



San Francisco Bay, California

Watershed Permit for Nutrients from Municipal Wastewater Discharges to San Francisco Bay

Overview

San Francisco Bay has historically been recognized as a nutrient-enriched water body but has not experienced adverse environmental impacts due to its nutrient resilience. Many factors have contributed to this resilience, including strong tidal mixing, light limitation due to high turbidity, and grazing pressure by clams. As a result, the bay is not currently on the Clean Water Act 303(d) list for nutrient impairment.

For the past 20 years, the bay has started to show evidence that its nutrient resilience may be declining. To address the nutrient contributions to the bay watershed by municipal wastewater dischargers, the State of California San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued a watershed-based permit in July 2014 and reissued it in 2019.

This case study focuses on the National Pollutant Discharge Elimination System (NPDES) Watershed Permit for Nutrients from Municipal Dischargers to San Francisco Bay (NPDES No. CA0038873) issued by the Regional Water Board. The permit implements a regional nutrient management strategy (NMS) to avoid nutrient-related impairments in the bay.

Watershed

San Francisco Bay Watershed, California

Key Water Quality Concerns

Excessive nutrients (nitrogen and phosphorus)

Stakeholder Involvement Techniques

- Stakeholder advisory group
- Discharger association

Case Study Issues of Interest

Type of Point Sources



Publicly Owned Treatment Works Discharges

Type of Watershed-Based Permit or Approach



Multisource Watershed-Based Permit

Highlighted Approach(es)



Implementation of Total Maximum Daily Loads or Other Watershed Pollutant Reduction Goals



Discharger Association



Coordinated Watershed Monitoring

Background

The history of nutrient resilience in the San Francisco Bay has been considered the product of several characteristics specific to the bay, including strong tidal mixing, high turbidity that limits light penetration, and high filtration by clams. However, recent data indicate an increase in phytoplankton biomass and a small decline in dissolved oxygen concentrations in many areas of the bay, suggesting that the bay's historic resilience may be weakening.

To address the bay's emerging nutrients issue, the Regional Water Board, in collaboration with the Southern California Coastal Water Research Program and the San Francisco Estuary Institute (SFEI), began developing nutrient numeric endpoints for the bay. As part of this process, the Regional Water Board developed a regional NMS in 2012 to avoid nutrient-related impairments in the bay. The NMS called for a collaborative effort to develop the science to support regulatory management decisions. The key goals of this effort included:

- Synthesis of the available scientific information and development of a science plan.
- Continued development of nutrient objectives.
- Development of a monitoring program to help model the bay ecosystem's response to nutrients.
- Development of implementation strategies.

Municipal wastewater treatment plants account for approximately 62 percent of the average annual total inorganic nitrogen load to San Francisco Bay. Inorganic nitrogen is the bioavailable form of nitrogen.

To date, a stakeholder advisory group has helped guide development of the numeric nutrient endpoints and implementation of the NMS. The Regional Water Board and stakeholder advisory group prepared a charter describing the guiding principles of the NMS, its organizational structure, participants' roles and responsibilities, and protocols for decision-making and communication.

What is the San Francisco Bay NMS?

The San Francisco Bay NMS is a regional initiative to develop the science needed for informed decisions about managing nutrient loads and maintaining beneficial uses within the bay. It was developed in response to the apparent changes in the bay's resilience to nutrient loading. Stakeholders, including federal and state agencies, local governments, nonprofit organizations, and academic institutions, provide funding and oversight. The goal of the NMS is to establish a reasonable and cost-effective program to support and implement major management decisions grounded in science.

To begin implementing the NMS, the Regional Water Board issued an NPDES watershed permit for discharges of nutrients to the bay in 2014 (2014 Permit). All the municipal wastewater treatment facilities that discharge nutrients to the bay were included in this first permit. The Regional Water Board reissued the permit in 2019 (2019 Permit).

Permit Strategy

The San Francisco Bay watershed-based permit covers 41 municipal wastewater treatment plants represented by 34 dischargers. These facilities produce about two-thirds of the nutrient load to the bay and its tributaries.

The watershed-based permit implements a phased approach to protect the bay's beneficial uses from the harmful effects of excess nutrients. The approach extends over multiple permit terms to determine the appropriate level of nutrient controls and identify actions necessary to manage nutrients in the bay. This watershed-based approach is intended to provide regulatory certainty that future actions to include nutrient removal requirements will result in desired water quality outcomes in the bay. It also

encourages collaboration among regulated entities and the Regional Water Board and provides opportunities for cost-sharing and economy of scale benefits.

