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Nutrient Regulatory Considerations

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NUTRIENT REGULATORY CONSIDERATIONS

Nutrient Strategy Development Project

1. INTRODUCTION

This paper was prepared for the Bay Area Clean Water Agencies (BACWA), a joint powers agency whose members collectively provide municipal sanitary services to more than seven million people in the San Francisco Bay Area. BACWA's mission is to provide an effective voice for its members' role as stewards of the San Francisco Bay environment through leadership, science, and advocacy. One of BACWA's goals is to ensure that environmental regulations and policies reflect the best available scientific, technical and economic information and that these regulations and policies balance environmental, social and economic sustainability.

Long-term water quality monitoring indicates that many portions of San Francisco Bay have experienced marked increases in chlorophyll-a, a pigment found in all green plants including phytoplankton. The cause of this increase is unknown, but may include changes in light regimes, changes in ecosystem function resulting from invasive species, and coastal influences. Often the availability of nitrogen is the factor that limits phytoplankton growth in estuaries. However, San Francisco Bay ambient nutrient concentrations are relatively high, and have not changed significantly in recent years. While San Francisco Bay nutrient concentrations are on par with those of other nutrient-impaired estuaries, such as the Chesapeake Bay, the San Francisco Bay has typically been considered resilient to the effects of nutrient loads and has not experienced similar water quality impairment. However, concern exists that changes in factors other than nutrient concentrations may lead to nutrient-related impairment.

As sources of nitrogen and phosphorous – the natural end products of wastewater treatment – BACWA member agencies recognize that, should current trends continue, they will play a key role in efforts to reduce nutrient loading. The experience of other wastewater utilities with water quality based nutrient management requirements in other watersheds nationwide may provide useful examples to BACWA managers facing potential nutrient control requirements. The approach to engagement in the regulatory process has yet to be developed. Information presented in this topic paper may help inform BACWA members and provide background to compare potential approaches to engagement in the evolving nutrient regulatory process.

BACWA's objective with respect to nutrients is to support the development of scientifically based regulations that will result in water quality improvements while balancing environmental and economic objectives. To this end, BACWA is developing information on the technical aspects of nutrient management as well as potential future regulatory framework. While BACWA's priority is to understand the estuary sufficiently to know whether nutrients are causing impairment, information is also being developed to support regulatory strategy development, should it be needed.

2. PURPOSE

The purpose of this topic paper is to provide information to BACWA member agencies to characterize the unique challenges posed by nutrient management regulatory requirements for municipal dischargers and to outline appropriate discharge permitting structures for practical, technically achievable, and economical compliance. In this way, a common understanding of the potential impacts of nutrient management regulatory requirements can be shared by BACWA members. A further objective is to develop a foundation for a nutrient regulatory strategic planning process for consideration by BACWA members. This includes engagement in two aspects of the nutrient management: (1) regulatory process; and (2) nutrient management/reduction actions.

This paper is the third in a series of three topic papers. All three papers are scheduled to be completed in the fall of 2011. Descriptions of the other two topic papers are provided below:

- **Water Quality Modeling:** The modeling topic paper presents a conceptual model of the relationships between phytoplankton biomass, nutrients, and physical and biological drivers in the San Francisco Bay (SFB) Estuary. The paper also presents a strawman approach for developing a nutrient based eutrophication model of the SFB Estuary.

- **Potential Impacts of Nutrient Removal Treatment**: This topic paper describes to BACWA member agencies the implications of transitioning from secondary to nutrient removal treatment. In particular, the topic paper: (1) describes a range of facility requirements and the potential impact on publically owned treatment works (POTWs) operations; (2) presents a basis for a range of unit costs; and (3) addresses the unintended consequences related to the conversion from secondary to nutrient removal treatment.

2.1 Overview of Nutrient Issues

Nationally, EPA began a program emphasizing the development of state numeric nutrient standards for nitrogen and phosphorus in 1998 with a goal of adopting numeric nutrient standards in all states by 2002. States have been slow to develop numeric nutrient standards and few states have actually adopted standards for all types of waterbodies.

2.2 Background on Numeric Nutrient Criteria

In June 1998, the EPA published the National Strategy for Development of Regional Nutrient Criteria. A key component of the strategy was that the EPA would develop waterbody-type technical guidance documents. EPA published technical guidance for developing criteria for lakes and reservoirs in May 2000, rivers and streams in June 2000, and estuaries and coastal waters in October 2001 and recommended nutrient criteria for most streams and lakes in January 2001 (EPA, 2003). In November 2001, EPA issued a memorandum to the states about planning the development and adoption of nutrient criteria into water quality standards. Key elements included the recommendation that the states develop local nutrient criteria based on the technical guidance manual processes.

2.2.1 May 2007 EPA Policy Statement

On May 25, 2007, Ben Grumbles, EPA Assistant Administrator, issued a memorandum entitled "Nutrient Pollution and Numeric Water Quality Standards" to State and Tribal water program directors. The memorandum provides an update on the EPA's commitment to accelerating the development of numeric nutrient water quality standards. As the EPA Assistant Administrator's memorandum notes, the overall progress has been uneven among States and Tribes since 1998.

Regarding the EPA's national nutrient strategy, the EPA noted that the focus is on the numeric nutrient criteria under the Clean Water Act and EPA's strategy is to adopt numeric criteria to eliminate the need to translate narrative criteria.

The EPA has four focus areas for nutrient criteria, including:

1. Working with states that are further away from adopting numeric criteria through the use of training and workshops;
2. Providing direct assistance to States that are close to adopting numeric nitrogen and phosphorus criteria;

3. Developing science-based approach for developing new Section 304(a) criteria for estuaries, wetlands, and large rivers; and
4. Clearly and effectively communicating the dangers of nutrient pollution and the merits of numeric nutrient criteria to states, nutrient sources, and the general public.

Grumbles noted that high nitrogen and phosphorus loadings result in harmful algal blooms (HABs), reduced spawning grounds and nursery habitats, fish kills, oxygen-starved hypoxic or “dead” zones, public health concerns related to impaired drinking water sources, and increased exposure to toxic microbes, such as cyanobacteria. The most widely known examples of significant nutrient impacts include the Gulf of Mexico and the Chesapeake Bay.

Descriptions of four watersheds of particular importance are included in the memorandum:

- Chesapeake Bay has an existing hypoxia problem with population increasing in the watershed by 150,000 people each year.
- The Gulf of Mexico has a prevalent and well-documented hypoxic “dead” zone. Thirty-one states contribute to the watershed and, through the 2001 Hypoxia Action Plan, the EPA Science Advisory Board reports that phosphorus plays a much greater role in the hypoxia problem than previously thought.
- In the Long Island Sound, dissolved oxygen is below standards in one-third to one-half of the Sound. Nitrogen loadings have been capped at 1990 loads, and a water quality trading program has been implemented in Connecticut for point sources with a market-based approach.
- In Puget Sound, the highest priority is to gain a better understanding of nutrient and bacteria loadings from septic systems through the Puget Sound Action Plan.

2.2.2 March 2011 EPA Policy Statement

More recently, on March 16, 2011 EPA Acting Assistant Administrator Nancy Stoner issued a memorandum entitled “Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions” to EPA Regional Administrators. This memorandum presents EPA's views on nutrient management and urges the EPA Regions "*to place new emphasis on working with states to achieve near-term reductions in nutrient loadings*" citing the following nutrient issues:

1. 50 percent of U.S. streams have medium to high levels of nitrogen and phosphorus.
2. 78 percent of assessed coastal waters exhibit eutrophication.
3. Nitrate drinking water violations have doubled in eight years.
4. A 2010 USGS report on nutrients in ground and surface water reported that nitrates exceeded background concentrations in 64% of shallow monitoring wells in agriculture and urban areas, and exceeded EPA's Maximum Contaminant Levels for nitrates in 7% or 2,388 of sampled domestic wells.
5. Algal blooms are steadily on the rise; related toxins have potentially serious health and ecological effects.

The March 2011 Acting Assistant Administrator Stoner memorandum builds upon the May 2007 Assistant Administrator Grumbles memorandum in encouraging states to adopt numeric nutrient standards. Key points of emphasis are summarized as follows:

- EPA is placing emphasis on the connection between nutrients and drinking water quality in establishing the basis for nutrient management in the introductory comments that state "*degradation of drinking and environmental water quality.*"

- EPA's view is that nutrients constitute a major water quality problem: "*nitrogen and phosphorus pollution has the potential to become one of the costliest and the most challenging environmental problems we face.*"

- EPA notes that states: "*need room to innovate and respond to local water quality needs, so a one-size-fits-all solution to nitrogen and phosphorus pollution is neither desirable nor necessary.*"

- EPA included an attachment with the memorandum entitled *"Recommended Elements of a State Nutrients Framework,"* to serve "a*s a tool to guide ongoing collaboration between EPA Regions and states in their joint effort to make progress on reducing nitrogen and phosphorus pollution."*

- EPA is continuing to place emphasis on state adoption of numeric nutrient criteria: "*It has long been EPA's position that numeric nutrient criteria targeted at different categories of water bodies and informed by scientific understanding of the relationship between nutrient loadings and water quality impairment are ultimately necessary for effective state programs*."

