacific Ocean at Jenner. The several alluvial valleys through which the river flows are separated by mountain gorges. Altitudes in the basin range from 4,480 feet to sea level. The principal tributaries of the Russian River are East Fork, Sulphur Creek, Maacama Creek, Dry Creek, and Mark West Creek. (Rantz and Thompson, 1967) All the facilities located in this basin that discharge to surface freshwater can be seen in Figure 3 below.

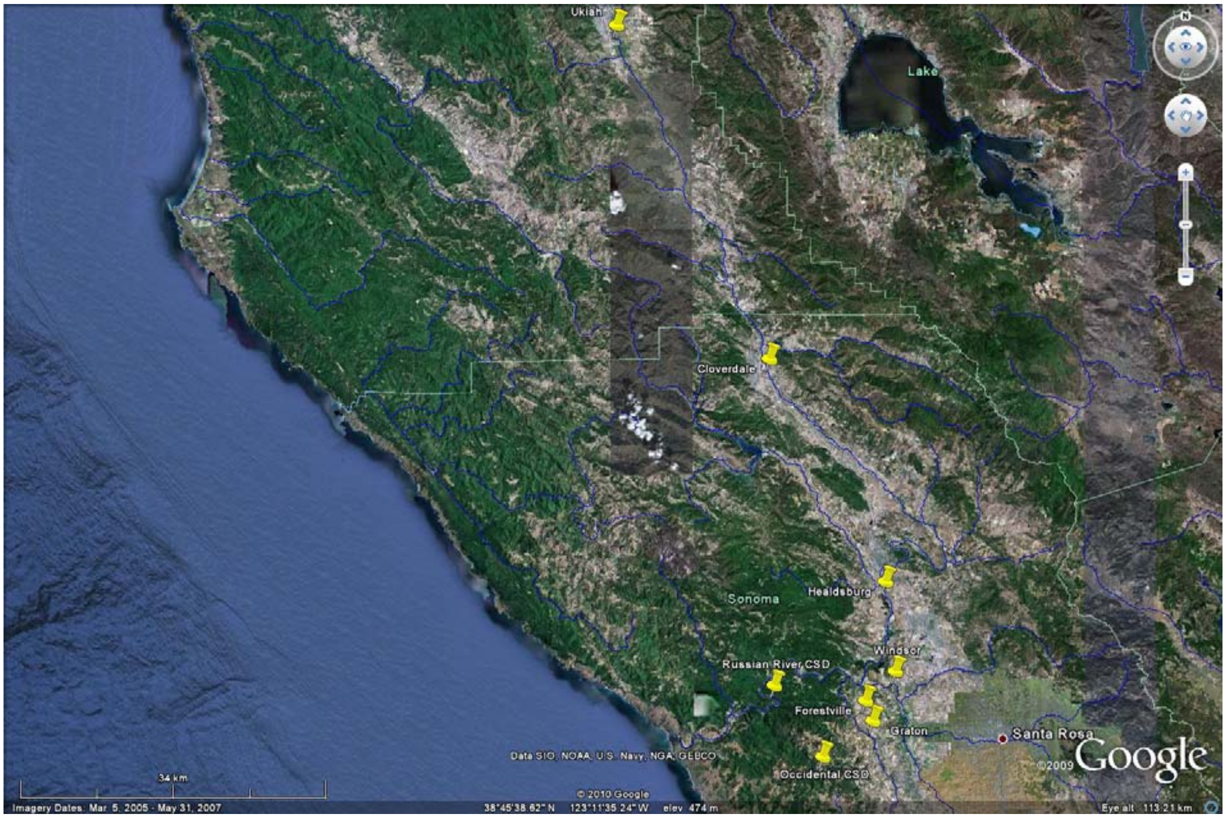

Figure 3. Russian River Basin Discharge Facilities

- Ukiah: Discharge is restricted to one percent of the Russian River during the discharge season (October 1 - May 14) as measured at Hopland USGS 11462500 gage. This facility currently has tertiary and secondary treatment. The last surface water discharge from the facility was in February 14, 2008 (pers. comm. Ann Burck, City of Ukiah, to Marcie Commins, November 30, 2009). Permitted Average Dry Weather Flow (ADWF) for this facility is 2.8 mgd, with 3.0 mgd after treatment plant upgrades.

- Cloverdale: Discharge is into Russian River through an approximately 12-18" pipe with no diffuser. It currently has secondary treatment. The current permit allows discharge during the discharge season at one percent of the flow of the Russian River if Waste Water Treatment Plant (WWTP) is upgraded to tertiary treatment stage. Permitted ADWF for this facility is 1.0 mgd.

- Healdsburg: Discharge is into Basalt Pond. Discharge goes from the storage pond through a straight corrugated metal pipe culvert outlet that is usually just above the water line. The new NPDES permit will measure the one percent discharge compliance as the combined Russian River flow at the Dry Creek confluent (USGS gages 11464000 and 11465350). Permitted ADWF is 1.4 mgd.

- Windsor: Discharge runs through 18'' pipe on the bank of Mark West Creek, tributary of Russian River, and can be underwater during high flow. Receiving water flow is measured at Trenton-Healdsburg Bridge. WWTP has currently tertiary treatment.

Discharge is restricted to one percent of receiving water during the discharge season. Permitted ADWF is 2.25 mgd.

- Forestville: Discharge is restricted to one percent of receiving water during the discharge season. Discharge goes into Jones Creek which is the tributary of Green Valley Creek, tributary of Russian River. Receiving water flow is measured at Iron Horse Bridge. WWTP is tertiary treatment type. Permitted ADWF for this facility is 0.13 mgd.

- Graton: Discharge is restricted to one percent of receiving water during the discharge season. Discharge goes into Atascadero Creek which is the tributary of Green Valley Creek of Russian River. Receiving water flow is monitored at Green Valley Road Bridge. WWTP has tertiary treatment for discharge. Permitted ADWF is 0.14 mgd.

- Occidental CSD: Discharge is restricted to one percent of receiving water during the discharge season. Discharge goes into Graham's Pond before it reaches Dutch Bill Creek, tributary of Russian River. Receiving water flow is measured at Camp Meeker which is considerably downstream of actual discharge. Flow in creek where discharge enters is fairly low. Permitted ADWF is 0.02 mgd (as of 1993).

- Russian River CSD: Discharge is restricted to one percent of receiving water during the discharge season and it runs into Russian River. Discharge is through a4" underground pipe which sticks out of the bank of the river horizontally out a little way into the river and is underwater most of the time. Permitted ADWF is 0.71mgd.

- Santa Rosa Subregional Water Reclamation System. During the discharge season, discharge is restricted to five percent of the Russian River as measured at Hacienda Bridge (USGS gauge No. 11-4670.00). Discharge is almost entirely from Delta Pond to the confluence of the Laguna de Santa Rosa and Santa Rosa Creek, tributaries of the Russian River. The Delta Pond discharge was recently upgraded to include a diffuser. Although average dry weather flow is currently 15 mgd, discharge is relatively infrequent since the Subregional Systems has approximately 1.5 billion gallons of storage and recycles about 95 percent of the water it produces in an average year.

Eel River Basin – Humboldt Bay – Mad River Basin. The Eel River drains an area of 3,684 square miles. Its major tributaries are the North Fork, Middle Fork, South Fork and Van Duzen Rivers. The river originates on the southern flank of Bald Mountain in northeastern Mendocino County (USGS 2000), and flows southeast, then west, through Mendocino National Forest and Lake County. The river turns northwest approximately 15 miles east of Willits, and flows northwest in a long isolated valley, collecting many tributaries including the Middle Fork Eel River and the North Fork Eel River. After the North Fork confluence, the Eel River flows through the southwestern corner of Trinity County then crosses Humboldt County from the southeast to northwest. The South Fork Eel River joins as the river valley widens. After passing Rio Dell, the Eel River is joined by the Van Duzen River. Below that confluence, the Eel passes Fortuna and enters the Pacific in central Humboldt County, approximately 15 miles south of Eureka (Benchmark Maps 2005). The Eel River watershed is bordered on the north by the Mad River watershed and Humboldt Bay. All the discharge facilities which are located in the area and discharge to surface freshwater are shown in Figure 4, below.