The first phase, coinciding with the issuance of the 2014 Permit, focused on gathering nutrient loading data to improve water quality models; understanding the fate and effects of nutrients in the bay; and evaluating potential treatment optimization, upgrades, and alternative nutrient reduction options. Permittees were required to support development of a science plan of necessary studies to support implementation of the San Francisco Bay Nutrient Management Strategy. A Nutrient Management Strategy Science Plan was developed with input from science advisors, a steering committee, and technical work group and was finalized in September 2016. The requirements of the 2014 permit were intended to set forth a regional framework to facilitate collaboration on studies that would inform future management decisions and regulatory strategies. The Regional Water Board developed the 2014 Permit in collaboration with the Bay Area Clean Water Agencies (BACWA), a discharger association representing the wastewater treatment agencies in the Bay Area. BACWA levies a nutrient surcharge on association members to fund permit compliance activities.

The second phase began with the issuance of the 2019 Permit, which continues to implement the regional framework established by the 2014 Permit. The goal of the second phase is to track and evaluate treatment plant performance, (including implementation of nutrient removal controls), fund nutrient monitoring programs and nutrient fate and effect studies, support load response modeling, and evaluate nutrient removal approaches using natural systems and wastewater recycling.

The third phase will be implemented during the next reissued permit, which is due to be reissued in 2024. The Regional Water Board will rely on the scientific information collected during the first two phases to establish nutrient effluent limitations, which could require treatment plants to implement facility optimization, upgrades, or other means to reduce nutrient loads to the bay. The Regional Water Board will also include a nutrient load and credit trading system between dischargers.

Permit Highlights

The 2019 Permit contains a unique combination of watershed-based permitting and adaptive management requirements. The permit requires that:

- Each discharger must conduct effluent monitoring for ammonia, nitrate-nitrite, total inorganic nitrogen, and total phosphorus.
- Dischargers must, either individually or through BACWA, submit an annual report that analyzes trends in flow and nutrient loadings.
- Each discharger classified as “major” must participate in a regional evaluation of potential nutrient discharge reduction approaches by natural systems (e.g., wetlands, horizontal levees) and water recycling.
- Dischargers must collaborate with other regional stakeholders to support receiving water monitoring efforts by providing a network of nutrient monitoring locations, adequate data to support fate and transport modeling, and studies of harmful algal bloom development.
- Dischargers must support updates and implementation of the science plan submitted under the 2014 Permit.

Requiring both effluent and ambient monitoring will produce robust data and relative scientific certainty to support the establishment of future effluent limitations. Each discharger will also know, through its optimization and treatment upgrade studies, the cost of any future nutrient reductions.

Permit Components

Effluent Limitations

Due to the uncertainty of the nutrient-related impacts in the bay, the Regional Water Board did not establish effluent limitations in the 2014 or 2019 Permits. However, as a precursor to potential effluent limitations in future permit renewals, the fact sheet for the 2019 Permit included non-enforceable estimates of nutrient load targets that dischargers classified as “major” may be expected to meet by 2024 (accounting for both current nutrient discharge performance and future population growth). Dischargers can use the nutrient load targets to begin implementing early actions to reduce nutrients and inform future facility planning efforts (e.g., treatment plant upgrades, wetland creation as tertiary treatment). Since nitrogen is the growth-limiting nutrient for phytoplankton in the bay, the nutrient load targets are expressed in terms of total inorganic nitrogen, the bioavailable form of nitrogen.

To determine nutrient load targets, the Regional Water Board used only dry season discharge data, by excluding nutrient removal variability caused by increased influent flows and lower temperatures during wet weather. Consequently, the Regional Water Board did not assign load targets to dischargers prohibited from discharging during the dry season because they store or recycle their wastewater during the dry season. The board determined the load targets by adding a 15 percent buffer to the current nutrient discharge performance (i.e., the maximum dry season average between May 1, 2014, and September 30, 2017) to account for population growth and variability and uncertainties in interannual load levels.

The Regional Water Board anticipates that effluent limitations in the 2024 Permit will be based on performance between May 2014 to September 2017. This will ensure that dischargers who took early actions to reduce nutrient discharges during the 2019 Permit term are not penalized with more stringent effluent limitations. Before implementing any load targets as effluent limitations, the Regional Water Board may adjust the targets to account for decreased recycled water demand, increased biosolids management, increased daytime worker population, or new or expanded waste-to-energy programs. The Regional Water Board also intends to establish a bay-wide load cap based on the aggregate of all discharges and will determine compliance based on the bay-wide cap. Individual discharges that exceed their limitations will only be considered in violation if the cap is not met.