- EPA addresses management of nonpoint sources in an affirmative way: "*In addition, our efforts promote innovative approaches to accelerate implementation of agricultural practices, including through targeted stewardship incentives, certainty agreements for producers that adopt a suite of practices, and nutrient credit trading markets*."

- EPA appears to be offering the states schedule flexibility for numeric standards rulemaking with the proviso that near-term reductions are made and while at the same time presuming that states will eventually develop numeric criteria: *"The timetable reflected in a State's criteria development schedule can be a flexible one provided the state is making meaningful near-term reductions in nutrient loadings to state waters while numeric criteria are being developed.*"

2.2.3 NRDC Petition for Rulemaking on Secondary Treatment

Other approaches to nutrient management have been suggested, including moving away from receiving water quality based standards to treatment technology based standards. In November 2007, the Natural Resources Defense Council (NRDC) filed a Petition for Rulemaking with the EPA to limit nutrient pollution from wastewater treatment facilities. Ten other regional and national environmental groups, including the Sierra Club and American Rivers, joined NRDC in the petition. NRDC argues that nitrogen and phosphorus effluent limitations should be a part of the base technology definition of secondary treatment. NRDC contended that the EPA must protect the public by establishing nutrient limits, specifically that the EPA unreasonably delayed publishing information on Secondary Treatment to remove excess nutrients. The NRDC also notes that nutrient control is properly included within "Secondary Treatment" and cites the following effluent nutrient levels as attainable:

- Effluent total phosphorus (TP) 0.3 mg/l and total nitrogen (TN) 3 mg/l are Consistently Attainable Using Current Technology.

- Effluent TP 1 mg/l and TN 8.0 mg/l is Attainable with Existing Technology Using Only Improved Biological Treatment Processes.

NRDC considers the EPA's approach to site-specific nutrient standards unreasonable and asserts that the EPA cannot rely on a water-quality based approach to control nutrient pollution. NRDC argues that nutrient pollution is widespread and justifies a generally-applicable standards approach to treatment for nutrients. NRDC cites the EPA as evidence of this conflict:

> *"Nutrient pollution is widespread. The most widely known examples of significant nutrient impacts include the Gulf of Mexico and the Chesapeake Bay. For these two areas alone, there are 35 States that contribute the nutrient loadings. There are also known impacts in over 80 estuaries/bays, and thousands of rivers, streams, and lakes. Virtually every State and Territory is impacted by nutrient-related degradation of our waterways. All but one State and two Territories have Clean Water Act Section 303(d) listed impairments for nutrient pollution. States have listed over 10,000 nutrient and nutrient-related impairments. Fifteen States have more than 200 nutrient-related listings each."* (EPA, 2007).

NRDC regards the EPA's reliance on site-specific standards as unreasonable given the pervasive nutrient pollution and the lack of numeric nutrient standards, which hinder the ability to require water-quality, based effluent limitations. NRDC calls for the EPA to specify the degree of nitrogen and phosphorus reduction attainable through secondary treatment.

2.2.4 National Association of Clean Water Agencies on the NRDC Petition for Rulemaking

The National Association of Clean Water Agencies (NACWA) provided comments on the NRDC Petition for Rulemaking on Secondary Treatment in a letter to EPA dated February 29, 2008 (NACWA 2008). NACWA expressed concern that the NRDC petition calling for nutrient limits as part of the secondary treatment process is not technically or financially practical, and that the approach is not the most effective or environmentally sensitive way to reduce nutrient pollution. NACWA criticized the proposed "one size fits all" approach to a water quality problem that is site-specific and best addressed through site-specific measures.

NACWA believes site-specific water quality efforts will be more effective than technology-based nutrient removal limits and cites five areas of concern with the NRDC Petition:

1. Legal basis for incorporating nutrient removal into secondary treatment,
2. Failure of the petition to address the contribution to nutrient loadings from non-point sources,
3. Potentially high costs for treatment plants to meet a national nutrient limit and whether such expenditures are cost-effective,
4. Increased negative environmental impacts of mandating a national nutrient removal limit, and
5. Inappropriateness of national limits for local and regional water quality issues.

NACWA points out that tertiary treatment for nutrient removal goes well beyond the original Congressional intent in the Clean Water Act for secondary treatment and that EPA has denied previous requests to include nutrient removal as part of secondary treatment standards. NACWA notes that the petition fails to acknowledge the impact of nonpoint sources of nutrients on water quality. Reliance on wastewater treatment technology alone will not be as effective in improving water quality as a water quality-based approach to controlling both point and nonpoint sources. Water quality-based projects are technically achievable and provide the best combination of environmental benefits, cost-effectiveness, and local flexibility to manage nutrients.

NACWA members have found that the cost of nutrient removal is substantial and that major expenditures are associated with expanding facilities because of the need for more plant site and infrastructure to accomplish necessary retrofits and upgrades.

There are a number of unintended negative environmental consequences of requiring across-the-board nutrient removal in terms of the carbon footprint and increased quantities of biosolids for disposal. Nutrient removal treatment requires substantial electrical power, resulting in indirect greenhouse gas emissions, as well as direct emissions of greenhouse gases and nitrous oxide, in particular. The adverse impacts of point source nutrient controls should be balanced with consideration of nonpoint source controls, which consume little energy and may reduce greenhouse gas emissions by sequestering carbon.

NACWA notes that a “one size fits all” approach to nutrient effluent limits is inappropriate because of the site-specific effects of nutrients and variability from watershed to watershed. The assimilative capacity of watersheds varies, as does the importance of nitrogen and/or phosphorus in different waterbodies, depending upon site-specific conditions. NACWA endorses the appropriate determination of site-specific water quality limits based on the established mechanisms in the Clean Water Act that allow communities to respond appropriately to the environmental needs of local water bodies in a cost effective manner.

3. NUTRIENT ENDPOINTS FOR SAN FRANCISCO BAY

3.1 Nutrient Loadings to San Francisco Bay

The San Francisco Bay watershed drainage encompasses most of the central and northern portions of the State of California. The watershed includes about 40 percent of California’s land (over 60,000 square miles) and 47 percent of the state’s total runoff. The bay is comprised of four bays: the North Bay, Central Bay, South Bay, and Suisun Bay. The bay has many water quality issues. The focus of this discussion is on the San Francisco Bay basin and nutrients.

According to the U.S. Geological Survey (USGS) “Human settlement around coastal water bodies has led to increased inputs of nutrients such as nitrogen and phosphorus. Many estuaries are now among the most intensively fertilized environments on Earth. Each day, San Francisco Bay receives more than 800 million gallons of municipal wastewater.” However, San Francisco Bay has historically been resilient to degradation from nutrient enrichment and not known for hypoxia or harmful algal species as found in other areas, such as Chesapeake Bay.

3.2 Point and Nonpoint Sources

Point sources primarily are treated municipal wastewater discharged from publicly owned treatment works (POTWs) and treated industrial wastewater resulting from industrial operations, processing, cleaning, and cooling. Municipal Separate Storm Sewer Systems (MS4s) permitted under Phase I and Phase II stormwater NPDES are also considered point sources. In about 1979 wastewater treatment was significantly improved, reducing the loads from POTWs. Today, the minimum level of performance is secondary treatment, while about thirty percent of the POTWs include advanced treatment. At the secondary treatment level, nutrient discharges are typically about 25 to 30 mg/L total nitrogen and 1 to 4 mg/L total phosphorus without biological removal, and 2 to 12 mg/L total nitrogen and 0.1 to 0.5 mg/L with biological removal. At the advanced treatment level, nutrient discharges may be less than 2 mg/L total nitrogen and less than 0.5 mg/L total phosphorus.

Nonpoint sources are essentially everything that is not a point source including diffuse agricultural pollutants as well as urban sources, stormwater runoff from areas not covered by MS4 stormwater permits, groundwater discharges, and atmospheric deposition. “Nonpoint source pollution is considered one of the top threats to the Bay’s ecological health and may account for a considerable proportion of the Bay’s total pollutant load. The Bay receives 90 percent of its freshwater from the Sacramento and San Joaquin Rivers and 10 percent from the watershed surrounding San Francisco Bay” (SFBCDC, 2003). Since most of the flow is from the Delta, most of the nonpoint source load is also from upstream. “Nonpoint source pollutants transported to the Bay come from Sacramento and San Joaquin Rivers, the Delta and the surrounding watersheds” (SFBCDC, 2003).