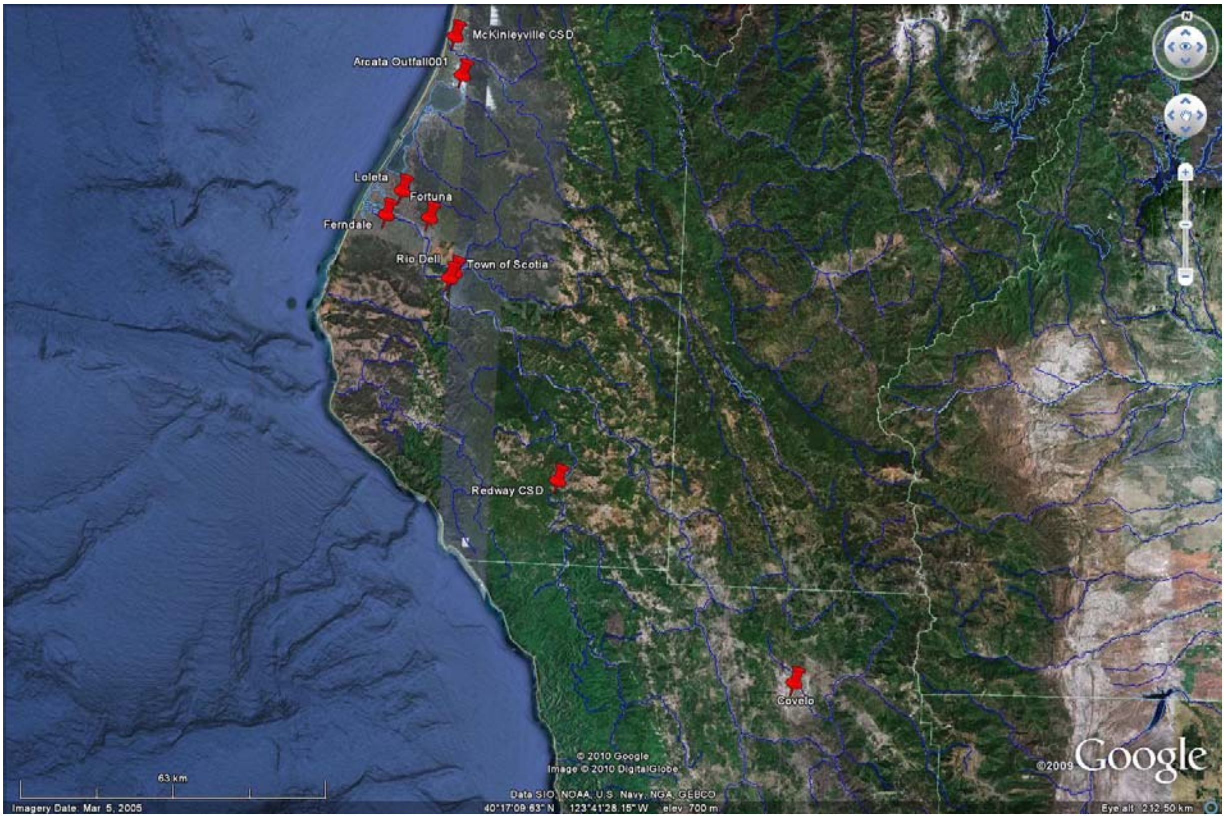

Figure 4. Eel River Basin – Humboldt Bay – Mad River Basin Discharge Facilities

- Covelo: Discharge, which is restricted to one percent of receiving water during the discharge season, runs through a 6" pipe to the bank of Grist Creek which is the tributary of Mill Creek, tributary of Middle Fork Eel Creek. Permitted ADWF is 0.08 mgd. The receiving water is dry for approximately 2/3 of the year but it can get up to 6 feet deep. The WWTP has secondary treatment. Discharge has never been needed from this facility so far (pers. comm. Tim Dennis, Covelo Community Services District to Marcie Commins, November 6, 2009. Covelo has four ponds. Evaporation in one pond is sufficient to meet their disposal needs in the summer, and evaporation in two ponds and percolation in the second appears to be to be sufficient in the winter.

- Redway CSD: Discharge, which is restricted to one percent of receiving water during the discharge season, runs into Eel River through 4" pipe which is approximately 25 feet above Eel River. There is no diffuser or other structure. Permitted ADWF is 0.19 mgd. WWTP has secondary treatment. USGS 11476500 South Fork Eel River gage is the closest station monitoring the receiving water flow.

- Town of Scotia: Discharge is restricted to one percent of receiving water during the discharge season and runs into Eel River through a12" pipe with a screen on end. Outfall is on the bank but while discharging it is nearly always underwater and a few feet out into the river. WWTP has secondary treatment. Receiving water flow is monitored at Scotia USGS 11477000 gage station.

- Rio Dell: Discharge is into Eel River and is restricted to one percent of receiving water during the discharge season through a14" discharge pipe. There is riprap where it spills out. Permitted ADWF is 0.3mgd. Receiving water flow is monitored by USGS 11477000 Eel River at Scotia gage.

- Fortuna: Discharge is restricted to one percent of receiving water during the discharge season and it runs into Strongs Creek, tributary of Eel River through 18" pipe on bank above the creek. It goes down a rock passage way with riprap. WWTP has secondary treatment. Permitted ADWF is1.5 mgd. Receiving water flow is monitored by USGS 11477000 Eel River at Scotia gage combined with the flow as measured at the Grizzly Creek gauging station (USGS 11478500).

- Ferndale: Discharge runs into Francis Creek/Salt River, tributary of Eel River through one 12" and one 6" pipe. The pipes are not operated at the same time. Proposed pipe is 8". Outfall is on the riverbank. Discharge is currently restricted to one percent of upstream receiving water flow during the discharge season. Current WWTP has secondary treatment. However, Ferndale is upgrading its plant to tertiary treatment, UV disinfection, and denitrification. Permitted ADWF for the new facility is planned to be 0.55 mgd.

- Loleta: Discharge is through a12" pipe that goes 1/4 mile through pasture land/wetland to a wetland. From there, it runs to an oxbow, which is a seasonal tributary to the Eel River. Discharge is restricted to one percent of Eel River flow during the discharge season. WWTP has secondary treatment. Permitted ADWF is 0.081 mgd. Receiving water flow is monitored at Scotia gauging station (USGS Station 11477000) combined with the flow as measured at the Grizzly Creek gauging station (USGS Station 11478500).

- Arcata: This facility has two outfalls: Outfall 001 discharges into Humboldt Bay while outfall 002 discharges into Arcata Marsh and Wildlife Sanctuary (AMWS). Discharge into Humboldt Bay must be in conjunction with discharge to AMWS. Discharge runs through 24" pipe to marsh, 26" pipe from marsh to the bay. Discharge to the bay is near the edge of the bay. Discharge rarely bypasses the marsh and reaches the bay. WWTP is designed for a dry weather flow of 2.3 mgd and a maximum hydraulic capacity through the primary system of 5.0 mgd. Flows in excess of 5.0 mgd bypass the primary system and are routed directly to the oxidation ponds for treatment.

- McKinleyville CSD: Discharge goes into Mad River through 12" pipe to a 15' long flexible rubber pipe anchored in concrete along the bottom. The pipe is in the hole that has been dug by an eddy around the old railway trestle. Plant design flow is 1.61mgd, permitted ADWF is 3.3 mgd. Discharge is restricted to one percent of receiving water and only when the Mad River exceeds 200 cfs during the discharge season. Receiving water flow is monitored at Highway 299 overpass (USGS Gage No. 11481000).

Klamath River Basin. There is only one discharge facility within the scope of this study, which is located in Klamath River basin extending from eastern Oregon to northern California coast, shown in Figure 5 below as the red outline.

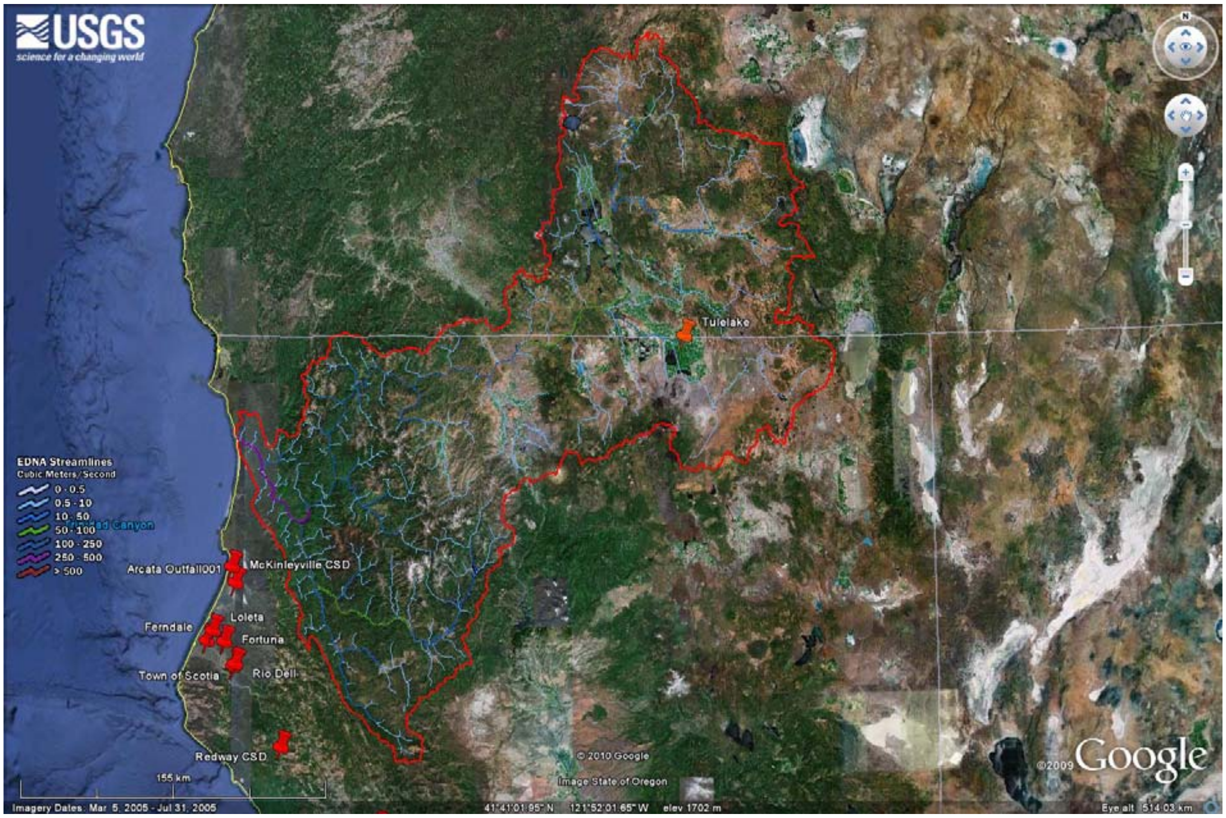

Figure 5. Klamath River Basin Discharge Facility: Tulelake (shown within red outline).