If current scientific information indicates that nutrient loads must be reduced bay-wide or within a subembayment (e.g., Lower South Bay, South Bay, Central Bay, or North Bay segments), the Regional Water Board will recognize early actions when determining future load reductions or caps. Early actions may include dischargers’ capital or operational improvements or other actions that significantly reduce nutrient loads during the current permit term. Under these circumstances, it’s likely that no further actions would be necessary for the design life improvements, provided that other dischargers could implement capital improvements to reduce nutrient loads below a bay-wide or subembayment cap.

If the Regional Water Board establishes more stringent load reductions or subembayment caps in the future, dischargers unable to immediately comply with resulting effluent limitations will be able to apply for a compliance schedule (which provides the discharger time to comply with their permit limit) if they meet the requirements of the state’s Policy for Compliance Schedules in NPDES Permits (Resolution No. 2008-0025). Dischargers who commit to robust master planning efforts to reduce nutrient discharges will be well positioned to justify and receive a compliance schedule.

Because portions of the bay share different nutrient sources and unique hydrodynamic characteristics, the Regional Water Board expects to evaluate compliance with any future effluent limitations on a subembayment scale (e.g., establishing subembayment load caps), with consideration of cost-effective and feasible nutrient management solutions. This approach, like the expected bay-wide load cap, provides a framework for the Regional Water Board to consider nutrient credit and load trading among dischargers when evaluating compliance with load caps.

Monitoring and Reporting Requirements

The 2019 Permit requires dischargers to conduct influent and/or effluent monitoring for nutrients. The required monitoring frequency depends on the facility design flow and classification as a “major” or “minor” discharger. A discharger may discontinue influent monitoring for nitrate-nitrite after two years if all concentrations are below 2 milligrams per liter (mg/L).

Influent Monitoring Requirements for Design Flow > 10.0 Million Gallons per Day (MGD)

Parameter	Monitoring Frequency
Total ammonia	1/quarter
Total Kjeldahl nitrogen	1/quarter
Nitrate-nitrite	1/quarter
Total phosphorus	1/quarter

Effluent Monitoring Frequencies

Parameter	Major Dischargers ≥ 10.0 MGD	Major Dischargers < 10.0 MGD	Minor Dischargers < 1.0 MGD
Total ammonia	2/month	1/month	1/year
Nitrate-nitrite	2/month	1/month	1/year
Total inorganic nitrogen	2/month	1/month	1/year
Total phosphorus	2/month	1/month	1/year

Dischargers must include monitoring results with their individual monthly or quarterly self-monitoring reports. The discharger is also required, by January 1 of each year, to either submit a separate annual nutrients report or state that it is participating in a group report submitted by BACWA. The report must include:

- Annual and monthly effluent flows.
- Effluent nutrient concentrations and mass loads.
- Nutrient loads relative to other dischargers in the same subembayment.
- An analysis of nutrient trends, load variability, and whether nutrient mass discharges are increasing or decreasing.
- A discussion of the status of special studies.

Where the trend analysis shows a significant change in load, the discharger must investigate the cause and provide a report describing the investigation and its results.

Special Provisions

The 2014 and 2019 Permits include special provisions requiring dischargers to evaluate options for improving nutrient removal. Dischargers can fulfill these requirements individually or in collaboration with other dischargers and regional stakeholders.

The 2014 Permit required major dischargers to evaluate potential nutrient reductions through treatment optimization, such as operational adjustments to existing treatment systems, process changes, minor upgrades, or opportunities for side-stream treatment. These evaluations included measures dischargers had already implemented, the anticipated beneficial and adverse ancillary impacts of each optimization proposal, planning level cost estimates for each option, and the anticipated impacts on nutrient loads.

The 2014 Permit also required major dischargers to evaluate potential upgrade technologies at each treatment plant or category of similar treatment works and the potential nutrient removal levels. This provision required dischargers to identify potential challenges to implementation, provide planning level capital and operating cost estimates, describe existing upgrades or pilot studies, and describe the potential beneficial and adverse ancillary impacts of each upgrade option. In addition to upgrades, dischargers were required to evaluate ways to reduce nutrient loading through alternative discharge scenarios in combination with or in lieu of upgrades.

The 2019 Permit also includes special provisions requiring major dischargers to conduct additional nutrient reduction evaluations. The first requirement is to evaluate options to reduce nutrient discharge using natural systems, such as treatment wetlands. Dischargers are also required to evaluate the potential for nutrient reductions through water recycling (e.g., irrigation).

Both the 2014 and 2019 Permits required dischargers to collaborate with other regional stakeholders to help develop and implement a science plan for studies needed to implement the NMS and support future consideration of management actions. Dischargers are also required to collaborate with other regional stakeholders to support receiving water monitoring for nutrients beyond the monitoring provided by the existing, discharger-funded San Francisco Bay Regional Monitoring Program.