Estimates of the nutrient load to the bay include 3.0 Mkg/yr from point sources and 1.5 Mkg/yr from nonpoint sources for nitrate and 1.0 Mkg/yr from point sources and 0.5 Mkg/yr from nonpoint sources for phosphate (SFBCDC, 2003, SFEI, 2000). A similar proportion of point source to nonpoint source was estimated as part of a nutrient budget that concluded, “Effluent from sewage treatment plants accounts for approximately 50% of the nutrient loading to the bay in winter and 80% of the summer loading” (Smith and Hollibaugh, 2006).

3.3 Spatial and Temporal Variability

The spatial and temporal variability of nutrients in the bay are significantly related to seasonal hydrographic patterns, inflow magnitudes, and the morphology of the basin and bay. “Delta outflow directly controls and often dominates the spatial and temporal distributions of most properties and biological processes in the northern reach. The relation between Delta outflow and biological processes in the southern reach, however, is less direct as biological activity has a relatively greater effect on the spatial and temporal distributions of these properties” (USGS, 1979). According to Smith and Hollibaugh (2006), “the North Bay, the major input of both DIN [Dissolved Inorganic Nitrogen] and DIP [Dissolved Inorganic Phosphorous] is river inflow, while STP [Sewage Treatment Plant] effluent input dominates in the South Bay.”

3.4 Development Approaches for Numeric Nutrient Criteria

Three general approaches for development of numeric nutrient criteria as described in EPA’s *Nutrient Criteria Technical Guidance Manuals* are reference conditions approaches, stressor-response analysis, and mechanistic modeling (EPA 2000a and EPA 200b). Each approach has advantages and limitations based on the available data and waterbody, and these approaches may be used either independently, or in combination. These approaches are summarized as follows:

- Reference condition: Criteria are developed based on statistical distributions and percentiles of nutrient concentrations from reference or similar waterbodies in a natural condition.

- Stressor-response: Criteria are developed based on a relationship between nutrients and biological conditions.

- Mechanistic modeling: Criteria are developed using water quality models that represent ecological processes applied to site-specific conditions.

Each of the approaches has been applied by various states. For example, stressor-response or numeric nutrient endpoints have been developed for USEPA Region IX and the California State Water Resources Control Board for streams, rivers, and lakes in California. Florida unsuccessfully undertook the reference condition approach. In Montana, the approach has included reviewing reference streams, as well as conducting site specific investigations, mechanistic modeling, and other studies focused on cause and effect relationships such as a public perception survey for evaluation of algal densities that impact recreational beneficial uses.

3.5 Numeric Nutrient Endpoints

The South California Coastal Water Research Project (SCCWRP) has developed a preliminary list of recommended activities (work elements) needed for the development of a numeric nutrient endpoint assessment framework for San Francisco Bay (McKee et al., 2011). Altogether a total of 34 work elements are listed and grouped into 5 categories (assessment framework, monitoring programs, Delta coordination, external load estimates, and load-response models). Overall, the work elements span the habitat types (e.g., submerged aquatic vegetation, subtidal, etc.) and indicators (primary, secondary, and supporting) described in the Numeric Nutrient Endpoint (NNE) Literature Review (McKee et al., 2011). At this time, work activities are not listed in accordance with priority or indicator hierarchy.

The amount of effort and funding needed to complete all of the work elements identified may be challenging. For example, Work Element 7 recommends that a work group of scientists be convened to synthesize available data on factors known to control primary productivity in different regions in the San Francisco Bay, develop a consensus on the relative importance of ammonium inhibition of phytoplankton blooms to Baywide primary productivity, and determine the next steps needed to incorporate ammonium into the NNE assessment framework.

The California State Water Resources Control Board (SWRCB) is using the Nutrient Numeric Endpoint (NNE) framework to develop nutrient water quality objectives for the San Francisco Bay. One of the first steps of the San Francisco Bay NNE framework is to develop numeric endpoints which describe the ecological response of an aquatic water body to nutrient over-enrichment. The NNE framework is a narrative process by which water quality objectives are translated into numeric values governed by the use of models. Draft NNEs have been developed as described in the Review of Indicators for Development of Nutrient Numeric Endpoints in California Estuaries (Sutula et al., 2011). The purpose of this document is to summarize written comments on the draft NNEs and the accompanying document entitled Numeric Nutrient Endpoint Development for San Francisco Bay Estuary: Literature Review and Data Gaps Analysis (McKee et al., 2011). These documents provide a foundation for initiating the NNE process for San Francisco Bay.

The development of numeric nutrient endpoints has included biological response indicators (e.g. chlorophyll-a, dissolved oxygen, harmful algae), a weight-of-evidence approach based on multiple indicators, and models to translate "target thresholds" to numeric criteria. "The NNE framework is based on the concept that biological response variables or indicators are better suited to evaluating beneficial use impairment rather than using pre-defined nutrient concentrations. The NNE approach permits a weight of evidence approach with multiple indicators rather than just one or two nutrient concentration values alone and thus provides greater scientific validity and defensibility" (BACWA, 2011). A 2011 literature review and data gaps analysis had three objectives (McKee et al., 2011):

1. Evaluate indicators to assess eutrophication and other adverse effects of anthropogenic nutrient loading in San Francisco Bay.
2. Summarize existing literature in San Francisco Bay using indicators and identify data gaps.
3. Investigate what data and tools exist to evaluate the trends in nutrient loading to the Bay.

The next steps that were recommended included (McKee et al., 2011):

- Develop an NNE assessment framework for San Francisco Bay
- Quantify Nutrient Loads
- Develop Load-Response Models
- Conduct a Monitoring Program to Develop and Implement the NNE Framework in San Francisco Bay
- Coordinate Development of the San Francisco Bay NNE Framework with Nutrient Management in the Delta

3.5.1 Protecting Water Quality and Beneficial Uses

The protection of water quality is evaluated by determining if the water body meets the assigned beneficial uses. If the associated water quality standards are not supportive of the beneficial use, then the water body is identified as impaired. The NNEs should be based on ecological response indicators which provide a more direct risk-based linkage to beneficial uses than nutrient concentrations or loads alone. Additionally, the cause-effect approach has a more direct linkage with beneficial uses as compared to reference criteria approaches that are based solely on water quality statistics from other water bodies. This is because, "except in extreme cases such as unionized ammonium causing toxicity, nutrients themselves do not impair beneficial uses" (SCCWRP, 2011). An objective of the NNEs is to provide a clear linkage to the beneficial uses.

3.5.2 Cause and Effect Relationships

"The cause-effect approach involves identifying the ecological responses of concern and mechanistically modeling the linkage back to nutrient loads and other co-factors controlling response" (SCCWRP, 2011). The cause-effect approach will be most heavily relied upon for NNEs. Other potential approaches include the use of reference condition statistics, however they may problematic due to lack of data, lack of appropriate reference sites and the greater likelihood of false negative and false positive determinations of adverse effects. The NNE framework is based on the diagnosis of eutrophication and associated cause and effects rather than nutrient concentrations.

3.5.3 Response Variables v. Numeric Nutrient Criteria

An important element for NNEs is having a scientifically sound and practical monitoring process that can accurately and precisely measure water quality responses over large geographic areas and over multiple year periods of time. Additional predictive models may be necessary to link response variables back to nutrient loads and other causal factors. Such predictive relationships will be important for selecting long-term management actions.

4. WASTEWATER TREATMENT TECHNOLOGY

The capability of wastewater treatment technologies to reduce effluent discharges of nitrogen and phosphorus has advanced dramatically in the last two decades. As an illustration, Table 1 presents a simplified example of the <u>potential</u> capabilities of wastewater treatment technology at various levels. Influent concentrations of nitrogen and phosphorus in municipal wastewater are compared with a variety of potential effluent levels and with a range of in-stream nitrogen and phosphorus reference condition concentrations typical of ecoregion criteria in the Western US (Eco-region I. Willamette and Central Valley, Ecoregion II Western Forested Mountains, Ecoregion III Xeric West, and Ecoregion IV Great Plains). Secondary treatment facilities produce effluent nutrient concentrations approximately the same as influent wastewater, with limited removal due to synthesis in biological treatment.