- Tulelake: Discharge goes into Lower Lost River and Tule Lake in upper Klamath River basin. The WWTP has secondary treatment. Permitted ADWF is 0.16 mgd. There is no seasonal prohibition on the discharge.

RELEVANT CONSTITUENTS

The Initial Staff Report for the 2007 Triennial Review of the Water Quality Control Plan for the North Coast Region (June 18, 2007) stated "A new policy, more limited in scope, allowing for conditional mixing zones for point source discharges should be considered. The policy would be focused only on pollutant limits intended to protect municipal supply (nitrates, chlorine break-down products, etc.)." Subsequent discussions with Water Board staff refined this to mean that the proposed basin plan amendment for mixing zones should be limited to pollutants with human health standards and possibly to limit potential constituents further to only nitrate and non-CTR chlorine break down products (DBPs). This section summarizes available data characterizing the quality of effluent discharged in the North Coast region and identifies constituents for which a discharger could reasonably be expected to seek credit for a mixing zone in the event that the Basin Plan is amended to permit such credit.

Most dischargers in the North Coast region monitor nitrate in their effluent. Available January 2008 through November 2009 self-monitoring reports (SMRs) for 18 of the North Coast dischargers were examined to determine existing effluent quality. Table 10 summarizes nitrate date for these dischargers. Table 10 also summarized Santa Rosa's storage pond nitrate data for

September 2006 through August 2010. Data for Healdsburg are for December 2008 through 2009.

Other than nitrate, non-CTR drinking water constituents are rarely and not systematically measured in North Coast dischargers' effluent. Examination of the 2008-09 SMRs for dischargers other than Santa Rosa revealed no exceedences of non-CTR constituents other than nitrate. Santa Rosa measured all Title 22 constituents (with the exception of DBPs) in storage ponds on four occasions in 2005-2006. In these samples, the only non-CTR constituent that exceeded its primary MCLs was aluminum with a maximum concentration of 5.9 mg/L (5.9 times the MCL of 1.0 mg/L). The only non-CTR constituents that exceeded their secondary MCLs were aluminum, manganese, color and turbidity. Non-CTR DBPs (five haloacetic acids (HAA5), bromate, and chlorite) were measured in Santa Rosa's treatment plant effluent (but not storage ponds) on one occasion in 2008 and reported in Appendix E of the DCP EIR. The concentrations of non-CTR DBPs did not exceed their respective criteria. However, Santa Rosa utilizes ultra violet for final effluent disinfection. North Coast dischargers that use chlorine disinfection may have higher concentrations of these DBP in their effluent.

Table 10. Summary of Effluent Nitrate Data for North Coast Discharger (in mg/L as N).

	Minimum Concentration	Maximum Concentration	Mean	Median	Number of Samples
Arcata	ND	1.4		0.23	14
Ferndale	0.24	2.8	1.7	0.97	7
Fortuna	18	36	27.2	29	5
Graton	0.2	5	2.4	1.9	21
Healdsburg	1.2	5	2.9	3	12
Loleta	21	37	30.9	34	5
Redway	16.8	25	20.4	20.4	2
Covelo	No Data				
Tule Lake	No Data				
Rio Dell	1.3	1.9	1.6	1.6	2
McKinleyville	<10	<10	<10	<10	12
RRCSD	10.6	39	28.9	31.5	10
Willits	9.3	9.3	9.3	9.3	1
Occidental	<0.2	2.4	0.49	<0.2	12
College of the Redwoods	No Data				
Windsor	2.1	6.4	4	3.6	6

Table 10. Summary of Effluent Nitrate Data for North Coast Discharger (in mg/L as N).					
	Minimum Concentration	**Maximum Concentration**	**Mean**	**Median**	**Number of Samples**
Forestville	1.8	37	10.1	8.9	21
Cloverdale	No Data				
Ukiah	2	3	2.5	2.6	3
Town of Scotia	<0.1	0.19	0.07	<0.1	6
Santa Rosa pond	6.4	8.3	7.8	8.0	12

POTENTIAL ENVIRONMENTAL IMPACTS

This section describes the potential environmental impacts of each of the mixing zone alternatives including beneficial impacts. At this time, the exact type, size, and location of compliance methods that might be implemented for future proposed projects to comply with the proposed Basin Plan Amendment are unknown. The permittee for each discharge will be required to conduct a project-level and site-specific impact analysis of the compliance methods that are selected for implementation as required by CEQA. Treatment plant upgrades, diffusers, and increased storage would all likely involve construction. Construction impacts are temporary in nature and well developed mitigation measures are available to minimize and, in some cases, completely avoid significant environmental impacts. Therefore this section does not further address construction impacts and instead concentrates on the impacts of permanent structures and operation of a mixing zone and the identified compliance measures.

Alternative 1 – No action. North Coast POTWs are likely to get permit limitations for nitrate and possibly other human health constituents in the foreseeable future. With the No Action Alternative, many of them will not be able to meet the permit limitations and will be required to implement one or more of the foreseeable methods of compliance (treatment plant upgrades, treatment wetlands, and/or source control).

Detrimental impacts from Alternative 1 include:

- Aesthetics – Treatment plant upgrades could involve new structures or expansion of existing structures. These have the potential to degrade the existing visual character or quality of the site and its surroundings. The new construction could also have lighting that could adversely affect nighttime views.

- Agricultural and Forestry Resources. Both treatment plant upgrades and treatment wetlands could convert farmland or forest land to non-farm or non-forest use.

- Biological Resources. Depending on the location, treatment plant upgrades could remove habitat resulting in an adverse impact on sensitive species or habitat.

- Cultural Resources. Depending on the location, both treatment plant upgrades and treatment wetlands could directly or indirectly destroy a unique paleontological resource or site or unique geologic feature. In addition, they could disturb any human remains, including those interred outside of formal cemeteries.

- Greenhouse Gas Emissions. Operation of treatment plant upgrades requires energy which would increase greenhouse gas emissions.

- Noise. Operation of the nutrient removal facilities may cause a substantial increase in noise levels in the vicinity of the facilities.

Beneficial impacts from Alternative 1 include:

- Biological Resources. A treatment wetland would increase wetland habitat.

- Recreation. Wetlands of all types, including treatment wetlands, attract birds and other wildlife that people enjoy viewing. A treatment wetland could be constructed with paths and other amenities to increase public use.

Alternative 2 – All human health constituents and small mixing zone size. North Coast POTWs are likely to get permit limitations for nitrate and possibly other human health constituents in the foreseeable future. Dischargers may be able to meet these limitations with the use of a mixing zone. However, depending on discharge and river flow conditions, dischargers may not be able to meet the mixing zone size without the use of a diffuser and/or storage.

Impacts from Alternative 2 include:

- Aesthetics. Both a storage reservoir and its associated pump station have the potential to degrade the existing visual character or quality of the site and its surroundings.

- Agricultural and Forestry Resources. Both storage reservoir and its associated pump station could convert farmland or forest land to non-farm or non-forest use.

- Biological Resources. Biological resources can be impacted by wastewater discharge if the wastewater contains substances that are detrimental to aquatic life or substances that are biostimulatory. Alternative 2 is restricted to mixing zones for constituents of concern to human health. With regard to detrimental substances, the conditions for the mixing zone state that for human health constituents with CTR criteria for the protection of aquatic life, the smaller of the mixing zone as determined by this policy and the mixing zone as determined by the SIP shall apply. Therefore mixing zones allowed by this Basin Plan Amendment would be equal to or more protective of aquatic organisms than existing conditions. For biostimulatory substances, the conditions for the mixing zone state that a mixing zone shall not result in an increase in plant growth that causes a nuisance or adversely affects beneficial uses. Therefore a mixing zone itself will not adversely impact biological resources. However, depending on the location, both storage reservoir and its associated pump station could remove habitat resulting in an adverse impact on sensitive species or habitat.

- Cultural Resources. Depending on the location, a storage reservoir could directly or indirectly destroy a unique paleontological resource or site or unique geologic feature. In addition, it could disturb any human remains, including those interred outside of formal cemeteries.

- Greenhouse Gas Emissions. Operation of pumps associated with a storage reservoir requires energy which would increase greenhouse gas emissions.

- Hydrology and Water Quality. By definition, a mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented." (USEPA, 1991). Therefore, increased concentrations of human health constituents with primary or secondary MCLs may be exceeded within the mixing zone. Since this alternative is defined as having a small mixing zone, the area in which MCL exceedences can occur is smaller than for Alternatives 3, 4, 6, and 7. In addition, this plume of increased concentration of constituents may limit future intake placement.