Permit Effectiveness

Environmental Benefits

This approach provides time to determine the most cost-effective and multi-beneficial means of maintaining and improving the bay's nutrient assimilative capacity. It allows the Regional Water Board time to study the bay; evaluate options to reduce nutrient loads; and develop models that predict the bay's response to increased or decreased nutrient loads under different scenarios, such as warmer temperatures, reduced turbidity, longer periods of stratification, and decreased grazing pressure from clams. These studies will help ensure that any future nutrient load reduction requirements will have the desired effect of preventing water quality impacts associated with nutrient over-enrichment.

This approach has also provided dischargers with time to evaluate the best options for nutrient load reduction, with an emphasis on options that could have environmental benefits beyond nutrient removal. By the end of the second watershed permit term, each discharger will have a portfolio of options with estimated costs for removing nutrients via treatment plant optimization, treatment plant upgrades, implementation of nature-based solutions (e.g., treatment wetlands), and wastewater recycling. This phased approach allows dischargers to consider innovative solutions with multiple environmental benefits. For example, horizontal levees, which are sloped treatment wetlands, have

been shown to remove constituents of emerging concern (e.g., pharmaceuticals) and provide protection from sea-level rise.

Benefits to the Discharger

The watershed-based nutrients permit allows dischargers to share costs and complete many of the permit requirements in collaboration with other regional stakeholders through BACWA, their regional association. This provides facilities with a more flexible and cost-effective approach to fulfilling their permit requirements. This flexibility not only helps dischargers meet their individual requirements, but it also allows for future economic growth in the region as it eases costs and resource demands.

Benefits to the Permitting Authority

The watershed-based permit benefits the permitting authority by providing a consistent approach for all municipal wastewater dischargers to the bay. This helps streamline the reissuance of individual permits because all nutrient-related issues are addressed through a single permit. This approach also allows for a mechanism to fund science (e.g., water quality modeling, special studies, receiving water monitoring) that can be directed through one research institution with expected funding levels established each permit term. This ensures consistency in data collection and interpretation, which makes oversight by the permitting authority less time-consuming and more efficient.

Lessons Learned

According to Regional Water Board staff, the most challenging aspects of developing the permit were 1) ensuring that all stakeholders could provide input and 2) balancing competing initiatives of ensuring that the permit would protect the bay in the future amidst a changing climate and ecosystem and preventing the establishment of overly restrictive permit requirements. To address these concerns, the Regional Water Board formed a steering committee, along with a governance structure that allows stakeholders to provide input on special studies, modeling, receiving water monitoring, and development of an assessment framework that will establish indicators for nutrient over-enrichment. Another challenge was settling on an appropriate funding level for dischargers to help develop science plans and studies.

The Regional Water Board noted that insufficient funding was also an initial challenge. For the 2014 Permit, the funding requirement for science plan development, receiving water monitoring, modeling, and special studies was set at \$880,000 per year. This proved to be insufficient to move enough projects forward, as other potential funding sources did not materialize at the desired level. To increase funding levels in the 2019 Permit, the Regional Water Board identified core studies that must be implemented and funding needs for those projects to move forward. Based on this information, the funding requirement was increased to \$2.2 million per year.

The Regional Water Board suggests that the watershed-based permitting approach used for the San Francisco Bay could be appropriate in other watersheds with an established research institution that is already trusted by stakeholders. This approach worked well because SFEI has taken the lead in monitoring and conducting water quality studies in the bay since 1992. Instead of requiring receiving water monitoring with each individual NPDES permit, dischargers provide financial contributions to the San Francisco Bay Regional Monitoring Program, which SFEI oversees. The program has governance and advisory committees that include regulators, dischargers, and nongovernmental organizations to guide where funds should be allocated. The watershed-based permit and associated funding for studies expanded SFEI's role in conducting more work related to nutrients, which has been instrumental to the success of this permitting strategy.

There could have been earlier and stronger incentives for dischargers to take early actions to reduce nutrients through projects with multiple benefits, such as wastewater recycling or nature-based solutions. It would be beneficial to have more grant funding available for projects with multiple benefits that may be more costly compared to conventional wastewater treatment upgrades for nutrient removal.

Resources

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https://sfbaynutrients.sfei.org/sites/default/files/2016_NMSSciencePlan_Report_Sep2016.pdf

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Permit Information:

Permit:
https://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2019/R2-2019-0017.pdf

Pollutants of Concern in Watershed:

Excessive nutrients (phosphorus and nitrogen)

Pollutants Addressed in Permit:

Total nitrogen and total phosphorus

Permit Issued:

July 1, 2014

Reissued:

July 1, 2019