Table 1. Generalized Comparison of Phosphorus and Nitrogen Concentrations for Wastewater, Effluent from Advanced Treatment[a] and Typical In-stream Nutrient Criteria[b] (WERF, 2010)

Parameter	Typical Municipal Raw Wastewater, mg/L	Secondary Effluent (No Active Nutrient Removal), mg/L	Typical Advanced Treatment Nutrient Removal (BNR), mg/L	Enhanced Nutrient Removal (ENR), mg/L	Limits of Treatment Technology, mg/L	Typical In-stream Nutrient Criteria[b], mg/L
Total Phosphorus	4 to 8	4 to 6	~1	0.25 to 0.50	0.05 to 0.07	0.010 to 0.050
Total Nitrogen	25 to 35	20 to 30	~10	4 to 6	3 to 4	0.1 to 0.600

[a] The expected nutrient treatment removal levels and associated effluent concentrations vary widely according to the averaging period and/or performance statistic employed.

[b] Typical in-stream targets generalized from Ecoregion I. Willamette and Central Valley, Ecoregion II Western Forested Mountains, Ecoregion III Xeric West, and Ecoregion IV Great Plains.

The entry level of nutrient removal facilities, designated in Table 1 as biological nutrient removal (BNR) is typically capable of producing effluent phosphorus of approximately 1 mg/L and effluent nitrogen of approximately 10 mg/L. Enhanced nutrient removal, or ENR, with effluent filtration and larger biological reactors, may produce effluent phosphorus in the range of 0.25 to 0.5 mg/L and effluent nitrogen of 4 to 6 mg/L. The most advanced nutrient removal systems operating at the maximum capability of treatment technology with multiple filtration steps or membranes, and larger biological reactors, may reduce effluent phosphorus to approximately 0.05 to 0.07 mg/L and effluent nitrogen to 3 to 4 mg/L.

Comparing the very best nutrient removal facilities with potential numeric nutrient targets based on ecoregion reference criteria reveals that effluent phosphorus may approach these in-stream targets should they be applied end-of-pipe. However, even the very best nitrogen removal facilities would have effluent much higher than in-stream target levels typical of the Western US. Since in-stream numeric nutrient criteria based on natural conditions are very low concentrations, they may result in very restrictive discharge permit limits that are lower concentrations than treatment technologies are capable of achieving if applied end-of-pipe.

This is a concern since wastewater utilities rely on surface waters for effluent management. Most discharges are to streams that are altered in many ways that result in conditions far from natural. Overly restrictive effluent limits for point sources may have unintended consequences that are not beneficial, such as diversion of effluent from streams with limited flow. Further, reduction in point sources alone will not improve water quality if nonpoint sources make up the majority of nutrient loadings in a waterbody.

5. DISCHARGE PERMITTING AND COMPLIANCE ISSUES

Surface water nutrient discharges should receive special consideration in discharge permitting. Unlike biochemical oxygen demand (BOD), ammonia nitrogen, and some toxic pollutants that can have acute effects in the aquatic environment, total nitrogen and phosphorus have seasonal impacts on receiving waters. Therefore, distinction should be made from these other effluent parameters upon which much of the existing EPA permit writer's guidance is based. Appropriate NPDES discharge permit structures for nutrients should be based on long averaging periods linked to the specific waterbody response to nutrient enrichment, such as seasonal limits based on long-term average values, or total loading for the compliance period (e.g., total pounds discharged on an annual or seasonal basis). For example, EPA determined that annual average nutrient limitations were appropriate for the Chesapeake Bay.

It is also important that consideration be given to variability and reliability of effluent performance from advanced nutrient removal facilities, especially those operating at low or very low levels. Appropriate NPDES permitting methodologies will avoid compliance issues that are immaterial to surface water quality protection. Short-term limitations, such as maximum daily and maximum weekly, should not be imposed for nutrients. Wastewater treatment at the limits of technology for the lowest possible effluent nutrient concentrations is highly variable over short timeframes, even though very effective removal rates are achieved over a longer term. Also, overly conservative assumptions as the bases for limit derivation, such as restrictive low frequency of occurrence receiving water flows and extreme and improbable coincident events, such as statistical extremes occurring in both receiving waters and effluent discharge quality, should be avoided.

5.1 Nutrient Discharge Permit Structures

The appropriate averaging period for nutrient discharges depends on the sensitivity of the water body to water quality degradation and where the discharge is in the watershed. EPA's NPDES Permit Writer's Manual (EPA, 1996) states that for municipal wastewater treatment plants, permit limits should be expressed in average monthly and average weekly limits. Maximum daily limits can be used for toxics in order to capture acute toxicity criteria. In general, averaging periods for nutrient discharges can be longer due to slower responses between discharge and water quality degradation. For larger water bodies, such as bays, sounds, estuaries, and lakes, a monthly or yearly averaging period is more appropriate. In some cases, weekly average nutrient discharges are appropriate. Daily discharges are rarely appropriate given the lack of response in degraded water quality over the course of a single day for nutrient discharges.

5.2 Translation of Numeric Nutrient Endpoints to Effluent Discharge Permits

Water quality (TMDL) and permitting (NPDES) programs are often administered by separate staff groups within state regulatory agencies and communication about the intent of water quality endpoints and the specifics required for the preparation of an NPDES permit are essential. The permitting authority is responsible for interpreting the water quality standards and TMDLs to develop the effluent limitations for the discharge. Their responsibility includes providing sufficient documentation in the administrative record to show how the NPDES permit requirements were developed and how compliance with those requirements will achieve the applicable water quality standards.

Since NPDES permit writers may not be involved with the development of water quality standards, such as numeric nutrient endpoints, there is the potential for a lack of understanding of the underlying water quality issues associated with the intended protection of beneficial uses. Often, draft

NPDES permits are based on pre-formulated guidance for permit structures, including monthly, weekly, and daily effluent limits that may not necessarily be appropriate for the situations involving nutrients. The watershed response to nutrient enrichment is generally over a seasonal time period longer than monthly or weekly time frames commonly used as the basis for NDPES permit limitations. Maximum weekly and maximum daily effluent limits for nutrients are overly restrictive and unnecessary to protect water quality from nutrient effects. However, NPDES permit guidance based on control of toxics is often used to justify maximum weekly and maximum daily effluent limits for non-toxic pollutants such as nutrients. While effluent restrictions over short time periods are necessary to protect receiving water quality from the discharges of toxics, such as ammonia nitrogen, chlorine residuals, and metals, they are seldom necessary for control of total nitrogen and phosphorus discharges.

5.3 Appropriate Averaging Periods for Nutrient Limits

Appropriate NPDES discharge permit structures for nutrients should include long averaging periods, such as annual or seasonal limits based on total loading over long periods or annual or seasonal averages. Consideration should be given to variability and reliability in both the receiving waters and in the effluent performance from wastewater treatment systems.

The NPDES regulations (40 CFR 122.45(d)) require that all permit limits be expressed as average monthly limits and average weekly limits for publicly owned treatment works (POTWs) and as both average monthly limits and maximum daily limits for all others, unless "impracticable." EPA established the basis for appropriate effluent limits for Chesapeake Bay in a 2004 memorandum that combines considerations of water quality responses with scientific and policy analysis (Hanlon, 2004). EPA found that NPDES effluent limits for nitrogen and phosphorus expressed as an annual limit in lieu of daily maximum, weekly average, or monthly average are appropriate for protection of Chesapeake Bay and its tidal tributaries. EPA stated:

> *"…permit limits expressed as an annual limit are appropriate and that it is reasonable in this case to conclude that it is 'impracticable' to express permit effluent limitations as daily maximum, weekly average, or monthly average effluent limitations."*

EPA found that establishing appropriate permit limits for nitrogen and phosphorus to protect water quality in Chesapeake Bay was different from setting limits for other parameters, such as toxics for the following reasons:

- The exposure period of concern for nutrients loadings to Chesapeake Bay and its tidal tributaries is very long,
- The area of concern is far-field (as opposed to the immediate vicinity of the discharge), and
- The average pollutant load rather than the maximum pollutant load is of concern.

The 2004 EPA memorandum notes that applicability to smaller scale embayments and tributaries was not considered. It is also noted that the annual average approach does not apply to other parameters that may impact dissolved oxygen such as BOD and ammonia nitrogen.

Unlike toxics and conventional parameters that have a direct and immediate impact on water quality, nutrients have no direct or immediate impact and must be processed in the aquatic environment in order to have an impact. Nutrient assimilation and processing delays and buffers the time between the discharge and the receiving water effect. The 2004 EPA memorandum further distinguishes appropriate nutrient permit limits from the guidance provided in EPA's "Technical Support Document for Water Quality Based Toxics Control" (TSD) (EPA, 1991). The TSD statistical procedures for acute and chronic aquatic life protection are not applicable for periods more than 30 days. The exposure period for nutrients is longer than one month and may be up to a few years, and the average exposure rather than the maximum is of concern.

For the Spokane River dissolved oxygen TMDL that resulted in very restrictive end points for phosphorus, BOD, and ammonia, seasonal average mass loading limits were found to be appropriate for NPDES permitting. Water quality modeling was used to investigate the sensitivity of water quality response to alternative effluent loading scenarios extending to different periods of the year and varying combinations of the key effluent parameters phosphorus, BOD, and ammonia to demonstrate equivalency with the final TMDL scenario (Moore et al., 2010).