- Noise. Operation of pumps associated with a storage reservoir may cause a substantial increase in noise levels in the vicinity of the pump station.

Recreation. A potential exists for people to conduct water contact recreation in a mixing zone and thus be exposed to concentrations of constituents that exceed the drinking water MCLs. Health and Safety Code §116365(a) requires the California Department of Public Health (CDPH), while placing primary emphasis on the protection of public health, to establish a contaminant's maximum contaminant level (MCL) at a level as close as is technically and economically feasible to its public health goal (PHG). PHGs are developed for contaminants in drinking water usually assuming consumption of a fixed volume of water per day over a lifetime. The daily consumption of water used to calculate PHGs varies but is approximately 2 liters. The concentration of human health constituents in most North Coast dischargers' effluent is unknown, but for this analysis was assumed to be at most ten times the primary MCL concentration. This is based on the maximum measured concentration of constituents in North Coast dischargers' effluent identified in the Relevant Constituents section (above) of up to 4 times the respective primary or secondary MCL concentration. An assumption of ten times the primary MCL concentration was used as a conservative estimate. Therefore recreational intake of water in the mixing zone of up to 0.2 liters (2/10) would not result in adverse effects, assuming a linear dose response curve. If a typical mouthful of water is 0.03 liters (1 oz.), recreational intake of 6 mouthfuls a day for a lifetime would not produce adverse effects. PHGs are generally developed for the most sensitive population. Thus some PHGs, such as those for nitrate and copper, are based on infant consumption of bottle formula made from drinking water. Infants are assumed to not be exposed to mixing zones. Thus a mixing zone is not expected to adversely impact recreation.

Beneficial Impacts of Alternative 2:

- Hydrology and Water Quality. The diffuser may benefit the water quality for some constituents (such as CTR constituents) for which this mixing zone Basin Plan Amendment does not apply by lowering the area of higher concentrations.

Alternative 3 – All human health constituents and medium mixing zone size. The difference between the description of Alternative 2 and Alternative 3 is only in the size of the mixing zone. Thus the impacts for Alternative 3 are the same as for Alternative 2 except that the area of water body in which impacts to Hydrology and Water Quality and Recreation occur is larger.

Alternative 4 – All human health constituents and large mixing zone size. For this alternative, the size of the mixing zone is assumed sufficient to make storage unnecessary. Thus most of the adverse impacts resulting from storage identified for Alternatives 2 and 3 do not apply to Alternative 4.

Adverse and beneficial impacts from Alternative 4 include:

- Hydrology and Water Quality. Adverse and beneficial impacts for Alternative 4 on Hydrology and Water Quality are as described for Alternative 2 except that the of water body in which impacts to Hydrology and Water Quality occur is larger than for either Alternative 2 or Alternative 3.

Alternative 5 – Nitrate and non-CTR DBPs and small mixing zone size. This Alternative differs from Alternative 2 in that it applies only to nitrate and non-CTR DBPs rather than all human health constituents. Therefore, the adverse and beneficial impacts from Alternative 5 are the same as Alternative 2 except that Hydrology and Water Quality impacts are more limited in scope.

Alternative 6 – Nitrate and non-CTR DBPs and medium mixing zone size. This Alternative differs from Alternative 3 in that it applies only to nitrate and non-CTR DBPs rather than all human health constituents. Therefore, the adverse and beneficial impacts from Alternative 5 are the same as Alternative 3 except that Hydrology and Water Quality impacts are more limited in scope.

Alternative 7 – Nitrate and non-CTR DBPs and large mixing zone size. This Alternative differs from Alternative 4 in that it applies only to nitrate and non-CTR DBPs rather than all human health constituents. Therefore, the adverse and beneficial impacts from Alternative 5 are the same as Alternative 4 except that Hydrology and Water Quality impacts are more limited in scope.

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APPENDIX A: COMPILATION OF CALIFORNIA DRINKING WATER MCLS AND SMCLS AND CALIFORNIA TOXICS RULE CRITERIA

California Drinking Water Primary Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL) and California Toxic Rule (CTR) Criteria (values in µg/L unless otherwise noted, a "-" indicates the constituent is not regulated[a], a blank cell indicates the constituent is regulated but no objectives have been developed)						
	Title 22		CTR			
			Freshwater Aquatic Life		Human Health	
	MCL	**SMCL**	**CMC[b]**	**CCC[c]**	**Water & Organisms**	**Organisms Only**
Physical Parameters						
Color (units)		15	-	-	-	-
Odor (Threshold Odor Number)		3	-	-	-	-
Specific Conductance (µmho/cm)		900/1600/2200 [d]	-	-	-	-
Total dissolved solids		500/1000/1500 [d]	-	-	-	-
Turbidity (NTU)		5	-	-	-	-
Inorganic Compounds						
Aluminum	1000	200	-	-	-	-
Antimony	6				14	4300
Arsenic	10		340	150		
Asbestos fibers (million fibers per liter > 10 µm)	7				7	
Barium	1000		-	-	-	-
Beryllium	4					
Cadmium[e]	5		4.3	2.2		
Chloride (mg/L)		250/500/600 [d]				
Chromium (total)[e]	50		549	178		
Chromium (VI)	-	-	16.0	12.0		
Copper[e]		1000	13.4	9.0	1300	
Cyanide	150		22	5.2	700	220,000
Fluoride (mg/L)	2		-	-	-	-
Iron (mg/L)		0.3	-	-	-	-
Lead[e]	-	-	65	2.5		
Manganese		50	-	-	-	-
Mercury	2				0.05	0.051

California Drinking Water Primary Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL) and California Toxic Rule (CTR) Criteria (values in µg/L unless otherwise noted, a "-" indicates the constituent is not regulated[a], a blank cell indicates the constituent is regulated but no objectives have been developed)						
	Title 22		**CTR**			
			Freshwater Aquatic Life		**Human Health**	
	MCL	**SMCL**	**CMC[b]**	**CCC[c]**	**Water & Organisms**	**Organisms Only**
Nickel[e]	100		468	52	610	4600
Nitrate (as N) (mg/L)	10		-	-	-	-
Nitrate (as NO3) (mg/L)	45		-	-	-	-
Nitrite (as N) (mg/L)	1		-	-	-	-
Total Nitrate/Nitrite (mg/L)	10		-	-	-	-
Selenium	50			5		
Silver[e]		100	3.4			
Sulfate (mg/L)		250/500/600 [c]	-	-	-	-
Thallium	2				1.7	6.3
Zinc[e]		5000	117	118		
Organic Chemicals						
1,1,1-Trichloroethane (TCA)	200					
1,1,2,2-Tetrachloroethane	1				0.17	11
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	1200		-	-	-	-
1,1,2-Trichloroethane	5				0.6	42
1,1-Dichloroethane	5					
1,1-Dichloroethylene (1,1 dichloroethene)	6				0.057	3.2
1,2 Dichloroethane	0.5		-	-	-	-
cis-1,2-Dichloroethylene	6		-	-	-	-
trans-1,2-Dichloroethylene	10		-	-	-	-
1,2,4-Trichlorobenzene	5					
1,2-Dichlorobenzene	600				2,700	17,000
1,2-Dichloroethane (EDC)	-	-			0.38	99
1,2-Dichloropropane	5				0.52	39

California Drinking Water Primary Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL) and California Toxic Rule (CTR) Criteria (values in µg/L unless otherwise noted, a "-" indicates the constituent is not regulated[a], a blank cell indicates the constituent is regulated but no objectives have been developed)						
	Title 22		**CTR**			
			Freshwater Aquatic Life		**Human Health**	
	MCL	**SMCL**	**CMC[b]**	**CCC[c]**	**Water & Organisms**	**Organisms Only**
1,3 Dichloropropene (1,3 Dichloropropylene)	0.5				10	1,700
1,2-Diphenylhydrazine	-	-			0.04	0.54
1,2-Trans-Dichloroethylene (trans-1,2-dichloroethene)	-	-			700	140,000
1,3-Dichlorobenzene	-	-			400	2,600
1,4-Dichlorobenzene	5				400	2,600
2,3,7,8-TCDD (Dioxin)	0.00003				0.000000013	0.000000014
2,4,5-TP (Silvex)	50		-	-	-	-
2,4-D (Formula 40, Weedar 64)	70		-	-	-	-
2,4,6-Trichlorophenol	-	-			2.1	6.5
2,4-Dichlorophenol	-	-			93	790
2,4-Dimethylphenol	-	-			540	2,300
2,4-Dinitrophenol	-	-			70	14,000
2,4-Dinitrotoluene	-	-			0.11	9.1
2,6-Dinitrotoluene	-	-				
2-Chloroethylvinyl Ether	-	-				
2-Chloronaphthalene	-	-			1,700	4,300
2-Chlorophenol	-	-			120	400
2-Methyl- 4,6-Dinitrophenol (4,6-Dinitro-O-Cresol)	-	-			13.4	765
2-Nitrophenol	-	-				
3,3 Dichlorobenzidine	-	-			0.04	0.077
3-Methyl 4-Chlorophenol (4-chloro-3-methylphenol, P-Chloro-M-Cresol)	-	-				
4,4'-DDD	-	-			0.00083	0.00084