5.4 Maximum Day and Maximum Week Dilemmas

Effluent discharge permit structures should avoid the creation of frameworks that result in compliance issues that are immaterial to surface water quality protection, such as maximum daily and maximum weekly limits, overly restrictive receiving water flow assumptions, and the assumption of extreme and improbable coincident events, such as statistical extremes in both receiving waters and effluent discharge quality.

Maximum weekly and maximum daily effluent limits for nutrients are overly restrictive and unnecessary to protect water quality from nutrient effects. Waterbody responses to nutrients occur over longer periods of time associated with the growth and decay of algae, eutrophication and hypoxia that may impair beneficial uses, deplete dissolved oxygen, or result in fish kills.

5.5 Effluent Mixing Zones

An effluent mixing zone is an area within a waterbody where a point source discharge undergoes initial dilution or mixing in the receiving water. Within the mixing zone, water quality standards may be exceeded as long as acutely toxic conditions are prevented and all beneficial uses, such as drinking water, fish habitat, recreation, and other uses are protected. In theory, the regulatory mixing zone allows for efficient natural pollutant assimilation. In practice, mixing zones can be used as long as the integrity of a water body is not impaired. Water quality standards must be met at the edge of a mixing zone.

The use of mixing zones and dilution appears to have questionable applicability to watershed impacts from nutrients since the effects of nutrients tend to be cumulative and caused by mass loadings rather than toxic effects associated with effluent concentration. Mixing zones and dilution may be useful in instances where maximum daily effluent limits (MDELs) and average monthly effluent limits (AMELs) are imposed and compliance may be difficult but, as discussed above, these short-term limitations for nutrients are impracticable and unnecessary in most situations involving nutrients. Nevertheless, regulatory agencies may approach effluent permitting for nutrients using mixing zone concepts and regulations.

5.6 Impaired Ambient Conditions

Impaired ambient water quality can create difficult situations for effluent discharge permitting since any additional contribution of nutrients may compound receiving water conditions and no cleaner water is available for dilution. By definition, impaired waterbodies that are 303(d) listed and require a

TMDL may not have assimilative capacity to receive additional loadings. In some waterbodies, this has led to the waterbody nitrogen and phosphorus target concentrations being applied at the end-of-pipe for effluent discharges. The result may be effluent limits that are below the limits of treatment technology.

5.7 Permit Requirements Beyond the Capability of Treatment Technology

The NPDES program requires that discharge permits include specific pollutant limitations. These discharge limits are initially set based on applicable treatment technology standards depending upon the specific pollutant or parameter, type of discharge or industry in the case of effluent guidelines. These technology-based limits are then evaluated to determine if the allowable discharges will comply with the receiving water quality requirements. If not, more restrictive limitations are to be established that are water quality-based. However, these water quality-based effluent limits (WQBELs) may represent levels that are beyond the capability of economically available treatment technology. An example is the NPDES permit issued to the City of Ruidoso, NM in 2007 with maximum daily concentration limits beyond the capabilities of treatment technology for both nitrogen (1.5 mg/L) and phosphorus (0.15 mg/L).

Dischargers facing these conditions must deal with treatment options that are very expensive to design, construct, operate, and maintain. Additionally, once operational the technologies are challenging to operate and maintain at such consistently low concentrations. With more dischargers competing for a smaller piece of the allowable pollutant allocation, requirements that exceed the capability of conventional and economical technology are becoming more common. This is the case with nitrogen and phosphorus limits with nutrient criteria continuing to be developed resulting in very low numeric standards.

There is not a common understanding or consensus between regulators, the public, and dischargers on the economics and feasibility of implementing such limitations that push the envelope of treatment technology capability. In fact, it is not yet clear if the available nutrient removal technologies are even able to consistently treat to such low concentrations, especially at higher flows.

5.8 Advanced Treatment and Nutrient Speciation

Appropriate consideration should be given to effluent discharge permitting regarding emerging areas of advanced scientific understanding of the effect of advanced nutrient removal treatment on both nutrient speciation and bioavailability. At the boundaries of the current understanding of science is investigation of nitrogen and phosphorus remaining after advanced treatment that may not be removable with current treatment technology. Nitrogen and phosphorus speciation are also important areas of nutrient research, both in terms of biodegradability in wastewater treatment and bioavailability in the water environment.

6. INFORMING THE REGULATORY DIALOG ON NUTRIENT MANAGEMENT

There are several challenges involved in developing numeric nutrient criteria and appropriate frameworks for discharge permitting. These include the complex relationship between nutrient discharges and water quality responses, and the lack of a common understanding between regulatory agencies and wastewater utilities of the capabilities and limitations of treatment technology. The combination results in the need for new approaches to the translation of numeric nutrient endpoints to discharge permit limits, especially at the lowest, most challenging effluent levels. At the lowest effluent levels, the structure of the discharge permit itself may determine whether or not compliance is feasible.

Fostering a constructive dialog between regulatory agencies, wastewater utilities, and other stakeholders has been found to be effective in bridging some of the gaps in the understanding of potential nutrient requirements and treatment technology capabilities. Technology transfer workshops, regulatory agency briefings, and discussions of implementation guidance for discharge permitting have all been effective in other locations at improving the potential for technically feasible and economically affordable outcomes. Since national guidance from EPA that links the development of numeric nutrient endpoints with implementation guidance for effluent discharge permitting for nutrients has been lagging, individual states have undertaken efforts to develop unique state approaches.

The development of numeric nutrient standards in Wisconsin, Colorado, and Montana has been accompanied by the consideration of implementation guidance for nutrient discharge permitting. In these states, diverse groups of stakeholders have participated in collaborative nutrient workgroups to craft both nutrient standards and implementation guidelines. An important driver in the dialog in these states has been the recognition of the potential for water quality standard rulemaking to result in infeasible effluent limits. That understanding of the gap between what may be required of new numeric nutrient standards, and the capabilities of wastewater facilities to comply with those standards, has led to unique regulatory solutions. While each of these states has undertaken a unique process shaped by state-specific considerations of water quality, there are some commonalities. In each state, questions have been raised about the adequacy of water quality data and the cause and effect relationship between nutrients and beneficial uses. The cost of wastewater treatment to meet new nutrient standards has been a topic of discussion, as have watershed loadings and nonpoint sources, adaptive management approaches, and compliance schedules for meeting new standards. Oversight from EPA and conformance with federal regulations has also entered into the dialog in these states.

The following sections provide a brief summary of the development of nutrient standards in Wisconsin, Colorado, and Montana.

6.1 Wisconsin Nutrient Standards

In late 2009, a coalition of environmental groups announced their intent to sue EPA to promulgate numeric nutrient criteria for phosphorus and nitrogen for the State of Wisconsin. The group stated the need to accelerate the process and enact standards as the rationale for threatening litigation. The group also believed that the Department of Natural Resources (DNR) had developed the science needed for sound phosphorus standards but had failed to promulgate those standards.

The DNR and the United States Geological Survey (USGS) have completed numerous water quality studies in Wisconsin. The DNR formed a technical advisory committee to assist with development of phosphorus criteria and to review draft rules for nutrient standards. The phosphorus criteria developed for streams is 0.075 mg/L and for large rivers is 0.100 mg/L. Proposed state rules were prepared for incorporation into Wisconsin Administrative Code as NR 102 water quality standards for Wisconsin surface waters and NR 106 procedures for calculating water quality based effluent limitations for toxic and organoleptic substances discharged to surface waters.

In 2010, Wisconsin passed parallel legislation for water quality criteria for phosphorus and implementation guidance on discharge permitting. Chapter NR 217 Effluent Standards and Limitations for Phosphorus defines an adaptive management approach to implementation. Numerical effluent limits for wastewater treatment plant discharges are based on incremental reductions from an initial permit at 1 mg/L for total phosphorus and in subsequent permit cycles at <0.6 mg/L, <0.50 mg/L and ultimately to water quality based effluent limits. Discharge permit compliance will be based on a running 12 month average basis.

6.2 Colorado Nutrient Standards

In 2002, the Colorado Department of Public Health and Environment (CDPHE) initiated a nutrient criteria development plan in response to EPA's recommendation to adopt nutrient criteria. The State of Colorado initiated preparation of numeric nutrient criteria with a decision not to adopt EPA ecoregion reference criteria in the interest of developing more site-specific standards. In addition, Colorado sought a more direct linkage to the causes and effect response to increased nutrient loads. While some nutrients are necessary to support aquatic life and fisheries, Colorado's focus for developing numeric nutrient standards is to prevent hyper-enrichment that leads to eutrophication.

Colorado has made significant progress in developing nutrient criteria and is working towards integrating those criteria into their water quality standards. The Colorado Water Quality Forum provides a forum for a dialog on the process to develop standards. The CDPHE approach is based on defining nutrient criteria with a stressor-response relationship linking nutrient concentrations with Colorado's macroinvertebrate multi-metric indices (MMIs). In 2011, this discussion has evolved into parallel tracks for two state regulations. A revision to Colorado Regulation 31 for surface water nutrient standards for cold and warm waters with in-stream standards for chlorophyll-a, phosphorus and nitrogen has been proposed for rulemaking in March 2012.

A new Nutrients Management Control Regulation (Colorado Regulation No. 85) is proposed to establish technology-based numeric nutrient limits for point source discharges. Colorado is proposing a treatment technology-based approach, as opposed to a strict water quality-based approach, because it is believed that this approach will proceed farther and more expeditiously over the next decade by focusing the primary control efforts. Effluent limits for existing treatment plants will be 1 mg/L total phosphorus (TP) and 10 mg/L total inorganic nitrogen (TIN) based on what has been labeled "first level" 3-stage biological nutrient removal (BNR). New treatment plants will be expected to be 4 and 5-stage BNR for effluent of 0.7 mg/L TP and 7 mg/L TIN. Discharge permit compliance will be based on a running annual median basis.

6.3 Montana Nutrient Standards

The State of Montana has been developing numeric nutrient criteria to control excessive nitrogen and phosphorus loadings to Montana's streams, rivers, and lakes since the early 2000s. Based on the studies completed by the State, the Montana Department of Environmental Quality (MDEQ) is initiating a rule-making phase for state adoption of numeric nutrient standards (MDEQ, 2010a).

Montana's approach to the development of numeric nutrient standards has included review of reference stream criteria as well as site specific investigations such as Clark Fork River and Yellowstone River studies. The MDEQ and University of Montana conducted a public survey of perceptions of stream health and bottom algae and the survey results were used to set in-stream chlorophyll standards for protection of recreational beneficial uses. A benthic algae density of 150 mg Chla/m^2 was considered to be a nuisance threshold.

Recognizing that numeric nutrient standards could result in effluent discharge limits beyond the capabilities of treatment technology, the Montana Nutrient Work Group, a diverse forum for discussion and development of standards that includes Montana DEQ staff, municipalities, industry and environmental groups, drafted a water quality variance bill in the state legislature. In 2009, Senate Bill 95 passed and provided for temporary nutrient standards under two conditions: (1) affordability; and (2) limits of treatment technology. The objective was to provide a legislative pathway to relief from compliance with numeric nutrient standards based on substantial and widespread economic impact, or the inability to meet the standards due to limitations in treatment technology. Senate Bill 95 did not explicitly define either the threshold for affordability or the definition of the limits of treatment technology. The affordability threshold for substantial and widespread economic hardship discussed by stakeholders and MDEQ in the Montana Nutrient Work Group during the formulation of Senate Bill 95 was based on an assumed 1 percent of median household income.

In the dialog with EPA that followed passage of Senate Bill 95, MDEQ sought concurrence from EPA on the assumption that 1 percent of median household income constituted the threshold for economic hardship. However, it was found that EPA's expectations for the affordability threshold were higher and based on a sliding scale of secondary economic indicators that result in 1 to more than 2 percent of median household income. As a result, a second water quality variance bill was passed in 2011. Senate Bill 367 provides for nutrient standards variances on a statewide general basis, and also for individual and alternative variances. The affordability analysis used to establish the basis for substantial and widespread economic impact is based on the potential need for addition of reverse osmosis to treatment facilities to comply with the proposed in-stream standards for nitrogen and phosphorus. Treatment technology standards are defined to establish discharge requirements under a variance. Larger treatment facilities are required to meet effluent limits of 1 mg/L TP and 10 mg/L TN (flows greater than 1 mgd). Smaller facilities are required to meet 2 mg/L TP and 15 mg/L TN (flows less than 1 mgd). Lagoon systems are to be held at existing levels of effluent quality performance. Discharge permit compliance will be based on a monthly average basis.

7. ALTERNATIVE APPROACHES TO REGULATORY ENGAGEMENT

BACWA may consider a variety of approaches to engagement in the regulatory process that range from waiting for the regulatory agencies to take action on nutrient management for San Francisco Bay, to leading certain aspects of the scientific and technical studies that serve as the foundation for nutrient management considerations. The key agencies for BACWA to consider engaging in developing a regulatory strategy are the USEPA, the State Water Resources Control Board (SWRCB), and the San Francisco Bay Regional Water Quality Control Board (RWQCB). The USEPA has delegated authority for implementation of the Clean Water Act in California to the SWRCB, which develops water quality objectives for the State's water bodies and works with RWQCBs to develop nutrient water quality objectives, using a nutrient numeric endpoint (NNE) framework. Objectives are ultimately adopted by the RWQCB but must be approved by both the SWRCB and EPA.

There are two dimensions of the nutrient regulatory process for which BACWA may consider development of a regulatory approach. One dimension is the development of the nutrient numeric endpoint framework. The second dimension is implementation of nutrient management and reduction activities. For each dimension, BACWA may consider the degree to which engagement is appropriate, from very conservative (wait and see) to more progressive approaches to lead these processes. Numeric nutrient criteria are based upon water quality studies, monitoring, modeling, and other scientific evaluations upon which targeted water quality conditions are based. Nutrient management and reduction activities include watershed loading analysis, prioritization of management efforts, identification of best management practices, economic analyses, wastewater treatment technology studies, pilot testing, and full-scale nutrient removal treatment.

BACWA may chose to follow the regulatory agencies, selectively engage with the agencies on key aspects of NNE development or nutrient reduction, or lead the agencies in these efforts. This range of engagement from conservative, wait and see, to more progressive efforts to lead the processes are characterized by differing levels of effort and timing in the planning and execution of activities.

7.1 Conservative Waiting Approach

If BACWA chooses to wait for the RWQCB to take actions on nutrient endpoint development and nutrient management, the expectation is that the process will evolve in fragments over time. The advantage of this approach is that it requires little upfront investment on BACWA's part. However, the disadvantage is that the outcomes may be somewhat unpredictable and there will be little opportunity to influence the process or inform potential outcomes.

7.2 Moderate Selective Engagement Approach

Consideration may be given to a more moderate approach of selective engagement with the agencies on nutrient endpoint development and nutrient management. The selective engagement approach is characterized by contributions to the development of the regulatory framework and nutrient management efforts in key areas. This may include water quality monitoring and modeling efforts linked to nutrient endpoint development. On the nutrient management side, this may include loading studies, characterization of point and nonpoint sources, and efforts to address key wastewater management issues such as wastewater treatment technologies and performance, and nutrient discharge permitting. The advantage of this approach is that BACWA is actively engaged in the entire process and has the opportunity to contribute key information which wastewater utilities are in the best position to provide in an accurate and reliable manner. The disadvantage of this approach is that BACWA will need to invest in both staff resources and supporting technical services in order to contribute to the process in a substantial way that will have credibility with the agencies. The expectation is that the selective engagement approach will result in improved outcomes which are protective of water quality while at the same time are technically feasible and economically affordable for wastewater utilities. There are many examples of the selective engagement approach to the regulatory process where wastewater utilities have targeted key aspects of the overall effort to exert leadership, such as BACWA's work on San Francisco Bay toxics, and the nutrient management efforts on the Spokane River in Washington and Idaho, and on the Chesapeake Bay.

7.3 Progressive Leadership Approach

At the most progressive end of the spectrum of potential approaches to the regulatory process, BACWA could consider leading the effort to construct the regulatory framework for nutrient management for San Francisco Bay. In this approach, BACWA would lead the technical development process for nutrient endpoints and demonstrate the preferred scientific approach to the RWQCB and other stakeholders. This would require that BACWA fund, staff, and manage the development effort. The advantage of this approach is that BACWA would have control and the opportunity to guide the process to practical outcomes for wastewater utilities. The disadvantage of this approach is the upfront investment of resources required and the feasibility of agency acceptance of a BACWA led process. There are fewer examples where wastewater utilities have led the nutrient management effort for a watershed. One example is the Clark Fork River Voluntary Nutrient Reduction Program (VNRP) where a diverse group of stakeholders worked together to conduct technical studies, develop nutrient endpoints, and implement nutrient reduction activities in a program that has been successful in improving water quality.

7.4 Case Study Examples

The following case study summaries highlight watershed management approaches that characterize a variety of levels of stakeholder involvement and engagement with regulatory agencies.