California Drinking Water Primary Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL) and California Toxic Rule (CTR) Criteria (values in µg/L unless otherwise noted, a "-" indicates the constituent is not regulated[a], a blank cell indicates the constituent is regulated but no objectives have been developed)						
	Title 22		**CTR**			
			Freshwater Aquatic Life		**Human Health**	
	MCL	**SMCL**	**CMC[b]**	**CCC[c]**	**Water & Organisms**	**Organisms Only**
4,4'-DDE	-	-			0.00059	0.00059
4,4'-DDT	-	-	1.1	0.001	0.00059	0.00059
4-Bromophenyl Phenyl Ether	-	-				
4-Chlorophenyl Phenyl Ether	-	-				
4-Nitrophenol	-	-				
Acenaphthene	-	-			1,200	2,700
Acenaphthylene	-	-				
Acrolein	-	-			320	780
Acrylonitrile	-	-			0.059	0.66
Alachlor (Lasso)	2		-	-	-	-
Aldrin	-	-	3.0		0.00013	0.00014
alpha-BHC	-	-			0.0039	0.013
alpha-endosulfan (endosulfan I)	-	-	0.22	0.056	110	240
Anthracene	-	-			9,600	110,000
Atrazine (Atranex, Crisazina)	1		-	-	-	-
Bentazon	18		-	-	-	-
Benzene	1				1.2	71
Benzidine	-	-			0.00012	0.00054
Benzo(a)anthracene	-	-			0.0044	0.049
Benzo(a)pyrene	0.2				0.0044	0.049
Benzo(ghi)perylene	-	-			0.0044	0.049
Benzo(k)fluoranthene	-	-				
beta-BHC	-	-			0.0044	0.049
beta-endolsulfan (endosulfan II)	-	-			0.014	0.046

California Drinking Water Primary Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL) and California Toxic Rule (CTR) Criteria (values in µg/L unless otherwise noted, a "-" indicates the constituent is not regulated[a], a blank cell indicates the constituent is regulated but no objectives have been developed)						
	Title 22		CTR			
			Freshwater Aquatic Life		Human Health	
	MCL	SMCL	CMC[b]	CCC[c]	Water & Organisms	Organisms Only
Bis(2-chloroethoxy) methane	-	-	0.22	0.056	110	240
Bis(2-chloroethyl) ether	-	-				
Bis(2-chloroisopropyl) ether	-	-			0.031	1.4
Bis(2-chloroisopropyl) ether	-	-			1,400	170,000
Bis(2-Ethylhexyl)Phthalate (Di(2-ethylhexyl)phthalate)	4				1.8	5.9
Bromate	10		-	-	-	-
Bromodichloromethane (dichlorobromomethane)	-	-			0.56	46
Bromoform	-	-			4.3	360
Butylbenzyl phthalate	-	-			3,000	5,200
Carbofuran (Furadan 4F)	18		-	-	-	-
Carbon tetrachloride	0.5				0.25	4.4
Chlordane	0.1		2.4	0.0043	0.00057	0.00059
Chlorite	1000		-	-	-	-
Chlorobenzene	-	-			680	21,000
Chlorodibromomethane (dibromochloromethane)	-	-			0.41	34
Chloroethane (ethyl chloride)	-	-				
Chloroform	-	-			reserved	reserved
Chrysene	-	-			0.0044	0.049
Dalapon	200		-	-	-	-
delta-BHC	-	-				
Dibromochloropropane	0.2		-	-	-	-
Dibenzo(a,h)anthracene	-	-			0.0044	0.049
Dieldrin	-	-	0.24	0.056	0.00014	0.00014

California Drinking Water Primary Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL) and California Toxic Rule (CTR) Criteria (values in µg/L unless otherwise noted, a "-" indicates the constituent is not regulated[a], a blank cell indicates the constituent is regulated but no objectives have been developed)						
	Title 22		CTR			
			Freshwater Aquatic Life		Human Health	
	MCL	SMCL	CMC[b]	CCC[c]	Water & Organisms	Organisms Only
Di(2-ethylhexyl)adipate	400		-	-	-	-
Diethyl phthalate	-	-			23,000	120,000
Dimethyl phthalate	-	-			313,000	2,900,000
Di-n-Butyl phthalate	-	-			2,700	12,000
Di-n-octyl phthalate (subset of dioctyl phthalate)	-	-				
Dinoseb	7		-	-	-	-
Diquat	20		-	-	-	-
Endothal	100		-	-	-	-
Endosulfan sulfate	-	-			110	240
Endrin	2		0.086	0.036	0.76	0.81
Endrin aldehyde	-	-			0.76	0.81
Ethylbenzene	300				3,100	29,000
Ethylene dibromide	0.05		-	-	-	-
Foaming Agents (MBAS)		500				
Glyphosate	700		-	-	-	-
Fluoranthene	-	-			300	370
Fluorene	-	-			1,300	14,000
Haloacetic acids (HAA5) [f]	60		-	-	-	-
Heptachlor (H-24,Heptox)	0.01		0.52	0.0038	0.00021	0.00021
Heptachlor epoxide	0.01		0.52	0.0038	0.0001	0.00011
Hexachlorobenzene	1				0.00075	0.00077
Hexachlorobutadiene	-	-			0.44	50
Hexachlorocyclopentadiene	50				240	17,000
Lindane (gamma-BHC)	0.2		0.95		0.019	0.063

California Drinking Water Primary Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL) and California Toxic Rule (CTR) Criteria (values in µg/L unless otherwise noted, a "-" indicates the constituent is not regulated[a], a blank cell indicates the constituent is regulated but no objectives have been developed)						
	Title 22		**CTR**			
			Freshwater Aquatic Life		**Human Health**	
	MCL	**SMCL**	**CMC[b]**	**CCC[c]**	**Water & Organisms**	**Organisms Only**
Hexachloroethane	-	-			1.9	8.9
Indeno(1,2,3-c,d)pyrene	-	-			0.0044	0.049
Isophorone	-	-			8.4	600
Methoxychlor (DMDT,Marlate)	30		-	-	-	-
Methyl bromide (bromomethane)	-	-			48	4,000
Methyl chloride (chloromethane)	-	-				
Methylene chloride (dichloromethane)	5				4.7	1,600
Molinate	20		-	-	-	-
Monochlorobenzene	70		-	-	-	-
MTBE	13	5	-	-	-	-
Naphthalene	-	-				
Nitrobenzene	-	-			17	1,900
N-Nitrosodimethylamine	-	-			0.00069	8.1
N-Nitrosodi-n-propylamine	-	-			0.005	1.4
N-Nitrosodiphenylamine	-	-			5	16
Oxamyl (vydate)	50		-	-	-	-
Pentachlorophenol [g]	1		19.5	15.0	0.28	8.2
Phenanthrene	-	-				
Phenol	-	-			21,000	4,600,000
Picloram	500		-	-	-	-
Polychlorinated biphenyls (PCBs or Arochlor) total	0.5					
Polychlorinated biphenyls 1016	-	-		0.014	0.00017	0.00017
Polychlorinated biphenyls 1221	-	-		0.014	0.00017	0.00017

California Drinking Water Primary Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL) and California Toxic Rule (CTR) Criteria (values in µg/L unless otherwise noted, a "-" indicates the constituent is not regulated[a], a blank cell indicates the constituent is regulated but no objectives have been developed)						
	Title 22		CTR			
			Freshwater Aquatic Life		Human Health	
	MCL	SMCL	CMC[b]	CCC[c]	Water & Organisms	Organisms Only
Polychlorinated biphenyls 1232	-	-		0.014	0.00017	0.00017
Polychlorinated biphenyls 1242	-	-		0.014	0.00017	0.00017
Polychlorinated biphenyls 1248	-	-		0.014	0.00017	0.00017
Polychlorinated biphenyls 1254	-	-		0.014	0.00017	0.00017
Polychlorinated biphenyls 1260	-	-		0.014	0.00017	0.00017
Pyrene	-	-			960	11,000
Simazine	4		-	-	-	-
Styrene	100		-	-	-	-
Tetrachloroethylene	5				0.8	8.85
Thiobencarb	70	1	-	-	-	-
Toluene	150				6,800	200,000
Total Trihalomethanes (THMs)[h]	80					
Toxaphene	3		0.73	0.0002	0.00073	0.00075
Trichloroethylene (TCE)	5				2.7	81
Trichlorofluoromethane (Freon 11)	150		-	-	-	-
Vinyl chloride	0.5				2	525
Xylenes (total)	1750		-	-	-	-
Microorganisms						
Total coliforms	[i]		-	-	-	-
Radionuclides						
Gross alpha (pCi/L)	15		-	-	-	-
Radium-226 and –228 (pCi/L)	5		-	-	-	-
Strontium-90 (pCi/L)	8		-	-	-	-
Tritium (pCi/L)	20,000		-	-	-	-