7.4.1 Conservative Approach: Evolving Ammonia Limits for San Francisco Bay and Delta Discharges

Effluent ammonia discharge permit limits are evolving on a permit-by-permit basis on San Francisco Bay and the Bay Delta in a manner that does not appear to be consistent. Effluent limits based on current ammonia standards and permit writer's reasonable potential analysis may lead to allowable ammonia concentration limits below current performance levels, depending upon how effluent dilution is considered. Contradicting this conventional approach to establishing effluent limits are calls to cap effluent ammonia discharges at current levels using performance statistics based on historical treatment performance.

Several BACWA member facilities (12 of the 45 facilities) are currently required to remove ammonia via nitrification (conversion of ammonium to nitrate) or nitrification / denitrification (nitrogen removal). These facilities are located in the southernmost portion of the South Bay and along the northern parts of the North Bay. The San Francisco Basin Plan contains water quality objectives for un-ionized ammonia of 0.025 mg/L as an annual median and 0.16 mg/L as a maximum upstream of the San Francisco Bay Bridge (Regional Board, 2010). The RWQCB uses the 90th percentile and median un-ionized ammonia fractions to develop daily maximum and the annual average un-ionized objectives as acute and chronic total ammonia objectives for discharge permitting. The un-ionized ammonia objectives from the Basin Plan must be translated to total ammonia using monitoring data for pH, salinity and temperature. As an example, this results in the equivalent total ammonia concentrations for acute toxicity of 5.0 mg/L and chronic toxicity of 1.6 mg/L for some areas of San Francisco Bay.

According to the individual NPDES permits, numerical ammonia limits were developed using the State Implementation Plan (SIP) methodology which requires the determination of dilution credit (along with other water quality parameters) to calculate average monthly and maximum daily effluent discharge limits. Calls to cap effluent ammonia discharges at current levels based on historical treatment performance are linked to the assertions of ammonia toxicity to copepods and inhibition of diatom algae productivity. However, Basin Plan water quality objectives have not been revised to reflect any potential changes associated with these assertions.

7.4.2 Selective Engagement Approach: Spokane River Dissolved Oxygen TMDL

The Spokane River watershed covers an area of about 6,640 square miles in Washington and Idaho. Excessive algae blooms and violations of water quality standards for dissolved oxygen and phosphorus that occurred in Lake Spokane resulted in the Washington Department of Ecology including the river on its 1996, 1998 and 2004 303(d) lists of impaired water bodies.

Washington Ecology began working on a Dissolved Oxygen Water Quality Improvement Project (TMDL) in 1998. In October 2004, Ecology released a draft TMDL for public comment that was controversial for a number of reasons, ranging from the application of the state dissolved oxygen water quality standard to a reservoir, to the extremely low, as low as 0.010 mg/L, effluent phosphorus levels contemplated for dischargers. Dischargers to the Spokane River had developed a Use Attainability Analysis and submitted a petition for rule making to revise the dissolved oxygen water quality criteria for the Spokane River and Lake Spokane. In an attempt to address these issues, the Spokane River TMDL Collaboration was initiated to foster a discussion on technical policy issues with the goal of completing the TMDL. The Collaboration included the Washington Department of Ecology, municipal and industrial dischargers, local governments, the Idaho Department of Environmental Quality (IDEQ), the EPA, the Spokane Tribe of Indians, environmental groups, and power companies.

The Collaboration developed the Foundational Concepts for the Spokane River TMDL Managed Implementation Plan. Discussions in the Collaboration addressed water quality modeling, wastewater treatment technology, effluent discharge permitting, and policy issues. Key outcomes from this dialog used for formulating the TMDL Managed Implementation Plan included multiple NPDES permit cycles for implementation of advanced treatment for phosphorus, a basis for water quality off-sets and trading, initiation of a nonpoint source management plan, consideration of bioavailability of phosphorus in future discharge permits, and a 10-year program evaluation and re-assessment.

The draft TMDL was revised and re-issued in 2007, and then again in 2009, and then finalized in February of 2010 (Moore et al., 2010). The final dissolved oxygen TMDL will require very low levels of effluent CBOD (4.2 mg/L), ammonia nitrogen (0.21 mg/L summer), and total phosphorus (0.042 mg/L in Washington and 0.036 mg/L in Idaho). Despite these very challenging effluent limits, the dialog with regulatory agencies on discharge permitting has resulted in a structure for effluent limits based on seasonal mass loading throughout the TMDL season from March through October. This permit structure avoids potential compliance issues associated with the variability in treatment performance at low effluent concentration levels and provides for feasible compliance in terms of reliability by avoiding monthly, weekly, and daily maximum limits.

7.4.3 Selective Engagement Approach: Chesapeake Bay

The history of water quality impacts from the pollution of Chesapeake Bay has been accelerating since the 1700s. These impacts include harmful effects on the oyster populations, shellfish beds, and bay grasses. Both point and nonpoint sources have caused these effects, including soil erosion from forest harvesting, agricultural tillage, fertilizers, coal burning wastes, and raw sewage. More scientific water quality surveys started to be conducted in the 1910s and water quality issues became widely recognized in the 1930s. This led to interstate conferences about protecting the Bay and led to both Maryland and Virginia creating water pollution control agencies. Although Baltimore was the last major American city to install sewer lines; it was one of the first to adopt a waste treatment system that protected the oyster beds.

Interest in environmental policies increased in the 1970s. The federal Clean Water Act was passed, establishing water quality standards and limiting the amount and type of pollutants entering Chesapeake Bay waterways. Activities also included the formation of environmental groups, the Susquehanna River Basin Commission, and an EPA five year study of Bay water quality (Flemer et al, 1983).

In the 1980s, a study on the Bay was published by EPA (Flemer et al, 1983). The findings included recommendations to address the overabundance of nitrogen and phosphorus pollution. This led to the Chesapeake Bay Agreement which established the Chesapeake Executive Council as the Bay Program's lead policy making authority, initiated a comprehensive water quality monitoring program, and started the first nutrient management efforts. Management efforts include enacting phosphate detergent bans in Maryland (1985), Washington D.C. (1986), Virginia (1988), and Pennsylvania (1990). The Chesapeake Bay Agreement also set a goal of reducing nitrogen and phosphorus entering the Bay by 40 percent. Additional activities included a lawsuit over the water quality of the Patuxent River which led to the introduction of biological nutrient removal at wastewater treatment plants in the basin.

Watershed management efforts in the 1990s included developing nutrient management plans for nearly one million acres of land in the watershed. In the late 1990s, the largest wastewater treatment facility in the area, the Blue Plains Wastewater Treatment Plant in the District of Columbia, added biological nutrient removal.

In 1999, two organizations (the American Canoe Association, Inc. and the American Littoral Society) sued in federal court to require that the states fully comply with the Clean Water Act for water quality protection of Chesapeake Bay. The result was a consent order, accepted by the states and EPA, which resulted in a new promise to complete studies to define the acceptable level of pollution in Bay tributaries and the Bay. In 2000, a goal to reduce nutrient and sediment pollution to remove the Bay from EPA's impaired water body listing by 2010 was agreed to in the document Chesapeake 2000 (Chesapeake Bay Program, 2000). This agreement effectively postponed the development of a TMDL.

In 2005, Chesapeake Bay jurisdictions implemented a permitting process that limited the amount of nitrogen and phosphorus that the Bay watershed's 483 significant wastewater treatment plants discharged. Pennsylvania established nutrient trading in December 2006. In 2007, Maryland set limits for municipal treatment plants discharging 500,000 gallons per day (gpd) or more that were based on the design flow of each plant as of April 2003, and concentrations of 3.0 mg/L total nitrogen and 0.3 mg/L total phosphorus using enhanced nutrient removal technology. To achieve these limits, Maryland established the Bay Restoration Fund with the purpose of creating a dedicated fund, financed by wastewater treatment plant users, to upgrade Maryland's wastewater treatment plants with enhanced nutrient removal (ENR) technology. In 2009, facilities claimed to have met 78 percent of the goal to reduce nitrogen and 99 percent of the goal to reduce phosphorus.

Unfortunately, like the earlier initiatives, The Chesapeake 2000 initiative fell short of its overall goals. While the point sources have made significant investments and reductions in nitrogen and phosphorus, water quality in the Bay had not improved because stormwater and agricultural nonpoint sources loads have not achieved similar degrees of reductions. Additional lawsuits resulted in EPA entering into a consent decree that required it to establish nutrient and sediment TMDLs for Virginia's impaired bay tributaries by no later than May 2, 2011. Additionally, the federal government responded to the lawsuits with Executive Order 13508 in 2009 requiring federal agencies to lead the effort to control pollution and protect wildlife habitats in the Chesapeake Bay watershed. In 2010, the EPA produced the Chesapeake Bay TMDL, describing it as the largest, most complex TMDL in the U.S. The TMDL is comprised of 92 smaller TMDLs for the impaired tributaries and bay segments. Table 2 summarizes the current and future effluent nutrient discharge limits for Chesapeake Bay dischargers.