California Drinking Water Primary Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL) and California Toxic Rule (CTR) Criteria (values in µg/L unless otherwise noted, a "-" indicates the constituent is not regulated[a], a blank cell indicates the constituent is regulated but no objectives have been developed)						
	Title 22		**CTR**			
			Freshwater Aquatic Life		**Human Health**	
	MCL	**SMCL**	**CMC[b]**	**CCC[c]**	**Water & Organisms**	**Organisms Only**
Uranium	20 pCi/L		-	-	-	-
Beta/photon emitters	4		-	-	-	-

a "Not regulated" means that means that if the "-" is under a Title 22 column, the constituent is not a Title 22 constituent and if the "-" is under a CTR column, the constituent is not a CTR constituent. This was done to distinguish those CTR constituents with no criteria yet developed.
b CMC = criterion maximum concentration (acute criteria)
c CCC = criterion continuous concentration (chronic criteria)
d maximum recommended, upper contaminant level, short term contaminant level
e The CTR criteria for these metals are hardness dependent. The values shown assume a hardness of 100 mg/L as $CaCO_3$
f haloacetic acids include monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, dibromoacetic acid
g The CTR criteria for pentachlorophenol are pH dependent. The values shown assume a pH of 7.8
j Total trihalomethanes include bromodichloromethane, bromoform, chloroform, and dibromochloromethane. These constituents are regulated individually under CTR
i A public water system is in violation of the total coliform MCL when any of the following occurs: (1) For a public water system which collects at least 40 samples per month, more than 5.0 percent of the samples collected during any month are total coliform-positive; or (2) For a public water system which collects fewer than 40 samples per month, more than one sample collected during any month is total coliform-positive; or (3) Any repeat sample is fecal coliform-positive or E. coli-positive; o r(4) Any repeat sample following a fecal coliform-positive or E. coli-positive routine sample is total coliform-positive.

APPENDIX B: NORTH COAST BASIN ENGINEERING ANALYSIS TO IDENTIFY FACILITY COSTS TO ACHIEVE NITROGEN REMOVAL

APPENDIX C: EQUATIONS AND METHODOLOGY

Fischer *et al*. (1979) developed a method for predicting concentration of a conservative substance in a river of width W and depth d (Equation 1).

$$\frac{C}{C_{\mathrm{Re}\,f}} = \frac{1}{\sqrt{4\pi x'}} \sum_{n'=-\infty}^{\infty} \left\{ \exp\left(\frac{-\left(y' - 2n' - y_0'\right)^2}{4x'} \right) + \exp\left(\frac{-\left(y' - 2n' + y_0'\right)^2}{4x'} \right) \right\} \qquad (1)$$

Where C is constituent concentration (mg/L) at x, y in the receiving water, C_{Ref} is the reference concentration (mg/L), x' is a surrogate for the distance-depth-flow relationship (Equation 9), y' and y_0' are distances from the right-bank as a percent of the channel width, and n' is number of image sources (usually 3 or 4). Additional details about each parameter are presented below. The above equation assumes that the channel is bounded on both sides by walls where the concentration gradient is zero ($\partial c/\partial y = 0$). In Equation 1, y' is the percentage of the full channel width from the right bank to where the concentration is being predicted and y_0' is the percentage of the channel width from the right bank to where the discharge is located (Equation 2 and 3). Typical combinations of y_0 and y are presented in Table 11 and Figure 6.

$$y_0' = \frac{y_0}{W} \qquad (2)$$

$$y' = \frac{y}{W} \qquad (3)$$

Table 11. Representative Values of y_0 and y for Common Discharge Locations and Concentration Points of Interest.

		Discharge Location		
		Right Bank	**Center**	**Left Bank**
Concentration Location	**Right Bank**	$y_0 = 0$ $y = 0$	$y_0 = 0.5W$ $y = 0$	$y_0 = 1W$ $y = 0$
	Center	$y_0 = 0W$ $y = 0.5W$	$y_0 = 0.5W$ $y = 0.5W$	$y_0 = 1W$ $y = 0.5W$
	Left Bank	$y_0 = 0$ $y = 1W$	$y_0 = 0.5W$ $y = 1W$	$y_0 = 1W$ $y = 1W$

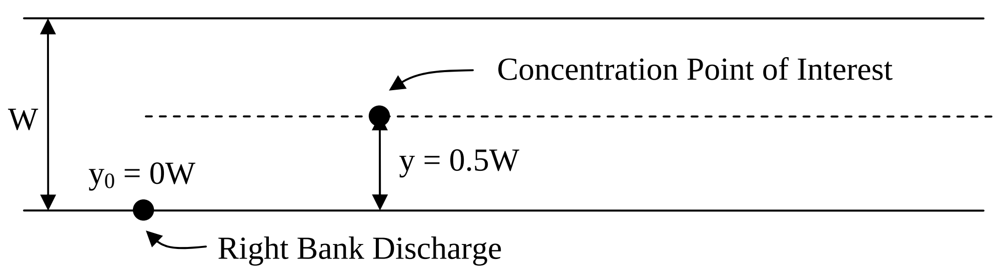

Figure 6. Representative channel with a right and centerline discharge.

To utilize Equation 1, the depth of flow and average cross sectional velocity needs to be known for the point downstream of the discharge. Assuming the channel is roughly rectangular, the depth and velocity can be determined using Manning's equation (Equation 4). (In this formulation, it is assumed that the channel width, *W*, and slope, *S*, are known.)

$$Q_r + Q_d = Q_{ds} = \frac{kdW}{n}\left(\frac{dW}{2d+W}\right)^{\frac{2}{3}}\sqrt{S} \qquad (4)$$

Where Q_r is the receiving water flow rate (m^3/s), Q_d is the discharge flow rate (m^3/s), Q_{ds} is the total downstream flow (m^3/s), *S* is slope (m/m), *n* is Manning's coefficient, and *k* is a unit dependent coefficient (1.0 for SI units and 1.486 for US units). Once depth is known, the cross sectional velocity, $\bar{u}$, can be calculated (Equation 5).

$$\bar{u} = \frac{Q_{ds}}{dW} \qquad (5)$$

Equation 1 makes use of two simplified terms: C_{Ref} and *x'*. C_{Ref} is a reference concentration (not to be confused with initial concentration in either the receiving or discharge water) (mg/m^3) (Equation 6). The numerator represents the mass flux of constituent (i.e., the mass of constituent being added to the river for each unit of time). The denominator is the volume flow rate of the channel at the point of discharge. Thus the reference concentration is the average concentration that would be observed if the constituent was instantaneously distributed throughout the water column and across width at the point of discharge with no ambient constituent concentration.

$$C_{Ref} = \frac{\alpha M}{\bar{u} dW} \qquad (6)$$

Where α is a conversion coefficient (1,000 liters = 1 cubic meters), *M* is the mass loading rate (mg/s), $\bar{u}$ is the average velocity in the cross section (m/s), *d* is the average depth (m), and *W* is the width of the cross section (m). The mass loading rate only accounts for the amount of constituent being added by the discharge (Equation 7). The ambient concentration is accounted for by the regulatory limit concentration.

$$M = \alpha Q_d C_d \qquad (7)$$

Where Q_d and C_d are the discharge flow rate (m^3/s) and concentration (mg/L), respectively. Combining Equations 6 and 7, yields a single equation for the reference concentration (Equation 8).

$$C_{Ref} = \frac{\alpha(\alpha Q_d C_d)}{\bar{u} dW} \qquad (8)$$

The second term in Equation 1, *x'*, is dimensionless (Equation 9). Where *x* is the distance downstream (m) and ε_t is the transverse mixing coefficient (m^2/s).

$$x' = \frac{x\varepsilon_t}{\bar{u} W^2} \qquad (9)$$

There are two different formulations for the transverse mixing equation Fischer *et al.* (1979): one assumes a straight channel (Equation 10) and the second assumes a curved channel (Equation 11).

$$\varepsilon_t = \beta d u^* \qquad (10)$$

$$\varepsilon_t \approx 25 \frac{\bar{u}^2 d^3}{R^2 u^*} \qquad (11)$$

The transverse mixing coefficient is dependent upon a constant coefficient (β) (Fischer *et al.* (1979) recommends a value of 0.15), depth (d) (m), the radius of the channel curve (R) (m), the velocity ($\bar{u}$) (m/s),and the shear velocity (u^*) (m/s). The curved channel transverse mixing coefficient needs the velocity of the channel which is dependent upon the channel width, W (m) and total flow, Q_{ds} (m^3/s). Overall, the curved channel has a much higher transverse mixing coefficient for the same parameter values, than the straight channel.

The shear velocity (Equation 12) depends on gravity (g) (9.81 m/s^2), and slope of the channel (S) (m/m). This is calculated the same for either a straight or curved channel.

$$u^* = \sqrt{gdS} \qquad (12)$$

Finally, Fischer *et al.* (1979) developed an equation that predicted the length required for complete mixing (Equation 13).

$$L = \gamma \frac{\bar{u} W^2}{\varepsilon_t} \qquad (13)$$

Where L is the distance to complete mix (m) and γ is a coefficient (0.1 for center channel discharges and 0.4 for bank side discharges). Equation 13 was developed assuming that “for *x’* greater than about 0.1 the predicted concentration is within 5% of its mean value everywhere on the cross section” (Fisher *et al.*, 1979, pg. 114).