7.4.4 Progressive Leadership Approach: Clark Fork River Voluntary Nutrient Reduction Program

A successful stakeholder-led watershed management program was developed for the Clark Fork River in western Montana in the 1990s which remains in place today. Nutrients in the Clark Fork River resulted in seasonal dense mats of filamentous algae and heavy growths of diatom algae. A watershed planning group led the development of a specific plan for implementation of nutrient management called the Clark Fork River Voluntary Nutrient Reduction Program (VNRP). The VNRP established in-stream nutrient targets which later became site specific water quality standards. The VNRP was approved by EPA as the equivalent to a TMDL and has been successful in improving water quality conditions on the Clark Fork.

Table 2. Summary of Nutrient Discharge Permit Limits for Chesapeake Bay[a]

State	Current Effluent Discharge Limits		2025 Effluent Discharge Limits Under New EPA TMDL[b]	
	TP, mg/L	TN, mg/L	TP, mg/L	TN, mg/L
Delaware	1.43 to 2	5.6 to 8	0.3 to 1	3 to 4
District of Columbia	1 to 3	4.7 to 8.7	0.18	3.9
New York	2 to 4	12 to 18	0.5	8
Maryland	0.5 to 3	6 to 18	0.3	4
Pennsylvania	1 to 3	8 to 12	0.8	6
Virginia	0.3 to 2.5	3 to 18.7	0.1 to 0.3	3 to 4
West Virginia	1 to 2	6 to 12	0.5	5

[a] Source: EPA Final Phase 1 Watershed Implementation Plans (WIPs)
[b] The TMDL targets 60 percent of nutrient reductions to be accomplished by 2017

7.4.4.1 Clark Fork River History

In 1984, a long range comprehensive study of the Clark Fork River in western Montana was initiated. The highest priority issue was algae growth and nutrients. In 1988, the results of the study included recommendations for addressing the issue including a coordinated program to investigate the sources and fate of nutrients. Congress authorized the program in Section 525 of the CWA amendments. From 1988 through 1992, Montana Department of Environmental Quality led the studies and developed a water quality management plan. In 1993, the Tri-State Water Quality Council was formed to implement the plan. In 1995, the Council started a voluntary approach to reducing nutrients "whereby the point source dischargers would be given an opportunity to develop actions for reducing nutrient loading to the river" (TSIC, 1998).

7.4.4.2 Voluntary Nutrient Reduction Program (VNRP)

The Nutrient Target Subcommittee was established by the Tri-State Implementation Council in 1994 to achieve consensus on in-stream nutrient targets for the Clark Fork River and to develop a basin-wide nutrient source reduction program to meet those targets. Subcommittee representation included the cities of Butte, Deer Lodge and Missoula; Stone Container Corporation; the University of Montana; the Clark Fork-Pend Oreille Coalition; the Missoula City-County Health Department; the Montana Department of Environmental Quality and EPA Region 8.

The subcommittee wrestled with the controversial questions and complex issues associated with the reduction of nutrient loading to the river. Over a period of approximately two years, the members built a foundation for open dialogue and trust as they worked to resolve these issues and concerns. Guided by the Council's April 1995 decision to take a voluntary approach rather than mandatory, permitted approach to the reduction strategy, the subcommittee completed its task of developing a specific plan of action embodied by the VNRP.

The ten-year VNRP called for site-specific measures to be taken by each of the four key point source dischargers and significant reductions in key nonpoint sources to meet specific in-stream algal density and nutrient targets. The targets and accompanying reduction measures were based on river study results, literature review, third party reviews, and citizen concerns about nuisance algae. The goal of the VNRP was to restore beneficial uses and eliminate nuisance algae growth in the Clark Fork River from Warm Springs Creek near Butte, MT to the Flathead River confluence. To reach this goal, the VNRP set in-stream chlorophyll-a targets for the Clark Fork River mainstem at a summer mean of 100 mg/m^2

and a peak of 150 mg/m^2. The in-stream nutrient concentration targets associated with this benthic algal density are 300 ug/L for total nitrogen and 20 ug/L upstream and 39 ug/L downstream of Missoula for total phosphorus.

A steady state fate and transport water quality model was used to simulate nutrient loadings and resultant water quality in the Clark Fork River. Multiple nutrient management scenarios were simulated with the model to arrive at the point source wasteload allocations and nonpoint source load allocations for the VNRP. The adopted VNRP management scenario is based on a nominal level of biological nutrient removal (BNR) with effluent total phosphorus of 1 mg/L and total nitrogen of 10 mg/L coupled with nonpoint source reductions based on extending sewers to a large urban/suburban area served by septic systems.

At three-year intervals during implementation of the VRNP, the program goals, discharger measures and river water quality are to be evaluated and revisions made as needed and agreed upon by subcommittee members. The City of Missoula upgraded its wastewater treatment plant to biological nutrient removal and the NPDES discharge permit was modified to incorporate the mass loading limits for nitrogen and phosphorus from the VRNP. The initial nonpoint source nutrient reduction effort was implemented and the targeted unsewered urban/suburban area was connected to the wastewater facility for nutrient removal.

REFERENCES

BACWA, 2011. Nutrient Strategy Development Project: The Utility of Water Quality Modeling for San Francisco Bay. September 16, 2011.

Chesapeake Bay Program, 2000. Chesapeake 2000. An agreement to reaffirm commitment to previously-adopted Chesapeake Bay Agreements and supporting policies. Signed by representatives of the Commonwealth of Virginia, State of Maryland, Commonwealth of Pennsylvania, District of Columbia, U.S. EPA, and Chesapeake Bay Commission.

EPA, 2000a. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. EPA-822-B-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

EPA, 2000b. Nutrient Criteria Technical Guidance Manual. Lakes and Reservoirs. EPA-822-B-00-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

EPA, 2003. Survey of States, Tribes and Territories Nutrient Standards. May 2003.

EPA, 2007. Memorandum Nutrient Pollution and Numeric Water Quality Standards. From Ben Grumbles, EPA Assistant Administrator for Water, to State Water Program Directors et al. Washington, DC.

Flemer, D.A., G.B. Mackiernan, W. Nehlsen, and V.K. Tippie, 1983. Chesapeake Bay: A Profile of Environmental Change. U.S. EPA, Region III, Philadelphia, PA.

McKee, L.J., Sutula, Gilbreath, A.N., Beagle, J., Gluchowski, D., and Hunt, J., 2001. Numeric nutrient endpoint development for San Francisco Bay- Literature review and Data Gaps Analysis. Southern California Coastal Water Research Project Technical Report No. 644. April 2011.

Hanlon, James A, 2004. Memorandum: Annual Permit Limits for Nitrogen and Phosphorus for Permits Designed to Protect Chesapeake Bay and its Tidal Tributaries from Excess Nutrient Loading under the National Pollutant Discharge Elimination System. Office of Water, U.S. EPA, Washington, DC.

Moore, David J. and Ross, James, 2010. Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load, Water Quality Improvement Report. Publication No. 07-10-073. Washington State Department of Ecology, Eastern Regional Office, Spokane, WA.

National Association of Clean Water Agencies (NACWA), Letter to Benjamin Grumbles, Assistant Administrator, Office of Water, USEPA, regarding NRDC Petition for Rulemaking on Secondary Treatment, February 29, 2008.

California Regional Water Quality Control Board – San Francisco Bay Region, 2010. San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan). Oakland, CA, December 31, 2010.

SFBCDC, 2003. Water Quality Protection and Nonpoint Source Pollution Control in San Francisco Bay. San Francisco Bay Conservation and Development Commission, San Francisco, CA.

SFEI, 2000. Contaminant Loads from Stormwater to Coastal Waters in the San Francisco Bay Region:

Comparison to other Pathways and Recommended Approach for Future Evaluation.

Smith, Stephen V. and James T. Hollibaugh, 2006. Water, salt, and nutrient exchanges in San Francisco Bay. American Society of Limnology and Oceanography 51(1, part 2) 504-517.

Tri-State Implementation Council. 1998. Nutrient Target Subcommittee, Clark Fork River Voluntary Nutrient Reduction Program (VNRP), August 1998.
http://www.tristatecouncil.org/documents/98vnrp_doc.pdf

USGS, 1979. Processes Affecting Seasonal Distributions of Water Properties in the San Francisco Bay Estuarine System. USGS, Menlo Park, CA.

WERF, 2010, *Nutrient Management: Regulatory Approaches to Protect Water Quality, Volume 1 – Review of Existing Practices*, HDR Engineering, Inc., Project #NUTR1R06i.