Regulatory Concentration

There is the possibility that the receiving water already has some of the constituent present. In these cases, the ambient concentration must be accounted for. Equation 1 assumes that the ambient (background) concentration is zero and that the discharge is the only source of the constituent. To avoid needing to account for mixing of the ambient constituent (it is assumed that the ambient concentration is already evenly distributed throughout the cross section), the regulatory concentration requirement is reduced by the amount of the ambient concentration.

For example, if the regulatory requirement (C_{Reg}) is 10 mg/m^3 and the ambient concentration (C_r) is 1 mg/m^3, then the applied regulatory requirement ($C_{Reg,App}$) is 9 mg/m^3. This essentially assumes that the discharge can only increase the concentration in the river, up to the point where the combined concentrations (ambient plus discharge) would result in the regulatory criteria being met (Equation 14).

$$C_{Reg,App} = C_{Reg} - C_r \qquad (14)$$

Determination of Mixing Length

The purpose of the model is to determine the distance downstream to achieve a regulatory concentration. As such, the concentration measurement location must be on the same flow line as the discharge (i.e., a center line discharge must have concentrations predicted at the centerline, whereas a right bank discharge must have concentrations predicted at the right bank). Equation 1 depends on values of y', y0', *x'* and *n*.

For each calculation of Equation 1, the values of *n* ranged from -4 to 4, in whole increments (i.e., -4, -3, -2, -1, 0, 1, 2, 3, and 4). Overall, additional *n* terms could further refine the summation, but overall the values did not substantially change. A curve is constructed relating the values of *x'* to C/C_{Ref} (Figure 7). With the values of depth, width, and velocity known, Equation 9 can be rearranged and solved for the downstream distance (*x*) (Equation 15).

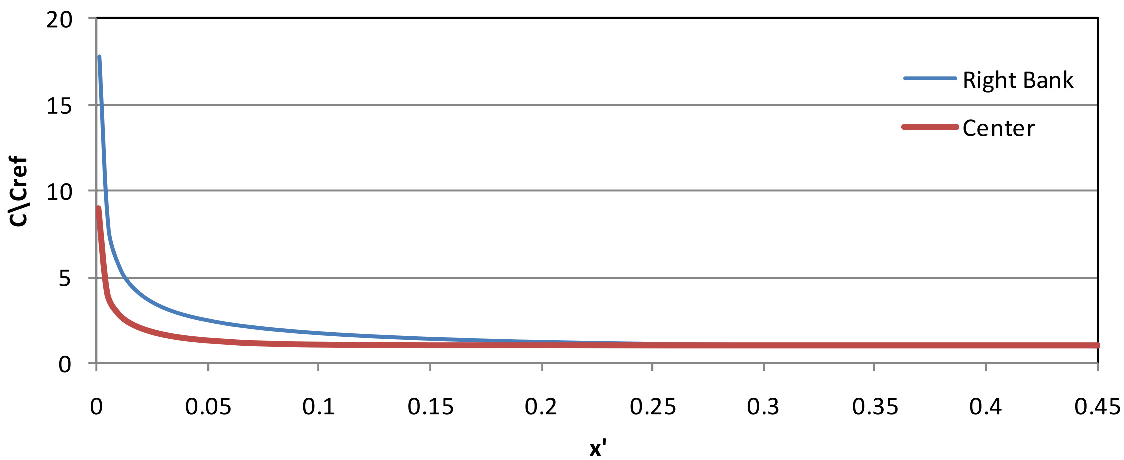

Figure 7. C/C_{Ref} as a function of *x'* for a right bank and center line discharge.

$$x = \frac{x'\bar{u}W^2}{\varepsilon_t} \qquad (15)$$

The reference concentration is known from Equation 8. Let φ equal the right-hand side of Equation 1 (Equation 16). Rearranging the terms yield a simple relationship between C and C_{Ref} (Equation 17).

$$\varphi = \frac{1}{\sqrt{4\pi x'}} \sum_{n'=-\infty}^{\infty} \left\{ \exp\left[\frac{-\left(y'-2n'-y_0'\right)^2}{4x'} \right] + \exp\left[\frac{-\left(y'-2n'+y_0'\right)^2}{4x'} \right] \right\} \qquad (16)$$

$$C = \varphi C_{Ref} \qquad (17)$$

The model has several discharge limit checks regarding high ambient conditions and high discharge concentrations. In both cases, the concentrations may be sufficiently high that the regulatory requirement cannot be achieved (i.e., complete mix concentration exceeds the regulatory requirement) or the distance calculated exceeds the complete mix distance. The complete mix concentration is calculated using the conservative mixing equation (Equation 18).

$$C_{ds} = \frac{Q_r C_r + Q_d C_c}{Q_r + Q_d} \quad (18)$$

If the ambient concentrations equal or exceed the regulatory requirement, then no additional discharge concentration is allowed because the complete mix concentration would be greater than or equal to the regulatory limit. In the case where the ambient condition equals the regulatory requirement and discharge concentration also equals ambient conditions, it is assumed that a mixing length is not needed because the concentrations were equal. Likewise, if the ambient condition equals the regulatory requirement and the discharge concentration is lower, then a regulatory mixing zone is not needed because the discharge is reducing the overall concentration.

If the ambient concentration is below the regulatory requirement, then some discharge should be possible. If the discharge concentration is sufficiently high to result in a complete mix concentration that exceeds the regulatory requirement, then the mixing length is not needed because for this discharge, compliance would not be achieved in an infinitely long mixing zone.

On the other hand, if the calculated mixing zone length (Equation 15) exceeds the complete mix length (Equation 13), but the complete mix concentration is less than or equal to the regulatory requirement, then the mixing zone length is set to the length calculated for complete mix. Recall that Equation 17 is exponential, so for very small values of x' (and by extension C), the value of the curve grows exponentially (Figure 7) resulting in distances that are greater than what are calculated by Equation 13.

Limitations

The formulation in Fischer *et al.* (1979) cannot be utilized when the mixing length is very near zero. Equation 1 uses an exponential equation which approaches infinity when x' approaches zero and approaches one (but does not reach it) as x' approaches infinity. This approach was developed to estimate potential ranges of mixing zones for simplified conditions (e.g., small, medium, and large receiving water sizes), and is not intended to represent site specific conditions at each discharge. Detailed field data and assessment of local conditions would be required to assess mixing zones for individual discharges.

Discussion

The parameters needed to determine the mixing zone length can be lumped into four broad categories:

- Channel morphology (width, depth, and slope),
- Receiving water conditions (flow and ambient concentration),
- Discharge conditions (flow, concentration, and location), and
- Criteria conditions (regulatory concentration and measurement location).

For the purposes of this discussion, a right-bank discharge ($y_0 = 0W$) is assessed. The concentration is measured on the right bank ($y = 0W$) and the regulatory nitrate concentration is 10.0 mg/L (assumed to be the same everywhere).

Base Parameter Values

The effects of each parameter on the mixing length (to achieve regulatory concentrations in the receiving water) can be determined if a base case of parameter values is developed:

- Width = 25.0 m
- Depth = 2.0 m
- Slope = 0.0002 m/m
- Receiving Water Flow = 50.0 m^3/s
- Receiving Water Concentration = 0.2 mg/L
- Discharge Flow = 5.0 m^3/s
- Discharge Concentration = 15 mg/L

When width, receiving water concentration, discharge flow, or discharge concentration are increased, the mixing zone length also increases. When depth, slope, or receiving water flow is increased, the mixing zone length decreases. Essentially, mixing zones are the smallest when small, low concentration discharges occur into deep, fast moving water bodies.

Flow Rate and Depth

Monthly average flow rates and associated depths for the four receiving water groups (very small, small, medium, and large) were obtained from various gages. If multiple data sets were available for a receiving water group, the values were aggregated to form a single data set[1]. A power function was fit through the available data, related water depth to a given flow rate.

Mixing Zone Lengths for Each Receiving Water Group

The approximate mixing zone length for each of the receiving water groups (i.e., very small, small, medium, and large) was estimated for a variety of parameter values (Table 12). Twelve flows and depths calculated using the regression equation were used, along with three different width values. The six different discharge concentrations were assessed and discharge flow was fixed at one percent of the ambient flow.

Table 12. Summary of Parameter Values.

		Receiving Water			Discharge	
Grouping	Widths (m)	Flow (m^3/s)	Depth (m)	Concentration (mg/L)	Flow (m^3/s)	Concentration (mg/L)
Very small	12, 23, 35	1 – 58	0.29 – 1.11	0.2	1%	11, 15, 20, 30, 35, 40
Small	49, 82, 115	197 – 3,814	3.82 – 7.55	0.2	1%	11, 15, 20, 30, 35, 40
Medium	82, 164, 246	101 – 10,536	3.56 – 9.61	0.2	1%	11, 15, 20, 30, 35, 40
Large	82, 164, 246	158 – 70,551	7.92 – 20.30	0.2	1%	11, 15, 20, 30, 35, 40

Overall, the very small receiving water group experienced the longest average distances to achieve the regulatory concentration, regardless of the discharge concentration. The small, medium, and larger receiving water groups had similar distance requirements, with the small receiving water group experiencing slightly shorter distances (Figure 8 and Table 13). For the very small receiving water group, the channel was relatively wide, with small, shallow flows. As

[1] There were two data sets (Ukiah and Cloverdale) available for the small receiving water group. However, the flow-depth data for Ukiah did not exhibit a strong relationship (i.e., depth increased with increasing flow), as a result, the regression relationship was developed using only the Cloverdale data, which did exhibit a consistent trend.

a result, the distance required varied from less than the width to more than twice the width of the channel. For the other three receiving water groups, the channel was wider than for the very small, but transported more flow and were deeper, resulting in less distance (usually about one width) being needed, even for high concentration discharges. Also, as expected, as discharge concentration increases, so does the mixing zone length.

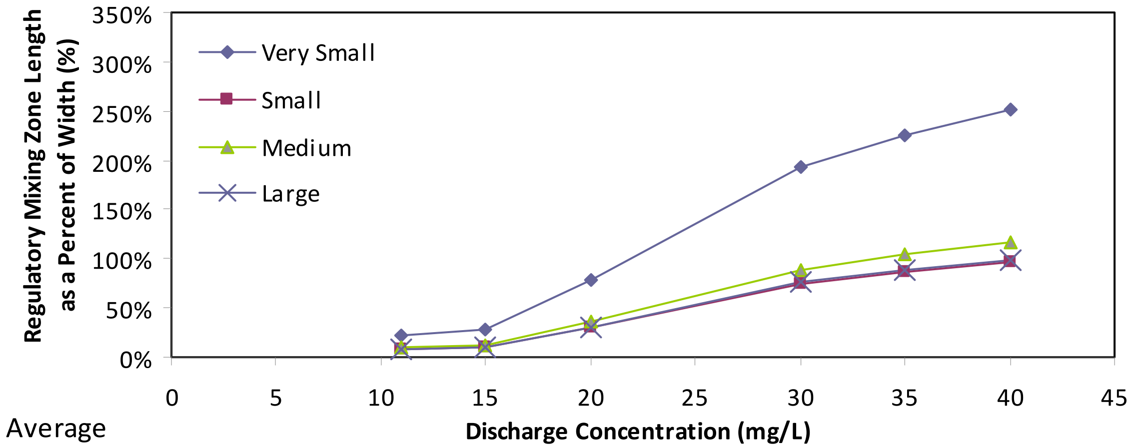

Figure 8.Average distance, as a percent of the channel width, to achieve the regulatory concentration requirement for different discharge concentrations.

Table 13. Mixing Zone Length as a Percentage of Channel Width for Various Receiving Water Groups and Discharge Concentrations.

	Mixing Zone (Min-Avg-Max) as a Percentage of Channel Width			
Discharge Concentration (mg/L)	**Very Small**	**Small**	**Medium**	**Large**
11	11%-14%-15%	15%-15%-17%	3%-8%-16%	0%-6%-11%
15	14%-17%-19%	18%-19%-20%	4%-10%-20%	0%-7%-13%
20	40%-49%-54%	51%-54%-58%	10%-29%-57%	1%-20%-37%
30	98%-120%-133%	125%-132%-143%	25%-72%-142%	3%-51%-92%
35	115%-141%-156%	146%-155%-167%	30%-84%-166%	4%-59%-108%
40	127%-156%-173%	162%-172%-185%	33%-93%-184%	4%-66%-120%

In general, for discharge concentrations less than double the 10 mg/L regulatory requirement, the mixing zone length is less than or equal to one channel width. For higher discharge concentration, the mixing zone length increases (Table 14). At the highest discharge concentration evaluated (40 mg/L), the mixing zone length was about three times the channel width (2.75W to 3.25 W) or less than twice the width for the small receiving water group.

Table 14. Mixing Zone Length as a Function of Channel Width for Various Receiving Water Groups and Discharge Concentrations.

	Maximum Mixing Zone Length As A Function of Channel Width			
Discharge Concentration (mg/L)	**Very Small**	**Small**	**Medium**	**Large**
11	0.25W	0.25W	0.25W	0.25W
15	0.25W	0.25W	0.50W	0.50W
20	0.75W	0.75W	0.75W	0.50W
30	1.50W	1.50W	1.50W	1.00W
35	1.75W	1.75W	1.75W	1.25W
40	1.75W	2.00W	2.00W	1.25W

Example

A right bank discharge of 0.5 m^3/s, with a concentration of 15 mg/L was released into a 25-meter wide river with a slope of 0.0002 and a radius of 10 m. The river has a flow of 50 m^3/s and an ambient concentration of 0.2 mg/L. The maximum allowable regulatory concentration was 10 mg/L. The channel depth was 2.0 m.

The total flow downstream was 50.5 m^3/s (50 + 0.5). The velocity was 1.01 m/s.

$$\bar{u} = \frac{Q}{dW} = \frac{50.5}{(2.0)(25)} = 1.01$$

The shear velocity and transverse mixing coefficient can be determined using the depth, width, and slope. The shear velocity is 0.0626 m/s, while the linear transverse mixing coefficient is 0.0188 m^2/s and the curved transverse mixing coefficient is 32.5693 m^2/s.

$$u^* = \sqrt{(9.81)(2.0)(0.0002)} = 0.0626$$

$$\varepsilon_t = (0.15)(2.0)(0.0626) = 0.0188$$

$$\varepsilon_t = 25\frac{(1.01^2)(2.0^3)}{(10^2)(0.0626)} = 32.5693$$

The discharge and point of interest are located on the right bank ($y' = y_0' = 0$). The values of n' range from -4 to 4 in increments of one. The C/C_{Ref} as a function of x' line is presented in Figure 7. The reference concentration is 0.35 mg/m^3:

$$C_{Ref} = \left(\frac{\left(1000\frac{L}{m^3}\right)\left(0.5\frac{m^3}{s}\right)\left(15\frac{mg}{L}\right)}{\left(1.01\frac{m}{s}\right)(25m)(2.0m)}\right)\left(1000\frac{L}{m^3}\right) = 0.35\frac{mg}{L}$$

A general curve relating a range of x' and C/C_{Ref} values can be developed as long as the value of y is known (i.e., the location of the discharge) (see Figure 7). The general curve uses a range of values for x' (0.45 to ~0.00) to determine the corresponding value of C/C_{Ref}. In this case, the discharge is located on the right bank, so the blue line is of interest. The range of x' values can be converted to their downstream distance (x) equivalents because the depth, velocity, and transverse mixing coefficient are known. Likewise, the values of the downstream concentration (C) can be determined because the value of C_{Ref} is known (Equation 17). See Table 15 and Figure 9.

Table 15. Representative Values for x' and C/C_{Ref} and the Associated Values of C and x.

x'	$C/C_{Ref} = \varphi$	$C = \varphi C_{Ref}$	$X = x'\varepsilon_t/uW^2$
0.002	12.61566	4.37176	67
0.001	17.84124	6.18261	34
0.0001	56.41896	19.55112	3.4
0.00001	178.41241	61.82608	0.3

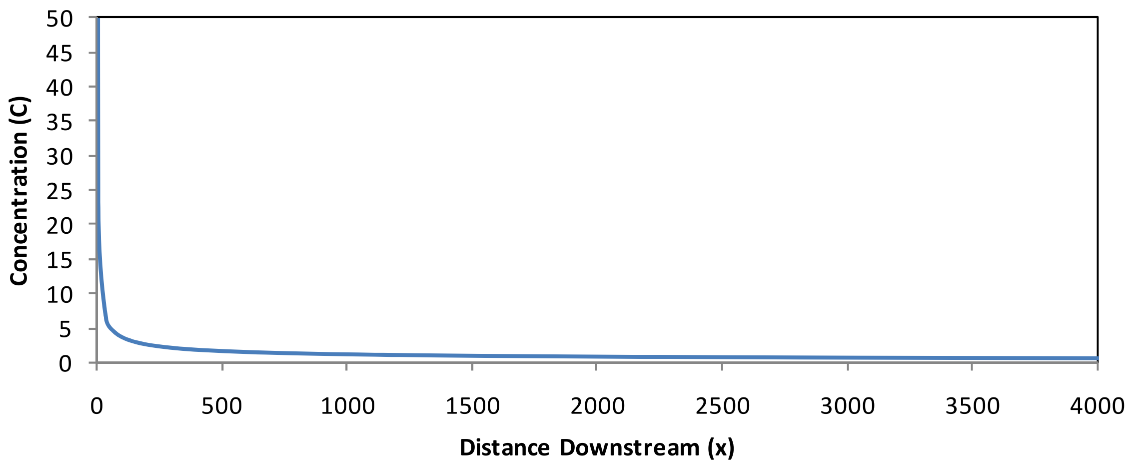

Figure 9. Concentration as a function of downstream distance.

Now the applied regulatory concentration must be determined. The regulatory concentration was 10 mg/L and the ambient concentration was 0.2 mg/L. As a result, the applied regulatory concentration is (10 mg/m^3 – 0.2 mg/m^3) 9.8 mg/m^3. The concentration versus downstream distance curve is assessed for the point where C equals 9.8 mg/L. Using Figure 9 and interpolating to find the value of x that corresponds to a C value of 9.8 mg/L, yields a distance of 25.4 m. The complete mix distance is 13,436 m, so the calculated distance is less. Thus it takes approximately one width (25.4 m / 25 m) to achieve the regulatory requirement when accounting for ambient conditions.